

OPEN PhD Position

Title: Chemisorbed molecules as an ideal electrode for spin injection into graphene

Co-Supervision :

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Summary of the project:

Graphene, an atomically thin carbon layer corresponding to a single plane of graphite, has triggered enormous interest across various scientific disciplines. Especially the fascinating physical properties observed at room temperature, such as the quantum Hall effect [Novoselov07] or a large coherence length and high mobility [Berger06], have attracted significant attention. Charge carriers have an effective mass which approaches zero and therefore can be represented as quasi-relativistic quasi-particles.

Graphene has also been considered as a promising material for the next generation of nano-opto-electronic devices. However, as graphene is a highly non-reactive semiconductor with zero band-gap, functionalization is difficult and thus hybrid hetero-structures, control of doping or well-defined nanostructures are not easily achievable. Chemically attaching (= grafting) a molecule to graphene is thus a major issue.

While "graphene-oxide", heavily decorated by oxygen-containing groups, is easily functionalized, we consider the electronic properties of "pure" graphene for which various ways of functionalization were studied. Graphene flakes have been modified in solution through slow cyclo-addition [Quinata10, Georgakil10], through more "aggressive" chemical reactions like fluoridation [Giraudet03], or with diazonium molecules [Bekyarova08]. These latter approaches have demonstrated the possibility to change the conductivity through manipulation of graphene by fluoridation [Withers10, Withers11] or to induce ferromagnetism at room temperature. While some samples with aryl-group grafting [Hong11] support above conclusions, they are still highly controversially discussed, especially with respect to the creation of a "defect"-site for grafting generated by irradiation on exfoliated graphene [Sepioni10]. The essentially random nature of the resulting chemisorption site may be responsible for observed differences.

In this context, we aim to control the sites for chemisorption by a combination of supra-molecular and covalent chemistry on graphene. We first will synthesize molecules which have active centers allowing generating a reaction within the plane of graphene. Due to their size and functions, these molecules will spatially order in exact commensuration within the plane of graphene. We will consider various chemically modified molecules and study how these modifications affect processes of self-assembly. The goal is to find conditions under which these molecules allow a chemical reaction when a voltage pulse is applied through the STM tip at a specific location on a reactive group of the molecule. We will study the so induced changes in the density of states by STM and STS-dI/dV maps (see figure) as a function of the nature of the site affected by the covalent bond.

This project will be performed in the laboratories of L. Simon and G. Reiter in Mulhouse and Freiburg, based on the research agreement signed between the two partners, which provides access to complementary techniques. Full UHV STM-AFM Q-plus, Kelvin probe and conductive AFM usable at variable temperatures located in Freiburg and LT-STM in Mulhouse which we dedicate to localized spectroscopy. The latter set-up also includes photoemission spectroscopy (XPS, UPS) allowing characterizing the chemisorption sites. For large ordered surface structures of several hundred nanometers we will be able to identify the Fermi surfaces. Synthesis of molecules is provided as part of an existing collaboration with the group of A. Gourdon, Director of Research at the CNRS laboratory CEMES Toulouse.

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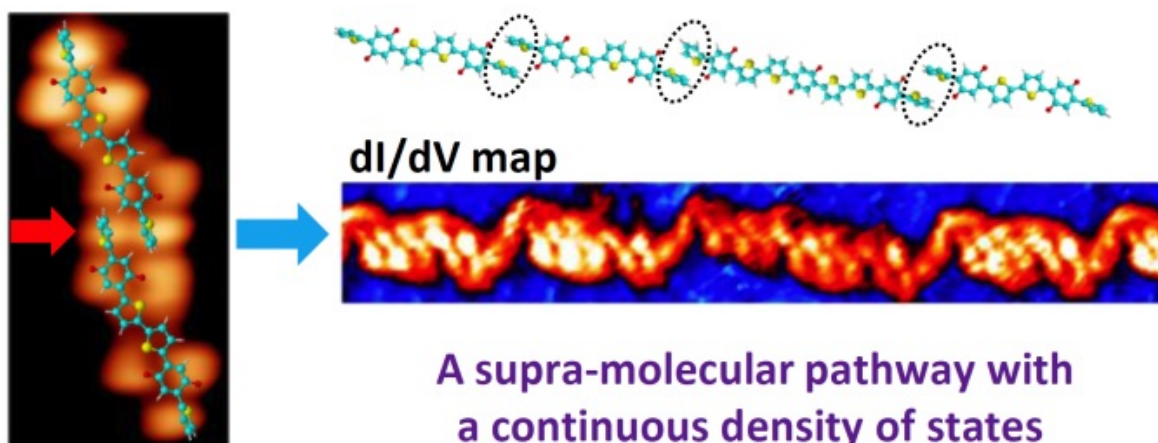
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