Curriculum Vitae: **Richard D. Braatz, Edwin R. Gilliland Professor**
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I. PERSONAL HISTORY AND PROFESSIONAL EXPERIENCE

A. Education

California Institute of Technology, Ph.D., Chemical Engineering, 1993
California Institute of Technology, M.S., Chemical Engineering, 1991
Oregon State University, B.S. with Honors, Chemical Engineering, 1988

B. Honors and Awards (Google Scholar h-index ≥ 95, total citations ≥ 40,000)

AIChE CAST Distinguished Service Award, 2025
John R. Ragazzini Education Award, American Automatic Control Council, 2023
Fellow of the Asia-Pacific Artificial Intelligence Association, 2023
Separations Division Innovation Award, American Institute of Chemical Engineers, 2019
Elected to the National Academy of Engineering, 2019
Fellow, American Institute of Chemical Engineers, 2018
Automatica Paper Prize, 2017
Excellence in Review Award, Industrial & Engineering Chemistry Research, 2015
Excellence in Education Award, International Society of Automation, 2015
Outstanding Reviewer, Chemical Engineering Science, 2015
AIChE CAST Computing in Chemical Engineering Award, 2014
AIChE PD2M Award for Outstanding Contribution to QbD for Drug Substance, 2013
Excellence in Technical Innovation Award, International Society of Automation, 2013
Distinguished Lecturer, IEEE Control Systems Society, 2013
Academy of Distinguished Engineers, Oregon State University, 2012
Control Systems Society Transition to Practice Award, Institute of Electrical and Electronics Engineers, 2011
Short List, Innovator of the Year Award, Institution of Chemical Engineers, 2010
Edwin R. Gilliland Professor of Chemical Engineering, MIT, 2010-date
Honorable Mention/Finalist, UCES Award, Krell Institute, 2009 and 2012
Research Collaboration Award, The Council for Chemical Research, 2009
Fellow, American Association for the Advancement of Science, 2008
Journal of Process Control Prize Paper Award (for theory/methodology), 2008
Journal of Process Control Prize Paper Award (for a survey), 2008
Fellow, International Federation of Automatic Control, 2008
Fellow, Institute of Electrical and Electronics Engineers, 2007
AIChE Excellence in Process Development Research Award, 2006
Millennium Chair of Chemical and Biomolecular Engineering, UIUC, 2006-2010
Lindsay Distinguished Lecturer, Texas A&M University, 2005-2006
Antonio Ruberti Young Researcher Prize, Institute of Electrical and Electronics Engineers, 2005
IEEE Transactions on Control Systems Technology Outstanding Paper Award, 2005
CAST Outstanding Young Researcher Award, American Institute of Chemical Engineers, 2005
Curtis W. McGraw Research Award, Engineering Research Council, 2004
CAST Directors' Award, American Institute of Chemical Engineers, 2003, 2015, 2018
University Scholar, University of Illinois, 2002-2005
Beckman Associate, UIUC Center for Advanced Study, 2002
Ernest W. Thiele Lectureship, University of Notre Dame, 2001

Collins Fellow, UIUC College of Engineering, 2001
Best Referee Award, Journal of Process Control, 2000
Donald P. Eckman Award, American Automatic Control Council, 2000
Council of Outstanding Early Career Engineers, Oregon State University, 2000
Dean's Teaching Fellow, UIUC College of Liberal Arts and Sciences, 2000
Xerox Award for Faculty Research, UIUC College of Engineering, 1999
Honorable Mention, UIUC Campus Award for Excellence in Guiding Undergraduate Research, 1999
Advisors List for Advising Excellence, UIUC College of Engineering, 1999, 2002
Outstanding Reviewer, Automatica, 1999, 2002
Teaching Excellence Award, UIUC School of Chemical Sciences, 1997
DuPont Young Faculty Award, 1995
Hertz Doctoral Thesis Prize, John and Fannie Hertz Foundation, 1994
American Control Conference Presentation Award, 1993, 2013, 2014
Hertz Fellow, 1991

C. List of Academic Positions since Final Degree

Director, Center for Continuous mRNA Manufacturing, MIT, 2022-date
Associate Faculty Director, Center for Biomedical Innovation, MIT, 2022-date
Affiliate Faculty, Center for Computational Science and Engineering, MIT, 2020-date
Affiliate Faculty, Schwarzman College of Computing, MIT, 2020-date
Research Officer, Department of Chemical Engineering, MIT, 2017-2022
Affiliate Faculty, Leaders for Global Operations, MIT, 2016-date
Affiliate Faculty, Center for Computational Engineering, MIT, 2015-2019
Graduate Officer, Department of Chemical Engineering, MIT, 2015-2016
Adjunct Professor, KAIST, 2013-2021
Affiliate Faculty, Sociotechnical Systems Research Center, MIT, 2013-date
Affiliate Faculty, Center for Biomedical Innovation, MIT, 2013-date
Affiliate Faculty, MIT Energy Initiative, 2011-date
Graduate Admissions Officer, Department of Chemical Engineering, MIT, 2011-2015
Affiliate Faculty, Novartis-MIT Center for Continuous Manufacturing, 2010-2019
Edwin R. Gilliland Professor of Chemical Engineering, Massachusetts Institute of Technology (MIT), 2010-date
Adjunct Professor, Department of Chemical and Biomolecular Engineering, UIUC, 2010-2015
Adjunct Professor, Department of Electrical and Computer Engineering, UIUC, 2010-2015
Visiting Scholar, School of Engineering and Applied Sciences, Harvard University, 2009-2010
Affiliate Faculty, Institute for Advanced Computing Applications and Technologies (IACAT), UIUC, 2008-2012
Lead, Research Project on Multiscale Simulation in Science and Engineering, IACAT, UIUC, 2008-2012
Affiliate Faculty, Institute for Genomic Biology, Regenerative Biology and Tissue Engineering Theme, UIUC, 2006-2010
Millennium Chair of Chemical and Biomolecular Engineering, UIUC, 2006-2010
Affiliate Faculty, Department of Mechanical Science and Engineering, UIUC, 2006-2010
Affiliate Faculty, Department of Electrical and Computer Engineering, UIUC, 2005-2010
Affiliate Faculty, Department of Mechanical and Industrial Engineering, UIUC, 2005-2006
Affiliate Faculty, Department of Bioengineering, UIUC, 2004-2010
Affiliate Faculty, Beckman Institute for Advanced Science and Technology, Molecular and Electronic Nanostructures Area, UIUC, 2004-2010
Applied Mathematics Faculty, UIUC, 2003-2012
Research Faculty, Center for Nanoscale Science and Technology, UIUC, 2003-2012
Visiting Professor of Chemical Engineering, Massachusetts Institute of Technology, 2002-2003
Professor of Chemical and Biomolecular Engineering, UIUC, 2002-2010

Beckman Associate, Center for Advanced Study, UIUC, 2001-2002
Affiliate Faculty, Bioengineering Program, UIUC, 2000-2004
Associate Professor of Chemical Engineering, UIUC, 2000-2002
Affiliate Faculty, Biotechnology Center, UIUC, 2000-2010
Senior Research Scientist, National Center for Supercomputing Applications (NCSA), UIUC, 1997-2002
Computational Science and Engineering Faculty, UIUC, 1995-2012
Assistant Professor of Chemical Engineering, Univ. of Illinois at Urbana-Champaign (UIUC), 1994-2000

D. Other Professional Employment (not including consulting)
Co-Founder and Chief Scientist, BioCurie, Inc., 2022-date
Visiting Research Scientist, DuPont Company, Wilmington, DE, 1993-1994
Visiting Research Scientist, Norwegian University of Science and Technology, Trondheim, 1993
Research Engineer, Chevron Research Company, Richmond, CA, 1988

E. Invited Lectures
1. Avery-Dennison Research Center, Pasadena, California, 1991.
2. Department of Chemical Engineering, Graduate Student Seminar Series, California Institute of Technology, Pasadena, California, 1992.
3. Department of Chemical Engineering, The Ohio State University, Columbus, OH, 1993.
4. Department of Chemical Engineering, University of Massachusetts, Amherst, MA, 1993.
5. Department of Chemical Engineering, University of Illinois, Urbana, IL, 1993.
6. Department of Chemical Engineering, Case Western Reserve University, Cleveland, OH, 1993.
7. Department of Chemical Engineering, Rice University, Houston, TX, 1993.
8. Department of Chemical Engineering, University of California, Berkeley, CA, 1993.
9. Department of Chemical Engineering, University of California, Santa Barbara, CA, 1993.
10. Department of Chemical Engineering, University of Pittsburgh, PA, 1993.
11. Department of Chemical Engineering, University of Trondheim, Norway, 1993.
12. Department of Control Engineering, University of Stuttgart, Germany, 1993.
13. Shell Westhollow Research Center, Houston, TX, 1993.
14. DuPont Experimental Station, Wilmington, DE, 1993.
15. 1st Annual Midwest Process Control Workshop, Systems and Control Center, School of Chemical Engineering, Purdue University, West Lafayette, IN, 1994.
16. DuPont Experimental Station, Wilmington, DE, 1994.
17. Decision and Control Laboratory, Coordinated Science Laboratory, University of Illinois, Urbana, IL, 1994.
18. International Paper Research Center, Mobile, AL, 1995.
19. Systems and Control Center, School of Chemical Engineering, Purdue University, West Lafayette, IN, 1995.
20. Weyerhaeuser Workshop on Modeling and Control of Kamyr Digesters and Paper Machines, Weyerhauser Research Center, Tacoma, WA, 1995.
21. Department of Chemical Engineering, University of Cincinnati, OH, 1996.
22. Complexity Seminar Series, Department of Mathematics, University of Illinois, Urbana, IL, 1997.
23. Merck Research Center, Rahway, NJ, 1997.
24. Centre National de la Recherche Scientifique (CNRS), Paris, France, 1997.
25. Department of Chemical Engineering, Northwestern University, Evanston, IL, 1998.
26. Merck Research Center, Rahway, NJ, 1998.
27. Center for Process Analytical Chemistry, University of Washington, Seattle, WA, 1998.
28. CIC TechForum98, Beckman Institute of Advanced Science and Technology, University of Illinois, IL, 1998.
29. Department of Chemical Engineering, University of Notre Dame, IN, 1999.
30. Bristol-Myers Squibb Research Center, New Brunswick, NJ, 1999.

31. American Institute of Chemical Engineers (AIChE), Illinois Chapter, Champaign, IL, 1999.
32. Systems and Control Center, School of Chemical Engineering, Purdue University, West Lafayette, IN, 1999.
33. Refining Technology Group, Amoco Oil Company, BP Amoco, Naperville, IL, 1999.
34. Merck Research Center, Rahway, NJ, 1999.
35. Department of Chemical Engineering, University of Florida, Gainesville, FL, 2000.
36. FBRM Users Forum, Orlando, FL, 2000.
37. International Paper Technology Center, Cincinnati, OH, 2000.
38. Abbott Laboratories, Chicago, IL, 2000.
39. Science and Engineering Education Scholars Program Workshop, University of Illinois, Urbana, IL, 2000.
40. Control 2000 Symposium, University of Illinois, Urbana, IL, 2000.
41. Department of Chemical Engineering, National University of Singapore, Singapore, 2000.
42. DuPont Singapore, Singapore, 2000.
43. Glaxo Wellcome Manufacturing, Singapore, 2000.
44. Department of Chemical Engineering, National University of Singapore, Singapore, 2000.
45. Kyoto University, Kyoto, Japan, 2000.
46. International Paper Technology Center, Cincinnati, OH, 2000.
47. International Conference on Chemical Process Control 6, Tucson, Arizona, 2001.
48. NUS-UIUC Joint Symposium, Department of Chemical Engineering, National University of Singapore, Singapore, 2001.
49. Annual Conference for NSF K-12 Mathematics, Science, and Implementation Projects, Washington, DC, 2001.
50. Decision and Control Laboratory, Coordinated Science Laboratory, University of Illinois, Urbana, IL, 2001.
51. FBRM Users Conference, Barcelona, Spain, 2001.
52. Annual Meeting of the Association for Crystallization Technology, Northbrook, Illinois, 2001.
53. Department of Chemical Engineering, University of California at Los Angeles, 2001.
54. Merck Research Center, Rahway, NJ, 2001.
55. **Plenary Lecture**, "Challenges, Theory, and Applications in Process Control," American Control Conference, Arlington, Virginia, 2001.
56. International Conference on Materials for Advanced Technologies, Symposium D: Crystallization and Interfacial Processes, Singapore, 2001.
57. International Conference on Materials for Advanced Technologies, Symposium H: Materials Science and Engineering Education in New Millennium, Singapore, 2001.
58. GlaxoSmithKline, Singapore, 2001.
59. Department of Chemical and Process Engineering, University of Sheffield, UK, 2001.
60. 2nd Pan American Workshop on Process Systems Engineering, Guaruja, Brazil, 2001.
61. **Ernest W. Thiele Lecture**, "Advances in the Control of Complex Chemical Systems", University of Notre Dame, IN, 2001.
62. "ChemViz II: Chemistry Visualization," Supercomputing2001, Denver, CO, 2001.
63. "Advances in the Control of Complex Chemical Systems," Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA, 2001.
64. "Robust Identification and Control of Batch Processes," Process Design, Operations, and Control Seminar, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA, 2001.
65. "Paracetamol Crystallization using FBRM and ATR-FTIR: Metastability and Agglomeration," FBRM Users Forum, Charleston, SC, 2002.
66. "Model Based Experimental Design and Optimization for Crystallization of a Pharmaceutical Compound," FBRM Users Forum, Charleston, SC, 2002.

67. “Challenges, Theory, and Applications of Process Control,” Department of Chemical Engineering, University of South Carolina, Columbia, SC, 2002.
68. “Advances in the Control of Complex Chemical Systems,” Department of Chemical Engineering, University of Massachusetts, Amherst, MA, 2002.
69. “Advances in the Control of Complex Chemical Systems,” Chemical Process Modeling and Control Research Center, Lehigh University, Bethlehem, PA, 2002.
70. “Control of Sheet and Film Processes,” Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA, October 18, 2002.
71. “Fault Detection and Diagnosis Applied to Whole Chemical Plants,” United Technologies Corporation Fuel Cells, South Windsor, Connecticut, October 29, 2002.
72. “Theory and Practice of Fault Detection and Diagnosis,” United Technologies Research Corporation, Connecticut, October 29, 2002.
73. “Systems Engineering of Nanomaterials Manufacturing Processes,” Process Design, Operations, and Control Seminar, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA, November 21, 2002.
74. “Advances in Crystallization Modeling and Control,” Merck, Rahway, NJ, February 24, 2003.
75. “Fundamentals of Crystallization Control,” Crystallization Training Seminar: Fundamentals of Batch Crystallization Design - A High-Tech Approach, Mettler-Toledo, New York, February 25, 2003.
76. “Measurement of Particle Size Distribution in Suspension Polymerization using Laser Backscattering and Process Video Microscopy,” Lasentec Users Forum, New York, February 26, 2003.
77. “Control of Sheet and Film Processes,” Systems Research Institute, Polytechnic University, Brooklyn, NY, February 27, 2003.
78. “Advances in the Control of Particulate Processes,” Department of Chemical Engineering, Chemistry, and Materials Science, Polytechnic University, Brooklyn, NY, February 28, 2003.
79. “Advances in the Control of Complex Chemical Systems,” Department of Chemical Engineering, University of California at Santa Barbara, CA, April 17, 2003.
80. “Advances in Crystallization Modeling and Control,” Sepracor, Inc., MA, May 20, 2003.
81. “Advances in Crystallization Control,” Institute of Chemical and Engineering Sciences, Singapore, June 13, 2003.
82. **Keynote Lecture**, “Multiscale Systems Engineering with Applications to Electronics Devices,” Center for Process Systems Engineering Inaugural Symposium, Georgia Institute of Technology, Atlanta, GA, September 9, 2003.
83. “Experimental Design and Control Strategies for Batch Crystallization,” Annual Meeting of the Association for Crystallization Technology, Groton, CT, September 15-17, 2003.
84. “Multiscale Systems Engineering with Applications to Electronic Devices,” Center for Nanoscale Science and Technology and Decision and Control Laboratory, Coordinated Science Laboratory, University of Illinois, Urbana, IL, October 8, 2003.
85. “Multiscale Systems Engineering with Applications to Microelectronics,” Department of Chemical Engineering, University of Delaware, Newark, DE, December 5, 2003.
86. **Semi-plenary Lecture**, “Advances in the Modeling and Control of Batch Crystallizers,” IFAC Symposium on Advanced Control of Chemical Processes, Hong Kong, January 14, 2004.
87. “Multiscale Systems and Control with Applications to Electronic Devices,” Department of Chemical Engineering, National Taiwan University, Taipei, Taiwan, January 16, 2004.
88. “Multiscale Systems and Control,” Center for Process Systems Engineering Consortium Meeting, Imperial College, London, United Kingdom, April 23, 2004.
89. “Advances in Crystallization Control,” Bristol Myers Squibb Research Center, New Brunswick, NJ, June 10, 2004.
90. “Modeling and Control of Multiscale Systems,” Annual Meeting of the McMaster Advanced Control Consortium, McMaster University, Hamilton, Ontario, Canada, June 23, 2004.

91. **Keynote Lecture**, "Perspectives on the Dynamics and Control of Multiscale Systems," International IFAC Symposium on Dynamics and Control of Process Systems, Cambridge, MA, July 5-7, 2004.
92. "Multiscale Systems Theory with Application to Electronic Devices," Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Canada, July 26-27, 2004.
93. "Advances in Crystallization using Laser Backscattering and ATR-FTIR Spectroscopy: Automation, Metastability, and Control," Institute of Chemical and Engineering Sciences, Singapore, August 6, 2004.
94. "New Technologies for the Modeling and Control of Industrial Crystallization," Kraft Foods, Chicago, IL, January 31, 2005.
95. "Uncertainty Quantification of Highly Nonlinear Processes," Laboratory for Product and Process Design, University of Illinois at Chicago, February 1, 2005.
96. "Multiscale Systems Theory with Applications to Microelectronic Devices," Illinois Institute of Technology, Chicago, IL, February 2, 2005.
97. "Multiscale Systems Theory with Applications to Microelectronic Processes," Ecole Polytechnique de Montréal, Quebec, Canada, February 17, 2005.
98. E. J. Hukkanen and R. D. Braatz, "Use of Process Analytical Technologies in Polymerization Processes," Mettler-Toledo AutoChem Real Time Analytics Users' Forum, New York, February 27-March 2, 2005.
99. "Chemometrics, Modeling, and Control in Pharmaceutical Crystallization," FDA Center for Drug Evaluation and Research, Department of Health & Human Services, U.S. Food and Drug Administration, Rockville, MD, March 29, 2005.
100. U. Ravaioli and R. D. Braatz, "Designing Simulations for Nanoscience Applications," National Center for Learning and Technology in Nanoscale Science and Engineering, webcast, May 16, 2005.
101. "Applications of Statistics to Multiscale Systems," Gordon Conference on Statistics in Chemistry and Chemical Engineering**,** Mount Holyoke College, South Hadley, MA, July 19, 2005.
102. "Applications of ATR-FTIR Spectroscopy and Laser Backscattering to the Design of Batch Crystallization Recipes," Annual Conference of the British Association for Crystal Growth, University of Sheffield, United Kingdom, September 4-6, 2005.
103. "Applications of ATR-FTIR Spectroscopy and Laser Backscattering to the Design of Batch Crystallization Recipes," AstraZeneca, Loughborough, United Kingdom, September 7, 2005.
104. "Applications of Statistics to Multiscale Systems," SIGENE, Norwegian University of Life Sciences, Ås, Norway, October 24, 2005.
105. **Annual Industry Lecture**, "Modeling and Simulation of Multiscale Chemical Systems," Norwegian Chemical Society, Oslo, Norway, October 25, 2005.
106. "Applications of Statistics to Multiscale Chemical Systems," Norwegian University of Science and Technology, Trondheim, Norway, October 27, 2005.
107. "Multiscale Systems Theory with Microelectronics Applications," Department of Engineering Cybernetics, Norwegian University of Science and Technology, Trondheim, Norway, October 27, 2005.
108. Richard C. Alkire and Richard D. Braatz, "Multiscale Modeling and Experiments on the Effect of Additives on Shape Evolution during Electrodeposition," Joint National Institute for Nanotechnology/Center for Nanoscale Science and Technology Workshop, University of Illinois, October 31, 2005.
109. "Multiscale Systems Approach to Electrochemical Processes," Department of Chemical and Biomolecular Engineering, University of Pennsylvania, Philadelphia, PA, November 16, 2005.
110. "Multiscale Predictive Modeling of Complex Systems," University of Oklahoma, Norman, OK, November 30, 2005.
111. "Multiscale Modeling of Complex Reacting Systems," School of Chemical, Biochemical, and Materials Engineering, University of Oklahoma, Norman, OK, December 1, 2005.

112. "Multiscale Simulation and Analysis of Microelectronics Processes," Lehrstuhl für Prozesstechnik, Aachen University, Germany, December 8, 2005.
113. "Multiscale Systems Theory with Applications to Microelectronic Processes," Engineering Cybernetics Seminar Series, University of Stuttgart, Germany, December 9, 2005.
114. "A Multiscale Systems Approach to Microelectronic Processes," International Conference on Chemical Process Control 7, Lake Louise, Alberta, Canada, January 9, 2006.
115. "Advances in Modeling, Monitoring, and Control of Pharmaceutical Crystallization," Schering-Plough Research Institute, Union, NJ, February 10, 2006.
116. "Multiscale Systems and Control," Symposium on Trends in Systems and Control Theory, Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg, Germany, March 1-2, 2006.
117. "Advances in Modeling, Monitoring, and Control of Pharmaceutical Crystallization," Global Pharmaceutical Research and Development, Abbott Laboratories, Illinois, March 7, 2006.
118. "A Multiscale Systems Approach to Microelectronic Processes," Department of Chemical Engineering and Materials, University of Loughborough, United Kingdom, March 27, 2006.
119. "Multiscale Modeling of Complex Reacting Systems," School of Chemical Engineering and Analytical Science, The University of Manchester, Manchester, United Kingdom, March 29, 2006.
120. **Distinguished Lecturer**, "Multiscale Systems Theory with Applications to Microelectronic Processes," Lindsay Lecture Series, Department of Chemical Engineering, Texas A&M University, College Station, TX, April 7, 2006.
121. "Modeling, Design, and Control of Multiscale Processes with Application to Batch Organic Crystallization," Process Chemistry & Engineering, Royal Society of Chemistry, Newcastle, United Kingdom, April 10, 2006.
122. "Multiscale Systems Theory with Microelectronics Applications," Automatic Control Laboratory, School of Engineering, Ecole Polytechnique Lausanne, Switzerland, April 13, 2006.
123. "A Multiscale Systems Approach to Microelectronic Processes," Department of Chemical Engineering, Carnegie Mellon University, Pittsburgh, PA, April 25, 2006.
124. "Online Monitoring of Crystallization Processes with Application to Batch Recipe Design," Process Crystallization in the Pharmaceutical and Chemical Industry, American Chemical Society ProSpectives Series, Philadelphia, PA, April 26-27, 2006.
125. "Advances in Modeling, Monitoring, and Control of Pharmaceutical Crystallization," Sepracor, Inc., MA, May 8, 2006.
126. "Advances in Modeling, Monitoring, and Control of Pharmaceutical Crystallization," Eli Lilly, IN, May 23, 2006.
127. "Online Monitoring of Crystallization Processes with Application to Batch Recipe Design," TAP Pharmaceuticals, Lake Forest, IL, August 10, 2006.
128. "Modeling and Design of Multiscale Chemical Systems," WebCAST lecture, American Institute of Chemical Engineers, Computing and Systems Technology Division, September 29, 2006.
129. "Challenges in the Scale-up of Crystallization for Specialty Products from Laboratory R&D through to Manufacturing Scale," 14th Larson Workshop, Association for Crystallization Technology, Princeton, NJ, October 10, 2006.
130. "Design of Crystallization Processes from Laboratory R&D to the Manufacturing Scale," Crystallization Process Development: Case Studies & Research, American Chemical Society ProSpectives Series, Boston, MA, February 26, 2007.
131. "Design of Crystallization Processes from Laboratory R&D to the Manufacturing Scale," Crystallization Process Development: Case Studies & Research, Pfizer, Groton, CO, February 28, 2007.
132. "Control of Polymorphism," TAP Pharmaceuticals, Lake Forest, IL, May 23, 2007.
133. R. D. Braatz (speaker) and L. Goh, "Five Non-Intuitive Things about the Nanoscale," NCLT Center-wide Meeting, Northwestern University, Evanston, IL, May 25, 2007.

134. **Keynote Lecture**, Z. K. Nagy, M. Fujiwara, and R. D. Braatz, "Recent Advances in the Modelling and Control of Cooling and Antisolvent Crystallization of Pharmaceuticals," 8th International IFAC Symposium on Dynamics and Control of Process Systems, Cancun, Mexico, June 6-8, 2007.
135. "Modeling and Design of Multiscale Chemical Systems," Department of Chemical Engineering, University of Texas at Austin, September 11, 2007.
136. "Process Analytical Technology for Crystallization Processes," Process Analytical Technology **Plenary Session**, AIChE Annual Meeting, Salt Lake City, UT, November 2007.
137. K. Chen, N. Nair, M. S. Strano, and R. D. Braatz (speaker). "Parameter Identification for Chirality-selective Single-walled Carbon Nanotube Chemical Reaction Networks," CAST **Plenary Session**, AIChE Annual Meeting, Salt Lake City, November 2007.
138. "Modeling and Design for Drug Delivery, Tissue Engineering, and Crystallization" Bend Research, Bend, OR, November 12, 2007.
139. "Advances in Crystallization Modeling and Control," Bend Research, Bend, OR, November 12, 2007.
140. "Modeling of Controlled Release Microspheres," Regenerative Biology and Tissue Engineering Theme, Institute for Genomic Biology, December 19, 2007, noon.
141. "Advances in PAT for Pharmaceutical Crystallization," Bristol-Myers Squibb Research Center, New Brunswick, NJ, February 19, 2008.
142. "Process Analytical Technology for Pharmaceutical Crystallization," Bristol-Myers Squibb Research Center, New Brunswick, NJ, February 19, 2008.
143. "Modeling and Design of Multiscale Chemical Systems," Department of Chemical Engineering, University of Waterloo, Canada, March 20, 2008.
144. **Plenary Lecture**, "Advances in the Control of Pharmaceutical Crystallization Processes," 19th China Process Control Conference, Beijing, China, July 23-26, 2008.
145. "Modeling and Design of Multiscale Chemical Systems," Department of Chemical Engineering, Tennessee Technological University, Cookeville, TN, September 16, 2008.
146. "Modeling of Pharmaceutical and Biomedical Systems," Department of Chemical Engineering, Tennessee Technological University, Cookeville, TN, September 16, 2008.
147. "Mathematical Modeling and Design of Biomolecular Systems," Department of Bioengineering, University of Illinois at Chicago, January 23, 2009.
148. Richard D. Braatz (speaker) and Paul J. A. Kenis, "Screening, Optimization, and Modeling of Protein and Pharmaceutical Crystallization within High-throughput Microfluidic Platforms," Symposium on Recent Challenges in Crystallisation Science and Engineering, Institute of Process Research and Development, University of Leeds, United Kingdom, March 24, 2009.
149. "Multiscale Simulation and Systems Engineering," Beckman Institute of Advanced Science and Technology, Urbana, Illinois, April 6, 2009.
150. "Robust Optimal Control of Distributed Parameter Systems," Institut für Automatik (Automatic Control Laboratory), Eidgenössische Technische Hochschule (Swiss Federal Institute of Technology), Zürich, Switzerland, April 20, 2009.
151. "Advances in Pharmaceutical and Protein Crystallization," Institut für Verfahrenstechnik (Institute for Process Engineering), Eidgenössische Technische Hochschule (Swiss Federal Institute of Technology), Zürich, Switzerland, April 21, 2009.
152. "Robust Optimal Control of Distributed Parameter Systems," Institut für Systemtheorie und Regelungstechnik (Institute for Systems Theory and Automatic Control), University of Stuttgart, Germany, April 22, 2009.
153. "PAT and Direct Design Approaches to Crystallisation," GlaxoSmithKline, Stevenage, United Kingdom, April 24, 2009.
154. "Crystallisation Modeling," GlaxoSmithKline, Stevenage, United Kingdom, April 24, 2009.
155. "Robust Optimal Control of Distributed Parameter Systems," Cymer Center for Control Systems and Dynamics, University of California at San Diego, CA, May 8, 2009.

156. "In-situ Process Video Microscopy, FBRM, and Kinetics Modeling of Emulsions," Procter and Gamble, Cincinnati, Ohio, June 4, 2009.
157. "Process Analytical Technology with Application to Industrial Crystallization," Procter and Gamble, Cincinnati, Ohio, June 4, 2009.
158. V. R. Subramanian (speaker), V. Boovaragavan, V. Ramadesigan, K. Chen, and R. D. Braatz. "Model Reformulation and Design of Lithium-Ion Batteries," Foundations of Computer-Aided Process Design, Breckenridge, CO, June 7-12, 2009.
159. R. D. Braatz (speaker), K. Chen, N. Nair, and M. S. Strano, "Modeling and Design of Carbon Nanotube-based Sensors," Purdue University, West Lafayette, Indiana, July 17, 2009.
160. R. D. Braatz (presenter), L. Goh, K. Kim, D. Reid, M. Rasche, and M. Fujiwara, "Interactive Simulations for Illustrating "Nano" Concepts: Nanoparticles, Nanowires, and Nanoporous Materials," Addressing the Challenges of Nanoscale Science and Engineering Education Symposium on Undergraduate Nano-Education, University at Albany, NY, August 6, 2009 (poster).
161. Contributor to "Nano 101" Session, 8th Annual NanoBusiness Conference, Chicago, Illinois, September 8, 2009. http://nanobusiness2009.com/index.php/program
162. "Computer-Aided Design of Spatially Controlled Release in Stem Cell Tissue Engineering," Topics in Bioengineering Seminar Series, School of Engineering and Applied Sciences, Harvard University, September 22, 2009.
163. "Robust Optimal Control of Finite-time Distributed Parameter Systems," Dynamical Systems, Control and Optimization Group, School of Engineering, Universite Catholiqué de Louvain, Belgium, October 13, 2009.
164. "Robust Optimal Control of Finite-time Distributed Parameter Systems," Optimization in Engineering Center, Faculty of Engineering Science, Katholieke Universiteit Leuven, Belgium, October 15, 2009.
165. "Robust Optimal Control of Finite-time Distributed Parameter Systems," Institute for Automation Engineering, Otto-von-Guericke-University, Magdeburg, Germany, October 22, 2009.
166. "Advances in Pharmaceutical and Protein Crystallization," Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg, Germany, October 23, 2009.
167. "Advances in Pharmaceutical and Protein Crystallization," Department of Chemical Engineering, University of Loughborough, England, October 26, 2009.
168. "Design and Control of Multiscale Chemical Systems," Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA, November 6, 2009.
169. "Multiscale Simulation in Science and Engineering," COMSEF **Plenary Session**: Opportunities for Chemical Engineering in Petascale Computing, AIChE Annual Meeting, Nashville, TN, November 9, 2009.
170. "The Role of Automatic Process Control in QbD," Emerging Topics **Plenary Session**, Topical I: Comprehensive Quality by Design in Pharmaceutical Development and Manufacture, AIChE Annual Meeting, Nashville, TN, November 11, 2009.
171. "Interactive Computational Engineering and Science Software for Nanoscale Applications," Education **Plenary Session**, International Conference for High Performance Computing, Networking, Storage and Analysis (SC09), Portland OR, November 15, 2009.
172. M. Kishida, D. W. Pack, and R. D. Braatz (speaker), "Computer-based Design for Stem Cell Tissue Engineering," Synthetic Biology: Building on Nature's Inspiration, 7th Annual National Academies Keck Futures Initiative (NAKFI) Conference, The National Academies, Irvine, California, November 19-22, 2009 (poster).
173. "Advances in Pharmaceutical Crystallization," Boehringer-Ingelheim, Connecticut, January 15, 2010.
174. "Design and Control of Multiscale Chemical Systems," Department of Chemical and Biological Engineering, Tufts University, Medford, Massachusetts, February 8, 2010.

175. "Computer-Aided Design of Spatially Controlled Release in Stem Cell Tissue Engineering," Department of Chemical and Biological Engineering, Rensselaer Polytechnic Institute, Troy, New York, April 30, 2010.
176. "Computer-Aided Design of Spatially Controlled Release in Stem Cell Tissue Engineering," Bio-Interest Group Seminar Series, Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, August 30, 2010.
177. "Spatially Controlled Release in Stem Cell Tissue Engineering," Percivia, Cambridge, Massachusetts, February 4, 2011.
178. "Advances in Pharmaceutical Crystallization," Sunovion Pharmaceuticals, Marlborough, Massachusetts, February 24, 2011.
179. "Design and Control of Multiscale Chemical Systems," Alchemy 2011: Energise the Future, National Institute of Technology, Tiruchirapalli, India, March 18, 2011 (via skype).
180. "Robust Optimal Control of Finite-time Distributed Parameter Systems," Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, Massachusetts, April 5, 2011.
181. "Estimation and Modeling of Crystal Size and Shape Evolution Using In Situ Tools," Millennium Pharmaceuticals, Cambridge, Massachusetts, May 5, 2011.
182. R. Lakerveld, R. D. Braatz, and P. I. Barton, "A Plant-wide Control Strategy for Continuous Pharmaceutical Manufacturing," Novartis, East Hanover, New Jersey, May 19, 2011 (poster).
183. "Process Systems Engineering and Intensification," Eni-MIT Workshop, Milan, Italy, June 29, 2011.
184. "NanoSystems Engineering: Analysis, Design, and Control at the Nanoscale," Institut für Chemie- und Bioingenieurwissenschaften (Institute for Chemical and Bioengineering), Eidgenössische Technische Hochschule (Swiss Federal Institute of Technology), Zürich, Switzerland, August 26, 2011.
185. "Efficient Polynomial-time Outer Bounds on State Trajectories for Uncertain Polynomial and Rational Systems," Institut für Systemtheorie und Regelungstechnik (Institute for Systems Theory and Automatic Control), University of Stuttgart, Germany, September 27, 2011.
186. **Keynote Speaker**, "Advances in Pharmaceutical Crystallization: Control of Polymorphic Identity, Shape, and Size Distribution," International Congress on Pharmaceutical Engineering Science, Graz, Austria, September 29, 2011.
187. "Fault-Tolerant Model Predictive Control of Refining," BP, Naperville, Illinois, November 16, 2011.
188. "Process Intensification," Eni-MIT Joint Steering Committee Meeting, Cambridge, Massachusetts, November 18, 2011.
189. "Quality by Design Approaches for Pharmaceutical and Biopharmaceutical Manufacturing Processes," Annual Biomanufacturing Summit, Massachusetts Institute of Technology, Cambridge, Massachusetts, November 18, 2011.
190. "Frontiers of Process Monitoring and Control of Industrial Systems," Pall Corporation Executive Briefing, Massachusetts Institute of Technology, Cambridge, Massachusetts, November 21, 2011.
191. "Control of Nano and Microchemical Systems," in Session on "Non-traditional Application Domains: Success Stories and Challenges," International Conference on Chemical Process Control VIII, Savannah, Georgia, January 11-13, 2012.
192. "Advances in Pharmaceutical Crystallization: Control of Polymorphic Identity, Shape, and Size Distribution," Millennium Pharmaceuticals, Cambridge, Massachusetts, January 20, 2012.
193. "Systems Nanotechnology: Identification, Estimation, and Control at the Nanoscale," Mork Family Department of Chemical Engineering and Materials Science, University of Southern California, Los Angeles, January 26, 2012.
194. "Advanced Control Techniques from Other Fields, Their Applicability, and Impact on Energy Storage," ARPA-E Workshop, Washington, DC, February 8, 2012.

195. "Chemical Engineering from Fish Oil to Systems Nanotechnology," School of Chemical, Biological, and Environmental Engineering, Oregon State University, Corvallis, Oregon, February 24, 2012.
196. "Abstracting Knowledge from Data: Fault Detection, Diagnosis, and Feedback Control," Data Analytics for the Energy Industry Workshop, The Royal Society of Chemistry, London, United Kingdom, March 20, 2012.
197. "Systems and Control of Lithium-ion Batteries," United Technologies Research Corporation, South Windsor, Connecticut, March 27, 2012.
198. **Julia Sung Distinguished Lecture**, "Advances in Pharmaceutical Crystallization: Control of Polymorphic Identity, Shape, and Size Distribution," Department of Chemical and Biological Engineering, University of British Columbia and the Vancouver Chapter of IEEE, Vancouver, British Columbia, Canada, March 29, 2012.
199. R. Lakerveld (speaker), J. M. B. Evans, B. Benyahia, R. D. Braatz, and P. I. Barton, "Implementing Continuous Manufacturing: The Synergy Between Plant-wide Control, Modeling, and QbD," Pharma QbD Forum, Berlin, Germany, April 24-25, 2012.
200. "Systems Nanotechnology: Identification, Estimation, and Control of Nanoscale Systems," Perspectives in Control Theory and Systems Biology - A Fest Colloquium on the Occasion of Frank Allgöwer's 50th birthday, Stuttgart, Germany, June 11, 2012.
201. **Semi-plenary Lecture**, "Systems Nanotechnology: Identification, Estimation, and Control of Nanoscale Systems," American Control Conference, Montréal, Quebec, Canada, June 27, 2012.
202. "Data-driven Methods for Fault Detection and Diagnosis," BP, Naperville, Illinois, July 26, 2012.
203. "Systems Nanotechnology: Moving From Nano-Science to Nano-Products," Future Innovation in Process Systems Engineering, Aldemar-Olympian Village, Western Peloponnese, Greece, August 29-31, 2012.
204. "Systems Nanotechnology: Estimation, Design, and Control of Nanoscale Systems," School for Engineering of Matter, Transport, and Energy, Arizona State University, Tempe, Arizona, September 10, 2012.
205. R. Lakerveld (speaker), B. Benyahia, P. L. Heider, H. Zhang, S. Mascia, J. M. B. Evans, R. D. Braatz, and P. I. Barton, "Case Study: The Application of a Plant-wide Control Strategy for a Continuous Pharmaceutical Process at the Novartis-MIT Center for Continuous Manufacturing," The University of Heidelberg International QbD/PAT Conference 2012, Heidelberg, Germany, September 26-27, 2012.
206. **Plenary Lecture**, "Control of Molecular Purity, Crystal Structure, and Particle Size Distribution in Pharmaceutical Crystallization," IEEE Multi-Conference on Systems and Control (MSC), Dubrovnik, Croatia, October 2-5, 2012.
207. "Systems Nanotechnology: Identification, Estimation, and Control of Nanoscale Systems," Center for Control, Dynamical-Systems, and Computation, University of California, Santa Barbara, October 12, 2012.
208. "Control of Molecular Purity, Crystal Structure, and Particle Size Distribution in Pharmaceutical Crystallization," Department of Chemical and Biomolecular Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea, October 22-23, 2012.
209. **Keynote Lecture**, "Systems Nanotechnology: Estimation, Design, and Control of Nanoscale Systems," Fall Symposium of the Korean Institute of Chemical Engineers, Pushan, South Korea, October 24, 2012.
210. **Plenary Lecture**, R. D. Braatz (speaker), "Looking to the Future in Continuous Pharmaceutical Manufacturing," Plenary Session on the Next Frontier in the Application of Quality by Design, AIChE Annual Meeting, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Lecture described in AIChE ChEnected news on October 31, 2012. The presentation is available on-line in AIChE ChemE on Demand at http://www.aiche.org/resources/chemeondemand/conference-presentations/looking-future-continuous-pharmaceutical-manufacturing.

211. "Computational Engineering and Science Software for Nanoscale Explorations," SIAM Computational Science and Engineering Conference, Boston, Massachusetts, February 27, 2013.
212. R. Lakerveld (speaker), B. Benyahia, P. L. Heider, H. Zhang, S. Mascia, J. M. B. Evans, R. D. Braatz, and Paul I. Barton, "A Plant-wide Control Strategy for an Integrated Continuous Pharmaceutical Pilot Plant," 10th Annual PAT and Quality by Design, London, United Kingdom, March 18-20, 2013.
213. "Design of a Novel Continuous Pharmaceutical Crystallizer," Millennium Pharmaceuticals, Cambridge, Massachusetts, May 17, 2013.
214. "Control in Continuous Pharmaceutical Manufacturing," U.S. Food and Drug Administration, White Oak campus, Silver Spring, Maryland, June 4, 2013.
215. "An Overview on Multiscale Modeling and Simulation I," Summer School of the International Max Planck Research Graduate School, Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg, Germany, September 2, 2013.
216. "An Overview on Multiscale Modeling and Simulation II," Summer School of the International Max Planck Research Graduate School, Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg, Germany, September 2, 2013.
217. "Perspectives on Modeling and Control of Li-ion Batteries," Systems and Control Seminar Series, Department of Electrical Engineering, Otto-von-Guericke University Magdeburg, Germany, September 4, 2013.
218. "Perspectives on Modeling and Control of Li-ion Batteries," Institute of Energy and Process Systems Engineering, Faculty of Mechanical Engineering, Technische Universität Braunschweig, Germany, September 6, 2013.
219. "Design and Control of Multiscale Chemical Systems," ABB Corporate Research Centre, Bangalore, India, September 10, 2013.
220. "Fast Model Predictive Control," ABB Corporate Research Centre, Bangalore, India, September 10, 2013.
221. **Keynote Address**, "Optimization and Control Using Population Balance Models," 5th International Conference on Population Balance (PB) Modelling 2013 (PBM-2013), Bangalore, India, September 11, 2013.
222. "An Introduction to Time Series Analysis," BP, September 16, 2013.
223. "Systems Nanotechnology: Engineering Nanomaterials for Chemical, Pharmaceutical, and Biological Applications," Department of Chemical Engineering, Purdue University, West Lafayette, Indiana, October 29, 2013.
224. "A Roadmap for the Multiscale Simulation of Lithium-ion Batteries," Materials for a Sustainable Energy Future Workshop III: Batteries and Fuel Cells, Institute for Pure & Applied Mathematics, University of California at Los Angeles, November 6, 2013.
225. "Control in Continuous Pharmaceutical Manufacturing," Novartis, Basel, Switzerland, 3 pm, November 11, 2013.
226. "Systems Nanotechnology: Engineering Nanomaterials for Chemical, Pharmaceutical, and Biological Applications," Department of Chemical Engineering, University of Massachusetts, Amherst, November 19, 2013.
227. **Plenary Lecture**, S. Streif, K.-K. K. Kim, P. Rumschinski, M. Kishida, D. E. Shen, R. Findeisen, and R. D. Braatz (speaker), "Robustness Analysis, Prediction and Estimation for Uncertain Biochemical Networks," Computer Applications in Bio Technology and 10th International Symposium on Dynamics and Control of Process Systems, Mumbai, India, December 16-20, 2013.
228. "Process Control in Continuous Manufacturing," PreCon Workshop on Control Strategy for Continuous Manufacturing, 28th International Forum and Exhibition on Process Analytical Technology (Process Analysis & Control), aka IFPAC 2014 Annual Meeting, Arlington, Virginia, January 20, 2014.
229. Richard Lakerveld (speaker), Brahim Benyahia, Patrick L. Heider, Haitao Zhang, Aaron Wolfe, Christopher J. Testa, Sean Ogden, Devin R. Hersey; Sal Mascia, James M. B. Evans, Richard D.

Braatz, and Paul I. Barton, "Plant-wide Control for Integrated Continuous Pharmaceutical Manufacturing," SMi Quality by Design. London, UK, February 25, 2014.

230. "Control of Molecular Purity, Crystal Structure, and Particle Size Distribution in Pharmaceutical Crystallization," Department of Chemical Engineering, University of Rhode Island, Kingston, Rhode Island, February 27, 2014.
231. "Ideas on Integration of OSIsoft into Chemical Engineering Curricula," OSIsoft Users Conference, San Francisco, California, March 27, 2014.
232. "Dynamic Modeling of Pharmaceutical Manufacturing Processes," Boehringer-Ingelheim Pharmaceuticals Inc., Ridgefield, Connecticut, April 30, 2014.
233. "Continuous Slug-Flow Crystallization," Millennium Pharmaceuticals, Cambridge, Massachusetts, May 23, 2014.
234. "Systems Technology in Biologics QbD Implementation," Workshop on PAT and QbD in Biopharmaceutical Industry, Biopharmaceutical Process and Quality Consortium 3rd Biopharmaceutical Summit, University of Massachusetts, Lowell, May 30, 2014.
235. "Control of Molecular Purity, Crystal Structure, and Particle Size Distribution in Pharmaceutical Crystallization," Beijing University of Chemical Technology, China, June 30, 2014.
236. "Control of Molecular Purity, Crystal Structure, and Particle Size Distribution in Pharmaceutical Crystallization," Tianjin University, China, July 1, 2014.
237. **Plenary Speaker**, "Robust Optimal Control of Finite-time Distributed Parameter Systems," International Conference on Mechatronics and Control, Jinzhou, China, July 5, 2014. http://icmc.bhu.edu.cn/pageples.asp
238. "Robust Optimal Control of Finite-time Distributed Parameter Systems," Harbin Institute of Technology, China, July 8, 2014.
239. **Plenary Lecture**, "Advances in the Design and Control of Continuous Pharmaceutical Crystallizers," British Association for Crystal Growth Annual Conference, University of Leeds, United Kingdom, July 15, 2014.
240. "Robust Optimal Control of Finite-time Nonlinear Distributed Parameter Systems," Workshop on Uncertain Dynamical Systems, Amsterdam, The Netherlands, August 20-22, 2014.
241. "Controlling Pharmaceutical Quality," **Plenary Session**, FDA/PQRI Conference on Evolving Product Quality, Bethesda, Maryland, September 16, 2014.
242. "Mathematical Modeling, Design, and Control of Continuous Viral Vaccine Manufacturing," Sanofi-Pasteur, Toronto, Canada, September 18, 2014.
243. "Advances in the Design and Control of Continuous Pharmaceutical Crystallizers," Department of Chemical and Biomolecular Engineering, Clemson University, South Carolina, September 25, 2014.
244. "Multiscale Simulation of Chemically Reacting Systems," **Schiesser Lecture in Scientific Computing**, Lehigh University, Bethlehem, Pennsylvania, October 15, 2014.
245. "Systems Nanotechnology: Identification, Estimation, and Control of Nanoscale Systems," Department of Electrical Engineering, Universidad de Concepción, Chile, November 3, 2014.
246. "Systems Nanotechnology: Identification, Estimation, and Control of Nanoscale Systems," Pontificia Universidad Católica de Valparaíso, Chile, November 4, 2014.
247. **Distinguished Lecture**, "Systems Nanotechnology: Identification, Estimation, and Control of Nanoscale Systems," XXI Congress of ACCA (Asociación Chilena de Control Automático), Faculty of Engineering, Universidad Central de Santiago de Chile, Santiago, Chile, November 7, 2014.
248. "A First-Principles Model-based Approach to Real-time Release," Real Time Parametric Release, BioMAN Annual Summit, Cambridge, November 14, 2014.
249. **CAST Lecture**, "From Molecules to Manufacturing Plants: A Journey Across Time and Length Scales," AIChE Annual Meeting, Atlanta, Georgia, November 18, 2014.
250. "Advanced Control of Manufacturing Processes," Brewer Science, East Hanover, Missouri, December 12, 2014.

251. "Theoretical Analysis of Temperature-Induced Nucleation in Dual Impinging Jet Mixers," SY-BIO Workshop, University of Texas at Dallas, March 25-26, 2015.
252. **Keynote Lecture**, "Advances in Biopharmaceutical Manufacturing," 15th IFAC/IEEE/IFIP/IFORS Symposium on Information Control Problems in Manufacturing, Ottawa, Canada, May 11, 2015.
253. "Process Intensification in Reaction Engineering and Crystallization," 25/50/75 Celebration for Professor H. Scott Fogler, University of Michigan, Ann Arbor, May 16, 2015.
254. Zhilong Zhu, You Peng, T. Alan Hatton (speaker), Kamal Samrane, Allan S. Myerson, and Richard D. Braatz, "Crystallization of Calcium Sulphate during Phosphoric Acid Production: Modeling Particle Shape and Size Distribution," International Symposium on Innovation and Technology in the Phosphate Industry, Marrakesh, Morocco, May 18-20, 2015.
255. "Continuous Pharmaceutical Manufacturing: Quality-by-Design, Systems Integration, and Control," Modernization in Manufacturing session, ISPE/FDA/PQRI Quality Manufacturing Conference, Washington, DC, June 1, 2015.
256. "Quality by Design and Data Analytics for Biopharmaceutical Manufacturing," GlaxoSmithKline, Philadelphia, PA, July 29, 2015.
257. **Plenary Lecture**, "Perspectives on Process Monitoring of Industrial Systems," IFAC Symposium on Fault Detection, Supervision, and Safety for Technical Processes (SAFEPROCESS), Paris, France, September 2-4, 2015.
258. "Optimal Control via Linear and Bilinear Matrix Inequalities," University of Pavia, Italy, September 14-16, 2015. Summer course.
259. "Dynamic Optimization and Control of Uncertain Systems," BP, September 15, 2015.
260. **Semi-Plenary Lecture**, "Nonlinear Model Predictive Control of Systems with Probabilistic Time-invariant Uncertainties," 5th IFAC Conference on Nonlinear Model Predictive Control, Seville, Spain, September 17, 2015.
261. "Robust Nonlinear Model Predictive Control for Industrial Systems," Industrial Session, 5th IFAC Conference on Nonlinear Model Predictive Control, Seville, Spain, September 19, 2015.
262. **Keynote Lecture**, "Control Systems Technology in the Advanced Manufacturing of Biologic Drugs," IEEE Multi-Conference on Systems and Control, Novotel Manly Pacific, Sydney, Australia, September 21-23, 2015 (oral presentation cancelled due to visa issues; peer-reviewed paper in conference proceedings).
263. "Recent Advances in Continuous Slug-flow Crystallization," Association for Crystallization Technology Workshop, Philadelphia, Pennsylvania, October 6, 2015.
264. "Continuous Biopharmaceutical Manufacturing: Quality-by-Design, Systems Integration, and Control," Conagen, Bedford, Massachusetts**,** October 26, 2015.
265. "Prediction and Real-time Control of Product Quality Attributes," BioProcess International Conference & Exhibition, Cambridge, Massachusetts, October 29, 2015.
266. "Systems Nanotechnology: Identification, Estimation, and Control of Nanoscale Systems," Control, Instrumentation and Robotics Seminar Series, Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, November 2, 2015.
267. "Recent Advances in Continuous Slug-flow Crystallization," Crystallization and Evaporation **Plenary Session**, AIChE Annual Meeting, Salt Lake City, November 9, 2015.
268. "Advanced Manufacturing of Pharmaceuticals," Session on Process Monitoring & Control - I. Intelligence Based Manufacturing Trends – Control Strategy for Continuous Manufacturing, IFPAC Annual Meeting & Thirteenth International Forum on Process Analytical Technology, Arlington, Virginia, January 25, 2016.
269. "Continuous Biopharmaceutical Manufacturing: Quality-by-Design, Systems Integration, and Control," Executive SmartLab Exchange, San Diego, California, February 23, 2016.
270. "Fast Robust Model Predictive Control of Advanced Manufacturing Systems," IEEE Control Systems Forum, February 25, 2016.

271. "Strategies to Accelerate Process Control Adoption in the Pharmaceutical Industry," FDA-AIChE Workshop on Adopting Continuous Manufacturing: Overcoming the Perceived Obstacles, March 1, 2016, Bethesda, Maryland.
272. "Advanced Control of Manufacturing Processes," Saint Gobain, Northboro, Massachusetts, March 24, 2016.
273. Kristen Severson, Marco Reis, and Richard D. Braatz (speaker), "Challenges and Research Directions in Big Data," Big Data **Plenary Session**, AIChE Spring National Meeting and 12th Global Congress on Process Safety, Houston, Texas, April 11, 2016.
274. "Advances in Process Control and Data Analytics," Dow Chemical Company, Houston, Texas, April 14, 2016.
275. "Control of Molecular Purity, Crystal Structure, and Particle Size Distribution in Pharmaceutical Crystallization," Boehringer-Ingelheim, Connecticut, April 18, 2016.
276. "Design for Product Quality Assurance in End-to-End Pharmaceutical Manufacturing," ISPE Continuous Manufacturing Conference, Baltimore, Maryland, April 20-21, 2016. "Closing Presentation: Examining Novel Continuous Manufacturing Processes and Equipment," American Biomanufacturing Summit, San Diego, CA, May 11, 2016.
277. "Smart Manufacturing of Pharmaceuticals," Intelligent based Manufacturing (IbM) University Lecture Series, Pfizer, webinar, June 21, 2016.
278. **Keynote Lecture**, "Advanced Manufacturing of Biopharmaceuticals" 13th International Conference on Informatics in Control, Automation and Robotics, Lisbon, Portugal, July 29-31, 2016.
279. "Plant-Wide Process Control Model for Biological Manufacturing," Process Characterization, Qualification and Control Conference, 8th Annual Bioprocessing Summit, Boston, August 19, 2016.
280. "Fast Robust Model Predictive Control of Advanced Manufacturing Systems," Laboratory for Dynamics and Control of Nanosystems, Department of Systems Engineering, University of Texas at Dallas, September 19, 2016.
281. "Emerging and Enabling Technologies in Control of Continuous Bioprocesses," Second International Symposium on Continuous Manufacturing of Pharmaceuticals, Cambridge, Massachusetts, September 27, 2016.
282. "Challenges and Research Directions in Big Data," Department of Chemical Engineering, University of Kyoto, Japan, October 4, 2016.
283. "Lecture 1: Introduction to Stochastic Chemical Kinetics," University of Kyoto, Japan, October 5, 2016.
284. "Lecture 2: Kinetic Monte Carlo Simulation," University of Kyoto, Japan, October 6, 2016.
285. "Lecture 3: KMC Simulation on Solid Surfaces," University of Kyoto, Japan, October 6, 2016.
286. "Lecture 4: Introduction to Multiscale Simulation," University of Kyoto, Japan, October 7, 2016.
287. "Case Study: Transitioning from Batch Processing to Continuous Manufacturing," 8th Annual Life Science Manufacturing & Quality Forum, San Antonio, Texas, October 13, 2016.
288. "Recent Advances in Continuous Slug-flow Crystallization," Northeast Section of the American Chemical Society Process Chemistry Symposium, Cambridge, Massachusetts, October 20, 2016.
289. "Introduction to Anomaly Detection," Decision Analytics DRL workshop on Anomaly Detection, BP, webinar, December 5, 2016.
290. "Systems Nanotechnology: Engineering Nanomaterials for Chemical and Biological Applications," Department of Chemical and Biological Engineering, University of Wisconsin, Madison, December 6, 2016.
291. "Challenges and Opportunities in Biopharmaceutical Manufacturing Control," Session on Grand Challenges. International Conference on Chemical Process Control, Tucson, Arizona, January 10, 2017.

292. "Modeling and Control of the Continuous Manufacturing of Large and Small-molecule Pharmaceuticals," 36th Anniversary Commemorative Lecture Series, Amgen, Cambridge, Massachusetts, February 16, 2017.
293. "Challenges and Opportunities in Biopharmaceutical Manufacturing Control," Advanced Manufacturing Technology in the Pharma/Bio Industry Session, IFPAC Annual Meeting, Bethesda, Maryland, February 27 – March 2, 2017. March 1, 2017. Abstract 219.
294. "Process Modelling and Real-Time Control for Manufacturing Biopharmaceuticals on Demand," 8th Annual Biotherapeutics Analytical Summit, Process Analytics and Characterization Conference, North Bethesda, Maryland, March 21-22, 2017.
295. Kristen Severson and Richard D. Braatz, "The Data Analytics Triangle," 3rd Big Data Analytics Topical Sessions, AIChE Spring National Meeting, San Antonio, Texas, March 29-31, 2017.
296. "Process Modeling and Control of Continuous Pharmaceutical Manufacturing," Pfizer, Groton, CT, May 3, 2017.
297. "Bioreactor Modeling for Process Intensification," BioMAN Workshop on Process Intensification for Biomanufacturing," Cambridge, Massachusetts, May 16, 2017.
298. "Continuous Manufacturing of (Bio)Pharmaceuticals," CPhI Connect, Philadelphia, Pennsylvania, May 17, 2017.
299. "Advances and Research Directions in Smart Manufacturing," MIT Club of the Delaware Valley, Philadelphia, Pennsylvania, May 17, 2017.
300. "Advanced Manufacturing of Biopharmaceuticals," Department of Chemical and Biological Engineering, Drexel University, Philadelphia, Pennsylvania, May 19, 2017.
301. "Challenges and Directions in Big Data," OSIsoft, San Leandro, California, May 22, 2017.
302. "The Data Analytics Triangle: Best Practices for Selecting Machine Learning Methods," OSIsoft, San Leandro, May 22, California, 2017.
303. "Smart Manufacturing of Biopharmaceuticals," OSIsoft, San Leandro, California, May 22, 2017.
304. **Plenary Lecture**, "Advanced Control of Pharmaceutical Crystallization," 6th International Symposium on Advanced Control for Industrial Processes, Taipei, Taiwan, May 29, 2017.
305. "A Vision of Advanced Manufacturing," 2040 Visions of Process Systems Engineering, Cambridge, Massachusetts, June 2, 2017. https://stephanopoulos-symposium.mit.edu/
306. "Advanced Pharmaceutical Manufacturing," The Power of Amgen Science and Technology: Experience Firsthand, Amgen, Cambridge, Massachusetts, June 2, 2017.
307. "Integrated Control and Monitoring of Continuous Biomanufacturing," Continuous Biomanufacturing: Current Success and Future Trend, University of Oxford, United Kingdom, June 26, 2017.
308. **Featured Presentation**, "Process Modeling and Real-Time Control for On-Demand, Continuous Biomanufacturing," 3rd Annual Conference on Continuous Processing in Biopharmaceutical Manufacturing Conference, 9th Annual Bioprocessing Summit, August 21-22, 2017, Boston, Massachusetts.
309. "Sparse Data-driven Models for the Manufacture of a Monoclonal Antibody," BioMAN Workshop on Setting Specifications for Biotherapeutic Products, Cambridge, Massachusetts, September 12, 2017.
310. **Distinguished Lecture**, "Systems Nanotechnology: Analysis, Design, and Control of Nanoscale Systems," Department of Chemical Engineering, University of Utah, Salt Lake City, Utah, September 18, 2017.
311. "Data Analytics I," MIT Smart Manufacturing Leadership Program, Cambridge, Massachusetts, September 19, 2017.
312. "Data Analytics II," MIT Smart Manufacturing Leadership Program, Cambridge, Massachusetts, September 19, 2017.
313. "Control and Systems Theory for Advanced Manufacturing," Workshop on Emerging Applications of Control and Systems Theory (EACST) in Honor of Vidyasagar's 70th Birthday, University of Texas at Dallas, September 28-29, 2017.

314. **Plenary Lecture**, "New Directions in the Control of Advanced Manufacturing Systems," 17th International Conference on Control, Automation and Systems, Jeju Island, South Korea, October 18-21, 2017.
315. "New Directions in the Control of Advanced Manufacturing Systems," Seoul National University, South Korea, October 21, 2017.
316. "Continuous Biopharmaceutical Manufacturing: Modeling, Design, and Fully Automated Control," ISPE Biopharmaceutical Manufacturing Conference, San Francisco, California, December 5, 2017.
317. **Keynote Speaker**, "A Fully Automated Biopharmaceutical Manufacturing Plant: Process Design, Modeling, and Control," Single-use Technologies and Continuous Processing, San Diego, California, January 8, 2018.
318. "Analytics: Monitoring and Control," Arconic Smart Manufacturing Professional Education Program, Cambridge, Massachusetts, January 25, 2018.
319. "Hands on Data Projects: Analytics – Continuous and Discrete," Arconic Smart Manufacturing Professional Education Program, Cambridge, Massachusetts, January 25, 2018.
320. Panel Presenter and Discussant, Data Science: Opportunities to Transform Chemical Sciences and Engineering Workshop, National Academics of Sciences, Engineering, and Medicine, NAS Building, Washington, DC, February 27-28, 2018. Summaries published in Data Science: *Opportunities to Transform Chemical Sciences and Engineering: Proceedings of a Workshop–in Brief*, The National Academies Press, Washington, DC, July 2018.
321. "Smart Data Analytics in Biomanufacturing," BioMAN Workshop on Data Analytics in Biomanufacturing, Cambridge, Massachusetts, May 21, 2018.
322. "Continuous Manufacturing of Vaccines," U.S. Food and Drug Administration, Silver Spring, Maryland, June 15, 2018.
323. "Future-Proof Operations – A Proactive Approach to Current DSP Challenges and Bottlenecks," Disruptive Downstream Technologies Conference, San Diego, June 21, 2018.
324. "Lowering the Barrier for Regulatory Approval of Disruptive Technologies," Disruptive Downstream Technologies Conference, San Diego, June 22, 2018.
325. **Plenary Speaker**, "Optimal Control of Uncertain Systems," Future Innovation in Process Systems Engineering VI, Porto Carras Meliton Resort Hotel, Chalkidiki, Greece, June 25, 2018.
326. "Population Balance Models for Crystal Nucleation and Growth: Multidimensional, Non-ideal Phase Equilibria, Growth Dispersion, and Impurities," Advanced School on Fluid Dynamics Effects on Particle Formation in Crystallization Processes, Udine, Italy, July 3, 2018.
327. "Coupling with CFD: Potential and Pitfalls I: Guidelines for Multiscale Simulation," Advanced School on Fluid Dynamics Effects on Particle Formation in Crystallization Processes, Udine, Italy, July 3, 2018.
328. Cezar da Rosa and Richard D. Braatz, "Coupling with CFD: Potential and Pitfalls II: Coupling PBM with CFD," Advanced School on Fluid Dynamics Effects on Particle Formation in Crystallization Processes, Udine, Italy, July 4, 2018.
329. Cezar da Rosa and Richard D. Braatz, "OpenCrys: Open-Source Software for the Multiscale Modeling of Combined Antisolvent and Cooling Crystallization in Turbulent Flow," Advanced School on Fluid Dynamics Effects on Particle Formation in Crystallization Processes, Udine, Italy, July 4, 2018.
330. "Optimal Design of Pharmaceutical Crystallizers," Advanced School on Fluid Dynamics Effects on Particle Formation in Crystallization Processes, Udine, Italy, July 6, 2018.
331. "Modeling and Control of the Continuous Manufacturing of Large and Small-molecule Pharmaceuticals," Politecnico di Torino, Italy, July 12, 2018.
332. "The Emerging Role of Big Data, Data Analytics, and Machine Learning in the Process Industries," Workshop on Advanced Tools for Data Analytics, 10th IFAC Symposium on Advanced Control of Chemical Processes, Shenyang, China, July 24, 2018.

333. "Kalman's Impact on Process Control, Estimation, and System Identification: Contributions to Chemical Process Systems," IFAC Symposium on Advanced Control of Chemical Processes, Shenyang, China, July 25, 2018. **Also write paper.**
334. Panelist Presenter and Discussant, "Integrated Continuous Manufacturing of Pharmaceuticals," Continuous Manufacturing for the Modernization of Pharmaceutical Production Workshop, National Academies of Sciences, Engineering, and Medicine, NAS Building, Washington, DC, July 30-31, 2018. Summaries published in *Continuous Manufacturing for the Modernization of Pharmaceutical Production: Proceedings of a Workshop*, The National Academies Press, Washington, DC, 2019. https://www.ncbi.nlm.nih.gov/books/NBK540224/
335. "Challenges and Opportunities in Big Data," AIChE Webinar, August 8, 2018. https://www.aiche.org/academy/webinars/challenges-and-opportunities-big-data
336. Panelist, Applying Industry 4.0 Concepts to Improve Biologics Manufacturing, BioProcess International Conference & Exhibition, Boston, MA, September 7, 2018.
337. "Design and Implementation of Fully Automated Biomanufacturing Unit Operations," BioProcess International Conference & Exhibition, Boston, MA, September 7, 2018.
338. "Therapeutic Protein Crystallization for Capture, Purification, Storage, and Formulation," BioMAN Workshop on Process Intensification for Protein Therapeutics, Cambridge, Massachusetts, September 11, 2018.
339. "Perspectives on Modeling, Prediction, and Control of Lithium-ion Batteries," Department of Energy Resources Engineering, Stanford University, October 8, 2018.
340. "Mathematical Modeling of Blown Film extrusion," Dow Chemical Company, Midland, Michigan, October 12, 2018.
341. **Keynote and Panelist**, "Industrial Internet of Things (IIoT) Applications and Industry 4.0," AIChE Annual Meeting, Pittsburgh, Pennsylvania, October 30, 2018.
342. "Systems and Control in Advanced Manufacturing," Control@MIT, Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, Massachusetts, November 2, 2018.
343. "Advanced Data Analytics and Control of Pharmaceutical Manufacturing," AstraZeneca, web seminar, November 23, 2018.
344. "Modeling Approaches to Support Continuous Manufacturing of Biopharmaceuticals," GlaxoSmithKline, King of Prussia, Pennsylvania, November 27, 2018.
345. "Robust Data Analytics in Biopharmaceutical Manufacturing," MIT AI in Life Sciences and Healthcare Conference, Cambridge, Massachusetts, December 4, 2018.
346. "Perspectives on Modeling, Prediction, and Control of Lithium-ion Batteries," Institute of Energy and Process Systems Engineering, Technical University of Braunschweig, Germany, January 17, 2019.
347. "Advanced Manufacturing of Biopharmaceuticals," École Polytechnique Fédérale de Lausanne, Switzerland, January 21, 2019.
348. "Advanced Analytics One: Data-Centric View of Manufacturing Processes," MIT SMART Manufacturing Leadership Program, Cambridge, Massachusetts, January 30, 2019.
349. "Advanced Analytics Two: Monitoring and Control," MIT SMART Manufacturing Leadership Program, Cambridge, Massachusetts, January 31, 2019.
350. "Data Analytics Methods," MIT SMART Manufacturing Leadership Program, Cambridge, Massachusetts, January 31, 2019.
351. "Advanced Battery Management Systems Design via Data-driven, First-principles, and Hybrid Approaches," MITEI Low-Carbon Energy Center Battery Storage Workshop, Cambridge, Massachusetts, April 1, 2019.
352. "MIT and the Department of Chemical Engineering," Joint FAU-MIT Workshop on the Design of Particulate Products by Continuous Processes, Massachusetts Institute of Technology, Cambridge, MA, April 4, 2019.

353. "Modeling and Optimization at MIT," Joint FAU-MIT Workshop on the Design of Particulate Products by Continuous Processes, Massachusetts Institute of Technology, Cambridge, MA, April 4, 2019.
354. "Model-based Design and Control of the Manufacturing of Continuous Particulate Products," Joint FAU-MIT Workshop on the Design of Particulate Products by Continuous Processes, Massachusetts Institute of Technology, Cambridge, MA, April 5, 2019.
355. **Opening talk**, "Data Science Education Using Real Data," Data Science Workshop Development, OSIsoft, San Francisco, California, April 8, 2019. Presentation published in *CACHE News*, Summer 2019.
356. "Modeling Approaches to Support Continuous Manufacturing of Biopharmaceuticals," Merck, Kenelworth, April 16, 2019.
357. "Challenges and Opportunities in Big Data," McMaster Advanced Control Consortium Meeting and Workshop, Hamilton, Ontario, Canada, May 15, 2019.
358. Panelist, "Current Buzz," McMaster Advanced Control Consortium Meeting and Workshop, Hamilton, Ontario, Canada, May 16, 2019.
359. "Digital Approaches for Process Development," U.S. Food and Drug Administration, White Oak campus, Silver Spring, Maryland, June 3, 2019.
360. "Machine Learning for Energy: Data Analytics for Anomaly Detection," Annual ENI-MIT Meeting, Milan, Italy, June 12, 2019.
361. Panelist, "Embracing Change: How Innovative Companies are Advancing Continuous Biopharma Manufacturing," MassBio Forum, Cambridge, Massachusetts, June 12, 2019.
362. "Optimal Control via Linear and Bilinear Matrix Inequalities," University of Pavia, Italy, July 1-4 2019. Summer course.
363. "Perspectives on Modeling, Prediction, and Control of Lithium-ion Batteries," University of Pavia, Italy, July 2, 2019.
364. "Continuous Viral Vector Manufacturing Based on Mechanistic Modeling and Novel Process Analytics," CBER Advanced Manufacturing Workshop, U.S. Food and Drug Administration, White Oak campus, Silver Spring, Maryland, July 9, 2019.
365. "Process Systems," The Future of Cyber Assisted Chemical Engineering Education, Breckenridge, Colorado, July 19-20, 2019.
366. "New Directions in the Control of Advanced Manufacturing Systems," Department of Chemical and Biological Engineering, Hong Kong University of Science and Technology, Kunming, China, July 30, 2019.
367. **Plenary**, "New Directions in the Control of Advanced Manufacturing Systems," 30th Chinese Process Control Conference, Kunming, China, August 1, 2019.
368. "Applying Industry 4.0 Concepts to Biologics Manufacturing," 11th Annual Bioprocessing Summit, 2nd Annual Digital Biomanufacturing, Cambridge Healthtech Institute, Boston, Massachusetts, August 14, 2019.
369. **Keynote Presentation**, "Process Control as an Enabling Technology for Continuous Vaccine Production," 11th Annual Bioprocessing Summit, 5th Annual Process Characterization and Control, Cambridge Healthtech Institute, Boston, Massachusetts, August 15, 2019.
370. "Mathematical Modeling, Real-time Sensing, and Parameter Estimation for Protein Crystallization in Droplet-based Systems," Max Planck Summer School on Particulate Systems: From Theory to Application, Magdeburg, Germany, August 28, 2019.
371. "Modeling, Sensing, Design, and Control of the Continuous Manufacturing of Protein Crystals," Max Planck Summer School on Particulate Systems: From Theory to Application, Magdeburg, Germany, August 28, 2019.
372. Weike Sun and Richard D. Braatz, "Smart Data Analytics for Biomanufacturing Process Modeling and Advanced Process Control," PAT & Advanced Process Controls Workshop, 16th Annual BioProcess International (BPI) Conference & Exposition, Boston, Massachusetts, September 9, 2019.

373. "Digital Transformation and Bioprocessing 4.0 – The Path to Smart Manufacturing," 16th Annual BioProcess International (BPI) Conference & Exposition, Boston, Massachusetts, September 11, 2019.
374. Round Table, New and Emerging Technology "What Gap Does Your Technology Fill," 16th Annual BioProcess International (BPI) Conference & Exposition, Boston, Massachusetts, September 11, 2019.
375. Panelist, "Digitalisation and Bioprocessing 4.0 – Strategies, Enabling Technologies and Analytics to Align and Transform Bioprocessing in a Digital Era," 16th Annual BioProcess International (BPI) Conference & Exposition, Boston, Massachusetts, September 12, 2019.
376. "Process Control, Automation, and Real-Time Release Testing for Continuous Processing," 16th Annual BioProcess International (BPI) Conference & Exposition, Boston, Massachusetts, September 12, 2019.
377. "Perspectives on Modeling, Prediction, and Control of Lithium-ion Batteries," Robert Frederick Smith School of Chemical and Biomolecular Engineering, Cornell University, Ithaca, New York, September 23, 2019.
378. "Systems and Control Theory for Advanced Manufacturing," University of California San Diego, Dynamic Systems and Control Series, Department of Mechanical and Aerospace Engineering, October 25, 2019.
379. "Process Design and Control for Continuous Viral Vaccine Manufacturing," Leaders in Innovation Seminar Series, MassBiologics, Boston, Massachusetts, November 8, 2019.
380. "Control of Polymorphism and Crystal Size Distribution in Pharmaceutical Crystallization," **Separations Division Plenary Session.** AIChE Annual Meeting, Orlando, Florida, November 11, 2019. Abstract 69c.
381. Richard D. Braatz and Weike Sun (speaker), "Big Data Analytics in the Advanced Manufacturing of Biopharmaceuticals," Next Gen Manufacturing topical: Big Data Analytics session. AIChE Annual Meeting, Orlando, Florida, November 11, 2019.
382. Panelist and Speaker, Data Science Education in Chemical Engineering session. AIChE Annual Meeting, Orlando, Florida, November 13, 2019.
383. "CACHE Initiatives in Process Systems," CACHE 50th Anniversary: The Future of Cyber-Assisted Chemical Engineering Education session. AIChE Annual Meeting, Orlando, Florida, November 13, 2019.
384. Gregory C. Rutledge, David Nicholson, Marat Andreev, Matthew R. Dobbins, J. Carl Pirkle, Jr., and Richard D. Braatz, "Multi-Scale Modeling of Semi-Crystalline Structure Development in Polymer Processing," Dow Chemical, Houston, Texas, December 12, 2019.
385. "New Directions in Advanced Manufacturing Systems," Dow Chemical, Midland, Michigan, December 13, 2019.
386. "State and Trends in AI/ML in the Process Industries," Accelerating Digitalization through Disruptive AI Innovation, AspenTech Tech Summit, Boston, Massachusetts, January 21, 2020.
387. "New Directions in the Control of Advanced Manufacturing Systems," Visitors of Excellence María de Maeztu Program, Institut de Robòtica i Informàtica Industrial, Polytechnical University of Catalonia, Barcelona, Spain, January 27, 2020.
388. Opening lecture, "Smart Process Analytics and Machine Learning," Symposium on Artificial Intelligence in Chemical Engineering, Institute for Chemical and Bioengineering, Swiss Federal Institute of Technology (ETH Zurich), Switzerland, February 5, 2020.
389. Opening lecture on Control and Analytics, "Modeling, Data Analytics, and Machine Learning for Process Development and Verification," National Academies Workshop on Innovations in Pharmaceutical Manufacturing, NAS Building, Washington, DC, February 27, 2020. Summary published in National Academies of Sciences, Engineering, and Medicine, *Innovations in Pharmaceutical Manufacturing: Proceedings of a Workshop–in Brief*, The National Academies Press, Washington, DC, 2020. https://doi.org/10.17226/25814

390. "Digital Transformation and Bioprocessing 4.0 – The Path to Smart Manufacturing," BioProcess International – Manufacturing Strategy & Technology, Webinar, June 22, 2020.
391. Panel Presenter and Discussant, "Ingredients for Industrial Intelligence: Machine learning and data analytics vs. systems theory and modeling," IFAC World Congress, Berlin, Germany, July 14, 2020. virtual
392. **Keynote Lecture**, "Systems and Control Theory for Advanced Manufacturing," Chinese Control and Decision Conference, Hefei, China, August 21, 2020. virtual
393. "Smart Process Data Analytics: Automated Data Analytics for Manufacturing Processes," Academic Partner Seminar, Dow Chemical, October 8, 2020. virtual
394. **Keynote Speaker**, "Advances in Process Control, Modeling, and Analytics for Biomanufacturing," PharmSci 360, New Orleans, Louisiana, November 2, 2020. virtual
395. "Machine Learning for Lithium-ion Batteries," Second Batteries and Supercaps Virtual Symposium: Advanced Computational Methods in Battery Research, Chemistry Europe, November 12, 2020. virtual
396. "Machine Learning for Lithium-ion Batteries," Medtronic, Minneapolis, Minnesota, November 12, 2020. virtual
397. Weike Sun and Richard D. Braatz (presenter), "Recognizing and Avoiding Big Data Analytics Traps in Applications," Big Data and Applications in Advanced Modeling and Manufacturing session, AIChE Annual Meeting, San Francisco, California, November 17, 2020, Abstract 224b. virtual
399. "Protein Crystallization for Drug Product Formulation," Intensified Bioseparations via Crystallization," Fall Workshop on Process Intensification: Downstream, Formulation and Product Development, Center for Biomedical Innovation, Cambridge, Massachusetts, November 18, 2020.
400. Panelist, Intensified Formulation Fill and Finish, Fall Workshop on Process Intensification: Downstream, Formulation and Product Development, Center for Biomedical Innovation, Cambridge, Massachusetts, November 18, 2020.
401. **Plenary Lecture**, "Industry 4.0 and Digital Transformation in Chemical Engineering," 14th Mediterranean Congress of Chemical Engineering, Barcelona, Spain, November 19, 2020.
402. "Developing Advanced Battery Prediction Techniques with Machine Learning," Wards Intelligence FOCUS: Electrification 2020, November 19, 2020.
403. "State-of-Health (SOH) Estimation for Lithium-ion Batteries," KAIST, South Korea, November 26, 2020.
404. "Machine Learning-based Identification, Prediction, and Control of Lithium-ion Batteries," Advanced Battery Management Workshop, IEEE Conference on Decision and Control, Jeju, South Korea, December 12, 2020.
405. "Advanced Control in Vaccine Manufacturing," COVID-19 Focus Session: Vaccines, IEEE Conference on Decision and Control, Jeju, South Korea, December 18, 2020. WeAT2.4. 10 am on Wednesday.
406. "Mathematical Modeling of Bioreactors for Recombinant Protein Production," John Lawrence Seminar Series in Biosciences, Lawrence Berkeley National Laboratory, Biological Systems and Engineering Division, January 5, 2021. virtual
407. **Plenary Talk**, "Advanced Process Analytics and Control in (Bio)pharmaceutical Manufacturing," Thirty-Fifth International Forum for Process Analytics & Control (IFPAC), March 1, 2021. Abstract ID 153.
408. "Using AI and Machine Learning in Product and Process Design," The Future of Manufacturing Symposium, MIT Industrial Liaison Program, Cambridge, MA, March 2, 2021. Virtual
409. Panelist, Discussion on the Future of Manufacturing, The Future of Manufacturing Symposium, MIT Industrial Liaison Program, Cambridge, MA, March 4, 2021. Virtual
410. "Industry 4.0 and Digital Transformation in Biomanufacturing," 8th Annual Biologics Manufacturing Asia 2021, March 16, 2021. Virtual

411. “Advanced Process Analytics and Control in (Bio)pharmaceutical Manufacturing,” Sanofi Pasteur Vaccine Analytics and Bioprocess Technology Seminar Series, March 17, 2021. Virtual
412. **Keynote Lecture**, Advanced Manufacturing of (Bio)pharmaceutical Products, 2020 Research Day, Department of Chemical and Biomedical Engineering, FAMU-FSU College of Engineering, Tallahassee, Florida. video
413. “Machine Learning and Multiscale Modeling Methods for Early Prediction and Accelerated Design of Lithium-Ion Batteries,” Optimizing Marine Battery 6 Kickoff Meeting, April 9, 2021.
414. “Current Trends and Future Directions in Continuous Manufacturing,” Sanofi CMC Scientific Webinar Series on CM, May 7, 2021.
415. “Advances in Recombinant Adeno-Associated Virus Manufacturing and Analytics,” U.S. Food and Drug Administration, Silver Spring, Maryland, May 11, 2021.
416. “The Smart Data Analytics Initiative for Biomanufacturing Processes,” BioMAN Meeting on Data Analytics along the Biomanufacturing Life Cycle, Massachusetts Institute of Technology, Cambridge, MA, May 18, 2021.
417. “Machine Learning-based Identification, Prediction, and Control of Lithium-ion Batteries,” University of Bayreuth, Germany, May 20, 2021.
418. “Pharma 4.0: Advanced Manufacturing of (Bio)Pharmaceutical Products,” Control Systems and Data Science towards Industry 4.0 Workshop Series, MIT Industrial Liaison Program, Massachusetts Institute of Technology, Cambridge, MA, May 20, 2021.
419. Discussant, Roundtable Discussion on Continuous Manufacturing in Biologics; Successes and Challenges, United States Pharmacopeia, May 26, 2021.
420. Panelist, Workshop 1: Cybersecurity, AI, IoT, Supply Chains, Automation, Robotics, and Additive Manufacturing. Trends in Invigoration of Manufacturing and Engineering (TIME), American Institute of Chemical Engineers, July 13, 2021.
421. Panelist, Workshop 2: Optimization, Process Control, Big Data, Sensors, Data Visualization, Virtual Reality, and Digital Twin. Trends in Invigoration of Manufacturing and Engineering (TIME), American Institute of Chemical Engineers, July 14, 2021.
422. “Protein Capture by Continuous Crystallization and Precipitation,” P4 New Technology II - Downstream Processing, NIIMBL Annual Meeting, Washington, DC, July 15, 2021.
423. “Crystallization of a Nonreplicating Rotavirus Vaccine Candidate,” Advances in Purification & Recovery, 13th Annual Bioprocessing Summit, Boston, Massachusetts, August 19, 2021.
424. **Plenary Lecture**, “Modeling, Sensing, Design, and Control of Crystallizing Proteins,” 21st International Symposium on Industrial Crystallization, Potsdam, Germany, August 30 – September 2, 2021. Virtual.
425. “Advanced Process Analytics and Control in (Bio)pharmaceutical Manufacturing,” Annual IFPAC/INDUNIV Summer Summit, September 1, 2021.
426. Panel Discussant, End to End Production: Continuous Manufacturing, Annual IFPAC/INDUNIV Summer Summit, September 1, 2021.
427. “Operation and Modelling of Industrial Crystallization Processes,” Tutorial C: Modeling, Monitoring and Control of Crystallization Systems, 21st International Symposium on Industrial Crystallization, Potsdam, Germany, September 2, 2021 (also served as discussant at the last part of the workshop)
428. “A Perspective on Process Systems Engineering,” CAPE-Lab - Computer Aided Process Engineering Laboratory, Department of Industrial Engineering, University of Padova, Italy, September 17, 2021. virtual
429. “Machine Learning and Multiscale Modeling Methods for Early Prediction and Accelerated Design of Lithium-Ion Batteries,” Columbia University, September 21, 2021. virtual
430. “Machine Learning-based Identification, Prediction, and Control of Lithium-ion Batteries,” Machine Intelligence for Manufacturing & Operations, MIMO Student Research Forum, Cambridge, Massachusetts, September 23, 2021.

431. "Applications of Matrix Theory to the Simulation, Analysis, and Optimal Control of Infinite-dimensional Singular Nonlinear Dynamical Systems," First NU-SIBAU International Workshop on Matrix Theory and its Applications, October 15-17, 2021. virtual
432. "Machine Learning-based Identification, Prediction, and Control of Lithium-ion Batteries," Carnegie Mellon University, Pittsburgh, Pennsylvania, October 19, 2021. virtual
433. **Keynote**, "Machine Learning-based Identification, Prediction, and Control of Lithium-ion Batteries," Systems & Control Division, 71st Canadian Chemical Engineering Conference, Montreal, Canada, October 24-27, 2021. Abstract 125.
434. Weike Sun, Fabian Mohr, Pil Rip Jeon, Moo Sun Hong, and Richard D. Braatz (speaker). Smart Process Analytics and Machine Learning. Session in Honor of Professor Venkat Venkatasubramanian's 65th Birthday, AIChE Annual Meeting, Boston, Massachusetts, November 9, 2021. Abstract 259,
435. **Keynote Talk**, Integrated Quality By Design in (Bio)Pharmaceutical Manufacturing, Session on Next-Gen Manufacturing in Pharma, Food, and Bioprocessing II. AIChE Annual Meeting, Boston, Massachusetts, November 10, 2021.
436. "Machine Learning and Multiscale Modeling Methods for Early Prediction and Accelerated Design of Lithium-Ion Batteries," Epoch Foundation of Taiwan, November 29, 2021. virtual
437. "Smart Process Analytics and Control in Biopharmaceutical Manufacturing," U.S. Food and Drug Administration, Silver Spring, Maryland, December 3, 2021.
438. "Rational Design of rAAV Production via Mechanistic Modeling," BioMAN Summit on Technologies to Expand the Reach of Cell and Gene Therapies, Massachusetts Institute of Technology, Cambridge, MA, December 16, 2021.
439. "Machine Learning-based Life-time Prediction and Charging Optimization of Lithium-ion Batteries," Qualcomm/Xiaomi EV Workshop, March 1, 2022.
440. "Rational Design of rAAV Production via Mechanistic Modeling," ILP Health Science Tech Conference: The Future of Cell & Gene Therapy, Massachusetts Institute of Technology, Cambridge, MA, April 12, 2022.
441. "Bio- and Chemical Manufacturing," Manufacturing @ MIT: 2022 and Beyond, Massachusetts Institute of Technology, Cambridge, MA, May 6, 2022.
442. "Machine Learning-based Lifetime Prediction of Lithium-Ion Batteries," Amazon Salon, May 24, 2022. virtual
443. **Keynote Address**, "New Directions in Advanced Manufacturing Systems," Advanced Manufacturing and Processing Conference, Bethesda, Maryland, June 1-3, 2022.
444. **Opening talk**, "Automated, Integrated, Modular Systems for the Manufacturing of Biopharmaceutical Drug Products," BioTalk US, Boston US, June 8-9, 2022.
445. "Smart Process Data Analytics for Biopharmaceutical Manufacturing," BioTalk US, Boston US, June 8-9, 2022. Replacement talk.
446. "Machine Learning-based Methods for Lifetime Prediction and Charging Optimization of Lithium-Ion Batteries," 3rd International Battery Manufacturing Days, ARTISTIC Project Webinar Series, Laboratoire de Réactivité et Chimie des Solides (LRCS), Centre National de la Recherche Scientifique (CNRS) and Université de Picardie Jules Verne, Amiens, France, June 13, 2022.
447. "An Introduction to Hyperspectral Imaging," Toyota Research Institute, July 6, 2022. Virtual.
448. "Advanced Manufacturing of Biotherapeutics: Modeling, Data Analytics, and Control," Worldwide R&D, Lonza, Switzerland, July 27, 2022. Zoom.
449. "AI/ML in Biomanufacturing: Automated, Integrated, Modular Systems," NIIMBL Annual Meeting, Washington DC, July 27, 2022.
450. "Smart Manufacturing of Pharmaceuticals," Drexel Smart Manufacturing REU Program, August 5, 2022.
451. **Opening Keynote**, "Automated, Integrated, Modular Systems for the Manufacturing of Biopharmaceutical Drug Products," 10th BioTalk Europe, Berlin, Germany, September 8-9, 2022.

452. "Smart Data Analytics Strategies for Biopharmaceutical Manufacturing," 10th BioTalk Europe, Berlin, Germany, September 8-9, 2022.
453. Panelist, "The Convergence of Process Intensification, Automation and Analytics, and PAT to Enable Continuous Processing and Biopharma 4.0," 10th BioTalk Europe, Berlin, Germany, September 8-9, 2022.
454. Richard D. Braatz and Retsef Levi, "Artificial Intelligence (AI)/Machine Learning (ML) analysis of Process, Operational and Adverse Event Data to Improve Biomanufacturing," 3rd Annual Extramural Research Science Day, U.S. Food and Drug Administration, September 13, 2022. Virtual
455. "Digital Simulation: What's Possible with Practical Application," UL MIT Technical and Operations Leaders Program, MIT Management Executive Education, Massachusetts Institute of Technology, Cambridge, MA, September 14, 2022.
456. "Fault Detection and Diagnosis," Intelligent Operations Infoshare, BP, September 23, 2022. virtual
457. "Advanced Manufacturing of Biotherapeutics: Modeling, Data Analytics, and Control," BioProcess International Conference & Exposition and Virtual Platform. Boston, Massachusetts, September 27-30, 2022.
458. Guest Lecturer, "Advanced Manufacturing of Biotherapeutics," BIOE 120 - Introduction to Bioengineering, University of Illinois at Urbana-Champaign, Urbana, Illinois, October 2, 2022.
459. Facilitator, Panel Session on Digitalization, ICB V Conference, October 9, 2022.
460. Richard D. Braatz, "MIT's Center for Biomedical Innovation: Integrated Solutions to Global Health," MIT-Takeda Project Presentation series: AI and ML for Health: Manufacturing, October 25, 2022.
461. Qihang Zhang, Ajinkya Pandit, Wenlong Tang, Charles Papageorgiou, Chris Mitchell, Yihua Yang, Michael Schwaerzler, Tolutola Oyetunde, Richard Braatz, Allan Myerson, and George Barbastathis, "Time Series Analysis from Video Data for Optimizing and Controlling Unit Operations in Production and Manufacturing," MIT-Takeda Project Presentation series: AI and ML for Health: Manufacturing, October 25, 2022.
462. Speaker and Panelist, "Gene Therapy Manufacturing," Successes and Challenges in Biomanufacturing – A Workshop, Board on Life Sciences, National Academies of Sciences, Engineering, and Medicine, October 25, 2022. Summary published in National Academies of Sciences, Engineering, and Medicine, *Successes and Challenges in Biomanufacturing: Proceedings of a Workshop–in Brief*, The National Academies Press, Washington, DC, 2023. https://doi.org/10.17226/26846/
463. Wei Xie, Richard D. Braatz, Jared Auclair, Jacqueline M. Wolfrum, Anthony J. Sinskey, Stacy L. Springs, Johan Trygg, Lennart Eriksson, Chris McCready, Zheng Li, Victor Saucedo, James Varughese, Mariana Carvalho, Steve R. Dziennik, Brian Polilli, Christopher Rode, and Treavor Jones, "PC4.1-206: Modularized PAT Online Training Platform to Accelerate the Workforce Innovation in Biopharmaceuticals Manufacturing," *NIIMBL National Meeting*, Washington, DC, October 27, 2022.
464. Panelist, TRI Workshop on Human-in-the-loop Autonomy, November 4, 2022.
465. "Advances in Process Analytics," Cytiva and Pall Corporation. November 18, 2022.
466. "Automated Process Development Workflows, Modular Systems, and Process Analytics," Danaher Corporation, December 1, 2022.
467. "Automated Process Development Workflows, Modular Systems, and Process Analytics," FujiFilm, Tokyo, Japan, January 23, 2023.
468. "Machine Learning-based Lifetime Prediction and Charging Optimization of Lithium-Ion Batteries," JERA Co., Inc., Tokyo, Japan, January 24, 2023.
469. "Automated Process Development Workflows, Modular Systems, and Process Analytics," Takeda, Tokyo, Japan, January 25, 2023.
470. "Machine Learning-based Lifetime Prediction and Charging Optimization of Lithium-Ion Batteries," NEC Corporation, Tokyo, Japan, January 26, 2023.

471. "Automated Process Development Workflows, Modular Systems, and Process Analytics," Shimadzu Corporation, Tokyo, Japan, January 26, 2023.
472. "Automated Process Development Workflows, Modular Systems, and Process Analytics," MIT Japan Conference, Tokyo, Japan, January 27, 2023.
473. Discussant, "Technology Solutions for Improving Manufacturing Reliability," Generic Drug Manufacturing Workshop: Technology Solutions for Improving Reliability or Generic Drug Manufacturing, MIT Sloan School of Management, Cambridge, MA, March 3, 2023.
474. **Keynote Lecture**. "End-to-end Integrated and Continuous Monoclonal Antibody Manufacturing," 6th Annual Intensified and Continuous Processing, BioProcessing Summit Europe, Cambridge Healthtech Institute, Barcelona, Spain, March 14-16, 2023.
475. "Advances in rAAV Gene Therapy Manufacturing," Sanofi, Waltham MA, April 14, 2023.
476. "Machine Learning-based Lifetime Prediction and Charging Optimization of Lithium-ion Batteries," Distinguished Seminars for Data Science series, City University of Hong Kong, April 4, 2023.
477. "Optimal Control of (Bio)pharmaceutical Manufacturing Systems," Technical University of Darmstadt, Germany, April 18, 2023.
478. "Digital Twins: A Revolution for Industrial Operations," Executive Management Program, Sloan School of Management, Cambridge, Massachusetts, May 9, 2023.
479. "Smart Bioprocess Analytics for Predictive Modeling," ACTIP Scientific Meeting, Neuchâtel, Switzerland, May 12, 2023.
480. Moderator, "Designing the Next-Generation Advanced Therapeutics Manufacturing Process," Pharma Manufacturing World Summit, Boston, Massachusetts, May 15-16, 2023.
481. "The Evolution of Manufacturing: Exploring the Digital Vision for the Future of Our Industry," Pharma Manufacturing World Summit, Boston, Massachusetts, May 15-16, 2023.
482. Moo Sun Hong, Fabian Mohr (presenter), Chris D. Castro, Benjamin T. Smith, Jacqueline M. Wolfrum, Stacy L. Springs, Anthony J. Sinskey, Roger A. Hart, Tom Mistretta, and Richard D. Braatz. Smart Process Analytics for the End-to-End Batch Manufacturing of Monoclonal Antibodies, BioTalk US, Quincy, Massachusetts, May 16, 2023.
483. **Keynote**, "Lifetime Prediction and Charging Optimization of Lithium-ion Batteries," TRI-D3BATT Workshop, Toyota Research Institute, Cambridge, Massachusetts, May 18-19, 2023.
484. "Feasability of the Selective Purification of AAV Capsids via Crystallization," ChromaChats: Next Generation Purification Platforms of AAVs. May 31, 2023.
485. "Advances in rAAV Manufacturing," 2nd Annual 2023 Viral Vector Development Symposium, MilliporeSigma, Burlington, Massachusetts, June 13, 2023.
486. "Mechanistic Modeling and Control of Vaccine Manufacturing," Vaccine Bioprocess Development & Commercialization Workshop, Cambridge, MA, June 14, 2023.
487. "Artificial Intelligence (AI) in the Process Industries," Patent Examiners Technical Training Program (PETTP), U.S. Patent and Trademark Office, June 21, 2023. Virtual.
488. "Hybrid Model & Updates on Auto ML for Process Data," Dow Inc., Lake Jackson, Texas, June 21-22, 2023.
489. **Plenary/Keynote**. "Digitalization of Biomanufacturing," 2023 Bioprocessing Summit, Boston, Massachusetts, August 15-17, 2023. August 16, 4:30 pm to 5 pm.
490. "Smart Process Data Analytics for Model Prediction," Opening lecture of the session on Data Analytics and AI for Soft Materials: Manufacturing and Healthcare. ACS Fall Meeting, San Francisco, California, August 16, 2023.
491. "Smart Process Analytics for the End-to-End Batch Manufacturing of Monoclonal Antibodies," 8th International Conference on Accelerating Biopharmaceutical Development (AccBio 2023). The Royal Sonesta, Boston, Massachusetts, September 6-8, 2023.
492. Richard D. Braatz, "Using Crystallization Tech to Improve AAV Yields," BioProcess International, Boston, Massachusetts, September 18-21, 2023.
493. Richard D. Braatz, "Harnessing Digital Twin for mRNA Manufacturing," 2nd mRNA Process Development & Manufacturing Summit, Boston, Massachusetts, September 26-28, 2023.

494. "Digital Twins and Process Control/Monitoring," FDA/PQRI Workshop on the Regulatory Framework for the Utilization of Artificial Intelligence in Pharmaceutical Manufacturing: An Opportunity for Stakeholder Engagement, September 26-27, 2023, virtual.
495. "A Digital Twin for Continuous mRNA Manufacturing," FDA Manufacturing Series, CBER Advanced Manufacturing Seminar Series, virtual, November 15, 2023.
496. "A Digital Twin for Continuous mRNA Manufacturing," MIT Research and Development Conference, Cambridge, Massachusetts, November 16, 2023.
497. "Machine Learning-based Lifetime Prediction and Charging Optimization of Lithium-ion Batteries," 23rd Annual Advanced Automotive Battery Conference, San Diego, California, December 11-14, 2023.
498. "A Digital Twin for the Continuous Manufacturing of mRNA Therapeutics," **Plenary Session**, IFPAC, Bethesda, Maryland, March 3-6, 2024.
499. "AI and Machine Learning in Biotherapeutics Process Development," Gordon Research Conference (GRC) on Biotherapeutics and Vaccines Development Gordon Conference, Galveston, Texas, March 17-22, 2024.
500. Panelist, "Purification Challenges for mRNA Production," Chromachats, virtual, March 21, 2024.
501. "Continuous Manufacturing of an AAV-based Gene Therapy," 8th CCP Summit: Commercializing Continuous Processing in Pharma, March 26-28, 2024.
502. "Machine Learning-based Lifetime Prediction and Charging Optimization of Lithium-ion Batteries," Technical University Vienna, Austria, April 18, 2024.
503. "Lithium Battery Tech (and How We Use Feedback to Improve It)," University of Hawaii, April 24, 2024.
504. "Building a Better Model in Manufacturing & Operations," Digital Transformation Forum, Boston Convention Center, Massachusetts, April 30 to May 1, 2024. https://www.digitaltransformationforum.com/.
505. **Keynote**, "Digital Twin for Continuous mRNA Manufacturing," Cell & Gene Therapy Talk, Boston, Massachusetts, May 6, 2024.
506. "Digital Twins: A Revolution for Industrial Operations," UL Solutions Technical Leaders Development Program, Executive Management Program, Sloan School of Management, Cambridge, Massachusetts, May 13, 2024.
507. "A Digital Twin for Integrated mRNA Manufacturing," Pharma Manufacturing World Summit, Boston, Massachusetts, May 15, 2024.
508. Panelist, "Purification Challenges for mRNA Production, Pt. 2," Chromachats, virtual, March 21, 2024.
509. **Keynote**, "Modeling and Simulation Applications in the Pharmaceutical Industry," PD2M Conference on Modeling and Simulation Applications in Pharmaceutical Development and Manufacturing," Cambridge, Massachusetts, May 21-22, 2024.
510. **Keynote**, "A Digital Twin for mRNA Manufacturing," Festival of Genomics & Biodata, Boston, Massachusetts, June 12-13, 2024.
511. Richard D. Braatz and Aaron Cowley. "End-to-End Integrated Continuous Manufacturing of RNA Therapeutics," DRIVe Tuesday Talk Series, BARDA, June 18, 2024. virtual.
512. "A Digital Twin for Continuous mRNA Manufacturing," BIOPlus - INTERPHEX Korea (BIX), [Technical Session 02] Innovation in mRNA Biotherapeutics, Seoul, South Korea, July 10-12, 2024.
513. **Keynote,** "Current Status and Promise of mRNA Biotherapeutics," BIOPlus - INTERPHEX Korea (BIX), Seoul, South Korea, July 10-12, 2024.
514. "Advances in rAAV Gene Therapy Manufacturing," Ajinomoto, Kyobashi, Japan, July 16, 2024.
515. "Using Crystallization Tech to Improve AAV Yields," Ajinomoto, Kyobashi, Japan, July 16, 2024.
516. "A Digital Twin for Continuous mRNA Manufacturing." MIT Tokyo Life Science Symposium, Tokyo, Japan, July 16, 2024.
517. "Machine Learning-based Methods for Lifetime Prediction and Charging Optimization of Lithium-Ion Batteries," Idemitsu Kosan Co., Ltd., Tokyo, Japan, July 17, 2024.

518. "Modeling and Simulation Applications in the Pharmaceutical Industry: Academic Perspective," Sekisui Chemical, Tokyo, Japan, July 17, 2024.
519. "A Digital Twin for Continuous mRNA Manufacturing," 4th Annual mRNA-Based Therapeutics Summit, Boston, Massachusetts, July 29-31, 2024.
520. Amgen Massachusetts Scientific Offsite, Cambridge, Massachusetts, August 6, 2024. afternoon
521. **Keynote Presentation**, "A Crystallization-based Approach for the Separation of Full and Empty AAV Capsids," 16th Annual Bioprocessing Summit, Boston, Massachusetts, August 19-22, 2024.
522. Richard D. Braatz and Aaron Cowley. **"**Developing a Smart, Digitally Controlled, Fully Integrated Continuous Manufacturing Production Line for xRNA," Advances in Product Quality Control for Biologic Medicines, BioMAN workshop, Cambridge, MA, September 12, 2024.
523. "Advances in Population Balance Modeling and Simulation," Invited talks: In Honor of Ramki's 85th Birthday to commemorate his Contributions to Biopharmaceutical Industry. AIChE Annual Meeting, San Diego, California, October 29, 2024. Abstract 282a.
524. **Keynote**, "Artificial Intelligence in Biomanufacturing," 2024 BioMAN Summit on Artificial Inteligence in Biomanufacturing, November 13-14, 2024.
525. "Integrating Textual Data into Automated Machine Learning for Process Applications" Third Workshop for the MIT-Google Program for Computing Innovation, Massachusetts Institute of Technology, Cambridge, Massachusetts, January 27, 2025.
526. Richard D. Braatz, Alan Edelman, Allan S. Myerson, Sungho Shin, and Guiyan Zang, "Automated Integration of Qualitative and Quantitative Mechanistic Knowledge with Machine Learning-based Modeling," Shell-MITEI Workshop, Massachusetts Institute of Technology, Cambridge, Massachusetts, February 4, 2025.
527. Martin Z. Bazant, Richard D. Braatz, Ju Li, Yoel Fink, and Sungho Shin, "Data-driven Internal Sensing and Rejuvenation of Battery Energy Storage Systems (BESS)," Shell-MITEI Workshop, Massachusetts Institute of Technology, Cambridge, Massachusetts, February 4, 2025.
528. "Applying a Cross-Modality Perspective to Advance the Manufacturing of New Drug Modalities," 9th Annual CCP Summit: Commercializing Continuous Processing in Pharma, Boston, Massachusetts, February 25-27, 2025.
529. "Incorporating Real-time Quantitative Risk Analysis into Digital Twins for Pharmaceutical Manufacturing," Data-Driven Solutions and Modeling-based Analytics for Small and Large Molecules, IFPAC 2025, N. Bethesda, Maryland, March 2-5, 2025.
530. "A Digital Twin for Continuous mRNA Manufacturing," Merck, West Point, Pennsylvania, March 6, 2025.
531. **Keynote**, "State-of-the-Art Technologies in Continuous Processing," Bioprocessing Summit Europe, Barcelona, Spain, March 19, 2025.
532. **Plenary**, "Common Pitfalls When Applying Machine Learning," Analytics & AI Plenary Session, AIChE Spring Meeting and Global Congress on Process Safety, Dallas, Texas, April 6-10, 2025.
533. Panelist, Revisiting a Decade of Digital Transformation, AIChE Spring Meeting and Global Congress on Process Safety, Dallas, Texas, April 6-10, 2025.
534. "Mechanistic Modeling, Analytics, and Automated Control of Continuous Manufacturing Platforms," Cytiva China Biopharmaceutical Downstream Process Summit, April 17, 2025. virtual
535. Panelist, Digitalization, Automation and Artificial Intelligence in Vaccine Manufacturing and Supply. World Vaccine Congress, Washington, DC, April 21-24, 2025.
536. **Keynote Speaker**, "Advances in Integrated Continuous (Bio)Pharmaceutical Manufacturing," 14th Symposium on Sustainability Through Technology, SK Pharmteco, Cambridge, Massachusetts, May 8, 2025.
537. Speaker/Panelist, "Model-based Manufacturing of mRNA-based Therapeutics," Designing RNA Therapies – Advances and Considerations in Data Analytics Session, RNA Discoveries and Therapeutics Conference, Mayo Clinic, Jacksonville, Florida, May 30-31, 2025.

538. **Keynote**, "Integrated, Continuous Manufacturing of mRNA-based Therapeutics," Accelerating Manufacturing, Science & Technology in Cell & Gene Therapy (CGT Talk), Framingham, Massachusetts, June 2, 2025.
539. "Accelerated Process Development Workflows," Vaccines Bioprocess Development & Commercialization Workshop, Cambridge, Massachusetts, June 3-5, 2025.
540. **Plenary Lecture**, "Population Balance Modeling for Emerging Biotherapeutic Products," 8th International Conference on Population Balance Modeling, Purdue University, West Lafayette, Indiana, August 11, 2025.
541. "Digital Twins for Vial-Based Continuous Lyophilization," 11th Annual Intensified and Continuous Bioprocessing, Bioprocessing Summit, Cambridge, Massachusetts, August 18-19, 2025.
542. Panelist, Future of Digital Transformation and AI in Bioprocessing, 6th Annual Digital Transformation & AI in Bioprocess, Bioprocessing Summit, Cambridge, Massachusetts, August 20-21, 2025.
543. "Smart Continuous Manufacturing of Biotherapeutics: Modeling, Analytics, and Control," Danaher Corporation, Cambridge, Massachusetts, October 29, 2025.
544. "AI and Machine Learning in Biomanufacturing," Danaher Corporation, Cambridge, Massachusetts, October 30, 2025.
545. "Digital Twins for Biotherapeutics Manufacturing," Sanofi, Cambridge, Massachusetts, November 19, 2025.
546. "Digital Twins for Efficient and Reliable EV Battery Management: Adaptive Fast Charging and Fault Prognostics," MIT Energy Initiative, Cambridge, Massachusetts, January 22, 2026.
547. **Keynote**, "Intensification of Cell and Gene Therapy Manufacturing: Modeling, Design, and Control," Advancing Manufacture of Cell & Gene Therapies IX, Hilton Head, South Carolina, February 1-5, 2026. https://engconf.us/conferences/biotechnology/advancing-manufacture-of-cell-and-gene-therapies-ix/
548. "AI-driven Diagnosis and Cycle Life Prediction for Lithium-ion Batteries," DENSO, March 25, 2026.

F. Offices Held in Professional Societies and Nonprofit Corporations

- Chapter Advisor, Zeta Chapter, Alpha Chi Sigma, 2000-2002
- Chair, Technical Committee on Industrial Process Control, IEEE Control Systems Society, 2002-2010
- Program Coordinator, Systems and Process Control (Area 10b), American Institute of Chemical Engineers, 2005
- Director, CAST Executive Committee, American Institute of Chemical Engineers, 2005-2007
- Chair, WebCAST Committee, American Institute of Chemical Engineers, 2006-2007
- Director, American Automatic Control Council, 2006-2007
- Chair, Awards Subcommittee for IEEE Transactions in Control Systems Technology Outstanding Paper Award, 2009-2011
- Board of Governors, IEEE Control Systems Society, 2010
- Second Vice Chair, CAST division, American Institute of Chemical Engineers, 2010
- Chair, Awards Committee, CAST division, American Institute of Chemical Engineers, 2010
- First Vice Chair, CAST division, American Institute of Chemical Engineers, 2011
- Chair, CAST division, American Institute of Chemical Engineers, 2012
- Past Chair, CAST division, American Institute of Chemical Engineers, 2013
- Board of Directors, Smart Manufacturing Leadership Coalition (a 501c6 organization), 2016-date
- Vice President and President Elect, American Automatic Control Council, Incorporated (a 501c3 organization), 2016-2017
- President, American Automatic Control Council, Incorporated (a 501c3 organization), 2018-2019
- Past President, American Automatic Control Council, Incorporated (a 501c3 organization), 2020-2021

- Vice President, International Federation of Automatic Control (a non-profit organization), 2023-date

G. Editorships and Advisory Boards of Journals, Other Learned Publications, or Programs

Institute of Electrical and Electronic Engineers
- IEEE Control Systems Society Conference Editorial Board, 1997-2000
- Associate Editor, IEEE Conference on Decision and Control, 1997-2000
- Associate Editor, American Control Conference, 1998-2000
- Associate Editor, Joint IEEE Conference on Decision and Control and the European Control Conference, 2005
- Associate Editor, IEEE Transactions on Automatic Control, 2008-2010
- Associate Editor, IEEE Control Systems Magazine, 2010
- Deputy Editor, IEEE Control Systems Magazine, 2010-2011
- Editor-in-Chief, IEEE Control Systems Magazine, 2012-2014
- Senior Editor, IEEE Life Sciences Letters, 2014-2017

International Federation of Automatic Control
- Associate Editor, Journal of Process Control, 2000-2013
- Associate Editor, Automatica, 2002-2018
- Editor, Special Issue on Advanced Control of Chemical Processes, Journal of Process Control, 2010-2014
- Editorial Board, Annual Reviews in Control, 2015-date
- Editorial Board, IFAC-PapersOnLine, 2017-2000

International Journal of Robust and Nonlinear Control
- Editor, Special Issue on Chemical Process Control, 2007

Optimal Control Applications and Methods
- Editor at Large, 2007-date

Computers and Chemical Engineering
- Editorial Advisory Board, 2010-date
- Editor, Special Issue in Honor of Manfred Morari, 2011-2014
- Co-editor, Special Issue on Pharmaceutical Manufacturing, 2017-2019

American Automatic Control Council
- AIChE Society Review Chair, 2005
- Editor, Invited Papers, 2007

American Chemical Society
- Advisory Board, Industrial Engineering and Chemistry Research, 2005-2007

The Control Handbook, Second Edition, CRC Press
- Editorial Board, 2008-2011

University of California at Santa Barbara
- Advisory Board, Computational Science and Engineering IGERT Program, 2006

University of Illinois at Urbana-Champaign
- Advisory Board, Informatics and Computation Ubiquitous throughout Baccalaureate Education Program, 2007-2010

University of Illinois at Chicago, Purdue University, and Colorado School of Mines
- Advisory Board, Integrating Cognition and Measurement with Conceptual Knowledge - Establishing the Validity and Diagnostic Capacity of Concept Inventories, NSF Award #DRL-0918552, 2010-2012

CACHE Corporation (a 501c3 organization)
- Academic Trustee, 2013-2021

Advanced Manufacturing National Program Office, White House-chartered Interagency Team (hosted by NIST)
- Advanced Manufacturing Partnership 2.0 (AMP 2.0) Technology Work Team, 2014

Springer Nature

- Editorial Board, Birkhäuser Control Engineering Series, 2014-date

American Institute of Chemical Engineers
- Associate Editor, AIChE Webinar Committee, 2016-2018

International Conference on Informatics in Control, Automation and Robotics
- Advisory Board, Doctoral Consortium, July 29, 2016

Handbook of Model Predictive Control
- Advisory Board, 2016-2018

Springer Nature
- Editorial Board, BMC Chemical Engineering, 2018-2020

Chinese Academy of Engineering
- Editorial Board, Engineering, 2020-June 2022

Research Council of Norway
- Advisory Board for the Innovation Project on Optimizing Marine Battery Operations, 2021-2022

H. Review/Award Panels and Advisory Boards
- UIUC/Hertz Fellowship Review Panel, 1994-2002, 2004-2010
- Ted Peterson Student Paper Award Panel, CAST Division, American Institute of Chemical Engineers, 1996
- Pulp and Paper Technical Association of Canada (PAPTAC) Review Panel, 1996-2002
- Computational Science and Engineering Proposal Review Panel, UIUC, 1997-1998, 2001-2002, 2008-2009
- Shen Postdoctoral Fellowship Award Panel, UIUC, 1999
- Alpha Chi Sigma (AXΣ) Outstanding Student Award Panel, Zeta Chapter, 1999
- Peer Review Panel, National Science Foundation, Phase I Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs
- CAST Directors' Award Panel, American Institute of Chemical Engineers, 2002, 2004, 2006, 2007
- Control Engineering Practice Award Panel, American Automatic Control Council, 2003
- Best Student Paper Award Panel, American Automatic Control Council, 2003-2005
- Best Student Paper Award Panel, IEEE Conference on Decision and Control, 2003-2005
- Hugo O'Schuck Award Panel, American Automatic Control Council, 2004, 2016
- Chair, CAST Directors' Award Panel, American Institute of Chemical Engineers, 2004
- CAST Division Awards Committee, American Institute of Chemical Engineers, 2005-2007, 2015-2017
- Advanced Placement Chemistry Virtual Laboratories Review Panel, The College Board, 2006-2009
- IEEE Control Systems Field Award Committee, 2007-2010
- Review Panel, U.S. Department of Energy, 2008, 2019, 2020
- External Evaluator, Department of Chemical Engineering, Queen's University, Ontario, Canada, 2008-2009
- Journal of Process Control Best Paper Prize Selection Committee, International Federation of Automatic Control, 2009-2011, 2012-2014
- Peer Review Panel, National Science Foundation, Process and Reaction Engineering Program, Chemical, Bioengineering, Environmental and Transport Systems (CBET) Division
- IEEE Control Systems Society Fellow Selection Committee, 2009-2010
- IEEE Control Systems Society Award Committee, 2009-2011
- Chair, Awards Subcommittee on TCST Outstanding Paper Award, 2009-2011
- Technology Review Panel, Catalan Institution for Research and Advanced Studies (ICREA), 2009-2010
- Awards Committee, CAST division, American Institute of Chemical Engineers, 2005-2014, 2015-2017
- Award Subcommittee, R.H. Wilhelm Award in Chemical Reaction Engineering, American Institute of Chemical Engineers, 2010

- Beckman Institute for Advanced Science and Technology Seed Proposal Panel, UIUC, 2010
- Panel Leader, Centre Proposal Review Panel, Research Council of Norway, 2011
- Natural Sciences and Engineering Research Council of Canada, 2014
- IFAC Applications Paper Prize Selection Committee, 2014
- Manfred Thoma Medal Selection Committee, International Federation of Automatic Control, 2015-2017
- Conagen Scientific Advisory Board, 2015-2018
- ExxonMobil Process Technology Capabilities Assessment Panel, 2016
- Pfizer Pharmaceutical Sciences Scientific Advisory Panel, 2017
- Peer Review Panel, National Science Foundation, Dynamics, Control, and Systems Diagnostics (DCSD) Program, Division of Civil, Mechanical, and Manufacturing Innovation
- IEEE Control Systems Society Transition to Practice Award, 2019
- External Evaluator, PhD Program in Pharmaceutical Engineering, Virginia Commonwealth University, 2019
- Peer Review Panel, National Science Foundation, Designing Materials to Revolutionize and Engineer our Future (DMREF) Program, Multi-directorate, Materials Genome Initiative
- Scientific Advisory Committee, Center for Utilization of Biological Engineering in Space (CUBES), a NASA Science and Technology Research Institute, University of California Berkeley, 2019-date
- Scientific Advisory Board, Repligen, 2019-date
- Roadmap Projects RFP-2 Waves I and III Evaluation Panels, Clean Energy Smart Manufacturing Innovation Institute, 2019 and 2020
- Chair, Process/Controls Technology Working Group, Clean Energy Smart Manufacturing Innovation Institute, 2017
- Lead, Data Analytics Affinity Group, Clean Energy Smart Manufacturing Innovation Institute, 2017-date
- Lead, Advanced Model Predictive Control and Optimization Affinity Group, Clean Energy Smart Manufacturing Innovation Institute, 2017-date
- SM for Chemical Processing Affinity Group, Clean Energy Smart Manufacturing Innovation Institute, 2017-date
- SM Platform Advisory Committee, Clean Energy Smart Manufacturing Innovation Institute, 2018-2020
- SM Platform Standing Committee, Clean Energy Smart Manufacturing Innovation Institute, 2020-date
- Alternate MIT Representative, Technical and Governing Activities Committees, National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL), 2017-date
- Awards Committee for the AIChE PD2M Award recognizing Outstanding Contribution to QbD for Drug Substance, 2020-2021
- Artificial Intelligence for Energy Storage Workshops, Joint Center for Energy Storage Research, U.S. Department of Energy Innovation Hub, August 17, October 29, 2020
- Scientific Advisory Board, a biotechnology company, 2021-date
- Chair, Scientific Advisory Board, BioCurie, Inc., 2021-date
- Danaher Corporation – advised on AI/ML for biomanufacturing processes, December 2022

I. Industrial Consulting, Collaborations, and/or Support

- Avery-Dennison – designed and implemented the first profile controller on an adhesive coating machine (1990-1991)
- DuPont – designed algorithms for sensor fusion and process control (1993-1994, 1995)
- International Paper Company – supervised the design and implementation (w/students) of fault detection and diagnosis systems for two large-scale industrial facilities worth $600 million (1996-2001)

- International Sematech – constructed simulation models and designed optimal control for rapid thermal annealing during ultrashallow junction formation in microelectronic devices (1998-2000, with students and Prof. E.G. Seebauer)
- Procter and Gamble – supervised the design of algorithms and software implementation (w/students) for the modeling and optimal control of chemical processes (2000-2003); consulting and research support on emulsion crystallization (2009-2010)
- Abbott Laboratories – consulted on in-situ sensor technologies for pharmaceutical crystallizers and chemical reactors (2002, 2006-2007); research support for crystallization modeling and novel crystallizer designs (2009-2010)
- Dow Chemical – consulted on fault diagnosis algorithms for large-scale chemical plants (2002, 2016) and collaborative research in multiscale modeling of blown film extrusion (2018-date)
- Merck – consulted and supervised the design and implementation (w/students) of modeling, sensor, and control algorithms on pharmaceutical crystallizers (1997-2005); collaborating on continuous viral vaccine manufacturing (2019)
- United Technologies Corporation – consulted with UTC Power (then UTC Fuel Cells) on the design and implementation of fault diagnosis systems for fuel cell power plants (2002-2003); research support by UTC Power and Sikorsky Aircraft Corporation for developing procedures for the optimal design of maintenance schedules (2004-2009)
- IBM – constructed simulation models for the copper electrodeposition process for making interconnects for microelectronic devices (2002-2008, with students and Dr. R.C. Alkire who was project lead)
- Sepracor/Sunovion Pharmaceuticals – consulted on the modeling and design of batch pharmaceutical crystallizers (2003, 2006, 2011)
- Round Table Group – member of this consortium of consulting professors in the chemistry, pharmaceutical, and chemical engineering areas (2003-2009)
- Bristol-Myers Squibb – consulted and collaborated on the modeling and design of batch pharmaceutical crystallizers (2004, 2008-2017)
- U.S. Food and Drug Administration – provided input on process analytical technologies for pharmaceutical crystallization and continuous manufacturing processes (2004-2005, 2012-2018)
- Pfizer – consulted or collaborated on crystallizer design and control (2006-2007, 2010-2011); served on Pharmaceutical Sciences Scientific Advisory Panel on Flexible API Supply Technologies (2017)
- Eli Lilly – supports research projects in pharmaceutical crystallization (2007-2009) and coauthored a commentary on synthesis, workup, and isolation on drug substance for continuous pharmaceutical manufacturing (2014-2015)
- Bend Research – supports research projects in pharmaceutical crystallization (2008-2009)
- OSIsoft – supports research projects in process control (2008-2010)
- GlaxoSmithKline – consulted on pharmaceutical process analytical technology (2009), coauthored a commentary on control systems engineering in continuous pharmaceutical manufacturing (2014-2015), and consulting on biopharmaceutical manufacturing (2018)
- Novartis – supported control of continuous pharmaceutical manufacturing facilities and collaborated on research (2010-2019)
- Millennium/Takeda Pharmaceuticals – supported research on continuous crystallization technology (2011-2015) and on machine learning in pharmaceutical manufacturing (2020-date)
- Boehringer-Ingelheim – consulted on pharmaceutical crystallization technology (2010, 2014, 2016)
- BP – supports development of methods for the design of fault-tolerant model predictive control systems (2011-date)
- Aegerion Pharmaceuticals – consulted on pharmaceutical crystallization (2011-2012)
- Biogen – consulting on process technologies (2012-2016)
- Industrial Machine Automation (IMA) – consulted on continuous pharmaceutical manufacturing (2013)
- Greene, Tweed & Co. – consulted on crystallization technology (2013-2014)

- Brewer Science – consulting on advanced manufacturing (2014)
- Vertex Pharmaceuticals –coauthored a commentary on control systems engineering in continuous pharmaceutical manufacturing (2014-2015)
- AstraZeneca – coauthored a commentary on synthesis, workup, and isolation on drug substance for continuous pharmaceutical manufacturing (2014-2015)
- Conagen – Scientific Advisory Board, consulting on biologics manufacturing (2015-2018)
- Emerson – collaborating on advanced control technology (2015-2018)
- Saint-Gobain – consulted on advanced manufacturing process control (2016-2018)
- Alkermes – consulting on continuous crystallization (2016)
- Continuus – consulting on polymerization reaction modeling (2016-2018)
- ExxonMobil – external panelist for Process Technology Capabilities Assessment (2016)
- Amgen – co-advised Master theses on equipment selection for continuous pharmaceutical manufacturing and optimization of process development workflows, and collaborated on first-principles modeling and control of continuous pharmaceutical manufacturing processes (2016-date)
- Bates White – consulted on the economics of continuous pharmaceutical manufacturing (2017)
- Sanofi-Pasteur – collaborated on viral vaccine manufacturing (2016-2019)
- Arconic – training in process data analytics (2017-2019)
- Repligen – data consulting, and member of the Scientific Advisory Board (2019-date)
- Havila, Equinor, Corvus Energy, and SINTEF Energy – advise on optimizing marine battery operations (2021)
- BioCurie – Chief Scientist and Chair, Scientific Advisory Board (2022-date)
- Danaher Corporation – advised on AI/ML for biomanufacturing processes, December 2022
- Sanofi – mRNA CMC Advisory Board (2025)

II. PUBLICATIONS

A. Doctoral Thesis

- *Robust Loopshaping for Process Control*, California Institute of Technology, Pasadena, California, 1993.

Received Hertz Doctoral Thesis Prize, and cited in one of the most popular textbooks on advanced process control (*Multivariable Feedback Control – Analysis and Design*, Wiley, 2nd edition, 2005).

B. Books/Compilations

1. E. L. Russell, L. H. Chiang, and R. D. Braatz. *Data-driven Methods for Fault Detection and Diagnosis in Chemical Processes*, Springer-Verlag, London, 2000.

The monograph describes new fault detection and fault diagnosis algorithms based on canonical variate analysis and Fisher discriminant analysis that outperform prior dimensionality reduction algorithms. These methods were implemented at many companies including International Paper, UTC Fuel Cells, and Dow Chemical (e.g., applications by Dow engineers are reported in *Comput. Chem. Eng.*, 28:1389-1401, 2004 and *Journal of Process Control*, 14:143-155, 2004).

2. A. P. Featherstone, J. G. VanAntwerp, and R. D. Braatz. *Identification and Control of Sheet and Film Processes*, Springer-Verlag, London, 2000. reviewed by B. Wayne Bequette, *IEEE Control Systems*, 22(3), 102-103, 2002, and Peter Wellstead, *International Journal of Robust and Nonlinear Control*, 13, 1177-1180, 2003.

The monograph describes our results on the model identification and control of sheet and film processes, which were incorporated into algorithms implemented by Honeywell on industrial paper machines, as described in a paper written by Honeywell engineers (*Automatica*, vol. 39, pages 779-792, 2003).

"Essential reading for researchers and engineers in the area" – Peter Wellstead, page 1178, above review.

3. L. H. Chiang, E. L. Russell, and R. D. Braatz. *Fault Detection and Diagnosis in Industrial Systems*, Springer-Verlag, London, 2001. Chinese translation available from China Machine Press, Beijing, China. Has been used in courses at universities in the United States, United Kingdom, Denmark, China, Sweden, and Finland. reviewed by Thomas McAvoy, *Journal of Process Control*, 12, 453-454, 2002; Jon Rigelsford, *Industrial Robot*, 28, 5, 2001; and Joe Au, *Measurement Science and Technology*, 12, 1745, 2001.) **2900+ citations**

This textbook synthesizes all three major approaches (data-driven, analytical, and knowledge-based) for fault detection and diagnosis.

"Excellent overview" – Thomas McAvoy, page 453, above review.
"Fault Detection and Diagnosis in Industrial Systems is a well written and informative text" – Jon Rigelsford, above review
"Provides a much-needed state-of-the-art exposition on fault detection and diagnosis" – Joe Au, above review.

4. R. D. Braatz, A. N. Ford Versypt, and L. M. Goh. *Nanoscale Drug Delivery Module: Teacher's Edition*, Materials World Modules, Northwestern University, Evanston, Illinois, 2012. Available at http://www.materialsworldmodules.org/index.php/modules-and-user-support/list-of-modules/nanoscale-drug-delivery-module.

5. R. D. Braatz, A. N. Ford Versypt, and L. M. Goh. *Nanoscale Drug Delivery Module*, Materials World Modules, Northwestern University, Evanston, Illinois, 2012. Available at http://www.materialsworldmodules.org/index.php/modules-and-user-support/list-of-modules/nanoscale-drug-delivery-module.

6. Masoud Soroush and Richard D. Braatz, editors. *Machine Learning and Artificial Intelligence: Methods and Concepts*, Elsevier, Amsterdam, Netherlands, 2024.

7. Masoud Soroush and Richard D. Braatz, editors. *Artificial Intelligence in Manufacturing: Applications and Case Studies*, Elsevier, Amsterdam, Netherlands, 2024.

C. Book Chapters

1. R. D. Braatz. Internal model control. In *The Control Handbook*, W. S. Levine, editor, CRC Press, Boca Raton, Florida, pp. 215-224, 1996 (invited).

Tutorial on Internal Model Control.

2. R. D. Braatz. Internal model control. In *Control Systems Fundamentals*, W. S. Levine, editor, CRC Press, Boca Raton, Florida, pp. 215-224, 2000 (invited reprint).

Tutorial on Internal Model Control.

3. R. D. Braatz (contributor). Materials and processing. In *Control in an Information Rich World: Report of the Panel on Future Directions in Control, Dynamics, and Systems*, R. M. Murray, editor, SIAM Press, Philadelphia, Pennsylvania, pp. 63-70, 2003 (invited).

The section on the future of control, dynamics, and systems in the areas of materials and processing was based mostly on text written with Frank Doyle.

4. Z. K. Nagy and R. D. Braatz. Recent advances in the optimal control of batch processes. In *Recent Research Developments in Chemical Engineering*, Volume 5, Transworld Research Network, pp. 99-127, 2003 (invited).

Reviews efforts to include the effect of model uncertainties on the design of optimal controllers for batch and semi-batch processes, including discussions of why the commonly used worst-case and expected value optimal control formulations for these processes are fundamentally flawed—that is, either are too optimistic and give poor robustness, or too pessimistic and give poor performance.

5. R. D. Braatz, M. Fujiwara, T. Wubben, and E. Rusli. Crystallization: Particle size control. In *Encyclopedia of Pharmaceutical Technology*, James Swarbrick, editor, 3rd edition, Marcel Dekker, New York, pp. 858-871, 2006 (invited).

Reviews the field of particle size control for crystallization processes.

6. E. J. Hukkanen, J. G. VanAntwerp, and R. D. Braatz. Identification and control of polymerization reactors. In *Identification and Control: The Gap between Theory and Practice*, Ricardo S. Sánchez-Peña, Joseba Quevedo Casín, and Vicenç Puig Cayuela, editors, Springer Verlag, London, Chapter 1, pp. 3-41, 2007 (invited).

Identifies the kinetic mechanism for the polymerization of PMMA by using a combination of ATR-FTIR spectroscopy, gel permeation chromatography, and statistical analysis. A reaction is identified that is missing in the kinetic mechanisms reported in the literature.

7. R. D. Braatz, E. G. Seebauer, and R. C. Alkire. Multiscale modeling and design of electrochemical systems. In *Electrochemical Surface Modification – Thin Films, Functionalization and Characterization*, *Advances in Electrochemical Science and Engineering*, R. C. Alkire, D. M. Kolb, J. Lipkowski, and P. N. Ross, editors, Wiley-VCH, Weinheim, Germany, Volume 10, Chapter 4, pp. 289-334, 2008 (invited).

Describes the field of multiscale modeling and design and its application to electrochemical and solid-state systems.

8. R. D. Braatz and M. Hovd. Process control and automation. In *Enciclopedia degli Idrocarburi* (*Encyclopaedia of Hydrocarbons*), Istituto Della Enciclopedia Italiana Fondata da Giovanni Treccani, Rome, Italy, Volume V: Instruments, Chapter 6.5, pp. 389-411, 2009 (invited).

Provides an introduction to process monitoring and control including model predictive control.

9. M. Kishida and R. D. Braatz. Internal model control. In *The Control Handbook*, 2nd edition, *Control System Fundamentals*, W. S. Levine, editor, CRC Press, Boca Raton, Florida, Chapter 9.7, 2011 (invited).

Tutorial on Internal Model Control that includes extensions to nonlinear and distributed parameter systems.

10. Z. K. Nagy and R. D. Braatz. Nonlinear model predictive control for batch processes. In *The Control Handbook*, 2nd edition, *Control System Applications*, W. S. Levine, editor, CRC Press, Boca Raton, Florida, Chapter 15, 2011 (invited).

Tutorial on robust model predictive control for finite-time systems.

11. I. Craig, C. Alrich, R. Braatz, et al. Control in the Process Industries. In *The Impact of Control Technology*, T. Samad and A. Annaswamy, editors, IEEE Control Systems Society, 2011. Available for download at http://ieeecss.org/main/IoCT-report (invited).

My test described the status and opportunities of process control in the pharmaceutical and electrochemical industries and on the remaining theoretical challenges in process control.

12. R. D. Braatz, M. Fujiwara, Z. K. Nagy, T. Wubben, and E. Rusli. Crystallization: Particle size control. In *Encyclopedia of Pharmaceutical Science and Technology*, James Swarbrick, editor, 4th edition, Taylor and Francis, New York, pp. 785-798, 2013 (invited).

Reviews the field of particle size control for crystallization processes.

13. R. D. Braatz. Advanced control of pharmaceutical crystallization. In *The Impact of Control Technology*, Second Edition, edited by T. Samad and A. Annaswamy, IEEE Control Systems Society, 2014. Available for download at http://ieeecss.org/general/impact-control-technology-2nd-edition.

A description of the impact of advanced control on pharmaceutical crystallization.

14. M. Jiang, N. C. S. Kee, X. Y. Woo, L. M. Goh, J. D. Tice, L. Zhou, R. B. H. Tan, C. F. Zukoski, M. Fujiwara, Z. K. Nagy, P. J. A. Kenis, and R. D. Braatz. Role of automatic process control in Quality by Design. In *Comprehensive Quality by Design for Pharmaceutical Product Development and Manufacture*, edited by G. V. Reklaitis, C. Seymour, and S. García-Munoz, and John Wiley & Sons Ltd, Hoboken, New Jersey, Chapter 3, pages 25-54, 2017 (invited).

A description of the role of automatic process control in Quality by Design that includes specific examples.

15. R. Lakerveld, P. L. Heider, K. D. Jensen, R. D. Braatz, K. F. Jensen, A. S. Myerson, and B. L. Trout. End-to-end continuous manufacturing: Integration of unit operations. In *Continuous Manufacturing of Pharmaceuticals*, edited by P. Kleinebudde, J. Khinnast, and J. Rantanen, Wiley, New York, Chapter 13, pages 447-483, 2017 (invited).

A description of the integration of unit operations within an end-to-end continuous manufacturing pilot plant constructed at the Massachusetts Institute of Technology.

16. J. A. Paulson, S. Streif, R. Findeisen, R. D. Braatz, and A. Mesbah. Fast stochastic model predictive control of end-to-end continuous pharmaceutical manufacturing. In *Process Systems Engineering for Pharmaceutical Manufacturing*, edited by Ravendra Singh and Zhihong Yuan, Elsevier, Amsterdam, Netherlands, Chapter 14, pages 353-378, 2018 (invited).

A fast model predictive control algorithm that takes probabilistic uncertainties into account is presented and demonstrated for an end-to-end continuous pharmaceutical manufacturing plant.

17. K. Severson, J. G. VanAntwerp, V. Natarajan, C. Antoniou, J. Thömmes, and R. D. Braatz. A systematic approach to process data analytics in pharmaceutical manufacturing: The data analytics triangle and its application to the manufacturing of a monoclonal antibody. In *Multivariate Analysis in the Pharmaceutical Industry*, edited by A. P. Ferreira, J. C. Menezes, and M. Tobyn, Academic Press, London, UK, Chapter 12, 295-312, 2018 (invited).

A systematic approach for the selection of data analytics methods is described and applied to the manufacturing of a monoclonal antibody at Biogen.

18. J. A. Paulson, E. Harinath, L. C. Foguth, and R. D. Braatz. Control and systems theory for advanced manufacturing. In *Emerging Applications of Control and System Theory*, edited by Roberto Tempo, Stephen Yurkovich, and Pradeep Misra, Lecture Notes in Control and Information Sciences, Springer Verlag, Cham, Switzerland, Chapter 5, 63-80, 2018 (invited).

Systems and control theory is described that is applicable to advanced manufacturing, while incorporating results and applications by the research group.

19. E. Harinath, L. C. Foguth, J. A. Paulson, and R. D. Braatz. Model predictive control of polynomial systems. In *Handbook of Model Predictive Control*, edited by Saša V. Raković and William S. Levine, Birkhäuser Basel, Switzerland, 221-237, 2019 (invited).

Theory and algorithms are described for the model predictive control of nonlinear dynamical systems in which the nonlinearities are polynomials; such systems commonly arise in chemical and biological processes.

20. Z. K. Nagy, M. Fujiwara, and R. D. Braatz. Monitoring and advanced control of crystallization processes. In *Handbook of Industrial Crystallization*, 3rd edition, edited by A. Myerson, D. Erdemir, and A. Y. Lee, Cambridge University Press, United Kingdom, Chapter 11, 313-3455, 2019 (invited).

Advances are described in the monitoring and control of crystallization processes.

21. J. Carl Pirkle, Jr., Michael L. Rasche, Richard D. Braatz, and Mo Jiang. Slug-flow continuous crystallization: Fundamentals and process intensification. In *The Handbook of Continuous Crystallization*, edited by Nima Yazdanpanah and Zoltan Nagy, Royal Society of Chemistry, London, United Kingdom, Chapter 5, 219-247, 2020 (invited).

The fundamentals of slug-flow continuous crystallization are described, which include the most advanced technologies, crystallization process models, fluid dynamics models, and control systems designs.

22. Xiaoxiang Zhu, Lifang Zhou, and Richard D. Braatz. Method of characteristics for the efficient simulation of population balance models. In *Optimization of Pharmaceutical Processes*, edited by Antonios Fytopoulos, Rohit Ramachandran, and Panos Pardalos, Springer Optimization and Its Applications, Cham, Switzerland, 33-52, 2022 (invited).

Derives an extremely fast and accurate DAE-based method-of-characteristics approach for the simulation of particulate processes, which transforms the population balance model into a small number of ordinary differential-algebraic-integral equations.

23. Anastasia Nikolakopoulou, Matthias von Andrian, and Richard D. Braatz. Fast model predictive control of modular systems for continuous manufacturing of pharmaceuticals. In *Optimization of Pharmaceutical Processes*, edited by Antonios Fytopoulos, Rohit Ramachandran, and Panos Pardalos, Springer Optimization and Its Applications, Cham, Switzerland, Volume 189, 289-322, 2022 (invited).

Methodologies are described for the plant-wide optimization and control of nonlinear modular systems for continuous-flow pharmaceutical manufacturing.

24. Sanket Diwale, Nathan Volchko, Alexander J. Bourque, Richard D. Braatz, and Gregory C. Rutledge. Data-driven discovery and design of additives for controlled polymer morphology and performance. In *Artificial Intelligence in Manufacturing: Applications and Case Studies*, edited by Masoud Soroush and Richard D. Braatz, Elsevier, papers due March 2022. Emailed nearly final version to coauthors on 4/16/2022. Emailed version 7 to Masoud on 6/22/2022. Uploaded final files with copyright permissions on 12/27/2022.

Methodologies are described for machine learning-based materials discovery and its application to polymers.

25. Jaewook Lee, Weike Sun, Jay H. Lee, and Richard D. Braatz. Learning first-principles knowledge from data. In *Machine Learning and Artificial Intelligence: Concepts and Methods*, edited by Masoud Soroush and Richard D. Braatz, Elsevier, papers due March 2022. Emailed to Masoud Soroush on 8/15/2022. Uploaded final files with copyright permissions on 12/27/2022.

Methodologies are described for combining artificial intelligence with machine learning to learn first-principles knowledge from process data.

D. Journal Papers (all citation numbers are from Google Scholar)

1. R. D. Braatz and M. Morari. Robust control for a noncollocated spring-mass system. *J. of Guidance, Control and Dynamics*, 15:1103-1110, 1992.

First paper to design a controller that satisfied all performance and robustness requirements and constraints for the "spring-mass benchmark problem" posed by Wie and Bernstein (*Proceedings of the American Control Conference*, pp. 961-962, 1990).

2. R. D. Braatz, M. L. Tyler, M. Morari, F. R. Pranckh, and L. Sartor. Identification and cross-directional control of coating processes. *AIChE J.*, 38:1329-1339, 1992. Reprinted in Part C of the PSE Virtual Issue of AIChE Journal, as one of the most cited papers in the journal on *Process Identification, State Estimation and Control*.

First application of profile control to an industrial coater, which resulted in 80% reduction in coating thickness variations at Avery-Dennison Company.

3. D. L. Laughlin, M. Morari, and R. D. Braatz. Robust performance of cross-directional basis-weight control in paper machines. *Automatica*, 29:1395-1410, 1993.

First application of circulant matrix theory to design robust controllers for large-scale paper machines.

4. R. D. Braatz and M. Morari. Minimizing the Euclidean condition number. *SIAM J. on Control and Optim.*, 32:1763-1768, 1994.

Derived a polynomial-time algorithm to compute the diagonal scaling matrices that minimize the Euclidean condition number—a problem first posed in the early 1960s in the linear algebra literature. This algorithm became a step in the Honeywell's Robust Multivariable Predictive Control Technology, as described in a paper by a Honeywell engineer (*Preprints of the Control Systems '96 Conference*, pp. 53-60, 1996), and was discussed in a textbook (*Multivariable Feedback Control – Analysis and Design*, Wiley, 1996)

5. R. D. Braatz, P. M. Young, J. C. Doyle, and M. Morari. Computational complexity of μ calculation. *IEEE Trans. on Automatic Control*, 39:1000-1002, 1994. **500+ citations**

Proved that robustness margin computation is NP-hard, which motivated the development of probabilistic robustness analysis algorithms by senior control theorists Pramod Khargonekar (U Michigan), Robert Stengel (Princeton), B. Ross Barmish (Wisconsin), Mathukumalli Vidyasagar (Tata Consulting Services), as well as many others. The result is widely cited including in textbooks on advanced control theory (e.g., *Linear Matrix Inequalities in System and Control Theory*, SIAM Press, 1994; *Robust and Optimal Control*, Prentice Hall, 1996; *Essentials of Robust Control*, Prentice Hall, 1998; *A Course in Robust Control Theory – A Convex Approach*, Springer Verlag, 2000; *Multivariable Feedback Control – Analysis and Design*, Wiley, 2nd edition, 2005).

6. J. H. Lee, R. D. Braatz, M. Morari, and A. Packard. Screening tools for robust control structure selection. *Automatica*, 31:229-235, 1995.

Derived the first methods for control structure selection that explicitly took structured model uncertainties into account.

7. R. D. Braatz, J. H. Lee, and M. Morari. Screening plant designs and control structures for uncertain systems. *Comput. Chem. Eng.*, 20:463-468, 1996.

Derived the first nonconservative tools for robust control structure selection for systems with general structured uncertainty descriptions, and showed that the heavily-used relative gain array and minimized condition number could under-predict control difficulties for these systems.

8. R. D. Braatz, M. Morari, and S. Skogestad. Loopshaping for robust performance. *Int. J. of Robust and Nonlinear Control*, 6:805-823, 1996.

Extended Bode's classical loopshaping methods to multiple parametric and dynamic uncertainty descriptions, multiple performance specifications, and to the design of decentralized controllers. Cited in *Multivariable Feedback Control – Analysis and Design*, Wiley, 2nd edition, 2005.

9. M. Hovd, R. D. Braatz, and S. Skogestad. SVD controllers for H2, H-infinity, and mu-optimal control. *Automatica*, 33:433-439, 1997.

Derived a robust control theory for sheet and film processes that was incorporated into algorithms implemented by Honeywell on industrial paper machines, as described in a paper written by Honeywell engineers (*Automatica*, vol. 39, pages 779-792, 2003). An interesting theoretical point is that the designed controllers are *super-optimal*, which is a much higher degree of optimality than provided by H_∞-optimal control theory. The paper is cited in an advanced controls textbook (*Multivariable Feedback Control – Analysis and Design*, Wiley, 1996).

10. I. G. Horn, J. R. Arulandu, C. J. Gombas, J. G. VanAntwerp, and R. D. Braatz. Improved filter design in internal model control. *Ind. Eng. Chem. Res.*, 35:3437-3441, 1996.

Developed a set of IMC control tuning rules that provided improved load disturbance suppression, which became a section of a process control textbook (Section 8.10 of *Process Control – Modeling, Design, and Simulation*, Prentice Hall, 2003).

11. R. D. Braatz and M. Morari. On the stability of systems with mixed time-varying parameters. *Int. J. of Robust and Nonlinear Control*, 7:105-112, 1997.

Derived a polynomial-time computable condition for robust stability that can be substantially less conservative for gain-scheduled and other multivariable systems with repeated real time-varying parameters.

12. E. L. Russell, C. P. H. Power, and R. D. Braatz. Multidimensional realization of large scale uncertain systems for multivariable stability margin computation. *Int. J. of Robust and Nonlinear Control*, 7:113-125, 1997.

Derived and implemented the most computationally efficient algorithm for constructing state-space realizations for large-scale uncertain systems.

13. E. Rios-Patron and R. D. Braatz. On the identification and control of dynamical systems using neural networks. *IEEE Trans. on Neural Networks*, 8:452, 1997.

Corrected the analysis of nonlinear dynamics in a highly-cited award-winning paper (*IEEE Trans. on Neural Networks*, vol. 1, pp. 4-27, 1990).

14. R. D. Braatz and J. G. VanAntwerp. Advanced cross-directional control. *Pulp & Paper Canada*, 98(7):T237-239, July 1997.

Described the first robust model predictive control algorithm with low on-line computational cost for the profile control of sheet and film processes (based on a 1996 proceedings paper written for an industrial audience).

15. A. P. Featherstone and R. D. Braatz. Control-oriented modeling of sheet and film processes. *AIChE J.*, 43:1989-2001, 1997.

Journal version of our 1995 ACC paper that was the first to explain the root cause of control-induced wrinkling in sheet and film processes, to derive a control design method to prevent the problem, and to provide strong theoretical support for the "singular value thresholding" method implemented in Honeywell's Robust Multivariable Predictive Control Technology and described by a Honeywell engineer on page 91 of the Winter 1996/1997 issue of *Petroleum Technology Quarterly*.

16. A. P. Featherstone and R. D. Braatz. Integrated robust identification and control of large scale processes. *Ind. Eng. Chem. Res.*, 37:97-106, 1998.

First journal paper to provide theoretical support for the "singular value thresholding" method for general dynamic systems (this extended paper 15).

17. C. L. Mangun, M. A. Daley, R. D. Braatz, and J. Economy. Effect of pore size on adsorption of hydrocarbons in phenolic-based activated carbon fibers. *Carbon*, 36:123-131, 1998.

First paper to apply first-principles modeling for the adsorption kinetics in activated carbon fibers. This paper extended the extensive efforts in modeling activated carbon granules, ion-exchange resins, and other related systems to activated carbon fibers.

18. A. P. Featherstone and R. D. Braatz. Input design for large scale sheet and film processes. *Ind. Eng. Chem. Res.*, 37:449-454, 1998.

Derived a procedure for the design of inputs for the identification of models for sheet and film processes that results in models that are one order-of-magnitude more accurate than models identified using the industrial standard bump tests.

19. E. L. Russell and R. D. Braatz. Model reduction for the robustness margin computation of large scale uncertain systems. *Comput. Chem. Eng.*, 22:913-926, 1998.

Derived the first model reduction algorithms computable for large-scale uncertain systems.

20. S. H. Chung and R. D. Braatz. Teaching antiwindup, bumpless transfer, and split-range control. *Chem. Eng. Edu.*, 32:220-223, 1998.

Described educational materials used to teach the concepts of antiwindup compensation, bumpless transfer, and split-range control to undergraduates.

21. R. D. Braatz and O. D. Crisalle. Robustness analysis for systems with ellipsoidal uncertainty. *Int. J. of Robust and Nonlinear Control*, 8:1113-1117, 1998.

Derived the robustness margin for a class of systems with ellipsoidal uncertainty that was more general than previous results published by various control theorists.

22. R. D. Braatz and M. R. Johnson. Process control laboratory education using a graphical operator interface. *Comp. Appl. Eng. Edu.*, 6:151-155, 1998.

Described a graphical operator interface developed for the undergraduate process control laboratory at the University of Illinois.

23. J. G. VanAntwerp, R. D. Braatz, and N. V. Sahinidis. Globally optimal robust process control. *Journal of Process Control*, 9:375-383, 1999.

Derived a numerical algorithm for solving optimization problems with bilinear matrix inequality constraints which, when it was published, was the most computationally efficient in the world, by a substantial margin. (Bilinear matrix inequalities are a general framework for robust controller design.)

24. S. H. Chung, D. L. Ma, and R. D. Braatz. Optimal seeding in batch crystallization. *Can. J. of Chem. Eng.*, 77:590-596, 1999. **~200 citations**

First comprehensive investigation of the effects of the seed distribution on the final crystal size distribution for a crystallization process. This optimization study explained various experimental results reported in the literature and concluded that (1) optimizing the seed distribution is an order-of-magnitude more important than optimizing the cooling profile, which was the focus of 100s of previous papers, and

(2) the coefficient of variation, used in several papers on the optimal control of batch crystallizers, can result in very poor crystal size distributions (large amounts of small crystals).

25. A. P. Featherstone and R. D. Braatz. Modal-based cross-directional control. *Tappi J.*, 82:203-207, 1999.

Described how the singular value decomposition of a process could be interpreted in terms of modal analysis, and used to simplify the modeling and control of sheet and film processes (based on a proceedings paper written for an industrial audience).

26. D. L. Ma, S. H. Chung, and R. D. Braatz. Worst-case performance analysis of optimal batch control trajectories. *AIChE J.*, 45:1469-1476, 1999.

First paper to quantify the effect of parameter *and* control implementation uncertainties on the performance of open-loop control policies for general nonlinear systems.

27. C. L. Mangun, R. D. Braatz, J. Economy, and A. J. Hall. Fixed bed adsorption of acetone and ammonia onto oxidized activated carbon fibers. *Ind. Eng. Chem. Res.*, 38:3499-3504, 1999.

First paper to apply first-principles models to modeling the adsorption kinetics in fixed beds of activated carbon fibers.

28. R. D. Braatz and E. L. Russell. Robustness margin computation for large scale systems. *Comput. Chem. Eng.*, 23:1021-1030, 1999.

Presented the first brief proof that the exact computation of robustness margins is NP-hard for systems with independent real perturbations and the first correct proof that the ε-approximation of robustness margin computations is NP-hard, for any given value for ε. These and other computational complexity results motivate the use of stochastic robustness methods, which are computable in polynomial-time and provide much more insights than worst-case approaches.

29. S. H. Chung, D. L. Ma, and R. D. Braatz. Optimal model-based experimental design in batch crystallization. *Chemom. Int. Lab. Syst.*, 50:83-90, 2000.

Most comprehensive study ever conducted on the model-based experimental design of a crystallization process. Its conclusions included: (1) highly accurate estimates of nucleation and growth kinetic parameters can be obtained with as few as four batch experiments, and (2) the selection of seeding characteristics is an order-of-magnitude more important than the cooling profile when designing batch crystallization experiments.

30. J. G. VanAntwerp and R. D. Braatz. Fast model predictive control of sheet and film processes. *IEEE Trans. on Control Syst. Tech.*, 8:408-417, 2000.

Derived the first robust MPC algorithm computationally efficient enough to be implemented on general large-scale sheet and film processes (this extended Paper 14).

31. J. G. VanAntwerp and R. D. Braatz. A tutorial on linear and bilinear matrix inequalities. *Journal of Process Control*, 10:363-385, 2000. **800+ citations**

The first tutorial on linear and bilinear matrix inequalities and their applications to problems in process systems engineering. The Optimal Control chapter of the Virtual Process Control textbook, edited by E.

Gatzke and J. Haun, Computer Aids for Chemical Engineering (CACHE) Corporation, Austin, Texas, 2007.

32. J. G. VanAntwerp and R. D. Braatz. Model predictive control of large scale processes. *Journal of Process Control*, 10:1-8, 2000.

Derived the first robust MPC algorithm computationally efficient enough to be implemented on *general* large-scale processes.

33. L. H. Chiang, E. L. Russell, and R. D. Braatz. Fault diagnosis in chemical processes using Fisher discriminant analysis, discriminant partial least squares, and principal component analysis. *Chemom. Int. Lab. Syst.*, 50:243-252, 2000. **750+ citations**

Derived fault diagnosis statistics based on Fisher discriminant analysis and showed that the statistics outperformed other data-based fault diagnosis methods. These statistics were implemented at many companies including International Paper, UTC Fuel Cells, and Dow Chemical (e.g., applications by Dow engineers are reported in *Journal of Process Control*, 14:143-155, 2004).

34. E. L. Russell, L. H. Chiang, and R. D. Braatz. Fault detection in industrial processes using canonical variate analysis and dynamic principal component analysis. *Chemom. Int. Lab. Syst.*, 51:81-93, 2000. **600+ citations**

Derived fault detection statistics based on state-space identification theory (canonical variate analysis) and showed that the statistics outperformed other fault detection statistics.

35. T. Togkalidou, R. D. Braatz, B. K. Johnson, O. Davidson, and A. Andrews. Experimental design and inferential modeling in pharmaceutical crystallization. *AIChE J.*, 47:160-168, 2001.

This application of experimental design and inferential modeling improved the productivity of a pharmaceutical crystallization process at Merck by 3.7-fold.

36. J. G. VanAntwerp, A. P. Featherstone, and R. D. Braatz. Robust cross-directional control of large scale sheet and film processes. *Journal of Process Control*, 11:149-178, 2001.

The most comprehensive paper on the design of robust controllers for profile control of sheet and film processes. The results were substantially more general than previous papers, and included more complete model reductions, low-order "tunable" controller designs, general interactions matrices, and uncertainty descriptions consisting of mixed linear, nonlinear, and time-varying perturbations. Many of the robust control design problems that were posed and solved in numerical examples are not solvable using any other techniques (due to limitations on the numerical accuracy of the algorithms, memory requirements larger than available in existing computers, or computational cost).

37. R. Gunawan, E. L. Russell, and R. D. Braatz. Comparison of theoretical and computational characteristics of dimensionality reduction methods for large scale uncertain systems. *Journal of Process Control*, 11:543-552, 2001.

Showed that dimensionality reduction methods can reduce the computational effort of robust controller synthesis and robust control structure selection by orders of magnitude, which enable their application to uncertain systems of increased input, output, and state dimensionality. The paper critically compared the methods of multidimensional singular value decompositions, successive multidimensional realization,

multidimensional Kalman decomposition, and multidimensional balanced truncation, both theoretically and in applications to two large-scale benchmark problems.

38. D. L. Ma and R. D. Braatz. Worst-case analysis of finite-time control policies. *IEEE Trans. on Control Syst. Tech.*, 9:766-774, 2001.

First paper to quantify the effect of parameter and control implementation uncertainties on the performance of open-loop control policies, for general uncertainty descriptions (including ellipsoid, min-max, and 1-norm). The approach was evaluated through application to the control of the shape of crystals used in nonlinear optics applications, where the nominal parameters and uncertainties were quantified from experimental data.

39. T. Togkalidou, M. Fujiwara, S. Patel, and R. D. Braatz. Solute concentration prediction using chemometrics and ATR-FTIR spectroscopy. *J. of Crystal Growth*, 231:534-543, 2001. **200+ citations**

The kinetics of nucleation, growth, and aggregation in crystallization processes are strongly dependent on the solute concentration. Although attenuated total reflection-Fourier transform infrared (ATR-FTIR) spectroscopy was first proposed as a technology for solute concentration measurement in 1994, several pharmaceutical companies had been unable to obtain solute concentration measurements of sufficient accuracy, and had given up on the technology. This paper reported in-situ solute concentration measurements in dense crystal slurries using ATR-FTIR spectroscopy and a combination of experimental design and chemometrics that were more than an order-of-magnitude more accurate than previously reported. This technology was quickly transferred to other academic laboratories and pharmaceutical companies (e.g., an application at Merck is described in Paper 47 and an application at Schering Plough is described in *Org. Proc. Res. Dev.*, vol. 8, pages 488-494, 2004).

40. E. L. Russell and R. D. Braatz. The average-case identifiability and controllability of large scale systems. *Journal of Process Control*, 12:823-829, 2002.

Showed that the procedure of selecting only square transfer functions to use for control purposes, which has been popular in the literature and industrial practice, is a poor practice for large-scale processes. The results were based on the asymptotic statistical theory of large matrices and Monte Carlo simulations.

41. R. D. Braatz, M. Fujiwara, D. L. Ma, T. Togkalidou, and D. K. Tafti. Simulation and new sensor technologies for industrial crystallization: A review. *Special Issue on Crystallization and Interfacial Processes*, *Int. J. of Modern Physics B*, 16:346-353, 2002 (invited).

Reviewed advances in sensor and simulation technologies for industrial crystallization, which was based on an invited lecture at a materials research conference.

42. R. Gunawan, D. L. Ma, M. Fujiwara, and R. D. Braatz. Identification of kinetic parameters in a multidimensional crystallization process. *Special Issue on Crystallization and Interfacial Processes*, *Int. J. of Modern Physics B*, 16:367-374, 2002.

The first time that laser backscattering and ATR-FTIR spectroscopy were used to identify the kinetic parameters for any crystallization process, and the first time that the kinetic parameters were identified for a batch crystallization process in which the crystals have more than one independent length scale.

43. D. L. Ma, D. Tafti, and R. D. Braatz. Compartmental modeling of multidimensional crystallization. *Special Issue on Crystallization and Interfacial Processes*, *Int. J. of Modern Physics B*, 16:383-390, 2002.

First paper to simulate the effects of imperfect mixing on both the size and shape distribution of crystals produced by solution crystallization (used a parallel implementation of high resolution algorithms).

44. D. L. Ma, D. K. Tafti, and R. D. Braatz. High-resolution simulation of multidimensional crystal growth. *Special Issue in Honor of William R. Schowalter*, *Ind. Eng. Chem. Res.*, 41:6217-6223, 2002 (invited).

Extended high resolution algorithms used in the astrophysics and aerodynamics communities for the solution of hyperbolic partial differential equations to population balance equations, and showed that the resulting algorithms are more than an order-of-magnitude more computationally efficient than the vast majority of PBE algorithms published by the PBE community.

45. D. L. Ma, D. K. Tafti, and R. D. Braatz. Optimal control and simulation of multidimensional crystallization processes. *Special Issue on Distributed Parameter Systems*, *Comput. Chem. Eng.*, 26:1103-1116, 2002 (invited).

Used parallel programming to investigate the effects of nonideal mixing on optimal control policies for batch crystallizers. One of the results is that the performance objective used in most optimal control studies of industrial crystallizers (maximize weight mean size) gives poor filtration characteristics.

46. S. Ang and R. D. Braatz. Experimental projects for the process control laboratory. *Chem. Eng. Edu*., 36:182-187, 2002. Invited reprint in *CACHE News*, Volume 55, Fall, 2002.

An overview of the undergraduate process control laboratory at UIUC.

47. T. Togkalidou, H.-H. Tung, Y. Sun, A. Andrews, and R. D. Braatz. Solution concentration prediction for pharmaceutical crystallization processes using robust chemometrics and ATR FTIR spectroscopy. *Org. Process Res. Dev.*, 6:317-322, 2002.

First successful application of ATR-FTIR spectroscopy to measure solution concentrations for a pharmaceutical crystallization with more than two species, which was for a Merck pharmaceutical in a mixture of three solvents. The calibration method quickly migrated throughout Merck and Schering Plough (e.g., as described in *Org. Proc. Res. Dev.*, 8:488-494, 2004).

48. M. Fujiwara, P. S. Chow, D. L. Ma, and R. D. Braatz. Paracetamol crystallization using laser backscattering and ATR-FTIR spectroscopy: Metastability, agglomeration, and control. *Crystal Growth & Design*, 2:363-370, 2002. **~350+ citations**

Described how laser backscattering and ATR-FTIR spectroscopy could be used to design nearly-optimal control policies for batch crystallizers, and demonstrated the approach through application to a challenging crystallization. The approach received the attention of the U.S. Food and Drug Administration (e.g., as discussed by FDA staff in *Advanced Drug Delivery Reviews*, 56:349-369, 2004) and many pharmaceutical companies (including Schering Plough as described in *Org. Proc. Res. Dev.*, 8:488-494, 2004).

49. D. L. Ma, J. G. VanAntwerp, M. Hovd, and R. D. Braatz. Quantifying the potential benefits of constrained control for a large scale system. *Special Section on Cross Directional Control*, *IEE Proceedings - Control Theory and Applications*, 149:423-432, 2002.

Used a combination of operator theory and optimization theory to derive conditions to determine whether a process would benefit significantly from the use of a constrained control algorithms (such as MPC). These were the first conditions that take into account the effects of measurement noise, disturbances, model uncertainties, plant directionality, and quantity of experimental data, and the conditions are computable for systems with thousands of inputs and outputs.

50. R. D. Braatz. Advanced control of crystallization processes. *Annual Reviews in Control*, 26:87-99, 2002 (invited). **300+ citations**

Reviewed advances in sensors, simulation, and control for crystallization processes, focusing on the period since the previous major review (1993-2001).

51. M. Fujiwara, J. C. Pirkle, Jr., T. Togkalidou, D. L. Ma, R. Gunawan, and R. D. Braatz. A holistic approach to materials process design. *J. of Materials Edu.*, 24:65-70, 2002 (invited).

Described an experimental laboratory and course materials to teach students how to design materials processes.

52. L. H. Chiang and R. D. Braatz. Process monitoring using causal map and multivariate statistics: Fault detection and identification. *Chemom. Int. Lab. Syst.*, 65:159-178, 2003.

Showed how a causal map could be incorporated into data-driven methods to detect and identify known, unknown, and multiple faults, without requiring extensive modeling effort.

53. J. C. Pirkle, Jr. and R. D. Braatz. Dynamic modeling of blown film extrusion. *Polymer Engineering & Science*, 43:398-418, 2003.

First comprehensive nonlinear dynamic analysis of flow instabilities in blown film extruders, which was based on first-principles models including a polymer crystallization constitutive equation. The paper showed that most of the boundary conditions used in previous simulation models can give qualitatively and quantitatively incorrect results.

54. M. Hovd, D. L. Ma, and R. D. Braatz. On the computation of disturbance rejection measures. *Ind. Eng. Chem. Res.*, 42:2183-2188, 2003. Reprinted in *Modeling, Identification, and Control*, 25:45-56, 2004.

Derived numerical algorithms to compute some disturbance rejection measures posed by Skogestad in the early 1990s.

55. D. L. Ma and R. D. Braatz. Robust identification and control of batch processes. *Special Issue on 2nd Pan American Workshop in Process Systems Engineering*, *Comput. Chem. Eng.*, 27:1175-1184, 2003 (invited).

Described the first approach for the robust identification and control of batch and semibatch processes, which applies to systems with nonlinearities, unstable zero dynamics, disturbances, measurement noise, time delays, and general uncertainty descriptions.

56. Z. K. Nagy and R. D. Braatz. Robust nonlinear model predictive control of batch processes. *AIChE J.*, 49:1776-1786, 2003. Reprinted in Part C of the PSE Virtual Issue of AIChE Journal, as one of the most cited papers in the journal on *Process Identification, State Estimation and Control*. **350+ citations**

The first robust batch MPC algorithm that is nonconservative, computable, and applicable to general nonlinear distributed parameter systems with realistic uncertainty descriptions.

57. R. Gunawan, M. Y. L. Jung, E. G. Seebauer, and R. D. Braatz. Maximum a posteriori estimation of transient enhanced diffusion energetics. *AIChE J.*, 49:2114-2123, 2003.

Applied maximum a posteriori estimation of the energetics in transient enhanced diffusion based on prior information from Paper 61 and after-anneal boron profiles measured using secondary ion mass spectroscopy at International Sematech.

58. Z. K. Nagy and R. D. Braatz. Worst-case and distributional robustness analysis of finite-time control trajectories for nonlinear distributed parameter systems. *IEEE Trans. on Control Syst. Tech.*, 11:694-704, 2003.

First application of the distributional robustness approach to analyze the effects of uncertainties on the time evolution of particle size distributions. The worst-case and distributional approaches apply to general smooth systems (that is, including systems with distributed state variables, nonlinearities, unstable zero dynamics, time delays, stochastic measurement noise, uncertainties, and disturbances of general location modeled as hard bounds or stochastically, etc.). Received the IEEE TCST Outstanding Paper Award.

59. T. O. Drews, R. D. Braatz, and R. C. Alkire. Parameter sensitivity analysis of Monte Carlo simulations of copper electrodeposition with multiple additives. *J. Electrochem. Soc.*, 150:C807-C812, 2003.

First algorithm for computing optimal parameter sensitivity estimates for stochastic simulation codes, with application to the kinetic Monte Carlo simulation of copper electrodeposition with multiple additives.

60. R. Gunawan, M. Y. L. Jung, R. D. Braatz, and E. G. Seebauer. Parameter sensitivity analysis applied to modeling transient enhanced diffusion and activation of boron in silicon. *J. Electrochem. Soc.*, 150:G758-G765, 2003.

Applied parameter sensitivity analysis and maximum likelihood estimation to construct first-principles simulation models of transient enhanced diffusion and activation of boron in silicon during post-implant annealing, based on density functional theory calculations and focused experiments reported in the literature.

61. M. Y. L. Jung, R. Gunawan, R. D. Braatz, and E. G. Seebauer. Ramp-rate effects in transient enhanced diffusion and dopant activation. *J. Electrochem. Soc.*, 150:G838-G842, 2003.

Derived an explanation for the effect of high ramp rates in rapid thermal annealing in terms of interactions between cluster dissociation, silicon interstitial concentrations, and profile spreading.

62. E. J. Hukkanen and R. D. Braatz. Measurement of particle size distribution in suspension polymerization using in situ laser backscattering. *Sensors & Actuators B*, 96:451-459, 2003.

Derived and applied the world's most accurate algorithm for estimating the particle size distribution from in situ laser backscattering data, based on geometric inverse modeling and optimization, which accounts for data nonidealities including measurement noise, surface roughness, and binning effects.

63. T. J. McAvoy and R. D. Braatz. Controllability limitations for processes with large singular values. *Ind. Eng. Chem. Res.*, 42:6155-6165, 2003.

Showed that the closed-loop control of processes with a large maximum singular value can result in poor transient performance as a result of valve accuracy considerations. This is the first paper to show that controllability issues can arise from *large* maximum singular values.

64. K. Dev, M. Y. L. Jung, R. Gunawan, R. D. Braatz, and E. G. Seebauer. Mechanism for coupling between properties of interfaces and bulk semiconductors. *Phys. Rev. B*, 68:195311, 2003.

Described a mechanism by which interface electronic properties affect dopant concentration profiles deep within the bulk semiconductor.

65. M. Kamrunnahar, R. D. Braatz, and R. C. Alkire. Parameter sensitivity analysis of pit initiation at single sulfide inclusions in stainless steel. *J. Electrochem. Soc*., 151:B90-B97, 2004.

Investigated the relationships between physicochemical parameters and the potential and concentration distributions for corrosion pit initiation.

66. M. Y. L. Jung, R. Gunawan, R. D. Braatz, and E. G. Seebauer. A simplified picture for transient enhanced diffusion of boron in silicon. *J. Electrochem. Soc.*, 151:G1-G7, 2004.

Derived an analytical model for post-implant annealing able to (1) predict the temperature at which transient enhanced diffusion begins to occur and (2) estimate the distance that the junction deepens as a function of initial cluster concentrations.

67. Z. K. Nagy and R. D. Braatz. Open-loop and closed-loop robust optimal control of batch processes using distributional and worst-case analysis. *Journal of Process Control*, 14:411-422, 2004. **250+ citations**

The first fixed-feedback batch control algorithm that is nonconservative, computable, and applicable to general nonlinear distributed parameter systems with realistic uncertainty descriptions.

68. R. Gunawan, M. Y. L. Jung, E. G. Seebauer, and R. D. Braatz. Optimal control of rapid thermal annealing in a semiconductor process. *Journal of Process Control*, 14:423-430, 2004.

First model-based computation of the optimal temperature profile in rapid thermal annealing (RTA), and first quantification of the effects of model uncertainties and control implementation inaccuracies for a semiconductor process. The robustness analysis indicated how much improvement in junction depth and boron activation uniformity can be achieved through improved metrology and RTA controller design.

69. M. Hovd and R. D. Braatz. Handling state and output constraints in MPC using time-dependent weights. *Modeling, Identification, and Control*, 25:67-84, 2004.

Showed that suitably-designed time-dependent weights on the penalty terms associated with state and output constraints results in vastly improved closed-loop performance for processes with nonminimum phase zeros.

70. M. Y. L. Jung, R. Gunawan, R. D. Braatz, and E. G. Seebauer. Effect of near-surface band bending on dopant profiles in ion-implanted silicon. *J. Appl. Phys.*, 95:1134-1139, 2004.

Used first-principles simulation models constructed from maximum a posteriori estimation to investigate the effects of band bending on dopant profiles that evolve during post-implant annealing, and to provide a mechanism to explain some conflicting observations for this process.

71. T. O. Drews, E. G. Webb, D. L. Ma, J. Alameda, R. D. Braatz, and R. C. Alkire. Coupled mesoscale-continuum simulations of copper electrodeposition in a trench. *AIChE J.*, 50:226-240, 2004.

Demonstrated that numerical instabilities could be suppressed and numerical accuracy improved by introducing low-pass filters (with small time constants) on information passed between dynamically coupled simulation codes.

72. J. G. VanAntwerp and R. D. Braatz. Discussion on design of cross-directional controllers with optimal steady-state performance. *European J. of Control*, 10:28-29, 2004 (invited).

Discussed theoretical generalizations to an anti-windup compensation scheme by Heath and Wills developed for sheet and film processes, and placed the paper in context with the literature on super-optimality and robust process control.

73. R. C. Alkire and R. D. Braatz. Electrochemical engineering in an age of discovery and innovation. *AIChE J.*, 50:2000-2007, 2004 (invited). **Cover article**.

Presented the accomplishments, recent advances, and future challenges in electrochemical engineering. One of the top 10 downloaded papers in *AIChE Journal* from January to September 2004 (downloaded 401 times in ~1 month).

74. E. Rusli, S. Ang, and R. D. Braatz. A quadruple tank process control experiment. *Chem. Eng. Edu.*, 38:171-181, 2004. Reprinted in *CACHE News*, 59, Fall 2004 (invited).

The first educational laboratory experiment that clearly demonstrates the extreme effects that time-varying dynamics can have on the controllability of the process.

75. J. C. Pirkle, Jr. and R. D. Braatz. Comparison of the dynamic thin shell and quasi-cylindrical models for blown film extrusion. *Polymer Engineering & Science*, 44:1267-1276, 2004.

Showed that the quasi-cylindrical model for blown film extrusion used by several researchers gives vastly different dynamic results than the dynamic thin shell model used by most researchers.

76. T. O. Drews, R. D. Braatz, and R. C. Alkire. Coarse-grained kinetic Monte Carlo simulation of copper electrodeposition with additives. *Int. J. Multiscale Computational Engineering*, 2:313-327, 2004.

The first atomic-scale and coarse-grained kinetic Monte Carlo simulation codes capable of simulating complex mechanisms consisting of both chemical and electrochemical reactions.

77. T. Togkalidou, H.-H. Tung, Y. Sun, A. Andrews, and R. D. Braatz. Parameter estimation and optimization of a loosely-bound aggregating pharmaceutical crystallization using in-situ infrared and laser backscattering measurements. *Ind. Eng. Chem. Res.*, 43:6168-6181, 2004.

The first application of model-based experimental design, parameter estimation, model selection, and optimization to the crystallization of a pharmaceutical, and the first application to a crystallization process that forms loosely-bound aggregates (this was a Merck pharmaceutical).

78. R. Gunawan, I. Fusman, and R. D. Braatz. High resolution algorithms for multidimensional population balance equations. *AIChE J.*, 50:2738-2749, 2004. **350+ citations**

A comprehensive simulation study with error analyses showed that high resolution finite volume algorithms adapted from compressible gas dynamics literature can improve the numerical accuracy with orders-of-magnitude lower computational cost than other finite difference and finite volume algorithms. This paper generalized the algorithm in Paper 24 to include size-dependent growth and improve the numerical accuracy for very small particles.

79. M. Y. L. Jung, R. Gunawan, R. D. Braatz, and E. G. Seebauer. Pair diffusion and kick-out: Contributions to diffusion of boron in silicon. *AIChE J.*, 50:3248-3256, 2004.

Stochastic robustness analysis applied to a first-principles model determined by maximum likelihood estimation indicated that lone interstitials are more likely to be the principal mobile species than B-Si complexes, during rapid thermal annealing in semiconductor device production.

80. E. Rusli, T. O. Drews, and R. D. Braatz. Systems analysis and design of dynamically coupled multiscale reactor simulation codes. *ISCRE Special Issue*, *Chem. Eng. Sci.*, 59:5607-5613, 2004.

The first paper to use control theory to gain insights into the numerical instabilities that can arise in multiscale simulation codes, as well as to design algorithms to suppress numerical stabilities and increase numerical accuracy. Nonlinear systems theory provided a constructive procedure for testing whether an arbitrary interconnection of simulation codes is well-posed.

81. R. D. Braatz, R. C. Alkire, T. O. Drews, and E. Rusli. Multiscale systems engineering with applications to chemical reaction processes. *ISCRE Special Issue*, *Chem. Eng. Sci.*, 59:5623-5628, 2004.

Defined the challenges and requirements associated with the design and control of multiscale systems, and described a systematic approach for addressing these problems using stochastic sensitivity analysis, Bayesian estimation applied to ab initio calculations and experimental data, model-based experimental design, hypothesis mechanism selection, and multi-step optimization.

82. H. An, J. W. Eheart, and R. D. Braatz. Stability-oriented programs for regulating water withdrawals in riparian regions. *Water Resources Research*, 40:W12301, 2004.

Investigated severe stream flow variability and instabilities that can arise from water withdrawal programs in riparian regions, and proposed the first techniques based on control theory for modifying the withdrawal programs to reduce stream flow variability.

83. M. Y. L. Jung, C. T. M. Kwok, R. D. Braatz, and E. G. Seebauer. Interstitial charge states in boron-implanted silicon. *J. Appl. Phys.*, 97:063520, 2005.

The interstitial charge states and ionization levels of boron and silicon during post-annealing were identified using a combination of experimental data and the first-principles model in Paper 57.

84. T. O. Drews, S. Krishnan, J. Alameda, D. Gannon, R. D. Braatz, and R. C. Alkire. Multi-scale simulations of copper electrodeposition onto a resistive substrate. *IBM J. Res. & Dev.*, 49:49-63, 2005.

Presented a multiscale simulation algorithm for simulating the surface roughness evolution during the electrodeposition of copper to form the initial seed layer across a resistive substrate, which consisted of multiple kinetic Monte Carlo codes coupled to one macroscopic finite difference code.

85. M. Fujiwara, Z. K. Nagy, J. W. Chew, and R. D. Braatz. First-principles and direct design approaches for the control of pharmaceutical crystallization. *Journal of Process Control*, 15:493-504, 2005 (invited). **400+ citations**

Received the *Journal of Process Control Prize Paper Award* for a survey for 2005-2008. Reviewed recent technological advances in the *in situ* control of pharmaceutical crystallization processes, and of future opportunities in polymorph control and protein crystallization.

86. C. T. M. Kwok, K. Dev, R. D. Braatz, and E. G. Seebauer. A method for quantifying annihilation rates of bulk point defects at surfaces. *J. Appl. Phys.*, 98:013524, 2005.

Identified the kinetics of annihilation of bulk point defects at silicon surfaces through a combination of D-optimal experimental design and maximum likelihood estimation applied to an experimental system that utilized multiple isotopes of silicon to increase resolution.

87. E. J. Hukkanen, J. A. Wieland, D. E. Leckband, A. Gewirth, and R. D. Braatz. Multiple-bond kinetics from single-molecule pulling experiments: Evidence of multiple NCAM bonds. *Biophysical J.*, 89:3434-3445, 2005.

Provided a systematic analysis of bond rupture kinetics for single protein bonds from bond breakage frequency distributions obtained from single-molecule pulling experiments. Application to AFM data from the neural cell adhesion molecule indicated that two spatially distinct bonds are formed between opposed proteins.

88. R. Vaidyanathan, M. Y. L. Jung, R. D. Braatz, and E. G. Seebauer. Measurement of defect-mediated diffusion: The case of silicon self-diffusion. *AIChE J.*, 52:366-370, 2006.

Measured the kinetics of defect-mediated diffusion through a combination of mathematical analysis and maximum likelihood estimation.

89. R. D. Braatz, R. C. Alkire, E. G. Seebauer, E. Rusli, R. Gunawan, T. O. Drews, and Y. He. Perspectives on the design and control of multiscale systems. *DYCOPS Special Issue*, *Journal of Process Control*, 16:193-204, 2006 (invited).

Received the *Journal of Process Control Prize Paper Award* for theory for 2005-2008. Discussed emerging techniques in *multiscale systems engineering*, which is the systematic design and control of systems whose length scales range from molecular to macroscopic.

90. E. Rusli, T. O. Drews, D. L. Ma, R. C. Alkire, and R. D. Braatz. Robust nonlinear feedback-feedforward control of a coupled kinetic Monte Carlo-finite difference simulation. *Journal of Process Control*, 16:409-417, 2006.

Designed robust feedforward-feedback controllers for a multiscale system that dynamically couples kinetic Monte Carlo (KMC) and finite difference (FD) simulation codes. The approach involved the identification of a low-order model with non-Gaussian stochastic variations that is averaged to compute a robust control with gain-scheduled filter.

91. G. X. Zhou, M. Fujiwara, X. Y. Woo, E. Rusli, H.-H. Tung, C. Starbuck, O. Davidson, Z. Ge, and R. D. Braatz. Direct design of pharmaceutical antisolvent crystallization through concentration control. *Crystal Growth & Design*, 6:892-898, 2006. **200+ citations**

Showed how to rapidly design nearly-optimal nonlinear state feedback control policies for batch antisolvent crystallizers by using laser backscattering and ATR-FTIR spectroscopy, and demonstrated the approach through application to a pharmaceutical crystallization at Merck.

92. T. O. Drews, A. Radisic, J. Erlebacher, R. D. Braatz, P. C. Searson, and R. C. Alkire. Stochastic simulation of the early stages of kinetically limited electrodeposition. *J. Electrochem. Soc.*, 153:C434-C441, 2006.

Simulated nucleation and the early stages of growth during metal electrodeposition by the kinetic Monte Carlo method, to investigate the effects of the overpotential and surface diffusion energetics on surface reaction and transport processes associated with surface morphology evolution.

93. X. Y. Woo, R. B. H. Tan, P. S. Chow, and R. D. Braatz. Simulation of mixing effects in antisolvent crystallization using a coupled CFD-PDF-PBE approach. *Crystal Growth & Design*, 6:1291-1303, 2006. **150+ citations**

Coupled turbulent computational fluid dynamics with population balance equations and micromixing models to simulate the effects of non-ideal mixing on the crystal size distribution during antisolvent crystallization.

94. R. D. Braatz, R. C. Alkire, E. G. Seebauer, T. O. Drews, E. Rusli, M. Karulkar, F. Xue, Y. Qin, M. Y. L. Jung, and R. Gunawan. A multiscale systems approach to microelectronic processes. *Special Issue on Chemical Process Control*, *Comput. Chem. Eng.*, 30:1643-1656, 2006 (invited).

Reviewed the progression of the semiconductor industry towards molecular and multiscale simulation, and how these simulation models can be coupled with multiscale systems tools to design processes that control events at the molecular scale while simultaneously optimizing all length scales from the molecular to the macroscopic. It is suggested that these tools enable nanoscale science and technology to move from an art to an engineering discipline.

95. E. G. Seebauer, K. Dev, M. Y. L. Jung, R. Vaidyanathan, C. T. M. Kwok, J. W. Ager, E. E. Haller, and R. D. Braatz. Control of defect concentrations within a semiconductor through adsorption. *Phys. Rev. Lett.*, 97:055503, 2006.

Showed how to control the concentrations of defects within bulk semiconductor by the controlled adsorption of gas on external surfaces.

96. N. Nair, M. L. Usrey, W.-J. Kim, R. D. Braatz, and M. S. Strano. Deconvolution of the photo-absorption spectrum of single-walled carbon nanotubes with (n,m) resolution. *Analytical Chemistry*, 78:7689-7696, 2006.

Developed an algorithm for determining the distribution of single-walled carbon nanotubes from an absorption spectrum to (n,m) resolution.

97. X. Zhang, M. Yu, C. T. M. Kwok, R. Vaidyanathan, R. D. Braatz, and E. G. Seebauer. Precursor mechanism for interaction of bulk interstitial atoms with Si(100). *Phys. Rev. B*, 74:235301, 2006.

Showed by modeling that the self-interstitial annihilation kinetics at the Si(100) surface are well described by a precursor mechanism in which the interstitials move substantial distances parallel to the surface before incorporation.

98. J. G. VanAntwerp, A. P. Featherstone, B. A. Ogunnaike, and R. D. Braatz. Cross-directional control of sheet and film processes. *Automatica*, 43:191-211, 2007.

Reviewed the field of profile control for sheet and film processes, focusing on major academic and industrial advances made in recent years.

99. X. Li, T. O. Drews, E. Rusli, F. Xue, Y. He, R. D. Braatz, and R. C. Alkire. Effect of additives on shape evolution during electrodeposition. Part I: Multiscale simulation with dynamically coupled kinetic Monte Carlo and moving-boundary finite-volume codes. *J. Electrochem. Soc.*, 154:D230-240, 2007. Correction *J. Electrochem. Soc.*, 154:S15, 2007.

Used multiple kinetic Monte Carlo simulations dynamically coupled with a moving boundary finite volume code to simulate the chemistry of additives during the electrodeposition of copper within a trench to form sub-micron interconnects.

100. Z. K. Nagy and R. D. Braatz. Distributional uncertainty analysis using power series and polynomial chaos expansions. *Special Issue on Advanced Control of Chemical Processes*, *Journal of Process Control*, 17:229-240, 2007. **200+ citations**

Provided an overview and comparison of computationally efficient approaches for computing the probability distribution functions for the states and outputs of finite-time nonlinear dynamical systems, along with recommendations on the selection of uncertainty analysis methods to use in the design of robust batch control systems.

101. E. Rusli, F. Xue, T. O. Drews, P. Vereecken, P. Andracacos, H. Deligianni, R. D. Braatz, and R. C. Alkire. Effect of additives on shape evolution during electrodeposition. Part II: Parameter estimation from roughness evolution experiments. *J. Electrochem. Soc*., 154:D584-D597, 2007.

Constructed a reaction mechanism for the additive-mediated electrodeposition of copper and identifies the kinetic parameters from current density and surface roughness measurements obtained by atomic force microscopy.

102. M. W. Hermanto, M.-S. Chiu, X. Y. Woo, and R. D. Braatz. Robust optimal control of polymorphic transformation in batch crystallization. *AIChE J.*, 53:2643-2650, 2007.

First paper to report optimal control of a polymorphic crystallization. A nonlinear state feedback controller designed to follow an optimal setpoint trajectory defined in the crystallization phase diagram simultaneously provided high batch productivity and robustness.

103. T. O. Drews, R. D. Braatz, and R. C. Alkire. Monte Carlo simulation of kinetically-limited electrodeposition on a surface with metal seed clusters. *Special Issue in honor of Dieter Kolb*, *Z. Phys. Chem.*, 221:1287-1305, 2007.

The effects of the seed cluster spacing, applied potential, and metal-substrate surface diffusion energy barrier on the time-evolution of the surface morphology during the electrodeposition was thoroughly investigated.

104. J. G. VanAntwerp and R. D. Braatz. Discussion on GPC robust design using linear and/or bilinear matrix inequalities. *European J. of Control*, 13:468-472, 2007 (invited).

Discussed the formulation of robust optimal controller design problems in terms of optimizations with bilinear matrix inequality constraints and numerical algorithms for solving these optimizations to global optimality.

105. N. Nair, W.-J. Kim, R. D. Braatz, and M. S. Strano. Dynamics of surfactant-suspended single walled carbon nanotubes in a centrifugal field. *Langmuir*, 24:1790-1795, 2008.

Provided a high quality dynamic model for one of the most heavily used methods for the separation of single-walled carbon nanotubes.

106. Z. K. Nagy, J. W. Chew, M. Fujiwara, and R. D. Braatz. Comparative performance of concentration and temperature controlled batch crystallizations. *Festschrift honoring Prof. Dale Seborg*, *Journal of Process Control*, 18:399-407, 2008 (invited). **200+ citations**

Provided extensive simulation and experimental evidence that the concentration-control method in Paper 48 is much more robust to parameter variations and disturbances than the temperature-control method most commonly used in literature and in industry.

107. C. T. M. Kwok, K. Dev, E. G. Seebauer, and R. D. Braatz. Maximum a posteriori estimation of activation energies that control silicon self-diffusion. *Automatica*, 44:2241-2247, 2008.

Improved estimates for the energetics of interstitial cluster dynamics through a combination of Bayesian estimation and an optimal experimental design for the rapid thermal annealing of isotopically-labeled silicon.

108. Y. Qin, X. Li, F. Xue, P. Vereecken, P. Andricacos, H. Deligianni, R. D. Braatz, and R. C. Alkire. The effect of additives on shape evolution during copper electrodeposition. Part III. Trench infill for on-chip interconnects. *J. Electrochem. Soc*., 155:D223-233, 2008.

Extensive validation and analysis of a model for describing the effect of additives as suppressors (PEG, Cl), accelerator (SPS), and inhibitor (HIT) on copper electrodeposition during the formation of on-chip interconnects.

109. Z. K. Nagy, M. Fujiwara, X. Y. Woo, and R. D. Braatz. Determination of the kinetic parameters for the crystallization of paracetamol from water using metastable zone width experiments. *Ind. Eng. Chem. Res.*, 47:1245-1252, 2008.

Developed a new approach for the estimation of crystallization kinetics from metastable zone experiments, by using a combination of population balance models, ATR-FTIR spectroscopy, and laser backscattering, and showed that past methods can result in large errors in the nucleation kinetics.

110. Z. Zheng, R. Stephens, R. D. Braatz, R. C. Alkire, and L. R. Petzold. A hybrid multiscale kinetic Monte Carlo method for simulation of copper electrodeposition. *J. Comput. Phys.*, 227:5184-5199, 2008.

Developed a computationally-efficient algorithm for the stochastic simulation of heterogeneous reactions that are highly stiff (have with many orders-of-magnitude variation in kinetic constants).

111. R. Gunawan, I. Fusman, and R. D. Braatz. Parallel high resolution finite-volume simulation of particulate processes. *AIChE J.*, 54:1449-1458, 2008.

Derived and implemented a high resolution algorithm for general population balance models that has nearly perfect processor scaling, resulting in 70× reduction in runtime for simulations of aerosol coagulation and gold nanoparticle formulation processes.

112. Z. K. Nagy, M. Fujiwara, and R. D. Braatz, Modelling and control of combined cooling and antisolvent crystallization processes. *Special Issue on Dynamics and Control of Process Systems*. *Journal of Process Control*, 18:856-864, 2008 (invited). **200+ citations**

First paper to derive a model-based optimal control algorithm that utilizes both cooling and antisolvent addition during the crystallization of pharmaceuticals; the approach gives significantly improved size distribution for the crystallization of lovastatin (a cholesterol-lowering drug).

113. M. W. Hermanto, N. C. Kee, R. B. H. Tan, M.-S. Chiu, and R. D. Braatz. Robust Bayesian estimation of the kinetics of the polymorphic crystallization of L-glutamic acid crystals. *AIChE J.*, 54:3248-3259, 2008.

Provided the first complete kinetic model for the polymorphic transformation of a solution crystallization process.

114. N. C. S. Kee, X. Y. Woo, L. M. Goh, E. Rusli, G. He, V. Bhamidi, R. B. H. Tan, P. J. A. Kenis, C. F. Zukoski, and R. D. Braatz. Design of crystallization processes from laboratory research and development to the manufacturing scale: Part I. *Am. Pharm. Rev.*, 11(6):110-115, 2008 (invited).
115. N. C. S. Kee, X. Y. Woo, L. M. Goh, E. Rusli, G. He, V. Bhamidi, R. B. H. Tan, P. J. A. Kenis, C. F. Zukoski, and R. D. Braatz. Design of crystallization processes from laboratory research and development to the manufacturing scale. Part II. *Am. Pharm. Rev.*, 11(7):66-74, 2008 (invited).

An overview of advances in the past five years on the development of process analytical technology for pharmaceutical crystallization processes, that includes experimental verification of the use of concentration control for selective growth of polymorphic crystals.

116. X. Y. Woo, R. B. H. Tan, and R. D. Braatz. Modeling and computational fluid dynamics-population balance equation-micromixing simulation of impinging jet crystallizers. *Crystal Growth & Design*, 9:156-164, 2009.

First paper to report the simulation of crystal nucleation and growth in impinging jet crystallizers that includes macromixing, micromixing, and the full population balance equation. Simulation results agreed

well with experimental data for lovastatin and the selective crystallization of polymorphs of L-histidine were investigated.

117. X. Y. Woo, Z. K. Nagy, R. B. H. Tan, and R. D. Braatz. Adaptive concentration control of cooling and antisolvent crystallization with laser backscattering measurement. *Crystal Growth & Design*, 9:182-191, 2009.

An adaptive concentration control strategy is proposed that employs measurement of the number of particle counts/sec provided by in situ laser backscattering, to detect the onset of nucleation and adapt the operating curve accordingly, further enhancing the robustness of the concentration control approach. Simulation and experimental results indicate that adaptive concentration control is robust to variations in the nucleation, growth, or dissolution rates due to scale-up or other changes in the process conditions.

118. M. W. Hermanto, R. D. Braatz, and M.-S. Chiu. High-order simulation of polymorphic crystallization using weighted essentially non-oscillatory methods. *AIChE J.*, 55:122-131, 2009.

First paper to report the simulation of population balance models using weighted essentially non-oscillatory methods. Simulation results suggest that these methods have superior numerical accuracy compared to other finite difference or finite volume methods when the particle size distributions are sharp or discontinuous.

119. C. T. M. Kwok, R. D. Braatz, S. Paul, W. Lerch, and E. G. Seebauer. Mechanistic benefits of millisecond annealing for diffusion and activation of boron in silicon. *J. Appl. Phys.*, 105:063514, 2009.

Numerical simulation and analytical modeling are used to explain the benefits of laser and flash annealing in activating boron and eliminating implantation-induced damage after ion implantation for transistor junction formation in silicon.

120. N. C. S. Kee, R. B. H. Tan, and R. D. Braatz. Selective crystallization of the metastable alpha-form of L-glutamic acid using concentration feedback control. *Crystal Growth & Design*, 9:3044-3051, 2009.

Experimental demonstration of the selective growth of large metastable crystals for a monotropic system, by application of robust nonlinear control.

121. N. C. S. Kee, P. D. Arendt, R. B. H. Tan, and R. D. Braatz. Selective crystallization of the metastable anhydrate form in the enantiotropic pseudo-dimorph system of L-phenylalanine using concentration feedback control. *Crystal Growth & Design*, 9:3052-3061, 2009.

Experimental demonstration of the selective growth of large metastable anhydrate crystals for an enantiotropic system, by application of robust nonlinear control.

122. M. W. Hermanto, M.-S. Chiu, and R. D. Braatz. Nonlinear model predictive control for the polymorphic crystallization of L-glutamic acid crystals. *AIChE J.*, 55:2631-2645, 2009.

The first nonlinear model predictive control strategy is developed for polymorphic transformation and shown to have high robustness to model uncertainties.

123. T. Jin, Y. Ito, X. Luan, S. Dangaria, C. Walker, M. Allen, A. Kulkarni, C. Gibson, R. Braatz, X. Liao, and T. Diekwisch. Elongated polyproline motifs facilitate enamel evolution through matrix subunit compaction. *PLoS Biology*, 7(12):e1000262, 2009.

The Braatz contribution was to suggest possible explanations for the dramatic compaction of polypeptide supramolecular assemblies compared to aggregates of shorter polypeptides, based on molecular simulations. The likely explanations were an increase in van der Waals attraction due to similar hydrophobicity and larger surface area, and a reduction in Brownian motion.

124. K. Chen, R. Vaidyanathan, E. G. Seebauer, and R. D. Braatz. General expression for effective diffusivity of foreign atoms migrating via a fast intermediate, *J. Appl. Phys*., 107:026101, 2010.

An exact general analytical expression is derived for the effective diffusivity of dopants that migrate via a highly mobile intermediate species.

125. C. T. M. Kwok, R. D. Braatz, S. Paul, W. Lerch, and E. G. Seebauer. An improved model for boron diffusion and activation in silicon. *AIChE J.*, 56:515-521, 2010.

A mathematical model for dopant diffusion is proposed that includes defect annihilation at surfaces, effects of near-surface band bending, and an improved representation of interstitial clustering. The model yields a substantially improved ability to predict behavior of implanted boron over a wide range of annealing conditions.

126. J. C. Pirkle, Jr. and R. D. Braatz. A thin-shell two-phase microstructural model for blown film extrusion. *J. of Rheology*, 54:471-505, 2010.

A thin-shell model for blown film extrusion is presented that combines dynamic equations for momentum conservation, a two-phase microstructural constitutive relation for flow-enhanced crystallization, viscoelasticity, and bubble-tube cooling. *One of the top 10 downloaded articles in the Journal of Rheology during the month of May 2010.*

127. V. R. Subramanian and R. D. Braatz. Current needs in electrochemical engineering education. *Electrochemical Society Interface*, 19(1):37-38, 2010 (invited).

Provides perspectives on how electrochemical engineering education should change in the immediate future to best adapt to changes in the energy field.

128. L. M. Goh, K. J. Chen, V. Bhamidi, G. He, N. C. S. Kee, P. J. A. Kenis, C. F. Zukoski, and R. D. Braatz. A stochastic model for nucleation kinetics determination in droplet-based microfluidic systems. *Crystal Growth & Design*, 10:2515-2521, 2010.

The Chemical Master equation is presented and solved analytically for characterizing homogeneous or heterogeneous nucleation in droplet-based microfluidic systems. The analytical expressions are used to determine nucleation kinetics from induction times measured for paracetamol and lysozyme at high supersaturation in an evaporation-based high-throughput crystallization platform.

129. J. C. Pirkle, Jr., M. Fujiwara, and R. D. Braatz. A maximum-likelihood parameter estimation for the thin-shell quasi-Newtonian model for a laboratory blown film extruder. *Special Issue in Honor of Thomas Edgar*, *Ind. Eng. Chem. Res.*, 47:8007-8015, 2010.

Determined maximum-likelihood parameter estimates from measured spatial radii and temperature profiles for a laboratory-scale blown film process extruding a linear low density polyethylene (LLDPE) polymer. The nonlinear distributed parameter model included non-Newtonian fluid mechanics, crystallization, and nonuniform heat transfer.

130. M. Kishida and R. D. Braatz. Worst-case analysis of distributed parameter systems with application to the 2D reaction-diffusion equation. *Special Issue on Optimal Process Control*, *Optimal Control Applications & Methods*, 31:433-449, 2010 (invited).

Designed polynomial-time algorithms for computing tight bounds on the worst-case maximum deviations in a spatial field due to parametric uncertainties and applied the algorithms to the optimal control of a 2D system with chemical reaction and diffusion.

131. K. Chen, N. Nair, M. S. Strano, and R. D. Braatz. Identification for chirality-dependent adsorption kinetics in single-walled carbon nanotube reaction networks. *Special Issue on Nanoscale Simulation of Molecular and Biological Systems*, *J. of Computational & Theoretical Nanoscience*, 7:2581-2585, 2010 (invited).

A computationally efficient numerical algorithm is derived for determining chirality-dependent adsorption rate constants for single-walled carbon nanotubes.

132. V. Ramadesigan, R. N. Methekar, V. R. Subramanian, F. Latinwo, and R. D. Braatz. Optimal porosity distribution for minimized Ohmic drop across a porous electrode. *J. Electrochem. Soc.*, 157:A1328-A1334, 2010.

Designed an algorithm for the optimization of the spatial variation of microstructure within a porous electrode for a lithium-ion battery.

133. M. W. Hermanto, R. D. Braatz, and M.-S. Chiu. Integrated batch-to-batch and nonlinear model predictive control for polymorphic crystallization in pharmaceutical crystallization. *AIChE J.*, 57:1008-1019, 2011.

Designed a nonlinear model predictive control algorithm that accounts for within-batch and batch-to-batch variations for a polymorphic pharmaceutical crystallization.

134. N. C. S. Kee, R. B. H. Tan, and R. D. Braatz. Semiautomated identification of the phase diagram for enantiotropic crystallizations using ATR-FTIR spectroscopy and laser backscattering. *Special Issue in Honor of C. C. Yu*, *Ind. Eng. Chem. Res*., 50:1488-1495, 2011 (invited).

A semi-automated procedure was developed and implemented for measuring the phase diagram in a dimorphic crystallization using ATR-FTIR spectroscopy and laser backscattering.

135. N. C. S. Kee, P. D. Arendt, L. M. Goh, R. B. H. Tan, and R. D. Braatz. Nucleation and growth kinetics estimation for *L*-phenylalanine hydrate and anhydrate crystallization. *CrystEngComm*, 13:1197-1209, 2011 (invited).

An efficient experimental design and model identification procedure for an enantiotropic crystallization was developed that utilizes feedback control and staged experiments.

136. X. Y. Woo, R. B. H. Tan, and R. D. Braatz. Precise tailoring of the crystal size distribution by controlled growth and continuous seeding from impinging jet crystallizers. *CrystEngComm*, 13:2006-2014, 2011 (invited).

Optimal control strategies are proposed to manufacture crystals with a targeted size distribution by combining controlled seeding by impinging jet crystallization with a batch crystallizer operating at a controlled growth rate.

137. J. C. Pirkle, Jr. and R. D. Braatz. Instabilities and multiplicities in non-isothermal blown film extrusion including the effects of crystallization. *Special Issue in Honor of Thomas McAvoy*, *Journal of Process Control*, 21:405-414, 2011 (invited).

Stable operating regions and multiple steady-states are investigated for blown film extrusion that includes the effect of crystallization on the rheological properties of the polymer.

138. R. N. Methekar, P. W. C. Northrup, K. Chen, R. D. Braatz, and V. R. Subramanian. Kinetic Monte Carlo simulation of surface heterogeneity in graphite electrodes for lithium-ion batteries: Passive layer formation. *J. Electrochem. Soc.*, 158:A363-A370, 2011.

Molecular simulation of passive layer formation and capacity fade for graphite electrodes in lithium-ion batteries.

139. V. Ramadesigan, V. Boovaragavan, M. Arabandi, N. A. Burns, K. Chen, R. D. Braatz, and V. R. Subramanian. Parameter estimation and capacity fade analysis of lithium-ion batteries using reformulated models. *J. Electrochem. Soc.*, 158:A1048-A1054, 2011. **250+ citations**

The paper demonstrates the accurate prediction of battery lifetime from the voltage-discharge curves obtained during the initial charge-discharge cycles.

140. Z. W. Ulissi, J. Zhang, A. A. Boghossian, N. F. Reuel, S. F. E. Shimizu, R. D. Braatz, and M. S. Strano. Applicability of birth-death Markov modeling for single molecule counting using single-walled carbon nanotube fluorescent sensor arrays. *J. Phys. Chem. Lett.*, 2:1690-1694, 2011.

An exact solution of a Chemical Master equation enables the efficient unbiased estimation of the local concentration of nitric oxide from single-molecule adsorption and desorption events detected by near-infrared fluorescence of DNA-wrapped single-walled carbon nanotubes.

141. A. A. Boghossian, J. Zhang, F. T. Le Floch, Z. W. Ulissi, P. Bojo, J.-H. Han, J.-H. Kim, J. R. Arkalgud, N. F. Reuel, R. D. Braatz, and M. S. Strano. The chemical dynamics of nanosensors capable of single molecule detection. *J. Chem. Phys.*, 135:art no. 084124, 2011.

Approaches are compared for the optimal estimation of kinetics from the measurement of single-molecule adsorption and desorption events on single-walled carbon nanotubes via stochastic quenching.

142. V. Ramadesigan, P. W. C. Northrop, S. De, S. Santhanagopalan, R. D. Braatz, V. R. Subramanian. Modeling and simulation of lithium-ion batteries from a systems engineering perspective. *J. Electrochem. Soc.*, 159:R31-R45, 2012. **900+ citations**

Molecular, macroscopic, and multiscale modeling and design of lithium-ion batteries are reviewed, with a discussion of promising research directions.

143. Z. K. Nagy and R. D. Braatz. Advances and new directions in crystallization control. *Annu. Rev. Chem. Biomol. Eng.*, 3:55-75, 2012 (invited). **350+ citations**

A critical review of the crystallization control field, which describes advances in universities and industry and points to future advances expected to occur in crystallization systems and control technologies.

144. K. K. K. Kim, E. Rios-Patron, and R. D. Braatz. Robust nonlinear internal model control of Wiener systems. *Special Issue in Honor of Kenneth Muske*, *Journal of Process Control*, 22:1468-1477, 2012 (invited).

A demonstration of a polynomial-time algorithm for computing robust nonlinear controllers for Wiener systems that is directly generalizable to Hammerstein and sandwich systems.

145. M. Jiang, M. H. Wong, Z. Zhu, J. Zhang, L. Zhou, K. Wang, A. N. Ford Versypt, T. Si, L. M. Hasenberg, Y.-E. Li, and R. D. Braatz. Towards achieving a flattop crystal size distribution by continuous seeding and controlled growth. *Chem. Eng. Sci.*, 77:2-9, 2012.

For the first time, highly uniform crystals are generated by combining hot and cold saturated solutions in a dual impinging jet mixer. The mixer is used to generate continuous seed crystals that greatly enhance control of the crystal size distribution.

146. K. Chen, L. M. Goh, G.W. He, P. J. A. Kenis, C. F. Zukoski, and R. D. Braatz. Identification of nucleation rates in droplet-based microfluidic systems. *Chem. Eng. Sci.*, 77:235-241, 2012.

An approach utilizing microfluidic systems is proposed for estimating the nucleation rates at high supersaturations needed for the first-principles modeling of dual-impinging-jet and vortex-mixer crystallizers.

147. L. Goh, M. Kishida, and R. D. Braatz. On the analysis of robust stability of metabolic pathways. *IEEE Control Systems*, 32(4):92-94, 2012.

A metabolic pathway is constructed that shows that a proposed method for the analysis of the robust stability analysis of metabolic networks can produce misleading results.

148. Z. W. Ulissi, M. S. Strano, and R. D. Braatz. Control of nano and microchemical systems. *Special Issue on Chemical Process Control*, *Comput. Chem. Eng.*, 51:149-156, 2013 (invited). CACE Most Downloaded Articles, September 2012 – August 2013.

Strategies for the control of nano and microchemical systems are reviewed that include (1) exploiting structure within the stochastic equations that describe molecular interactions, (2) manipulating molecular bonds at system boundaries, and (3) manipulating molecules and nanoscale objects through external magnetic and electric fields.

149. M. Kishida, A. N. Ford Versypt, D. W. Pack, and R. D. Braatz. Optimal control of one-dimensional cellular uptake in tissue engineering. *Optimal Control Applications & Methods*, 34:680-695, 2013.

A control problem motivated by tissue engineering is formulated and solved to control the uptake of growth factors (signaling molecules) to spatially and temporally regulate cellular processes for the desired growth or regeneration of a tissue.

150. L. Zhou, M. Su, B. Benyahia, A. Singh, P. I. Barton, B. L. Trout, A. S. Myerson, and R. D. Braatz. Mathematical modeling and design of layer crystallization in a concentric annulus with and without recirculation. *AIChE Journal*, 59:1308-1321, 2013.

A mathematical model is presented for novel layer crystallization in a concentric annulus with recirculation.

151. E. P. Chang, R. D. Braatz, and T. A. Hatton. Pervaporation of emulsion droplets for the templated assembly of spherical particles: A population balance model. *AIChE Journal*, 59:3975-3985, 2013.

A membrane emulsification and pervaporation approach is proposed for the manufacture of uniform nanoparticles, and a three-dimensional population balance model is developed that is used to gain insights into operations and design.

152. K.-K. K. Kim and R. D. Braatz. Generalised polynomial chaos expansion approaches to approximate stochastic model predictive control. *MPC Special Issue*, *International Journal of Control*, 86:1324-1337, 2013.

Develops a computationally efficient model predictive control algorithm for dynamical systems subject to stochastic parametric uncertainties and exogenous disturbances.

153. M. L. Rasche and R. D. Braatz. The pitfalls of readily available solutions: Physically consistent global analysis of species transport from a spherical particle. *IEEE Control Systems*, 33(5):54-56, 2013. Reprinted in CACHE News, Winter 2018.

Provides an example in which the incorporation of physical understanding into global stability analysis of a partial differential equation reported correctly characterizes the stability while analysis based on naïve application of a reported analytical solution of the partial differential equations incorrectly characterizes the stability.

154. K.-K. K. Kim, D. E. Shen, Z. K. Nagy, and R. D. Braatz. Wiener's polynomial chaos for the analysis and control of nonlinear dynamical systems with probabilistic uncertainties. *IEEE Control Systems*, 33(5):58-67, 2013.

An introduction to polynomial chaos theory and its application to robust control.

155. M. Molaro and R. D. Braatz. Speeding up Matlab® programs by orders of magnitude. *IEEE Control Systems*, 33(6):135+, 2013.

156. S. Mascia, P. L. Heider, H. Zhang, R. Lakerveld, B. Benyahia, P. I. Barton, R. D. Braatz, C. L. Cooney, J. M. B. Evans, T. F. Jamison, K. F. Jensen, A. S. Myerson, and B. L. Trout. End-to-end continuous manufacturing of pharmaceuticals: Integrated synthesis, purification, and final dosage formation. *Angewandte Chemie*, 52(47):12359-12363, 2013. **Hot Paper. Research Highlight in *Nature***, 502:274, 2013 (doi:10.1038/502274d). **700+ citations**

Continuous manufacture of a finished drug product starting from chemical intermediates is reported. The continuous pilot-scale plant used a novel route incorporating many advantages available to continuous flow to produce API and drug product in one integrated system.

157. R. Lakerveld, B. Benyahia, R. D. Braatz, and P. I. Barton. Model-based design of a plant-wide control strategy for a continuous pharmaceutical plant. *AIChE Journal*, 59:3671-3685, 2013.

Designed a plant-wide control structure for an end-to-end continuous pharmaceutical pilot plant.

158. R. Lakerveld, B. Benyahia, P. L. Heider, H. Zhang, R. D. Braatz, and P. I. Barton. Averaging level control to reduce off-spec material in a continuous pharmaceutical pilot plant. *Processes*, 1:330-348, 2013.

Experimental demonstration of the superior performance of an optimal averaging control scheme over classical control for a continuous pharmaceutical pilot plant.

159. A. N. Ford Versypt, D. W. Pack, and R. D. Braatz. Mathematical modeling of drug delivery from autocatalytically degradable PLGA microspheres—A review. *Journal of Controlled Release*, 165:29-37, 2013. **~400 citations**

Reviews mechanistic models for drug release from PLGA microspheres that specifically address interactions between phenomena generally attributed to autocatalytic hydrolysis and mass transfer limitation effects.

160. M. Kishida, P. Rumschinski, R. Findeisen, and R. D. Braatz. Efficient polynomial-time outer bounds on state trajectories for uncertain polynomial systems using skewed structured singular values. *IEEE Trans. on Automatic Control*, 59:3063-3068, 2014.

A new approach is proposed for determining polynomial-time outer bounds on state trajectories for discrete-time polynomial systems with uncertain initial state and fixed and/or time-varying uncertain parameters and disturbances.

161. M. Kishida and R. D. Braatz. Skewed structured singular value-based approach for the construction of design spaces: Theory and applications. *IET Control Theory & Applications*, 8(14):1321-1327, 2014.

Numerical algorithms are proposed for the determination of sets of input parameters that ensure that product quality specifications are satisfied for lumped/distributed parameter, singular/descriptor, and multi-agent systems.

162. Q.-L. Su, R. D. Braatz, and M.-S. Chiu. Modeling and Bayesian parameter estimation for semibatch pH-shift reactive crystallization of L-glutamic acid. *AIChE Journal*, 60(8): 2828-2838, 2014.

The first mathematical model is developed for semi-batch pH-shift reactive crystallization that takes into account the effects of protonation and deprotonation in the species balance of glutamic acid, crystal size distribution, polymorphic crystallization, and non-ideal solution properties.

163. K.-K. K. Kim and R. D. Braatz. Observer-based output feedback control of discrete-time Luré systems with sector-bounded slope-restricted nonlinearities. *Int. J. of Robust & Nonlinear Control*, 24:2458-2472, 2014.

Two types of observer-based output feedback control design methods for Luré systems with sector-bounded slope-restricted nonlinearities are presented, compared, and analyzed with regard to robustness to model uncertainties and insensitivity to output disturbances.

164. K.-K. K. Kim, S. Skogestad, M. Morari, and R. D. Braatz. Necessary and sufficient conditions for robust reliable control in the presence of model uncertainties and system component failures. *Manfred Morari Special Issue*, *Comput. Chem. Eng.*, 70:67-77, 2014.

Necessary and sufficient conditions are derived for several forms of system reliability, for systems with and without uncertainties, in terms of structured singular values of certain transfer functions. Several existing results are shown to be either conservative or computationally expensive.

165. K.-K. K. Kim and R. D. Braatz. Computational complexity and related topics of robustness margin calculation using μ theory: A review of theoretical developments. *Manfred Morari Special Issue*, *Comput. Chem. Eng.*, 70:122-132, 2014.

Reviews results on the computational complexity of robust control problems, including less known results with broad implications, and discusses the most likely future directions in robust control.

166. K.-K. K. Kim, K. S. Cheong, K. Chen, and R. D. Braatz. Analysis of a synthetic gene switching motif: Systems and control approaches. *ADCHEM Special Issue*, *Journal of Process Control*, 24:341-347, 2014.

A nonlinear model for a synthetic gene switch involving two positive feedback loops is analyzed using a wide variety of systems and control approaches.

167. J. K. Scott, R. Findeisen, R. D. Braatz, and D. M. Raimondo. Input design for guaranteed fault diagnosis using zonotopes. *Automatica*, 50:1580-1589, 2014. **~200+ citations**

A set-based input design method is proposed for ensuring the detectability of faults in the outputs of a dynamical system subject to simultaneous or sequential faults, uncertainties in model parameters and initial conditions, actuator and state constraints, and bounded disturbances and measurement noise.

168. H. Jang, J. H. Lee, K.-K. K. Kim, and R. D. Braatz. Fast moving horizon estimation for a two-dimensional distributed parameter system. *Comput. Chem. Eng.*, 63:159-172, 2014.

Develops a moving horizon algorithm that estimates multidimensional state fields in real time.

169. A. N. Ford Versypt and R. D. Braatz. Analysis of finite difference discretization schemes for diffusion in spheres with variable diffusivity. *Comput. Chem. Eng.*, 71:241-252, 2014.

An algorithm is derived for the simulation of diffusion in spheres with general diffusivity dependencies that is much more accurate and numerically stable than past algorithms. These diffusion problems arise in the first-principles modelling of drug delivery from biodegradable polymeric microspheres.

170. X. Zhu, D. W. Pack, and R. D. Braatz. Modelling intravascular delivery from drug-eluting stents with biodurable coating: Investigation of anisotropic vascular drug diffusivity and arterial drug distribution. *Computer Methods in Biomechanics and Biomedical Engineering*, 17(3):187-198, 2014.

The mathematical modeling of the intravascular drug delivery of a hydrophobic drug from a medicated stent provides insights into how changes in the arterial tissue, stent parameters, and drug properties influence spatial uniformity in the arterial wall and provide guidance for designing medicated stents with improved efficacy.

171. J. Min, R. D. Braatz, and P. T. Hammond. Tunable staged release of therapeutics from layer-by-layer coatings with clay barrier interlayer. *Biomaterials*, 35(8), 2507-2517, 2014. **Ranked as Highly Cited Paper by ISI Web of Science in September 2016 as being in the top 1% in the field of materials science.**

A self-assembled polymer-based conformal coating for orthopedic implant applications is developed as a dual-purpose biomimetic implant surface that provides staggered and/or sustained release of an antibiotic followed by active growth factor.

172. Q.-L. Su, R. D. Braatz, and M.-S. Chiu. Concentration control for semi-batch pH-shift reactive crystallization of L-glutamic acid. *ADCHEM Special Issue*, *Journal of Process Control*, 24:415-421, 2014.

A just-in-time strategy is proposed for the control of pH-shift reactive crystallizations.

173. M. Jiang, X. Zhu, M. C. Molaro, M. L. Rasche, H. Zhang, K. Chadwick, D. M. Raimondo, K.-K. K. Kim, L. Zhou, Z. Zhu, M. H. Wong, D. O'Grady, D. Hebrault, J. Tedesco, and R. D. Braatz. Modification of crystal shape through deep temperature cycling. *David Himmelblau and Gary Powers Memorial Special Issue*, *Ind. Eng. Chem. Res.*, 53:5325-5336, 2014.

Constructed a population balance model for growth and dissolution along multiple crystal axes with high predictive value using data from a single well-designed dynamic experiment, and experimentally demonstrated that substantial changes in crystal shape can be acheived by a small number of well-designed temperature cycles.

174. B. Suthar, V. Ramadesigan, S. De, R. D. Braatz, and V. R. Subramanian. Optimal charging profiles for mechanically constrained lithium-ion batteries. *Physical Chemistry Chemical Physics*, 16:277-287, 2014.

Presents model-based strategies for optimally charging lithium-ion batteries while ensuring minimal mechanical damage to the electrode particles during intercalation.

175. X. Zhu and R. D. Braatz. Two-dimensional contribution map for fault identification. *IEEE Control Systems*, 33(5):72-77, 2014.

A 2D contribution map is described that enables a greater understanding of a fault and how its effects are propagated through a dynamical system.

176. M. Jiang, Z. Zhu, E. Jimenez, J. Xu, C. Papageorgiou, J. Waetzig, A. Hardy, and R. D. Braatz. Continuous-flow tubular crystallization in slugs spontaneously induced by hydrodynamics. *Crystal Growth & Design*, 14:851-860, 2014.

A continuous-flow crystallizer design is described that exploits intense mixing and a multiphase hydrodynamic flow instability to generate high-quality crystals in minutes, comparing to the hours required by traditional crystallizers.

177. A. Mesbah, A. N. Ford Versypt, X. Zhu, and R. D. Braatz. Nonlinear model-based control of thin-film drying for continuous pharmaceutical manufacturing. *John Congalidis Memorial Special Issue*, *Ind. Eng. Chem. Res.*, 53(18):7447-7460, 2014.

A first-principles model was developed and a control system designed for the startup of a thin-film drying process used in the continuous manufacturing of pharmaceutical tablets.

178. H. T. Zhang, R. Lakerveld, P. L. Heider, M. Y. Tao, M. Su, C. J. Testa, A. N. D'Antonio, P. I. Barton, R. D Braatz, B. L. Trout, A. S. Myerson, K. F. Jensen, and J. M. B. Evans. Application of continuous crystallization in an integrated continuous pharmaceutical pilot plant. *Crystal Growth & Design*, 14(5):2148-2157, 2014.

This paper describes the design and operation of a continuous reactive crystallization of aliskiren hemifumarate as part of an integrated continuous pharmaceutical pilot plant

179. X. Zhu and R. D. Braatz. Modeling and analysis of drug-eluting stents with biodegradable PLGA coating: Consequences on intravascular drug delivery. *Journal of Biomechanical Engineering*, 136(11):111004, 2014.

A mathematical model of drug delivery, distribution, and pharmacokinetics provides insights into the design and evaluation of biodegradable PLGA-coated drug-eluting stents for improved intravascular drug delivery.

180. P. W. C. Northrop, B. Suthar, V. Ramadesigan, S. Santhanagopalan, R. D. Braatz, and V. R. Subramanian. Efficient simulation of lithium-ion battery models for enabling electric transportation. *J. Electrochem. Soc.*, 161(8):E3149-E3157, 2014.

Review of battery management systems in electric vehicles, and the potential for the inclusion of first-principles models for providing enhanced estimation and control.

181. B. Suthar, P. W. C. Northrop, R. D. Braatz, and V. S. Subrahmanian. Optimal charging profiles with minimal intercalation-induced stresses for lithium-ion batteries using reformulated pseudo 2-dimensional models. *J. Electrochem. Soc.*, 161(11):F3144-F3155, 2014.

Optimal current profiles are determining for charging a lithium-ion battery by restricting the intercalation-induced stresses to a pre-determined limit estimated using porous electrode theory.

182. X. Zhu and R. D. Braatz. A mechanistic model for drug release in PLGA biodegradable stent coatings coupled with polymer degradation and erosion. *Journal of Biomedical Materials Research: Part A*, 103(7):2269-2279, 2015.

A mathematical model for polymer degradation and erosion and coupled drug release from a biodegradable drug-eluting stent is developed and validated.

183. I. R. Baxendale, R. D. Braatz, B. K. Hodnett, K. F. Jensen, M. D. Johnson, P. Sharratt, J.-P. Sherlock, and A. J. Florence. Achieving continuous manufacturing: Technologies and approaches for synthesis, work-up and isolation of drug substance. *Journal of Pharmaceutical Sciences*, 104(3):781-791, 2015. **200+ citations**

This white paper highlights current challenges and opportunities associated with continuous synthesis, workup, and crystallization of active pharmaceutical ingredients (drug substances).

184. A. S. Myerson, M. Krumme, M. Nasr, H. Thomas, and R. D. Braatz. Control systems engineering in continuous pharmaceutical processing. *Journal of Pharmaceutical Sciences*, 104(3):832-839, 2015.

This white paper provides a perspective of the challenges, research needs, and future directions for control systems engineering in continuous pharmaceutical processing.

185. B. Jiang, D. Huang, X. Zhu, F. Yang, and R. D. Braatz. Canonical variate analysis-based contributions for fault identification. *Journal of Process Control*, 26:17-25, 2015.

State-space identification methods are presented for the identification of process variables most strongly associated with faults that take dynamics and strong multivariable interactions into account.

186. J. A. Paulson, A. Mesbah, X. Zhu, M. C. Molaro, and R. D. Braatz. Control of self-assembly in micro- and nanoscale systems. *Journal of Process Control*, 27:38-49, 2015.

Reviews and provides an outlook on future directions in the control of self-assembling systems at the micro- and nanoscale.

187. B. Jiang, X. Zhu, D. Huang, J. A. Paulson, and R. D. Braatz. A combined canonical variate analysis and Fisher discriminant analysis (CVA-FDA) approach for fault diagnosis. *Comput. Chem. Eng.*, 77:1-9, 2015.

A computationally efficient fault diagnosis algorithm is proposed that improves discriminatory power by incorporating state-space identification to improve the handling of serial correlations in the data.

188. Y. Son, Q. H. Wang, J. Paulson, C.-J. Shih, A. Rajan, K. Tvrdy, S. Kim, B. Alfeeli, R. Braatz, and M. Strano. Layer number dependence of MoS_2 photoconductivity using photocurrent spectral atomic force microscopic imaging. *ACS Nano*, 9:2843-2855, 2015.

Photocurrent spectral atomic force microscopy is used to image the current with and without illumination generated between a biased PtIr tip and MoS_2 nanosheets.

189. L. L. Simon, H. Pataki, G. Marosi, F. Meemken, K. Hungerbühler, A. Baiker, S. Tummala, B. Glennon, M. Kuentz, G. Steele, H. J. M. Kramer, J. W. Rydzak, Z. Chen, J. Morris, F. Kjell, R. Singh, R. Gani, K. V. Gernaey, M. Louhi-Kultanen, J. O'Reilly, N. Sandler, O. Antikainen, J. Yliruusi, P. Frohberg, J. Ulrich, R. D. Braatz, T. Leyssens, M. von Stosch, R. Oliveira, R. B. H. Tan, H. Wu, M. Khan, D. O'Grady, A. Pandey, R. Westra, E. Delle-Case, D. Pape, D. Angelosante, Y. Maret, O. Steiger, M. Lenner, K. Abbou-Oucherif, Z. K. Nagy, J. D. Litster, V. K. Kamaraju, and M.-S. Chiu. Assessment of recent process analytical technology (PAT) trends: A multiauthor review. *Org. Process Res. Dev.*, 19:3-62, 2015. **400+ citations**

Reviews recent trends in the design, analysis, and control of pharmaceutical manufacturing processes.

190. M. Kishida, D. W. Pack, and R. D. Braatz. Optimal spatial field control for controlled release. *Optimal Control Applications & Methods*, 36(6): 968–984, 2015.

A computationally efficient algorithm is developed for the design of polymeric microparticles distributed within three spatial dimensions for the controlled temporal and spatial release of molecules within a tissue construct.

191. M. Kishida and R. D. Braatz. Ellipsoidal bounds on state trajectories for discrete-time systems with linear fractional uncertainties. *Optimization and Engineering*, 16(4):695-711, 2015.

Algorithms are proposed for computing ellipsoid bounds on state trajectories for discrete-time polynomial systems with uncertain initial state and time-invariant or time-varying uncertain parameters and disturbances.

192. L. H. Chiang, B. Jiang, X. Zhu, D. Huang, and R. D. Braatz. Diagnosis of multiple and unknown faults using the causal map and multivariate statistics. *Journal of Process Control*, 28:27-39, 2015.

A data-driven process monitoring method is proposed that combines multivariable statistics with causal analysis based on the structure of the process flowsheet to significantly improve the diagnosis of multiple and unknown faults.

193. M. Jiang, C. D. Papageorgiou, J. Waetzig, A. Hardy, M. Langston, and R. D. Braatz. Indirect ultrasonication in continuous slug-flow crystallization. *Crystal Growth & Design*, 15(5):2486-2492, 2015.

An indirect ultrasonication-assisted nucleation process is designed that is integrated with a slug-flow crystallizer to produce crystals with controllable mean size and narrow size distribution.

194. K. A. Severson, J. G. VanAntwerp, V. Natarajan, C. Antoniou, J. Thömmes, and R. D. Braatz. Elastic net with Monte Carlo sampling for data-based modeling in biopharmaceutical manufacturing facilities. *Comput. Chem. Eng.*, 80:30-36, 2015.

A machine learning algorithm is developed that is effective for constructing predictive models using heterogeneous data of limited quality and quantity.

195. R. Lakerveld, B. Benyahia, P. L. Heider, H. Zhang, A. Wolfe, C. Testa, S. Ogden, D. R. Hersey, S. Mascia, J. M. B. Evans, R. D. Braatz, and P. I. Barton. The application of an automated control strategy for an integrated continuous pharmaceutical pilot plant. *Org. Process Res. Dev.*, 19(9):1088-1100, 2015.

The experimental application is described of an automated plant-wide control strategy to a continuous pharmaceutical pilot plant that manufactured tablets that met all chemical specifications.

196. M.-J. Kim, R. D. Braatz, J. T. Kim, and C.-K. Yoo. Indoor air quality control for improving passenger health in subway platforms using an outdoor air quality dependent ventilation system. *Building and Environment*, 92:407-417, 2015.

A ventilation control system is designed for controlling the concentration of airborne particles in subway platforms.

197. You Peng, Zhilong Zhu, Richard D. Braatz, and Allan S. Myerson. Gypsum crystallization during phosphoric acid production: Modeling and experiments using the mixed-solvent-electrolyte thermodynamic model. *Ind. Eng. Chem. Res.*, 54(32):7914-7924, 2015.

The first population balance model for gypsum crystallization is developed for gypsum crystallization that takes non-ideal solution thermodynamics into account.

198. H. Jang, J. H. Lee, and R. D. Braatz. State estimation of the time-varying and spatially localized concentration of signal molecules from the stochastic adsorption dynamics on the carbon

nanotube-based sensors and its application to tumor cell detection. *PLoS ONE*, 10(11):e0141930, 2015.

Improved algorithms are proposed for estimating time-varying local concentrations of signal molecules with a carbon-nanotube (CNT)-based sensor array system, based on particle filtering, generalized pseudo-Bayesian estimation, and the Markov chain Monte Carlo method.

199. B. Jiang, X. Zhu, D. Huang, and R. D. Braatz. Canonical variate analysis-based monitoring of process correlation structure using causal feature representation. *Journal of Process Control*, 32:109-116, 2015.

A method is proposed for monitoring faults associated with changes in process structure by combining casual dependencies computed for the process network with canonical variate analysis.

200. M. Jiang, C. Gu, and R. D. Braatz. Understanding temperature-induced primary nucleation in dual impinging jet mixers. *Special Issue on Continuous Crystallisation*, *Chem. Eng. Process.: Process Intensification*, 97:187-194, 2015 (invited).

A theoretical analysis involving boundary layer theory explains how primary nucleation can be induced in a dual impinging jet mixer that combines hot and cold saturated solutions.

201. J. C. Pirkle, Jr., L. C. Foguth, S. J. Brenek, K. Girard, and R. D. Braatz. Computational fluid dynamics modeling of mixing effects for crystallization in coaxial nozzles. *Special Issue on Continuous Crystallisation*, *Chem. Eng. Proc.: Process Intensification*, 97:213-232, 2015 (invited).

The most detailed modeling and design analysis of crystallization in coaxial mixers, which employs a simulation that couples population balance modeling of crystal nucleation and growth with computational fluid dynamics modeling of macro- and microscale mixing.

202. M. Jiang, D. Li, H.-H. Tung, and R. D. Braatz. Effect of jet velocity on crystal size distribution from antisolvent and cooling crystallizations in a dual impinging jet mixer. *Special Issue on Continuous Crystallisation*, *Chem. Eng. Proc.: Process Intensification*, 97:242-247, 2015 (invited).

This paper demonstrated the manufacture of pharmaceutical crystals of greatly improved shape and size distribution by combining cooling and antisolvent continuous crystallization within a dual-impinging jet mixer.

203. M. Kishida and R. D. Braatz. Quality-by-Design by skewed spherical structured singular value. *IET Control Theory & Applications*, 9(15):2202-2210, 2015.

An algorithm for the construction of hyperellipsoidal design spaces is derived based on an extension to robust control theory.

204. A. N. Ford Versypt, P. D. Arendt, D. W. Pack, and R. D. Braatz. Derivation of an analytical solution to a reaction-diffusion model for autocatalytic degradation and erosion in polymer microspheres. *PLoS ONE*, 10(8):art no. e0135506, 2015.

An analytical expression is derived for predicting the conditions under which drug release from PLGA microspheres transitions from diffusion-controlled to erosion-controlled release, for understanding the

dynamic coupling between the PLGA degradation and erosion mechanisms, and for designing drug release particles.

205. L. Zhang, S. Zhuang, and R. D. Braatz. Switched model predictive control of switched linear systems: Feasibility, stability and robustness. *Automatica*, 67:8-21, 2016. **200+ citations**

Theoretical conditions are derived for feasibility, stability, and robustness analysis of a switched MPC algorithm proposed for switched linear dynamical systems.

206. H. Jang, J. H. Lee, and R. D. Braatz. Estimation of local concentration from measurements of stochastic adsorption dynamics using carbon nanotube-based sensors. *Korean J. Chem. Eng.*, 33(1):33-41, 2016.

A maximum likelihood estimation (MLE) method is proposed for estimating time-varying local concentration of the target molecule proximate to the sensor from the measured intensity vs. time profile resulted from monomolecular adsorption and desorption on the surface of a carbon nanotube-based sensor.

207. Indrani Bhattacharyya, Mark C. Molaro, Richard D. Braatz, and Gregory C. Rutledge. Free surface electrospinning of aqueous polymer solutions from a wire electrode. *Chemical Engineering Journal*, 289:203-211, 2016.

A more robust model is developed for the manufacture of nanofibers by free surface electrospinning from a wire electrode.

208. S. Streif, K.-K. K. Kim, P. Rumschinski, M. Kishida, D. E. Shen, R. Findeisen, and R. D. Braatz. Robustness analysis, prediction and estimation for uncertain biochemical networks: An overview. *Journal of Process Control*, 42:14-34, 2016 (invited).

Techniques for robustness analysis, estimation, and prediction for biochemical reaction networks are reviewed.

209. M. S. Reis, R. D. Braatz, and L. H. Chiang. Big data challenges and future research directions. *Chem. Eng. Prog.*, 112(3):46-50, March 2016 (invited).

Perspectives are provided on big data and its potential role in the chemical process industry, and future research directions are proposed.

210. Jouha Min, Ki Young Choi, Erik C. Dreaden, Robert F. Padera, Richard D. Braatz, Myron Spector, and Paula T. Hammond. Designer dual therapy nanolayered implant coatings eradicate biofilms and accelerate bone tissue repair. *ACS Nano*, 10(4):4441-4450, 2016. **Cover article**. **200+ citations**

Multilayer polymer coatings that controllably release antibiotic and growth factor are shown to (1) protect a prosthetic implant against continuing threats of bacteria over time, (2) facilitate early deposition of bone on the implant, and (3) have significantly higher bone-implant interfacial tensile strength and long-term stability, indicating the potential of this strategy for single-stage treatment of prosthesis-related infections.

211. Q.-L. Su, M. W. Hermanto, R. D. Braatz, and M.-S. Chiu. Just-in-time-based extended prediction self-adaptive control for batch processes. *Journal of Process Control*, 43:1-9, 2016.

An adaptive nonlinear model predictive control algorithm is proposed that has low online computational cost by using multiple localized state-space models.

212. H. Jang, K. K. K. Kim, R. D. Braatz, R. B. Gopaluni, and J. H. Lee. Regularized maximum likelihood estimation of sparse stochastic monomolecular biochemical reaction networks. *Comput. Chem. Eng.*, 90:111-120, 2016.

A new method is proposed for the determination of the structure and kinetic parameter values for a class of biochemical reaction networks that is based on the exact analytical solution of the corresponding Chemical Master equation.

213. M. Kishida and R. D. Braatz. On the analysis of the eigenvalues of uncertain matrices by μ and ν: Applications to bifurcation avoidance and convergence rates. *IEEE Trans. on Automatic Control*, 61(3):748-753, 2016.

New theoretical results are derived that provide (1) sufficient conditions to avoid bifurcations for dynamical systems with parametric uncertainties and (2) bounds on the convergence rate for uncertain stable matrices and uncertain Markov matrices.

214. M. Torchio, L. Magni, R. B. Gopaluni, R. D. Braatz, and D. M. Raimondo. LIONSIMBA – A Matlab framework based on a finite volume model suitable for Li-ion battery design, simulation, and control. *J. Electrochem. Soc.*, 163(7):A1192-A1205, 2016. **300+ citations**

Software that implements porous electrode theory for Li-ion batteries is presented that is suitable for the development of model-based advanced battery management systems.

215. Darin O. Bellisario, Joel A. Paulson, Richard D. Braatz, and Michael S. Strano. An analytical solution for exciton generation, reaction, and diffusion in nanotube and nanowire-based solar cells. *The Journal of Physical Chemistry Letters*, 7(14):2683-2688, 2016.

A concise analytical framework is developed for the orientation and density tradeoff on exciton collection computed from a deterministic model of a carbon nanotube (CNT) photovoltaic device that incorporates single- and aggregate-nanotube photophysics. This analysis extends to any excitonic solar cell with anisotropic transport elements, including polymer, nanowire, quantum dot, and nanocarbon photovoltaics.

216. M. J. Kim, R. D. Braatz, J. T. Kim, and C. K. Yoo. Economical control of indoor air quality in underground metro station using an iterative dynamic programming-based ventilation system. *Indoor and Built Environment*, 25:949-961, 2016.

An iterative dynamic programming approach is proposed for the control of air quality in underground metro stations.

217. A. Tulsyan, Y. Tsai, R. B. Gopaluni, and R. D. Braatz. State-of-charge estimation in Li-ion batteries: A particle filter approach. *Journal of Power Sources*, 331:208-223, 2016.

The first nonlinear stochastic estimator is proposed that is capable of real-time estimation of the state-of-charge in lithium-ion batteries.

218. J. K. Scott, D. M. Raimondo, G. R. Marseglia, and R. D. Braatz. Constrained zonotopes: A new tool for set-based estimation and fault detection. *Automatica*, 69:126-136, 2016. **Automatica Paper Prize. 300+ citations**

A new class of sets, *constrained zonotopes*, is proposed that demonstrate significant advantages over alternatives for set-based state estimation and fault detection.

219. Mo Jiang and Richard D. Braatz. Integrated control of continuous (bio)pharmaceutical manufacturing. *Am. Pharm. Rev.*, 19(6):110-115, 2016 (invited).

This article describes the efficient design plant-wide control systems using modular plant-wide simulation, with the key strategies illustrated for a small-molecule pharmaceutical pilot plant and a bench-scale biologic drug manufacturing platform, each with total manufacturing times less than 50 hours.

220. M. L. Rasche, M. Jiang, and R. D. Braatz. Mathematical modeling and optimal design of multi-stage slug-flow crystallization. *Comput. Chem. Eng.*, 95:240-248, 2016.

The first mathematical model and systematic procedure is proposed for the optimal design of multi-stage slug-flow crystallizers.

221. Dongying Erin Shen and Richard D. Braatz. Polynomial chaos-based robust design of systems involving probabilistic uncertainties. *AIChE Journal*, 62(9):3310-3318, 2016 (invited).

A new algorithm is proposed for the design of nonlinear dynamical systems with probabilistic uncertainties that reduces computational cost by an order of magnitude in two case studies.

222. Kristen Severson, Paphonwit Chaiwatanodom, and Richard D. Braatz. Perspectives on process monitoring of industrial systems. *Annual Reviews in Control*, 42:190-200, 2016 (invited).

Challenges and future directions in process monitoring are articulated, and it is argued using several algorithms from the group that the biggest advances are likely to come from hybrid methods.

223. D. M. Raimondo, G. R. Marseglia, R. D. Braatz, and J. K. Scott. Closed-loop input design for guaranteed fault diagnosis using set-valued observers. *Automatica*, 74:107-117, 2016.

An efficient algorithm is derived for the computation of the optimal input for guaranteeing the diagnosis of faults within a specified time horizon.

224. K.-K. K. Kim and R. D. Braatz. Robust static and fixed-order dynamic output feedback control of discrete-time parametric uncertain Luré systems: Sequential SDP relaxation approaches. *Optimal Control Applications & Methods*, 38(1):36-58, 2017.

Design methods are proposed for static and fixed-order dynamic output feedback controllers for discrete-time Luré systems with sector-bounded nonlinearities in the presence of parametric uncertainties.

225. Marcello Torchio, Lalo Magni, Richard D. Braatz, and Davide M. Raimondo. Design of piecewise affine and linear time varying based model predictive control strategies for advanced battery management systems. *J. Electrochem. Soc.*, 164(4):A949-A959, 2017.

Advanced model predictive control strategies are proposed for the design of advanced battery management systems.

226. M. Jiang, G. Chen, and R. D. Braatz. Analysis of focused indirect ultrasound via high-speed spatially localized pressure sensing and its consequences on nucleation. *Chem. Eng. Proc.: Process Intensification*, 117:186-194, 2017.

High-speed needle-like pressure transducers are used to analyze the effects of focused indirect ultrasound on the nucleation of crystals from solution.

227. Theodora Kourti, Rapti Madurawe, Kurt Brorson, David Doleski, Dolores Hernán Pérez de la Ossa, Jean Hu-Primmer, Christian Airiau, Gretchen A. Allison, Richard D. Braatz, Yanxi Tan Cain, Lawrence de Belder, Steve Hammond, Jun Huang, Christopher Hwang, Gordon (Randy) Lambertus, Catherine MacConnell, Steve Miller, Christine M. V. Moore, David Pappa, Wyatt Roth, Vidya Swaminathan, Kelly Swinney, Kelly Tolton, and Andre Walker. Continuous manufacturing. *Pharmaceutical Engineering*, 37(3):35-42, May/June 2017 (invited).

This article discusses business benefits, regulatory considerations, current good manufacturing practices, control strategies, end-to-end manufacturing, process analytical technology, multivariable statistical process control, soft sensors, validation, sampling, and post-launch experiences in continuous (bio)pharmaceutical manufacturing.

228. Kristen Severson, Brinda Monian, J. Christopher Love, and Richard D. Braatz. A method for learning a sparse classifier in the presence of missing data for high-dimensional biological datasets. *Bioinformatics*, 33(18):2897-2905, 2017.

Classification methods are developed that produce sparse models from high-dimensional biological datasets with missing data, and applied to gene expression data from a microarray for classifying between two types of acute leukemia.

229. A. Mesbah, J. A. Paulson, R. Lakerveld, and R. D. Braatz. Model predictive control of an integrated continuous pharmaceutical manufacturing pilot plant. *Org. Process Res. Dev.*, 21(6):844-854, 2017.

Real-time model predictive control is demonstrated in a realistic simulation of an end-to-end pharmaceutical manufacturing plant modeled by more than 7000 differential-algebraic equations.

230. B. Jiang and R. D. Braatz. Fault detection of process correlation structure using canonical variate analysis-based correlation features. *Journal of Process Control*, 58:131-138, 2017.

An algorithm based on canonical variate analysis is derived for the detection of changes in process correlation structure.

231. Nima Yazdanpanah, Christopher J. Testa, Siva R. K. Perala, Keith D. Jensen, Richard D. Braatz, Allan S. Myerson, and Bernhardt L. Trout. Continuous heterogeneous crystallization on excipient surfaces. *Crystal Growth & Design*, 17(6):3321-3330, 2017.

A continuous crystallization process is invented in which active pharmaceutical ingredient is crystallized directly onto the surface of excipient crystals.

232. Fridolin Röder, Richard D. Braatz, and Ulrike Krewer. Multi-scale simulation of heterogeneous surface film growth mechanisms in lithium-ion batteries. Focus Issue on Mathematical Modeling of Electrochemical Systems at Multiple Scales in Honor of John Newman, *J. Electrochem. Soc.*, 164(11):E3335-3344, 2017.

A multi-scale simulation model is constructed for SEI formation that combines porous electrode theory with kinetic Monte Carlo simulation of heterogeneous surface mechanisms.

233. Q.-L. Su, M. W. Hermanto, R. D. Braatz, and M.-S. Chiu. Integrated B2B-NMPC control for a semi-batch pH-shift reactive crystallization of L-glutamic acid. *AIChE Journal*, 63(11):5007-5018, 2017.

An integrated batch-to-batch nonlinear model predictive control strategy is proposed that integrates multiway partial least-squares with extended prediction self-adaptive control.

234. Kristen Severson, Mark C. Molaro, and Richard D. Braatz. Principal component analysis of process datasets with missing values. Special Issue on Process Data Analytics, *Processes*, 5(3):38, 2017. **Cover article**.

Algorithms are reviewed for the construction of multivariate statistical process control charts based on incomplete datasets, and guidance is provided on which methods to apply based on the particular type of application.

235. Mo Jiang, Kristen Severson, J. Christopher Love, Helena Madden, Patrick Swan, Li Zang, and Richard D. Braatz. Opportunities and challenges of real-time release testing in biopharmaceutical manufacturing. *Biotechnology & Bioengineering*, 114(11):2445-2456, 2017. **One of the most downloaded articles in the journal in 2017-2018.**

This article reviews process analytical technology and control strategies that enable real-time release testing for the critical quality attributes in biopharmaceutical manufacturing.

236. P. M. Desai, V. Puri, D. Brancazio, B. S. Halkude, J. E. Hartman, A. V. Wahane, A. R. Martinez, K. D. Jensen, E. Harinath, R. D. Braatz, J.-H. Chun, and B. L. Trout. Tablet coating by injection molding technology – Optimization of coating formulation attributes and coating process parameters. *European Journal of Pharmaceutics and Biopharmaceutics*, 122:25-36, 2018.

A solvent-free injection molding (IM) coating technology is developed that is compatible with continuous manufacturing of injection molded tableting.

237. Vibha Puri, David Brancazio, Eranda Harinath, Alexander R. Martinez, Parind M. Desai, Keith D. Jensen, Jung-Hoon Chun, Richard D. Braatz, Allan S. Myerson, and Bernhardt L. Trout. Demonstration of pharmaceutical tablet coating process by injection molding technology. *International Journal of Pharmaceutics*, 535(1-2):106-112, 2018.

A solvent-free integrated hot melt extrusion-injection molding process is demonstrated that produces coated tablets with precision coat features.

238. K. K. K. Kim, E. Ríos Patrón, and R. D. Braatz. Standard representation and unified stability analysis for dynamic artificial neural network models. *Neural Networks*, 98:251-262, 2018.

A comprehensive overview of the theory of dynamic artificial neural networks, with error bounds on approximations to nonlinear dynamical systems and new computationally efficient conditions for stability analysis.

239. Moo Sun Hong, Kristen Severson, Mo Jiang, Amos E. Lu, J. Christopher Love, and Richard D. Braatz. Challenges and opportunities in biopharmaceutical manufacturing control. Special Issue on Foundations of Computer Aided Process Operations / Chemical Process Control, *Comput. Chem. Eng.*, 110:106-114, 2018. https://doi.org/10.1016/j.compchemeng.2017.12.007

Challenges and opportunities in biopharmaceutical manufacturing are described for (1) microscale technologies for high-speed continuous processing, (2) plug-and-play modular unit operations with integrated monitoring and control systems, (3) dynamic modeling of unit operations and entire biopharmaceutical manufacturing plants to support process development and plant-wide control, and (4) model-based control technologies for optimizing startup, changeover, and shutdown.

240. Mo Jiang and Richard D. Braatz. Low-cost noninvasive real-time imaging for tubular continuous-flow crystallization. *Chem. Eng. Techn.*, 41(1):143-148, 2018.

A low-cost real-time stereoscopic imaging system is described for the in situ imaging of microcrystals through curved walls of tubular crystallizers.

241. M. L. Rasche, B. W. Zeiger, K. S. Suslick, and R. D. Braatz. Mathematical modelling of the evolution of the particle size distribution during ultrasound-induced breakage of aspirin crystals. *Chem. Eng. Res. Des.*, 132:170-177, 2018.

The first mathematical model of ultrasound-induced breakage of crystals is developed that describes the effects of solvent viscosity and applied power on the particle size distribution.

242. A. Nikdel, R. D. Braatz, and H. M. Budman. A systematic approach for finding the objective function and active constraints for dynamic flux balance analysis. *Bioprocess and Biosystems Engineering*, 41(5):641-655, 2018.

The first approach is proposed for automatically finding the active constraints in dynamic flux balance analysis, by incorporating a simple machine learning method.

243. J. M. Schall, J. S. Mandur, R. D. Braatz, and A. S. Myerson. Nucleation and growth kinetics for combined cooling and antisolvent crystallization in a mixed-suspension, mixed-product system: Estimating solvent dependency. *Crystal Growth & Design*, 18(3):1560-1570, 2018.

A population balance-based algorithm is proposed for the estimation of nucleation and growth kinetics for combined cooling-antisolvent crystallization.

244. Qiugang Lu, Benben Jiang, R. Bhushan Gopaluni, Philip D. Loewen, and Richard D. Braatz. Locality preserving discriminative canonical variate analysis for fault diagnosis. *Comput. Chem. Eng.*, 117:309-319, 2018.

A new data-driven algorithm is proposed that combines local structure preservation with canonical variate analysis to significantly improve fault diagnosis performance.

245. Cezar A. da Rosa and Richard D. Braatz. Multiscale modeling and simulation of macromixing, micromixing, and crystal size distribution in radial mixers/crystallizers. *Ind. Eng. Chem. Res.*, 57(15):5433-5441, 2018.

The most detailed study on the design and operation of continuous-flow crystallizers using radial mixers, including a new design of crystallizers with multiple radial inlets that is shown to deliver improved mixing compared to one radial inlet.

246. Cezar A. da Rosa and Richard D. Braatz. OpenCrys: Open-source software for the multiscale modeling of combined antisolvent and cooling crystallization in turbulent flow. *Ind. Eng. Chem. Res*., 57(34):11702-11711, 2018.

An open-source software is released for the multiscale simulation of micro- and macromixing, heat and mass transfer, and particle size distributions in turbulent flow.

247. Qiugang Lu, Benben Jiang, R. Bhushan Gopaluni, Philip D. Loewen, and Richard D. Braatz. Sparse canonical variate analysis approach for process monitoring. *Journal of Process Control*, 71, 90-102, 2018.

A new algorithm is proposed that constructs dynamic models for process monitoring purposes that are functions only of process inputs that significantly affect performance.

248. Laura E. Crowell, Amos E. Lu, Kerry R. Love, Alan Stockdale, Steven M. Timmick, Di Wu, Yu (Annie) Wang, William Doherty, Alexandra Bonnyman, Nicholas Vecchiarello, Chaz Goodwine, Lisa Bradbury, Joseph R. Brady, John J. Clark, Noelle A. Colant, Aleksander Cvetkovic, Neil C. Dalvie, Diana Liu, Yanjun Liu, Craig A. Mascarenhas, Catherine B. Matthews, Nicholas J. Mozdzierz, Kartik A. Shah, Shiaw-Lin Wu, William S. Hancock, Richard D. Braatz, Steven M. Cramer, and J. Christopher Love. On-demand manufacturing of clinical-quality biopharmaceuticals. *Nature Biotechnology*, 36:988-995, 2018. http://doi.org/10.1038/nbt.4262

A fully automated bench-top manufacturing system is presented for the end-to-end production of 100s to 1000s of doses of high-quality formulated biologic drugs in about 3 days.

249. Ulrike Krewer, Fridolin Röder, Eranda Harinath, Richard D. Braatz, Benjamin Bedürftig, and Rolf Findeisen. Dynamic models of Li-ion batteries for diagnosis and operation – A review and perspective. *J. Electrochem. Soc.*, 165(16):A3656-A3673, 2018. **200+ citations**

Dynamic models for the diagnosis and operation of Li-ion batteries are reviewed and compared in terms of physical insight, capabilities, and limitations.

250. F. Röder, R. D. Braatz, and U. Krewer. Direct coupling of continuum and kinetic Monte Carlo models for multiscale simulation of electrochemical systems. *Comput. Chem. Eng.*, 121:722-735, 2019.

Numerical algorithms and guidelines are provided for the efficient and robust multiscale simulation of electrochemical systems.

251. Lauren Farias, Jeferson A. de Souza, Richard D. Braatz, and Cezar A. da Rosa. Coupling of the population balance equation into a two-phase model for the simulation of combined cooling and antisolvent crystallization using OpenFOAM. *Comput. Chem. Eng*., 123, 246-256, 2019.

A multiphase model is proposed that dynamically couples the spatially varying population balance equation with macro- and micromixing turbulent fluid dynamics to simulate the most widely used crystallizations used in the pharmaceutical industry.

252. Kristen A. Severson, Peter M. Attia, Norman Jin, Benben Jiang, Zi Yang, Nicholas Perkins, Michael H. Chen, Muratahan Aykol, Patrick K. Herring, Dimitrios Fraggedakis, Martin Z. Bazant, Stephen J. Harris, William C. Chueh, and Richard D. Braatz. Data-driven prediction of battery cycle life before capacity degradation. *Nature Energy*. 4:383-391, 2019. **Cover article**. The paper is discussed by Maitane Berecibar, "Accurate predictions of lithium-ion battery life," *Nature*, 568(7752):325-326, April 18, 2019. **~2000+ citations**

We report accurate cycle life prediction for Li-ion batteries before any capacity degradation has occurred, by the application of machine learning using features constructed from the full voltage-capacity discharge relationship.

253. Mo Jiang and Richard D. Braatz. Designs of continuous-flow crystallizers: Developments and practice. *CrystEngComm*, 21:3534-3551, 2019 (invited).

This review of recent research advances in continuous-flow crystallization includes a five-step general design procedure, generally applicable process intensification strategies, and practical insights.

254. Jennifer Schall, Gerard Capellades, Jasdeep Mandur, Richard D. Braatz, and Allan S. Myerson. Incorporating solvent-dependent kinetics to design a multi-stage, continuous, combined cooling/antisolvent crystallization process. *Org. Process Res. Dev.*, 23(9), 1960-1969, 2019.

A methodology is proposed that includes mathematical modeling of solvent effects in the model-based design of multi-stage continuous crystallizations

255. Domenico Coluccia, Davide Fissore, Antonello Barresi, and Richard D. Braatz. A new mathematical model for monitoring the temporal evolution of the ice crystal size distribution during freezing in pharmaceutical solutions. *European Journal of Pharmaceutics and Biopharmaceutics*, 148:148-159, 2020.

A new mathematical model of the freezing of a (bio)pharmaceutical solution is developed and experimentally validated, with innovations being the represent of the stochastic variation in primary nucleation from an analytical solution of Chemical Master Equation and the population balance modeling of the subsequent crystal size distribution.

256. Muratahan Aykol, Jens S. Hummelshøj, Abraham Anapolsky, Koutarou Aoyagi, Martin Z. Bazant, Thomas Bligaard, Richard D. Braatz, Scott Broderick, Daniel Cogswell, John Dagdelen, Walter Drisdell, Edwin Garcia, Krishna Garikipati, Vikram Gavini, William E. Gent, Livia Giordano, Carla P. Gomes, Rafael Gomez-Bombarelli, Chirranjeevi Balaji Gopal, John M. Gregoire, Jeffrey C. Grossman, Patrick Herring, Linda Hung, Thomas F. Jaramillo, Laurie King, Ha-Kyung Kwon, Ryosuke Maekawa, Andrew M. Minor, Joseph H. Montoya, Tim Mueller, Colin Ophus, Krishna Rajan, Rampi Ramprasad, Brian Rohr, Daniel Schweigert, Yang Shao-Horn, Yoshinori Suga, Santosh K. Suram, Venkatasubramanian Viswanathan, Jay F. Whitaker, Adam P. Willard, Olga Wodo, Chris Wolverton, and Brian D. Storey. The Materials Research Platform: Defining the requirements from user stories. *Matter*, 1(6):1433-1438, 2019.

Requirements are defined for a materials research platform that accelerates materials discovery and design.

257. Joel A. Paulson, Edward A. Buehler, Richard D. Braatz, and Ali Mesbah. Stochastic model predictive control with joint chance constraints. Special issue on Model Predictive Control, *International Journal of Control*, 93(1):126-139, 2020.

An optimal control algorithm is proposed that simultaneously accounts for hard input constraints and stochastic disturbances while providing optimal risk allocation, which is demonstrated for a continuous acetone-butanol-ethanol fermentation for the production of biofuels.

258. Hongbo Zhao, Brian D. Storey, Richard D. Braatz, and Martin Z. Bazant. Learning the physics of pattern formation from images. *Phys. Rev. Lett.*, 124(6):060201, 2020.

A method is proposed to simultaneously extract multiple constitutive relations from a small set of images of pattern formation, and demonstrated for electrochemical systems. Reconstruction of the free energy functional, which contains nonlinear dependence on the state variable and differential or convolutional operators, is demonstrated, which demonstrates the learning of nonequilibrium thermodynamics from only a few snapshots of the dynamics.

259. Shin-Hyuk Kim, Jay H. Lee, and Richard D. Braatz. Multi-phase particle-in-cell coupled with population balance equation (MP-PIC-PBE) method for multiscale computational fluid dynamics simulation. *Comput. Chem. Eng.*, 134:106686, 2020.

A method is proposed for simulating multi-scale multiphase particulate flows that couples the meso-scale fluid dynamics, discrete particle tracking, and micro-scale particle size distribution dynamics.

260. Y. Wan, V. Puig, C. Ocampo-Martinez, Y. Wang, E. Harinath, and R. D. Braatz. Fault detection for uncertain LPV systems using probabilistic set-membership parity relation. *Journal of Process Control*, 87:27-36, 2020.

An approach is proposed for fault detection of linear parameter-varying systems that exploits probabilistic information on parameter uncertainties.

261. Peter M. Attia, Aditya Grover, Norman Jin, Kristen A. Severson, Todor M. Markov, Yang-Hung Liao, Michael H. Chen, Bryan Cheong, Nicholas Perkins, Zi Yang, Patrick K. Herring, Muratahan Aykol, Stephen J. Harris, Richard D. Braatz, Stefano Ermon, William C. Chueh. Closed-loop optimization of fast-charging protocols for batteries with machine learning. *Nature*, 578:397-402, 2020. https://rdcu.be/b1U6H 200 **~800 citations**

A closed-loop machine learning methodology is developed and demonstrated to efficiently determine fast-charging protocols for maximizing battery cycle life, reducing to 16 days what would take over 500 days by exhaustive search.

262. Sai Varun Aduru, Suryanarayana Kolluri, Manan Pathak, Richard D. Braatz, and Venkat R. Subramanian. Real-time nonlinear model predictive control (NMPC) strategies using physics-based models for advanced lithium-ion battery management systems (BMS). *J. Electrochem. Soc.*, 167(6):063505, 2020.

An NMPC strategy is proposed that directly employs porous electrode theory for making predictions while having fast enough on-line computational time to be implementable in advanced lithium-ion battery management systems.

263. Andrea Pozzi, Marcello Torchio, Richard D. Braatz, and Davide Raimondo. Optimal charging of an electric vehicle battery pack: A real-time sensitivity-based MPC approach. *Journal of Power Sources*, 461:228133, 2020.

A model predictive control algorithm with very low on-line computational cost is derived for optimally charging electric vehicle battery packs.

264. Patrick Herring, Chirranjeevi Balaji Gopal, Muratahan Aykol, Joseph H. Montoya, Abraham Anapolsky, Peter M. Attia, William Gent, Jens S. Hummelshøj, Linda Hung, Ha-Kyung Kwon, Patrick Moore, Daniel Schweigert, Kristen A. Severson, Santosh Suram, Zi Yang, Richard D. Braatz, and Brian D. Storey. BEEP: A python library for battery evaluation and early prediction. *SoftwareX*, 11:100506, 2020.

An open-source Python-based framework is release for the management and processing of high-throughput battery cycling data-streams.

265. Weike Sun, Antonio R. Paiva, Peng Xu, Anantha Sundaram, and Richard D. Braatz. Fault detection and identification using Bayesian recurrent neural networks. Process Analytics and Machine Learning Special Issue, *Comput. Chem. Eng.*, 141:106991, 2020.

A Bayesian network approach is proposed that provides uncertainty estimates which allow for simultaneous fault detection, identification, and propagation analysis of complex nonlinear dynamical systems.

266. Ali Mesbah, Joel A. Paulson, and Richard D. Braatz. An internal model control design method for failure-tolerant control with multiple objectives. *Comput. Chem. Eng.*, 140:106955, 2020.

A general internal model control (IMC) structure is proposed for the design of control systems with multiple objectives that retain optimal performance when any controller is taken off-line, for example, due to actuator and/or sensor failures.

267. Weike Sun and Richard D. Braatz. ALVEN: Algebraic Learning Via Elastic Net for static and dynamic nonlinear model identification. Process Analytics and Machine Learning Special Issue, *Comput. Chem. Eng.*, 143:107103, 2020. https://doi.org/10.1016/j.compchemeng.2020.107103

A machine learning algorithm is proposed for the construction of interpretable nonlinear models from noisy and limited data that is able to learn first-principles relationships that arise in physical, chemical, and biological systems.

268. Elçin Içten, Andrew Maloney, Matthew G. Beaver, Dongying Erin Shen, Xiaoxiang Zhu, Lauren R. Graham, Jo Anna Robinson, Seth Huggins, Ayman Allian, Roger Hart, Shawn D. Walker, Pablo Rolandi, and Richard D. Braatz. A virtual plant for integrated continuous manufacturing of a carfilzomib drug substance intermediate. Part 1: CDI-promoted amide-bond formation. Special Issue on Flow Chemistry Enabling Efficient Synthesis, *Org. Process Res. Dev.*, 24(10):1861-1875, 2020. DOI: 10.1021/acs.oprd.0c00187

A mechanistic model is constructed for the continuous manufacturing of the chemotherapy drug carfilzomib intermediate, morpholine amide 3, and the model of the closed-loop system including the effects of disturbances is analyzed and experimentally validated in production-scale operations.

269. Elçin Içten, Andrew Maloney, Matthew G. Beaver, Xiaoxiang Zhu, Dongying Erin Shen, Jo Anna Robinson, Andrew T. Parsons, Ayman Allian, Seth Huggins, Roger Hart, Pablo Rolandi, Shawn D. Walker, and Richard D. Braatz. A virtual plant for integrated continuous manufacturing of a carfilzomib drug substance intermediate. Part 2. Enone synthesis via a

Barbier-type Grignard process. Special Issue on Flow Chemistry Enabling Efficient Synthesis, *Org. Process Res. Dev.*, 24(10):1876-1890, 2020. DOI: 10.1021/acs.oprd.0c00188

A mixed continuous-discrete simulation model is constructed for the continuous manufacturing of the chemotherapy drug carfilzomib intermediate, enone 2, which includes a new mechanistic model for the heterogenous Barbier-type Grignard reaction. The model is used to design a robust process control strategy and analyze the dynamic effects of disturbances, model uncertainties, equipment failures, and discrete magnesium charging to the chemical reactor.

270. Andrew J. Maloney, Elçin Içten, Gerard Capellades, Matthew G. Beaver, Xiaoxiang Zhu, Lauren Graham, Derek B. Brown, Daniel J. Griffin, Rahul Sangodkar, Ayman Allian, Seth Huggins, Roger Hart, Pablo Rolandi, Shawn D. Walker, and Richard D. Braatz. A virtual plant for integrated continuous manufacturing of a carfilzomib drug substance intermediate. Part 3: Manganese-catalyzed asymmetric epoxidation, crystallization, and filtration. Special Issue on Flow Chemistry Enabling Efficient Synthesis, *Org. Process Res. Dev.*, 24(10):1891-1908, 2020. DOI: 10.1021/acs.oprd.0c00189

A mechanistic model is constructed for the continuous manufacturing of the chemotherapy drug carfilzomib intermediate, (R,R)-epoxyketone 2 and used to design a robust process control strategy and analyze the closed-loop performance, particularly on chiral purity.

271. Weike Sun and Richard D. Braatz. Opportunities in tensorial data analytics for chemical and biological manufacturing processes. Process Analytics and Machine Learning Special Issue, *Comput. Chem. Eng.*, 143:107099, 2020. https://doi.org/10.1016/j.compchemeng.2020.107099

Multilinear subspace learning methods and other tensorial data analytics methods are reviewed, which are applicable to real-time video, chemical imaging, and hyphenated methods.

272. Krishna Shah, Akshay Subramaniam, Lubhani Mishra, Taejin Jang, Martin Z. Bazant, Richard D. Braatz, and Venkat R. Subramanian, Perspective: Challenges to moving to multiscale battery models – Where Electrochemistry meets and demands more from Math. *J. Electrochem. Soc.*, 167(13):133501, 2020 (invited). **Editor's Choice**.

Challenges associated with the numerical simulation of first-principles battery models are described, such as local singularities and boundary layers, and benchmark models are provided for testing the efficiency and accuracy of numerical methods designed to simulate these systems.

273. Moo Sun Hong, Weike Sun, Amos E. Lu, and Richard D. Braatz. Process analytical technology and digital biomanufacturing of monoclonal antibodies. *Am. Pharm. Rev.*, 23(6):122-125, September/October 2020 (invited).

This article discusses strategies and components of the digital biomanufacturing approach, including mechanistic models and their validation, automation of the construction of models by data analytics and machine learning to improve efficiency and improve model quality, and real-time feedback control of critical quality attributes.

274. Weike Sun and Richard D. Braatz. Smart process analytics for predictive modeling. *Comput. Chem. Eng.*, 144:107134, 2021. https://doi.org/10.1016/j.compchemeng.2020.107134

An automated framework is proposed for the selection of data analytics and machine learning methods based on the data characteristics and domain knowledge.

275. Sirish L. Shah, Bhavik R. Bakshi, Jinfeng Liu, Christos Georgakis, Benoit Chachuat, Richard D. Braatz, and Brent R. Young. Meeting the challenge of water sustainability: The role of process systems engineering. *AIChE J.*, 67(2):e17113, 2021. https://doi.org/10.1002/aic.17113

Open research problems and future direction in water sustainability are discussed, including in the areas of mathematical modeling, systems analysis, decision support systems, and closed-loop control.

276. Moo Sun Hong and Richard D. Braatz. Mechanistic modeling and parameter-adaptive nonlinear model predictive control of a microbioreactor. *Comput. Chem. Eng.*, 147:107255, 2021. https://doi.org/10.1016/j.compchemeng.2021.107255

An analytical solution to a mechanistic model is derived for the spatiotemporal transport of oxygen through a gas-permeable membrane to the cells within a microbioreactor, and used to improve the spatial control of dissolved oxygen during cell growth compared to the existing controls.

277. Moo Sun Hong, Kawaljit Kaur, Nishant Sawant, Sangeeta B. Joshi, David B. Volkin, and Richard D. Braatz. Crystallization of a non-replicating rotavirus vaccine candidate. *Biotechnology & Bioengineering*, 118(4):1750-1756, 2021. https://doi.org/10.1002/bit.27699

A systematic approach is described for the design of the crystallization of a rotavirus vaccine candidate using first-principles models and preliminary experimental data.

278. Amos E. Lu, Andrew J. Maloney, Neil C. Dalvie, Joseph R. Brady, Kerry R. Love, J. Christopher Love, and Richard D. Braatz. Modeling of copy number stability in Pichia pastoris. *Biotechnology & Bioengineering*, 118(5);1832-1839, 2021. https://doi.org/10.1002/bit.27698

The first mathematical model is proposed and experimentally validated for genetic copy number stability for recombinant protein production for Pichia pastoris, and a continuous process is proposed to stabilize copy number during continuous bioreactor operation.

279. Andreas L. Gimpel, Georgios Katsikis, Sha Sha, Andrew John Maloney, Moo Sun Hong, Tam Nguyen, Jacqueline Wolfrum, Stacy L. Springs, Anthony J. Sinskey, Scott R. Manalis, Paul W. Barone, and Richard D. Braatz. Analytical methods for process and product characterization of recombinant adeno-associated virus-based gene therapies. *Molecular Therapy: Methods & Clinical Development*, 20:740-754, 2021. https://doi.org/10.1016/j.omtm.2021.02.010

This literature review serves as a guide for the selection of analytical methods targeting quality attributes for rapid, high-throughput process characterization during process development of recombinant adeno-associated virus-mediated gene therapies.

280. Muratahan Aykol, Chirranjeevi Balaji Gopal, Abraham Anapolsky, Patrick K. Herring, Bruis van Vlijmen, Marc D. Berliner, Martin Z. Bazant, Richard D. Braatz, William C. Chueh, and Brian D. Storey. Perspective: Blending physics and machine learning for predicting battery lifetime. *J. Electrochem. Soc.*, 168(3):030525, 2021.

Existing and new approaches are described for combining physics-based and machine learning models for predicting battery lifetimes.

281. Hongbo Zhao, Richard D. Braatz, and Martin Z. Bazant. Image inversion with uncertainty quantification for pattern-forming systems. *J. Comput. Phys.*, 436:110279, 2021.

Uncertainties in the discovery of physics from images in pattern-forming systems are thoroughly analyzed using PDE-constrained optimization, Bayesian statistics, and analytical methods.

282. Moo Sun Hong, M. Lourdes Velez-Suberbie, Andrew J. Maloney, Andrew Biedermann, Kerry R. Love, J. Christopher Love, Tarit K. Mukhopadhyay, and Richard D. Braatz. Macroscopic modeling of bioreactors for recombinant protein producing Pichia pastoris in defined medium. *Biotechnology & Bioengineering*, 118:1199-1212, 2021.

The most advanced macroscopic bioreactor model is constructed for recombinant protein production by Pichia pastoris for substrates, biomass, total protein, other medium components, and off-gas components. The bioreactor model is able to predict pH, the precipitation occurrence and quantity of media components, and run-to-run variability.

283. Nicholas J. Mozdzierz, Yongkyu Lee, Moo Sun Hong, Moritz H. P. Benisch, Michael L. Rasche, Uku Erik Tropp, Mo Jiang, Richard D. Braatz. Mathematical modeling and experimental validation of continuous slug-flow tubular crystallization with ultrasonication-induced nucleation and spatially varying temperature. Special Issue on Continuous Crystallization. *Chemical Engineering Research and Design*, 169:275-287, 2021.

A slug-flow crystallizer is designed for the control of crystal size distribution by employing spatially varying temperature and ultrasonication.

284. Christoph Herwig, Frank B. Nygaard, Michelangelo Canzoneri, Stacy L. Springs, Jacqueline M. Wolfrum, Richard D. Braatz, Stefan Robert Kappeler, and Valentin Steinwandter. Data science for Pharma 4.0™, drug development, and production – Part 1. *Pharmaceutical Engineering*, 41(2): 40-47, March-April 2021 (invited). https://ispe.org/pharmaceutical-engineering/march-april-2021/data-science-pharma-40tm-drug-development-production
285. Stefan R. Kappeler, Frank Nygaard, Michelangelo Canzoneri, Stacy L. Springs, Jacqueline M. Wolfrum, Richard D. Braatz, Valentin Steinwandter, and Christoph Herwig. Data science for Pharma 4.0™, drug development, and production – Part 2. *Pharmaceutical Engineering*, 41(3): 43-49, May-June 2021 (invited). https://ispe.org/pharmaceutical-engineering/may-june-2021/data-science-pharma-40tm-drug-development-production-part

Perspectives are provided on Pharma 4.0, digital transformation, and data science and their optimal use in drug development and manufacturing.

286. Sha Sha, Andrew J. Maloney, Georgios Katsikis, Tam Nguyen, Caleb Neufeld, Jacqueline Wolfrum, Paul W. Barone, Stacy Springs, Scott R. Manalis, Anthony J. Sinskey, and Richard D. Braatz. Cellular pathways of recombinant adeno-associated virus production for gene therapy. *Biotechnology Advances*, 49:107764, 2021. http://doi.org/10.1016/j.biotechadv.2021.107764

The cellular pathways are analyzed for recombinant AAV (rAAV) production and wild-type replication to provide insights into molecular and process approaches for improving rAAV production efficiency.

287. Kevin M. Tenny, Richard D. Braatz, Yet-Ming Chiang, and Fikile R. Brushett. Leveraging neural networks and genetic algorithms for determining electrode properties in redox flow batteries. *J. Electrochem. Soc.*, 68(5):050547.

A neural network-based strategy is developed for accelerating the design of electrodes in redox flow batteries.

288. Jungjin Park, Hongbo Zhao, Stephen Dongmin Kang, Kipil Lim, Chia-Chin Chen, Young-Sang Yu, Richard D. Braatz, David A. Shapiro, Jihyun Hong, Michael F. Toney, Martin Z. Bazant, and William C. Chueh. Fictitious phase separation in lithium layered oxides driven by electro-autocatalysis. *Nature Materials*, 20:991-999, 2021. https://doi.org/10.1038/s41563-021-00936-1

The phase separation reported during delithiation in lithium-layered oxides is shown to be fictitious, and a many-particle population model is used to show that the observed experimental data are actually the result of autocatalytic electrochemical reactions in which the interfacial exchange current increases with the extent of delithiation.

289. Tam N. T. Nguyen, Sha Sha, Moo Sun Hong, Andrew J. Maloney, Paul W. Barone, Caleb Neufeld, Jacqueline Wolfrum, Stacy L. Springs, Anthony J. Sinskey, and Richard D. Braatz. Mechanistic model for production of recombinant adeno-associated virus via triple transfection of HEK293 cells. *Molecular Therapy: Methods & Clinical Development*, 21:642-655, 2021. **Cover article.** https://doi.org/10.1016/j.omtm.2021.04.006

The first mechanistic model is developed for the synthesis of rAAV viral vectors by triple plasmid transfection, and used to reveal potential process bottlenecks to rAAV production.

290. B. Bedürftig, M. Oldenburger, T. Hüfner, E. Richter, R. D. Braatz, A. Gruhle, and R. Findeisen. Measuring the reversible heat of lithium-ion cells via current pulses for modeling of temperature dynamics. *Journal of Power Sources*, 506:230110, 2021.

A low-cost technique is proposed for accurate determination of the reversible heat in lithium-ion cells by measuring the temperature difference generated by two current pulses of opposite polarity.

291. Dongying E. Shen, Yiming Wan, Sergio Lucia, Rolf Findeisen, and Richard D. Braatz. Polynomial chaos-based H_2-optimal output-feedback control of systems with probabilistic parametric uncertainties. *Automatica*, 131:109743, 2021.

H_2-optimal static and dynamic output-feedback control design algorithms with rigorous robust stability guarantees are derived for linear time-invariant uncertain systems with nonlinear dependence on time-invariant probabilistic parametric uncertainties.

292. Moo Sun Hong, Amos E. Lu, Rui Wen Ou, Jacqueline Wolfrum, Stacy C. Springs, Anthony J Sinskey, and Richard D. Braatz. Model-based control for column-based continuous viral inactivation of biopharmaceuticals. *Bioengineering & Biotechnology*, 118(8):3215-3224, 2021. https://doi.org/10.1002/bit.27846

A low-cost, column-based continuous viral inactivation system is designed and experimentally validated that provides precision control of logarithmic viral reduction values over extended operation.

293. Jinwoo Park, Jae Hyun Cho, and Richard D. Braatz. Mathematical modeling and analysis of microwave-assisted freeze-drying in biopharmaceutical applications. *Comput. Chem. Eng.*, 153:107412, 2021. https://doi.org/10.1016/j.compchemeng.2021.107412

Mechanistic models are derived in a proposed lyophilization process in which two energy transfer mechanisms – microwave irradiation and thermal conduction – occur simultaneously. A factor of five reduction in the primary drying time is predicted.

294. Shinhyuk Kim, Richard D. Braatz, and Jay H. Lee. Multi-scale fluid dynamics simulation based on MP-PIC-PBE method for PMMA suspension polymerization. *Comput. Chem. Eng.*, 152: 107391, 2021.

A multi-scale multi-phase computational fluid dynamics model is derived for PMMA suspension polymerization that simulates the flow patterns of suspended particles.

295. Marc D. Berliner, Daniel A. Cogswell, Martin Z. Bazant, and Richard D. Braatz. PETLION: Open-source software for millisecond-scale porous electrode theory-based lithium-ion battery simulations. *J. Electrochem. Soc.*, 168(9):090504. https://doi.org/10.1149/1945-7111/ac201c

A high-performance implementation of the porous electrode theory model (PETLION) is designed for use in parameter estimation, identifiability analysis, SOH/SOC estimation, and real-time control. The software is more than 100x faster than the most computationally efficient publicly available Matlab implementation.

296. Marc D. Berliner, Hongbo Zhao, Supradim Das, Michael Forsuelo, Benben Jiang, William H. Chueh, Martin Z. Bazant, and Richard D. Braatz. Nonlinear identifiability analysis of the porous electrode theory model of lithium-ion batteries. *J. Electrochem. Soc.*, 168, 090546, 2021. https://doi.org/10.1149/1945-7111/ac26b1

This article precisely quantifies the lack of identifiability of PET model parameters from discharge data, and describes specific approaches to resolving identifiability issues associated with Li-ion batteries.

297. Nicholas J. Mozdzierz, Moo Sun Hong, Yongkyu Lee, Moritz H. P. Benisch, Mo Jiang, Allan S. Myerson, and Richard D. Braatz. Tunable protein crystal size distribution via continuous slug-flow crystallization with spatially varying temperature. *CrystEngComm*, 23, 6495-6505, 2021. https://doi.org/10.1039/D1CE00387A **Cover article**

A tunable continuous process for protein crystallization is designed and shown to have the potential to become a low-cost platform technology for producing protein crystals for a variety of biologic drug product formulations.

298. Moo Sun Hong, Amos E. Lu, Jaehan Bae, Jong Min Lee, and Richard D. Braatz. A droplet-based evaporative system for the estimation of protein crystallization kinetics. *Crystal Growth & Design*, 11, 6064-6075, 2021. https://doi.org/10.1021/acs.cgd.1c00231 PMCID# PMC8569678

A dual-angle tightly controlled droplet-based evaporative system is designed for the determination of the crystallization phase diagram and kinetics using only a droplet (on the order of μL) of protein solution.

299. Benben Jiang, William E. Gent, Fabian Mohr, Supratim Das, Marc D. Berliner, Michael Forsuelo, Hongbo Zhao, Peter M. Attia, Aditya Grover, Patrick K. Herring, Martin Z. Bazant, Stephen J. Harris, Stefano Ermon, William C. Chueh, and Richard D. Braatz. Bayesian learning for rapid prediction of lithium-ion battery cycling protocols. *Joule*, 5(12):3187-3203, 2021. **Cover article** https://doi.org/10.1016/j.joule.2021.10.010

A new data-driven methodology is developed for the rapid, accurate prediction of the cycle life of new cycling protocols using a single test lasting only 3 cycles, enabling rapid exploration of cycling protocol design spaces with orders of magnitude reduction in testing time.

300. Moo Sun Hong, Amos E. Lu, Andrew J. Maloney, Rui Wen Ou, Jacqueline M. Wolfrum, Stacy L. Springs, Anthony J. Sinskey, and Richard D. Braatz. Applying PAT to the continuous digital biomanufacturing of monoclonal antibodies. *Pharma Focus Asia*, 44:42-46, 2021. (invited) https://issuu.com/verticaltalk/docs/pfa-issue-44?e=2216358/88302911

This article describes experiences in the modeling, design, control, and operation of continuous monoclonal antibody manufacturing processes.

301. Benben Jiang, Marc D. Berliner, Kun Lai, Patrick A. Asinger, Hongbo Zhao, Patrick K. Herring, Martin Z. Bazant, and Richard D. Braatz. Fast charging design for lithium-ion batteries via Bayesian optimization. *Applied Energy*, 307:118244, 2022.

A machine learning strategy is proposed for optimizing rapid charging protocols while explicitly including constraints that limit battery degradation while having faster convergence than previous strategies.

302. Georgios Katsikis, Iris E. Hwang, Wade Wang, Vikas S. Bhat, Nicole L. McIntosh, Omair A. Karim, Bartlomiej J. Blus, Sha Sha, Vincent Agache, Jacqueline M. Wolfrum, Stacy L. Springs, Anthony J. Sinskey, Paul W. Barone, Richard D. Braatz, Scott R. Manalis. Weighing the DNA content of Adeno-Associated Virus vectors with zeptogram precision using nanomechanical resonators. *Nano Letters*, 22(4):1511-1517, 2022. https://doi.org/10.1101/2021.11.15.468734

A method is demonstrated for using Suspended Nanomechanical Resonators (SNR) to directly measure both AAV mass and aggregation from a few microliters of sample within minutes, achieving resolution near 10 zeptograms which corresponds to 1% of the genome holding capacity of the AAV capsid.

303. Pil Rip Jeon, Moo Sun Hong, and Richard D. Braatz. Compact neural network modeling of nonlinear dynamical systems via the standard nonlinear operator form. *Comput. Chem. Eng.*, 169:107674, 2022. https://doi.org/10.1016/j.compchemeng.2022.107674

A compact low-order neural network structure is proposed and demonstrated that is amenable to theoretically rigorous stability and performance analyses.

304. Pavan K. Inguva, Kaylee C. Schickel, and Richard D. Braatz. Efficient numerical schemes for population balance models. *Comput Chem. Eng.*, 162:107808, 2022. https://doi.org/10.1016/j.compchemeng.2022.107808

A low-cost finite difference scheme is proposed that employs specially constructed meshes and/or variable transformations to achieve zero numerical discretization error for some classes of population balance models.

305. Marian Chatenet, Bruno G. Pollet, Dario Dekel, Fabio Dionigi, Jonathan Deseure, Pierre Millet, Richard D. Braatz, Martin Z. Bazant, Michael Eikerling, Iain Staffell, Paul Balcombe, Yang Shao-Horn, and Helmut Schäfer. Water electrolysis: From textbook knowledge to the latest scientific strategies and industrial developments. *Chemical Society Reviews*, 51:4583-4762, 2022. http://doi.org/10.1039/D0CS01079K **800+ citations**

The latest scientific advances in electrocatalytic water splitting are reviewed.

306. Anastasia Nikolakopoulou, Moo Sun Hong, and Richard D. Braatz. Dynamic state feedback controller and observer design for dynamic artificial neural network models. *Automatica*, 146:110622, 2022.

Methods are presented for the design of full dynamic state feedback controllers and state and output observers that have guaranteed theoretical properties for systems approximated by dynamic artificial neural networks.

307. Doraiswami Ramkrishna and Richard D. Braatz. Whither chemical engineering? *AIChE Journal*, 68(10):e17829. https://doi.org/10.22541/au.164873324.42029245/v1

This article discusses whether chemical engineering research is continuing to provide for a growing core of fundamental understanding for formulating and solving important societal problems in which material systems undergo changes in composition and energy.

308. J. Lund, H. Wang, R. D. Braatz, and R. E. García. Machine learning of phase diagrams. *Materials Advances*, 3, 8485-8497, 2022. http://doi.org/10.1039/D2MA00524G

A machine learning method is proposed for constructing materials phase diagrams that is three to five orders of magnitude faster than previous algorithms, while identifying previously missed stable and metastable phases and associated properties.

309. Richard D. Braatz, Moo Sun Hong, Weike Sun, and Brian W. Anthony. Teaching process data analytics and machine learning at MIT. *Chem. Eng. Edu.*, 56(4):226-230, 2022.

This article describes experiences with teaching process data analytics and machine learning, including in a joint undergraduate/graduate course for students in chemical and mechanical engineering and engineering management developed at MIT.

310. Joachim Schaeffer and Richard D. Braatz. Latent Variable Method Demonstrator – Software for understanding multivariate data analytics algorithms. *Comput. Chem. Eng.*, 167:108014, 2022. https://arxiv.org/abs/2205.08132.

Interactive open-source software is developed for teaching, learning, and understanding latent variable and related data analytics/machine learning methods.

311. Marc D. Berliner, Benben Jiang, Daniel A. Cogswell, Martin Z. Bazant, and Richard D. Braatz. Novel operating modes for the charging of lithium-ion batteries. *J. Electrochem. Soc.*, 169(10):100546, 2022. https://doi.org/10.1149/1945-7111/ac9a80

The constrained optimal charging of lithium-ion batteries is reformulated, using general operating modes, as a mixed-continuous discrete (aka hybrid) simulation, which enables nonlinear model predictive control to be implementable in real-time while directly using sophisticated physics-based battery models.

312. Sanket Diwale, Maximilian K. Eisner, Corinne Carpenter, Weike Sun, Gregory C. Rutledge, and Richard D. Braatz. Bayesian optimization for material discovery processes with noise. *Molecular Systems Design & Engineering*, 7, 622-636, 2022. http://doi.org/10.1039/D1ME00154J

An augmented Bayesian optimization approach is proposed for materials discovery with noisy and unreliable measurements and applied to the discovery of additives for the promotion of nucleation of polyethylene crystals based on non-equilibrium molecular dynamics.

313. Yiming Wan, Dongying E. Shen, Sergio Lucia, Rolf Findeisen, and Richard D. Braatz. A polynomial chaos approach to robust H_∞ static output-feedback control with bounded truncation error. *IEEE Transactions on Automatic Control*, 68(1):470-477, 2023. http://doi.org/10.1109/TAC.2022.3140275

An H_∞-optimal static output-feedback control design algorithm with rigorous robust stability guarantee is derived for linear time-invariant uncertain systems with probabilistic time-invariant parametric uncertainties.

314. Pavan K. Inguva and Richard D. Braatz. Efficient numerical schemes for multidimensional population balance models. *Comput Chem. Eng.*, 170:108095, 2023. https://doi.org/10.1016/j.compchemeng.2022.108095

Low-cost finite difference schemes are derived that employ specially constructed meshes and/or variable transformations to simulate classes of multidimensional population balance models that produce low to no numerical discretization errors.

315. Christopher T. Canova, Pavan K. Inguva, and Richard D. Braatz. Mechanistic modeling of viral particle production. *Biotechnology & Bioengineering*, 120:629-641, 2023. https://doi.org/10.1002/bit.28296

Mechanistic modeling strategies are reviewed for the production of viral particles, both at the cellular and bioreactor scales.

316. Anastasia Nikolakopoulou and Richard D. Braatz. Polynomial NARX-based nonlinear model predictive control of modular chemical systems. *Comput. Chem. Eng.*, 177:108272, 2023. https://doi.org/10.1016/j.compchemeng.2023.108272

A real-time nonlinear model-based control algorithm is proposed and demonstrated for the control of modular chemical systems.

317. Giacomo Galuppini, Marc D. Berliner, Daniel A. Cogswell, Debbie Zhuang, Martin Z. Bazant, and Richard D. Braatz. Nonlinear identifiability analysis of multiphase porous electrode theory-based battery models: A lithium iron phosphate case study. *Journal of Power Sources*, 573:233009, 2023. https://doi.org/10.1016/j.jpowsour.2023.233009

This first identifiability analysis is carried out for Multiphase Porous Electrode Theory-based models which identifies parameters that cannot be estimated from charge/discharge data, explains lack of identifiability in terms of battery physics, and proposes approaches for removing the lack of identifiability.

318. Joachim Schaeffer, Paul Gasper, Esteban Garcia-Tamayo, Raymond Gasper, Masaki Adachi, Juan Pablo Gaviria-Cardona, Simon Montoya-Bedoya, Anoushka Bhutani, Andrew Schiek, Rhys Goodall, Rolf Findeisen, Richard D. Braatz, and Simon Engelke. "Machine learning benchmarks for the classification of equivalent circuit models from solid state electrochemical impedance spectra," *J. Electrochem. Soc.*, 170:060512, 2023. https://doi.org/10.1149/1945-7111/acd8fb.

Machine learning methods are developed for classifying equivalent circuit models from electrochemical impedance data. Open-source software and data from over 9000 EIS measurements are released.

319. Francesco Destro, Prasanna Srinivasan, Joshua M. Kanter, Caleb Neufeld, Jacqueline M. Wolfrum, Paul W. Barone, Stacy L. Springs, Anthony J. Sinskey, Sylvain Cecchini, Robert M. Kotin, and Richard D. Braatz. Mechanistic modeling explains the production dynamics of recombinant adeno-associated virus with the baculovirus expression vector system. *Molecular Therapy – Methods and Clinical Development*, 30:P122-P146, 2023. https://doi.org/10.1016/j.omtm.2023.05.019

A mechanistic model is derived and validated that describes the key extracellular and intracellular phenomena occurring during the production of recombinant adeno-associated virus in the baculovirus expression system, and the model is used to provide insights on potential bottlenecks that limit the formation of full capsids.

320. Prakitr Srisuma, Ajinkya Pandit, Qihang Zhang, Moo Sun Hong, Janaka Gamekkanda, Fabio Fachin, Nathan Moore, Dragan Djordjevic, Michael Schwaerzler, Tolutola Oyetunde, Wenlong Tang, Allan S. Myerson, George Barbastathis, and Richard D. Braatz. Thermal imaging-based state estimation of a Stefan problem with application to cell thawing. *Comput. Chem. Eng.*, 173:108179, 2023. https://doi.org/10.1016/j.compchemeng.2023.108179

A thermal imaging-based system is designed for real-time estimation of the spatiotemporal progression of cell thawing in vials, which is the key step in cell therapy.

321. Prakitr Srisuma, George Barbastathis, and Richard D. Braatz. Analytical solutions for the modeling, optimization, and control of microwave-assisted freeze drying. *Comput. Chem. Eng.*, 177:108318, 2023. https://doi.org/10.1016/j.compchemeng.2023.108318

Exact and approximate analytical solutions for conductive and microwave-assisted freeze drying are derived and applied to parameter estimation, parameter space analysis, and optimal control.

322. Moo Sun Hong, Fabian Mohr, Chris D. Castro, Benjamin T. Smith, Jacqueline M. Wolfrum, Stacy L. Springs, Anthony J. Sinskey, Roger A. Hart, Tom Mistretta, and Richard D. Braatz. Smart process analytics for the end-to-end batch manufacturing of monoclonal antibodies. *Comput. Chem. Eng.*, 179:108445, 2023. https://doi.org/10.1016/j.compchemeng.2023.108445

Data-driven models are constructed for the prediction of product- and process-specific characteristics during the production of two different monoclonal antibodies, using a method that automatically selects the best data analytics/machine learning tools.

323. Giacomo Galuppini, Marc D. Berliner, Huada Lian, Debbie Zhuang, Martin Z. Bazant, and Richard D. Braatz. Efficient computation of safe, fast charging protocols for multiphase lithium-ion batteries: A lithium iron phosphate case study. *Journal of Power Sources*, 580:233272, 2023. https://doi.org/10.1016/j.jpowsour.2023.233272

A fast algorithm is developed for the computation of optimal charging protocols for multiphase lithium-ion batteries which has computational cost that is the same as that of a single battery simulation.

324. Alexis Geslin, Bruis van Vlijmen, Xiao Cui, Arjun Bhargav, Patrick A. Asinger, Richard D. Braatz, and William C. Chueh. Selecting the appropriate features in battery lifetime predictions. *Joule*, 7(9), 1956-1965, 2023. https://doi.org/10.1016/j.joule.2023.07.021

This article discusses many mistakes associated with information leadage that have been made in the literature on battery lifetime prediction.

325. Qihang Zhang, Janaka C. Gamekkanda, Ajinkya Pandit, Wenlong Tang, Charles Papageorgiou, Chris Mitchell, Yihui Yang, Michael Schwaerzler, Tolutola Oyetunde, Richard D. Braatz, Allan S. Myerson, and George Barbastathis. From laser speckle to particle size distribution in drying powders: A Physics-Enhanced AutoCorrelation-based Estimator (PEACE). *Nature Communications*, 14:1159, 2023. https://doi.org/10.1038/s41467-023-36816-2

A theoretical relationship is derived from the particle size distribution (PSD) to images of scattering patterns, which is used to develop a physics-enhanced autocorrelation-based estimator (PEACE) machine learning algorithm for measuring the PSD from images of a powder surface.

326. Hongbo Zhao, Haitao Dean Deng, Alexander E. Cohen, Jongwoo Lim, Yiyang Li, Dimitrios Fraggedakis, Benben Jiang, Brian D. Storey, William C. Chueh, Richard D. Braatz, and Martin Z. Bazant. Learning heterogeneous reaction kinetics from X-ray movies pixel-by-pixel. *Nature*, 621(7978):289-294, 2023. https://doi.org/10.1038/s41586-023-06393-x

Heterogeneous reaction kinetics are learned from in-operando scanning transmission X-ray microscopy images of lithium iron phosphate nanoparticles undergoing driven phase transformations.

327. Utkarsh Utkarsh, Valentin Churavy, Yingbo Ma, Tim Besard, Prakitr Srisuma, Tim Gymnich, Adam R. Gerlach, Alan Edelman, George Barbastathis, Richard D. Braatz, and Christopher Rackauckas. Automated translation and accelerated solving of differential equations on multiple GPU platforms. *Computer Methods in Applied Mechanics and Engineering*, 419:11659, 2024. https://doi.org/10.1016/j.cma.2023.116591

An open-source software is developed for massively parallel solving of ensembles of ordinary differential equations and stochastic differential equations on GPUs, which supports event handling, automatic differentiation, and incorporation of datasets via the GPU's texture memory.

328. Jinwook Rhyu, Dragana Bozinovski, Alexis B Dubs, Naresh Mohan, Elizabeth M. Cummings Bende, Andrew J. Maloney, Miriam Nieves, Jose Sangerman, Amos E. Lu, Moo Sun Hong, Anastasia Artamonova, Rui Wen Ou, Paul W. Barone, James C. Leung, Jacqueline M Wolfrum, Anthony J. Sinskey, Stacy L. Springs, and Richard D. Braatz. Automated outlier detection and estimation of missing data. Comput. Chem. Eng., 180:108448, 2024. https://doi.org/10.1016/j.compchemeng.2023.108448

An approach is proposed for automatically detecting outliers and estimating missing data using various general-purpose algorithms while reducing the impact of outliers.

329. J. Schaeffer, E. Lenz, W. C. Chueh, M. Z. Bazant, R. Findeisen, and R. D. Braatz. Interpretation of high-dimensional linear regression: Effects of nullspace and regularization demonstrated on battery data. *Comput. Chem. Eng.*, 180:108471, 2024. https://doi.org/10.1016/j.compchemeng.2023.108471

A nullspace perspective is proposed that informs the building of interpretable regression models on high-dimensional data.

330. Fabian Mohr, Moo Sun Hong, Chris D. Castro, Benjamin T. Smith, Jacqueline M. Wolfrum, Stacy L. Springs, Anthony J. Sinskey, Roger A. Hart, Tom Mistretta, and Richard D. Braatz.

Tensorial approaches combining time series and batch data for the end-to-end batch manufacturing of monoclonal antibodies. *Comput. Chem. Eng.*, 182:108557, 2024. https://doi.org/10.1016/j.compchemeng.2023.108557.

Algorithms are developed that combine second- and third-order tensorial analytics to construct preditive models of higher predictive accuracy by taking batch-to-batch correlations into account.

331. P. Srisuma, G. Barbastathis, and R. D. Braatz. Mechanistic modeling and analysis of thermal radiation in conventional, microwave-assisted, and hybrid freeze drying for biopharmaceutical manufacturing. *International Journal of Heat and Mass Transfer*, 221:125023, 2024. https://doi.org/10.1016/j.ijheatmasstransfer.2023.125023

A new mechanistic model is developed and validated that describes complex thermal radiation during primary drying in conventional, microwave-assisted, and hybrid freeze drying.

332. G. Galuppini, M. D. Berliner, H. Lian, D. Zhuang, M. Z. Bazant, and R. D. Braatz. Efficient computation of robust, safe, fast charging protocols for lithium-ion batteries. *Control Engineering Practice*, 145:105856, 2024. https://doi.org/10.1016/j.conengprac.2024.105856

A stochastic optimal control approach is proposed for the efficient computation of safe, fast charging protocols that explicitly accounts for parametric uncertainties affecting the battery model and guarantees probabilistically robust constraint satisfaction.

333. Maria del Carme Pons Royo, Jing Guo, Vivekananda Bal, Moo Sun Hong, Paul W. Barone, Stacy L. Spring, Anthony J. Sinskey, Torsten Stelzer, Bernhardt L. Trout, Allan S. Myerson, and Richard D. Braatz. Advances in crystallization and precipitation technologies for biotherapeutics. SBE Special Section on Engineering Biotherapeutics, *Chem. Eng. Prog.*, 25-31, May 2024 (invited).

Advances are described in crystallization and precipitation technologies for the manufacturing of monoclonal antibodies and gene therapy products.

334. Gerrit Ipers, Junning Jiao, Shakul Pathak, Ruqing Fang, Marc D. Berliner, Wei Li, Weihan Li, Richard D. Braatz, Martin Z. Bazant, and Juner Zhu. Rapid simulation of electro-chemo-mechanical deformation of Li-ion batteries based on porous electrode theory. *J. Electrochem. Soc.*, 171(5): 050557, 2024. https://doi.org/10.1149/1945-7111/ad4f1e

A porous electrode theory-based model of the deformation of Li-ion batteries is implemented in PETLION and shown to capture the reversible thickness change caused by Li-ion (de-)intercalation and the irreversible thickness change due to the rearrangement and consolidation of particles.

335. S. H. Kim, M. S. Hong, and R. D. Braatz. Investigation of particle flow effects in slug flow crystallization using the multiscale computational fluid dynamics simulation. *Chem. Eng. Sci.*, 297:120238, 2024. https://doi.org/10.1016/j.ces.2024.120238

A multi-scale model is developed for simulating the gas-liquid-solid multiphase flow that occurs during slug-flow crystallization.

336. Giacomo Galuppini, Qiaohao Liang, Prabhakar A. Tamirisa, Jeffrey A. Lemmerman, Melani G. Sullivan, Michael J. M. Mazack, Partha M. Gomadam, Martin Z. Bazant, and Richard D. Braatz. Improving diagnostics and prognostics of implantable cardioverter defibrillator batteries with

interpretable machine learning models. *Journal of Power Sources*, 610:234668, 2024. https://doi.org/10.1016/j.jpowsour.2024.234668

A machine learning approach is proposed that predicts the performance of lithium batteries used in Medtronic Implantable Cardioverter Defibrillators and Cardiac Resynchronization Therapy Defibrillators while providing clues on how to improve battery design and production.

337. En Ze Linda Zhong-Johnson, Ziyue Dong, Christopher T. Canova, Francesco Destro, Marina Cañellas, Mikaila C. Hoffman, Jeanne Maréchal, Timothy M. Johnson, Gabriela S. Schlau-Cohen, Maria Fátima Lucas, Richard D. Braatz, Kayla G. Sprenger, Christopher A. Voigt, and Anthony J. Sinskey. Analysis of poly(ethylene terephthalate) degradation kinetics of evolved *Is*PETase variants using a surface crowding model. *Journal of Biological Chemistry*, 300(3):105783, 2024. https://doi.org/10.1016/j.jbc.2024.105783

A macromolecular crowding-based biochemical model is developed and used to analyze the effects of mutations on the properties of PETases and show that crowding behavior should be targeted for enzyme engineering for improved PET degradation.

338. Nathan Merica Stover, Krystian Kamil Ganko, and Richard D. Braatz. Mechanistic modeling of in vitro transcription incorporating effects of magnesium pyrophosphate crystallization. *Biotechnology & Bioengineering*, 121(9):2636-2647, 2024. https://doi.org/10.1002/bit.28699

The first mechanistic model of in vitro transcription is developed that includes nucleation and growth of magnesium pyrophosphate crystals and subsequent agglomeration of crystals and DNA.

339. P. Seber and R.D. Braatz. Recurrent neural network-based prediction of O-GlcNAcylation sites in mammalian proteins. *Comput. Chem. Eng.*, 189:108818, 2024. https://doi.org/10.1016/j.compchemeng.2024.108818

Machine learning models are constructed for predicting the presence of O-GlcNAcylation based on protein sequences that are two-fold more effective than previous models.

340. Qiaohao Liang, Giacomo Galuppini, Partha M. Gomadam, Prabhakar A. Tamirisa, Jeffrey A. Lemmerman, Michael J. M. Mazack, Melani G. Sullivan, Richard D. Braatz, and Martin Z. Bazant. Physics-based modeling of pulse and relaxation of high-rate Li/CF_x-SVO batteries in implantable medical devices. *Journal of Power Sources*, 610:234671, 2024. https://doi.org/10.1016/j.jpowsour.2024.234671

A physics-based model is developed that accurately predicts the performance of Medtronic's implantable medical device battery, lithium/carbon monofluoride (CF) - silver vanadium oxide (SVO), under both low-rate background monitoring and high-rate pulsing currents.

341. Francesco Destro, Pavan K. Inguva, Prakitr Srisuma, and R. D. Braatz. Advanced methodologies for model-based optimization and control of pharmaceutical processes. *Current Opinion in Chemical Engineering*, 45:101035, 2024 (invited). https://doi.org/10.1016/j.coche.2024.101035

This perspective discusses recent advances in model-based optimization, state estimation, and control of (bio)pharmaceutical processes.

342. D. Zhuang, M. L. Li, V. K. Lam, R. D. Braatz, W. C. Chueh, and M. Z. Bazant. Physics-informed design of Hybrid Pulse Power Characterization (HPPC) tests for rechargeable batteries. *J. Electrochem. Soc.*, 171(5):050510, 2024. http://doi.org/10.1149/1945-7111/ad4394

A physics-based theoretical framework for HPPC tests is developed which accurately determines kinetic parameters that capture root causes of battery degradation.

343. Minsu Kim, Joachim Schaeffer, Marc D. Berliner, Berta Pedret Sagnier, Martin Z. Bazant, Rolf Findeisen, and Richard D. Braatz. Fast charging of lithium-ion batteries while accounting for degradation and cell-to-cell variability. *J. Electrochem. Soc.*, 171(9):090517, 2024. https://doi.org/10.1149/1945-7111/ad76dd.

A method is proposed for the optimal design of fast charging protocols for lithium-ion batteries while accounting for cell-to-cell variability and battery degradation.

344. Prakitr Srisuma, George Barbastathis, and Richard D. Braatz. Real-time estimation of bound water concentration during lyophilization with temperature-based state observers. *Int. J. Pharmaceutics*, 665:124693, 2024. https://doi.org/10.1016/j.ijpharm.2024.124693

A method is developed for the real-time estimation of the residual moisture during water during secondary drying in lyophilization, without requiring any online concentration measurement.

345. Shimin Wang, Martin Guay, and Richard D. Braatz. Extremum-seeking regulator for a class of nonlinear systems with unknown control direction. *IEEE Transactions on Automatic Control*, 69(12): 8931-8937, 2024. http://doi.org/10.1109/TAC.2024.3426890

The robust output regulation problem is solved for a class of nonlinear dynamical systems subject to unknown control direction, with stability proven by using a Lye bracket averaging technique.

346. Qihang Zhang, George Barbastathis, Ajinkya Pandit, Zhiguang Liu, Zhen Guo, Shashank Muddu, Yi Wei, Deborah Pereg, Neda Nazemifard, Charles Papageorgiou, Yihui Yang, Wenlong Tang, Richard D. Braatz, and Allan S. Myerson. Non-invasive estimation of the powder size distribution from a single speckle image. *Light: Science & Applications*, 13(1):200, 2024. https://doi.org/10.21203/rs.3.rs-4082496/v1

A method is developed for the non-invasive estimation of the particle size distribution of a powder based on speckle imaging that requires less than one second per measurement.

347. Jinwook Rhyu, Debbie Zhuang, Martin Z. Bazant, and Richard D. Braatz. Optimum model-based design of diagnostics experiments (DOE) with hybrid pulse power characterization (HPPC) for lithium-ion batteries. *J. Electrochem. Soc.*, 171(7):070544, 2024. https://doi.org/10.1149/1945-7111/ad63ce

We design and validate a set of efficient optimal hybrid pulse power characterization (HPPC) diagnostics using model-based design of experiment (DOE) methods, applying knowledge of degradation effects on pulse kinetics and cell properties.

348. Francesco Destro, Weida Wu, Prasanna Srinivasan, John Joseph, Vivekananda Bal, Caleb Neufeld, Jacqueline M. Wolfrum, Scott R. Manalis, Anthony J. Sinskey, Stacy L. Springs, Paul W. Barone, and Richard D. Braatz. The state of technological advancement to address challenges

in the manufacture of rAAV gene therapies. *Biotechnology Advances*, 76:108433, 2024. https://doi.org/10.1016/j.biotechadv.2024.108433

We describe the state of the art in the manufacturing of rAAV gene therapies, including a review of advances published by the Braatz group over the previous ~5 years.

349. Francesco Destro and Richard D. Braatz. Efficient simulation of viral transduction and propagation for biomanufacturing. *ACS Synthetic Biology*, 13(10):3173-3187, 2024.

Computationally efficient multiscale modeling software is released for determining genetic and process designs that optimize transduction-based biomanufacturing platforms and viral amplification processes.

350. Prasanna Srinivasan, Christopher T. Canova, Sha Sha, Tam N. T. Nguyen, John Joseph, Jose Sangerman, Andrew J. Maloney, Georgios Katsikis, Rui Wen Ou, Moo Sun Hong, Jaclyn Ng, Arella Yuan, Daniel Antov, Sally Song, Wenyu Chen, Caleb Neufeld, Jacqueline M. Wolfrum, Paul W. Barone, Anthony J. Sinskey, Stacy L. Springs, and Richard D. Braatz. Multidose transient transfection of human embryonic kidney 293 cells modulates recombinant adeno-associated virus2/5 Rep protein expression and influences the enrichment fraction of filled capsids. *Biotechnology & Bioengineering*, 121(12):3694-3714, 2024. https://doi.org/10.1002/bit.28828

This study experimentally validates predictions from our mechanistic modeling that the proportion of filled AAV capsids can be increased during triple transient transfection-based production by multiple dosing.

351. Joachim Schaeffer, Eric Lenz, Duncan Gulla, Martin Z. Bazant, Richard D. Braatz, and Rolf Findeisen. Gaussian process-based online health monitoring and fault analysis of lithium-ion battery systems from field data. *Cell Reports Physical Science*, 5(11):102258, November 20, 2024. https://doi.org/10.1016/j.xcrp.2024.102258

We develop probabilistic fault detection rules using recursive spatiotemporal Gaussian processes and apply to field data for 28 battery systems to provide further the understanding of how battery packs degrade and fail in the field.

352. Cedric Devos, Saikat Mukherjee, Pavan Inguva, Shalini Singh, Yi Wei, Sandip Monda, Huiwen Yu, George Barbastathis, Torsten Stelzer, Richard D. Braatz, and Allan S. Myerson. Impinging jet mixers: A review of their mixing characteristics, performance considerations, and applications. *AIChE Journal*, 71(1):e18595, 2025. http://doi.org/10.1002/aic.18595

This review provides a comprehensive overview of research related to impinging jet mixers, with an emphasis on the mixing characteristics and the influence of design and process parameters on the mixing performance.

353. Fabian Mohr, Elia Arnese Feffin, Massimliano Barolo, and Richard D. Braatz. Smart Process Analytics for Process Monitoring. *Comput. Chem. Eng.*, 194:108918, 2025. https://doi.org/10.1016/j.compchemeng.2024.108918

Algorithms and software are developed for automatically selecting the data analytics/machine learning method for process monitoring, based on the data characteristics.

354. P. Seber and R.D. Braatz. Linear and neural network models for predicting N-glycosylation in Chinese Hamster Ovary cells based on B4GALT levels. *Comput. Chem. Eng.*, 194:108937, 2025. https://doi.org/10.1101/2023.04.13.536762

This article constructs a neural network model for the prediction of the distribution of glycans on N-glycosylation sites that has 10-fold smaller median prediction error than previous models.

355. Mona A. Kanso, Shalini Singh, Alan J. Giacomin, and Richard D. Braatz. Rheology of mRNA-loaded lipid nanodumbbells. *Physics of Fluids*, 37(2): 023109, 2025. https://doi.org/10.1063/5.0251449

Analytical expressions are derived for the relaxation time, rotational diffusivity, zero-shear viscosity, shear stress relaxation function, steady-shear viscosity, and both the viscous part and minus the elastic part of the complex viscosity for mRNA-loaded lipid nanoparticles.

356. Seokyoung Hong, Krishna Gopal Chattaraj, Jing Guo, Bernhardt L Trout, and Richard D Braatz. Enhanced O-glycosylation site prediction using explainable machine learning technique with spatial local environment. *Bioinformatics*, 41(2): btaf034, 2025. https://doi.org/10.1093/bioinformatics/btaf034

The prediction of O-GlcNAcylation sites on proteins is improved by employing an explainable machine learning technique that takes 3D spatial information around the target site into account.

357. Liang Wu and Richard D. Braatz. A direct optimization algorithm for input-constrained MPC. *IEEE Transactions on Automatic Control*, 70(2):1366-1373, 2025. https://doi.org/10.1109/TAC.2024.3463529

An algorithm is derived that certifies the on-line execution time of linear model predictive control (MPC), nonlinear MPC (via online linearized schemes), and adaptive MPC.

358. Shimin Wang, Martin Guay, Zhiyong Chen, and Richard D. Braatz. A nonparametric learning framework for nonlinear robust output regulation. *IEEE Transactions on Automatic Control*, 70(4): 2134-2149, 2025. https://doi.org/10.1109/TAC.2024.3470065

A method is developed for the design of robust output regulators for nonlinear dynamical systems that guarantees convergence of the estimation and tracking error even when the underlying controlled system dynamics are complex or poorly understood.

359. Jayprakash Yadav, Shihab Uddin, Francesco Civati, Wenchuan Ma, Andreas Liebminger, Wolfgang Teschner, Guillaume André, Bernhardt L. Trout, Richard D. Braatz, and Allan S. Myerson. Developing ultra-high concentration formulations of human immune globulins for subcutaneous injectables. *Journal of Pharmaceutical Sciences*, 114(3):1605-1614, 2025. https://doi.org/10.1016/j.xphs.2025.01.028

A high-concentration suspension-based formulation of human immune globulins is developed via spray drying.

360. Joachim Schaeffer, Jinwook Rhyu, Robin Droop, Rolf Findeisen, and Richard D. Braatz Interpretation of high-dimensional regression coefficients by comparison with linearized compressing features. *Comput. Chem. Eng.*, 198:109009, 2025. https://doi.org/10.1016/j.compchemeng.2025.109099

A method is developed an approach for understanding the relationships between nonlinear features and high-dimensional functional data.

361. Maria del Carme Pons Royo, Tyler Arnold, Isabella Perez Rodriguez, Nicole Ostrovsky, Mushriq Al-Jazrawe, Andrew Hatas, Vico Tenberg, Allan S. Myerson, and Richard D. Braatz. Purification of messenger RNA directly from crude IVT using polyethylene glycol and NaCl precipitation. *Process Biochemistry*, 156:263-273, 2025. https://doi.org/10.1016/j.procbio.2025.06.002

A rapid and efficient precipitation-based method for messenger RNA capture and purification from crude in vitro transcription material is described that provides high yield and purity.

362. Cedric Devos, Aniket Udepurkar, Peter Sagmeister, Ariana S. Hodlewsky, Julie Chen, Andrew Hatas, Nicole Ostrovsky, Mushriq Al-Jazrawe, Joy I. Ren, Andy Y. Liu, Richard D. Braatz, and Allan S. Myerson. Manufacturing mRNA-loaded lipid nanoparticles with precise size and morphology control. *ACS Nano*, 19(38):33991-34002, 2025. https://doi.org/10.1021/acsnano.5c09800

We develop a novel process for the manufacturing of mRNA-loaded lipid nanoparticles in which the size and morphology are precisely controlled.

363. Bruis van Vlijmen, Vivek Lam, Patrick A. Asinger, Xiao Cui, Devi Ganapathi, Shijing Sun, Patrick K. Herring, Chirranjeevi Balaji Gopal, Natalie Geise, Haitao D. Deng, Henry L. Thaman, Stephen Dongmin Kang, Amalie Trewartha, Abraham Anapolsky, Brian D. Storey, William E. Gent, Richard D. Braatz, and William C. Chueh. Interpretable data-driven modeling reveals complexity of battery aging. ChemRxiv, http://doi.org/10.26434/chemrxiv-2023-zdl2n-v2

Interpretable machine learning is applied to a diverse battery cycling dataset is published with a broad range of degradation trajectories, consisting of 363 high-energy-density commercial Li(Ni,Co,Al)O/Graphite + SiO cylindrical 21700 cells cycled under 218 unique cycling protocols.

364. Tam N. T. Nguyen, Damdae Park, Christopher T. Canova, Jose Sangerman, Prasanna Srinivasan, Rui Wen Ou, Georgios Katsikis, Moo Sun Hong, Paul W. Barone, Caleb Neufeld, Jacqueline M. Wolfrum, Stacy L. Springs, Anthony J. Sinskey, and Richard D. Braatz. Perfusion-based production of rAAV via an intensified transient transfection process. *Biotechnol. Bioeng.*, 122(6):1424-1440, 2025. https://doi.org/10.1002/bit.28967

A mechanistic model that we developed is used to design and experimentally validate an intensified process for rAAV production that combines perfusion with high cell density re-transfection.

365. Prakitr Srisuma, George Barbastathis, and Richard D. Braatz. Simulation-based approach for fast optimal control of a Stefan problem with application to cell therapy. *Automatica*, 179:112398, 2025. https://doi.org/10.1016/j.automatica.2025.112398

A new efficient way is developed for finding control and state trajectories in optimal control problems by transformation into a system of differential-algebraic equations (DAEs), and applies the approach to a cell therapy application.

366. Vivekananda Bal, Moo Sun Hong, Jacqueline M. Wolfrum, Paul W. Barone, Stacy L. Springs, Anthony J. Sinskey, Robert M. Kotin, and Richard D. Braatz. An integrated experimental and

modeling approach for crystallization of complex biotherapeutics. *Cryst. Growth Des.*, 25(11): 3687-3696, 2025. https://doi.org/10.1021/acs.cgd.4c01720

Coupled population balance and species balance equations are developed to extract nucleation and growth kinetics for crystallization of recombinant adeno-associated virus (rAAV) capsids.

367. Jinwook Rhyu, Joachim Schaeffer, Michael L. Li, Xiao Cui, William C. Chueh, Martin Z. Bazant, and Richard D. Braatz. Systematic feature design for cycle life prediction of lithium-ion batteries during formation. *Joule*, 9(5):101884, 2025. https://doi.org/10.1016/j.joule.2025.101884

A systematic feature design framework is proposed that requires minimal domain knowledge for accurate cycle life prediction during the formation step for lithium-ion batteries.

368. Liang Cao, Jingyi Wang, Jianping Su, Yi Luo, Yankai Cao, and Richard D. Braatz. Comprehensive analysis on machine learning approaches for interpretable and stable soft sensors. *IEEE Transactions on Instrumentation and Measurement*, 74:9517217, 2025. https://doi.org/10.1109/TIM.2025.3556830

A comprehensive review and analysis of machine learning-based approaches for the design of interpretable and stable soft sensor models.

369. Yingjie Ma, Jing Guo, Andrew J. Maloney, and Richard D. Braatz. Quasi-steady-state approach for efficient multiscale simulation and optimization of mAb glycosylation in CHO cell culture. *Chem. Eng. Sci.*, 318:122162, 2025. https://doi.org/10.1016/j.ces.2025.122162

A computationally efficient numerical algorithm is proposed for the multiscale mechanistic modeling of glycosylation for monoclonal antibodies.

370. Steven J. Burcat, Rohan P. Kadambi, Lorenzo Stratta, Richard D. Braatz, Roberto Pisano, Bernhardt L. Trout, and Alexander Slocum. Vacuum compatible spring wire system for mass measurement of vials during lyophilization. *Precision Engineering*, 96:729-744, 2025. https://doi.org/10.1016/j.precisioneng.2025.07.007

A sensor is invented that measures the mass of each individual vial throughout the lyophilization process, allowing tracking of the sublimitation rate during lyophilization.

371. Steven J. Burcat, Rohan P. Kadambi, Lorenzo Stratta, Richard D. Braatz, Roberto Pisano, and Alexander H. Slocum, and Bernhardt L. Trout. Forced gas convection for uniform freezing of lyophilization vials. *Journal of Pharmaceutical Innovation*, 20(4):153, 2025. https://doi.org/10.1007/s12247-025-10037-0

A forced gas convective freezing chamber is designed for continuous lyophilization in suspended vials in cross-flow that improves reduces vial-to-vial variations during freezing.

372. Giovanni Aprile, Cedric Devos, Thomas Vetter, Gerard Capellades, Kevin P. Girard, Christopher L. Burcham, Venkateswarlu Bhamidi, Daniel Green, Torsten Stelzer, Richard D. Braatz, and Allan S. Myerson. Reflecting on barriers to continuous pharmaceutical crystallization. *Nature Chem. Eng.*, 2:520-523, 2025. https://doi.org/10.1038/s44286-025-00268-w

This commentary discusses why continuous crystallization, despite its success in other industries, has been underutilized in pharmaceutical manufacturing.

373. Sunkyu Shin, Cedric Devos, Aniket Pradip Udepurkar, Pavan K. Inguva, Allan S. Myerson, Richard D Braatz. Mechanistic modeling of lipid nanoparticle (LNP) precipitation via population balance equations (PBEs). *Chemical Engineering Journal*, 523:167786, 2025. https://doi.org/10.1016/j.cej.2025.167786

A mechanistic model for lipid nanoparticle (LNP) fabrication is developed based on population balance equations (PBEs) that reproduces the experimentally measured particle size distributions (PSDs).

374. Huiwen Yu, Prakitr Srisuma, Cedric Devos, Jie Wang, Allan S. Myerson, and Richard D. Braatz. Hyperspectral imaging techniques for lyophilization: Advances in data-driven modeling strategies and applications. *Advanced Science*, 12(33):e08506, 2025. https://doi.org/10.1002/advs.202508506

This article reviews and discusses the literature on the application of hyperspectral imaging on lyophilization, and the strategies that use the resulting data to build models.

375. Mohammed Aatif Shahab, Nathan Merica Stover, Hasan Al-Mahayni, Prakitr Srisuma, Jie Wang, Sunkyu Shin, Anish Dighe, Bernhardt L. Trout, Allan S. Myerson, and Richard D. Braatz. End-to-end digital twin software for continuous mRNA manufacturing. *International Journal of Pharmaceutics*, 686:126301, 2025. https://doi.org/10.1016/j.ijpharm.2025.126301

Digital twin software is developed for end-to-end continuous manufacturing of mRNA therapeutics.

376. Vivekananda Bal, Jacqueline M. Wolfrum, Paul W. Barone, Stacy L. Springs, Anthony J. Sinskey, Robert M. Kotin, and Richard D. Braatz. Selective enrichment of full AAV capsids. *ACS Nano*, 19(40):35348-35369, 2025. https://doi.org/10.1021/acsnano.5c00566

A selective crystallization method is invented for the purification of full AAV capsids that is highly efficient, highly scalable, and economical, and improves product quality.

377. Pavan K. Inguva, Saikat Mukherjee, Pierre J. Walker, Mona A. Kanso, Jie Wang, Yanchen Wu, Vico Tenberg, Srimanta Santra, Shalini Singh, Shin Hyuk Kim, Bernhardt L. Trout, Martin Z. Bazant, Allan S. Myerson, and Richard D. Braatz. Mechanistic modeling of lipid nanoparticle formation for the delivery of nucleic acid therapeutics. *Biotechnology Advances*, 84:108643, 2025. https://doi.org/10.1016/j.biotechadv.2025.108643

This article describes strategies for the mechanistic modeling of the highly nonideal thermodynamics and the kinetic, transport, and particle phenomena that occur during lipid nanoparticle formation, spanning from the subatomic to the intraparticle, interparticle, micromixing, and macromixing length scales.

378. Maria del Carme Pons Royo, Tyler Arnold, Isabella Perez Rodriguez, Nicole Ostrovsky, Mushriq Al-Jazrawe, Andrew Hatas, Allan S. Myerson, and Richard D. Braatz. Continuous purification of mRNA by precipitation and sequential TFF. *Separation and Purification Technology*, 379(1):134837, 2025. https://doi.org/10.1016/j.seppur.2025.134837

A low-cost, high-yield, fully continuous precipitation-based method is developed for mRNA purification.

379. Wallace Gian Yion Tan, Krystian K. Ganko, Srimanta Santra, Matthias von Andrian, and Richard D. Braatz. Offset-free stochastic quadratic dynamic matrix control formulations using polynomial

chaos expansions. *Control Engineering Practice*, 165:106514, 2025. https://doi.org/10.1016/j.conengprac.2025.106514

Stochastic model predictive control methods are developed that have zero offset and low on-line computational cost for linear dynamical systems of arbitrarily high state dimension, while being robust to probabilistic uncertainties.

380. Prakitr Srisuma, Gang Chen, and Richard D. Braatz. Mechanistic modeling of continuous lyophilization for biopharmaceutical manufacturing. *Advanced Science*, 12(47):e11693, 2025. https://doi.org/10.1002/advs.202511693

This article presents the first mechanistic model for a complete continuous lyophilization process, which comprehensively incorporates and describes key transport phenomena in all three steps of lyophilization, and applies the model to process design and optimization.

381. Sunkyu Shin, Cedric Devos, Aniket Pradip Udepurkar, Pavan K. Inguva, Allan S. Myerson, and Richard D. Braatz. Mechanistic modeling of lipid nanoparticle (LNP) precipitation via population balance equations (PBEs). *Chemical Engineering Journal*, 523, 167786, 2025. https://doi.org/10.1016/j.cej.2025.167786

A population balance equation (PBE)-based model is developed that captures the evolution of the particle size distribution (PSD) during LNP fabrication, to provide mechanistic insight into how kinetic processes control LNP size.

382. Etienne Boulais, Aniket Udepurkar, Cedric Devos, Martin Z. Bazant, Allan S. Myerson, and Richard D. Braatz. Steady advection-diffusion in polygonal microfluidic mixers. *Journal of Fluid Mechanics*, 1024:A36, 2025. https://doi.org/10.1017/jfm.2025.10840

Analytical solutions are derived for both flow and concentration profiles everywhere in microfluidic mixers with arbitrary numbers of inlets.

383. Marc D. Berliner, Minsu Kim, Xiao Cui, Vivek N. Lam, Patrick A. Asinger, Martin Z. Bazant, William C Chueh, Richard D, Braatz. Bayesian analysis of interpretable aging across thousands of lithium-ion battery cycles. *eTransportation*, 26:100486, 2025. https://doi.org/10.1016/j.etran.2025.100486

This work proposes an approach for the diagnosis of the aging of lithium-ion batteries by predicting the trajectories of the diffusion coefficients and reaction rate constants of the electrodes, and demonstrates the approach Tesla Model 3 cells with a nickel cobalt aluminum oxide (NCA) cathode and silicon oxide–graphite anode.

384. Nathan Merica Stover, Soroush Ahmadi, Jacob Rosenfeld, Francesco Destro, Allan S. Myerson, and Richard D. Braatz. Model-based optimization of fed-batch in vitro transcription. *ChemBioChem*, 26(21):e202500485, 2025. https://doi.org/10.1002/cbic.202500485

A mechanistic model for fed-batch IVT is developed and used to design optimized fed-batch protocols to maximize the formation of RNA while controlling concentrations of nucleoside triphosphates.

385. Elia Arnese-Feffin, Birgit Braun, Nidhish Sagar, Ivan Castillo, Luis A. Briceno-Mena, Caterina Rizzo, Jinsou Xu, Leo H. Chiang, Linh Bui, and Richard D. Braatz. The incorporation of

qualitative knowledge in hybrid modeling. *Comput. Chem. Eng.*, 205(Part 2):109484, 2026. https://doi.org/10.1016/j.compchemeng.2025.10948

A systematic approach is developed for incorporating qualitative and quantitative knowledge into the building of data-driven models.

386. Mateo Arcila-Osorio, Francesco Destro, Carlos Ocampo-Martinez, Jordi Llorca, and Richard Braatz. A benchmark simulator for advanced control of ethanol steam reforming. *Renewable Energy*, 256(Part I):124743, 2026. https://doi.org/10.1016/j.renene.2025.124743

A nonlinear dynamic simulator is developed for an ethanol steam reforming process designed for pure hydrogen production for fuel-cell applications.

387. Elia Arnese-Feffin and Richard D. Braatz. Common pitfalls in machine learning. *Chem. Eng. Prog.*, January 2026.

Common pitfalls that commonly occur when applying machine learning are summarized and best practices which do not run into those pitfalls are described.

388. Maria del Carme Pons Royo, Vico Tenberg, Torsten Stelzer, Allan S. Myerson, and Richard D. Braatz. Continuous precipitation of biotherapeutics: A review. *ChemBioEng Reviews*, 13(1):e70040, 2026. https://doi.org/10.1002/cben.70040

This review discusses the critical factors, key design elements, application examplesm, and promising future directions for the continuous precipitation-based capture and purification of biotherapeutics.

389. Nathan Merica Stover, Marieke De Bock, Julie Chen, Jacob Rosenfeld, Maria del Carme Pons Royo, Allan S. Myerson, and Richard D. Braatz. Systems analysis of the kinetics of in vitro transcription from interactions of T7 RNA polymerase and DNA. *Archives of Biochemistry and Biophysics*, 110737, 2026. https://doi.org/10.1016/j.abb.2026.110737

A kinetic method is developed and analytized for the in vitro transcription (IVT) system that incorporates the steps of promoter binding, initiation, and elongation.

390. Yingjie Ma, Jing Guo, Alexis B. Dubs, Krystian K. Ganko, and Richard D. Braatz. Adaptive nonlinear model predictive control of monoclonal antibody glycosylation in CHO cell culture. 169:106731, 2026. https://doi.org/10.1016/j.conengprac.2025.106731

An adaptive nonlinear model predictive control (ANMPC) framework is developed for the control of glycosylation in the fed-batch production of monoclonal antibodies, using a multiscale model that links extracellular conditions to intracellular Golgi reactions to predict glycan profiles.

391. Yunhong Che, Yusheng Zheng, Jinwook Rhyu, Jia Guo, Shimin Wang, Remus Teodorescu, and Richard D. Braatz. Mechanistically guided residual learning for battery state monitoring throughout life. *Nature Communications*, 17: 855, 2026. https://doi.org/10.1038/s41467-025-67565-z

Mechanistic leading residual learners are developed to enhance the monitoring of battery charge and health states, as well as guide safety warnings.

392. Bernhardt L. Trout, Steven J. Burcat, Rohan P. Kadambi, Lorezno J. Stratta, Richard D. Braatz, Roberto Pisano, and Alexander H. Slocum. Continuous lyophilization of suspended vials with per-vial online analytics. *Journal of Pharmaceutical Sciences*, 115(2):104157, 2026. https://doi.org/10.1016/j.xphs.2026.104157

Continuous lyophilization is achieved with magnetically levitated trays moving through partitioned process zones with integrated mass and temperature sensing.

393. Etienne Boulais and Richard D. Braatz. Radial variations in residence time distribution for pipe flows. *Physics of Fluids*, 38:012006, 2026. https://doi.org/10.1063/5.0307692

We use Monte Carlo simulations to quantify the difference in age at differential radial positions for suspensions of low-diffusing particles in pipe flows, and show the existence of two different regimes: a "transitional" regime where delay compounds with channel length and a "far-field" regime where diffusion counterbalances advection.

394. Liang Wu, Wei Xiao, and Richard D. Braatz. EIQP: Execution-time-certified and infeasibility-detecting QP solver. *IEEE Transactions on Automatic Control*, final files submitted November 2025. http://doi.org/10.1109/TAC.2025.3631575

An infeasible-path interior point algorithm is proposed that has the best theoretical iteration complexity, which provides guarantees that model predictive control calculations converge in real time within the available control hardware.

395. Yingjie Ma, Jing Guo, and Richard D. Braatz. GlycoPy: An equation-oriented and object-oriented software for hierarchical modeling, optimization, and control in Python. Under review. https://arxiv.org/abs/2601.01413

An equation-oriented, object-oriented software framework is developed for process modeling, optimization, and nonlinear model predictive control of glycosylation.

396. Liang Wu, Yunhong Che, Richard D Braatz, Jan Drgona. A Time-certified Predictor-corrector IPM Algorithm for Box-QP. *IEEE Control Systems Letters*, in press December 24, 2025. http://doi.org/10.1109/LCSYS.2025.3647842

A predictor-corrector interior-point algorithm is developed that has $O(n^{1/2})$ iteration complexity while achieving a five-fold speedup over the most closely related method.

E. Patents/Technology Disclosures

1. R. D. Braatz and J. G. VanAntwerp. Fast Model Predictive Ellipsoid Control Process, U.S. Patent #6,064,809, May 16, 2000.

A robust model predictive control algorithm is invented with low computational expense, referenced by many patents including U.S. Patent 6,289,490 filed by Stephen Boyd of Stanford and 6,381,505 and 6,714,899 filed by Dean Kassmann of Aspen Technology, Inc.

2. E. G. Seebauer, R. D. Braatz, M. Y. L. Jung, and R. Gunawan. Methods for Controlling Dopant Concentration and Activation in Semiconductor Structures, U.S. Patent #7,846,822, December 7, 2010. **130+ citations**

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Injection modeling technology is invented for coating pharmaceutical tablets.

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Machine learning methods are described for the accurate prediction of battery lifetime based on the initial cycling data.

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140. R. D. Braatz. Emerging problems in integrated biomedical microsystems. *Special Session on Modeling and Control of Micro and Nanosystems*, *American Control Conference*, St. Louis, MO, June 2009.
141. M. Kishida and R. D. Braatz. Optimal 3D spatial field control of nonlinear spatially distributed systems with state feedback. *IFAC Workshop on Control of Distributed Parameter Systems*, Toulouse, France, July 20-24, 2009. Abstract 27.
142. V. Boovaragavan, R. Methekar, V. Ramadesigan, V. Subramanian and R. Braatz. Dynamic optimization of lithium-ion batteries - Current profiles for improved utilization. *216th ECS Meeting*, Vienna, Austria, October 4-9, 2009. Abstract 241.
143. V. Ramadesigan, V. Boovaragavan, R. Methekar, M. Arabandi, V. Subramanian and R. Braatz. Towards model-based optimal design of lithium-ion batteries. *216th ECS Meeting*, Vienna, Austria, October 4-9, 2009. Abstract 242.
144. V. Ramadesigan, V. Boovaragavan, R. Methekar, V. Subramanian, K. Chen, and R. Braatz. Modeling capacity fade of lithium-ion batteries: Challenges in identifying and quantifying possible mechanisms. *216th ECS Meeting*, Vienna, Austria, October 4-9, 2009. Abstract 720.
145. J. C. Pirkle, Jr., V. Subramanian, and R. D. Braatz. Expediting the numerical simulation of lithium-ion battery models. *AIChE Annual Meeting*, Nashville, TN, November 8-13, 2009. Abstract 374g.
146. V. Ramadesigan, V. Boovaragavan, R. N. Methekar, V. Subramanian, K. Chen, R. D. Braatz, and J. C. Pirkle, Jr. Modeling capacity fade of lithium-ion batteries: Challenges in identifying and quantifying possible mechanisms. *AIChE Annual Meeting*, Nashville, TN, November 8-13, 2009. Abstract 200c.
147. V. Boovaragavan, R. N. Methekar, V. Ramadesigan, V. Subramanian, and R. D. Braatz. Dynamic optimization of lithium-ion batteries: Current profiles for improved utilization. *AIChE Annual Meeting*, Nashville, TN, November 8-13, 2009. Abstract 356e.

148. A. N. Ford, D. W. Pack, and R. D. Braatz. Mechanistic modeling of PLGA microparticle drug delivery systems. *AIChE Annual Meeting*, Nashville, TN, November 8-13, 2009. Abstract 178l.
149. A. N. Ford, D. W. Pack, and R. D. Braatz. Design of PLGA microparticle drug delivery systems using mechanistic reaction-diffusion model. *AIChE Annual Meeting*, Nashville, TN, November 8-13, 2009. Abstract 261d.
150. V. Subramanian, V. Ramadesigan, V. Boovaragavan, R. N. Methekar, M. Arabandi, and R. D. Braatz. Towards model-based optimal design of lithium-ion batteries. *AIChE Annual Meeting*, Nashville, TN, November 8-13, 2009. Abstract 143c.
151. J. C. Pirkle, Jr., M. Fujiwara, and R. D. Braatz. Model identification of blown film extrusion. *AIChE Annual Meeting*, Nashville, TN, November 8-13, 2009. Abstract 374b.
152. N. A. Burns, R. Basavaraj, V. Ramadesigan, F. Latinwo, R. D. Braatz, V. R. Subramanian, Identification of dominant mechanisms for capacity fade of lithium-ion batteries. *AIChE Annual Meeting*, Nashville, TN, November 8-13, 2009. Abstract 63j.
153. R. Methekar, V. Ramadesign, V. Subramanian, K. Chen, and R. D. Braatz. Continuum and multi-scale modeling of performance curves and capacity fade in lithium-ion batteries. *TMS Annual Meeting and Exhibition*, Seattle, WA, February 14-18, 2010.
154. V. Ramadesigan, R. Methekar, V. Subramanian, F. Latinwo, and R. Braatz. Optimal design of electrode material properties for lithium-ion batteries. *217th ECS Meeting*, Vancouver, BC, Canada, April 25-30, 2010. Abstract 249.
155. R. Methekar, V. Ramadesigan, V. Subramanian, and R. Braatz. Maximization of energy storage and minimization of capacity fade in lithium-ion battery pack. *217th ECS Meeting*, Vancouver, BC, Canada, April 25-30, 2010. Abstract 393.
156. V. Subramanian, V. Ramadesigan, R. Methekar, K. Chen, and R. Braatz. Continuum and multiscale modeling of performance curves and capacity fade in lithium-ion batteries. *217th ECS Meeting*, Vancouver, BC, Canada, April 25-30, 2010. Abstract 1242.
157. V. Ramadesigan, R. N. Methekar, R. D. Braatz, and V. R. Subramanian. Modeling and simulation of lithium ion batteries from systems engineering perspective. *218th ECS Meeting*, Las Vegas, NV, October 10-15, 2010. Abstract 226.
158. J. Vernille, J. E. Tabora, A. Rogers, J. Albrecht, R. D. Braatz, and M. Fujiwara. Crystallization development of a pharmaceutical API through implementation of real-time supersaturation feedback control. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 141b.
159. X. Zhu, D. W. Pack, and R. D. Braatz. Intravascular delivery from drug-eluting stents: Effect of anisotropic diffusivity and drug loading on arterial drug distribution. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 639f.
160. A. Rogers, J. Albrecht, J. Vernille, J. Tabora, F. Ricci, M. Fujiwara, and R. D. Braatz. Automated crystallization platform: Integrating hardware, software, and PAT to expedite the process of crystallization development. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 355d.
161. J. C. Pirkle, Jr. and R. D. Braatz. Non-isothermal blown film extrusion including crystallization: Instabilities, multiplicities, and mapping of stable operating regions. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 289d.
162. A. N. Ford, D. W. Pack, and R. D. Braatz. Design of PLGA microparticle drug delivery systems using a reaction-diffusion model. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 288f.
163. B. Zeiger, M. L. Rasche, R. D. Braatz, and K. S. Suslick. Sonofragmentation: Experimental observations and population-balance modeling. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 164f.
164. R. Lakerveld, R. D. Braatz, and P. I. Barton. A plant-wide control strategy for continuous pharmaceutical manufacturing. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 444c.

165. V. Ramadesigan, R. N. Methekar, S. De, R. D. Braatz, and V. Subramanian. Estimation of state of charge of a lithium-ion battery pack. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 327f.
166. R. N. Methekar, K. Chen, P. Northrop, R. D. Braatz, and V. Subramanian. Kinetic Monte Carlo simulation of surface heterogeneity for lithium-ion batteries: Passive layer formation and simulation of capacity fade. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 636c.
167. V. Ramadesigan, J. C. Pirkle Jr., S. De, P. Northrop, R. N. Methekar, R. D. Braatz, and V. Subramanian. Modeling and simulation of lithium ion batteries from systems engineering perspective. *AIChE Annual Meeting*, Salt Lake City, UT, November 2010. Abstract 375z.
168. V. R. Subramanian, R. N. Methekar, V. Ramadesigan, and R. D. Braatz. Systems engineering of lithium ion batteries. *ASME International Mechanical Engineering Congress & Exposition*, Vancouver, British Columbia, Canada, November 12-18, 2010. Abstract IMECE2010-39928.
169. P. Northrop, R. Methekar, V. Subramanian, K. Chen, and R. Braatz. Kinetic Monte Carlo simulation of surface heterogeneity for lithium-ion batteries: Passive layer formation and simulation of capacity fade. *219th ECS Meeting*, Montreal, Canada, May 1-6, 2011. Abstract 470.
170. V. Ramadesigan, R. Braatz, G. Sikha, and V. Subramanian. Optimal design of electrode properties for Li-ion batteries using physics-based efficient reformulated models. *219th ECS Meeting*, Montreal, Canada, May 1-6, 2011. Abstract 1603.
171. V. Ramadesigan, R. Methekar, R. Braatz, and V. Subramanian. Dynamic optimization for maximization of energy storage and minimization of capacity fade. *219th ECS Meeting*, Montreal, Canada, May 1-6, 2011. Abstract 1624.
172. M. L. Rasche, B. W. Zeiger, K. S. Suslick, and R. D. Braatz. Modeling the evolution of the particle size distribution during ultrasound-induced breakage. *18th International Symposium on Industrial Crystallization*, Zürich, Switzerland, September 13-16, 2011. Poster. Abstract 127.
173. M. Jiang, M. Fujiwara, M. H. Wong, Z. Zhu, J. Zhang, L. Zhou, K. Wang, A. N. Ford, T. Si, L. M. Hasenberg, and R. D. Braatz. Achieving a target crystal size distribution by continuous seeding and controlled growth. *18th International Symposium on Industrial Crystallization*, Zürich, Switzerland, September 13-16, 2011.
174. M. Jiang, L. Zhou, X. Zhu, M. Molaro, D. O'Grady, D. Hebrault, J. Tedesco, and R. D. Braatz. In-situ identification of two-dimensional growth and dissolution kinetics for rod-like crystals. *18th International Symposium on Industrial Crystallization*, Zürich, Switzerland, September 13-16, 2011. Poster.
175. K. Chen, L. M. Goh, G.W. He, V. Bhamidi, P. J. A. Kenis, C. F. Zukoski, and R. D. Braatz. Identification of bounds on nucleation rates in droplet-based microfluidic systems. *18th International Symposium on Industrial Crystallization*, Zürich, Switzerland, September 13-16, 2011.
176. P. Northrop, V. Subramanian, and R. Braatz. Coupling of Kinetic Monte-Carlo simulations with continuum level models to examine capacity fade. *220th ECS Meeting*, Boston, Massachusetts, October 9-14, 2011. Abstract 672.
177. V. Ramadesigan, P. Northrop, V. Subramanian, and R. Braatz. Continuous and discrete approaches for modeling capacity fade in lithium-ion batteries. *220th ECS Meeting*, Boston, Massachusetts, October 9-14, 2011. Abstract 736.
178. V. Ramadesigan, P. Northrop, S. De, S. Santhanagopalan, R. Braatz, and V. Subramanian. Multiscale modeling and simulation of lithium-ion batteries from systems engineering perspective. *220th ECS Meeting*, Boston, Massachusetts, October 9-14, 2011. Abstract 747.
179. J. E. Tabora, S. Murugesan, J. Vernille, M. L. Rasche, M. Fujiwara, and R. D. Braatz. Implementation of a high-resolution population balance solver to model pharmaceutical crystallizations. *AIChE Annual Meeting*, Minneapolis, Minnesota, October 16-21, 2011. Abstract 83b.

180. L. Zhou, K.-N. Ma, H. Feng, and R. D. Braatz. Optimal control of antisolvent and cooling crystallization. *AIChE Annual Meeting*, Minneapolis, Minnesota, October 16-21, 2011. Abstract 83c.
181. A. N. Ford, D. W. Pack, and R. D. Braatz. Modeling of dynamic hindered diffusion of drugs from biodegradable PLGA microspheres with evolving porous structure. *AIChE Annual Meeting*, Minneapolis, Minnesota, October 16-21, 2011. Abstract 101h.
182. M. Jiang, M. Molaro, M. L. Rasche, H. Zhang, K. Chadwick, L. Zhou, M. Wong, Z. Zhu, D. Hebrault, D. O'Grady, J. Tedesco, and R. D. Braatz. Estimation and modeling of crystal size and shape evolution using in situ tools. *AIChE Annual Meeting*, Minneapolis, Minnesota, October 16-21, 2011. Abstract 548a.
183. X. Zhu and R. D. Braatz. Mathematical modeling of intravascular drug delivery in drug-eluting stents with biodegradable coating. *AIChE Annual Meeting*, Minneapolis, Minnesota, October 16-21, 2011. Abstract 621e.
184. V. Ramadesigan, P. Northrop, S. De, G. Sikha, R. Braatz, and V. Subramanian. Model based optimal design of electrode architecture of lithium-ion batteries. *221st ECS Meeting*, Seattle, Washington, May 6-10, 2012. Abstract 1047.
185. R. D. Braatz and R. C. Alkire. Keynote 5: An overview of multiscale simulation algorithms: Guidelines and pitfalls to avoid. *Summer School on Molecular and Multiscale Simulation*, National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign, 2012.
186. E. P. Chang, R. D. Braatz, and T. A. Hatton. Controlled emulsion droplet solvent evaporation for the continuous and consistent production of particles. *Association in Solution III - Self-Assembly: From Bio-Colloids to Nano-Engineering*. Bifröst University, Iceland, July 22-27, 2012. Poster 9.
187. P. Northrop, R. Braatz, and V. Subramanian. Simultaneous coupling of kinetic Monte-Carlo simulations with continuum models to examine capacity fade. *Pacific Rim Meeting on Electrochemical and Solid-State Science (PRiME 2012)*, *Joint International Meeting of the 222nd ECS Meeting and the 2012 Fall Meeting of the Electrochemical Society of Japan*, Honolulu, Hawaii, October 7-12, 2012. Abstract #730.
188. V. Ramadesigan, P. Northrop, R. Braatz, and V. Subramanian. Dynamic optimization using efficient reformulated models for maximizing energy storage and life of lithium-ion batteries. *Pacific Rim Meeting on Electrochemical and Solid-State Science (PRiME 2012)*, *Joint International Meeting of the 222nd ECS Meeting and the 2012 Fall Meeting of the Electrochemical Society of Japan*, Honolulu, Hawaii, October 7-12, 2012. Abstract #1082.
189. J. C. Pirkle, Jr., L. C. Foguth, S. Brenek, K. Girard, and R. D. Braatz. Modeling and simulation of coaxial crystallizers by dynamically coupled population balance, macromixing, and micromixing models. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 23d.
190. Q.-L. Su, M. W. Hermanto, R. D. Braatz, M.-S. Chiu. A new extended prediction self-adaptive control (EPSAC) strategy for batch control. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 713g.
191. R. D. Braatz. Looking to the future in continuous pharmaceutical manufacturing. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 43a.
192. M. Kishida and R. D. Braatz. A model-based approach for the construction of design spaces in Quality-by-Design. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 146a. The presentation is available on-line in AIChE ChemE on Demand at http://www.aiche.org/resources/chemeondemand/conference-presentations/model-based-approach-construction-design-spaces-quality-design
193. A. N. Ford Versypt, D. W. Pack, and R. D. Braatz. Modeling of drug delivery from PLGA microspheres using reaction-diffusion equations with hindered diffusion. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 258a.

194. X. Zhu and R. D. Braatz. A predictive model for coupled polymer degradation, erosion, and drug release in PLGA biodegradable stent coatings. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 351e.
195. H. Jang, J. H. Lee, and R. D. Braatz. Design of a parameter and state estimation method for detecting local concentration on the surface of a carbon-nanotube based sensor. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 647a.
196. M. Jiang, X. Zhu, M. Molaro, M. L. Rasche, D. M. Raimondo, K.-K. Kim, H. Zhang, K. Chadwick, L. Zhou, Z. Zhu, M. Wong, D. O'Grady, D. Hebrault, J. Tedesco. and R. D. Braatz. A multidimensional population balance model for growth and dissolution identified from a designed temperature-cycling experiment. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 604g.
197. B. W. Bequette and R. D. Braatz. Overview of CAST activities and programming. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 16a.
198. A. A. Boghossian, J. Zhang, F. Le Floch-Yin, Z. Ulissi, P. Bojo, J.-H. Han, J.-H. Kim, J. Arkalgud, N. F. Reuel, R. D. Braatz, and M. S. Strano. The chemical dynamics of nanosensors capable of single-molecule detection. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2012. Abstract 759e.
199. L. C. Foguth, B. Benyahia, R. Lakerveld, P. I. Barton, and R. D. Braatz. Quality-by-Design for continuous pharmaceutical manufacturing. *Symposium on Continuous Pharmaceutical Manufacturing*, Cambridge, MA, November 13, 2012. Poster.
200. R. Lakerveld, B. Benyahia, P. L. Heider, H. Zhang, S. Mascia, J. M. B. Evans, R. D. Braatz, and P. I. Barton. Plant-wide control for continuous pharmaceutical manufacturing. *Symposium on Continuous Pharmaceutical Manufacturing*, Cambridge, MA, November 13, 2012. Poster.
201. R. Lakerveld, B. Benyahia, P. L. Heider, H. Zhang, A. Wolfe, C. Testa, S. Ogden, D. R. Hersey, S. Mascia, J. M. B. Evans, R. D. Braatz, and P. I. Barton. Plant-wide control of an integrated continuous pharmaceutical pilot plant. *9th European Congress of Chemical Engineering*, World Forum, The Hague, The Netherlands, April 21-25, 2013.
202. V. Ramadesigan, B. Suthar, P. Northrop, S. Santhanagopalan, R. Braatz, and V. Subramanian. Optimal control of Li-ion batteries based on reformulated models. *223rd ECS Meeting*, Toronto, Canada, May 16, 2013. Abstract 293.
203. B. Suthar, V. Ramadesigan, P. Northrop, S. Santhanagopalan, R. Braatz, and V. Subramanian. Real time state estimation of reformulated lithium-ion battery model for advanced battery management systems (BMS). *223rd ECS Meeting*, Toronto, Canada, May 16, 2013. Abstract 294.
204. P. Northrop, V. Subramanian, and R. Braatz. Integration of a Kinetic Monte Carlo algorithm with continuum models to examine capacity fade. *223rd ECS Meeting*, Toronto, Canada, May 14, 2013. Abstract 414.
205. H. Jang, R. D. Braatz, and J. H. Lee. Integrated parameter and state estimation method for carbon nanotube-based nanosensor arrays distributed on 2D field. *9th World Congress on Chemical Engineering*, Seoul, Korea, August 18-23, 2013, Abstract FrO-T405-4.
206. J. Min, P. T. Hammond, and R. D. Braatz. Modeling pH-induced release of polyanions from weak polyelectrolyte multilayer films. *Biomedical Engineering Society* (*BMES*) *Annual Meeting*, Seattle, Washington, September 25-28, 2013. Abstract 230.
207. X. Zhu, L. Zhou, and R. D. Braatz. Efficient simulation of population balance models by an improved method of characteristics approach. *AIChE Annual Meeting*, San Francisco, California, November 3-8, 2013. Abstract 199a.
208. L. Zhou, M. Su, B. Benyahia, A. Singh, P. I. Barton, B. L. Trout, A. S. Myerson, and R. D. Braatz. Mathematical modeling and design of layer crystallization in a concentric annulus with and without recirculation. *AIChE Annual Meeting*, San Francisco, California, November 3-8, 2013. Abstract 241a.

209. B. K. Suthar, V. Ramadesigan, S. De, R. D. Braatz, and V. R. Subramanian. Optimal charging profile for mechanically constrained lithium ion battery. *224th ECS Meeting*, October 27 – November 1, 2013. Abstract 253.
210. E. Chang, R. D. Braatz, and T. A. Hatton. Evaporation of emulsion droplets for the templated assembly of spherical particles: A population balance model. *AIChE Annual Meeting*, San Francisco, California, November 3-8, 2013. Abstract 300g.
211. A. Mesbah, A. N. Ford Versypt, X. Zhu, and R. D. Braatz. Nonlinear model predictive control for a continuous pharmaceutical manufacturing system: A comparison of control strategies for a thin-film formation process. *AIChE Annual Meeting*, San Francisco, California, November 3-8, 2013. Abstract 432g.
212. A. Mesbah, R. Lakerveld, and R. D. Braatz. Plant-wide model predictive control of a continuous pharmaceutical manufacturing process. *AIChE Annual Meeting*, San Francisco, California, November 3-8, 2013. Abstract 443a.
213. M. Jiang and R. D. Braatz. Mathematical modeling and analysis of cooling crystallization within dual-impinging-jet mixers. *AIChE Annual Meeting*, San Francisco, California, November 3-8, 2013. Abstract 536a.
214. A. N. Ford Versypt and R. D. Braatz. Analysis of finite difference schemes for diffusion in spheres with variable diffusivity. *AIChE Annual Meeting*, San Francisco, California, November 3-8, 2013. Abstract 651c.
215. A. N. Ford Versypt and R. D. Braatz. Mechanistic modeling of PLGA microsphere drug delivery: Analytical autocatalytic degradation of polymer and hindered diffusion of drug. *AIChE Annual Meeting*, San Francisco, California, November 3-8, 2013. Abstract 666a.
216. M. Jiang and R. D. Braatz. Design criteria for the crystallization of pharmaceuticals within dual-impinging-jet mixers. *AAPS Annual Meeting & Exposition*, San Antonio, Texas, November 10-13, 2013. Abstract T3289.
217. P. W. C. Northrop, V. R. Subramanian, and R. D. Braatz. Integration of a 2+1D kinetic Monte Carlo algorithm with continuum models for SEI layer analysis of lithium-ion batteries. *225th ECS Meeting*, Orlando, Florida, May 11-16, 2014. Abstract 549.
218. B. Suthar, P. W. C. Northrop, S. De, V. Ramadesigan, R. D. Braatz, and V. R. Subramanian. Optimal charging profile for mechanically constrained lithium-ion batteries using reformulated pseudo two dimensional models. *225th ECS Meeting*, Orlando, Florida, May 11-16, 2014. Abstract 321.
219. L. Zhou, M. Su, S. T. Ferguson, Y. Youn, B. Benyahia, A. Singh, P. I. Barton, B. L. Trout, A. S. Myerson, and R. D. Braatz. Modeling and design of layer/falling film solution crystallization. *International Symposium for Continuous Manufacture of Pharmaceuticals*, Cambridge, Massachusetts, May 20-21, 2014
220. A. Mesbah and R. D. Braatz. Dynamic modeling and control of a pharmaceutical thin-film drying process. *International Symposium for Continuous Manufacture of Pharmaceuticals*, Cambridge, Massachusetts, May 20-21, 2014.
221. B. Suthar, P. W. C. Northrop, R. D. Braatz, and V. R. Subramanian. Optimal charging profile for lithium-ion batteries at subzero temperatures. *2014 ECS and SMEQ Joint International Meeting*, October 5-10, 2014. Abstract #42081.
222. J. Min, R. D. Braatz, and P. T. Hammond. Tunable staged release of therapeutics from layer-by-layer coating with clay interlayer barrier. *Biomedical Engineering Society* (*BMES*) *Annual Meeting*, San Antonio, Texas, October 22-25, 2014.
223. J. Min, P. T. Hammond, and R. D. Braatz. Modeling release behaviors of stimuli-responsive polyelectrolyte multilayer films. *Biomedical Engineering Society* (*BMES*) *Annual Meeting*, San Antonio, Texas, October 22-25, 2014.
224. J. Min, R. D. Braatz, and P. T. Hammond. Tunable staged release of therapeutics from layer-by-layer coating with clay interlayer barrier. *Real Time Release: The Path to Efficient Supply of High Quality Biopharmaceuticals?*, Cambridge, Massachusetts, November 14, 2014.

225. A. Mesbah, J. A. Paulson, and R. D. Braatz. Stochastic output feedback control of nonlinear systems with probabilistic uncertainties: Application to control of polymorphic transformations in batch crystallization. *AIChE Annual Meeting*, Atlanta, Georgia, November 16-21, 2014. Abstract 206a.
226. M. Jiang, Z. Zhu, E. Jimenez, J. Xu, C. Papageorgiou, J. Waetzig, A. Hardy, and R. D. Braatz. Continuous-flow tubular crystallization in slugs spontaneously induced by hydrodynamics. *AIChE Annual Meeting*, Atlanta, Georgia, November 16-21, 2014. Abstract 321b. Best presentation in session.
227. J. Min, P. T. Hammond, and R. D. Braatz. Mathematical modeling of macromolecular release of stimuli-responsive polyelectrolyte multilayer films. *AIChE Annual Meeting*, Atlanta, Georgia, November 16-21, 2014. Abstract 527a. Best presentation in session.
228. J. K. Scott, R. D. Braatz, and D. M. Raimondo. Input design for active fault diagnosis using zonotopes. *AIChE Annual Meeting*, Atlanta, Georgia, November 16-21, 2014. Abstract 587e.
229. J. Paulson, A. Mesbah, and R. D. Braatz. Stochastic model predictive control of high-dimensional systems: An end-to-end continuous pharmaceutical manufacturing case study. *AIChE Annual Meeting*, Atlanta, Georgia, November 16-21, 2014. Abstract 610b.
230. M. Jiang and R. D. Braatz. Cooling crystallization within dual-impinging-jet mixers: Mathematical modeling, theory analysis, and experimental validation. *AIChE Annual Meeting*, Atlanta, Georgia, November 16-21, 2014. Abstract 755b.
231. Richard D. Braatz, "Control of Multiscale Dynamical Systems," *SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 20, 2015.
232. Jouha Min, Richard D. Braatz, Myron Spector, and Paula T. Hammond. 'Two-in-One' multilayer coatings for prosthesis-related infections. *American Chemical Society Annual Meeting*, Boston, Massachusetts, August 19, 2015. Abstract PMSE 353.
233. J. Min, K. Y. Choi, R. F. Padera, R. D. Braatz, M. Spector, and P. T. Hammond. Two-in-one multilayer coatings for prosthesis-related infection. *Gordon Research Conference on Biomaterials and Tissue Engineering*, Girona, Spain, July 19-24, 2015.
234. Nicholas J. Mozdzierz, Amos E. Lu, Alan Stockdale, John J. Clark, Noelle A. Colant, Joel A. Paulson, Richard D. Braatz, Kerry R. Love, and J. Christopher Love. Designing a microbial cultivation platform for continuous biopharmaceutical production. *Integrated Continuous Biomanufacturing II*, Berkeley, California, November 1-5, 2015. Poster 37.
235. J. Min, R. D. Braatz, and Paula T. Hammond. 'Two-in-one' multilayer coatings for prosthesis-related infections. *AIChE Annual Meeting*, Salt Lake City, November 8-13, 2015. Abstract 11f.
236. Joel A. Paulson, Edward A. Buehler, Richard D. Braatz, and Ali Mesbah. Stochastic model predictive control with bounded inputs and joint state chance constraints: Application to a continuous acetone-butanol-ethanol fermentation process. *AIChE Annual Meeting*, Salt Lake City, November 8-13, 2015. Abstract 204f.
237. Mo Jiang and R. D. Braatz. Recent advances in continuous slug-flow crystallization. *AIChE Annual Meeting*, Salt Lake City, November 8-13, 2015. Abstract 224a.
238. Kristen Severson, Jeremy G. VanAntwerp, Venkatesh Natarajan, Chris Antoniou, Jörg Thömmes, and Richard D. Braatz. Elastic net with Monte Carlo sampling for data-based modeling in biopharmaceutical manufacturing facilities. *AIChE Annual Meeting*, Salt Lake City, November 8-13, 2015. Abstract 243a (poster). **CAST Director's Award**.
239. J. K. Scott, D. M. Raimondo, G. R. Marseglia, and R. D. Braatz. Constrained zonotopes: A new tool for set-based computations. *AIChE Annual Meeting*, Salt Lake City, November 8-13, 2015. Abstract 246s (poster).
240. Mo Jiang, C. D. Papageorgiou, J. Waetzig, A. Hardy, M. Langston, and R. D. Braatz. Indirect ultrasonication in continuous slug-flow crystallization. *AIChE Annual Meeting*, Salt Lake City, November 8-13, 2015. Abstract 294b.
241. M. L. Rasche, M. Jiang, and R. D. Braatz. Dynamic modeling and control of multi-stage slug-flow crystallization. *AIChE Annual Meeting*, Salt Lake City, November 8-13, 2015. Abstract 730e.

242. Kristen Severson, Jeremy G. VanAntwerp, Venkatesh Natarajan, Chris Antoniou, Jörg Thömmes, and Richard D. Braatz. A case study of data analytics for the manufacturing of a monoclonal antibody, *AIChE Annual Meeting*, Salt Lake City, November 8-13, 2015. Abstract 759a.
243. Kristen Severson, Jeremy G. VanAntwerp, Venkatesh Natarajan, Chris Antoniou, Jörg Thömmes, and Richard D. Braatz. Elastic net with Monte Carlo sampling for data-based modeling in biopharmaceutical manufacturing facilities. *8th Annual Biomanufacturing Summit: Cell and Gene Therapy Products: Meeting the Biomanufacturing Challenges*, Cambridge, MA, November 18-19, 2015 (poster).
244. J. Min, K. Y. Choi, E. C. Dreaden, R. D. Braatz, M. Spector, and Paula T. Hammond. 'Two-in-one' multilayer coatings for prosthesis-related infections. *2015 MRS Fall Meeting and Exhibit*, Boston, Massachusetts, November 29 – December 4, 2015. Abstract F6.04 (poster).
245. Eranda Harinath, Mo Jiang, Joel A. Paulson, Lucas Foguth, Dongying Erin Shen, and Richard D. Braatz Control systems engineering for continuous pharmaceutical manufacturing. *Second International Symposium on Continuous Manufacturing of Pharmaceuticals*, Cambridge, Massachusetts, September 26-27, 2016 (poster).
246. P. M. Desai, V. Puri, D. Brancazio, A. R. Martinez, J. E. Hartman, K. D. Jensen, E. Harinath, R. D. Braatz, J.-H. Chun, A. S. Myerson, B. L. Trout. Tablet coating by injection molding technology. *AAPS Annual Meeting and Exposition*, Denver, Colorado, November 13-17, 2016 (poster). Abstract 22W0100.
247. Joel A. Paulson, T. Alan Hatton, and Richard D. Braatz. An efficient method for deriving normalization constants for eigenfunctions of Sturm-Liouville problems and its application to the Graetz Problem for diffusive and convection heat/mass transfer. *AIChE Annual Meeting*, San Francisco, California, November 13-18, 2016. Abstract 22h.
248. Jouha Min, Richard Braatz, Myron Spector, and Paula Hammond. Nanolayer multi-therapy scaled delivery from implant surface. *AIChE Annual Meeting*, San Francisco, California, November 13-18, 2016. Abstract 136h.
249. Mo Jiang, Charles D. Papageorgiou, Josh Waetzig, Andrew Hardy, Marianne Langston, and Richard D. Braatz. Process intensification for continuous slug-flow pharmaceutical crystallization. *AIChE Annual Meeting*, San Francisco, California, November 13-18, 2016. Abstract 286e.
250. Kristen Severson, Brinda Monian, J. Christopher Love, and Richard D. Braatz. A method for learning a sparse classification model in the presence of missing data. *AIChE Annual Meeting*, San Francisco, California, November 13-18, 2016. Abstract 341f.
251. Jouha Min, Ki Young Choi, Eric Dreaden, Robert Padera, Richard Braatz, Myron Spector, and Paula Hammond. Designer dual therapy nanolayered implant coatings eradicate biofilms and accelerate bone tissue repair. *AIChE Annual Meeting*, San Francisco, California, November 13-18, 2016. Abstract 404b.
252. Mo Jiang and Richard D. Braatz. Cooling crystallization within micromixers: Mathematical modeling, theoretical analysis, and experimental validation. *AIChE Annual Meeting*, San Francisco, California, November 13-18, 2016. Abstract 579b.
253. Zhilong Zhu, You Peng, Kamal Samrane, Allan S. Myerson, and Richard D. Braatz. A multidimensional population balance model for predicting crystal size and aspect ratio in the production of phosphogypsum. *AIChE Annual Meeting*, San Francisco, California, November 13-18, 2016. Abstract 597a.
254. R. D. Braatz and M. A. Henson. Applied statistics and data analytics. *ASEE Summer School for Chemical Engineering Faculty*, Raleigh, North Carolina, July 29 – August 2, 2017.
255. You Peng, Zhilong Zhu, Kamal Samrane, Richard D. Braatz, and Allan S. Myerson. Crystallization of calcium sulfate dihydrate during phosphoric acid production in the presence of magnesium ions. *AIChE Annual Meeting*, San Francisco, California, November 13-18, 2016. Abstract 656a.
256. Fridolin Röder, Ulrike Krewer, Richard D. Braatz. Multi-scale simulation of surface film growth mechanisms in lithium-ion batteries. *68th Annual Meeting of the International Society of Electrochemistry*, Providence, Rhode Island, August 27 – September 1, 2017.

257. Kristen Severson, Paphonwit Chaiwatanodom, Mark C. Molaro, and Richard D. Braatz. Semi-supervised anomaly detection for production oil wells. *AIChE Annual Meeting*, Minneapolis, Minnesota, California, October 29 – November 3, 2017. Abstract 19g.
258. Mo Jiang, J. Carl Pirkle, Jr., and Richard D. Braatz. Theoretical analysis and process design for dual-impinging jet cooling crystallization. *AIChE Annual Meeting*, Minneapolis, Minnesota, California, October 29 – November 3, 2017. Abstract 186j.
259. Tor Aksel N. Heirung, Joel A. Paulson, Richard D. Braatz, and Ali Mesbah. A tractable method for closed-loop active fault diagnosis of stochastic linear systems. *AIChE Annual Meeting*, Minneapolis, Minnesota, California, October 29 – November 3, 2017. Abstract 284c.
260. Mo Jiang, Chen Gu, and Richard D. Braatz. Pinducer analysis for the design of a nucleation subsystem for continuous slug-flow crystallization. *AIChE Annual Meeting*, Minneapolis, Minnesota, California, October 29 – November 3, 2017. Abstract 472a.
261. Mo Jiang and Richard D. Braatz. Advanced scalable continuous manufacturing platform for pharmaceuticals and chemicals based on slug flow. *IFPAC Annual Meeting*, North Bethesda, Maryland, February 11-14, 2018. Session CIII.
262. Gregory C. Rutledge, Richard D. Braatz, George Rodriguez, and Andy H. Tsou. Discovery and design of additives for novel polymer morphology and performance. Materials Genome Initiative Principal Investigators Meeting, College Park, Maryland, March 26-27, 2018. Extended abstract and poster.
263. P. Desai, V. Puri, D. Brancazio, B. Halkude, J. Hartman, A. Wahane, A. Martinez, K. Jensen, E. Harinath, R. Braatz, J.-H. Chun, and B. L. Trout. Tablet coating by injection molding technology: Characterization of coating materials for optimal process and product performance. *8th World Congress on Particle Technology*, Orlando, Florida, April 22-26, 2018. Abstract 51c.
264. Richard D. Braatz, Stacy Springs, and Paul Barone. Data analytics, modeling, and control of biopharmaceutical manufacturing. *NIIMBL National Meeting*, Washington, DC, May 16, 2018. Poster.
265. Michael Forsuelo, Benben Jiang, Kristen A. Severson, Peter Attia, Aditya Grover, Norman Jin, Zi Yang, Nick Perkins, Michael Chen, Todor Markov, Bryan Cheong, Muratahan Aykol, Patrick K. Herring, Stephen J. Harris, Stefano Ermon, William C. Chueh, and Richard D. Braatz. Machine learning and porous electrode theory driven capacity fade modeling and optimal fast charging. *Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, San Francisco, May 31, 2018. Poster.
266. Weike Sun, Benben Jiang, and Richard D. Braatz. Concurrent canonical variate analysis for process operating condition deviations and dynamic anomalies monitoring. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2018.
267. Weike Sun and Richard D. Braatz. Review and comparative study of nonlinear PCA fault detection methods. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2018. Approved by Weike on February 25, 2018. Emailed to ExxonMobil for review on the same day. Got approval on March 20, 2018. Poster. Abstract 183a. **CAST Directors' Award**
268. Mo Jiang, Boxuan Li, Amos E. Lu, Thomas D. Roper, Frank Gupton, and Richard Braatz. Single-step continuous purification from liquid-liquid-solid mixture: Design and experimental implementation for an HIV drug intermediate. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2018. Abstract 200x.
269. J. A. Paulson, E. Harinath, L. Foguth, and R. D. Braatz. Perspectives on the control of advanced manufacturing systems. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2018. Abstract 257a.
270. Richard D. Braatz. Industrial Internet of Things (IIoT) Applications and Industry 4.0. AIChE Annual Meeting, Pittsburgh, Pennsylvania, October 28 – November 2, 2018. Abstract 287c.
271. L. Foguth, E. Harinath, J. Paulson, and R. D. Braatz. Integrated quality by design for continuous pharmaceutical manufacturing: Accounting for dynamics and feedback. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2018. Abstract 328f.

272. Jonggeol Na, Jong Woo Kim, Kyeongsu Kim, Eranda Harinath, Mo Jiang, Jong Min Lee, Bernhardt L. Trout, and Richard D. Braatz. Stochastic multiscale model-based predictive control via polynomial chaos theory: Manufacturing of thin films for pharmaceutical applications. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2018. Abstract 456f.
273. Moo Sun Hong and Richard D. Braatz. Mechanistic modeling and parameter-adaptive nonlinear model predictive control of a microbioreactor. *AIChE Annual Meeting*, Pittsburgh, Pennsylvania, October 28 – November 2, 2018. Abstract 667e.
274. Moo Sun Hong and Richard D. Braatz. Mechanistic modeling and parameter-adaptive nonlinear model predictive control of a microbioreactor. *Driving Innovation in Cell and Gene Therapy Manufacturing*, Cambridge, Massachusetts, December 11-12, 2018. Poster.
275. Weike Sun and Richard D. Braatz. Smart data analytics in biomanufacturing. *Driving Innovation in Cell and Gene Therapy Manufacturing*, Cambridge, Massachusetts, December 11-12, 2018. Poster.
276. Weike Sun, Kristen A. Severson, and Richard D. Braatz. Smart data analytics in biomanufacturing. *MIT Stephen A. Schwarzman College of Computing Launch*, Massachusetts Institute of Technology, Cambridge, Massachusetts, February 28, 2019. Poster.
277. P. Attia, A. Grover, N. Jin, K. Severson, B. Cheong, J. Liao, M. H. Chen, N. Perkins, Z. Yang, P. H. Herring, M. Aykol, S. J. Harris, R. D. Braatz, S. Ermon, and W. C. Chueh. Closed-loop optimization of battery fast charging procedures. *International Battery Association 2019*, La Jolla, San Diego, California, March 3-8, 2019. Poster. *ECS Meeting Abstracts*, Abstract MA2019-03 227.
278. Moo Sun Hong, Nicholas J. Mozdzierz, Mo Jiang, and Richard D. Braatz. Improving biopharmaceutical stability and minimizing cold-chain burden using continuous protein crystallization. *Joint FAU-MIT Workshop on the Design of Particulate Products by Continuous Processes*, Massachusetts Institute of Technology, Cambridge, MA, April 6, 2019. Poster.
279. Mo Jiang and Richard D. Braatz. Exploiting a multiphase flow instability for manufacturing therapeutic protein crystals. *NIIMBL Technology Workshop on Process Intensification*, Boston, Massachusetts, April 25, 2019.
280. Moo Sun Hong, Nicholas J. Mozdzierz, Mo Jiang, and Richard D. Braatz. Improving biopharmaceutical stability and minimizing cold-chain burden using continuous protein crystallization. *NIIMBL Technology Workshop on Process Intensification*, Boston, Massachusetts, April 25, 2019. Poster.
281. Sai Varun Aduru, Manan Pathak, Suryanarayana Kolluri, Richard D. Braatz, and Venkat R. Subramanian. Nonlinear model predictive control strategies for optimal charging of a lithium-ion battery. *235th ECS Meeting*, Dallas, Texas, May 26-30, 2019. *ECS Meeting Abstracts*, Abstract MA2019-01 106.
282. Benben Jiang, Marc Berliner, Michael Forsuelo, Kristen A. Severson, Hongbo Zhao, Dimitrios Fraggedakis, Martin Z. Bazant, Richard D. Braatz, Peter Attia, Norman Jin, Nick Perkins, Zi Yang, Michael Chen, Stephen J. Harris, William C. Chueh, Muratahan Aykol, and Patrick K. Herring. Machine learning for prediction of battery cycle life. *Second Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, San Francisco, May 29-30, 2019. Poster.
283. Weike Sun and Richard D. Braatz. Smart process data analytics for model prediction. *Foundations of Process Analytics and Machine Learning* (FOPAM), Raleigh, North Carolina, August 6-9, 2019. Abstract ID 5. Poster.
284. Weike Sun, Antonio R. Paiva, Peng Xu, Anantha Sundaram, and Richard D. Braatz. Fault detection and identification using Bayesian recurrent neural networks. *Foundations of Process Analytics and Machine Learning* (FOPAM), Raleigh, North Carolina, August 6-9, 2019. Abstract ID 11. Poster.
285. Fabian Mohr, Weike Sun and Richard D. Braatz. Smart process data analytics for supervised classification. *Foundations of Process Analytics and Machine Learning* (FOPAM), Raleigh, North Carolina, August 6-9, 2019. Abstract ID 38. Poster.
286. Kristen A. Severson, Peter M. Attia, Norman Jin, Benben Jiang, Zi Yang, Nicholas Perkins, Michael H. Chen, Muratahan Aykol, Patrick K. Herring, Dimitrios Fraggedakis, Martin Z. Bazant,

Stephen J. Harris, William C. Chueh, and Richard D. Braatz. Data-driven prediction of battery cycle life before capacity degradation. *Foundations of Process Analytics and Machine Learning* (FOPAM), Raleigh, North Carolina, August 6-9, 2019. Abstract 35. Poster.

287. Amos E. Lu (and Richard D. Braatz and co-workers). Digital transformation in biomanufacturing. *Integrated Continuous Biomanufacturing IV*, Brewster (Cape Cod), Massachusetts, October 6-10, 2019.
288. Richard D. Braatz. An integrated approach to modelling, data, and control for pharmaceutical manufacturing. *AIChE Annual Meeting*, Orlando, November 10–15, 2019. Abstract 11f.
289. David P. Piñeiro, Anastasia Nikolakopoulou, Johannes Jäschke, Truls Gundersen, and Richard D. Braatz. Self-optimizing control of a continuous pharmaceutical manufacturing plant. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 29b.
290. Moo Sun Hong, Amos E. Lu, and Richard D. Braatz. A systematic model-based approach for the design and control of protein crystallization. *AIChE Annual Meeting*, Orlando, Florida November 10–15, 2019. Abstract 29d.
291. Richard D. Braatz and Weike Sun (speaker). Big data analytics in the advanced manufacturing of biopharmaceuticals. Big Data Analytics session. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 52b (invited).
292. Richard D. Braatz. Control of polymorphism and crystal size distribution and in pharmaceutical crystallization. **Separations Division Plenary Session.** *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 69c.
293. Elçin Içten Gençer, Xiaoxiang Zhu, Matthew Beaver, Ayman Allian, Seth Huggins, Pablo Rolandi, Roger Hart, Shawn Walker, Andrew Maloney, Gerard Capellades Mendez, and Richard D. Braatz. A virtual plant for synthetic continuous manufacturing via integrated systems-based modeling. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 126f.
294. Moo Sun Hong, M. Lourdes Velez-Suberbie, Andrew J. Maloney, Andrew Biedermann, Kerry R. Love, J. Christopher Love, Tarit K. Mukhopadhyay, and Richard D. Braatz. Macroscopic modeling of bioreactors for recombinant protein producing Pichia pastoris in defined medium. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 175am. Poster.
295. Corinne L. Carpenter, Gregory C. Rutledge, and Richard D. Braatz. Accelerated design of molecular additives for polymer crystallization. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 181ar. Poster.
296. Matthew R. Dobbins, J. Carl Pirkle, Jr., Marat Andreev, Gregory C. Rutledge, and Richard D. Braatz. Mathematical modeling of blown film extrusion using the discrete slip-link rheological model. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 181bq. Poster.
297. Weike Sun and Richard D. Braatz. Smart process data analytics: Automated and robust data analytics for manufacturing processes. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 193a.
298. Shin Hyuk Kim, Richard D. Braatz, and Jay H. Lee. Multiphase particle-in-cell coupled population balance equation method for multiscale computational fluid dynamics. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 336c.
299. Weike Sun and Richard D. Braatz. Probabilistic PCA for multivariate process monitoring and comparison with PCA. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 370b. Poster.
300. Domenico Colucci, Davide Fissore, and Richard D. Braatz. Mathematical modeling of the freezing of pharmaceutical solutions. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 471e.
301. Richard D. Braatz. CACHE perspective. Data Science Education in Chemical Engineering Panel Discussion. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 516b (invited).

302. Moo Sun Hong, Amos E. Lu, Jaehan Bae, Jong Min Lee, and Richard D. Braatz. A droplet-based evaporative crystallization system for protein crystallization kinetics estimation. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 558cd. Poster.
303. Richard D. Braatz. CACHE Initiatives in Process Systems. CACHE 50th Anniversary: The Future of Cyber-Assisted Chemical Engineering Education session. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 571e (invited).
304. Elçin Içten Gençer, Xiaoxiang Zhu, Matthew Beaver, Ayman Allian, Seth Huggins, Pablo Rolandi, Roger Hart, Shawn Walker, Andrew Maloney, Gerard Capellades Mendez, and Richard D. Braatz. Process control strategy for synthetic continuous manufacturing. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 577f.
305. Matthias von Andrian, Anastasia Nikolakopoulou, and Richard D. Braatz. Autonomous design of advanced control systems for modular chemical systems. *AIChE Annual Meeting*, Orlando, Florida, November 10–15, 2019. Abstract 705e.
306. Weike Sun, Kristen A. Severson, and Richard D. Braatz. Smart data analytics in drug manufacturing. *AI Powered Discovery and Manufacturing*, Cambridge, Massachusetts, February 27-28, 2020. Poster.
307. Hongbo Zhao, Brian D. Storey, Richard Braatz, and Martin Bazant. Inverse learning of material physics through in-situ image data and continuum modeling. *Bulletin of the American Physics Society*, *APS March Meeting*, Denver, Colorado, March 4, 2020. Abstract M34.00007.
308. Benben Jiang, Kristen A. Severson, Fabian Mohr, Marc D. Berliner, Patrick A. Asinger, Supratim Das, Dimitrios Fraggedakis, Peter M. Attia, Will E. Gent, Aditya Grover, Norman Jin, Bruis Vlijmen, Xiao Cui, Vivek Lam, Nicholas Perkins, Zi Yang, Michael H. Chen, Patrick Herring, Chirranjeevi B. Gopal, Muratahan Aykol, Stephen J. Harris, Stefano Ermon, William C. Chueh, Martin Z. Bazant, Richard D. Braatz, Machine learning-based prediction and classification of battery lifetimes. *Third Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, May 28, 2020.
309. Patrick A. Asinger, Fabian Mohr, Marc D. Berliner, Benben Jiang, Daniel A. Cogswell, Debbie Zhuang, Martin Z. Bazant, Richard D. Braatz, William E. Gent, Vivek Lam, Xiao Cui, Bruis van Vlijmen, Gabriel B. Crane, William C. Chueh, Chirranjeevi B. Gopal, and Patrick Herring. BEEP: A python library for battery evaluation and early prediction. *Third Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, May 28, 2020.
310. Marc D. Berliner, Hongbo Zhao, Supratim Das, Michael Forsuelo, William H. Chueh, Martin Z. Bazant, and Richard D. Braatz. *Third Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, May 28, 2020.
311. Daniel A. Cogswell, Fabian Mohr, Marc D. Berliner, Richard D. Braatz, and Martin Z. Bazant. Electrochemically resolved acoustic emissions for battery formation and cycling. *Third Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, May 28, 2020.
312. Jarrod Lund, Williams Wang, Richard Braatz, and R. Edwin Garcia. Data driven thermodynamic property prediction in phase diagram space. *Third Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, May 28, 2020.
313. Hongbo Zhao, Haitao Deng, Brian Storey, William C. Chueh, Richard D. Braatz, and Martin Z. Bazant. *Third Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, May 28, 2020.
314. Supratim Das, Michael Forsuelo, Daniel A. Cogswell, Debbie Zhuang, Tao Gao, Richard D. Braatz, William C. Chueh, and Martin Z. Bazant. *Third Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, May 28, 2020.

315. Peter M. Attia, Aditya Grover, Norman Jim, Kristen A. Severson, Todor Markov, Jerry Liao, Michael H. Chen, Bryan Cheong, Nicholas Perkins, Zi Yang, Patrick K. Herrig, Muratahan Aykol, Stephen J. Harris, Richard D. Braatz, Stefano Ermon, and William C. Chueh. *Third Annual Toyota Research Institute Accelerated Materials Design and Discovery (AMDD) Workshop and Conference*, May 28, 2020.
316. Moo Sun Hong and Richard D. Braatz. Optimal design and control of advanced biomanufacturing systems. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 3ci.
317. Elizabeth M. Cummings Bende, Andrew J. Maloney, Dragana Boszinovski, Jose Sangerman, Amos E. Lu, Moo Sun Hong, Nili Persits, Anastasia Artamonova, Rui Wen Ou, Weike Sun, Jacqueline Wolfrum, Paul W. Barone, Rajeev J. Ram, Stacy Springs, Richard Braatz, and Anthony J. Sinskey. Process development, characterization, and understanding in an integrated continuous monoclonal antibody manufacturing testbed. *AIChE Annual Meeting*, San Francisco, California, November 16-20, 2020. Abstract 8e.
318. Sha Sha, Tam Nguyen, Andrew J. Maloney, Caleb Neufeld, Georgios Katsikis, Paul W. Barone, Jacqueline Wolfrum, Stacy Springs, Scott Manalis, Anthony J. Sinskey, and Richard Braatz. A mechanistic analysis of recombinant adeno-associated virus productivity in biomanufacturing. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 157v. poster
319. Andreas Gimpel, Georgios Katsikis, Sha Sha, Andrew J. Maloney, Moo Sun Hong, Tam Nguyen, Jacqueline Wolfrum, Stacy Springs, Anthony J. Sinskey, Scott Manalis, Paul W. Barone, and Richard Braatz. Process analytical technologies for recombinant adeno-associated virus-based gene therapy. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 157aa. poster
320. Matthew R. Dobbins, J. Carl Pirkle, Jr., Marat Andreev, David A. Nicholson, Gregory C. Rutledge, and Richard D. Braatz. Model of nonisothermal blown film extrusion using the perturbation expansion technique. Mathematical modeling of blown film extrusion using the discrete slip-link rheological model. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 161y. poster
321. Nathan Volchko, Gregory C. Rutledge, and Richard D. Braatz. Heterogeneous nucleation mechanisms in polyolefins: Experiments linked with molecular simulations. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 161av. poster
322. Moo Sun Hong, Amos E. Lu, and Richard D. Braatz. Digitalization of biopharmaceutical manufacturing. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. November 20, Abstract 195e.
323. Weike Sun and Richard D. Braatz. Recognizing and avoiding big data analytics traps in applications. Big Data and Applications in Advanced Modeling and Manufacturing session. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 224b.
324. Anastasia Nikolakopoulou and Richard D. Braatz. Automated optimization and control of modular chemical systems. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 334v. poster
325. Andrew J. Maloney, Elizabeth M. Cummings Bende, Dragana Bozinovski, Amos Enshen Lu, Jose Sangerman, Moo Sun Hong, Anastasia Artamonova, Rui Wen Ou, Weike Sun, Jacqueline Wolfrum, Paul W. Barone, Stacy C. Springs, Anthony J. Sinskey, and Richard D. Braatz. Process control strategy development for an integrated continuous platform for monoclonal antibody manufacturing. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 367d.
326. Hongbo Zhao, Brian D. Storey, Richard Braatz, and Martin Z. Bazant. Inverse learning of material physics through image data and continuum modeling. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 477d.
327. Moo Sun Hong, Amos E. Lu, Andrew J. Maloney, Elizabeth M. Cummings Bende, Dragana Bozinovski, Jose Sangerman, Anastasia Artamonov, Rui Wen Ou, Paul W. Barone, Jacqueline

Wolfrum, Stacy Springs, Anthony J. Sinskey, and Richard Braatz. First-principles dynamic simulation of an integrated continuous biomanufacturing platform. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 542e.

328. Andrew J. Maloney, Amos E. Lu, Neil C. Dalvie, Joseph R. Brady, Kerry Routenberg Love, J. Christopher Love, and Richard Braatz. Modeling of copy number variability in Pichia pastoris. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 620b.
329. Tam Nguyen, Sha Sha, Andrew J. Maloney, Caleb Neufeld, Jacqueline Wolfrum, Stacy Springs, Paul W. Barone, Anthony J. Sinskey, and Richard Braatz. Mathematical modeling of gene therapy manufacturing. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 667d.
330. Anastasia Nikolakopoulou and Richard D. Braatz. Polynomial NARMAX-based nonlinear model predictive control of modular chemical system. *AIChE Annual Meeting*, San Francisco, California, November 15-20, 2020. Abstract 716c.
331. K. Shah, A. Subramaniam, L. Mishra, T. Jang, M. Bazant, R. Braatz, and V. R. Subramanian. Challenges in moving to multiscale battery models – Where electrochemistry meets and demands more from math. *Pacific Rim Meeting on Electrochemical and Solid-State Science (PRiME 2020)*, October 4-9, 2020. Abstract F03-1604.
332. Iris E. Hwang, Georgios Katsikis, Sha Sha, Vincent Agache, Paul W. Barone, Jacqueline Wolfrum, Stacy C. Springs, Anthony J. Sinskey, Richard D. Braatz, and Scott R. Manalis. Measuring the DNA cargo of viruses using nanofluidics. *73rd Annual Meeting of the APS Division of Fluid Dynamics*, November 22-24, 2020. Abstract J13.00004.
333. Tam Nguyen, Sha Sha, Moo Sun Hong, Andrew J. Maloney, Paul W. Barone, Caleb Neufeld, Jacqueline Wolfrum, Stacy L. Springs, Anthony J. Sinskey, and Richard D. Braatz. Mechanistic model for production of recombinant adeno-associated virus via triple transfection of HEK293 cells. *BioMAN Meeting on Data Analytics along the Biomanufacturing Life Cycle*, Massachusetts Institute of Technology Cambridge, MA, May 18-20, 2021. Poster.
334. Moo Sun Hong, Amos E. Lu, Rui Wen Ou, Jacqueline Wolfrum, Stacy L. Springs, Anthony J. Sinskey, and Richard D. Braatz. Model-based control for continuous viral inactivation of biopharmaceuticals. *BioMAN Meeting on Data Analytics along the Biomanufacturing Life Cycle*, Massachusetts Institute of Technology Cambridge, MA, May 18-20, 2021. Poster.
335. Tam N. T. Nguyen, Sha Sha, Moo Sun Hong, Andrew J. Maloney, Paul W. Barone, Caleb Neufeld, Jacqueline Wolfrum, Stacy L. Springs, Anthony J. Sinskey, and Richard D. Braatz. Mechanistic model for production of recombinant adeno-associated virus via triple transfection of HEK293 cells. *BioMAN Meeting on Data Analytics along the Biomanufacturing Life Cycle*, Massachusetts Institute of Technology Cambridge, MA, May 18-20, 2021. Poster.
336. Fabian Mohr and Richard D. Braatz. Smart data analytics for biomanufacturing processes. *BioMAN Meeting on Data Analytics along the Biomanufacturing Life Cycle*, Massachusetts Institute of Technology Cambridge, MA, May 18-20, 2021. Poster.
337. Seongkyu Yoon, Richard D. Braatz, David McNally, Wenzhen Huang, Sarah Kostanski, and Yong Suk Lee. PC2.2-160 Building Cooperative Biomanufacturing Workforce Training Network (BioTnet). *NIIMBL Annual Meeting*, Washington, DC, July 14-16, 2021. Poster
338. Richard D. Braatz, David McNally, Anthony Grippe, and Shashi Kudugunti. Continuous Cell Culture for Viral Vaccines, *NIIMBL Annual Meeting*, July 14-16, 2021. Poster.
339. Supratim Das, Michael Forsuelo, Debbie Zhuang, Richard Braatz, William C. Chueh, and Martin Z. Bazant. Theory of formation cycling of graphite by understanding primary and secondary SEI. 240th ECS Meeting (October 10-14, 2021) (Batteries and Energy Storage), Abstract MA2021-02 415.
340. Moo Sun Hong, Amos E. Lu, Jaehan Bae, Jong Min Lee, and Richard D. Braatz. Design and control of novel droplet-based system for estimating protein crystallization kinetics. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 182a.

341. Joachim Schaefer and Richard D. Braatz. Interactive software for teaching multivariable data analytics. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 241e. Reprinted in *CACHE News*, Winter 2022.
342. Weike Sun, Fabian Mohr, Pil Rip Jeon, Moo Sun Hong, and Richard D. Braatz. Smart process analytics and machine learning. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 259e.
343. Dragana M. Bozinovski, Elizabeth M. Cummings Bende, Andrew J. Maloney, Jose Sangerman, Alexis B. Dubs, Amos E. Lu, Moo Sun Hong, Nili Persits, Anastasia Artamonova, Rui Wen Ou, Weike Sun, Jacqueline Wolfrum, Paul W. Barone, Rajeev J. Ram, Stacy Springs, Richard Braatz and Anthony J. Sinskey. Biomanufacturing and testbed development for the continuous production of monoclonal antibodies. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 293c.
344. Tam N. T. Nguyen, Sha Sha, Caleb Neufeld, Paul W. Barone, Jacqueline Wolfrum, Stacy L. Springs, Anthony J. Sinskey, and Richard D. Braatz. Model-based design of recombinant adeno-associated viral vector production. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 293f.
345. Richard D. Braatz, Weike Sun, and Brian W. Anthony. Teaching process data analytics and machine learning. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 449a.
346. Panelist, Teaching Data Science to Students and Teachers I, *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021.
347. **Keynote Talk.** Richard D. Braatz, Moo Sun Hong, Amos E. Lu, and Weike Sun. Integrated Quality by Design in (bio)pharmaceutical manufacturing. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 541d.
348. Moo Sun Hong, Amos E. Lu, Rui Wen Ou, Jacqueline Wolfrum, Stacy L. Spring, Anthony J. Sinskey, and Richard D. Braatz. Model-based control for column-based continuous viral inactivation of biopharmaceuticals. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 493c.
349. Moo Sun Hong and Richard D. Braatz. Process modeling and control of digital biopharmaceutical manufacturing. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021. Abstract 584a.
350. Anastasia Nikolakopoulou and Richard D. Braatz. Optimization and control of modular chemical systems for continuous manufacturing of pharmaceuticals. *AIChE Annual Meeting*, Boston, Massachusetts, November 7-12, 2021.
351. Joachim Schaeffer, Rolf Findeisen, and Richard D. Braatz. Analysis of nonlinear features in the machine learning-based modeling of lithium-ion batteries. *18th Symposium on Modeling and Experimental Validation of Electrochemical Energy Technologies*, Hohenkammer, Germany, March 14-16, 2022. poster
352. Hongbo Zhao, Haitao D. Deng, William Chueh, Richard D. Braatz, and Martin Bazant. Learning material physicsfrom images of battery primary particles. *Bulletin of the American Physics Society*, *APS March Meeting*, Chicago, Illinois, March 14-18, 2022. Abstract G32.00003.
353. Tam Nguyen, Sha Sha, Jose Sangerman, Moo Sun Hong, Jaclyn Ng, Paul Barone, Caleb Neufeld, Jacqueline Wolfrum, Stacy Springs, Anthony Sinskey, and Richard Braatz. Multi-transfection method for improving recombinant adeno-associated virus production. *ACS Spring Meeting*, San Diego, California, March 20-24, 2022. Abstract 3652485.
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450. Difei Zhang, Nischita Kaza, Yaocheng Tian, Yi Wei, Prakitr Srisuma, Hiroyuki Kusaka, Yuichiro Kunai, Takahiro Nambara, Masahiro Kashiwagi, Yumi Yamada, Richard Braatz, and George Barbastathis. Neural-PDE modeling of reaction-diffusion using time-series imaging for sub-diffraction-limit 3D lithography. *Proc. SPIE*, Volume 13568, Modeling Aspects in Optical Metrology X, 1356803, August 8, 2025.
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452. Yash Samantaray, Jinwook Rhyu, Young Ko, Alexander E Cohen, Richard D Braatz, Martin Z Bazant. Interpretable acoustic emissions from Li-ion batteries. *Electrochemical Society Meeting*, Chicago, Illinois, October 12-16, 2025. Abstract MA2025-02 710.
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455. Elia Arnese Feffin, Nidhish Sagar, Luis Briceno-Mena, Birgit Braun, Ivan Castillo, Caterina Rizzo, Linh Bui, Jinsuo Xu, Leo Chiang, and Richard D. Braatz. Leveraging qualitative information to improve hybrid models. *AIChE Annual Meeting*, Boston, Massachusetts, November 2-6, 2025. Abstract 13b.
456. Cedric Devos, Aniket Udepurkar, Peter Sagmeister, Ariana S. Hodlewsky, Julie Chen, Richard Braatz, and Allan Myerson. Investigation into the critical process parameters for lipid nanoparticle precipitation in impinging jet mixers. *AIChE Annual Meeting*, Boston, Massachusetts, November 2-6, 2025. Abstract 165b.
457. Mona Kanso, Shalini Singh, A. Jeffrey Giacomin, and Richard Braatz. Understanding the hydrodynamic diameter distribution of mRNA encapsulated vaccines. *AIChE Annual Meeting*, Boston, Massachusetts, November 2-6, 2025. Abstract 187ae.
458. Konstantinos Zinelis, Cedric Devos, Peter Sagmeister, Aniket Udepurkar, Allan Myerson and Richard Braatz. Multiscale modeling of lipid nanoparticle self-assembly and bleb formation. *AIChE Annual Meeting*, Boston, Massachusetts, November 2-6, 2025. Abstract 187an.
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461. Francesco Destro, Aleix Salvador Pomarol, Pavan K. Inguva, and Richard D. Braatz. A hybrid characteristics/lines numerical method for quasilinear hyperbolic systems. *AIChE Annual Meeting*, Boston, Massachusetts, November 2-6, 2025. Abstract 206c.
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465. Aniket Udepurkar, Cedric Devos, Peter Sagmeister, Ariana Hodlewsky, Julie Chen, Richard Braatz, and Allan Myerson. Continuous manufacturing of mRNA-loaded lipid nanoparticles: Structural and morphological insights. *AIChE Annual Meeting*, Boston, Massachusetts, November 2-6, 2025. Abstract 438d.
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467. Pavan K. Inguva and Richard D. Braatz. Towards a multiscale mechanistic model of lipid nanoparticle formation. *AIChE Annual Meeting*, Boston, Massachusetts, November 2-6, 2025. Abstract 588af.
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471. Konstantinos Zinelis, Fateme Molajafari, Cedric Devos, Aniket Udepurkar, Peter Sagmeister, Andy Liu, Allan Myerson, and Richard Dean Braatz. Toward rational design of lipid nanoparticles: A multiscale framework for nucleic acid delivery. *Division of Fluid Dynamics Annual Meeting*, Houston, Texas, November 22-24, 2025.

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2. Moving Past Trial-and-Error with Richard Braatz. Massachusetts Institute of Technology, Cambridge, Massachusetts, February 13, 2012. https://www.youtube.com/watch?v=xG0NU97EO8k
3. Alumni Stories: Richard Braatz. Oregon State University, Corvallis, Oregon, May 21, 2012. https://www.youtube.com/watch?v=HJn2kdTx6_k
4. An Overview of Multiscale Simulation Algorithms, Guidelines and Pitfalls to Avoid. Molecular and Multiscale Simulation Summer School, June 18, 2002. https://nanohub.org/resources/14323
5. Systems Nanotechnology: Identification, Estimation, and Control of Nanoscale Systems. IEEE Control Systems Society Presentation Library, 2012. http://ieeecss.org/presentations/grid?field_cc_pres_type_ref_target_id=289
6. A Roadmap for the Multiscale Simulation of Lithium-ion Batteries. National Science Foundation Mathematical Sciences Institute, November 6, 2013. https://mathinstitutes.org/videos/videos/3089
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18. NSF DMREF Project: A New Approach to Design of Polymer Morphology, Materials Research Society Meeting, November 21, 2018. https://www.youtube.com/watch?v=gziLEWFYu7w
19. Accelerated Materials Design & Discovery: Data Driven Battery Design. Toyota Research Institute, December 2018. https://vimeo.com/user24801969/review/292772163/1bcbcdd18e
20. Anton Simeonov, Literature Review: Advanced Biologic Therapies and Advanced Biologics Manufacturing, *Genetic Engineering & Biotechnology News*, January 18, 2019. https://www.genengnews.com/topics/drug-discovery/literature-review-advanced-biologic-therapies-and-advanced-biologics-manufacturing/
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M. Additional Videos (abridged)

1. 2012 MIT ChE Grad Student First Year Skit: The Richard Braatz Book Club. Massachusetts Institute of Technology (MIT), Department of Chemical Engineering, December 2012. https://www.youtube.com/watch?v=UhGd48W_A_s (includes quotes taken from 10.34 class)
2. MIT Course X First Year Xmas Skit 2017. Massachusetts Institute of Technology (MIT), Department of Chemical Engineering, December 2017. https://www.youtube.com/watch?v=P7IphlBwNkM (actor)
3. 2018 MIT ChemE Nth-Year Skit. Massachusetts Institute of Technology (MIT), Department of Chemical Engineering, December 2018. https://www.youtube.com/watch?v=cqSfUCkqovs&feature=youtu.be (actor)

N. Blogs

1. Richard D. Braatz and Jong Min Lee. TC Annual Meeting at ADCHEM 2018. *IFAC Blog*, November 9, 2018. http://blog.ifac-control.org/introduction/t-c-6-1-chemical-process-control/

III. RESIDENT INSTRUCTION

A. Supervision of Graduate Students

1. Andrew Paul Featherstone, Ph.D. 1997, "Control Relevant Identification of Large Scale Sheet and Film Processes," Manufacturing Solutions Leader, Packaging Dynamics
2. Evan Lee Russell, Ph.D. 1998, "Process Monitoring of Large Scale Systems," Control Technology Manager, ExxonMobil
3. Jeremy Glen VanAntwerp, Ph.D. 1999, "Globally Optimal Robust Control for Large Scale Sheet and Film Processes," Professor, Department of Engineering, Calvin College
4. Ernesto Rios-Patron, Ph.D. 2000, "A Generic Framework for Nonlinear Analysis and Control," Chief Engineering Officer, Americas Mining Corporation - Grupo México
5. Leo Hao-Tien Chiang, Ph.D. 2001, "Fault Detection and Diagnosis for Large Scale Systems," Senior Research Specialist, Dow Chemical Company
6. David Lei Ma, Ph.D. 2002, "Simulation and Optimization of Multidimensional Crystallization Processes," Senior Research Engineer, Pratt & Whitney
7. Timokleia Togkalidou, Ph.D. 2002, "Robust Nonlinear Control using Bilinear Matrix Inequalities with Application to a Batch Crystallization Process," General Chemical State Laboratory of Greece, Athens
8. Rudiyanto Gunawan, Ph.D. 2003, "Simulation and Optimal Control of Transient Enhanced Diffusion," Associate Professor at the University at Buffalo
9. Michael Yoo Lim Jung, Ph.D. 2003, "New Surface and Optically Stimulated Physics for Modeling Diffusion in Si" (primary advisor: Prof. E. G. Seebauer), Patent Agent, Walnut, CA
10. Timothy Owen Drews, Ph.D. 2004, "Multiscale Simulation of Nanofabricated Structures: Application to Copper Electrodeposition for Electronic Devices," Senior Software Engineer, GE Oil and Gas
11. Eric John Hukkanen, Ph.D. 2004, "A Systems Approach to the Modeling and Control of Molecular, Microparticle, and Biological Distributions," Principal Scientist, DuPont
12. Effendi Rusli, Ph.D. 2006, "Modeling and Control of Nucleation and Growth Processes with Application to Electrodeposition and Crystallization Processes," Engineer, PT Lautan Luas Tbk, Indonesia

13. Xing Yi Woo, Ph.D. 2007, "Modeling and Simulation of Antisolvent Crystallization: Mixing and Control," Head of Research Data Integration and Senior Principal Investigator at Bioinformatics Institute, A*STAR
14. Xiaohai Li, Ph.D. 2007, "Multiscale Simulation and Model-based Optimal Design of Copper Electrodeposition," R&D Engineer, Synopsys, Hillsboro, Oregon
15. Charlotte Tsz Mei Kwok, Ph.D. 2007, "Advanced Methods for Defect Engineering in Silicon" (primary advisor: Prof. E. G. Seebauer), Research Scientist, Taiwan Semiconductor Manufacturing Company
16. Mohan Karulkar, Ph.D. 2007, "Additive-assisted Copper Nucleation on Gold: The Role of Multiscale Modeling" (primary advisor: Prof. R. C. Alkire), Principal Staff Member, Sandia National Laboratories
17. Martin Wijaya Hermanto, Ph.D. 2009, "Optimal Control of Solvent-Mediated Polymorphic Transformations," Chemometrician, GlaxoSmithKline, Singapore
18. Joshua David Isom, Ph.D. 2009, "Exact Solution of Bayes and Minimax Change Detection Problems," R&D, Process Data Technologies Group, Air Products & Chemicals
19. Nicholas Chung Shen Kee, Ph.D. 2009, "Design and Modeling of Pharmaceutical Polymorphic Crystallization Processes," Lead PAT Specialist, Merck, Singapore
20. Masako Kishida, Ph.D. 2010, "Robust Optimal Boundary and Spatial Field Control of Distributed Parameter Systems" (Mechanical Science and Engineering), Associate Professor, National Institute of Informatics in Tokyo, Japan
21. Ashlee Nicole Ford Versypt, Ph.D. 2012, "Modeling of Controlled-Release Drug Delivery from Autocatalytically Degrading Polymer Microspheres," Professor of Chemical Engineering, University at Buffalo
22. Kwang Ki Kim, Ph.D. 2013, "Model-Based Robust and Stochastic Control, and Statistical Inference for Uncertain Dynamical Systems" (Aerospace Engineering), Associate Professor of Electrical Engineering, Inha University, South Korea
23. Qinglin Su, Ph.D. 2014 (National University of Singapore), "Modeling, Monitoring, and Control of pH-shift Reactive Crystallization" (primary advisor: Min-Sen Chiu), Vertex
24. Lifang Zhou, Ph.D. 2014, "Mathematical Modeling and Design of Novel Semi-continuous and Continuous Crystallizations," Reservoir Engineer, Saudi Aramco
25. Xiaoxiang Zhu, Ph.D. 2014, "Mathematical Modeling and Simulation of Intravascular Drug Delivery from Drug-Eluting Stents with Biodegradable PLGA Coating," Research Scientist, Amgen
26. Mo Jiang, Ph.D. 2015, "Pharmaceutical Crystallization Design Using Micromixers, Multiphase Flow, and Controlled Dynamic Operations," Associate Professor, Arizona State University
27. Michael L. Rasche, Ph.D. 2015, "Mathematical Modeling, Simulation, and Optimal Design of Pharmaceutical Crystallizers," Adjunct Assistant Professor of Mathematics, University of North Carolina at Asheville
28. Zachary Ward Ulissi, Ph.D. 2015, "Modeling and Simulation of Stochastic Phenomena in Carbon Nanotube-Based Single Molecule Sensors," Senior Research Manager at Meta Fundamental AI Research and Adjunct Professor, Carnegie Mellon University
29. Hong Jang, Ph.D. 2015 (KAIST), "State and Parameter Estimation for Inherent Stochastic Nanobiosystems," postdoc at KAIST
30. Mark Christopher Molaro, Ph.D. 2016, "Computational Statistical Methods in Chemical Engineering," Data Science Manager, Meta
31. Jouha Min, Ph.D. 2016, "Modeling of Molecular Release from Layer-by-Layer Polyelectrolyte Polymeric Films," Assistant Professor, University of Michigan
32. Lucas Foguth, Ph.D. 2016, "Integration of Quality-by-Design into Control Systems Design for Continuous Pharmaceutical Manufacturing," Officer, U.S. Navy
33. Joel Anthony Paulson, Ph.D. 2016, "Modern Control Methods for Chemical Process," Associate Professor, University of Wisconsin

34. You Peng, Ph.D. 2017, “Crystallization of Calcium Sulphate during Phosphoric Acid Production: Improving Filtration through Improvement in Particle Shape and Size Distribution,” Process Modeling, Dow Chemical
35. Zhilong (Peter) Zhu, Ph.D. 2017, “Multidimensional Population Balance Modeling and Optimization of Continuous Reactive Crystallization,” Senior Strategy Consultant/Data Scientist, IBM
36. Dongying (Erin) Shen, Ph.D. 2017, “Optimal Control of Dynamical Systems with Time-invariant Probabilistic Parameter Uncertainties,” Data Scientist, Amgen
37. Kristen Ann Severson, Ph.D. 2018, “Machine Learning for Applications in Chemical and Biological Engineering,” Senior Researcher, Microsoft Research
38. Nicholas J. Mozdzierz, Ph.D. 2018, “Developing Scalable and Modular Technologies for Continuous Biopharmaceutical Production,” Scientist, Upstream Process Development, Sana Biotechnology, Inc.
39. Amos Enshen Lu, Ph.D. 2019, “Systems Engineering for Biomanufacturing,” Research Scientist, Sanofi
40. Matthias Freiherr von Andrian-Werburg, Ph.D., 2020, “Fast Stochastic Model Predictive Control under Parametric Uncertainties,” Model Based Systems Engineer, Whirlpool Corporation
41. Weike Sun, Ph.D. 2020, “Advanced Process Data Analytics,” consulting company
42. Andrew John Maloney, Ph.D. 2021, “Case Studies in the Modeling and Control of Continuous Pharmaceutical Manufacturing Processes,” Research Scientist, Amgen
43. Moo Sun Hong, Ph.D. 2021, “Model-Based Design and Control of Biopharmaceutical Manufacturing Processes,” Assistant Professor, Seoul National University
44. Paphonwit Chaiwatanodom, Ph.D. 2021, “Fault Detection and Identification of Large-scale Dynamical Systems,” self-employed
45. Anastasia Nikolakopoulou, Ph.D. 2021, “Automated Optimization and Control of Modular Chemical Systems,” Scientist, Process Operation and Modeling, Sanofi
46. Kaylee W. Schickel, Ph.D. 2022, “Design and Analysis of Methods to Eliminate Oscillatory Behavior in Bioreactors for Viral Vaccine Manufacturing”
47. Tam Ngoc Thanh Nguyen, Ph.D. 2023, Scientist, BioNTech
48. Marc Dylan Berliner, Ph.D. 2023, Julia Company
49. Flemming Holtorf, Ph.D. 2024, with Alan Edelman, Postdoc at MIT
50. Fabian Mohr, Ph.D. 2024, Quantitative Researcher, Fidelity Investments
51. Rohan Patrick Kadambi, Ph.D. 2025, Merck
52. Pavan Krishna Inguva, Ph.D. 2025, Takeda
53. Joachim Schaeffer, Ph.D. 2025, Technischen Universität Darmstadt, Fellow, Pivotal Research
54. Prakitr Srisuma, CSE/ME, 2021-date, with George Barbastathis, postdoc, MIT
55. Nathan Merica Stover, PhD. 2025, Engineer, BioCurie
56. Jinwook Rhyu, Ph.D. 2025, “Interpretable Approaches for Optimizing the Pulse Diagnostics and Formation for Lithium-ion Batteries,” postdoc at MIT

1. Andrew P. Featherstone, M.S. 1995, “Control Relevant Identification of Structured Large Scale Systems”
2. Evan L. Russell, M.S. 1996, “Multidimensional Realization and Model Reduction of Large Scale Uncertain Systems”
3. Jeremy G. VanAntwerp, M.S. 1997, “Globally Optimal Robust Control for Systems with Nonlinear Time-Varying Perturbations”
4. Ernesto Rios-Patron, M.S. 1997, “Nonlinear Stability Analysis of Discrete and Continuous Time Systems with Applications to Artificial Neural Networks”
5. Leo H.-T. Chiang, M.S. 1999, “Chemometrics and Discriminant Analysis for Fault Diagnosis”
6. David L. Ma, M.S. 1999, “Worst-case Performance Analysis of Optimal Batch Control Trajectories”

7. Timokleia Togkalidou, M.S. 1999, “Inferential Modeling in Pharmaceutical Crystallization”
8. Rudiyanto Gunawan, M.S. 2000, “Dimensionality Reduction and Robustness Analysis of Large Scale Systems”
9. Irene Fusman, M.S. 2002, “High Resolution Simulation of Multi-Dimensional Crystal Growth with Aggregation,” Senior Process Engineer, Armored AutoGroup
10. Effendi Rusli, M.S. 2003, “Nonlinear Control of a Kinetic Monte Carlo-Finite Difference Simulation”
11. Joshua Isom, M.S. 2004, “Economic Design of Stateless Control Charts for Deteriorating Systems,” Systems and Software Engineer
12. Xiaohai Li, M.S. 2004, “Simulation of Shape Evolution in Moving Boundary Systems”
13. Mohan Karulkar, M.S. 2004, “Multiscale Simulation of Copper Electrodeposition Along a Resistive Substrate”
14. Charlotte T. M. Kwok, M.S. 2005, “Systems-Based Modeling of a New Method for Defect Engineering in Transistor Junction Fabrication”
15. Li May Goh, M.S. 2007, “Dynamic Analysis of Pharmaceutical and Biological Systems from the Nano- to Microscale,” Engineering Manager, Separation Technologies Applied Research and Translation Centre, NTUitive Pte. Ltd.
16. Paul D. Arendt, M.S. 2008, “Controlled Drug Release Delivery Optimization of Polymer Micro Spheres and Growth of Crystals with Desired Microstructures” (General Engineering), Lead Modeler, Discover Financial Services
17. Kwang-Ki Kim, M.S. 2009, “Robust Control for Systems with Sector-Bounded, Slope-Restricted, and Odd Monotonic Nonlinearities Using Linear Matrix Inequalities” (Aeronautical Engineering)
18. Ashlee N. Ford, M.S. 2009, “Biodegradable Polymeric Drug Delivery: Parallel Simulation and Optimal Drug Release Profiles”
19. Xiaoxiang Zhu, M.S. 2010, “Modeling and Simulation of Coronary Stents: Intravascular Drug Delivery and Arterial Drug Distribution”
20. Michael L. Rasche, M.S. 2010, “Computational Fluid Dynamics and Population Balance Modeling of Particulate Systems”
21. Lifang Zhou, M.S. 2010, “Optimal Control of Antisolvent and Cooling Crystallization”
22. Folarin Latinwo, M.S. 2011, “Robust Optimization Techniques and Design of Li-ion Batteries,” Staff Modeling Engineer, Synopsis, Inc.
23. Jochen Cremer, M.S., 2016, “Inversion-based Internal Model Control of Chemotaxis” (Process Systems Engineering, University of Aachen), Associate Professor of Electrical Engineering, Mathematics, and Computer Science, Delft University of Technology
24. Kevin Peng, M.S. and M.B.A., 2017, “An Equipment Selection Methodology for Continuous Manufacturing of Small-Molecule Drugs,” Research Engineer, Amgen
25. Moritz Hans Peter Benisch, M.S. 2017, “Dynamic Modeling, Simulation, Optimisation, and Control of Countercurrent Slug Flow Crystallization” (Chemical and Bioengineering, ETH Zürich, Switzerland), Accenture Switzerland
26. Maria Dominique Bautista Rustia, M.S. Mechanical Engineering and M.B.A., 2018, “Augmenting Drug Process Development Capacity through Applications of Lean Principles and High Throughput Technology,” Operations Associate, McKinsey & Company
27. Stanislas Marie Buiatti, M.S. 2018, “Multiscale Modeling and Simulation of Crystallization Using OpenFOAM” (Chemical Engineering and Biotechnology, Ecole Polytechnique Lausanne, Switzerland), Ph.D. Student, Ecole Polytechnique Lausanne, Switzerland
28. Michael Forsuelo, M.S. 2019, “Lifetime Prediction for Lithium-ion Batteries Undergoing Fast Charging Protocols,” Graduate Student, Massachusetts Institute of Technology
29. Hillary Rae Doucette, M.S. Electrical Engineering and Computer Science and M.B.A., 2019, “Commercial Technology Transfer Optimization for Drug Substance Process Development,” Amgen

30. Ketan Kumar, MBA and M.S. Chemical Engineering, 2020, "Product Management Framework for the Development of Automation Solutions for Biologics Drug Substance Manufacturing," Amgen
31. Andreas L. Gimpel, M.S. 2020, "A Systematic Workflow for the Investigation of Crystallization as a Separation Process for Biomanufacturing of rAAV-based Gene Therapies," (Chemical and Bioengineering, ETH Zürich, Switzerland), PhD student at ETH
32. Joachim Schaeffer, M.S. Energy Science and Technology, ETH Zürich, 2021, "Advanced Feature Design for Battery Lifetime Prediction," PhD student at Technischen Universität Darmstadt
33. Elias Machado Roberty, M.S. in Engineering and Management, 2021, "Predictive Analytics Applications for Oil and Gas Processing Facilities," Research Engineer, Chevron
34. Lois Eileen Nersesian, MBA and M.S. 2022, coadvised with Levi Retsef, "Text Analytics to Inform Deviation Root Cause Analysis in Biomanufacturing"
35. Andrew C. Mikkelson, MBA and M.S. 2022, coadvised with Levi Retsef, "Biomanufacturing Automation Plug-and-Play"
36. Robin Droop, M.S. 2022, Technical University of Munich, Battery MLOps Engineer, BMW Group
37. Jackson A. Albright, MBA and M.S. 2025, coadvised with Roy E. Welsch, "Computer Vision for Cell Line Development"
38. Nidhish Sagar, M.S. Nuclear Engineering, 2025, graduate student at the Univesrity of Cambridge

1. Alexis Breanna Dubs, 2020-date, Lyo
2. Krystian Kamil Ganko, 2020-date
3. Christopher Canova, 2021-date
4. Jinwook Rhyu, 2021-date
5. Pedro Seber e Silva, 2021-date
6. Hasan Al-Mahayni, 2023-date
7. Wallace Tan Gian Yion, 2023-date
8. Younghyeon Kim, 2023-date (w/Allan S. Myerson)
9. Jacob Ian Sass, 2023-date
10. Marieke De Bock, 2023-date
11. Jacob Rosenfeld, 2023-date
12. Efstathios Iliakis, 2023-date
13. Andy Liu, 2024-date (w/Allan S. Myerson)
14. Jacob Rosenfeld, 2024-date
15. Jacob Saas, 2024-date
16. Wallace Tan Gian Yion (w/Sungho Shin)
17. Swathi Ganesh, 2024-date (w/Allan S. Myerson/Bernhardt L. Trout)
18. Jingxian Zhang, 2024-date (w/Allan S. Myerson/Bernhardt L. Trout)
19. Younghyeon Kim, 2025-date (w/Allan S. Myerson/Bernhardt L. Trout)
20. Palak Vora, 2025-date (w/Allan S. Myerson/Bernhardt L. Trout)
21. James Kah Chun Law, 2025-date (w/Allan S. Myerson/Bernhardt L. Trout)
22. Hyungjoon (Daniel) Ji, 2025-date
23. Pragnay Nevatia, 2025-date (w/Allan S. Myerson/Bernhardt L. Trout)
24. Yingshuang Cheng, 2025-date

B. Supervision of Postdoctoral Fellows/Senior Research Associates/Research Scientists

1. Jay Alameda, 1997-2000, Senior Research Programmer, National Center for Supercomputing Applications
2. Mst Kamrunnahar, 2001-2003, Research Associate, Center for Neural Engineering, Department of Engineering Science and Mechanics, Pennsylvania State University
3. Pui Shan (Ann) Chow, 2001, Senior Research Fellow, Institute of Chemical and Engineering Sciences, Singapore

4. Zoltan K. Nagy, 2001-2003, Professor of Chemical Engineering, Purdue University
5. Yuan (Eric) He, 2003-2005 (joint with Prof. R. Alkire), Technical Staff/Manager, Synopsis
6. Mitsuko Fujiwara, 1999-2011, self-employed
7. J. Carl Pirkle Jr., 2000-2019
8. Hong Chen, 2005-2006, Senior Staff, Synopsis
9. Lisa Bievenue, 2006-2008, Project Coordinator, University of Illinois at Urbana-Champaign
10. Kejia Chen, 2008-2009, Data Scientist, Google
11. Richard Lakerveld, 2010-2012 (joint with Prof. P. I. Barton), Assistant Professor, Hong Kong University of Science and Technology
12. Masako Kishida, 2010-2012, Associate Professor, National Institute of Informatics, Tokyo, Japan
13. Brahim Benyahia, 2011-2012 (joint with Prof. P. I. Barton), Senior Lecturer, Department of Chemical Engineering and Materials Science, University of Loughborough
14. Joseph K. Scott, 2012-2013, Associate Professor, Department of Chemical and Biomolecular Engineering, Georgia Institute of Technology
15. Ashlee N. Ford Versypt, 2012-2014, Professor, University at Buffalo
16. Stefan Streif, 2013, Professor, Technische Universität Chemnitz
17. Ali Mesbah, 2012-2014, Associate Professor, University of California, Berkeley
18. Eranda Harinath, 2013-2018, Head of Process Modeling, mRNA Center of Excellence at Sanofi
19. Jasdeep Singh Mandur, 2014-2017, Research & Development, Merck
20. Michael L. Rasche, 2015-2017, Adjunct Assistant Professor of Mathematics, University of North Carolina at Asheville
21. Mo Jiang, 2015-2017, Associate Professor, Arizone State University
22. Yiming Wan, 2015, 2016-2018, Assistant Professor, Huazhong University of Science and Technology
23. Cezar Augusto da Rosa, 2015-2016, Professor, University Federal Rio Grande, Brazil
24. Sergio Lucia, 2016, Professor & Chair of Process Automation Systems, Technical University of Dortmund
25. Benben Jiang, 2016-2021, Associate Professor, Beijing University of Chemical Technology
26. Gerard Capellades Mendez, 2018 and 2020, Assistant Professor, Rowan University
27. Elizabeth Cummings Bende, 2018-2021 (joint with Anthony Sinskey and Stacy Springs), Process Development Scientist, Amgen
28. Arie Havasov, 2018-2019, Senior Associate Process Modeling Scientist, Pfizer
29. Corinne Carpenter, 2018-2019, Head of Translational Research, nference
30. Sha Sha, 2019-2021, Scientist II, Ultragenyx Pharmaceutical Inc.
31. Amos E. Lu, 2019-2020, Data Scientist, Sanofi
32. Mutti-Ur Rehman, 2020-2021, Associate Professor of Mathematics, Sukkur IBA University
33. Giacomo Galuppini, 2020-2023, Assistant Professor, University of Pavia
34. Frederik Doerr, 2020-2021
35. Keon Ho, 2020-2021, Research Scientist, Korea Research Institute of Standards and Science
36. Jinwoo Park, 2020-2021, Assistant Professor, Dongguk University, South Korea
37. Pil Rip Jeon, 2020-2021, Assistant Professor, Chemical Engineering, Kongju National University, South Korea
38. Hamza Ismail, 2020-2022 (with Allan Myerson)
39. Sanket Diwale, 2020-2023
40. Vivek Bal, 2020-date
41. Moo Sun Hong, 2021-2023, Assistant Professor, Seoul National University
42. Damdae Park, 2021-2022, Assistant Professor, Chungnam National University
43. Yi Zhang, December 1, 2021-November 31, 2022
44. Shin Hyuk Kim, 2021-2022 (with Jay H. Lee at KAIST), Assistant Professor, Hanbat National University 28

45. Francesco Civati, 2021-2022 (with Allan Myerson and Bernhardt Trout), Senior Scientist, Vertex Pharmaceuticals
46. Anish Dighe, 2022-2025, Senior Scientist, Merck
47. Francesco Destro, 2022-2025, Engineering, BioCurie
48. Jay Yadav, 2022-2025
49. Ayse Eren, 2022-2025 (with Allan Myerson), Senior Scientist, Vertex Pharmaceuticals
50. Andreas Himmel, 2022 (with Rolf Findeisen at TU Darmstadt), Forschungs- und Entwicklungsingenieur (Research and Development Engineer), IAV
51. Janine Matschek, 2022 (with Rolf Findeisen at TU Darmstadt)
52. Yingjie Ma, August 2022-2025, Assistant Professor, Nanjing University
53. Jing Guo, August 8, 2022-2025, Assistant Professor, Polytechnique Montréal 30
54. Naresh Mohan, 2022-date
55. Andrew Cashmore, 2022-2025
56. Ted Raymond, 2022-2023
57. Seokyoung Hong, 2022-2025, postdoc in Jong Min Lee's group, Seoul National.
58. Liang Wu, 2023-2025, postdoc at John Hopkins University
59. Srimanta Santra, 2023-2025
60. Prabhat Kumar Mishra, 2023, assistant professor, IIT Bombay
61. Maria del Carme Pons Royo, 2023-date
62. Jie Wang, 2023-2025
63. Shashank Venkat Muddu, 2023-2025
64. Woosung Lee, 2023-2025
65. Saikat Mukherjee, 2023-2025, Professor, Indian Institute of Technology
66. Huiwen Yu, 2023-2025
67. Minsu Kim, 2023-date
68. Kyojin Jang, 2023-2024
69. Mona Kanso, 2023-2025, Research Scientist, Merck
70. Mohammed Aatif Shahab, 2023-2025, Systems Engineer, BioCurie
71. Shimin Wang, 2023-2025, Assistant Professor at Hong Kong
72. Shalini Singh, 2023-2025, postdoc, University of British Columbia
73. Yanchen Wu, 2023-date
74. Hyungseok (Hyu) Kim, 2023-2025, Scientist I, Sanofi
75. Cao Liang, 2023-2025
76. Shengling Shi, 2023-2025, Assistant Professor at the Delft Center for Systems and Control, Delft University of Technology (TU Delft)
77. Sunkyu Shin, 2023-2025, postdoc in William Green's lab at MIT
78. Suzane Martins Cavalcanti, 2024
79. Steven Burcat, 2024-2025, postdoc at MIT
80. Aniket Udepurkar, 2024-date, with Allan Myerson
81. Leilei Cui, 2024-2025, Assistant Professor, University of New Mexico
82. Yunhong Che, 2024-date
83. Fateme (Baran) Molajafari, 2025-date, with Allan Myerson
84. Prakitr Srisuma, 2025-date, with Allan Myerson
85. Rohan Patrick Kadambi, 2025, Merck
86. Jinwook Rhyu, 2026-date, with Martin Bazant

C.1. Service on Ph.D. Examination Committees

UIUC: N. Agarwal (Mechanical Science and Engineering), H. An (Civil and Environmental Engineering), N. Andrews, L. Ang, M. Balmas, X. Bao, K. Benak (Material Science and Engineering), Paul Blowers, Lyndon Brown (Computer and Electrical Engineering), Kyle Carmarda, G. Channell, K. S. Cheong

(prelim only), Leo Chiang (Chair), Y. P. G. Chua (Chair), M. Daley (Material Science and Engineering), A. Dalton, J. DesNoyer, Kapil Dev, P. Dimitrakopoulos, T. Drews, Steven Duke, E. Eliadis, A. Ee Lui (Chair), Andrew Featherstone (Chair), M. Forrest (prelim only), Ashlee N. Ford (Chair), Kevin Furman, Joshua Gray, Rudiyanto Gunawan (Chair), C. Gupta, Rebecca Harman-Baker (Computer Science), Guangwen He, Alice Hollister, J. Z. Hua, E. Hukkanen (Chair), Joshua Isom (Chair), Suzanne Jogun, Michael Jung, Mohan Karulkar, Nicholas C. S. Kee, Y. Kondratenko, Rebecca Kruse (Chemistry), Charlotte Kwok, James Ledbetter, X. Li (Chair), H.-H. Lin (Mechanical and Industrial Engineering), D. Lubomirsky, M. Luebbers, E. Lui, Diana Llera-Rodriguez, David Lei Ma (Chair), E. Metsi, Nitish Nair (MIT), S. W. Daniel Ong, Rakesh Parekh, Yan Qin, Michael Rasche (Chair), Ernesto Rios-Patron (Chair), Effendi Rusli (Chair), Evan Russell (Chair), Supreet Saini, Wolfgang Schmidt, Joseph Shectman (Mechanical and Industrial Engineering), Ryan Stephens, Kalena Stovall, S. Talreja, W. L. Tang (Chair), Fred Thomas, Tina Togkalidou (Chair), Jeremy VanAntwerp (Chair), Dirk Van Hyning, Xing Yi Woo (Chair), Feng Xue, Rama Vaidyanathan, Yannis Voudouris, Matthew Willis, Kang Wu, C. Yeung, Jennifer L. Younker, P. Zamora, L. L. Zhan Zhu

MIT partial list: Nitish Nair, Spencer Schaber, Lifang Zhou (advisor), Xiaoxiang Zhu (advisor), Stuart Harwood, Kamil Khan, Mo Jiang (advisor), Zachary Ulissi (co-advisor), Sivaraman Ramaswamy, Brandon J. Reizman, Qing Xu, Mark C. Molaro (advisor), Lee William Drahushuk, Jouha Min (co-advisor), Joel A. Paulson (advisor), Lucas Foguth (advisor), Tsai-ta Christopher Lai, Jicong Li, Raymond Smith (presider), Matthew Johnson, Dongying (Erin) Shen (advisor), You Peng (co-advisor), Zhilong Zhu (advisor), Mary Catherine “Catie” Bartlett, Kristen A. Severson (advisor), Elizabeth (Liza) M. Y. Lee, Garrett Ryan Dowdy, Amos E. Lu (advisor), Jennifer M. Schall, Suzane Martins Cavalcanti, Matthias E. Freiherr von Andrian-Werburg (advisor), Michael Forsuelo (advisor), Weike Sun (advisor), Kehang Han (presider), Yili Qian (Mechanical Engineering), Rohit Kannan, Nian Liu, Supratim Das (presider), Andrew John Maloney (advisor), Paphonwit Chaiwatanodom (advisor), Kosi C. Aroh, Moo Sun Hong (advisor), Hongbo Zhao (presider), Kaylee Schickel (advisor), Anastasia Nikolakopoulou (advisor), Tam Ngoc Thanh Nguyen (advisor), Marc Dylan Berliner (advisor),

Qingying (Jennie) Zeng, Yen-Ting Wang, Xiaorui Dong, Surya Effendy, Hamid Doosthosseini, Matthew Robert Dobbins (advisor), Fabian Mohr (advisor), Patrick Asinger (advisor), Rohan Patrick Kadambi (advisor), Alexis (Lexi) Breanna Dubs (advisor), Krystian Kamil Ganko (advisor), Pavan Krishna Inguva (advisor), Chinmay Shripad Gangal, Alexander Ethan Cohen, Michael Li, Manolis Kellis, Prakitr Srisuma (advisor), Qihang Zhang (EECS), Hamid Doost Hosseini

Washington University in St. Louis: Venkatasailanathan Ramadesigan, Paul W.C. Northrop, BharatKumar Suthar

KAIST: Hong Jang, Shin-Hyuk Kim

Otto-von-Guericke-Universität Magdeburg: Daniel Hast

C.2. External Examiner on Ph.D. Theses

- Cheng Cheng, Chemical and Biomolecular Engineering, National University of Singapore
- Calin-Cristian Cormos, Chemistry and Chemical Engineering, Babes-Bolyai University Cluj-Napoca, Romania
- Zhang Yong, Electrical and Computer Engineering, National University of Singapore
- Vinay Kumar Kariwala, Chemical and Materials Engineering, University of Alberta
- Ana-Maria Cormos, Chemistry and Chemical Engineering, Babes-Bolyai University, Cluj-Napoca, Romania

- Guangwen (Wen) He, Chemical and Biomolecular Engineering, National University of Singapore
- Hok Chung Alex Chen, Chemical Engineering, The University of Queensland, Australia
- Christian Lindenberg, Mechanical and Process Engineering, Swiss Federal Institute of Technology (ETH), Zürich
- Huang Wen, Chemical and Biomolecular Engineering, National University of Singapore
- Marcello Torchio, Computer Science Engineering, University of Pavia, Italy
- Giovanni Maria Maggioni, Mechanical and Process Engineering, Swiss Federal Institute of Technology (ETH), Zürich
- Fridolin Röder, Mechanical Engineering, Technical University of Braunschweig, Germany (now a junior professor at the University of Bayreuth)
- Shin Hyuk Kim, Chemical and Biomolecular Engineering, KAIST, South Korea (now an assistant professor at Hanbat National University)
- Jarrod Lund, Materials Engineering, Purdue University
- Morten Wahlgreen Kaysfeld, Technical University of Denmark (DTU)

C.3. Visiting Faculty/Scientists

- Rudiyanto Gunawan, Department of Chemical and Biomolecular Engineering, National University of Singapore (December 2010), Associate Professor, University at Buffalo
- Rolf Findeisen, Institute for Automation Engineering, Laboratory for Systems Theory and Automatic Control, Otto-von-Guericke University Magdeburg, Germany (August 2011, Summer 2012, Summer 2013, Summer 2017)
- Davide M. Raimondo, Dipartimento di Informatica e Sistemistica, Universita' degli Studi di Pavia, Italy (2012)
- Lixian Zhang, Research Center of Intelligent Control and Systems. Harbin Institute of Technology, China (2012-2013)
- R. Bhushan Gopaluni, Department of Chemical and Biological Engineering, University of British Columbia, Vancouver, Canada (2012-2013)
- Yanyang Wu, East China University of Science and Technology, Shanghai, China (2013-2014)
- Jeremy G. VanAntwerp, Calvin College, Grand Rapids, Michigan (2013-2014)
- Jingcai Cheng, Institute of Process Engineering, Chinese Academy of Sciences, Beijing (2014-2015)
- Saima Noor, COMSATS Institute of Information Technology, Pakistan (2015-2016)
- Hector Budman, University of Waterloo (2015)
- Carlos Ocampo-Martinez, Technical University of Catalunya (2015)
- Brijesh Dixit, Indian Railways (2016)
- Jong Min Lee, Seoul National University, South Korea (2016-2017)
- Ulrike Krewer, Karlsruhe Institute of Technology (2017)

E. Courses Taught (with recent instructor and course scores received by students)

E.1 University of Illinois at Urbana-Champaign

1. The Chemical Engineering Profession
2. Introduction to Chemical Engineering
3. Chemical Rate Processes and Reactor Design
4. Chemical Process Control and Dynamics
5. Open-ended Experimental Design/Process Development
6. Applied Mathematics in Chemical Engineering (graduate)
7. Large-scale Systems Theory (graduate)

8. Chemical Reaction Engineering (graduate)
9. Advanced Topics in Heat and Mass Transfer (graduate)
10. Electrochemical Engineering (undergraduate and graduate)
11. Optimal Control (graduate)
12. Systems Engineering (graduate)

E.2 Massachusetts Institute of Technology

1. Systems Engineering (10.551, graduate, Spring 2003 and Spring 2011-date)
2. Advanced Systems Engineering (10.552, graduate, Fall 2011, Fall 2017)
3. Materials Systems Engineering Seminar (10.985, graduate, Spring 2011-date)
4. Numerical Methods (10.34, graduate, 2012-2014, 2018)
5. Analysis of Transport Phenomena (10.50, graduate, Fall 2015)
6. Process Data Analytics (10.354/10.554, undergraduate/graduate, Fall 2019, Fall 2020)

E.3 Professional Education Courses

a. Applying Machine Learning to Engineering and Science, MIT xPro
b. Bioprocess Data Analytics and Machine Learning (MIT/U Mass Lowell), October 2020, June 2021 (lecturer rating: 4.78, materials rating: 4.56, overall course rating: 4.56)
c. Industrial Lyophilization Training (U Mass Lowell/Merck/U Conn/PSI/FDA/MIT), February 2021

IV. SERVICE (PUBLIC, PROFESSIONAL/DISCIPLINARY, AND UNIVERSITY)

A. Service to Disciplinary and Professional Societies and Associations

1. National Academies of Science, Engineering, and Medicine

Member, 2019-date; Invited Participant, Tenth German-American Frontiers of Engineering Symposium, April 25-28, 2007; Organizing Committee, Indo-American Frontiers of Engineering (IAFOE) Symposium, Irvine, California, February 28-March 1, 2008; Co-Chair for Session on Manufacturing in the Chemical and Automotive Industries, IAFOE Symposium, 2008; Invited Participant, 7th Annual National Academies Keck Futures Initiative (NAKFI) Conference, The National Academies, Irvine, California, November 19-22, 2009; Invited Panelist, A Chemical Sciences Roundtable Workshop on "Data Science: Opportunities to Transform Chemical Sciences and Engineering," Washington, DC, February 27-28, 2018; Panelist, "Integrated Continuous Manufacturing of Pharmaceuticals," Session on Integration, Continuous Manufacturing for the Modernization of Pharmaceutical Production, National Academies of Science, Engineering, and Medicine, Washington DC, July 30-31, 2018; Discussion leader in expert systems/data science/machine learning, Section 3 meeting, National Academy of Engineering, Washington, DC, October 7, 2019; Opening lecture on Control and Analytics, "Modeling, Data Analytics, and Machine Learning for Process Development and Verification," National Academies Workshop on Innovations in Pharmaceutical Manufacturing, Washington, DC, February 27, 2020; Virtual Workshop on Barriers to Innovations in Pharmaceutical Manufacturing, Board on Chemical Sciences and Technology of the National Academies, June 2-3, 2020; Section 3 Search Committee, 2020-date; Reviewer, Innovations in Pharmaceutical Manufacturing on the Horizon: Technical Challenges, Regulatory Issues, and Recommendations, National Academies Press, Washington, DC, 2021; Was one of three individuals in a half-hour discussion on molecular additive discovery and design for advanced polymers with the National Academies of Sciences, Engineering, and Medicine's Committee on "Advising NSF on its Efforts to Achieve the Nation's Vision for the Materials Genome Initiative (DMREF);" Chair, Section 3 Process Systems Engineering Search Sub-Committee, National Academy of Engineering, 2022-date; Study Committee, Options for a National Plan for Smart Manufacturing, National Academies of Sciences,

Engineering, and Medicine, 2022-date; Speaker and Panelist, Successes and Challenges in Biomanufacturing – A Workshop, Board on Life Sciences, National Academies of Sciences, Engineering, and Medicine, October 25, 2022; Invited participant, Aligning Science, Health, Business and Technology for the Future: A Forum for Achieving an Intelligent HealthScience System, National Academy of Medicine, December 12-13, 2022; Member, Committee on the Options for a National Plan for Smart Manufacturing, 2022-2023; Member, Organizing Committee for the Workshop on State-of-the-Art in Smart Manufacturing, 2022-2023; Moderator, Plenary Session 1:State-of-the-Art in SM Enabled by New Computational Tools and Methods, Workshop on State-of-the-Art in Smart Manufacturing, 2023; Moderator, Plenary Session 2: New Sensing Modalities and Digital Thread for SM, Workshop on State-of-the-Art in Smart Manufacturing, 2023

2. Institute of Electrical and Electronic Engineers (IEEE)

Fellow, 2007-date; Senior Member, 2005-2007; Member, 1994-2005; Control Systems Society, 1994-date; Conference Editorial Board, Control Systems Society, 1997-2000; Robust Control Working Group, 1996-1999; Participant at the IEEE CSS/NSF Workshop on New Directions in Control Engineering Education, 1998; CSS Technical Committee on Robust Control (TCRC), 1999-2009; International Programme Committee, IEEE International Conference on Control Applications (CCA), 2000-2002; International Programme Committee, IEEE Computer-Aided Control System Design Conference, 2000-2002; Chair of the Technical Committee on Industrial Process Control, Control Systems Society (CSS), 2002-2011; Technical Committee on Industrial Process Control (named was changed to Process Control), Control Systems Society (CSS), 2002-date; CSS Technical Activities Board, 2002-2010; Associate Editor for Nonlinear Systems, Emerging Control Theory and Applications, Biological Systems, and Applications, Joint IEEE Conference on Decision and Control and the European Control Conference (CDC-ECC'05), 2005; IEEE Control Field Award Committee, 2007-2010; Chair for Session on Distributed Parameter Systems III, IEEE Conference on Decision and Control, 2008; IEEE Control Systems Society Award Committee, 2009-2011; Chair, Awards Subcommittee on Transactions in Control Systems Technology Outstanding Paper Award, 2009-2011; IEEE Control Systems Society Fellow Selection Committee, 2009-2010; CSS Technical Committee on Systems with Uncertainty, 2009-2019; Participant, International Workshop on the Impact of Control: Past, Present, and Future, Berchtesgaden, Germany, October 18-21, 2009; CSS Board of Governors, 2010; Associate Editor, IEEE Control Systems Magazine, 2010; Deputy Editor-in-Chief, IEEE Control Systems Magazine, 2010-2011; International Program Committee, IEEE International Symposium on Computer-Aided Control System Design, 2010; Co-organizer and Co-chair for Session on Uncertainty Analysis and Robust Model Based Control, IEEE International Symposium on Computer-Aided Control System Design, 2010; International Program Committee, Joint Symposium on Computer-Aided Control System Design and Systems with Uncertainty, 2011; Co-organizer for Session on Robust Model-based Control: Part I, IEEE International Symposium on Computer-Aided Control System Design and Systems with Uncertainty, 2011; Co-organizer for Session on Robust Model-based Control: Part II, IEEE International Symposium on Computer-Aided Control System Design and Systems with Uncertainty, 2011; Task Force on Promotion of CSS Publications, 2011-2012; Editor-in-Chief, IEEE Control Systems Magazine, 2012-2014; Liaison Representative, IEEE Technical Activities Board Magazine Committee, 2012-2014; Publication Activities Board, 2012-2014; International Program Committee, Joint Symposium on Computer-Aided Control System Design and Systems with Uncertainty, 2013; Senior Editor, IEEE Life Sciences Letters, 2014-2017; Co-Organizer for Session on New Directions in Robust Optimal Control, IEEE Conference on Decision and Control, 2014; Session Chair, SY-BIO Workshop, 2015; International Program Committee, IEEE Conference on Norbert Wiener in the 21st Century, 2016; ACC representative, CSS Ad-hoc Committee on Conference Publications, 2016; International Program Committee, IEEE Conference on Control Technology and Applications, 2018; IEEE Control Systems Society Transition to Practice Award, 2019-date; IEEE Senior Member Application Review Panel, 2019; CSS Technical Committee on Robust and Complex Systems (TCRCS), 2019-date; General Chair, IEEE Conference on Decision and Control, Jeju Island, South Korea, 2020; Member, IEEE Technical Committee on

Distributed Parameter Systems, 2020-date; Session Chair, Embedded Convex Optimization for Control, IEEE Conference on Decision and Control, December 14, 2020; Co-presenter, Lithium-ion Battery Management Systems Workshop, IEEE Conference on Decision and Control, December 12-13, 2020; Program Committee, IEEE Conference on Decision and Control, 2021; Lead Advocate in Opposition of the Proposed Constitutional Amendment, Article XIV, 2022

3. American Automatic Control Council (AACC)

Arrangements for the Model Predictive Control Workshop (for Manfred Morari and Evanghelos Zafiriou), American Control Conference, 1991; Chair for Session on Control Relevant Identification and Fault Detection, American Control Conference, 1994; Organizer and Chair for Session on Control of Uncertain Systems, American Control Conference, 1994; Chair for Session on Process Monitoring, American Control Conference, 1995; Chair for Session on Statistical Process Monitoring, American Control Conference, 1995; Co-chair for Session on Control of Sheet and Film Forming Processes, American Control Conference, 1997; Chair for Session on Parameter Identification, American Control Conference, 1998; Chair for Session on Control of Particulate Systems, American Control Conference, 2000; Chair for Session on Novel Formulations of Model Predictive Control, American Control Conference, 2001; Program Committee, American Control Conference, 2003-2005, 2007-2009, 2011; Organizer and Presenter (with Jay H. Lee and Babatunde A. Ogunnaike), Workshop on Advanced Process Control, American Control Conference, 2004; Co-Chair for Session on Process Control and Identification, American Control Conference, 2004; Co-Chair for Session on Scheduling and Discrete Event Systems, American Control Conference, 2004; Co-Chair for Session on Sliding Mode Control II, American Control Conference, 2004; AIChE Society Review Chair, 2005; Chair for Session on Modeling and Identification of Process Control, American Control Conference, 2005; Director, 2006-2007 (acting director for many subsequent years); Vice-Chair for Invited Sessions, American Control Conference, 2007; Organizing Committee, American Control Conference, 2007, 2010, 2015; Chair for Session on Biomedical Systems, 2007; Chair for Session on Nonlinear Estimation, 2007; Chair for Session on Modeling and Simulation, American Control Conference, 2008; Organizer and Presenter (with Jay H. Lee and Joseph Lu), Workshop on Model Predictive Control with Applications, American Control Conference, 2008; Organizer and Presenter (with Mayuresh Kothare and Murti Salapaka), Special Session on Modeling and Control of Micro and Nanosystems, American Control Conference, 2009; Co-Chair for Session on Dynamic Optimization, 2009; Chair for Session on Observers for Nonlinear Systems, 2009; Co-Chair for Session on Stochastic Adaptive Control, 2009; Steering Committee, 2007-2019; Program Chair, American Control Conference, 2010; Chair for Plenary Session on Sampling, American Control Conference, 2010; Chair for Semiplenary Session on Control as a Key Technology for Radical Innovation in Wind Energy Generation, 2010; Chair for Semiplenary Session on Cooperative Control and Mobile Sensor Networks in the Ocean, 2010; Presenter, Workshop on Ideas and Technology of Control Systems, American Control Conference, June 29, 2010; Member, Board of Directors Committee on Society Reimbursement, 2011; Richard E. Bellman Control Heritage Award Subcommittee, 2011-2012, 2014; IFAC 2020 World Congress Bid Committee, 2011-2013; ACC Return Target Policy Assessment Committee, 2012-2013; Donald P. Eckman Award Subcommittee, 2013; Chair for Session on Identification: Optimal Input Design and Convex Methods, 2013; General Chair, American Control Conference, 2015; Chair for Plenary Session on Energy Efficient Buildings: A Systems Approach, 2015; Chair for Semiplenary Session on New Directions in Advanced Control of Semiconductor Manufacturing, 2015; Chair for Semiplenary Session on Magnetic Control of Therapy to Hard-to-Reach Disease Targets, 2015; Vice President, 2016-2017; O. Hugo Schuck Best Paper Award Committee, 2016; Nominating Committee, 2016-date; Chair, Professional Ethics Committee, 2017, 2018, 2023; President, 2018-2019; Chair, Publication Partnerships Committee, 2018-2019; Past President, 2020-2021; Chair, Nominating Committee, 2020-2021; IFAC World Congress Bid Committee, 2020-2022; Ad-hoc Committee to Review the AACC Travel Policy, 2022; Chair, IFAC WC Steering Committee, 2023-date

4. International Federation of Automatic Control (IFAC)

Co-chair for Session on Multivariable and Robust Control, IFAC World Congress, 1996; International Programming Committee, 6th IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS), 1999-2001; Area Chair for Biochemical and Materials Processing System Modeling and Control, 6th IFAC Symposium on Dynamics and Control of Process Systems, 2000-2001; International Programming Committee, 7th IFAC Symposium on Advanced Control of Chemical Processes (ADCHEM), 2003; Chair for Session on Pharmaceutical Process Control, IFAC World Congress, 2002; International Programming Committee, IFAC Workshop on Time Delay Systems, Rocquencourt, France, September 2003; Co-chair for Session on Microelectronics Manufacturing Process Simulation and Control, IFAC Symposium on Advanced Control of Chemical Processes, Hong Kong, 2003; Technical Area Chair for Particulate and Polymer Processes, 6th IFAC Symposium on Dynamics and Control of Process Systems, Boston, 2004; Chair for Session on Batch Process Modeling and Control, 6th IFAC Symposium on Dynamics and Control of Process Systems, Boston, 2004; Member, Technical Committee on Chemical Process Control (TC 6.1), 2005-date; Area Chair for Batch Process Modeling and Control, IFAC Symposium on Advanced Control of Chemical Processes, Gramado, Brazil, 2006; Chair for Session on Identification and Diagnosis of Mechatronic Systems, IFAC World Congress, 2008; Fellow, International Federation of Automatic Control, 2008; International Program Committee, IFAC Symposium on Advanced Control of Chemical Processes, Instanbul, Turkey, July 12-15, 2009; Journal of Process Control Best Paper Selection Committee, 2009-2011; 2012-2014; International Program Committee, IFAC Symposium on Dynamics and Control of Process Systems, 2010; Chair for Session on Process Control Applications I, IFAC World Congress, 2011; Vice-Chair, Technical Committee on Chemical Process Control, 2012-2017, 2020-2023; Chair, International Program Committee, IFAC Symposium on Advanced Control of Chemical Processes, Singapore, July 10-13, 2012; International Program Committee, IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes (SAFEPROCESS), 2012, 2015, 2021, 2024; Technical Committee on Biosystems and Bioprocesses (TC 8.4), 2012-date; International Program Committee, 12th Computer Applications in Bio Technology (CAB), 2013; International Program Committee, International Symposium on Dynamics and Control of Process Systems, December 18-20, 2013; IFAC Applications Paper Prize Selection Committee, 2014; International Program Committee, IFAC Symposium on Advanced Control of Chemical Processes, Whistler, Canada, June 7-10, 2015; International Program Committee, IFAC Symposium on Dynamics and Control of Process Systems and Computer Applications in Bio Technology, June 6-8, 2016; Manfred Thoma Medal Selection Committee, 2015-2017; International Programme Committee, 6th IFAC Conference on Foundations of Systems Biology (FOSBE), October 9-12, 2016; Chair, Technical Committee on Chemical Process Control, 2017-2020; Member, Technical Committee on Biological and Medical Systems (TC 8.2), 2017-date; Member, Technical Committee on Optimal Control (TC 2.4), 2017-date; Member, Technical Committee on Robust Control (TC 2.5), 2017-date; Member, Technical Committee on Distributed Parameter Systems (TC 2.6), 2017-date; International Programming Committee, IFAC Symposium on Advanced Control of Chemical Processes (ADCHEM), Shenyang, China, July 25-27, 2018; Panelist, "Kalman's Impact on Process Control, Estimation, and System Identification," IFAC Symposium on Advanced Control of Chemical Processes (ADCHEM), Shenyang, China, July 25, 2018; Area Chair, Robust Model Predictive Control, 6th IFAC International Conference on Nonlinear Model Predictive Control, Madison, Wisconsin, August 19-22, 2018; International Program Committee, 6th IFAC International Conference on Nonlinear Model Predictive Control, Madison, Wisconsin, August 19-22, 2018; Chair, Young Author Award Prize Competition Committee, International Conference on Advanced Control of Chemical Processes, 2018; Chair, Keynote Session on Data Analytics and Process Monitoring, International Conference on Advanced Control of Chemical Processes, 2018; International Program Committee, IFAC Workshop on Control of Smart Grid and Renewable Energy Systems (CSGRES), Jeju, Korea, June 10-12, 2019; International Program Committee, IFAC Symposium on Dynamics and Control of Process Systems including Biosystems, Florianópolis, Brazil, April 23-26, 2019; International Program Committee, IFAC World Congress, Berlin, Germany, July 12-17, 2020; Editor for TC 6.1 Power and Process System - Chemical Process

Control, IFAC World Congress, Berlin, Germany, July 12-17, 2020; Associate Editor for TC 8.2 Robust Control, IFAC World Congress, Berlin, Germany, July 12-17, 2020; Vice Chair of the Conference Board (CC5-CC9, applications), 2020-2023; Corresponding Member, Technical Committee on Non-Linear Control Systems (TC 2.3), 2020-date; IFAC Technical Committee on Fault Detection, Supervision & Safety of Technical Processes (SAFEPROCESS, TC 6.4), 2000-date; International Programming Committee, IFAC Symposium on Advanced Control of Chemical Processes (ADCHEM), Venice, Italy, June 13-16, 2021; Chair, Quality Control Task Force, IFAC Conference Board, 2020-2023; International Program Committee, Workshop Series on Control Systems and Data Science towards Industry 4, Hong Kong, 2021; International Program Committee, IFAC Workshop on Control Applications of Optimization (CAO), Gif-sur-Yvette (Paris-Saclay), France, July 18-22, 2022; IFAC Technical Committee on Process and Energy Systems (TC 6.3), 2022-date; Co-organizer, Workshop on Lithium-Ion Batteries: Challenges and Opportunities, 13th IFAC Symposium on Dynamics and Control of Process Systems, including Biosystems (DYCOPS 2022), Busan, Republic of Korea, June 14-17, 2022; Associate Editor, TC 6.1 Chemical Process Control, International Federation of Automatic Control, 2023; Chair, Conference Board, 2023-2026; Vice President (Conferences), 2023-2026; IFAC Council, 2023-2026; IFAC Distinguished Lecturer Program Committee, 2023-2026; International Program Committee, 12th IFAC Symposium on Control of Power and Energy Systems (CPES), Rabat, Morocco, July 10-12, 2024; International Program Committee, 10th IFAC International Conference on Foundations of Systems Biology (FOSBE), Corfu Island, Greece, September 8-11, 2024; National Organizing Committee, 14th IFAC Symposium on Dynamics and Control of Process Systems, including Biosystems (DYCOPS 2025), Bratslava, Slovakia, June 16-19, 2025; IFAC Conference Board Liaison, 14th IFAC Symposium on Dynamics and Control of Process Systems, including Biosystems (DYCOPS 2025), Bratslava, Slovakia, June 16-19, 2025

5. American Institute of Chemical Engineers (AIChE)

Fellow, 2018-date; Life Member, 2011-date; Senior Member, 1998-2018; Member, 1991-1998; Computing and Systems Technology (CAST) Division, 1993-date; Co-chair for Session on Control Relevant Identification and Estimation, Fall Annual Meeting, 1995; Co-chair for Session on Design and Control, Spring National Meeting, 1996; Area 10b Acting Representative to the CAST Executive Committee, Spring National Meeting, St. Louis, 1996; Chair for Session on Plant-wide and Decentralized Control, Fall Annual Meeting, 1996; Chair for Session on Robust Control, Fall Annual Meeting, 1997; Chair for Session on Plant-wide Control, Fall Annual Meeting, 1998; Co-chair for Session on Topics in Systems and Process Control, Fall Annual Meeting, 1999; Vice-Chair for Session on Advances in Process Control, Fall Annual Meeting, 2001; Chair for Session on Control with Advances in Process Control II, Fall Annual Meeting, 2002; CAST Directors' Award Panel, 2002, 2004, 2006, 2007, 2010; Chair, CAST Directors' Award Panel, 2004; CAST Division Programming Board, 2003-2005; Chair for Session on Advances in Process Control, Fall Annual Meeting, 2003; CAST Executive Committee, 2003-2007, 2010-2013; National Programming Committee, 2003-2005; WebCAST Committee, 2003-2010; Chair for Session on Modeling and Control for Microelectronics Manufacturing, Fall Annual Meeting, 2004; Program Coordinator for Systems and Process Control (Area 10b), 2005; Chair for Session on Hybrid Multiscale Simulation, Fall Annual Meeting, 2005; Chair for Session on Recent Developments in Systems and Process Control, Fall Annual Meeting, 2005; Director of CAST Division, 2005-2007; CAST Awards Committee, 2005-2013; 2015-date; Chair for Session on Nonlinear Process Control, Fall Annual Meeting, 2006; WebCAST Committee Chair, 2006-2007; EPBC Dissemination Working Group, 2007-2008; Co-chair for Systems and Process Control Centennial Session, 2008; Computing Practice Award Nominations Committee, 2008; Chair for Session on Modeling and Identification, 2009; Second Vice Chair, CAST division, 2010; Chair, CAST Awards Committee, 2010; Awards Subcommittee, R.H. Wilhelm Award in Chemical Reaction Engineering, 2010; Chair for Tentative Session on Modeling and Identification, 2010; First Vice Chair, CAST division, 2011; Chair for Session in Honor of Manfred Morari's 60th Birthday I, Fall Annual Meeting, 2011; Chair for Session in Honor of Manfred Morari's 60th Birthday II, Fall Annual Meeting, 2011; Chair, Nominations Committee, CAST division, 2011, 2013;

Chair, CAST division, 2012; Council of Division and Forum Officers, 2012; Chair, Nominations Committee for the David Himmelblau Award for Innovations in Computer-Based Chemical Engineering Education, 2012; AIChE's Speakers Corner, 2012-date; Past Chair, CAST division, 2013; Nominations Committee, CAST division, 2014; Expert Panel, Pharmaceutical Discovery, Development and Manufacturing Forum Awards Ceremony, November 17, 2014; Associate Editor, Webinar Advisory Editors Committee, 2016-2017; Panelist, Session VI: Panel Discussion & Recap of Workshop, FDA-AIChE Workshop on Adopting Continuous Manufacturing, March 2, 2016; member, Particle Technology Forum, 2016-date; Poster Judge, AIChE Beer Brewing Competition, 2018; Taste Judge, AIChE Beer Brewing Competition, 2018; Award Committee, AIChE Pharmaceutical Discovery, Development & Manufacturing (PD2M) Student Award, 2019; Panelist, Data Science Education in Chemical Engineering, AIChE Annual Meeting, Orlando, Florida, October 28 – November 2, 2019; Division 15 Poster Judge, AIChE Annual Meeting, Orlando, Florida, October 28 – November 2, 2019; Award Committee, PD2M Award recognizing Outstanding Contribution to QbD for Drug Substance, 2020; Meeting Program Chair, AIChE Annual Meeting, Boston, Massachusetts, 2021; Session Chair, Academia-Industry Partnership: Preparing Students to be Leaders in Industry, AIChE Annual Meeting, Boston, Massachusetts, 2021; Session Chair, Academia-Industry Partnership: The Undergraduate Curriculum, AIChE Annual Meeting, Boston, Massachusetts, 2021 (both sessions are part of the Bridging the Skills Gap in Chemical Engineering program); Session Chair, John M. Prausnitz AIChE Institute Lecture, AIChE Annual Meeting, Boston, Massachusetts, 2021; Session Co-chair, Crystallization of Pharmaceutical and Biological Molecules, AIChE Annual Meeting, Phoenix, Arizona, 2022; Session Cochair, Process Innovation in Bioseparations, AIChE Annual Meeting, Orlando, Florida, November 6-10, 2023

6. National Center for Supercomputing Applications:
Intranet Advisory Committee (1998); Subcommittee on Grants and Contracts (1998); Local Anchor, Chemical Engineering Applications Technology Team (1997-2000); XSEDE User Requirements Evaluation and Prioritization (UREP) team (2016-2022)

7. EFCE Working Party on Computer Aided Process Engineering
International Programming Committee, Joint International Symposium on Process Systems Engineering and European Symposium on Computer Aided Process Engineering, Trondheim, Norway, 1997; Subcommittee on Control and Operations, Joint International Symposium on Process Systems Engineering and European Symposium on Computer Aided Process Engineering, 1997; Chair for Session on Control Structure Design, Joint International Symposium on Process Systems Engineering and European Symposium on Computer Aided Process Engineering, 1997; International Program Committee, Joint Process Systems Engineering/European Symposium on Computer Aided Process Engineering, Garmisch-Partenkirchen, Germany, 2005-2006; International Scientific Committee, European Symposium on Computer Aided Process Engineering, Bucharest, Romania, May 27-30, 2007

8. Computer Aids in Chemical Engineering Education (CACHE) Corporation
Chair for Poster Session, International Conference on Chemical Process Control (CPC V), 1996; Coauthor of "Experimental Projects for the Process Control Laboratory," CACHE News, Fall 2002 (invited reprint); Coauthor of "A Quadruple Tank Process Control Experiment," CACHE News, Fall 2004 (invited reprint); Academic Trustee, 2013-2021; Technical Advisory Committee, International Conference on Chemical Process Control, 2010-2012, 2015-2017; Lead, Statistics Activities (2013-2017); Member, Standing Committee on Awards (2014-2021); Task Force on Education Module Development (a merger of multiple past task forces), 2014-2021; Member, Teaching Resources Center Committee, 2016-2017; Coordinator, Session Proposals for the ASEE Summer School for Chemical Engineering Faculty, 2015-2017; Co-chair, Ad-hoc Committee on Data Analytics, 2017-2019; Founding Conference Chair, Foundations of Process Analytics and Machine Learning (FOPAM), 2017-2019; Chair, Standing Committee on Awards, 2018-2021; Co-organizer, Pre-conference Workshop on Process Data Analytics and Machine Learning, FOPAM, 2019; Chair of Session on Data Analytics Education for Chemical

Engineers, FOPAM, 2019; Co-chair, Task Force on Data Analytics, 2019-2021; Task Force on Teaching Process Control, 2019-date; Nominating Committee, 2020; Committee to Define to New Member Category, 2020-2021; International Programming Committee, Joint Chemical Process Control (CPC) and Foundations of Computer-Aided Process Operation, San Antonio, Texas, January 8-12, 2021; Author of "Applied Statistics and Data Analytics," CACHE News, Summer 2022; Program Committee, Foundations of Process Analytics and Machine Learning (FOPAM), 2022-2023; Chair, Industrial Data Science Applications I Session, Foundations of Process Analytics and Machine Learning (FOPAM), 2023; Rapporteur, Foundations of Process Analytics and Machine Learning (FOPAM), 2023

9. American Society for Engineering Education (ASEE)

Member, 1996-date; Co-organizer for the Session on the Role of the Computer in Undergraduate Process Control Education, ASEE Summer School for Chemical Engineering Faculty, 1997; Co-organizer for the Session on Applied Statistics and Data Analytics, ASEE Summer School for Chemical Engineering Faculty, 2017; Leader for the Session on Computers in Chemical Engineering, ASEE Summer School for Chemical Engineering Faculty, 2017; Judge, Poster Session, ASEE Summer School for Chemical Engineering Faculty, 2017; Participant, ASEE/AIChE Summer School for Engineering Faculty Workshop Workshop, May 25, 2022; Workshop on Applied Statistics and Data Analytics, ASEE Summer School for Chemical Engineering Faculty, Colorado School of Mines, July 24-29, 2022

10. Miscellaneous Chairs/Organization

Organizer for Workshop on Control Techniques from Biological Inspiration, Annual Conference on Neural Information Processing Systems, 1994; Co-Organizer for Second Midwest Process Control Workshop, 1996; Chair for Session on Process Control, Allerton Conference on Communication, Control, and Computing, 1996; Organizer and Session Moderator for the Third Midwest Process Control Workshop, 1999; Organizer and Session Moderator for the Control 2000 Symposium, 2000; Co-chair for Session on Biomineralization, Pharmaceuticals, and Food Crystallization, Symposium D: Crystallization and Interfacial Processes, International Conference on Materials for Advanced Technologies, 2001; Vice-Chairman for Session on Process Systems Engineering 3, 3rd Chemical Engineering Conference for Collaborative Research in Eastern Mediterranean, 2003; Afternoon Session Chair for Symposium B: Pharmaceuticals, Polymers, & Fine Chemicals, Annual Meeting of the British Association for Crystal Growth, 2005; Organizing Committee, Frontiers in Chemical Engineering Educational Workshop, AIChE Annual Meeting, 2005; International Advisory Board, Control of Particulate Processes VII, 2006; Co-Organizer for Process Systems Engineering Consortium Meeting, 2005, 2006, 2008, 2009, 2011 (all with corresponding workshops); Organizer and Moderator for Process Systems Engineering Consortium Meeting, 2007, 2010, 2013; Organizer for the Workshop on Advanced Crystallization Technologies, 2007; Co-organizer for Session on Recent Advances and Problems in Modeling Nucleation, 15th Larson Workshop, Association for Crystallization Technology, 2007; Co-Organizer for Workshop on Population Balance Modeling and Its Applications, 2008; Scientific Committee, International Symposium on Industrial Crystallization, 2008, 2011, 2014, 2017, 2019; Discussion Leader for Session on Best Practices for Curriculum/Course Development/Outreach to the General Public, Global NSEE Workshop, 2008; Steering Committee, Larson Workshops, Association for Crystallization Technology, 2009-2012; Organizer and Co-presenter for Workshop on Crystallization, Santa Barbara, California, 2009; Organizer and Chair for Session on High Throughput Screening and Microreactor Technology for Crystallization, 16th Larson Workshop, Association for Crystallization Technology, 2009; Organizer and Chair for Session on New and Emerging Technologies for Crystallization, 17th Larson Workshop, Association for Crystallization Technology, 2010; Co-presenter for Short Course on Pharmaceutical Crystallization and Downstream Processing: Batch and Continuous Processing, MIT, Cambridge, June 13-15, 2011; Organizer for the Quality by Design Workshop, 2011, 2013; Scientific Committee, Co-organizer for Session on Novel and Emerging Crystallization Technology, 18th Larson Workshop, Association for Crystallization Technology, 2012; Organizer for the Summer School on Molecular and Multiscale

Simulation, National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign, 2012; Panelist for Session II: Improving Scientific and Technical Knowledge to Support Continuous Manufacturing, Promoting Continuous Manufacturing in the Pharmaceutical Sector, The Brookings Institution, Washington, DC, October 19, 2015 (discussions included in the *Promoting Continuous Manufacturing in the Pharmaceutical Sector: Meeting Summary*, The Brookings Institution, Washington, DC); Session Chair for the Workshop on Perspectives on Systems and Control, Zürich, Switzerland, May 19-20, 2016; Program Committee, Panelist, and Session Chair for the Keynote Lecture by Houria Siguerdidjane, 13th International Conference on Informatics in Control, Automation and Robotics, Lisbon, Portugal, July 29-31, 2016; Panelist, Second International Symposium on Continuous Manufacturing of Pharmaceuticals, Cambridge, MA, September 27, 2016; Panelist, Session on Data, Apps, Composability, Security, and Reference Architectures, NIST/OAGi Workshop: Enabling Composable Service-Oriented Manufacturing Systems, April 10-11, 2017; Panelist, Session on Summary, Convergence, and Directionally on Resolved, NIST/OAGi Workshop: Enabling Composable Service-Oriented Manufacturing Systems, April 10-11, 2017; Co-organizer and Chair of Session 9 of 2040 Visions of Process Systems Engineering, A Symposium at MIT on the Occasion of George Stephanopoulos' 70th Birthday and Retirement from MIT, June 1-2, 2017; Co-chair for session on Continuous Cell Culture/Perfusion Bioreactors, Continuous Biomanufacturing: Current Success and Future Trend, University of Oxford, United Kingdom, June 27, 2017; Chairperson for the session on Continuous Processing in Biopharmaceutical Manufacturing, The Bioprocessing Summit, Boston, MA, August 21, 2017; Scientific Committee, International Conference on Population Balance Modeling (PBM), Ghent, Belgium, 2018; Scientific Advisory Board, Continuous Biomanufacturing: Current Success and Future Trend, LMH, Oxford University, June 20-22, 2018; Chair, Disruptive Technologies Conference, San Diego, June 21-22, 2018; Poster Judge, McMaster Advanced Control Consortium Meeting and Workshop, Hamilton, Ontario, Canada, May 14, 2019; Regional Program Co-Chair, 19th International Conference on Control, Automation and Systems, Jeju, South Korea, October 15-18, 2019; Chair for session on Digitalization: Tools to Track, Visualize and Control Continuous Processes, Fourth ECI Conference on Integrated Continuous Biomanufacturing (ICB IV), Brewster (Cape Cod), Massachusetts, October 6-10, 2019; Panel Judge, Asia Pacific Bioprocessing Excellence Awards (ABEA), 2021-date; Discussant, Roundtable Discussion on Continuous Manufacturing in Biologics; Successes and Challenges, United States Pharmacopeia, May 26, 2021; Poster Judge, International Symposium on Industrial Crystallization, Potsdam, Germany, August 30 – September 2, 2021; Presider, Integrated and Continuous Manufacturing: Automation, Control and PAT, ACS Spring Meeting, San Diego, California, March 20-24, 2022; Abstract Screening Committee, AAPS PharmSci 360, Boston, Massachusetts, October 16-19, 2022; International Program Committee, 20th International Conference on Informatics in Control, Automation and Robotics (ICINCO), 2023; International Program Committee, 15th International Conference on Neural Computation Theory and Applications (NCTA), 2023; Chair, Cell & Gene Therapy Talk, Boston, Massachusetts, May 6, 2024; Chairman, Accelerating Manufacturing, Science & Technology in Cell & Gene Therapy (CGT Talk), Framingham, Massachusetts, June 2, 2025; Chairpseron, Optimization and Acceleration of Downstream Processes, 11th Annual Advances in Purification & Recovery, Bioprocessing Summit, Cambridge, Massachusetts, August 20-21, 2025

11. Miscellaneous Society Memberships

Member, Society for Industrial and Applied Mathematics (SIAM), 1994-1998, 2019-2100; Member, SIAG on Control & Systems Theory, 2020-date; Member, Technical Association of the Pulp and Paper Industry, 1995-1998; Member, Alpha Chi Sigma, 1994-date; Member, Materials Research Society, 2001-2002; Member, American Chemical Society, 2002-2003, 2006-2008, 2022-date; Member, Society of Manufacturing Engineers, 2003-2005; Member, ISA, 2003-2005; Senior Member, ISA, 2005-2008; Member, Electrochemical Society, 2005-2008, 2019-date; Member, American Association for the Advancement of Science (AAAS), 2007-2008; AAAS Fellow, 2008-date; American Association of Pharmaceutical Scientists (AAPS), 2018-date; American Physical Society (APS), 2019-date

12. Reviewer for

Science; PNAS; Nature Communications; Chemical Reviews; iScience; IEEE Transactions on Automatic Control; IEEE Control Systems Letters; Automatica; IEEE Transactions on Control of Network Systems; SIAM Journal on Control and Optimization; SIAM Journal on Applied Mathematics; Annual Reviews in Control; Systems & Control Letters; Applied Numerical Mathematics; Optimization Letters; Crystal Growth and Design; Journal of Applied Physics; Journal of Rheology; Rheologica Acta; Journal of Colloid and Interface Science; Electrochimica Acta; Analytical Chemistry; Journal of the Electrochemical Society; ECS Journal of Solid State Science and Technology; IEEE Transactions on Semiconductor Manufacturing; Journal of Microelectromechanical Systems; PLoS Computational Biology; PLoS ONE; Lab on a Chip; Journal of Computational Physics; Mathematical Programming Series B; Linear Algebra and its Applications; IEEE Transactions on Robotics & Automation; Journal of Mathematical Analysis and Applications; Journal of Crystal Growth; CrystEngComm; Biomicrofluidics; The Journal of Physical Chemistry B; The Journal of Physical Chemistry Letters; Physica E; Journal of Pharmaceutical Sciences; ChemComm; Macromolecular Theory & Simulations; Colloids and Surfaces A: Physicochemical and Engineering Aspects; AIChE Journal; IEEE Transactions on Control Systems Technology; Chemometrics and Intelligent Laboratory Systems; Journal of Process Control; Organic Process Research and Development; Journal of Biotechnology; Mathematical Biosciences; Biotechnology and Bioengineering; Molecular Pharmaceutics; Pharmaceutics; Biotechnology Progress; Engineering in Life Sciences; Drug Delivery Letters; Current Drug Delivery; Cell and Gene Therapy Insights; Microscopy and Microanalysis; European Journal of Pharmaceutical Sciences; Drug Discovery Today; Medical & Biological Engineering & Computing; Process Biochemistry; Processes; Polymers; Joule; Crystals; Applied Mathematical Modelling; IEEE/ASME Transactions on Mechatronics; IEEE Access; IEEE Transactions on Neural Networks; Journal of Physics and Chemistry of Solids; Journal of Energy Storage; International Journal of Modern Physics B; Computers & Chemical Engineering; Reviews in Chemical Engineering; Chemical Engineering Science; International Journal of Robust and Nonlinear Control; Spectroscopy Letters; Journal of Sensors; Polymer Engineering & Science; Journal of Applied Polymer Science; Polymer International; Particle & Particle Systems Characterization; Drying Technology; Optimal Control Applications & Methods; IET Control Theory and Applications; IET Science, Measurement & Technology; International Journal of Control; Optimization and Engineering; ASME Journal of Dynamical Systems, Measurement, and Control; International Journal of Modelling and Simulation; International Journal of Heat and Mass Transfer; Hydrological Processes; Asian Journal of Control; Journal of the Franklin Institute; IIE Transactions; European Journal of Control; Canadian Journal of Chemical Engineering; ESAIM Journal on Control, Optimization, and the Calculus of Variations; International Journal of Applied Mathematics & Computer Science; Reaction Chemistry & Engineering; Simulation: Transactions of the Society for Modeling and Simulation International; Chemical Engineering Journal; Chemical Engineering Research and Design - Part A: Transactions of the Institution of Chemical Engineers; Chemical Engineering and Processing: Process Intensification; Chemical Engineering and Technology; Advanced Power Technology; International Journal of Systems Science; International Journal of Intelligent Automation and Soft Computing; Environmental Science & Technology; Separation Science and Technology; Separation and Purification Technology; ISA Transactions; ASCE Journal of Natural Hazards; Resources, Conservation, and Recycling; Process Safety and Environmental Protection; Dynamics and Control; Journal of Complexity; IEEE Transactions on Industrial Electronics; Particuology; Chemical Engineering Communications; Journal of Food Process Engineering; Chemical Engineering Education; Pharmaceutical Patent Analyst; Pulp & Paper Canada; Latin American Applied Research; Brazilian Journal of Chemical Engineering; Journal of Zhejiang University; Springer Verlag Lecture Notes on Control and Information Science Series; Prentice Hall (textbook review); McGraw-Hill (textbook review); Wiley (research monograph and textbook reviews); Cambridge University Press (textbook review); Oxford University Press (textbook review); Taylor & Francis/CRC Press (book review); IFAC World Congress; IEEE Conference on Decision and Control; IEEE International Conference on Control Applications; IEEE International Symposium on Intelligent Control; IEEE International Conference on Industrial Technology; International Conference on

Informatics in Control, Automation and Robotics; IEEE Conference on Norbert Wiener in the 21st Century; American Control Conference; European Control Conference; International Symposium on Advanced Control of Chemical Processes; Foundations of Computer-Aided Process Design; Foundations of Computer-Aided Process Operations; International Conference on Foundations of Systems Biology in Engineering (FOSBE); Process Systems Engineering; International Conference on Chemical Process Control; International Symposium on Chemical Reaction Engineering; European Symposium on Computer Aided Process Engineering; IFAC Symposium on Dynamics and Control of Process Systems; IFAC Symposium on Dynamics and Control of Process Systems, including Biosystems; IFAC Symposium on Fault Detection, Supervision, and Safety of Technical Processes; IFAC Conference on Nonlinear Model Predictive Control (NMPC); IFAC Workshop on Time Delay Systems; IFAC Symposium on Advances in Control Education; IFAC Symposium on Mechatronic Systems / International Conference on Motion and Vibration Control; World Congress of Chemical Engineering; NUMDIFF Conference on Numerical Treatment of Differential Equations; Mediterranean Conference on Control and Automation; ASME Annual Dynamic Systems and Control Conference; IEEE Symposium Series on Computational Intelligent Doctoral Consortium; International Conference on Control and Fault-Tolerant Systems; Indian Control Conference; AIChE Annual Meeting; National Science Foundation; U.S. Department of Energy; American Chemical Society Petroleum Research Fund; U.S. Office of Naval Research; U.S. Naval Sea Systems Command; U.S. Department of Agriculture; European Research Council; Swiss National Science Foundation; United Kingdom Engineering & Physical Sciences Research Council; Netherlands Foundation for Fundamental Research on Matter; Netherlands Organization for Scientific Research; National Sciences and Engineering Research Council of Canada; Research Council of Norway; Austrian Science Fund; A*Star Science and Engineering Research Council of Singapore; Chilean Comisión Nacional de Investigación Científica y Tecnológica; Italian Research Assessment VQR

B. University/Campus Service

1. Massachusetts Institute of Technology (MIT):
Campus: MITEI Steering Committee, Research Center for Environmental Protection at Hydrocarbon Energy Production Frontiers (2010-2014); Skolkovo Tech Faculty Search Committee, Energy sub-committee (2013-2015); Review panel, MIT Summer Research Program (2016); Research Financial Management Focus Group (2016); Faculty Search Committee, MIT Institute for Data, Systems, and Society (2017-2018); MISTI Global Seed Funds Evaluation Committee (2018-date); Faculty Working Group, Re-imagining Research Administration (2019); International Scientific Advisory Committee, MIT A+B Applied Energy Symposium (2019-2021); Reviewer, Abdul Latif Jameel Water and Food Systems Lab Seed Grant Program (2020); CSE 6.0002 Steering Committee, 2020; Lead, Intelligent Processes Theme, MIT Machine Intelligence for Manufacturing and Operations, 2020; Panelist, Decarbonization of Fuels and Transportation, MIT Climate Grand Challenges Research Initiative (November 10, 2020); Graduate Admissions Committee, Center for Computational Science and Engineering (2021-date); Landmark Bio-MIT Advisory Group (advisory to the MIT Provost, 2022-date); Edgerton Award Selection Committee (2024-date)
Chemical Engineering: Graduate Admissions Officer (2010-2015); Graduate Admissions Committee (2010-2018); Graduate Committee (2010-date); Qualifying Exam Committee, Transport Area (2010-2016); ACCESS Sub-committee (2011-2015); Class of 2014 Advisor (2011-2014); Awards Committee (2011-date); Faculty Search Committee (2013-date); Faculty Mentor for James W. Swan (2013-2021); Class of 2017 Advisor (2014-2017); Graduate Officer (2015-2016); Long Range Planning Committee (2015-2016); Faculty Mentor for Heather Kulik (2015-2024); Research Officer (2017-2022); Class of 2020 Advisor (2017-2020); Faculty Mentor for Connor Coley (2019-date); 10-ENG Advisor for Computing (that is, the Engineering Computation, Process Data Analytics, and Manufacturing Design concentrations) (2019-date); Represented the department in communications with the Common Ground

Subcommittee on Computing Thinking (2021); Co-lead, Research Frontiers/Leadership Committee (2022-2023) ; Faculty Mentor for Sungho Shin (2024-date); Class of 2028 Advisor (2025-date)

2. University of Illinois at Urbana-Champaign (UIUC):
Campus: UIUC/Hertz Fellowship (1994-2002, 2004-2008); UIUC Senator (1999-2001); Research Computing Working Group for UIUC Information Technology Strategic Plan (2006-2007); Informatics PhD Development Committee (2008-2009); Named Faculty Appointment Committee (2009-2010)
College of Engineering: Placement (1994-1995); Executive Subcommittee on Strategic Planning for Computers and Networks (1994-1997); Library (1994-2001); Executive Subcommittee on Computers and Networks (1997-2001); Computational Science and Engineering Steering Committee, Chemical Engineering Representative (1999-2001); Chair for the Bioengineering Graduate Curriculum (2000-2001); Acting Departmental Representative on Administrative Committee and Department Heads Meeting (September 2003; April 2004; April 2009); Executive Subcommittee to Review GE/TE courses (Managing Advanced Technology in Industry and Case Studies in Advanced Technology Management in Industry), 2007; Chair, Executive Subcommittee to Review ECE courses Large-scale System Analysis, Power System Control, Power System Dynamics & Stability (2007); Chair, Executive Subcommittee to Review CS course Introduction to Bioinformatics (2007); Alternate Departmental Representative to the Executive Committee (served August 26, September 30, October 14 & 21, November 4, December 16, 2008; March 10, 2009); Internal Review Panel for Pre-proposals to the NSF Materials Research Instrumentation Program (2009);
College of Liberal Arts and Sciences: Faculty Mentor, LAS Teaching Academy (2001-2002); LAS Executive Committee (2003-2005); SCS Director Search Committee (2005-2006);
School of Chemical Sciences: Library (1994-1995); Graduate Student Recruitment (1994-1995); Coordinating Committee for Computer and Electronic Services (1998); Computer Center Advisory Committee (1997-2000); CANS Scientific Software Consultant Search (1999); Computer Applications and Network Services-Electronic Services (1999-2000); CANS Research Programmer Search (2001); Courses and Curricula (2000-2002); Chapter Advisor for the Zeta Chapter of Alpha Chi Sigma (2000-2002); Executive Committee (2004-2007); Endowed Professor Selection Committee (2006); Materials Chemistry Laboratory Review (2008);
Chemical Engineering/Chemical and Biomolecular Engineering: Graduate Student Awards (1994-1995); Shen Postdoctoral Fellowship (1994-1995, 1999); Graduate Recruiting (1994-1997); Grading Appeals (1996-1997); Workstation Manager (1995-1998); Renovation, Undergraduate Control Laboratories (1996-1999); Administrative (1994-2010); Administrative Squad C leader (1996-1997); Computer Facilities (1995-2002, 2003-2006); Undergraduate Advising (1994-2002, 2003-2009); Staff (2000-2010); Systems Bioinformatics (2001-2002); Chair, Undergraduate Curriculum (2001-2002); Senior Staff (2002-2010); Development (2004-2006); Undergraduate Grievance Capricious Grading (2005-2006); Chair, Faculty Recruiting Committee, hired four faculty in the bio area, two in tissue engineering (2005-2009); Awards (2005-2007); Campaign Committee (2008); Chair, Grading Policy Committee (2008); Session Chair, Oral Qualifying Committee (2009);
Bioengineering: Reviewer for Senior Thesis (Brian Kritzberg, 2005); Participated in graduate recruiting (2005);
Mechanical Science and Engineering: Participated in interviews of potential faculty (2007)