World Academy of Science, Engineering and Technology
International Journal of Physical and Mathematical Sciences
Vol:18, No:09, 2024

Field-Free Orbital Hall Current-Induced Deterministic Switching in the MO/$Co_{71}Gd_{29}$/Ru Structure

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Abstract : Spin-polarized currents offer an efficient means of manipulating the magnetization of a ferromagnetic layer for big data and neuromorphic computing. Research has shown that the orbital Hall effect (OHE) can produce orbital currents, potentially surpassing the counter spin currents induced by the spin Hall effect. However, it's essential to note that orbital currents alone cannot exert torque directly on a ferromagnetic layer, necessitating a conversion process from orbital to spin currents. Here, we present an efficient method for achieving perpendicularly magnetized spin-orbit torque (SOT) switching by harnessing the localized orbital Hall current generated from a Mo layer within a Mo/CoGd device. Our investigation reveals a remarkable enhancement in the interface-induced planar Hall effect (PHE) within the Mo/CoGd bilayer, resulting in the generation of a z-polarized planar current for manipulating the magnetization of CoGd layer without the need for an in-plane magnetic field. Furthermore, the Mo layer induces out-of-plane orbital current, boosting the in-plane and out-of-plane spin polarization by converting the orbital current into spin current within the dual-property CoGd layer. At the optimal Mo layer thickness, a low critical magnetization switching current density of 2.51×10^{6} A cm^{-2} is achieved. This breakthrough opens avenues for all-electrical control energy-efficient magnetization switching through orbital current, advancing the field of spin-orbitronics.

Keywords : spin-orbit torque, orbital hall effect, spin hall current, orbital hall current, interface-generated planar hall current, anisotropic magnetoresistance
Conference Title : ICMSE 2024 : International Conference on Magnetism and Spin Electronics
Conference Location : San Francisco, United States
Conference Dates : September 26-27, 2024