Study of graphene and 2D heterostructures based on MX2 functionalized by lanthanides intercalation.

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Since several years graphene and now other 2D material such as dichalcogenide are the subject of intense reasearch for their functionalization in order to modifiy their electronic properties, band structure and creates new type of Fermion. In this subject, we propose to study the functionalization of graphene and other 2D systems of MX2 type (such as MoS2, WS2) as well as heterostructures based on these systems, by the deposition/intercalation of lanthanides (Er, TB and Yb), either in the form of individual diluted atoms, or as a layer or several ordered mono-atomic layers. In the case of graphene on silicon carbide the deposition of these elements following by an annealing leads to the intercalation of atoms under the graphene layer. This has been already observed for differents elements such as noble-[1], alkaly- and rare-hearth metals [2], leading to increase the electron doping level of the graphene layer. Recently we have showed that using Terbium atoms a complex band structure is obtained and we observe a highly eletron doping with a electron density reaching 10^{-15} cm^{-2} which is up to two order of magnitude higher than the doping level reached for other elements [3]. The band structure of this highly n-doped monolayer graphene showed a kink (a deviation from the linear dispersion of the Dirac cone), which has been associated with an electron-phonon coupling constant one order of magnitude larger than those usually obtained for graphene with intercalated alkali metals.

Our goal is to systematically study the modifications of the band structure using angle-resolved photo-emitted electron spectroscopy (ARPES) combined scanning tunneling microscopy (STM) and local spectroscopy (STS). We aim to reveal the interplay between eletron-phonon coupling and the doping level for these elements. We will determine the conditions to probe this complexe band structure by using Fourier Transform Scanning Tunneling Spectroscopy which use Quasi Particle Interferences (QPI's) process for the determination of the local band structure [4]. The whole will be supported by theoretical studies and transport measurement through external collaborations. We will systematically study the nature of 2D electron gas and the expected physical properties, superconductivity, spin orbit coupling, with the implication of a magnetic order or not depending on the lanthanide studied. These studies will be for other 2D material such as MoS2.

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