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Ultrafast Magnetic Memory Bits Using All-Optical Magnetic Switching

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Up until now, magnetic nanodots used for magnetic random access memory have required spin-polarized currents to transfer the angular momentum needed to switch the magnetization and thereby switch the magnetic memory bit. This particular switching process, however, is limited to nanosecond or greater timescales – too slow for use as low-level cache in energy efficient electronics systems. On the other hand, this work aims to achieve ultrafast femtosecond switching of nanomagnetic dots without the use of spin-polarized currents. Using just linearly polarized light, several research groups have demonstrated all-optical magnetization switching in large GdFeCo magnetic dots, ranging from several microns [1-4] down to 400 nm [5]; this work characterizes the switching behavior as these dots are scaled down further in size, with the aim of minimizing the energy required for switching the magnetic memory bit. The fabrication process, magnetization behavior and optical switching behavior are additionally characterized to better understand how size affects the functionality of these optically-switchable ferrimagnets. Knowledge of this behavior will allow future developments of simultaneously *ultra*small and *ultra*fast magnetic memory systems, thereby enabling increased data storage in future electronics.

In order to maintain perpendicular magnetic anisotropy in the nanoscale dots of this work, high concentrations of cobalt were utilized. Rather than the GdFeCo compositions typically found in literature, this work demonstrates all-optical switching (AOS) in Gd-Co alloys excluding the iron; therefore iron was proven not to be necessary for the AOS process. The nanoscale dots were fabricated from a material stack of Ta (3)/Pt (3)/$Gd_{1-x}Co_x$ (10)/Pt (5), where layer thicknesses in nanometers are indicated in parentheses. The concentration of Co in the samples varied from 70 to 76%. Using a lift-off method and e-beam lithography, the dots where patterned from 5 μm down to 200 nm. Magneto-Optical Kerr Effect measurements using a Ti-Sapphire laser confirmed hysteresis loops with out-of-plane magnetization behavior (Fig. 1). Furthermore, *all-optical switching was achieved on all sizes of the out-of-plane dots down to 200 nm in diameter.* These results represent a major advancement toward the prospect of an ultrafast integrated memory using nanoscale GdCo magnets.

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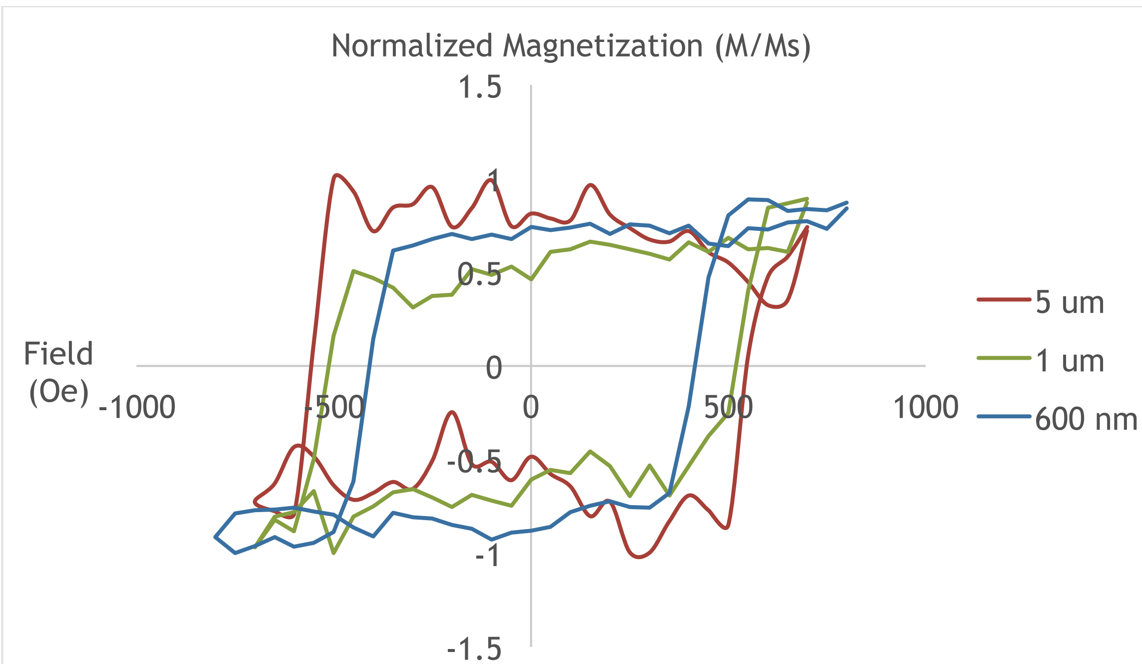

Fig. 1 – Normalized magnetic hysteresis loops of 5 μm, 1 μm, and 600 nm diameter dots of $Gd_{29}Co_{71}$. All dots successfully achieved all-optical switching.