SOgraph: Tailoring Spin-Orbit effects in Graphene for spin-orbitronic applications

Main area: Advanced nanofabrication and spintronics
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Abstract

The development of all-graphene spintronic devices requires that, in addition to its passive capability to transmit spins over long distances, other active properties are incorporated to graphene. Recent advances by some of the partners have led to the generation of long range magnetic order and spin filtering in graphene by molecular functionalization as well as the introduction of giant spin-orbit coupling (SOC) in the electronic bands of graphene by intercalation of Pb. The SOgraphene proposal incorporates these developments as the base for designing novel nanoarchitectures targeting the investigation of the role and the control of SOC in graphene as a source of large chiral exchange interaction, commonly known as Dzyaloshinskii–Moriya interaction (DMI), leading to stabilization and manipulation of magnetic skyrmions, and/or as efficient source of large pure spin current by Spin Hall Effect (SHE).

Magnetic skyrmions are topologically protected spin structures on the nanometer scale that hold promise as information carriers in ultradense memory and logic spintronic devices, owing to the extremely low spin-polarized currents needed to move them. The SHE, a SOC-induced phenomenon allowing the conversion of charge current into spin currents, is promising for the creation of spin currents in spintronic devices. It has been demonstrated recently for the first time that it can be obtained by introduction of SOC in graphene. The combination of high charge mobility and large induced SOC in graphene results in a room-temperature (RT) gate-tunable SHE, a crucial ingredient in realizing spintronics paradigms such as the spin field effect transistor, potentially even the quantum spin Hall insulator. So far, the search of these magnetic functionalities related to SOC into graphene is scarce. The SOgraphene proposal aims to i) create, ii) characterize, iii) image, and iv) test all-graphene spin-orbitronic systems/devices functional at RT by exploiting the advantages of combining ferromagnetic (FM) and/or non-magnetic (NM) heavy metals underneath of a graphene (gr) layer. In particular, the following stack sequences gr/Pb/Co/NM2 and gr/Pb/insulating will be explored. Different issues will be addressed: a) induce large interfacial chiral interactions and skyrmions in perpendicular magnetic anisotropy (PMA) ultra-thin Co layers in proximity with Pb, b) induce SOC and SHE in graphene by the proximity of Pb; and c) the combined proximities of graphene with Pb and Co to imprint skyrmionic textures into graphene. For the three cases, the gate-tunability of graphene would, in addition, allow electric field control of such interface-induced effects. In view of practical applications, SOgraphene will open the way for the development of the next generation of low-power, faster and smaller spin-orbitronic devices in 21st century.

The SOgraphene consortium is composed by four research institutions (IMDEA, UMIPHY, Soleil) and one SME (IPM srl) from three countries (Spain, France, Italy) and comprises a group of experts in the required fabrication and characterization techniques, theory, as well as the facilities and engineering expertise to produce the proposed systems/devices. In addition, the Consortium complements the capabilities already available at the Graphene Flagship, making available a list of sophisticated techniques.

Consortium

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