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Tunnel barrier enhanced voltage signals generated by magnetization precession of a single ferromagnetic layer[1]

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A variety of experimentally observed phenomena involving nonlocal magnetization dynamics in magnetic multilayers are due to two complementary effects: (i) the transfer of spin angular momentum accompanying charge currents driven by the applied bias voltage between ferromagnetic layers results in torques that (for sufficiently high current densities) generate spontaneous magnetization precession and switching; and (ii) the precessing magnetization of a ferromagnet (FM) pumps spins into adjacent normal metal layers (NM) with no applied bias. In particular, the spin pumping effect is a promising candidate for realizing a spin battery device [1] as a source of elusive pure spin currents (not accompanied by any net charge transport) emitted at the FM/NM interface, where steady magnetization precession of the FM layer is sustained by the absorption of external rf radiation under the FMR conditions. We report the electrical detection of magnetization dynamics in an $Al/AlO_x/Ni_{80}Fe_{20}/Cu$ tunnel junction, where a $Ni_{80}Fe_{20}$ ferromagnetic layer is brought into precession under the ferromagnetic resonance (FMR) conditions. The dc voltage generated across the junction by the precessing ferromagnet is enhanced about an order of magnitude compared to the voltage signal observed in Cu/FeNi/Pt structures [2]. A structure of Cu (100nm)/Al (10nm)/AlO_x (2.3nm)/$Ni_{80}Fe_{20}$ (20nm)/Cu (70nm)/Au (25nm) was fabricated on a Si substrate with a 1μm thick thermal oxide layer. The bottom-most 100 nm Cu layer was patterned into a coplanar waveguide (CPW) and the rest of the structure was patterned into a pillar structure on the signal line of the CPW. Dc voltages $\sim \mu$V were observed in the $Al/AlO_x/Ni_{80}Fe_{20}/Cu$ tunnel junction when the $Ni_{80}Fe_{20}$ is in the ferromagnetic resonance. The dc voltages increase as the precession cone angle and frequency increase. We discuss the relation of this phenomenon to magnetic spin pumping and speculate on other possible underlying mechanisms responsible for the enhanced electrical signal.

[1] A. Brataas et al. PRB 66, 060404 (2002)
[2] M. V. Costache et al. PRL 97, 216603 (2006)

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