Spin-Orbit Torque Switching of Magnetic Tunnel Junctions by Oxide Material

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Principal Investigator(s): Robert A. Buhrman

User(s): Arnab Bose

Affiliation(s): Applied and Engineering Physics, Cornell University

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Contact: buhrman@cornell.edu, ab2729@cornell.edu

Primary CNF Tools Used: 5x stepper, AJA sputtering, ASML, JEOL 6300, Oxford

Abstract:

Generation of spin-orbit torques (SOT) has remained one of the major aspects of spintronics for the past decade [1]. It has been shown that SOT can be efficiently created by the heavy metals such as Pt, Ta, W [1] and with their alloys [1]. It can be useful for magnetic memory application [1-2]. We recently studied SOT in oxide-based systems such as $SrRuO_3$ [2], IrO_2, etc. We aimed to implement switching of magnetic tunnel junctions (MTJ) using the intrinsic spin Hall effect of oxide materials.

Summary of Research:

To quantify SOT, the spin torque ferromagnetic resonance (ST-FMR) technique is used [1]. Basic device structure of an ST-FMR device and an MTJ are shown below (Figures 1 and 2). ST-FMR devices are fabricated by two-step optical lithography processes. Initially optical lithography is done on a film consisting of a ferromagnet/non-magnet bi-layer, followed by Ar-ion milling and lift off process. Another step of optical lithography is done to make contact pads on the small micron size devices, which also involves sputtering and lift-off process. The CNF 5x stepper is used for optical lithography and contact metallization is done by CNF-AJA sputtering instrument. MTJ fabrication is very complex and involves many steps — i.e. sputtering the MTJ film --> optical lithographys to make the channel (ASML) --> etching the channel --> lift off the resist --> electron-beam lithography (JEOL 6300)+plasma etching (Oxford) to make a pattern of the MTJ pillar on the channel --> selective Ar-ion etching to remove other material apart from the non-magnetic base or heavy metal --> SiO_2 evaporation (even hour evaporator) --> lift off the resist --> final layer of optical lithography (ASML) for contact pad patterning --> sputtering Ti(5nm)/Pt(60nm) by AJA at CNF --> lift off.

Characterization of the device fabrication is monitored by tapping mode AFM to confirm the existence of the channel and the pillar. Detailed method of the device fabrication can be found in reference [1]. Our devices are aimed to operate for fast and reliable magnetic memory application.

References:

[1] L. Liu, et al., Science 336, 555 (2012) and citations of this paper.

[2] Y. Ou, et al., NanoLetters 19, 63663-3670 (2019).

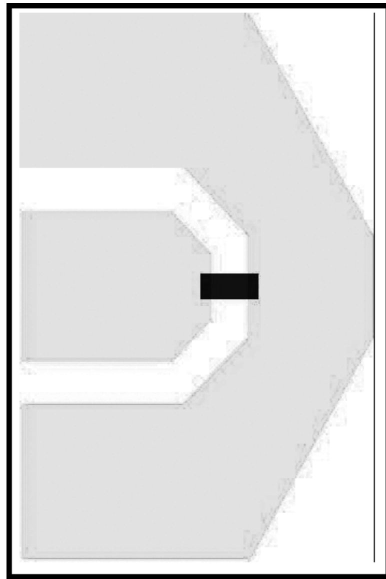

Figure 1: Schematics of an ST-FMR device.

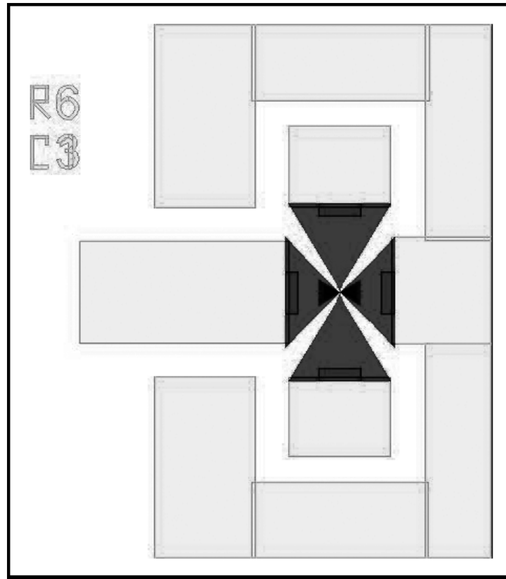

Figure 2: Schematics of an MTJ.