MIT PROFESSIONAL EDUCATION
SHORT PROGRAMS

NEW FOR 2013

Materials By Design

Instructor(s): Markus J. Buehler
Associate Professor of Civil and Environmental Engineering, MIT

Date:
June 17–20, 2013

Location:
MIT Campus
Cambridge, MA

Fee:
$2,750

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Overview

The demand for high-performance materials with superior properties, flexibility, and resilience calls for a new design paradigm from the molecular scale upwards. This course covers the science, technology, and state of the art in atomistic, molecular, and multiscale modeling and experiment, applied to describe how mechanical properties of materials can be improved. Through lectures and hands-on labs, participants will learn how materials failure, studied from a first principles perspective, can be applied in an effective “learning-from-failure approach” to design and make novel materials. Participants will also learn how superior material properties in nature and biology can be mimicked in bioinspired materials for applications in new technology.

Who Should Attend

This course will be of interest to scientists, engineers, managers, and policy makers working in the area of materials design, development, manufacturing, and testing. The program is of particular interest to industries where highly functional materials tailored for specific purposes are needed. The focus on mechanical properties includes domains such as biomaterials and implants, adhesives, construction materials, and structural materials for the aero-astro and automotive industries.

Program Outline

Participants will be exposed to both theoretical and applied concepts and systematically learn the basic methods in this emerging field of computational materials science, allowing them to understand this new technology in the context of their specific material applications. The focus on materials failure enables numerous high-impact applications where materials are designed for structural applications and where fracture processes are critical for the material’s durability.

Applied case studies include hierarchical composites, carbon nanotube and silk-based fibers, and “on-demand” protein-based biomaterials. Through these examples, participants will learn how the merger of traditional notions of “material” and “structure” enables an expanded design space in which new material properties can be achieved by simply rearranging a material’s basic elements, rather than introducing new ones. The systems perspective to materials design used here opens new paths towards understanding, designing, and predicting complex materials behavior for the development of “ultimate materials” that combine the best of all basic elements and that amplify the properties of the building blocks in a synergistic manner.

Detailed lecture notes will be provided with numerous examples and references to the literature sources, articles, and weblinks. The program includes a detailed discussion of manufacturing techniques including 3D printing, self-assembly, microfluidics and other technologies. We will distribute and analyze material samples designed based on multiscale simulations and manufactured using 3D printing and other techniques. The program includes morning sessions (9 am-12:30pm) and afternoon labs (1:30-5 pm). A reception will be held on Day 1 and ample opportunities to meet with the instructor and to network with other participants will be provided.

The program is based on two textbooks written by the instructor (will be distributed to all participants):

- [1] M.J. Buehler, *Atomistic Modeling of Materials Failure*, Springer, 2008
- [2] S.W. Cranford, M.J. Buehler, *Biomateriomics*, Springer, 2012

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About the Instructor

Markus J. Buehler is an internationally renowned materials scientist and professor at the Massachusetts Institute of Technology, in the Department of Civil and Environmental Engineering. He directs the Laboratory for Atomistic and Molecular Mechanics (LAMM), serves as the Co-Director of the MIT Computation for Design and Optimization Program, Director of the MIT-Germany Program, and leads the Mechanics and Materials Group in Civil and Environmental Engineering.

Buehler's primary research interest is to identify and apply innovative approaches to design better materials from less, using a combination of high-performance computing, new manufacturing techniques, and advanced experimental testing. He combines bio-inspired materials design with high-throughput approaches to create materials with architectural features from the nano- to the macro-scale, and applies them to various domains that range from composites for vehicles, coatings for energy technologies, to innovative and sustainable construction materials.

Buehler is a sought-after lecturer and has given hundreds of invited, keynote, and plenary talks throughout the world. His scholarly work is highly-cited and includes more than 200 articles on computational materials science, biomaterials and nanotechnology, many in high-impact journals such as Nature and PNAS. He authored two monographs in the areas of computational materials science and bio-inspired materials design, and is a founder of the emerging research area of materiomics. He has appeared on numerous TV and radio shows to explain the impact of his research to broad audiences.

Buehler received the National Science Foundation (NSF) CAREER award, the United States Air Force Young Investigator Award, the Navy Young Investigator Award, and the Defense Advanced Research Projects Agency (DARPA) Young Faculty Award, as well as the Presidential Early Career Award for Scientists and Engineers (PECASE), the highest honor bestowed by the United States government on outstanding scientists and engineers in the early stages of their careers. He was an invitee and plenary speaker at several National Academy of Engineering Frontiers of Engineering Symposia. He recently received the Harold E. Edgerton Faculty Achievement Award for exceptional distinction in teaching and in research or scholarship, the highest honor bestowed on young MIT faculty. Other major awards include the TMS Hardy Award, the MRS Outstanding Young Investigator Award, the ASME Thomas J. R. Hughes Young Investigator Award, the ASME Sia Nemat-Nasser Medal, the ASCE Rossiter W. Raymond Memorial Award, the ACS Stephen Brunauer Award, the ASCE Alfred Noble Prize, and the Leonardo da Vinci Award given by the Engineering Mechanics Institute of ASCE.

He serves as a member of the editorial board of several international publications, including the Journal of the Royal Society Interface, and is editor-in-chief of BioNanoScience, a journal he co-founded. He is the founding Chair of the Biomechanics Committee at the Engineering Mechanics Institute of the American Society of Civil Engineers (ASCE), a member of the U. S. National Committee on Biomechanics, and Co-Chair of the Nanoengineering in Biology in Medicine Steering Committee of the American Society of Mechanical Engineers (ASME), and has organized numerous symposia at the Materials Research Society (MRS). He has chaired several international conferences in the area of materials science and engineering, nanotechnology, nanomedicine and biomechanics.