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Spin-Orbit Torque-Assisted Switching in Magnetic Insulator Thin Films with Perpendicular Magnetic Anisotropy

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As an in-plane charge current flows in a heavy metal film with spin-orbit coupling, it produces a torque that can induce magnetization switching in a neighboring ferromagnetic metal film. Such spin-orbit torque (SOT)-induced switching has been studied extensively in recent years and has shown higher efficiency than switching using conventional spin-transfer torque. This presentation reports the SOT-assisted switching in heavy metal/magnetic insulator systems.[1] The experiments made use of Pt/$BaFe_{12}O_{19}$ bi-layered structures. Thanks to its strong spin-orbit coupling, Pt has been widely used to produce pure spin currents in previous studies. $BaFe_{12}O_{19}$ is an M-type barium hexagonal ferrite and is often referred as BaM. It is one of the few magnetic insulators with strong magneto-crystalline anisotropy and shows an effective uniaxial anisotropy field of about 17 kOe. It's found that the switching response in the BaM film strongly depends on the charge current applied to the Pt film. When a constant magnetic field is applied in the film plane, the charge current in the Pt film can switch the normal component of the magnetization ($M_\perp$) in the BaM film between the up and down states. The current also dictates the up and down states of the remnant magnetization when the in-plane field is reduced to zero. When $M_\perp$ is measured by sweeping an in-plane field, the response manifests itself as a hysteresis loop, which evolves in a completely opposite manner if the sign of the charge current is flipped. When the coercivity is measured by sweeping an out-of-plane field, its value can be reduced or increased by as much as about 500 Oe if an appropriate charge current is applied. 1. P. Li, T. Liu, H. Chang, A. Kalitsov, W. Zhang, G. Csaba, W. Li, D. Richardson, A. Demann, G. Rimal, H. Dey, J. S. Jiang, W. Porod, S. Field, J. Tang, M. C. Marconi, A. Hoffmann, O. Mryasov, and M. Wu, Nature Commun. 7:12688 doi: 10.1038/ncomms12688 (2016).