Tailoring Graphene for Spintronics

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The development of graphene spintronic devices requires that, in addition to its capability to passively transmit spins over long distances, new magnetic functionalities are incorporated to graphene. By growing epitaxially graphene on single crystal metal surfaces under UHV conditions [1] and either adsorbing molecules on it or intercalating heavy atoms below it, long range magnetic order or giant spin-orbit coupling, respectively, can be added to graphene.

i) *Achieving long range magnetic order by a monolayer of electron acceptor molecules adsorbed on graphene /Ru(0001).*

Epitaxial graphene is spontaneously nanostructured forming an hexagonal array of 100 pm high nanodomes with a periodicity of 3 nm [2]. Cryogenic Scanning Tunnelling Microscopy (STM) and Spectroscopy and DFT simulations show that TCNQ molecules deposited on gr/Ru(0001) acquire charge from the (doped) substrate and develop a sizeable magnetic moment revealed by a prominent Kondo resonance. The molecular monolayer self-assembled on graphene develops spatially-extended spin-split electronic bands. The predicted spin alignment in the ground state is visualized by spin-polarized STM at 4.6 K [3]. The system shows promising perspectives to become an effective graphene-based spin filter device.

ii) *Introducing a giant spin-orbit interaction on graphene/Ir(111) by intercalation of Pb.* The intercalation of an ordered array of Pb atoms below graphene results in a series of sharp pseudo-Landau levels in the differential conductance revealed by STS at 4.6 K. The vicinity of Pb enhances by four orders of magnitude the, usually negligible, spin-orbit interaction of graphene. The spatial variation of the spin-orbit coupling creates a pseudo-magnetic field that originates the observed pseudo-Landau levels [4]. This may allow the processing and controlled manipulation of spins in graphene.

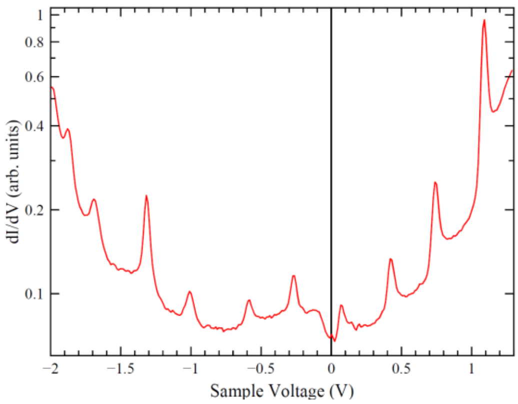

Fig. 1: Differential conductance for Pb-intercalated graphene

References

[1] A.L. Vázquez de Parga et al, Phys. Rev. Lett. 100, 056807 (2008)
[2] B. Borca et al, Phys. Rev. Lett. 105, 036804 (2010)
[3] M. Garnica et al, Nature Physics 9, 368 (2013)
[4] F. Calleja et al, Nature Physics 11, 43 (2015)