Intercalation of graphene on SiC: tuning the electronic structure of graphene by proximity coupling and inducing novel 2D interlayer band structures

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Epitaxial graphene grown on silicon carbide (SiC) has proven to be a suitable candidate for carbon-based electronics [1] as it is directly prepared on a wide band gap semiconductor, thus avoiding cumbersome and size-restricting flake exfoliation or transfer procedures. Homogeneous graphene layers can be fabricated with defined atomic thickness on a wafer scale by using sublimation growth under argon atmosphere [2]. The first carbon layer that is grown is still partially covalently bound to the SiC substrate and is usually called buffer-layer or zero-layer graphene (ZLG). A second layer of carbon can be grown underneath the first one, decoupling it from the substrate, which is referred to as monolayer graphene (MLG). Alternatively, intercalation – a technique used to insert foreign atomic species between the SiC surface and the ZLG – can be used to saturate the dangling bonds of SiC thereby decoupling the carbon layer leading to so-called quasi-freestanding monolayer graphene (QFMLG) as first demonstrated with hydrogen [3].

Intercalation can be used to tune the doping of graphene ranging from the hole regime through charge neutrality to strong n-doping thereby reaching or even going beyond the van Hove singularity (VHS) of graphene's π*-bands. Besides the precise tuning of the doping level of graphene, intercalation can also be used to stabilize otherwise unstable 2D layers underneath the graphene. Those interlayers often exhibit electronic properties strongly deviating from those of their bulk counterpart.

In this poster, we summarize the research highlights of our group within the DFG funded research unit FOR5242. We will demonstrate that the intercalation of Tb can dope graphene beyond the VHS, with a flat band scenario emerging along the $\overline{KMK'}$ direction of the Brillouin zone, residing 70 meV below the Fermi level. This strong n-doping is theoretically predicted to induce d-wave superconductivity with a critical temperature in the range of 300 – 600 mK [4]. Furthermore, we show that the confinement of metallic materials like Ag and Te leads to the development of semiconducting 2D interlayer bands: In the case of Ag the atomic structure of the interlayer and in consequence its band structure as well as the graphene doping and electron-plasmon coupling can be steered by the amount of intercalant by defect engineering of the ZLG. [5] We will also show the first example of an intercalated transition metal alloy, namely AgTe. The possibility to intercalate alloys gives rise to completely new aspects in the field of intercalation and expands the possibilities to tune the band structure of graphene as well as that of the interlayer. Interestingly, the AgTe interface band is metallic in nature, in contrast to the pure Ag and Te interlayers which are semiconducting. Last but not least, we have extensively studied the intercalation of Pb [6-8], which not only shows a pronounced momentum-space spin texture in the Pb layer itself, but also tends to induce a noticeable spin-polarization in the graphene π-bands via proximity coupling.

References:

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