Research Laboratory of Electronics

The Research Laboratory of Electronics (RLE), founded in 1946, was the Institute's first interdisciplinary research laboratory. RLE grew out of the wartime MIT Radiation Laboratory and was formed to bring together physicists and electrical engineers to work on problems in electromagnetic radiation, circuits, and specialized vacuum tubes. Over the years, RLE's research interests have branched in many directions so that today it is the most intellectually diverse of MIT's interdisciplinary research laboratories.

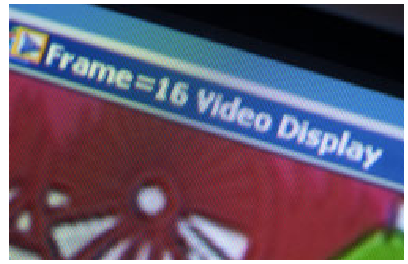
RLE research is currently conducted by approximately 40 faculty members affiliated with the Departments of Electrical Engineering and Computer Science, Physics, Mechanical Engineering, Materials Science and Engineering, Aeronautics and Astronautics, the Division of Biological Engineering, the Engineering Systems Division, and the Harvard-MIT Division of Health Sciences and Technology. During the past year, approximately 250 graduate students and 60 undergraduates from 11 MIT departments pursued research within RLE. The research is supported primarily by Department of Defense (DoD) agencies, the Department of Energy (DOE), the National Science Foundation (NSF), the National Institutes of Health (NIH), and the National Aeronautics and Space Administration (NASA). In addition, numerous projects are funded through industry and private foundations. RLE research is widely varied within six major interrelated groupings: circuits, systems, signals, and communications; physical sciences; quantum computation and communication; nanoscale science and engineering; photonic materials, devices, and systems; and communication biophysics.

Detailed information about RLE research in 2003–2004 can be found in *RLE Progress Report No. 146*, available at http://www.rle.mit.edu/Publications/prog.htm. Research highlights of the past year are summarized in the present report.

Circuits, Systems, Signals and Communications

Professor Jacob White uses a range of engineering design applications to drive research in simulation and optimization algorithms and software. He has recently developed a novel approach to automatically generating low-order models for communication integrated circuits that will speed design tests by orders of magnitude while retaining high accuracy. He is currently working with the Neolinear Division of Cadence Design Systems and with National Semiconductor to demonstrate that his approach can dramatically accelerate the simulation of realistic communication circuits.

Professor Luca Daniel leads research that ranges from the development of highly efficient integral equation solvers for high-frequency integrated circuits and packages to the development of techniques for generating parameterized reduced-order models of analog components and subsystems. During the past year he has developed, mathematically proved, and numerically verified multi-parameter Krylov-subspace moment-matching algorithms that provide full-field solver accuracy for parasitic extraction in linear systems that may be linearly or nonlinearly dependent on their geometrical parameters

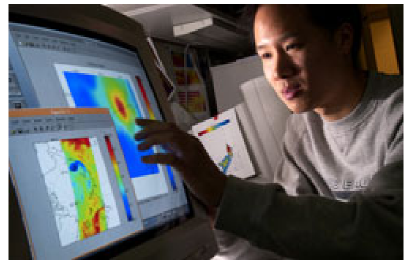


Professor Jae Lim's Advanced Telecommunications and Signal Processing (ATSP) group participated in the design of the Grand Alliance digital high-definition television (HDTV) system, which served as the basis for the US digital television standard adopted in 1996 by the Federal Communications Commission. Since then, Professor Lim has focused his efforts on making improvements to digital television, as well as other real-world problems in audio and digital communications. One specific project in which significant progress has been made this year is the use of video enhancement bits to permit video transmission—within the limits of the broadcast HDTV standard—at substantially higher resolutions. In particular, the goal is to achieve progressively scanned video with a resolution in excess of 1,000 lines at 60 frames per second.

Professor Vivek Goyal joined the MIT faculty and RLE in January 2004. He is building a research group whose focus will be the estimation problems that arise in sensor networks and source coding. Recently, he has established an efficient approach to computing the estimation performance of Kalman filters in jump linear systems. This result may lead to revised objective functions for designing the filters that are used in speech and audio coding.

Professor Alan Oppenheim has continued to work on a broad array of problems in the area of signal processing and its applications. Recent notable achievements include the use of frame representations to compensate for quantization and channel loss errors in communication systems, and the application of non-uniform grid sampling to address the "missing pixel" problem. Other significant results that have been obtained include mathematical models for biological networks and their evolution, and data selection techniques for binary hypothesis testing.

Professor Gregory Wornell, who directs the Center for Wireless Networking, is interested in the algorithmic and architectural aspects of the design of multimedia networks, wireless communication and sensor networks, and reliable circuits and microsystems. During the past year, he has developed a game-theoretical analysis of the source requantization problem, and showed that successive refinement constraints common in popular compression algorithms may be less important than once thought. In other work, he has performed a quantitative analysis and comparison of application-layer versus physical-layer diversity in wireless networks. This comparison shows that application-layer approaches—such as multiple-description coding—can be made as efficient as physical-layer channel coding by appropriately modifying the network architecture to make reliability information available to the upper layers.

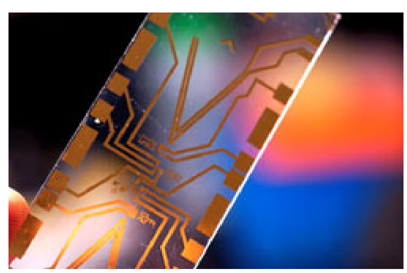


Professor David Staelin and Dr. Philip Rosenkranz have continued their work on the development of instruments and algorithms for retrieving atmospheric and surface parameters from data collected by airborne or satellite sensors. A major recent development—arising from examining several years of satellite data—revealed global precipitation trends, including the interesting result that the most prominent diurnal variation in precipitation is associated with the major deserts of the world, where the scarce rainfall is preferentially evident a few hours after sunset. In other work, a model for computing microwave brightness temperatures was extended to account for the effect of scattering from the ocean and ice-covered surfaces on the downwelling flux.

Professor Rahul Sarpeshkar is pursuing a collection of projects in biologically inspired electronics, including a low-power bionic ear processor, time-based hybrid computing, and analog VLSI vision systems. He has created a 211 μW analog, bionic-ear signal processor that cuts power consumption by more than an order of magnitude—as compared to conventional digital processors for cochlear implants—and is soon to be commercialized. He has also developed a novel, ear-inspired companding algorithm, for hearing in noise, which has application both to cochlear implants and speech-recognition systems.

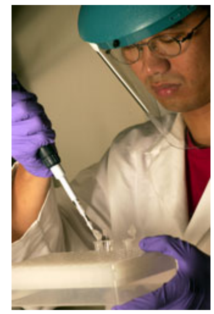
Professor Donald Troxel, in collaboration with Professor Carl Thompson of the Materials Science and Engineering Department, is working on tools and techniques for system-level assessment of the reliability of integrated circuits (ICs), with a particular focus on electromigration and thermal effects. He has developed and released SYSREL, the first public-domain tool for system-level interconnect reliability, and he has applied for a patent on a novel method for cooling three-dimensional ICs.

Professor John Wyatt's long-term goal is the development of a retinal implant device to restore some level of useful vision to patients with outer retinal diseases, such as retinitis pigmentosa or macular degeneration. A key result of the past year's work is a circuit that greatly reduces the electrical power required by any tissue stimulator. This circuit—for which a patent application has been filed—should be useful in cardiac pacemakers, cochlear implants, and other neural-stimulation applications in which power efficiency is an issue.



Professor Joel Voldman's research interest is the development of microtechnology to aid the study of cell biology. Specific technologies that he is working on include electrical approaches for positioning single cells, microfluidics for exposing cells to a variety of growth conditions, and electrical separation approaches for isolating specific cells from their milieu. During the past year, he has developed a simple, yet very strong microscale trap that enables the creation of cell constructs with great precision, and study of the precise patterns of cell function.

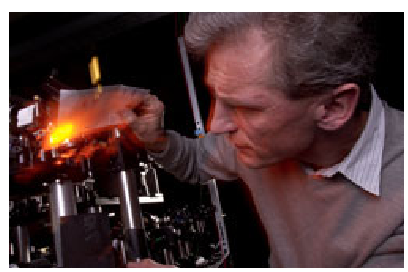
Professor Dennis Freeman has been developing an interferometric-illumination technique that decouples the resolution of a light microscope from its working distance, depth of focus, and field of view. This approach dramatically increases the design space for optical microscopy, enabling high resolution to be obtained in combination with large working distance, depth of focus, and field of view. During the past year he has shown that the information received when an object is scanned using a fixed set of beam parameters is sufficient to reconstruct a high-resolution image of that object, thus speeding up image acquisition by eliminating the need to vary the amplitudes and phases of the beams being employed.



Professor Jongyoon Han's Nanofluidic BioMEMS group is focused on the design, fabrication, and testing of new kinds of molecular sieves and filters for next-generation biomolecule assays in the new era of genomics, proteomics, and glycomics. Recently, Professor Han has demonstrated the first protein-size separation in nanofluidic-filter devices. This advance opens up a new possibility for biomolecule sorting, in that this device did not require any polymeric gel or liquid sieving media. His device may also find application in carbohydrate biology, by solving the challenging problem of carbohydrate separation and hence help develop understanding of the roles of carbohydrate molecules in the human body.

Physical Sciences

Professors Daniel Kleppner and Thomas Greytak lead the Ultracold Hydrogen group, whose studies center on the structure of atomic hydrogen, ultracold collisions, the properties of hydrogen as a quantum gas, and ultrahigh precision spectroscopy. Their principal activities for the last year include construction and demonstration of a mode-locked laser for optical frequency metrology of hydrogen, and construction of an apparatus designed to trap and cool hydrogen that employs a thermalizing agent and uses buffer-gas cooling techniques.



Professor Wolfgang Ketterle's research concentrates on the properties of Bose-Einstein condensates and Fermi seas, the use of ultracold atoms for precision measurements, and the study of many-body physics through experiments with quantum degenerate gases. This past year he has achieved a record-low temperature of less than 500 picookelvin in a very weak trap using a combination of gravitational and magnetic forces. These samples have thermal velocities of 1 mm/s, and a sound speed of 100 μm/s. Such low-temperature, low-density ensembles are important for spectroscopy, metrology, and atom optics. In addition, they are predicted to experience quantum reflections from material surfaces.

Professor David Pritchard is working on precision mass spectrometry of ions. By implementing simultaneous comparisons of two ions in a Penning trap—in order to eliminate the effect of magnetic-field noise—he has been able to compare the masses of single ions with relative accuracy below 1 part in 10^{11}. This represents an order of magnitude improvement in precision over his previous comparison system, and an advance of nearly four orders of magnitude since he began working this problem in 1983. It firmly established his atomic-mass measurements as the most accurate in the world. Among the consequences of this achievement are his test of $E = mc^2$ to 3 parts in 10^7, an improvement by a factor of 40 over previous tests, and the possibility for replacing the standard for mass with a crystal of pure silicon and his accurate determination of the weight of ^{28}Si.

Professor Vladan Vuletic joined the MIT faculty and RLE at the start of the 2003–2004 academic year. The focus of his research is new methods for manipulating atoms in a regime wherein quantum-mechanical aspects dominate their behavior. During the past year he has developed a new general technique for laser cooling that can be used to stop the center-of-mass motion of arbitrary particles which scatter light. He has also measured the fundamental, Casimir-Polder force between ultracold atoms and a surface.

Professor John Joannopoulos has been working on the development and application of a new method for the dynamical simulation of multiple shock waves in solids. Study of the propagation of shock waves in condensed matter has led to new discoveries ranging from new metastable states of carbon to the metallic conductivity of hydrogen on Jupiter. Until now, the standard approach to microscopic studies of shock-wave dynamics has been through non-equilibrium molecular dynamics (NIMD) simulations, whose computational load grows quadratically in the evolution time. His new technique circumvents this difficulty by requiring simulation of only a small piece of the system through dynamic regulation of the applied stress. This reduces the computational burden to one that is nearly linear in the simulation time. Moreover, this method does not require any prior knowledge of the system that is to be simulated.

Professor Jin Kong's research on electromagnetics addresses a variety of problem areas, including left-handed media, unexploded ordnance (UXO) detection, multi-functional wideband radio-frequency systems, and synthetic-aperture radar (SAR) interferometry. His work on left-handed media includes both theory and numerical simulations related to their characterization and their applications as radar absorbers or in lightweight directive antennas. In SAR interferometry he has been investigating the use of space-time adaptive processing to provide robust moving-target indication from space-based platforms.

Professor Abraham Bers and Dr. Abhay Ram are engaged in theoretical research on plasma electrodynamics and its applications. They have recently completed a new formulation of the hydrodynamic description for linear waves in a high-temperature, collisionless plasma in a magnetic field. This formulation is important to understanding and implementing plasma heating and current drive by means of plasma waves excited from external electromagnetic power sources.

Quantum Computation and Communication

Professor Seth Lloyd investigates methods for constructing quantum computers and quantum communication systems using atomic physics, quantum optics, and superconducting electronics, and he collaborates with experimental groups—at MIT and elsewhere—in these areas. He is also interested in theoretical aspects of quantum information processing. While on sabbatical at NEC Basic Research Laboratories in Tsukuba, Japan, this academic year, he collaborated with the Tsai-Nakamura group to build and program the first simple superconducting quantum computers.

Professor Jeffrey Shapiro and Dr. Franco Wong have been working on the generation of entangled photons and their applications in quantum communications and quantum cryptography. During the past year they have continued development of the high-flux sources polarization-entangled photons based on degenerate and non-degenerate bi-directionally pumped, parametric downconverters. These entanglement sources, when further developed, will be employed in an architecture for long-distance, high-fidelity qubit teleportation that they are instantiating, in collaboration with other researchers from MIT and Northwestern University (NU). As part of this project, they have demonstrated 90% upconversion—from the fiber-telecom wavelength band to the visible—at the single-photon level, which is the first step toward the quantum-state frequency converter required by the MIT/NU architecture. In addition, Professors Lloyd and Shapiro have derived the fundamental limit on the reliable transmission of classical information through the pure-loss Bosonic channel.

Professor Terry Orlando is using superconducting circuits as components for quantum computing and as model systems for nonlinear dynamics. The goal of the present research is to use superconducting quantum circuits to perform the measurement process, to model the sources of decoherence, and to develop scalable algorithms. The particular device being studied is made from a loop of niobium interrupted by three Josephson junctions. Progress made during the last year includes demonstrating spectroscopy and measuring the intrawell relaxation time in a persistent-current quantum bit (qubit); implementing a new, inductance-measurement approach to qubit readout; and developing fast, on-chip control circuitry for qubit manipulation.

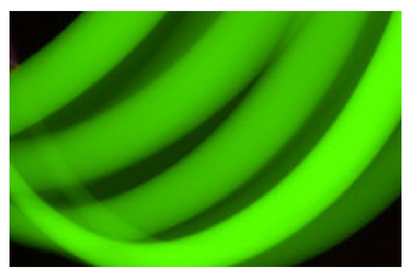
Nanostructures

Professor Henry Smith directs the NanoStructures Laboratory (NSL), whose dual mission is the development of advanced nanofabrication technology and the application of that technology to research in optical, electronic, and magnetic devices. Among his many research highlights from the past year are the following. Together with Professors Joannopoulos and Ippen, he fabricated three-dimensional photonic crystal devices in high-refractive-index silicon using electron-beam lithography, and characterized their optical properties. This marks the first time that anyone had incorporated point defects within a 3-D photonic crystal, and it points the way toward more elaborate photonic crystal structures for controlling light. In another application of electron-beam lithography, he fabricated several types of ring-resonator channel-dropping filters in high-index-contrast silicon nitride. Under test, the performance of these filters was in excellent agreement with theoretical models. It is expected that these channel-dropping filters will play a crucial role in future wavelength-division multiplexed, fiber-optic communication systems.

Professor Karl Berggren joined the MIT faculty and RLE in the fall of 2003. His research group focuses on questions surrounding the application and fabrication of devices whose operation is based on the foundations of quantum mechanics. In recent work he has been fabricating nanowire structures to be used as superconducting, meander-wire, single-photon detectors. The next step with these structures will be to integrate them into an optical cavity to improve their quantum efficiency. In other work, he is using genetic algorithms for proximity-effect modeling of electron-beam lithography. The primary motivation for this work is to improve the structures being fabricated for the superconducting, single-photon detectors, but the proximity effect has long been recognized as a key problem limiting the uniformity of patterns drawn with electron-beam lithography, and hence its solution is of considerable importance for a wide range of nanoscale patterning applications.

Photonic Materials, Devices, and Systems

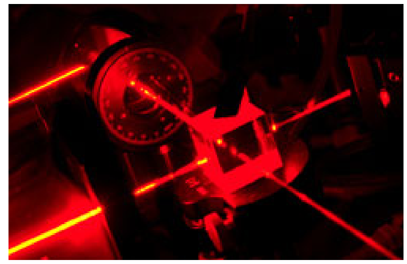
Professor Leslie Kolodziejski and Dr. Gale Petrich are working on the design and fabrication of photonic and opto-electronic devices, including photonic crystal defect waveguides, photonic-crystal-based superprisms, integrated optical logic gates, saturable Bragg reflectors, nanoelectromechanical optical switches, and nanocavity lasers. In collaboration with Professors Ippen and Kärtner, they have designed, fabricated, and characterized very wideband, saturable Bragg mirrors that are extremely important components for the mode-locking and self-starting of ultrafast pulsed lasers. Because of the flexibility of material base and fabrication method, they have been able to fabricate reflectors for a wide variety of laser cavities—operating from visible to infrared wavelengths—and this has stimulated considerable interest from several laser manufacturers.



Professor Erich Ippen has continued his work on the generation and application of ultrashort optical pulses, and the study and development of high-index-contrast integrated photonic devices. During the past year he has developed a novel bismuth-oxide-doped fiber laser, which offers the possibility of ultrashort-pulse operation in a compact, widely tunable device. Together with Dr. Wong and Professor Kärtner, he has demonstrated an optical clock that works without carrier-envelope phase control. These and other advances are leading to more precise frequency standards for navigation and metrology. His work on high-index-contrast integrated photonics—which includes collaboration with Professor Smith on 3-D photonic crystals and integrated photonic add-drop filters—will facilitate direct integration of photonics and silicon electronics.

Professor Yoel Fink is interested in optical materials and photonic bandgap structures that will lead to new approaches to efficient generation, localization, and transport of light. During the past year, he has developed a low-loss, hollow-core, photonic-bandgap fiber for 10.6 μm light. This fiber, which is capable of high-power transmission, is being commercialized for use in laser surgery. In other work, Professor Fink has demonstrated a photoconductive fiber array that may be used for optical tracking.

Professor Franz Kärtner is working on ultrashort pulse generation—in the few-cycle regime—with applications to frequency metrology, as well as on miniaturized femtosecond lasers, and high-density integrated optics made of high-index contrast silicon waveguides. During the past year, he has invented a new synchronization scheme that enables tight synchronization of mode-locked lasers to radio-frequency (RF) signals and the extraction of RF signals from optical pulses trains. This technique is entirely electronic—hence it avoids photodetector nonlinearities and temperature sensitivity—making it extremely important for the proposed MIT X-ray laser facility.



Professor James Fujimoto divides his research efforts between two areas: laser medicine and diagnostics, and ultrashort-pulse laser technology. He continues to pioneer optical coherence tomography (OCT), a field which was created by his group in 1990. OCT is an emerging medical imaging technology that is analogous to ultrasound. During the past year, in collaboration with Jay Duker, MD, the chairman of ophthalmology at Tufts University, Professor Fujimoto has begun clinical studies of a new generation of ultrahigh resolution OCT imagers. To date, they have studied over 500 patients at the New England Eye Center, including subjects with glaucoma, diabetic retinopathy, and age-related macular degeneration. The new instrument provides a significant improvement in the ability to visualize fine details that could, in turn, lead to earlier and more sensitive indicators of disease.

Professor Marc Baldo is interested in electronic and optical processes in molecules. During the past year his work has focused on making electrical connections to protein-molecular complexes, i.e., to create archetypal molecular circuits. He achieved a notable success when he made a solar cell out of components derived from spinach. This is the first time anyone has succeeded in integrating this type of biological complex into a solid-state device.

Professor Vladimir Bulovic's laboratory is addressing a wide variety of topics related to hybrid organic/inorganic optical and electronic devices. Recent achievements include: CdZ/ZnS quantum-dot light emitters—embedded in organic films—that are tunable from the green to the red; the first electrically-pumped exciton-polariton light emitter; the first method for in-plane growth of elongated, millimeter-scale organic crystal needles; active-matrix feedback circuits that compensate for the non-uniformities in organic light-emitting arrays; and a fully lithographic process for integrating organic opto-electronic and electronic devices with lithographic accuracy.

Professor Rajeev Ram addresses the science questions that arise during the development of new or improved opto-electronic devices. He is also interested in the applications of opto-electronic technology to communications and to biology and biotechnology. Some highlights from his recent work include: the development of spatially-resolved thermal profiling for wafer-scale, non-invasive mapping of the optical power distribution inside photonic integrated circuits; development of a technique for fabricating birefringence-free ridge waveguides, which will enable realization of his design for a waveguide optical isolator; in-situ demonstration of the use of Raman spectra to estimate the composition of a bacterial growth culture; and progress toward a system to perform multiple microbial growth experiments in parallel, based on meso-scale fluidic devices. In addition, Professor Ram leads the MIT Communications Technology Roadmapping (CTR) program—sponsored by the Microphotonics Center Industry Consortium—whose unique strength is that it incorporates a deep understanding of the underlying photonic technologies with a comprehensive view of the communications value chain, including industry, business, and policy dynamics.

Professor Qing Hu's research is focused on the development of terahertz (THz) lasers and electronics. His THz quantum cascade lasers have achieved world-record performance in many respects: the highest operating temperature in the pulsed mode (137 K); the highest operating temperature in continuous-wave mode (97 K); and the longest wavelength (141 μm). These sources will be of great importance in opening up the THz spectral region for remote sensing, imaging, communications, and ultrafast signal processing.

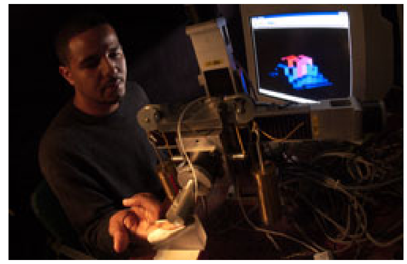
Professor Peter Hagelstein works on a variety of applied problems relating to an unconventional approach to energy generation, as well as the general problem of thermal-to-electrical energy conversion. In recent work on thermal-to-electrical conversion with thermal diodes, he has developed a model for a new, solid-state power converter comprised of a hot-side emitter and a cold-side converter that are separated by a very small vacuum gap. Previous experiments on an initial version of this device showed promising results. The modeling work enables parameter selection for device optimization, and may lead to a new class of solid-state converters with near-Carnot limited thermal-to-electrical conversion efficiencies.

Communication Biophysics

Professor Kenneth Stevens leads a research group whose general focus is to develop quantitative models for human speech production and perception. Recent efforts have concentrated on the discrete form in which sounds and words are stored in memory, the process by which a speaker transforms these discrete representations into the highly-variable speech signal, and how a listener extracts the linguistic information from the speech signal. This research has application to improved algorithms for speech synthesis from text and for automatic speech recognition. It is also relevant to the study of normal and deviant speech development in children.

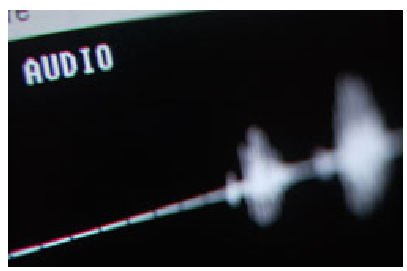
Professor Louis Braida and Dr. Julie Greenberg have as their long-term research goal the development of improved hearing aids and cochlear implants. Specific goals for their work include evaluating the effects of style of speech articulation on speech reception by the hearing impaired; developing accurate analytic models to predict the effects of speech-signal alterations on intelligibility; and developing signal processing techniques that will increase the effectiveness of hearing aids. One of their recent results is the development of a suite of simulators for sensorineural hearing loss and hearing aids that permit wide flexibility in the choice of parameters and allow normal-hearing listeners to be used in tests of hearing-aid processing algorithms.

Dr. Charlotte Reed's research has, as its long-term goal, the development of tactual aids that can serve as hearing substitutes for persons who are profoundly deaf or deaf-blind. More generally, her research is relevant to the development of improved tactual and haptic displays for a broad class of applications, including virtual environment and teleoperator systems. During the past year she has extended her measurement studies of the information-transfer rate of multidimensional tactual signals to include sequential identification tasks. In other experiments she had demonstrated improved tactual display of consonant voicing.



Dr. Mandayam Srinivasan directs the Laboratory for Human and Machine Haptics, whose research focus is understanding the scientific underpinnings of human touch and developing haptic technology for a variety of applications. Some recent results from this work are the following. Substantial improvements have been made in finite-element models of both monkey and human fingertips through the use of empirical data derived from optical coherence tomography. The Instrumented Screw Driver has been developed and used to study a person's ability to sense and control torque. Animal experiments, in collaboration with Massachusetts General Hospital, have been performed to establish real-time tissue models for surgical simulators.

Dr. Andrew Oxenham is addressing how peripheral changes in hearing can affect the more central auditory processes involved in speech and music perception. In one project, he is relating speech perception to psychoacoustic measures of cochlear integrity, beginning with a fundamental study of cochlear nonlinearities in humans. Other work, on complex pitch reception in complex environments, has as one of its goals answering the age-old question of whether place or timing information is most important in conveying frequency information.



Dr. Joseph Perkell has two principal projects underway—"Constraints and Strategies in Speech Production," and "The Effects of Hearing Status on Adult Speech Production"—both of which could have long-term applications in diagnosing and treating communication disorders. One recent experimental result—obtained from comparing the performance of normal-hearing and hearing-impaired subjects—suggests that hearing oneself and/or hearing others plays a role in maintaining the phonemic goals the listener acquired during first-language learning.

Professor Dennis Freeman made further advances in his work investigating the way the inner ear processes sound. During the past year, he has fabricated a novel microelectromechanical probe to study the mechanical impedance of the tectorial membrane, a key tissue that mechanically stimulates the hair cells within the cochlea. His measurements indicate that this membrane has both viscous and elastic components, with the latter being four to five times larger than the former over a wide frequency range. This work greatly extends knowledge of the tectorial membrane's material properties.

RLE Conference Facility

During the past year, the laboratory embarked on a process of refurbishing its core space. While its research facilities have undergone a remarkable and intensive process of renewal—driven by the creation of new research initiatives and the arrival of new faculty—the laboratory had not modernized any of its common spaces since they were created in the 1950s to 1970s. That situation changed dramatically and for the better this year, when the new RLE Conference Center—the centerpiece of this renovation process—was opened. Comprising two conference rooms, each equipped with modern projection and networking capabilities, that can be joined into a single large space, this facility doubles the size of RLE's previous conference room. Moreover, the new rooms have been named in honor of two individuals who made profound contributions to the intellectual life and success of RLE: Professors Jonathan Allen and Hermann Anton Haus.

The new conference rooms were dedicated on May 14, with the Allen and Haus families in attendance. At that time the creation of two named funds were announced: the Jonathan Allen Junior Faculty Fund, an endowment to strengthen faculty career development in RLE; and the Hermann Anton Haus Fund, a resource to support a visiting lecturer program in RLE.

Professor Shapiro and Mrs. Allen

Mrs. Haus and Professor Shapiro

Appointments, Awards, and Events

Dr. Karl K. Berggren was appointed assistant professor of electrical engineering

Dr. Vivek Goyal was appointed assistant professor of electrical engineering.

Dr. Vladan Vuletic was appointed assistant professor of physics. Effective 1 July 2004, he was promoted to associate professor of physics, and appointed the Lester Wolfe career development associate professor of physics.

Professor Jongyoon Han was appointed the Karl van Tassel career development assistant professor of electrical engineering and biological engineering.

Professor Vladimir Bulovic was promoted to associate professor of electrical engineering, effective 1 July 2004.

Dr. Julie E. Greenberg was promoted to principal research scientist.

Dr. Marin Soljacic was appointed principal research scientist.

Dr. Andrew J. Oxenham was appointed a lecturer in the Division of Health Sciences and Technology.

Professors Jongyoon Han and Joel Voldman received National Science Foundation CAREER Awards.

Professor Daniel Kleppner co-chaired the American Physical Society Study Group on Boost-Phase Intercept Systems for National Missile Defense.

Professor Anantha P. Chandrakasan and Gregory W. Wornell were elected fellows of the Institute of Electrical and Electronics Engineers.

Professor Jeffrey H. Shapiro was elected a fellow of the American Physical Society.

Dr. Andrew J. Oxenham was elected a fellow of the Acoustical Society of America.

Professor Yoel Fink received the 2004 Initiatives in Research Award from the National Academy of Sciences.

Professor Jin A. Kong received the 2004 Electromagnetics Award from the Institute of Electrical and Electronics Engineers.

Professor David E. Pritchard received the 2004 Max Born Award from the Optical Society of America.

Professor Kenneth N. Stevens shared the 2004 James L. Flanagan Speech and Audio Processing Award from the Institute of Electrical and Electronic Engineers.

Dr. Joseph Perkell was selected to be the Willard R. Zemlin Lecturer at the 2004 Annual Meeting of the American Speech-Language-Hearing Association.

Ms. Irina Sigalovsky and Dr. Hanfeng Yuan shared the 2004 Helen Carr Peake Research Prize.

Ms. Mary Young received a 2003 MIT Excellence Award.

Dr. Gale Petrich and Ms. Arlene Wint received 2004 MIT Infinite Mile Awards.

Dr. Janet Slifka was the chair of "From Sound to Sense: 50+ Years of Discoveries in Speech Communication," a conference held on the MIT campus from June 11 to June 13, 2004.

Affirmative Action

RLE has worked and will continue working to increase the number of women and minorities in career positions in the laboratory, in the context of the limited pool of qualified technical applicants and the unique qualifications of RLE's sponsored research staff. Specific measures will include: (1) maintaining our high standards for recruitment procedures that include sending job postings to minority colleges and organizations; (2) working closely with the RLE faculty/staff supervisor at the beginning of each search to identify ways of recruiting minority and women candidates for the new position; and (3) being committed to finding new techniques to identify more effectively women and minority candidates. During the past year, one woman was promoted to principal research scientist and one was hired as a research scientist.

Jeffrey H. Shapiro
Director
Julius A. Stratton Professor of Electrical Engineering

More information about the Research Laboratory of Electronics can be found online at http://www.rle.mit.edu.