Microsystems Technology Laboratories

The Microsystems Technology Laboratories (MTL) mission is to foster world-class research, education, and innovation at the nano- and microscales. Science and technology supported by MTL can help solve some of the world's greatest problems in resources (energy, water, and frequency bands, for example), information and communications, health, security, and transportation, to name a few. Researchers all over MIT have been engineering new materials, structures, devices, circuits, and systems using MTL's facilities and services in search of new solutions and applications. Most MTL's research programs are highly interdisciplinary and encompass integrated circuits, systems, communication technologies, machine learning, electronic and photonic devices, micro-electro-mechanical systems (MEMS), bio-MEMS, molecular devices, medical devices, nanotechnology, sensors, and actuators.

Currently, our core faculty is composed of 55 members representing seven departments across the Schools of Engineering and Science. While our faculty are principally drawn from the Departments of Electrical Engineering and Computer Science (EECS), Mechanical Engineering (MechE), and Materials Science and Engineering (DMSE), we continue to see expanding interest and engagement from faculty in the Departments of Biological Engineering (BE), Chemical Engineering (ChemE), Chemistry, and Physics. In addition, because circuits, sensors, and devices are integral to a virtually unlimited range of applications, we have built and continue to strengthen collaborations and interactions with many other research labs and centers across the Institute, including the Research Laboratory of Electronics (RLE), the MIT Energy Initiative, the Institute for Medical Engineering and Sciences (IMES), the Materials Processing Center, the Materials Research Laboratory (MRL), the Computer Science and Artificial Intelligence Laboratory, the Koch Institute for Integrative Cancer Research, and the Institute for Soldier Nanotechnology. MTL core faculty serve the Institute and the global community in significant leadership positions across the Institute. We are honored to note that MTL's core faculty includes MIT president Rafael Reif, Provost Martin Schmidt, School of Engineering dean Anantha Chandrakasan, MechE head Evelyn Wang, Associate Department Head for Education of Mechanical Engineering Rohit Karnik, MIT.nano inaugural director Vladimir Bulović, Electrical Engineering faculty head Joel Voldman, RLE director Marc Baldo, and MRL co-director Carl Thompson.

Since the inception, MTL has historically managed a set of shared experimental facilities in Buildings 39 and 24, that currently host more than 150 fabrication and analytical tools and serve a community of about 400 students and postdoctoral researchers coming from all corners of the Institute. When the new MIT.nano building was completed, the administrative management of these fabrication facilities was transferred to MIT.nano at the end of FY2019. The physical transfer of the fabrication environment, equipment, and tools into Building 12 is in progress. During the transitional period, the fabrication capabilities in Building 39 (referred to as Fab39), including diffusion, lithography, deposition, etching, and packaging, continued to be available to the entire MIT community and outside researchers until the COVID-19 research ramp down. MIT.nano has recently ramped up all fabrication facilities including Fab39 to 50% following Research Ramp up Phase Two guidelines.

MTL continues to manage an information technology infrastructure that supports state-of-the-art, computer-aided design (CAD) tools for device, circuit, and system design and serves a community of about 219 students and postdocs from all over MIT. This includes providing access to some of the most advanced commercial integrated circuit fabrication processes available in the world today through strong MTL relationships with major semiconductor manufacturers. In combination with the 417 unique MTL fabrication users (in addition to users from cooperating government research laboratories, domestic and international universities, and Fabrication Facilities Access companies), in total 565 distinct MIT students and postdocs from 27 different departments, laboratories, and centers carried out their research in MTL's facilities or used MTL's design services in the last fiscal year.

Integration Laboratory with the Research Laboratory of Electronics

There is already a great deal of overlap and collaboration between the RLE and MTL communities, with many joint members and complementary strengths in government- and industry-sponsored research. About a year ago, the then Electrical Engineering associate department head, Professor Joel Voldman, charged a committee to look into the possibility of MTL/RLE integration. The committee submitted its recommendation to Professor Voldman in late May 2019. The committee was overwhelmingly positive about the integration, provided that MTL's identity, community, culture, activities, and strong interaction with industry, as well as the Institute's support of MTL, be maintained. The committee identified many benefits to be gained by the integration, including the following: MTL will gain a much larger research footprint by tapping into RLE's large array of research areas; MTL's Microsystems Industrial Group (MIG) companies will have easier access to much broader range of research conducted within the integrated structure; and, in return, MTL will bring to the RLE community the expertise in community and culture, building and industry, and interactions to the enterprise.

Since early March 2020, RLE director Professor Marc Baldo and MTL director Hae-Seung "Harry" Lee met weekly to design an action plan for the committee's recommendation. We propose to progressively integrate MTL and RLE to better serve both these objectives within our communities.

To preserve precious discretionary resources, efficient delivery of research administration services is best funded by allocation. The appropriate scale for an allocation unit performing experimental work is approximately $50 million in volume per year, corresponding to at least 50 active principal investigators. RLE is a good example of a robust allocation unit with a long tradition of successful delivery of administrative services.

On the other hand, vibrant intellectual communities such as MTL require a focus that is impossible to achieve in such a large allocation unit. The historical success of MTL also demonstrates the communal focus provided by a central discretionary resource that is maintained by the community and reinvested within the community.

The complementary advantages of the RLE and MTL models suggest that the integration of the two laboratories be pursued with the following goals:

1. Growth of the MTL intellectual community and maintenance of the distinct MTL identity
2. More diversified and robust financial resources, including improved support for faculty startup packages
3. Removal of legacy barriers between MTL and RLE; transfer of space to the combined RLE/MTL and decoupling of space from participation in intellectual communities
4. Transition of MTL administration from MIG support to the RLE allocation model
5. Continuation of CAD/compute services, which MTL has provided to the broader MTL community for decades
6. Harness synergy between MTL and the new quantum consortium in the RLE Center for Quantum Engineering

We anticipate the process will be progressive with fiscal integration beginning as new research proposals from MTL faculty run through RLE in summer 2020. Existing accounts will remain within MTL, and the account will take their natural course until full integration, which we expect will take two to three years. We believe such a progressive transition will be minimally disruptive to both labs, and provide opportunity to strengthen MTL's intellectual community.

To prepare for this potential transition, we intend to fully summarize the financial state of both labs and develop a detailed execution plan for the combination of MTL and RLE. We are currently working with the Office of Vice President for Research, and School of Engineering to finalize the plan. We will provide you with the plan as soon as it is available.

Industry Engagement

MTL partners with industry through the Microsystems Industrial Group (MIG) consortium. The member companies within the MIG support MTL research and operations through a membership fee. Members of the MIG's Industrial Advisory Board (IAB) guide in shaping the vision of MTL.

MTL hosted its annual IAB meeting on Thursday, January 30, 2020, with representatives from 10 MIG member companies in attendance. The inaugural dean of the MIT Schwarzman College of Computing, Daniel Huttenlocher; director of MIT.nano, Vladimir Bulović; and selected members of the core faculty, presented the future of computing, facilities, and current research initiatives, and the IAB representatives participated in a wide-ranging and thoughtful discussion on the current state and the future of computing, nanofabrication research, and facilities at MIT. MIG company representatives attending the IAB meeting included Susan Feindt and Sam Fuller (Analog Devices), Chorn-Ping Chang (Applied Materials), David Carter (Draper), George Courville and Anthony Taylor (Edwards Vacuum), Oliver Beyer, Vivek Dave and Felix Loske (Harting), Takanobu Haga and Hiroshi Suzuki (Hitachi), Dirk Pfeiffer (IBM), Nerissa Draeger (Lam Research), Tomo Tanaka (NEC), Jim Wiesner (Texas Instruments), and Chuei-Tang Wang (Taiwan Semiconductor Manufacturing Company ([TSMC]).

IAB board members and MTL faculty at the IAB meeting on January 28, 2020.

MIG member companies engage with MTL core faculty, students, and researchers in many ways, including online access to the MTL résumé site, assistance with recruiting events on campus, exclusive access to MTL's annual research conference (MARC), MIG fund customization, faculty visits, and priority access to MTL resources. One of the unique benefits that member companies receive is the opportunity to have a scientist or engineer in residence on campus as an active participant in the research activities of an MTL-affiliated faculty member or research center. This past year, there have been six visitors from MIG member companies:

- March 6: Shinichi Yorozu (NEC)
- April 1: Carlos Diaz (TSMC)
- April: Chuei-Tang Wang (TSMC)
- April 9 and July 1: Takanobu Haga (Hitachi)
- Sam Fuller (ADI) with Charles Sodini
- Anthony Taylor (Edwards) with Luis Velásquez-Garcia

In July 2020, MTL held the inaugural virtual Microsystems Mini Technical Symposium. It featured speakers from four MTL core faculty members including, Professors Jing Kong, Luqiao Lu, Jelena Notaros, and Vivienne Sze. A variety of topics were presented, including low-dimensional materials, spintronics, integrated photonics, and efficient computing. The event was open to the MTL and MIT.nano communities, as well as members of the MIG and MIT.nano consortium. The event was recorded and has been made available as a resource to members. It was extremely well received by the members of MIG and the Member Advisory Panel.

Among other significant activities with MIG companies, in October 2019, Lam Research, co-sponsored by MTL and MIT.nano organized a Lam Technical Symposium at the MIT Media Lab, in which Brian Anthony, Duane Boning, Anantha Chandrakasan, Vladimir Bulović, Jesús del Alamo, Anette Hosoi, and Jeff Lang participated.

In September 2019, Mukesh V. Khare, vice president at IBM Research, presented as part of the MTL Seminar Series.

In November 2019, Vishal Tandon, a senior member of the technical staff at Draper, presented as part of the MTL Seminar Series.

Throughout the year, industrial member company representatives from ADI, Draper, Edwards, Harting, Hitachi, IBM, Lam Research, Texas Instruments, and TSMC visited MTL to discuss specific research.

Research Centers

Four centers affiliated with MTL provide the opportunity for MIG member companies and other companies to become engaged in focused research initiatives, these are: the Center for Integrated Circuits and Systems; the MIT Gallium Nitride Energy Initiative; the Medical Electronic Device Realization Center; and the MIT-MTL Center for Graphene Devices and 2D Systems.

The mission of the Center for Integrated Circuits and Systems (CICS) is to promote new research initiatives in circuits and systems design, as well as provide a tighter technical relationship between MIT's research and relevant industry. CICS investigates a wide range of circuits and systems, including wireless and wireline communication, high-speed and radio frequency (RF) circuits, microsensor/actuator systems, imagers, digital and analog signal processing circuits, biomedical circuits, and power conversion circuits, among others. Nine faculty members participate in the CICS: Harry Lee, Anantha Chandrakasan, Ruonan Han, Song Han, David Perreault, Negar Reiskarimian, Max Shulaker, Charles Sodini, and Vivienne Sze. The CICS provides a unique opportunity for faculty, especially junior faculty to develop close relationships with industry participants. In FY2020, CICS hosted two research reviews where the consortium members were invited to participate, one held on campus in November 2019, and the other held virtually in May 2020.

The MIT/MTL Gallium Nitride (GaN) Energy Initiative is an interdepartmental program focused on the advancement of the science and engineering of GaN-based materials and devices for energy applications. The GaN Energy Initiative provides a holistic approach to GaN research for energy applications, and coordinates work on the growth, technology, novel devices, circuits, and systems to take full advantage of the unique properties of GaN. The GaN Energy Initiative is especially focused on developing new, beyond-state-of-the-art solutions to system-level applications in RF power amplification, mixed-signal electronics, energy processing, and power management, as well as advanced optoelectronics. Most of the work is done on GaN materials and devices that are compatible with Si fabrication technologies, in close collaboration with industrial partners to accelerate the insertion of these devices into systems.

The vision of the MIT Medical Electronic Device Realization Center (MEDRC) is to revolutionize medical diagnostics and treatments by bringing health care directly to the individual and to create enabling technology for the future information-driven health care system. The MEDRC, launched in May 2011 currently has four member companies

(Analog Devices, IBM, Nihon Kohden, and Philips Research) at a funding level of approximately $1.5 million per year. The MEDRC serves as a focal point for engagement with researchers across MIT, the medical device and microelectronics industries, venture-funded startups, and the Boston medical community. The MEDRC companies strongly support the newly formed IMES Industrial Group (IIG) to broaden industry participation with IMES faculty and students. Over the past year Professors Sodini and Thomas Heldt organized the first meeting of the IIG with all MEDRC members, Abiomed, and Novartis attending.

The MIT-MTL Center for Graphene Devices (MIT-CG) and 2D Systems brings together MIT researchers and industrial partners to advance the science and engineering of graphene and other two-dimensional materials. Specifically, the center explores advanced technologies and strategies that enable 2D materials, devices, and systems to provide discriminating or breakthrough capabilities for a variety of system applications ranging from energy generation/storage and smart fabrics and materials to optoelectronics, RF communications, and sensing. In all these applications, the MIT-CG supports the development of the science, technology, tools, and analysis for the creation of a vision for the future of new systems enabled by 2D materials.

2020 Research Highlights

A few of MTL's notable research results are highlighted below, and the MTL website holds more comprehensive details on MTL research accomplishments, activities, people, and awards.

Professor Anantha Chandrakasan

N95 filtering facepiece respirators (FFR) and surgical masks are essential in reducing airborne transmission of disease, particularly during the COVID-19 pandemic. However, there are major limitations to the current N95 FFR and surgical masks, including masking of facial features, waste, and integrity of these systems after decontamination. Collaborators at MIT MechE and Brigham and Women's Hospital have been developing an N95-comparable face mask to address the worldwide shortage of personal protective equipment in the current COVID-19 pandemic. The elastomeric, transparent masks are long-lasting and can be decontaminated through variety of simple methodologies (microwaving, UV exposure, isopropanol, and bleach), which are widely available in hospitals and do not damage the mechanical properties of the system. Professor Chandrakasan's team in this project has been designing a biometric sensor interface for those masks, which can provide information regarding the mask's fit, the filter functionality, and the condition of the mask, as well as various physiological parameters. Instead of having two filters in the mask, our proposed system closes off one of the filter reservoirs and integrates a sensor. The interface consists of sensors to measure temperature, pressure, and humidity, as well as sensors to monitor CO_2 levels and volatile organic compounds. In the long-term, a system like this could be useful to provide user feedback on appropriate mask fit, when to replace the filter or mask, fatigue, and illness. So far, the respirator has been tested and evaluated among health care workers at two large hospitals (Massachusetts General Hospital and Brigham and Women's Hospital).

Jesús del Alamo

In the presence of prominent gate oxide trapping, the conventional technique for channel mobility extraction in MOSFETs based on IV-CV measurements becomes inadequate. This is the consequence of two different effects associated with oxide traps: gate voltage stretch-out and electron trapping and detrapping in the oxide at the MHz-range frequencies that are commonly utilized. In thin-channel planar InGaAs MOSFETs, both effects are observed and found to result in a severe overestimation of mobile charge and subsequently an underestimation of mobility using IV-CV. To address this issue, we demonstrate a new mobility extraction technique (RF-ID) based on concurrent IV and S-parameter measurement in the GHz regime that is largely immune to oxide trapping. Excellent agreement with Hall measurements as well as with theoretical predictions from Poisson-Schrodinger simulations give confidence to the new technique. Importantly, the new technique is not limited to InGaAs planar MOSFETs, but applies to any device geometry and any material system. Promising mobility of approximately 1100 cm^2/Vs is found in quantum-well planar InGaAs MOSFETs with 4 nm-thick channel.

Ruonan Han

The rapid surge of data transmission within computation, storage, and communication infrastructures is pushing the speed boundary of traditional, copper-based electrical links. Recent realizations of 100 gigabytes per second (Gbps) electrical wired links require advanced FinFET technologies, complicated packaging and cables, and power-consuming equalization. Optical fiber links, on the other hand, allow for high-speed transmission over long distances, but their high component cost and stringent requirements for operation temperature and fiber alignment prevent the wide applications in meter-level, inter-rack, and back-plane scenarios. In this project, THz waves were employed over a dielectric waveguide to realize high-speed data transmission, which exploits the low-loss, broadband medium while maintaining full compatibility with existing silicon IC platforms. Using a 130 nm SiGe BiCMOS technology, the multichannel, multiplexer/coupler-integrated transmitter delivers a data rate of 105 Gbps (35×3 Gbps). To demodulate each channel, a 35 Gbps coupler-integrated receiver is also developed. This link, including the chipset and a 0.4 mm-wide, 30 cm-long dielectric ribbon, experimentally demonstrates the potential speed, efficiency, size, and cost advantages of THz fiber links.

Song Han

Deep learning (DL) models need to be deployed on diverse hardware platforms, ranging from cloud servers with trillions of FLOPs/s to mobile phones and microcontrollers that have orders of magnitude lower computation and memory. To achieve the best performances, it requires many deep learning experts to carefully tune the architecture of the DL model for each hardware and efficiency constraint. Meanwhile, it also requires vast computational resources to train these DL models, causing excessive CO_2 emissions. Professor Song Han's group investigated an efficient AutoML technique called Once-for-All (OFA) to reduce the cost of deep learning. They developed an OFA Network that trains one large neural network comprising many pretrained subnetworks of different sizes that can be tailored to diverse hardware platforms without retraining. It automatically finds the most efficient neural architecture without manual design. This reduces the carbon footprint by three orders of magnitude compared to conventional neural architecture search approaches, while reducing the inference time by 1.5 to 2.6 times. The OFA also received many low-power computer vision contest awards in flagship AI conferences, demonstrating that it consistently outperformed human design.

Thomas Heldt, Charles Sodini, and Vivienne Sze

Current clinical assessment of neurodegenerative diseases (e.g., Alzheimer's disease) requires trained specialists, is mostly qualitative, and is commonly done only intermittently. Therefore, these assessments are affected by an individual physician's clinical acumen and by a host of confounding factors, such as patient's level of attention. Quantitative, objective, and more frequent measurements are needed to mitigate the influence of these factors. A promising candidate for a quantitative and accessible diseases progression monitor is eye movement. Eye movement features are observed to be significantly different between healthy subjects and patients in the clinical literature. However, these features are commonly measured with expensive, high-speed, IR-illuminated cameras, which limits the accessibility. The goal of this research is to develop a cost-effective, portable system that measures these features outside of the clinical environment.

Previously, the group showed they can accurately measure reaction time—the time difference between a stimulus presentation and the initiation of the corresponding eye movement—using iPhone cameras, by combining a deep convolutional neural network for gaze estimation with a model-based approach for saccade onset determination. They have since developed an application to facilitate data collection and include error rate measurement. With a large amount of data collected, they can validate the effect of age on eye movement and error rate measurements leading to a better understanding of the relationship between these features and disease progression.

Harry Lee and Anantha Chandrakasan

Private data security is an important and active area of research. Although data security have garnered a high level of attention for data communication and digital hardware, security loopholes exist at the mixed-signal interface between analog circuits and a digital processor. Recent studies have suggested that analog-to-digital converters (ADC) may represent a critical security loophole by leaking the confidential signal data through its supply current waveforms or electromagnetic emissions through a power side-channel attack (PSA). Given a wide range of ADC applications, identifying and removing ADC-related security vulnerabilities is important to enhance the information security of the entire signal chain. This work demonstrates neural network based PSA's as well as their mitigation of common ADCs. The results showed the PSA's proposed in this work are extremely effective, and can reveal the private data with very high accuracy (over 99%). This research further developed a prototype ADC resistant to PSA's. This ADC utilizes an on-chip circuit referred to as a current equalizer that isolates current spikes that contain information on the output data from the power supply traces. The experimental data demonstrated that the PSA was rendered ineffective when the PSA protection was activated.

Luis Velásquez-Garcia

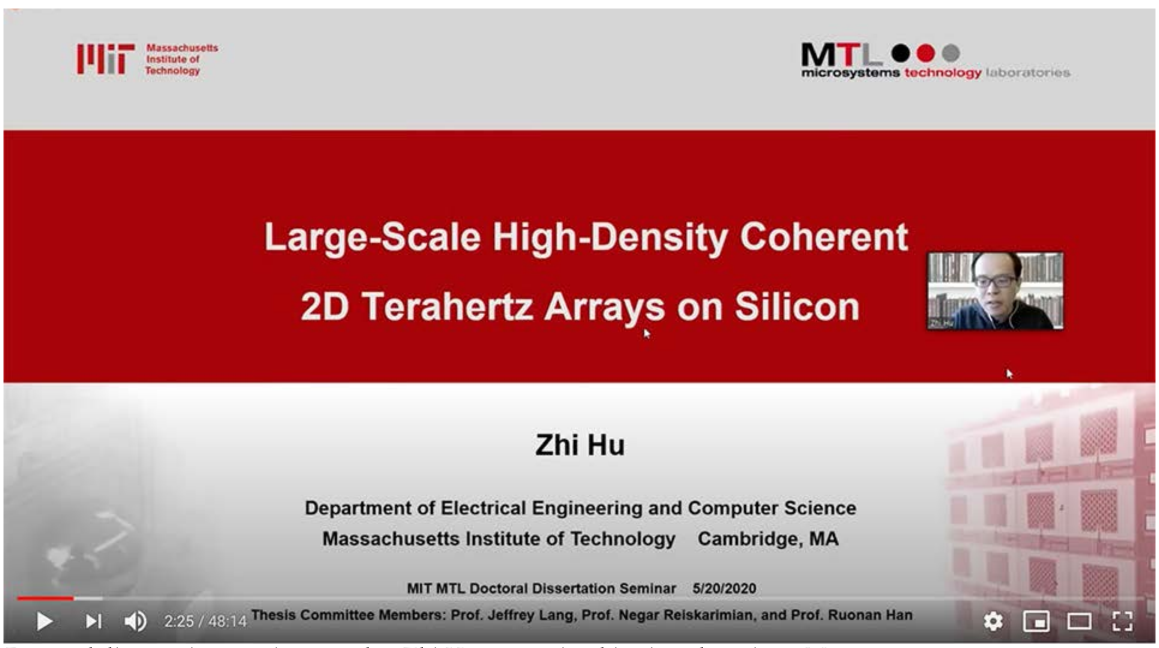
The Velásquez-Garcia Group conducted groundbreaking research on additively manufactured MEMS and Nanoelectromechanical systems (NEMS), focusing on power conversion devices for compact, autonomous microsystems. For example, in collaboration with MTL MIG member Edwards Vacuum, they demonstrated the first monolithic, fully 3D-printed, multimaterial miniature (approximately 1 cm^3) magnetic pumps in the literature. The reported pumps have a valveless design that greatly simplifies the operation of the device and consumes less power and is less prone to clogging compared to state-of-the-art devices. The pump fabrication takes less than 75 minutes to complete and costs under $3.89 in materials, creating a fully assembled pump with all components integrated—including the magnets. The experimental characterization of the pumps shows no pump degradation over 14-million cycles and the maximum flowrate attained (7.88 mL/min at 198 Hz) surpasses those from state-of-the-art, 3D-printed miniature liquid pumps. The devices can be used to move fluids in a wide range of compact applications, including implantable medical electronics, handheld analytical instrumentation, and portable energy sources.

2020 Program Highlights

In FY2020, MTL welcomed the fourth cohort of visiting faculty, postdocs, and students under the partnership MIT established with Tecnológico de Monterrey in FY2015. One faculty member (Professor J. Oseguera) and three postdoctoral fellows were hosted by principal investigators in four labs across MIT. The visiting researchers' interests ranged from biopolymer synthesis and microfluidics to health care. As a further component of this program, MTL's Luis Velásquez-Garcia hosted approximately 80 students, postdocs, and faculty in summer 2020 in two separate one-week sessions of the nanoLab hands-on course on nanotechnology. Since the Tecnológico de Monterrey program is geared toward fabrication, after a series of discussions among the MTL director Harry Lee, the former MTL director Jesús del Alamo, the MIT.nano director Vladimir Bulović, and Tecnológico de Monterrey representatives Arturo Molina Gutiérrez, Manuel Indalecio Zertuche Guerra, Ricardo Ambrocio Ramírez-Mendoza, and Adriana Vargas-Martínez, it was decided in late December 2019 to transfer the program from MTL to MIT.nano.

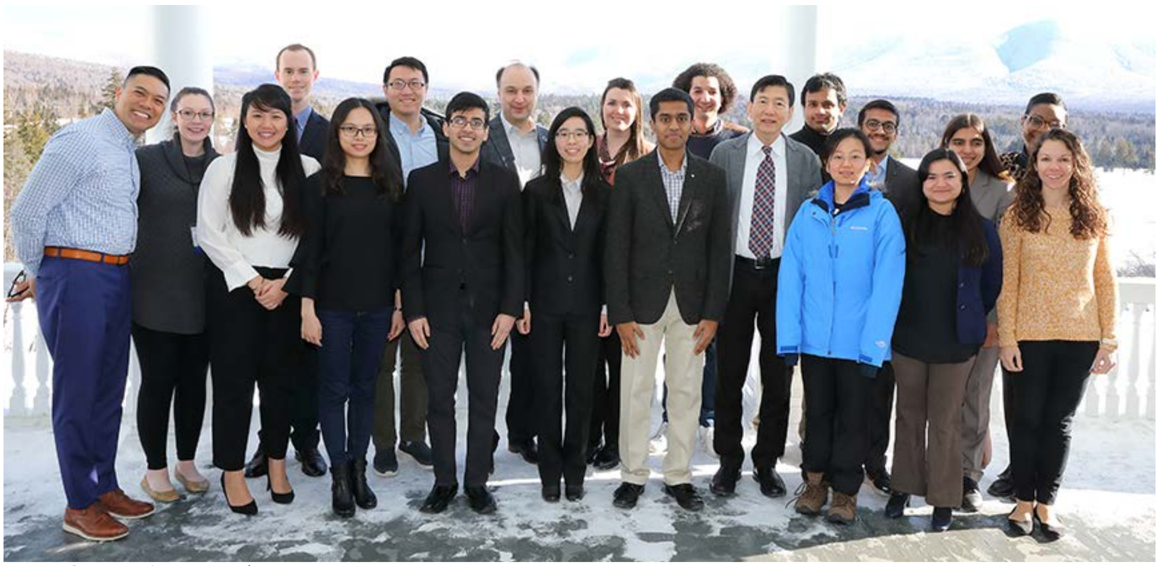
MTL engages the community in a number of technical events and programs. In both fall and spring of each academic year, the laboratory hosts a seminar series spanning diverse technical areas. The seminars are organized by a committee chaired by Luis Velásquez-Garcia, and all seminars are open to the public. In addition to these regular seminars, MTL hosts one doctoral dissertation seminar (DDS) each semester featuring a speaker selected from recent MTL PhD graduates, as well as occasional executive seminars featuring senior leaders from the MIG member companies. In December 2019, Cheng Wang's dissertation, "Terahertz CMOS Spectroscopic System-on-Chip-Towards Precise Timing and Rapid Gas Sensing," was selected for DDS presentation. Wang conducted his PhD under the supervision of Professor Ruonan Han in EECS. In May 2020, the DDS award winner was Zhi Hu, who presented his dissertation, "Large-Scale High-Density Terahertz Radiator and Receiver Arrays on Silicon Chips." Zhi Hu also conducted his PhD under the supervision of Professor Han.

Doctoral dissertation seminar speaker Cheng Wang and the MTL director Harry Lee, December 11, 2019.



Doctoral dissertation seminar speaker Zhi Hu presenting his virtual seminar, May 20, 2020.

Every January, MTL holds the Microsystems Annual Research Conference (MARC) run by MTL graduate students. The 2020 MARC was co-chaired by graduate students Mayuran Saravanapavanantham and Rachel Yang. MARC is broadly attended by industry, faculty, students, and staff, as it provides a unique opportunity to learn about research in the diverse areas encompassed by MTL while fostering interactions among the MTL community. The 2020 event was held from January 28 to 29 at the Omni Mount Washington Resort in Bretton Woods, New Hampshire. Of the participants, there were 212 students, postdocs, faculty, staff, and industry partners in attendance this year, including 25 Microsystem Industrial Group company guests and 16 student/postdoc organizers. MTL students, postdocs, and researchers presented more than 80 posters. The MARC agenda also featured a dinner keynote by Reed Sturtevant, general partner at The Engine (a company built by MIT to facility the launch of new technologies through startup incubation), and a conference-opening keynote delivered by Mark Rosker, director of the US Defense Advanced Research Projects Agency's Microsystems Technology Office.



MARC committee members, 2020.

Facilities Update

Upon completion of the new MIT.nano building, the administrative management of these fabrication facilities was transferred to MIT.nano at the end of FY2019. The physical transfer of the fabrication environment, equipment, and tools into Building 12 is in progress. During the transitional period, the fabrication capabilities in Building 39 (referred to as Fab39) including diffusion, lithography, deposition, etching, and packaging, continued to be available to the entire MIT community and the outside world until the COVID-19 research ramp down. MIT.nano has recently ramped up all fabrication facilities, including Fab39 to 50% following Research Ramp up Phase Two guidelines.

New equipment purchases and capabilities will be initiated and carried out by MIT. nano. Although now technically the administrative responsibility of MIT.nano, MTL continues to provide oversight to the Fab39 in support of the research activities of around 450 faculty, students, and postdocs from inside and outside MIT. In addition, MTL financially supports MIT.nano by providing $50 thousand of the $150 thousand MIG membership fee it receives from each company to MIT.nano.

Outreach and Educational Activities

MTL actively engages in School of Engineering initiatives: the Women's Technology Program (WTP) and the SuperUROP and UROP Programs, as described below.

Women's Technology Program

The Women's Technology Program was created in 2002 to encourage high school-age women with strong math, science, and analytical abilities to pursue studies in engineering and computer science. The program provides these women with positive women role models, college-level computing and engineering experience, and an understanding of what engineers and scientists do and how they work. Participants in WTP-EECS have an opportunity during the summer for a hands-on experience in the microfabrication facilities of MTL, under the guidance of a female graduate student whose research depends heavily on using the MTL fabrication facilities. These young women go through the fabrication steps needed to transfer a group photograph onto a silicon wafer. Each student receives a wafer that displays the image of the group. Feedback from students has been very positive, and the picture wafers are a great reminder of their summer at MIT. Unfortunately, WTP was cancelled for summer 2020 due to the pandemic.

Undergraduate Research Opportunity Program and SuperUROP

Undergraduate Research Opportunity Program (UROP) and SuperUROP engage MIT undergraduate students and promotes direct interaction with faculty and industry sponsors, cultivates student creativity and professional development, and encourages students to consider the ethical and entrepreneurial aspects of their work. In FY2020, there were 28 undergraduate students in the program working in MTL.

Core Faculty Appointments and Promotions

The following appointments and promotions involving MTL faculty took place in this fiscal year:

- Negar Reiskarimian—a graduate of Columbia University—(EECS), joined MTL as a core faculty member in July 2019
- William Oliver (EECS) and Juejun Hu (DMSE) joined MTL's the core faculty in July 2019 as associate professors
- Kevin Chen—a graduate of Harvard University—joined MTL as a core faculty member in January 2020
- Jelena Notaros (EECS) joined MTL's core faculty in June 2020 as an assistant professor
- Luqiao Liu (EECS) was promoted to associate professor in MTL
- Joel Voldman was named EECS faculty head at the MIT Schwarzman College of Computing
- Eugene Fitzgerald was appointed CEO and director of the Singapore-MIT Alliance for Research and Technology
- Jesús del Alamo (EECS) was elected fellow of the Materials Research Society
- Will Oliver (EECS) and Vivienne Sze (EECS) were promoted to associate professors with tenure
- Tomas Palacios (EECS) was appointed as the new industry officer

Awards and Honors

MTL faculty and students regularly receive recognition for their research contributions and accomplishments with numerous national and international awards. The following are awards and distinctions collected by MTL affiliated faculty, staff, and students during the reporting period:

- Jesús del Alamo won the IPRM Award 2020, received the IEEE Cledo Brunetti Award, and was honored with the 2019 University Research Award for excellence in semiconductor technology research
- Polina Anikeeva and her co-authors were featured on the cover of *Science* for research on artificial muscles
- 2020 MacVicar Faculty Fellows include Polina Anikeeva and William Tisdale
- Yu-Hsin Chen won the Outstanding Dissertation Award at 2019 International Symposium on Computer Architecture
- Luca Daniel won the EECS Caloggero Award
- Brenda Garcia and Luis Velásquez-Garcia won the Best Paper Award at Transducers 2019
- Ruonan Han was selected as the 2020–2022 IEEE Microwave Theory and Technique Distinguished Microwave Lecturer
- Song Han won the 2020 NSF Career Award and was selected among 35 innovators under 35 in 2019 by the *MIT Technology Review*
- Theia Henderson (co-advised by Vivienne Sze and Sertac Karaman) was presented the 2020 David Adler Memorial Thesis Award
- Juejun Hu received the Early Career Achievement Award
- Pablo Jarillo-Herrero was presented the 2020 Oliver E. Buckley Condensed Matter Physics Prize and the Wolf Prize in Physics 2020
- Han Kai, Ji Lin, and Kuan Wang won first place for Low Power Computer Vision Challenge in the DSP Track at ICCV 2019; and also won first place for Wake Words Challenge in the deployable today category at CVPR 2019
- Peter Li (co-advised by Vivenne Sze and Sertac Karaman) won first prize at the 2020 Grand Finals of the Association for Computing Machinery Student Research Competition
- Wenjie Lu won the 2018 Best Student Paper Award at IEEE International Electron Devices Meeting 2019
- Hironoku Okumura won the Young Researcher Award at 2019 International Conference on Solid State Devices and Materials
- Tomas Palacios was featured in the January 7, 2020 *New York Times* article by Amos Zeeberg, "The Superpowers of Super-Thin Materials"

- Tomas Palacios' group received the 2019 IEEE George E. Smith Award for the best paper published in *IEEE Electron Device Letters*; the winning paper was "Large-Area 1.2-kV GaN Vertical Power FinFETs With a Record Switching Figure of Merit"
- Pao-Chuan Shih won the Best Poster Award at 2019 International Conference on Nitride Semiconductors
- Amr Suleiman won the 2018 Best Student Paper Award at IEEE Symposium on VLSI Circuits 2019
- Vivienne Sze won the ACM-W Rising Start Award and Edgerton Faculty Award
- Hanrui Wang and Zhongxia Linng won first place for the MicroNet Challengein the NLP track at NeurlPS 2019

Administrative Update

Our staff is integral to MTL's success and infrastructure. The following are staffing updates that occurred during the reporting period:

- MTL's Human Resources administrator Katrina Mounlavongsy left MIT in January 2020. This position's responsibilities are being reevaluated, and recruiting will begin in January 2021 for a new Human Resources representative to support MTL.
- MTL hired a new fiscal officer, Flora Whitney, in September 2019, she resigned from MIT in July 2020. MTL is currently recruiting for a new fiscal officer who will report to both MTL and RLE as we begin the integration of our finances.
- MTL hired Meghan Melvin in February 2020 as our communications officer.
- Elizabeth Green joined us in February 2020 as a senior administrative assistant supporting the MTL director and HQ.
- Jami Mitchell, administrative assistant, was selected as a recipient of the MIT School of Engineering's 2020 Infinite Mile Award.

Hae-Seung "Harry" Lee
Director
Advanced Telecommunication and Signal Processing Professor of Electrical Engineering
Department of Electrical Engineering and Computer Science