Low-current spin-orbit torque switching of W/CoFeB/MgO nanodots by tuning W resistivity

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Spin-orbit torque (SOT) allows electrical control of a magnetization orientation in magnetic heterostructures [1-3]. To achieve an efficient control of the magnetization orientation, material systems that exhibit large Slonczewski-like torque efficiency (ξ_{SL}) are desirable. Previous studies have revealed that magnetic heterostructures with W underlayer generate large ξ_{SL} whose magnitude can be enhanced by increasing W resistivity (ρ_W) [4-6]. In this work, we study SOT-induced switching of W/CoFeB/MgO nanodots for various ρ_W.

We deposit W(5)/CoFeB(2.4)/MgO(1.3)/Ta(1) (thickness in nm) on Si substrate by DC/RF magnetron sputtering. Ar gas pressure to deposit W is varied from 0.13 to 0.28 Pa to change ρ_W, leading to a change in ξ_{SL} from -0.03 to -0.92. By using electron beam lithography and Ar ion milling, films are processed into in-plane magnetized elliptic nanodot arrays with a nominal size of 100 × 400 nm^2. Widths of the channel and Hall probes are 3 and 1 μm, respectively. The fabricated dot arrays are annealed at 300 °C for 1 hour. We apply an in-plane current orthogonal to magnetic easy axis and detect the SOT switching via the change in the planar Hall resistance [7,8]. Figure 1 shows differential planar Hall resistance (ΔR) as a function of applied current (I). A clear hysteresis indicating SOT switching is observed. Figure 2 shows ρ_W dependence of switching current density flowing into W layer (J_{SW}). J_{SW} decreases with increasing ρ_W down to 0.75 MA/cm^2 at ρ_W = 783 μΩcm. The reduction of J_{SW} can be mainly attributed to the enhancement of ξ_{SL}. We will elaborate the relationship between switching current and the evaluated spin-orbit torque.

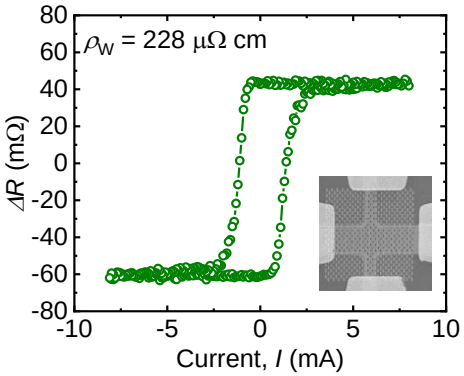

Fig.1 Differential planar Hall resistance versus vs applied current of nano dot arrays. Inset shows an image of dot arrays and Hall probe.

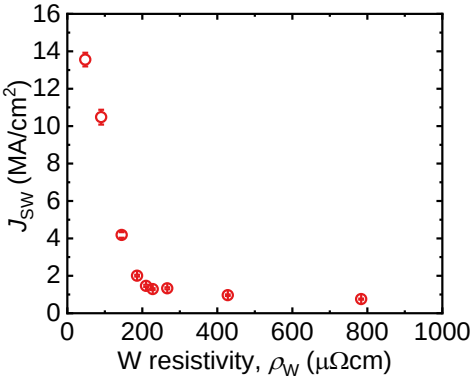

Fig.2 W resistivity dependence of switching current density flowing into W layer.

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