Spin-Current-Induced Magnetization Dynamics in Multiferroic Pt/Co/BTO/LSMO Tunnel Junctions

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The data stored in Magneto-Tunnel Junction (MTJ) as the magnetization orientation of a ferromagnetic electrode, results in a different tunneling current detected by the other ferromagnetic electrode of a fixed magnetization. Nowadays, MTJs serve as a basic memory cell of the magnetic random access memory - MRAM. With ongoing development, it has become possible to replace the magnetic field (originally used for the writing of the magnetization orientation) with a spin polarized current flowing through the junction (STT-MRAM), and then with the current flowing only through the high spin-orbit coupling material neighboring one of the electrodes (SOT-MRAM). We studied the static, dynamic and temperature dependent magneto-transport properties of the Pt/Co/BTO/LSMO mutliferroic tunnel junction (MFTJ) with BTO as a ferroelectric barrier. The multilayer structure was grown on a high quality crystalline STO substrate by means of pulsed laser deposition, which enables epitaxial layer-by-layer growth. The MFTJ was patterned into micrometer-size devices using the ion-etching-free lithography process. The measured static properties indicate that the MFTJ has multiferroic properties with the tunneling magnetoresistance (TMR) present below 260 K and tunneling electro-resistance (TER) reaching four orders of magnitude at T = 10 K. In such a structure, exhibiting both TMR and TER, we were able to induce the magnetization dynamics of Co by the spin Hall effect in Pt top layer by an in-plane RF current application. The room temperature SOT-FMR measurements revealed only the peak from the Co layer, as expected in the two-point in-plane measurement configuration. Surprisingly, at temperatures below 260 K, the second peak is also present, although the RA product of the BTO tunnel barrier prevents any charge currents from tunneling [1]. Both the linewidth and the resonance peak evolution with the magnetic field is in the agreement with the LSMO dynamics. The LSMO magnetization process is induced by the RF Oersted field and the signal is picked up by the inverse spin Hall effect in the Pt/Co bilayer. This observation of the dynamics of both ferromagnetic electrodes of the MFTJ together with a coexistence of the magneto- and electro-resistance proves multifunctionality of the developed multilayer system.

References:

[1] J. Pawlak et al., Adv. Electron. Mater., submitted (2023)