HiMagGraphene: Atomic-scale control of graphene magnetism using hydrogen atoms

Main area: Advanced nanofabrication and spintronics
Keywords: Epitaxial graphene; scanning tunnelling microscopy/spectroscopy; magnetism; spintronics
Duration (months): 36
Total project funding: € 612 095

Abstract

The selective generation of local magnetic moments in graphene layers is a key requirement to realize graphene spintronics, but still remains as a major experimental challenge. The main goal of this project is to provide an unambiguous experimental proof of this possibility by the adsorption and further manipulation of single H atoms on graphene layers.

The incorporation of magnetism to the long list of graphene capabilities has been pursued since its first isolation in 2004. The use of spin as an additional degree of freedom would represent a tremendous boost to the versatility of graphene based devices. On one hand, spin information transfer or spin diffusion phenomena are favored by the expected long spin relaxation times of graphene carriers. On the other, graphene magnetism and charge transport can take place in the same pi bands and thus a major potential in future spintronics applications can be anticipated.

Since the early days of graphene research, all theoretical predictions agree that graphene can be magnetized at will by the adsorption of single H atoms. However, experimental efforts to provide a direct proof of such remarkable predictions have so far been unsuccessful, mainly due to the difficulties of providing, at the same time, an atomistic characterization and control of the hydrogenated graphene samples.

The project will try to overcome these challenges and to go even beyond theoretical expectations by using scanning tunnelling microscopy/spectroscopy (STM/STS) in ultrahigh-vacuum (UHV) environments as main experimental technique. UHV-STM with very different capabilities will be used, which will give access to a wide range of temperatures (10mK-400K), magnetic fields (0-14T), and substrates (from epitaxial to gatable exfoliated graphene).

Our starting point is our recent (unpublished) observation that the adsorption of a single H atom on a decoupled graphene layer induces a 20meV separated double peeak at the Fermi energy, most probably due to spin-splitting. These preliminary results also show that it is possible to use the STM tip to manipulate H atoms with atomic, which we will exploit to tailor the magnetism of selected graphene regions.

The research will be performed for graphene layers on different substrates. The evolution of the generated magnetic moments will be systematically investigated as a function of magnetic field, temperature, and electric gating. This will enable us to confirm the magnetic nature of the observed H induced split-state, to understand the collective magnetic state generated by ensembles of H atoms, to test its temperature stability and to manipulate the magnetic properties by external electronic gating. Finally, the unexpected possibility to arrange H atoms on graphene with any desired geometry will enable the realization of experiments restricted so far to a pure theoretical framework.

Consortium

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Klaus Kern - Max-Planck Institute - Germany - Funded by: DFG
Jean-Yves Veuillen - Centre National Recherche Scientifique - France - Funded by: ANR