Orientational anisotropy of magnetic damping in Ta/CoFeB/MgO heterostructures

B. Rana[1,2] and Y. Otani[2,3]

[1]*ISQI, Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*
[2]*CEMS, RIKEN, Wako, Japan*
[3]*ISSP, University of Tokyo, Kashiwa, Japan*

Magnetic damping, one of the key parameters of magnetic materials, can be controlled by spin current induced torques [1], electric field [2]; and by engineering electronic band structure at the Fermi level [3]. Being a tensor quantity the damping also depends on the orientation of magnetization, known as Orientational anisotropy. This Orientational anisotropy originates from the anisotropy in the spin-orbit coupling (SOC) and density of states (DOS) in the ferromagnetic layer (bulk) and at the interfaces (for heterostructures made of ultrathin films) [4]. Hence, Orientational anisotropy provides a great tool for tuning magnetic damping by changing the orientation of magnetization, which is quite appealing from the application point of view.

Here, we report orientational anisotropy of damping in Ta/CoFeB/MgO heterostructures deposited on Si/SiO_2 and $LiNbO_3$ substrates. The damping parameter in the films are extracted by performing ferromagnetic resonance (FMR) measurements based on spin pumping and inverse spin Hall effect (ISHE) technique [2]. The studied multilayers possess both: perpendicular magnetic anisotropy (PMA) with interfacial origin and in-plane magnetic anisotropy (IMA) with bulk origin. We observe that the orientational anisotropy of damping is composed of four-fold and two-fold anisotropy terms. The four-fold anisotropy originates from extrinsic two-magnon scattering (TMS), which occurs because the uniform magnons are scattered from inhomogeneities or imperfections present at Ta/CoFeB interface. The two-fold anisotropy, on the other hand, originates from the anisotropy in bulk SOC of CoFeB film and correlates with IMA of the films. We find that when IMA is very small, it has too little influence on two-fold anisotropy to be experimentally identified. However, as IMA increases, it starts to influence two-fold anisotropy in damping. These results will help to design the orientational anisotropy in damping in future spintronics devices by engineering bulk and interfacial SOC strengths.

References:

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