MIT Industrial Liaison Program Faculty Knowledgebase Report

Spintronics: Putting a spin on electronics for low-power computing (Repeat)

October 27, 2020 7:30 pm - 9:30 pm

7:30pm

Welcome and Introduction
Jewan Bae
Director, MIT Corporate Relations

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Jewan John Bae comes to MIT Corporate Relations with more than 20 years of experience in the specialty chemicals and construction industries. He facilitates fruitful relationships between MIT and the industry, engaging with executive level managers to understand their business challenges and match them with resources within the MIT innovation ecosystem to help meet their business objectives.

Bae's areas of expertise include new product commercialization stage gate process, portfolio management & resource planning, and strategic planning. He has held various business leadership positions at W.R. Grace & Co., the manufacturer of high-performance specialty chemicals and materials, including Director of Strategic Planning & Process, Director of Sales in the Americas, and Global Strategic Marketing Director. Bae is a recipient of the US Army Commendation Medal in 1986.

Carl V. Thompson
Director, Materials Research Laboratory (MRL)

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Professor Thompson joined the MIT faculty in 1983. He is Director of MIT's Materials Research Laboratory and co-Director of the Skoltech Center for Electrochemical Energy Storage. His research interests include processing of thin films and nanostructures for applications in microelectronic, microelectromechanical, and electrochemical systems. Current activities focus on development of thin film batteries for autonomous microsystems, IC interconnect and GaN-based device reliability, and morphological stability of thin films and nano-scale structures. Thompson holds an SB in materials science and engineering from MIT and a PhD in applied physics from Harvard University.

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7:35pm

Exploiting and controlling the electron spin in materials by design
Geoffrey Beach
Co-director, Materials Research Laboratory (MRL)
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Professor Geoffrey Beach worked in UCSD's Center for Magnetic Recording Research to develop novel magnetic thin-film nanocomposites for ultrafast data storage applications. He later went on to the University of Texas at Austin as a Postdoctoral Fellow in the Department of Physics and the Texas Materials Institute where he made important discoveries in magnetization dynamics and spin-transfer torque in nanoscale magnetic structures. His current research interests focus on spin dynamics and “spin-electronics” in nanoscale magnetic materials and devices. Developing ways to store information more densely and to access it more quickly requires understanding the magnetization configurations in nanoscale structures and how they evolve in time. His work aims in part to understand and control spin excitations in magnetic materials whose dimensions approach fundamental magnetic length scales. One of the most exciting prospects in magnetism today is the possibility of electrical control of the magnetic state of a device, taking advantage of the coupling between spin and charge in a conducting ferromagnetic material. A major thrust of his research aims to harness the spin of the electron in magnetic materials to realize new approaches to spin-based storage and computation. Studying these processes requires the development of advanced instrumentation capable of probing magnetization dynamics at the shortest timescales and the smallest length scales. His group will work to develop new optical and electrical approaches to push the detection limits in order to enable development of new materials and structures to meet the information storage and processing demands of the future.

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A major obstacle for future progress in microelectronics is reducing power consumption. Devices that exploit the electron spin degree of freedom together with, or instead of, its charge, provide a pathway to meet this challenge. Solid-state spin-based devices have already entered the marketplace for nonvolatile memory applications, and the door to broader computing applications is now open. In this talk I will describe recently-discovered mechanisms, materials, and devices that offer a spin-based approach to augment conventional electronics as current technologies approach the end of their roadmap.

8:05pm

Spintronics for computation
Marc A. Baldo
Director, Research Laboratory of Electronics
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Director, Research Laboratory of Electronics

Professor Marc A. Baldo is a principal investigator in the Research Laboratory of Electronics (RLE) at the Massachusetts Institute of Technology (MIT). Professor Baldo’s research interests include molecular electronics, electrical and exciton transport in organic materials, energy transfer, metal-organic contacts, heterogeneous integration of biological materials, and novel organic transistors.

Professor Baldo received his B. Eng. (Electrical Engineering) from the University of Sydney in 1995 with first class honors and university medal, and his M.A. and Ph.D. from Princeton in 1998 and 2001, respectively. In 2002 he joined MIT as an Assistant Professor of Electrical Engineering. In 2004, he was appointed Esther and Harold E. Edgerton Assistant Professor of Electrical Engineering.

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New architectures for computation offer performance advantages for specific applications such as optimization and machine learning. In this talk, I will discuss the potential benefits of spintronics, with a focus at the system level. Collective switching of multiple spins promises to reduce the power delay product relative to conventional field effect transistors. But spintronic phenomena can also be exploited to realize novel devices such as programmable nonlinear function evaluators and coupled oscillators, providing potential benefits beyond traditional von Neumann architectures.

8:35pm

Invited Presentation Lightning Talks – Invited MIT Students and Postdocs

- Magnonics
- Computing with magnetic domain walls
- Spin currents in insulators
- Voltage controlled magnetism
- Materials for energy efficient computing

As part of the program for this webinar, we are offering breakout discussions with our presenting graduate students and postdocs. **In order to participate in these breakout rooms, you will need the latest version of Zoom (version 5.3.2)**. (If you need help determining your version of Zoom, please follow the instructions here.)

If you do not already have this version, **please update your Zoom client/application before joining the discussion**. Follow the instructions here to update Zoom.

8:55pm Parallel Lightning Presentation Break-out Discussions

Room #	Topic/ Invited Presenter/Position	Title and Abstract	Supervisor
1	Spin hall materials/devices and magnonics **Jiahao Han** Graduate Student	**Gated nonreciprocal magnon transmission from direction-dependent magnetic damping** An important application of magnetic materials in information processing and communication is to provide nonreciprocity. Conventional ferromagnet-based microwave circulators and optical isolators suffer from their bulk volume and the difficulty of being integrated into high-density circuits. We show that in an on-chip device with a magnetic gate, tunable nonreciprocal propagation can be realized in spin Hall effect-excited magnons with broadband spectrum. We identify a direction-dependent magnetic damping as the origin of the nonreciprocity. Our findings provide a general mechanism for introducing directional magnon transmission and lead to a design of passively gated magnon transistors for emergent chiral magnonic applications.	Prof. Luqiao Liu
2	Spin hall materials/devices and magnonics **Pengxiang Zhang** Graduate Student	**Current-induced Switching of Compensated Ferrimagnets and Antiferromagnets** Magnetic random access memories (MRAMs) using compensated ferrimagnets or antiferromagnets as free layers have great potentials of higher density, speed, and power efficiency. The advantages come from the fully compensated magnetic moments, allowing zero stray field and faster magnetic dynamics. Spin-orbit torque, an efficient way to switch ferromagnetic memory bits, may also switch compensated ferrimagnets and antiferromagnets efficiently. For compensated ferromagnets, we demonstrated the spin-orbit torque switching first in Co1-xTbx alloy, and then in Mn2Ru1?xGa, a Heusler alloy with lower damping and higher spin polarization. Furthermore, we clarified the complicated mechanisms of the current-induced switching in the canted antiferromagnet ?-Fe2O3.	Prof. Luqiao Liu
3	Spin currents in insulators **Ethan Rosenberg** Graduate Student	**Magnetic and spintronic properties of Y-substituted TmIG thin films** Thulium iron garnet (TmIG) has excited great interest due to record-breaking spin orbit torque-driven domain wall velocities over 2 km/s and the presence of the Dzyaloshinskii-Moriya interaction, which stabilizes chiral Néel domain walls. In this study we describe the static and dynamic magnetic properties of yttrium-substituted TmIG (TmYIG) thin films with a variety of Y:Tm ratios grown by pulsed laser deposition. We find that, by varying the Y:Tm ratio over a range of 0-0.67, we can tune the anisotropy energy of the film over	Prof. Caroline Ross

9:30pm	Wrap-up