

Magneto-switching: From Spin transfer torque to Plasmonic-enhanced Ultrafast Opto-Magnetism

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Spin transfer torque to switch magnetic bits attract immense interest in low energy fast memory chips¹. The speed of ferromagnetic switching is limited to the order of ferromagnetic resonance (~ a few hundred ps). The recently discovered phenomenon of ultrafast magnetization reversal in ferrimagnetic films^{2,3} is so far the fastest controllable mechanism of information recording where a bit of information can be written as a magnetic domain in the ferrimagnetic film (active layer). For example, the state-of-the-art hard drive writer performs at ~ 1.5 GHz while all-optical magnetization reversal can perform at ~1THz.⁴ Given that the speed of devices utilizing ultrafast magnetism phenomena is determined by the magnetization reversal time in the ferrimagnetic layer, which is < 5 ps, the ultimate speed of these devices is comparable to the data rates used in high-speed optical communication.

The active area dimension of the femtosecond optical switch or the size of the bit of a storage device utilizing the ultrafast magnetization reversal mechanism is limited by the diffraction limit of the laser beam. To resolve this issue and improve scalability of the proposed devices we exploit potential plasmonics effects using nanostructures patterned on top of the active layer. Moreover, we study the possible mechanisms responsible for the alternating sublattice crystalline anisotropy and magnetic order in ferrimagnetic materials utilizing voltage-induced and strain-induced effects as well as developing technology for ultrafast readout of the magnetization state in the recording layer by means of optical and electrical methods.

Utilizing the physical principles of the newly emerging area of ultrafast magnetism will allow the development of a revolutionary new technology for optical communications and signal processing that ultimately will allow bit-by-bit data routing, processing and storage within a 100 Gb/s data stream. Additionally, building blocks for optical on- and off-chip communication between separate processing units may be constructed to break the current bandwidth limit of copper based technology, that may enable the development of a new generation of ultimate-performance/energy-efficient information processing and communication technologies.

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