Hybrid Graphene – Molecular Magnet Devices for Spintronics

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Spintronic devices interconvert spin to charge information and nanostructured carbon systems turn out to be a unique platform to build hybrid devices at the molecular scale. Here, we focus on graphene based devices used as highly sensitive magnetometers. The key idea is to realize novel spintronic nano-architectures where the electrical current is controlled by the quantum properties of few single-molecule magnets grafted on top of the graphene layer.

As a first step, we explored different strategies to graft molecular nanomagnets on carbon surfaces. For example, we developed a two-steps procedure using Sulfur-terminated amine SAM to electrostatically attach antiferromagnetic rings on HOPG [1]. Alternatively, we employed $TbPc_2$ molecules appositely functionalized with pyrene groups that selectively graft to graphene on SiO_2 [2]. By means of micro-Raman spectroscopy and Atomic Force Microscopy we studied the coupling interaction between the two materials, that is carried mainly by the □-systems, preserving the integrity of the molecules and the intrinsic properties of graphene[2].

Secondly, we characterized the low temperature magnetoconductance of pristine graphene devices founding that below 1 K a magnetic hysteresis appears in the signal, when the field is swept at high enough rates (dB/dt > 10 mT) [3]. The magnetic signal does not depend on the size nor on the transport regime of the device. We attribute the origin of these hysteresis loops to the magnetization reversal of paramagnetic centers in graphene, which might originate from structural defects in the graphene layer, most probably vacancies [3].

Finally, we present the design and the realization of hybrid devices made by graphene nano-constrictions with sizes down to 10 nm, fabricated by Electron Beam Lithography and plasma etching, decorated with $TbPc_2$ magnetic molecules. The magnetization reversal of the molecules in proximity with graphene is detected by the magnetoconductivity of these hybrid devices, which shows the uniaxial magnetic anisotropy typical of the $TbPc_2$ SMMs. Our results depict the behaviour of multiple-field-effect nano-transistors with sensitivity at the single-molecule level [4][5].

References

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