Band engineering and surface magnetism in Graphene/ferromagnet hybrids

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Possibility for a thesis Yes

Spintronics, which exploits the coupling between the electron charge motion and their intrinsic magnetic moment, represents an emerging field predicted to lead to a technological revolution. A huge effort nowadays is dedicated to the development of novel materials liable to increase the existing technology performances or that will enable the exploitation of new properties. Within this respect, the discovery of graphene has opened a fascinating research field with ultimate goal of using graphene as a building block for next generation electronics due to the exceptionally high electron mobility ensured by the linear dispersion of the graphene band structure (Dirac Cones) [1]. Pristine graphene is a diamagnetic material in which electrons spins experience almost no coupling with electron charge motion (in a classical picture). Therefore, besides spin transport [2,3], the common wisdom suggests that pristine graphene has no particular use for spintronic or data storage applications. This situation changes dramatically when graphene is interfaced with other materials to form the so-called **hybrid systems**. In these kinds of systems it is possible to **engineer the graphene band structure**, preserving the natural high electron mobility and introducing novel properties (see Fig. 1 as example [4]). **The aim of this project is to fabricate and characterize graphene hybrid model systems suitable for spintronic applications.** In particular graphene will be interfaced with magnetically polarized heavy metals (HM) lying on ferromagnetic (FM) thin films in order to induce, at the same time, exchange interaction and spin orbit splitting in the graphene Dirac Cones by interface effects. The internship will consists in the quantum engineering, in ultrahigh vacuum condition, of novel graphene/ferromagnet nano-hybrids and their *in-situ* analysis in real space by means of Scanning tunneling spectroscopy (STM) and in reciprocal space by means of angle resolved photoemission (ARPES).

This project represents a first fundamental study of the possibility to exploit the graphene outstanding properties for magnetic information and spintronic applications by using several interfaces effects at the same time. In fact the realization of the **first crystalline graphene/HM/FM thin film system will serve as a possible model system for *racetrack memory* prototypes and will elucidate the possibility to engineer the graphene spin texture** going towards its use as base material for spintronic applications. In all the cases, the system and interface qualities play a crucial role in the strength of the expected effects.

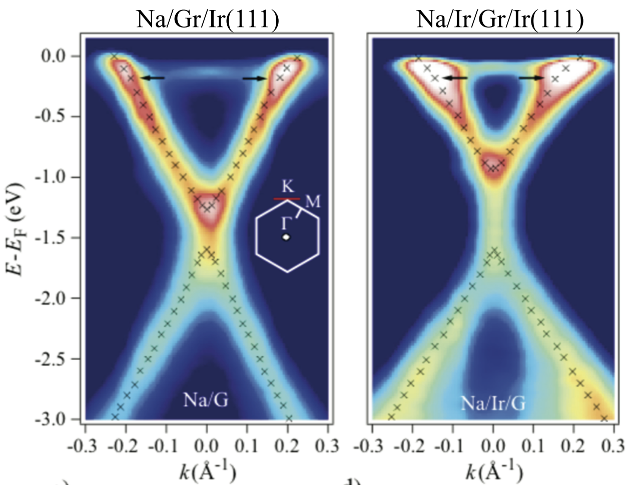

Fig. 1 Band engineering of Graphene(Gr): Electronic doping and band gap opening in Gr/(111) due to Na adsorption (left). Enlargement of band gap due to mutual effect of Na adsorption and Ir self-assembled nanostructures [4]

The first objective of the project will then be the fabrication and the structural characterization of the desired highly crystalline hybrid system. *The second objective* will be the in-depth magnetic characterization of the system. In this phase the magnetic coupling between the different elements will be addressed. *The last objective* will then be the resolution of the system band structure to reveal the coexistence of exchange and spin orbit splitting in the graphene Dirac Cones.

With us, the student will daily handle state-of-the-art high resolution and low temperature apparatuses for atomic scale, local (scanning tunneling and atomic force microscopy at 1K under ultra-high vacuum) or k-resolved spectroscopy (angle resolved photoemission spectroscopy at low temperature and very high resolution). He will benefit of a careful and responsive supervision of the members of the research group who are used to communicate their scientific and technical knowledge. In the case of a continuation with a PhD thesis, the student will also participate to several measurements campaigns at synchrotron radiation facilities.

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[3] B. Dlubak, *et al*., Nat. Phys. **8** 557 (2012).
[4] M. Papagno *et al.,* ACS Nano **6** 199 (2011).