Theoretical insights into spin-orbit induced phenomena at graphene/ferromagnet interfaces

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In recent years, spin-orbit phenomena including perpendicular magnetic anisotropy (PMA) and Dzyaloshinskii-Moriya interaction (DMI) played a major role in advent of spin-orbitronics [1]. Whilst these phenomena have been traditionally explored at interfaces comprising heavy ferromagnet (FM) with heavy metal (HM) [2] or oxide [3], here we demonstrate that graphene/FM interfaces represents a viable alternative for advancing spintronic and spin-orbitronic applications since graphene induces significant PMA [4] and DMI [5] values in adjacent FM metal. Using first principle calculations, we elucidate physical mechanisms of PMA and DMI at graphene/FM interfaces by providing their layer resolved magnetocrystalline anisotropy energies (MAE). It follows that the graphene enhances the PMA contributions from several interfacial Co layers [Fig. 1]. Next, the DMI at graphene/Co(Ni) interfaces is due to Rashba effect since the corresponding spin-orbit energy is located at FM atom as shown in Fig. 2 [5], unlike Fert-Levy mechanism at FM/HM interfaces [2]. Finally, we propose multilayer stacks, which allows further enhancement of PMA and DMI as shown in Fig. 2. We acknowledge EU H2020 Programme Graphene Flagship (agreement No. 696656).

References

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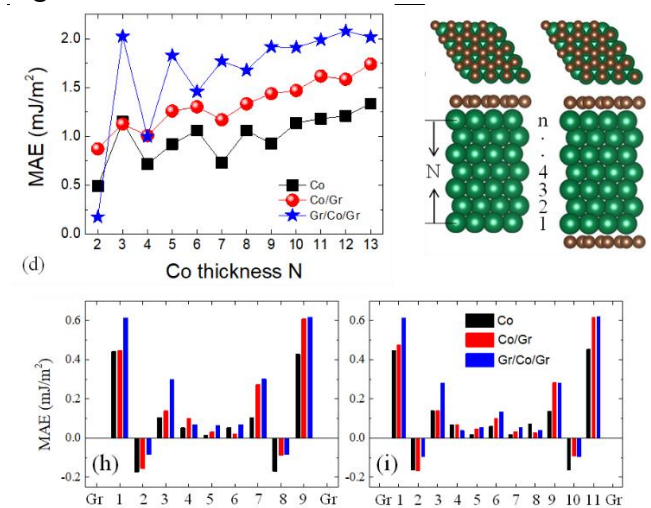
Figures

Figure 1: (Top) MAE as a function of Co thickness N (monolayers) for Co, Co on graphene, and Gr/Co/Gr, respectively. (Bottom) Layer resolved local MAE for cases with 9 & 11 Co monolayers.
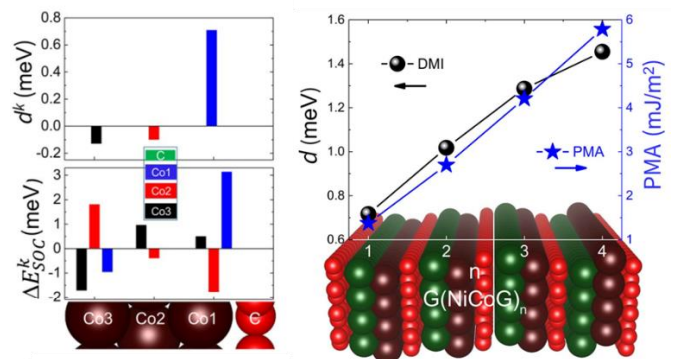

Figure 2: (Left) Layer-resolved DMI parameter d^k of the kth layer for a graphene/Co(3 ML) slab with atomic-layer-resolved localization of the associated spin-orbit energy ΔE_{soc}^k. (Right) DMI and PMA correlation for multilayers of graphene/[Co/Ni/graphene]$_n$.