Interfacial Phenomena in Ferromagnetic/Non-Magnetic Thin-Films: DMI and Proximity Magnetisation; Spin Transport, Spin-Mixing Conductance and the Spin Diffusion Length

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Abstract: A range of interfacial physics has emerged in ferromagnetic/non- magnetic (FM/NM) systems that opens up new avenues for physical understanding and offers potential for spintronic applications. Here the relationship between the Dzyaloshinskii-Moriya interaction across the FM/NM interface and magnetic polarisation of the NM layer is presented and a detailed study of spin transport across FM/NM interfaces explains the role of the interface structure and new analysis shows the spin-diffusion length is actually thickness dependent.

1. INTRODUCTION

There are many exciting areas of research linked to interfacial effects in FM/NM systems, such as interface spin-orbit interactions (SOI), spin-currents from the spin Hall effect (SHE), spin-orbit torques (SOT) [1], interfacial Dzyaloshinskii-Moriya interaction (DMI), proximity-induced-magnetization (PIM) of non-magnetic metals and ferromagnetic damping where interfacial effects and spin pumping into non-magnetic layers can yield new insights. Here, new insights into interfacial DMI and proximity-induced-moments in NM transitions metals in direct contact with FM thin-films and the influence of interfacial structure and spin-diffusion length on spin-transport are described.

2. DMI and PROXIMITY POLARISATION

The interfacial DMI and PIM in Pt was studied as a function of Au and Ir spacer layers in Pt/Co/Au,Ir/Pt. The length-scale for both interactions is sensitive to sub-nanometre changes in the spacer thickness, and they correlate over sub mono-layer spacer thicknesses, but not for thicker spacers. The spacer layer thickness dependence of the Pt PIM for both Au and Ir shows a rapid monotonic decay, while the DMI changes rapidly but has a two-step approach to saturation and continues to change, even after the PIM is lost [2], see fig. 1. The effect of DMI and damping on domain wall behaviour in NiFe/Pt nanowires is also discussed [3].

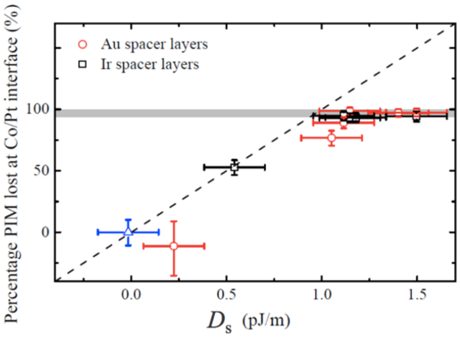

Fig.1. DMI and proximity polarization as a function of spacer layer, SL, thickess in a Pt/Co/SL/Pt system [1].

3. INTERFACIAL SPIN TRANSPORT

Spin transport across FM/NM interfaces is introduced [4] and, the effects of interface structure [5] and NM thickness [6] on spin current propagation across the interface are discussed in terms of the spin-flip probability and new insight that shows a consistent understanding is obtained when a thickness dependent spin-diffusion length in the NM layer is used. An extensive set of samples varying the thickness of both the FM and NM layers was analysed with spin-pumping theory that was extended to include a thickness dependent spin-diffusion length that was linked to the thickness dependence of the resistivity. This new analysis shows the importance of interface structure and a thickness dependent spin-diffusion length for spin propagation [7].

Sample	Spin-flip probability, ϵ	Constant λ_{sf}	Thickness Dependent λ_{sf}
Pt(fcc)/Co(fcc)	0.17	1.6 nm	9.4 nm
Co(fcc)/Pt(fcc)	0.26	1.6 nm	9.5 nm
Pt(fcc)/a-CoFeB	0.11	1.6 nm	6.6 nm
Co(hcp)/Ru(hcp)	0.004	-	22.4 nm
Co(fcc)/Ru(hcp)	0.003	-	22.4 nm

Table 1. Summary of spin flip probability and spin-diffusion length obtained for interfacial spin transport.

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