Ultrafast Spintronics

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Magnetic nanodevices are receiving great attention these days due to their non-volatility and potential for extremely low energy dissipation. The field is rapidly evolving from rotating magnetic disks for mass storage to on-chip magnetic random access memory (MRAM). MRAM is in the advanced product development phase in a number of companies and is expected to be in widespread commercial application very soon. There is also intense interest in the possibility of magnetic logic devices. This area of research involves engineering control of electron spins in electronic devices, and is known as spintronics. One of the major drawbacks of spintronic devices is their intriniscally low speed, typically in the nsec range, while today's advanced CMOS devices switch in psec timescales. However, recent studies of ultrafast optical excitation of magnetic materials have revealed a new regime of magnetization dynamics. For example, fsec pulsed laser irradiation of a magnetic thin film can reverse the direction of the magnetic moment in less than a psec, even in the absence of an external magnetic field, a phenomenon known as all optical switching (AOS). Thusfar, the applications suggested for these fascinating phenomena have primarily involved some type of rotating disk based optical data storage. However, we have recently demonstrated ultrafast *all-electronic* switching of a magnetic thin film triggered purely by electrical current, with a very low switching energy. Our results pave the way to realize devices suitable for on-chip magnetic memory (and perhaps even logic) with switching speed in the range of a few picoseconds, i.e. two orders of magnitude faster than present MRAM, with comparable energy dissipation. In this talk, I will introduce the field of ultrafast spintronics and share some of our exciting results.

Jeffrey Bokor is the Paul R. Gray Distinguished Professor of Engineering in the department of Electrical Engineering and Computer Sciences (EECS) at UC Berkeley, with a joint appointment as Senior Scientist in the Materials Science Division at Lawrence Berkeley National Laboratory. He also serves as Chair of the Electrical Engineering Division in the EECS Department. He received the B.S. degree in electrical engineering from the Massachusetts Institute of Technology in 1975, and the M.S. and Ph.D. degrees in electrical engineering from Stanford University in 1976 and 1980, respectively. From 1980 to 1993, he was at AT&T Bell Laboratories where he did research on a variety of topics in laser science, surface science, advanced lithography for integrated circuits, as well as semiconductor physics and technology, and held several management positions. He joined the Berkeley faculty in 1993. From 2012 to 2017, he served as Associate Dean for Research in the College of Engineering. His current research activities include nanomagnetics/spintronics, graphene electronics, nanophotonics, and nano-electromechanical systems. He is a fellow of IEEE, APS, and OSA.