

UC Berkeley

UC Berkeley Previously Published Works

Title

Single Shot Ultrafast all Optical Magnetization Switching of Ferromagnetic Co/Pt Multilayers

Permalink

<https://escholarship.org/uc/item/180324cm>

Journal

2017 FIFTH BERKELEY SYMPOSIUM ON ENERGY EFFICIENT ELECTRONIC SYSTEMS & STEEP TRANSISTORS WORKSHOP (E3S), 2018-January

ISBN

9781538632901

Authors

Gorchon, Jon
Lambert, Charles-Henri
Yang, Yang
[et al.](#)

Publication Date

2017-10-01

DOI

10.1109/e3s.2017.8246170

Peer reviewed

Single shot ultrafast all optical magnetization switching of ferromagnetic Co/Pt multilayers

Jon Gorchon^{1,2}, Charles-Henri Lambert², Yang Yang³, Akshay Pattabi², Richard B. Wilson⁴, Sayeef Salahuddin^{1,2}, Jeffrey Bokor^{1,2}

¹ Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720, USA.

² Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, CA 94720, USA.

³ Department of Materials Science and Engineering, University of California, Berkeley, CA 94720, USA.

⁴ Department of Mechanical Engineering and Materials Science and Engineering Program, University of California, Riverside, CA 92521, USA.

The ability to control magnetism in sub-picosecond timescales using laser pulses has potential applications in fast magnetic devices. It has been demonstrated that a single femto-second laser pulse can reverse the magnetization of a film within a few picoseconds [1], a phenomenon called as all-optical switching (AOS). However, this phenomenon thus far has been observed only in ferrimagnetic GdFeCo films. On the other hand, ferromagnetic films, which are of greater interest than ferrimagnets in many technological applications, need multiple laser pulses for magnetization reversal [2], making the overall effect slow and energy inefficient. Fast, single-shot switching of a ferromagnet can open up new avenues for spintronic devices that operate at unprecedented picosecond timescales, thereby making them viable non-volatile replacements for silicon based RAMs and logic devices.

In this work, we demonstrate single-shot helicity independent AOS of a ferromagnetic Co/Pt film, exchange coupled to GdFeCo film (Fig 1a). The two perpendicularly magnetized layers are separated by a Pt spacer of thickness d . We observe that a single 70 fs laser pulse toggles the magnetization of both the GdFeCo and the Co/Pt (Fig 1b).

Introducing a quarter-wave plate in the optic path enables depth-sensitive MOKE [3], which allows the separation of the magnetic signals arising from the two layers. Time-resolved MOKE measurements on our system show that AOS is achieved in both layers, with the Co/Pt ferromagnet switching within 7 ps (Fig 1c), mediated by its exchange with the GdFeCo. This result, to our best knowledge, is the fastest reported switching of a ferromagnetic film, and it demonstrates the feasibility of ultrafast ferromagnet-based spintronic devices.

Acknowledgment:

This work was primarily supported by the Director, Office of Science, Office of Basic Energy Sciences, Materials Sciences and Engineering Division, of the U.S. Department of Energy under Contract No. DE-AC02-05-CH11231 within the Nonequilibrium Magnetic Materials Program (MSMAG). We also acknowledge support by the National Science Foundation Center for Energy Efficient Electronics Science (materials synthesis, sample fabrication, and experimental equipment).

References:

- [1] Radu, I. et al, Nature 472, 205 (2011).
- [2] Lambert, C.-H. et al., Science 345, 1337–1340 (2014).
- [3] Schäfer, R., J. Magn. Magn. Mater. 148, 226–231 (1995).

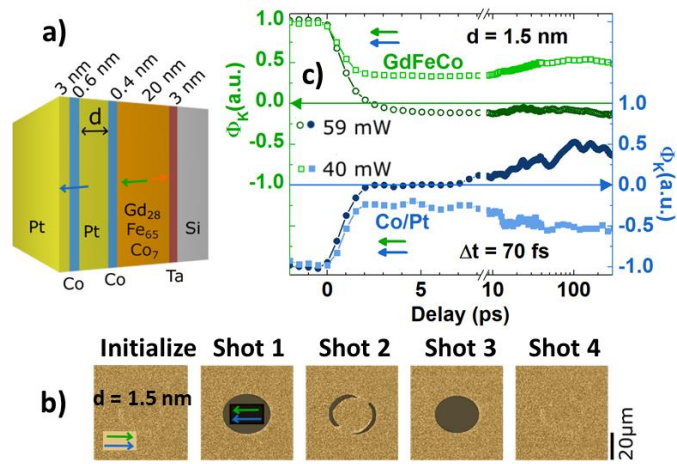


Figure 1: GdFeCo/Co/Pt(d nm)/Co/Pt stack series with Pt spacer of thickness d . The green, orange and blue arrows represent the magnetization of FeCo (dominant sublattice), Gd and Co/Pt respectively. b) MOKE images of single shot all-optical switching of the layers for a spacer thickness of 1.5 nm. c) Depth-sensitive time-resolved MOKE experiments showing demagnetization (green and blue squares) and AOS (circles) on sample $d=1.5$ nm.