Interactions across ferromagnetic/heavy metal thin-film interfaces: Proximity-induced magnetisation, spin transport and the Dzyaloshinskii-Moriya interaction

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Several physical mechanisms in magnetism are linked to electronic interactions that take place across the interface between magnetic (FM) and non-magnetic (NM) thin-film layers. These interactions are significant for spintronics applications and are the subject of on-going research including on interfacial Dzyaloshinskii-Moriya interactions (iDMI) and the proximity-induced-magnetization (PIM) of heavy metals in contact with a FM layer. The materials and structure at the interface are critical to these effects and also to the spin transport through the interface, which in FM/NM systems is key for magnetic damping, via the pumping of spin current into NM layers, and for spin-orbit torque (SOT) switching, that results from the propagation of spin-current into a FM layer. The linkage between these interfacial phenomena has been the subject of debate, such as the relationship between DMI and proximity induced magnetisation and the role of PIM in spin transport across FM/NM interfaces. Further debate surrounds the determination of the spin-diffusion length from FMR and spin-pumping through insulating layers. The focus here is on the relationships between these interfacial phenomena and spin-transport across the interface.
The relationship between interfacial proximity-induced magnetisation and iDMI is presented for the Co/Pt system [1], as a function of Au and Ir spacer layers in Pt/Co/Au,Ir/Pt. The nature of PIM in heavy metals layered with ferrimagnetic systems is then discussed for Pt in contact with rare earth:transition metal alloy films, to understand the relationship between the Pt moment and the two ferrimagnetic sublattices. Spin transport across FM/NM interfaces is shown to be affected by the interface structure [2], NM thickness [3] and the role of PIM on spin current propagation across the interface is discussed. A new fuller physical analysis of spin-transport from spin-pumping is presented [4] that provides consistent values with a thickness dependent spin-diffusion length for the NM layer. Finally, detailed experimental analysis addresses the question of spin current tunnelling through an insulating oxide layer [5], which indicates that structural imperfections may suggest tunnelling.

References:

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