Effect of normal metal seed and capping layers on the magnetization dynamics of permalloy thinfilms

[O]Satya Prakash Pati[1] and Yasushi Endo[1,2]
[1]Department of ElectricalEngineering, Graduate School of Engineering, Tohoku University
[2]Center for Spintronics Research Network, Tohoku University
Email: sppati@ecei.tohoku.ac.jp

Study of spin transport across normal metal/ ferromagnet/normal metal (NM/FM/NM) has attracted enormous interest after exploitation of spin pumping [1], inverse spinHall effect [2] like phenomena for applications in MRAM, magnetic data storage and spin-logic. Spin current ($J_{S,\ pump}$) generated from a precessing magnetization of a FM injects into both adjacent NM and dissipates under the influence of strong spin orbit interaction (SOI) resulting in an enhancement of damping parameter [3] due to loss of angular momentum is known as spin pumping[1]. Dissipation of $J_{S,pump}$ depends on the material properties of NM can be parameterized as spin mixing conductance ($g_{\uparrow\downarrow}$). There are many ongoing debates on the other external parameter effecting spin current dissipation induced Gilbert damping e.g. interfacial spin resistance, proximity induced spin polarization, magnetic dead layer at interface etc. Herein, we evaluate the magnetization dynamics in a various thick permalloy (Py) film with both NM seed and capping layers (Pt or Cu), and discuss in detail the effect of NM seed and capping layers on the dynamics of Py thin films.

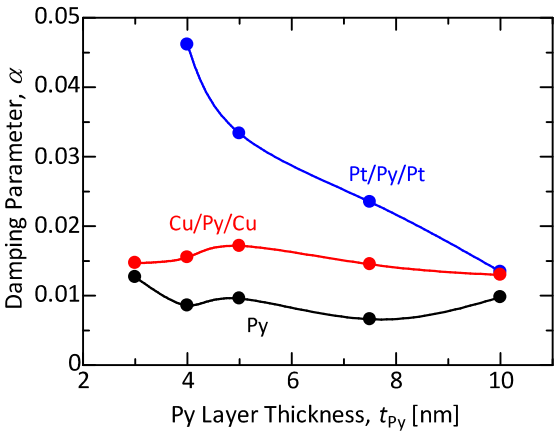

Figure 1: Py layer thickness (t_{Py}) dependent damping parameter of bare Py and sandwiched with Cu or Pt.

Fig.1 shows the Gilbert damping parameter (α) as a function of Py layer thickness for Py thin films with NM seed anc capping layers(NM=Cu and Pt). In case of NM=Cu, α almost remains constant when Py layer thickness decreases. Their values are a little larger than those of bare Py thin films, and are approximately 0.015 - 0.017.On the other hand, in case of NM=Pt,αincreases remarkably from 0.012 to 0.046 when Py layer thickness decreases. The differences between Cu and Pt layers can be explained as the spin diffusion length (λ_{sf})[4]: In case of NM=Cu, $\lambda_{sf}$is larger than a Cu layer thickness and hence spin mixing inside Cu is negligible resulting in no change ofα. However, in case of NM=Pt, λ_{sf} is shorter than a Pt layer thickness, so $J_{S,pump}$ fully relax within Pt layer and hence α is enhanced. In addition, the enhancement of α for Pt case can be attributed to the enhanced electron-magnon scattering as an electron accumulation can occur at the Py/Pt interface[5].Therefore, this result reveals that the λ_{sf} of NM seed and capping layer plays an important role with the magnetization dynamics of Py thin film.

This work was partly supported by JSPS KAKENHI Grant Number JP26289082, JP17H03226, JP17F17070 from MEXT, Japan and Murata Science Foundation and ASRC in Japan. S. P. Pati would like to thank JSPS for the international post-doctoral research fellowship (ID no: P17070).

References:

[1] Y. Tserkovnyak *et.al.*Phys.Rev.Lett, 88,117601(2002)
[2] I.M. Miron *et.al.* Nature 476, 189 (2011)
[3] A. Brataas *et.al.*Phys.Rev. B 66,060404 (2002)
[4]M. Tokac *et.al.* Phys.Rev. Lett. 115,056601 (2015)
[5] L. Berger *et.al.* Phys. Rev. B. 54, 9353 (1996)