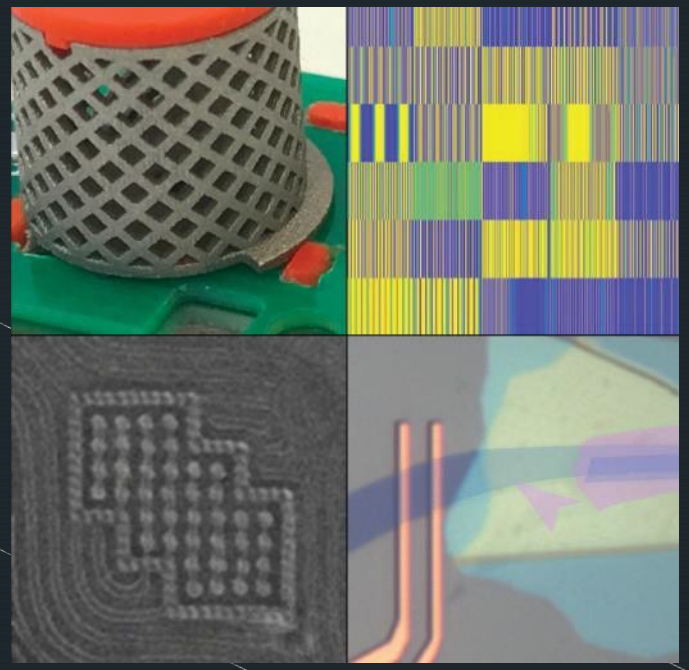
Microsystems Technology Laboratories @ MIT

Tomás Palacios
tpalacios@mit.edu

Outline

1. MTL Mission and Organization
2. 2023 Research Highlights
3. Microsystems Industrial Group
4. Coming up in 2024…

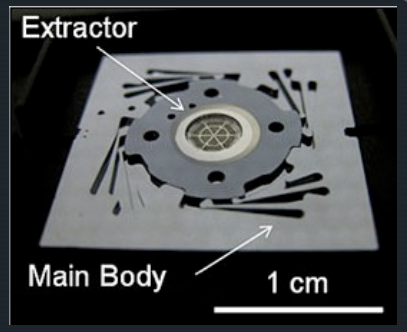


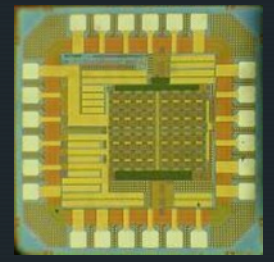
MTL Mission and Organization

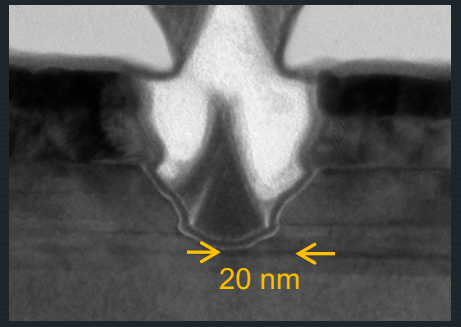
Massachusetts Institute of Technology

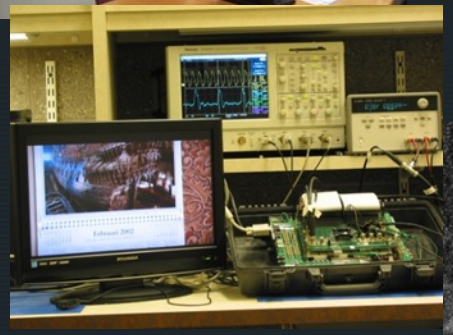
MTL Mission

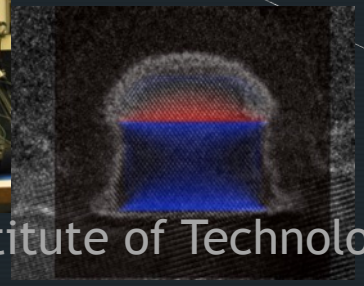
- MTL = Home of *microsystems research and education* at MIT.
- Microsystems = From materials to systems through innovations in materials, nanotechnology, molecular devices, sensors, electronic and photonic devices, MEMS, bio-MEMS, integrated circuits, packaging and prototyping, etc.



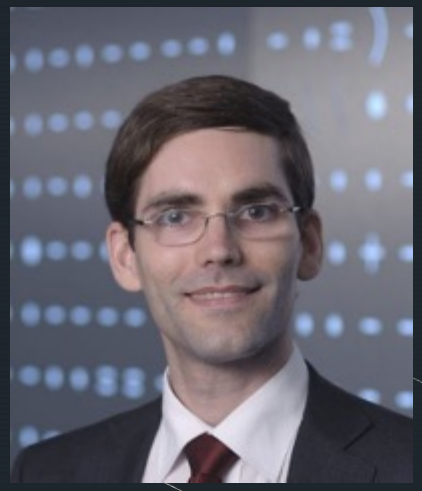




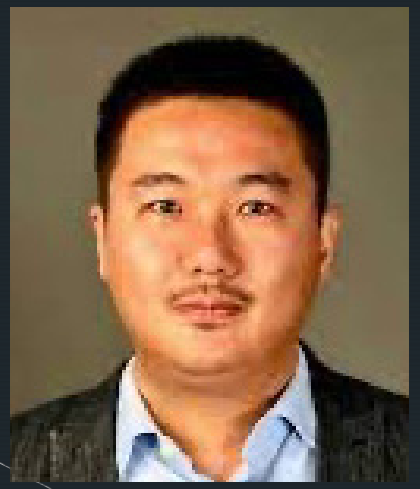




MTL Leadership Team



Prof. Tomas Palacios
Director



Prof. Ruonan Han
Associate Director

Prof. Bilge Yildiz
Associate Director

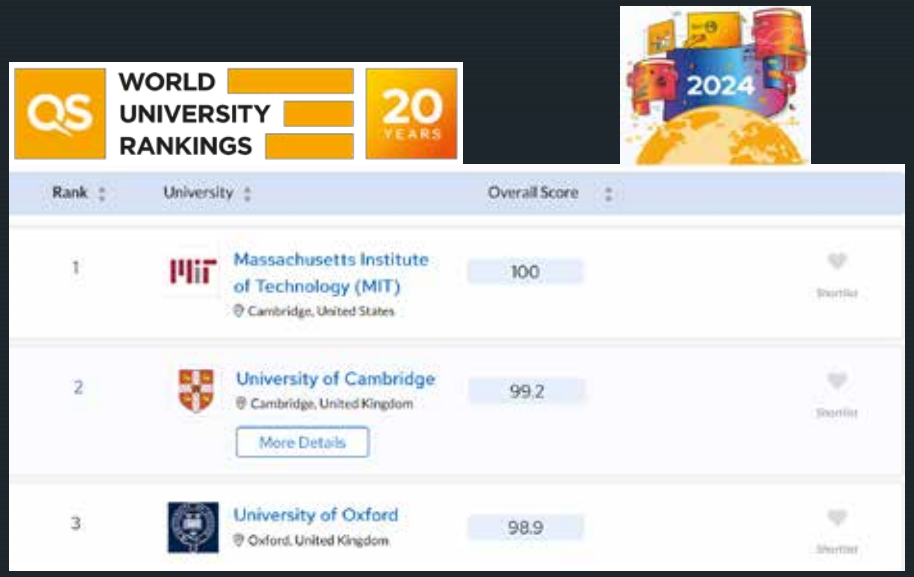
Prof. Duane Boning
Assoc. Dir. for CAD and IT

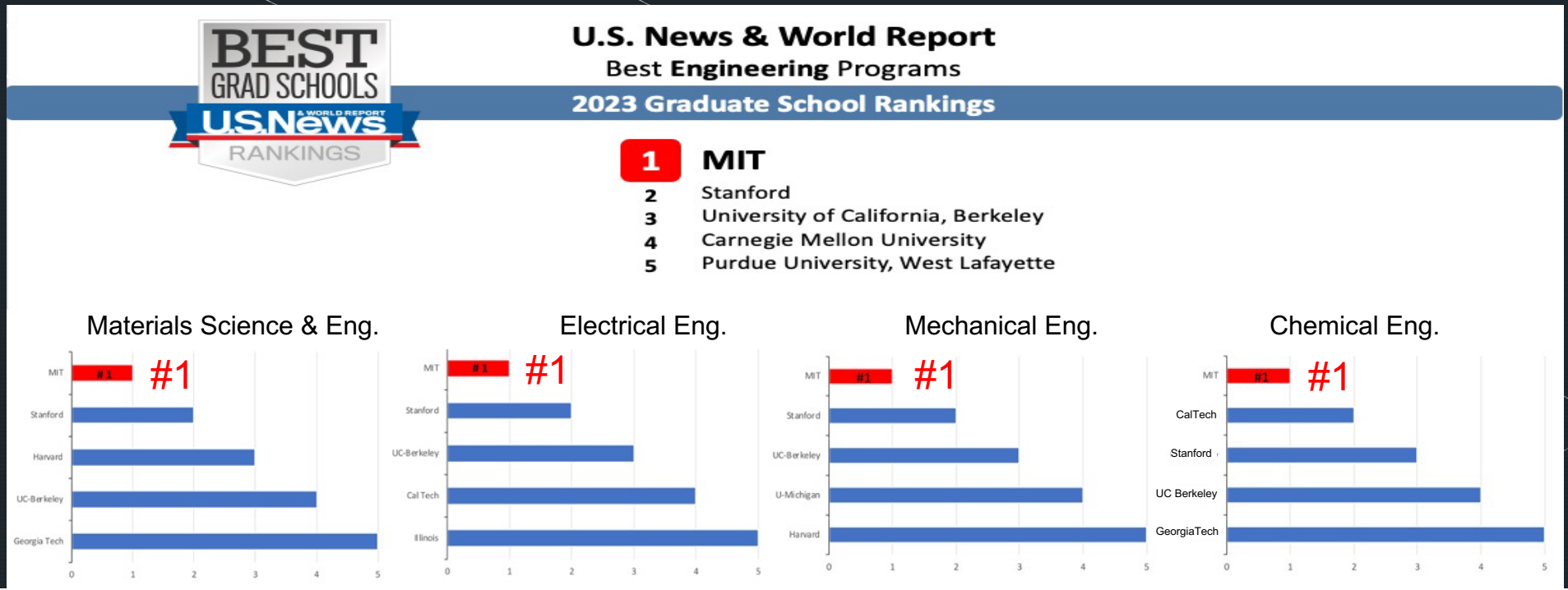
Dr. Charles Hsu
Consortium Manager


60+ Core Faculty in 7 Departments

Key enablers

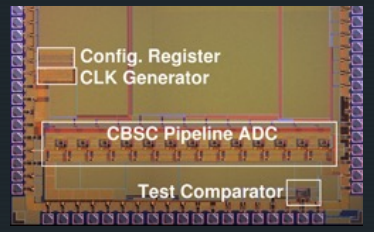
- Outstanding students and postdocs
- Full commitment to excellence
- Interdisciplinary research communities





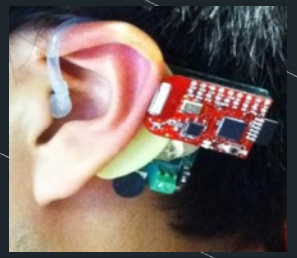
MTL Interdisciplinary Research Communities

MIT Center for Integrated Circuits and Systems (CICS)



- Mixed-signal, speech, video, medical, bio, power
- 6 faculty, 70 postdocs + students

MEDRC
MEDICAL ELECTRONIC DEVICE REALIZATION CENTER



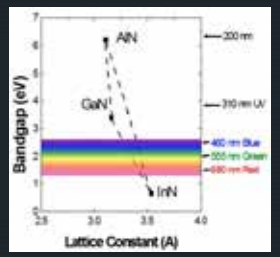
- Wearable devices, imaging, monitoring, lab-on-a-chip
- 7 faculty, 20 postdocs + students

MIT AI Hardware Program

- **A comprehensive multi-disciplinary effort to revolutionize AI Hardware**

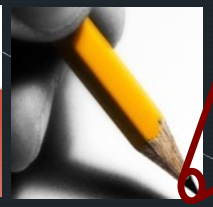
MTL Interdisciplinary Research Communities

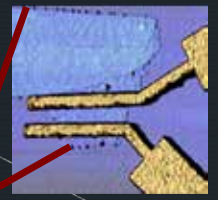
MIT GaN Energy Initiative



- Power electronics, RF amplifiers and filters, LED technology
- 11 faculty, 30 postdocs + students

MIT-MTL Center for Graphene Devices and 2D Systems





- Growth, electronic devices, physics, circuits and systems
- 17 faculty, 40 postdocs + students
- Industrial consortium

MIT EECS Alliance

- Focus on undergraduate and MSc workforce development
- 6 months internships
- Student outreach

. . .

Key enablers

- Outstanding students and postdocs
- Core faculty and staff committed to excellence
- Interdisciplinary research communities
- Access to world-class experimental facilities


MIT.nano
100,000 sq.ft.
of research and laboratory space
is ready for the next opportunity


150+
TOOLS &
INSTRUMENTS
INSTALLED


44
MIT.nano staff members are domain experts dedicated to assisting researchers with their work.
MIT.nano

Key enablers

- Outstanding students and postdocs
- Core faculty and staff committed to excellence
- Interdisciplinary research communities
- Access to world-class experimental facilities
- Strong Start-up Ecosystem

Key enablers

- Outstanding students and postdocs
- Core faculty and staff committed to excellence
- Interdisciplinary research communities
- Access to world-class experimental facilities
- Strong Start-up Ecosystem
- Vibrant industrial consortium


ANALOG
DEVICES


GlobalFoundries


NEC


APPLIED
MATERIALS


HITACHI
Inspire the Next


soitec


Texas
Instruments


DRAPER


IBM


EDWARDS

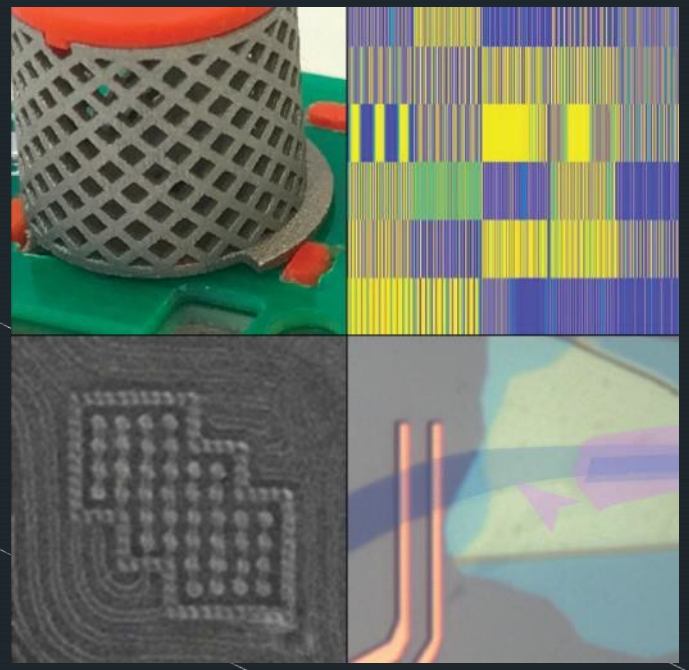

ERICSSON


muRata
INNOVATOR IN ELECTRONI


Lam
RESEARCH


tsmc


LOCKHEED MARTIN



2023 Research Highlights

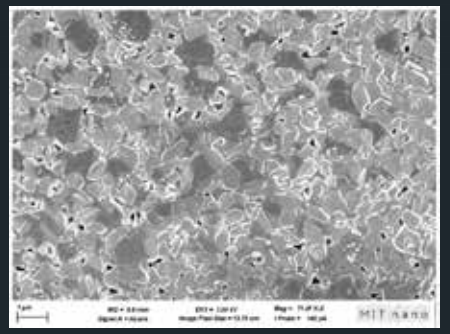
MTL Annual Research Report 2023

100’s of abstracts in:

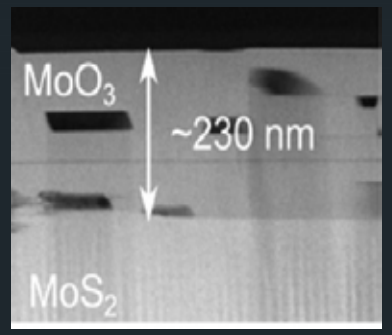
- Biology, Medical Devices, and Systems
- Circuits and Systems
- Devices (Electronic, Magnetic, Superconducting)
- Energy and Sustainability
- Integrated Photonics and Optoelectronics
- Machine Learning and other Accelerators
- MEMS, Thermal, Fluidic Devices, and Robotics
- Nanoscience, Nanotechnology, Nanomaterials
- Quantum Science and Engineering
- Semiconductor Manufacturing and Supply Chain

For access, please send an email to ebgreen@mit.edu

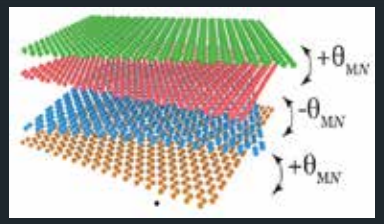
MTL: from materials to systems (going through technology, devices and ICs)



ML-driven Perovskite Search (Bulovic)

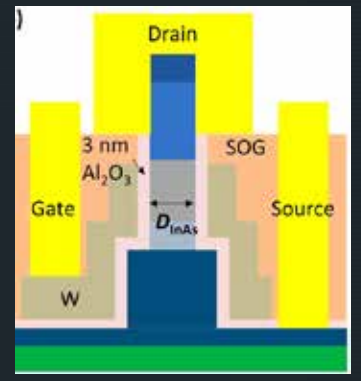


MoO_3/MoS_2 Structures (Jaramillo)

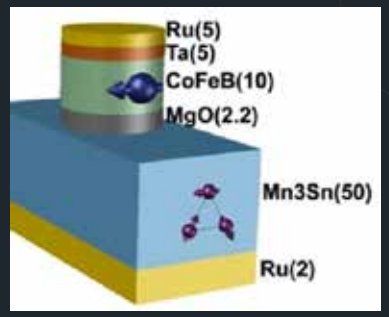


Magic-twisted Ferroelectics and Superconductors (Jarillo)

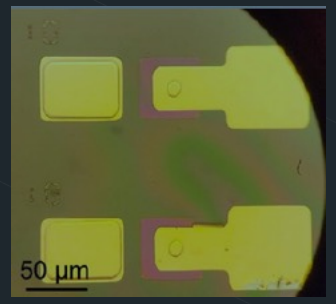
Protonic Devices for ML (del Alamo)



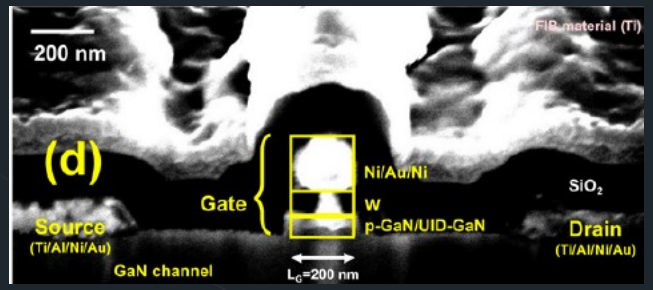
6 nm GaSb/InAs Tunnel FETs (del Alamo)



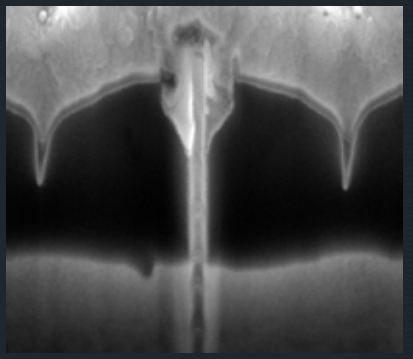
Antiferromagnetic Tunnel Junction with Ultra-High Field Resilience (Liu)



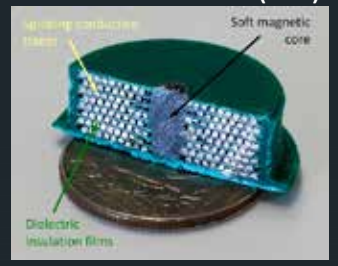
Perovskite Ferroelectric Memory (Kim)



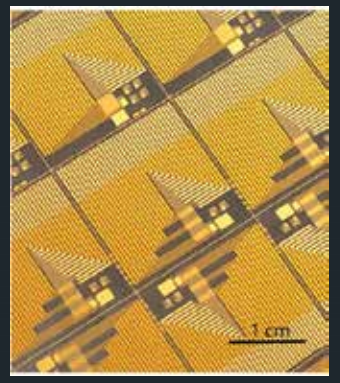
GaN CMOS Technology (Palacios)



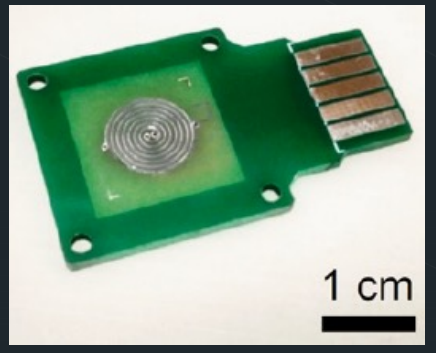
Optically-controlled GaN Power Switches (Palacios)



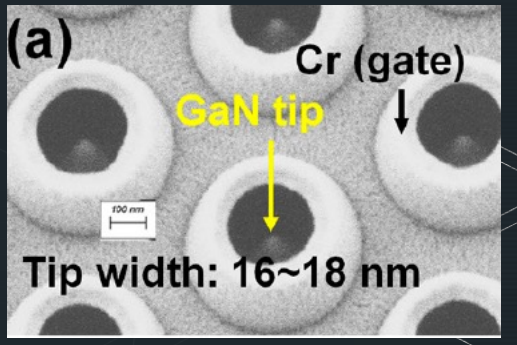
3D-printed compact solenoids (Velásquez-García)



eNose with 4000+ graphene sensors (Palacios)

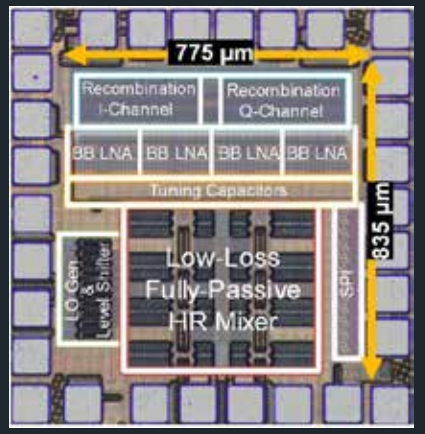


CNT Field Emission Sources (Velasquez-Garcia)

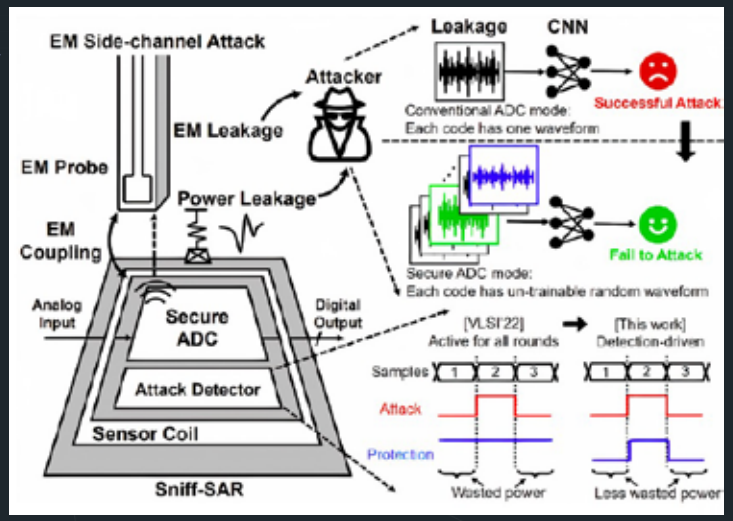


GaN-based Field Emitters (Palacios)

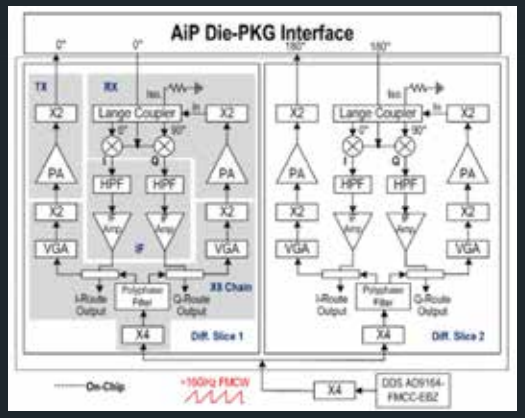
Chips



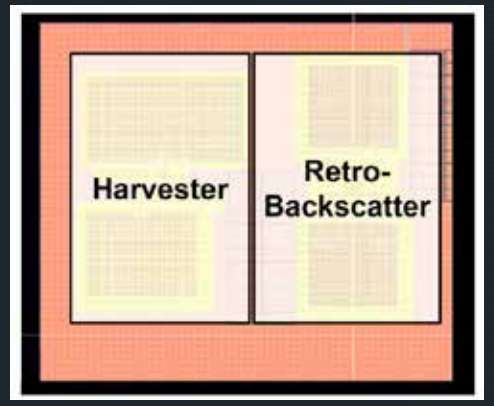
5G NR Receiver
(Reiskarimian)



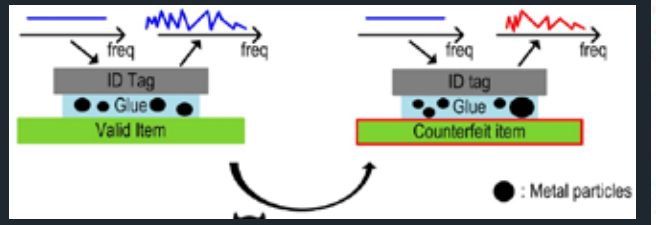
9.8 fJ/c.s Secure ADC
(Lee, Chandrakasan)



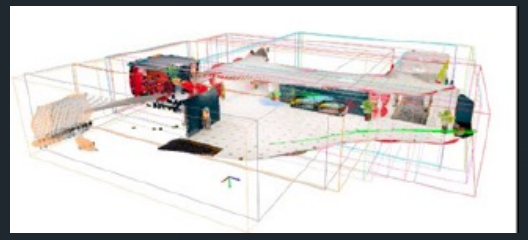
A 260-GHz Transceiver
22nm AiP (Han)



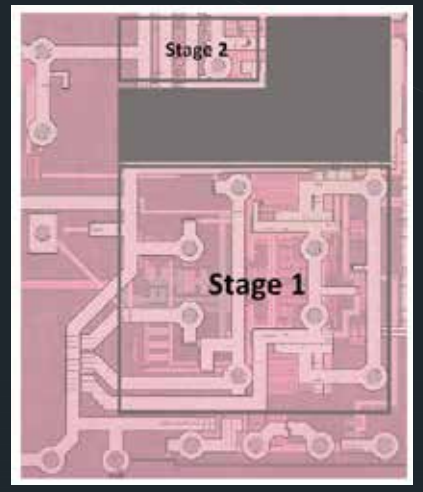
Retro-Backscatter THz ID
(Han, Chandrakasan)



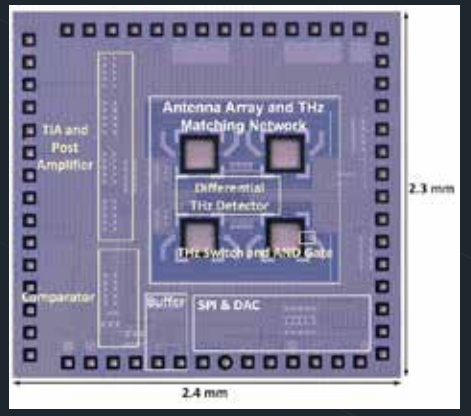
THz Unclonable Anti-tampering
ID Tag (Han)



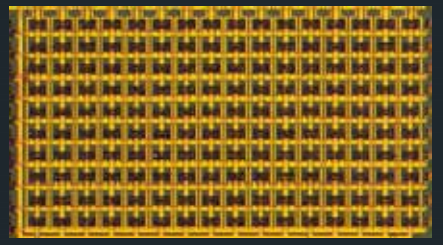
Memory-efficient Gaussian-fitting for Depth
Images in Real Time (Sze)

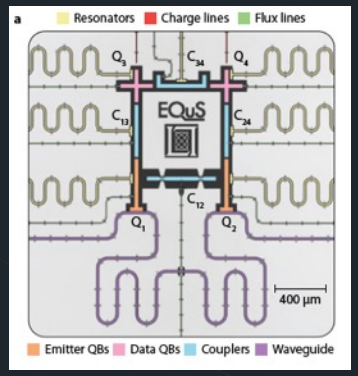


Pipelined ADC with time-
interleaved Sub-
ADC/DAC in 16nm (Lee)



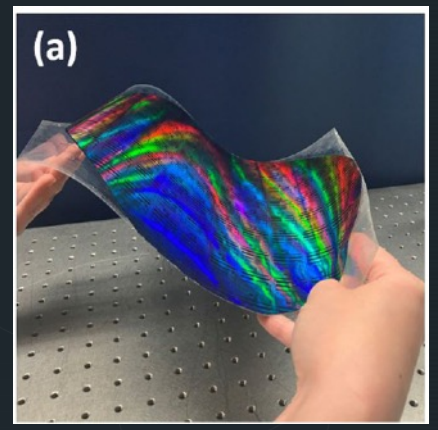
Cryo-CMOS Backscattered
Transceiver (Englund, Han)





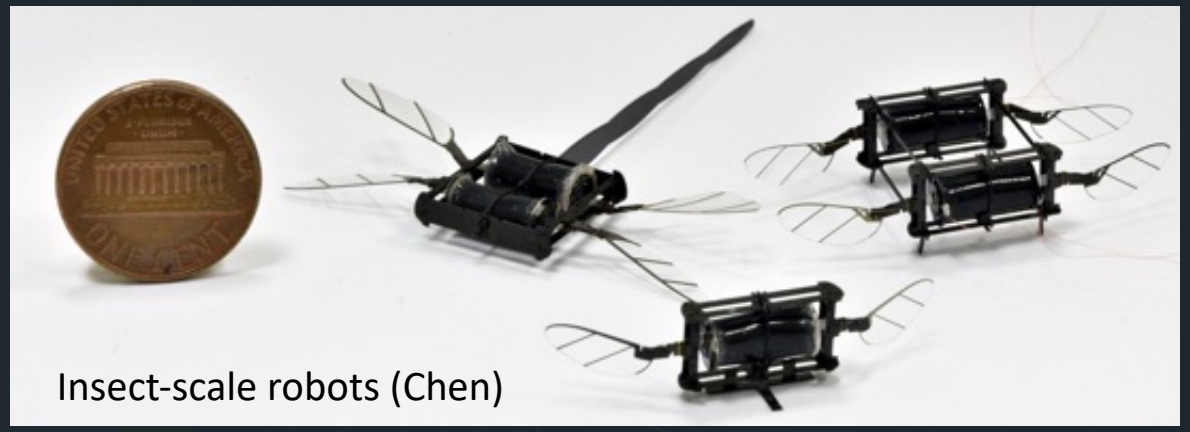
Superconducting
Quantum Chip
(Oliver)

500C GaN Memory
(Palacios)



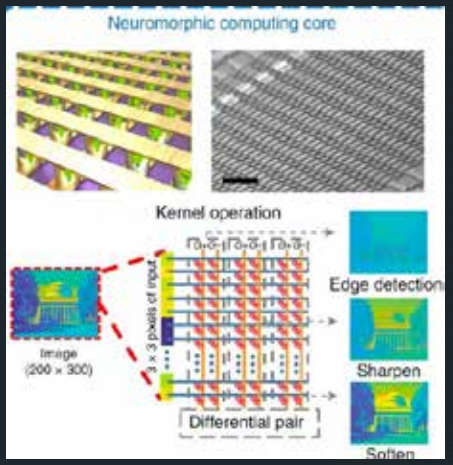
Integrated photonics chip on
flexible wafer (Notaros)

Systems

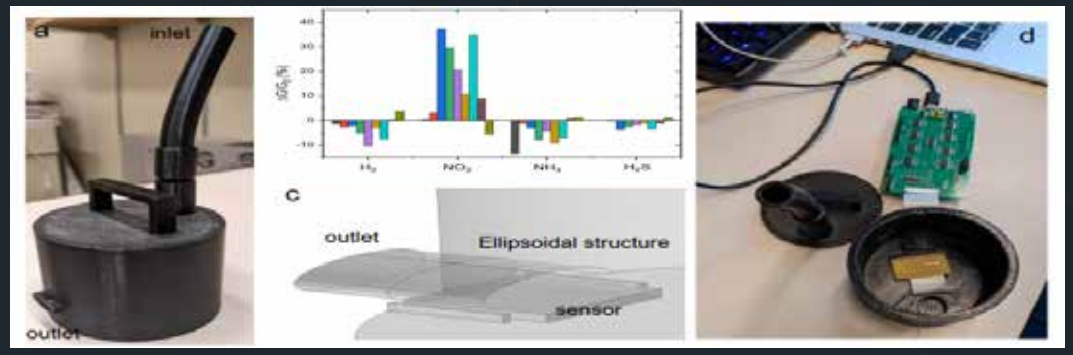


Insect-scale robots (Chen)

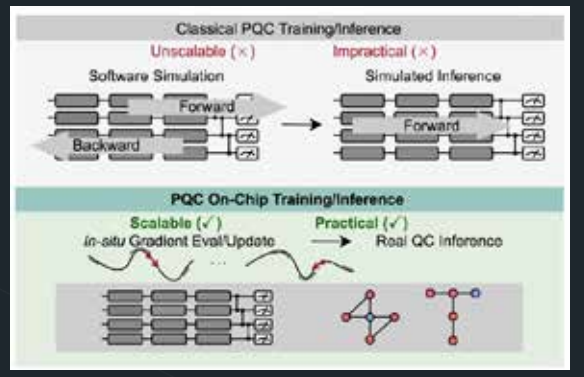
Smart Fabrics (Palacios, Matusik)



Reconfigurable Sensor Computing System (Kim)

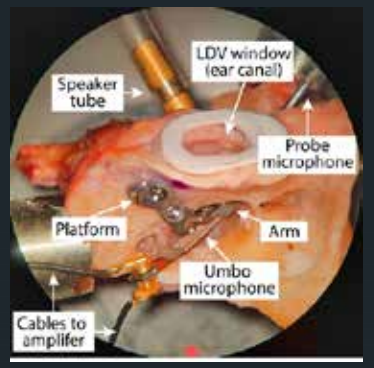


Graphene-based Breathalyzer (Kong, Swager, Palacios)

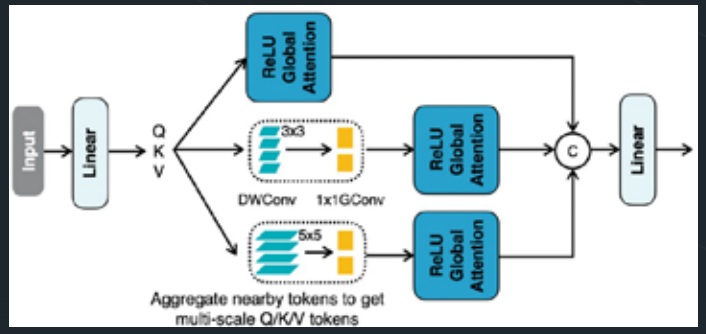


Quantum On-Chip Training (Han)

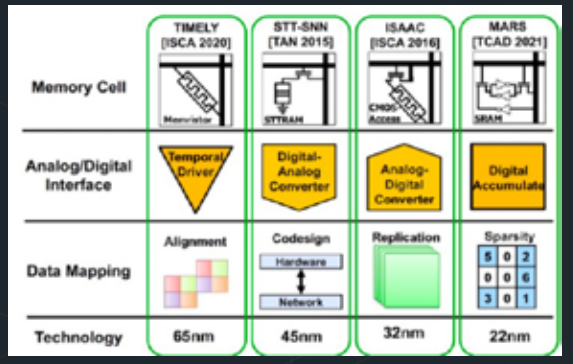
Neuromorphic Computing with Probabilistic Nanomagnets (Liu)



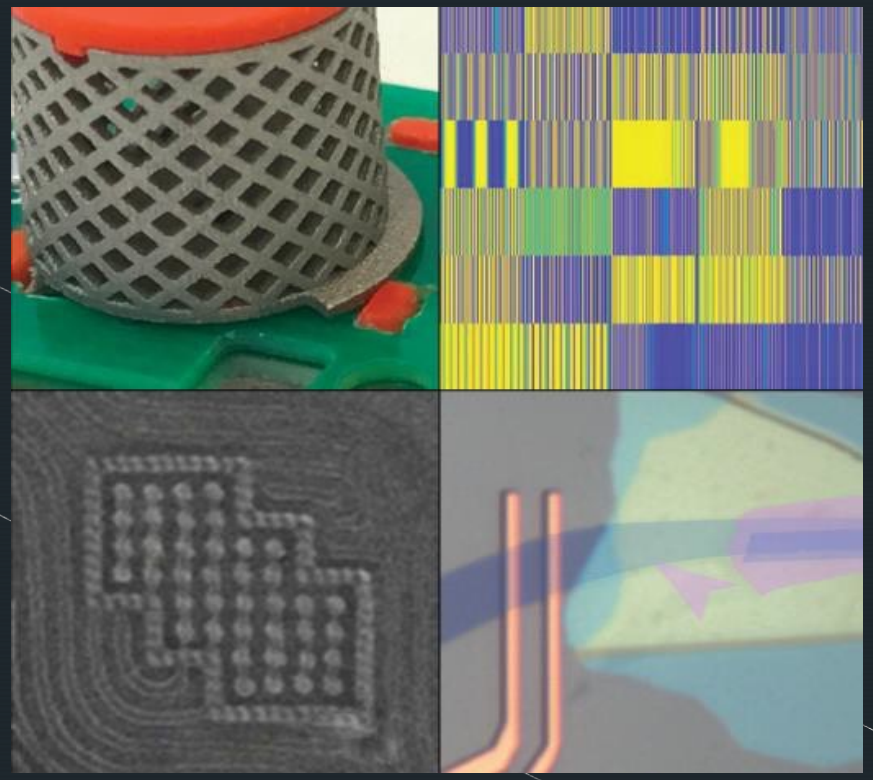
Cochlear Microphones (Lang)



Efficient On-Device Semantic Segmentation (Han)



Architectural Evaluation of Processing-in-Memory Accelerators (Sze)



Microsystems Industrial Group

Ecosystem:

Industrial Advisory Board
Visitor Program
Company-days at MIT
MTL-day at Company
Start-up Networking

Access to MIT.nano
Support with Fabrication

R&D:

Customization
Grand Challenge Projects
Master Research Agreement
Annual Research Conference
Annual Report & Newsletter

GaN Energy Initiative
AI Hardware Program
Climate & Sustainability
…

MTL MICROSYSTEMS TECHNOLOGY LABORATORIES

Microsystems Industrial Group

Talent Acquisition:

Custom Recruiting Events
Deep Tech Career Fair
Student Resume Book
Undergraduate Internship

EECS Alliance (Undergrads)

WFD:

MSc/PhD Co-advisor Program
MTL Seminar Series
Mini Technical Symposium
Professional Ed. Courses
Faculty Visits

MTL Newsletters

MTL MICROSYSTEMS TECHNOLOGY LABORATORIES

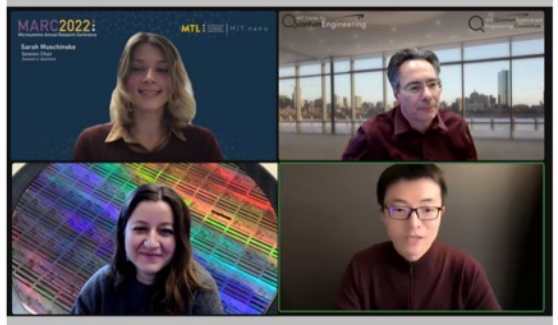
Microsystems Technology Laboratories

news & updates

Featured Story

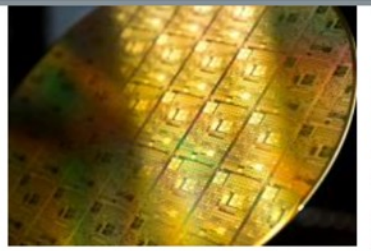
Last-minute pivot leads to record-setting Microsystems Annual Research Conference

Virtual conference gathered students, faculty, and industry partners to explore the future of microsystems and nanotechnology.

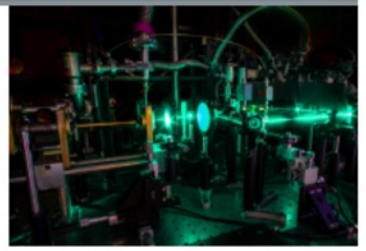


Research Highlights & Faculty News

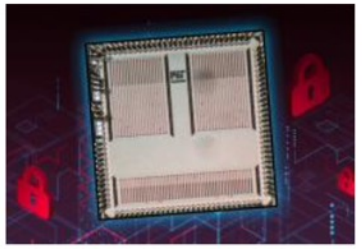
New program bolsters innovation in next-generation artificial intelligence hardware



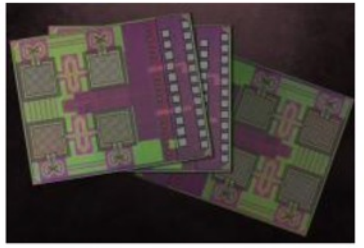
Workshop tackles a critical gap slowing the development of new hardware technologies



You've probably never heard of terahertz waves, but they could change your life



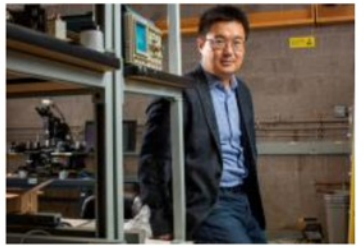
Toward a stronger defense of personal data



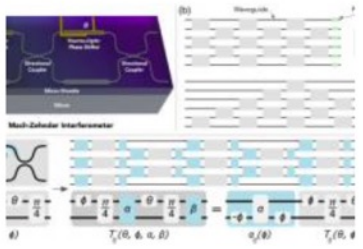
Reasserting U.S. leadership in microelectronics

Giving bug-like bots a boost

MIT Future Founders Initiative announces prize competition



Pushing the limits of electronic circuits



Hardware error correction for programmable photonics

To be included in our mailing list, please send an email to ebgreen@mit.edu

2023 Deep Tech Career Fair

- 200+ students, researchers and postdoc attendees
- Attendees met with representatives from some member companies of MTL, MIT.nano, MIT Center for Quantum Engineering and the MIT AI Hardware Program.

MARC2024:
Microsystems Annual Research Conference

- Keynote Speaker: Ted Letavic, Corporate Fellow and Senior Vice President of Technology Innovation, GlobalFoundries
- Panelists:
  - Ionut Radu, Soitec
  - Erika Bechtold, UpNano
  - Fredrik Dahlgren, Ericsson
  - Michael Haverty, Applied Materials
  - Michael Perrott, TI
  - Dirk Pfeiffer, IBM
  - Esther Jeng, IBM
  - Paul Ferguson, ADI

- 134 posters
- 263 attendees including
  - 27 industry guests
- 20 student/postdoc organizers

MTL Mini Technical Symposiums

November 16, 2022 – Speakers Prof. Vladimir Bulovic, Mayuran Saravanapavanantham, Dr. Jinchi Han, Prof. Harry Lee, Dr. Anand Chandrasekhar, Prof. Marc Baldo, Brooke McGoldrick, Prof. Jesus del Alamo, Murat Onen

July 20, 2022 – Speakers Prof. Duane Boning, Zhengxing Zhang, Prof. Tomas Palacios, Jiadi Zhu, Prof. Kevin Chen, Suhan Kim, Prof. Farnaz Niroui, Spencer Zhu

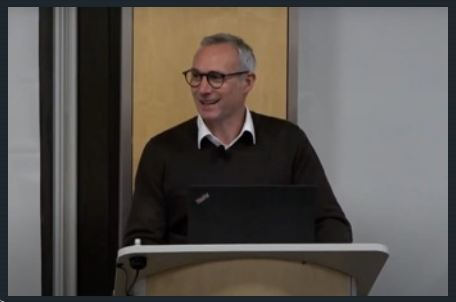
April 12, 2023 ***Integrated Photonics*** Speakers Prof. Jelena Notaros, Prof. Dirk Englund, Prof. JJ. Hu, Prof. Lionel Kimerling, Prof. Rajeev Ram, Prof. Duane Boning, and Dr. Cheryl Sorace-Agaskar

(planning stages) ***Sustainability and Microelectronics***

MTL MICROSYSTEMS TECHNOLOGY LABORATORIES

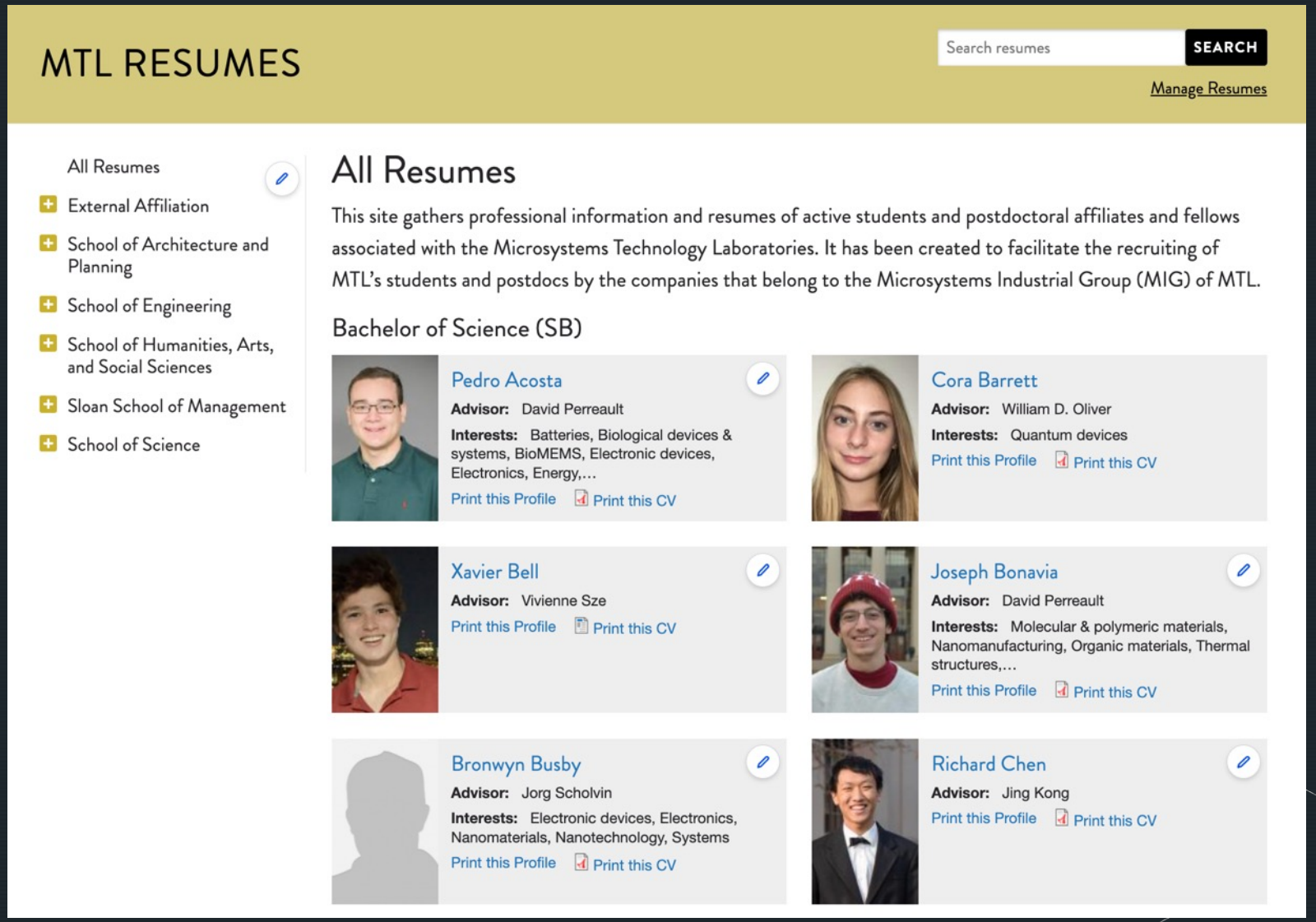
MTL Seminar Series in 2023

- *Tony Yen (ASML):* "EUV Lithography: What's Happening and What's Next" (March 9)
- *Sean Lie (cerebras):* "Thinking Outside the Die: Trillion Transistor Chips for the ML Accelerator of the Future" (March 16)
- *Austin Minnich (Caltech)*: Towards the fundamental limits of noise performance of III-V high electron mobility transistor microwave amplifiers (March 23)
- *Steven Kosier (SkyWater Technology)*: Microfabrication in Industry (April 20)
- *Nadim Chowdhury (MIT, DDS)*: GaN Complementary Metal-oxide-semiconductor (CMOS) Technology on GaN-on-Si (May 18)
- *Ashwin Seshia (Cambridge University)*: Vibrating beam MEMS accelerometers for gravity and seismic measurements (August 29)
- *Murat Onen (MIT)*: Devices and Algorithms for Analog Deep Learning (September 14) – Joint with AI HW Program
- *Wenjie Lu (Analog Devices)*: AI Transformation in Analog Systems (September 28) – Joint with AI HW Program
- *Vivek Dave (HARTING)*: IIoT, Industry 4.0, and Industrial Machine Learning: a 25-year retrospective, current lessons-learned, and future trajectories (October 5)
- *Gerold Schropfer (Lam Research)*: Improving Your Understanding of Advanced MEMS Design Problems: Design and Simulation for Innovation, Better Reliability, Manufacturing and Performance (October 19)
- *Krishna Persaud (University of Manchester)*: Bioelectronic Noses – an emerging field (October 26)
- *Ali Khakifirooz (Intel)*: (November 9)
- *James Covington (University of Warwick)*: Digital Smell Recreation and Generation: 50 years of struggle (November 16)
- *John Rozen (IBM)*: Sustainable Compute for the Broad AI Era (November 30) – Joint with AI HW Program



100's of seminars available online for MIG members. Send email to ebgreen@mit.edu for access

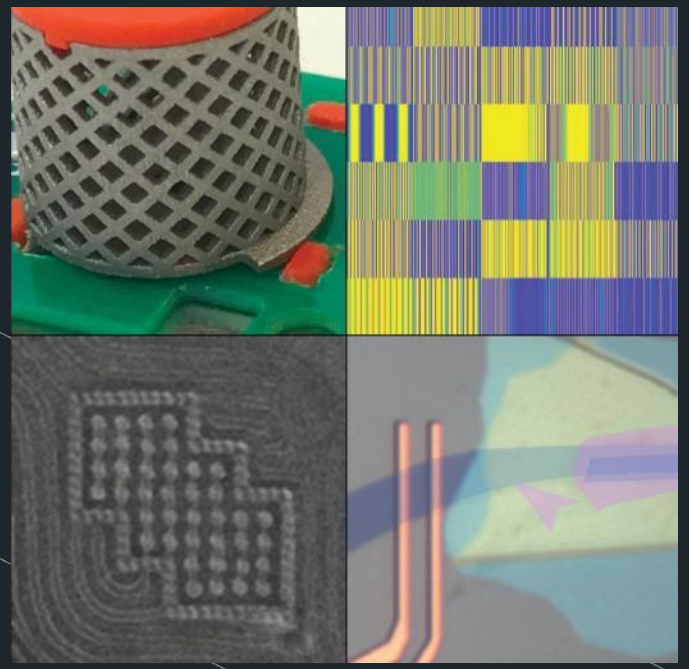
MTL Resume Site



322 resumes from 14 academic departments

MTL Grand Challenge –
The Digital Nose Project

…and many more initiatives!!



Coming Up in 2024…


40
MTL
MICROSYSTEMS
TECHNOLOGY
LABORATORIES

Other on-going projects…

- Large initiative on *Microelectronics for Health Care*
- *Co-working Space*
- *K-12 Microelectronics Education*
- *TEDx at MTL* on the Future of Microelectronics (April 2024)
- *Microelectronics @ MIT Day* to celebrate 40th anniversary of MTL (Oct. or Nov. 2024)
- *Professional Education* in microelectronics
- *Master Agreement* with MIG companies

Microsystems Technology Laboratories @ MIT

Powering the next wave of microelectronics innovation together!