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Voltage-Induced Ferromagnetic Resonance in Magnetic Tunnel Junctions[1]

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Excitation of sub-nanosecond magnetic dynamics by an electric field is a grand challenge in the field of spintronics. The ability to perform high-speed manipulation of magnetization by electric fields rather than by current-induced spin torques or magnetic fields would greatly improve energy efficiency of spintronic devices such as nonvolatile magnetic memory and logic. In this talk, I will discuss our experiments on excitation of ferromagnetic resonance in CoFeB/ MgO/ CoFeB magnetic tunnel junctions by the combined action of voltage-controlled magnetic anisotropy (VCMA) and spin transfer torque [1]. Our measurements reveal that GHz-frequency VCMA torque and spin torque in low resistance (resistance-area product of a few Ohm $\cdot$ μm^2) CoFeB-based magnetic tunnel junctions have similar magnitudes, and thus that both torques are equally important for understanding high-speed voltage-driven magnetization dynamics in CoFeB magnetic tunnel junctions such as magnetization switching and auto-oscillations induced by spin torque. As an example, we show that VCMA can increase the sensitivity of a microwave signal detector based on a magnetic tunnel junction to the sensitivity level of semiconductor Schottky diodes. Our measurements also demonstrate that ferromagnetic resonance in high resistance magnetic tunnel junctions can be excited by VCMA alone without a significant contribution from the spin torque drive. I will conclude this talk with a discussion on how voltage-induced ferromagnetic resonance can be used for quantitative measurements of various voltage-dependent torques in magnetic tunnel junctions: in-plane and perpendicular spin torques as well as VCMA torque.

[1] J. Zhu *et al.*, Phys. Rev. Lett. **108**, 197203 (2012)

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