Extreme doping and many-body interaction in epitaxial graphene on SiC(0001)

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High doping levels and significant many-body interaction strengths can be induced by tailored atomic intercalation in epitaxial graphene on SiC(0001) promising applications such as plasmonic device engineering or superconductivity.

Wafer scale epitaxial graphene grown on SiC single crystals is regarded as a suitable candidate for carbon based electronics. Although the presence of the SiC substrate has a strong influence on the electronic and structural properties of the graphene layers, these properties can be manipulated by functionalizing the graphene/SiC interface on an atomic scale. Intercalation under the first carbon honeycomb layer can relieve the strong covalent bonds of its atoms to the SiC(0001) substrate and manipulate the p-band structure in a large range of aspects. We have shown in recent years that this carbon layer can be turned into quasi-free standing monolayer graphene and that designed doping levels are accessible [1-4]. Here, I will demonstrate how extreme doping levels and drastic renormalization magnitudes give access to novel graphene properties that may promise applications such as plasmonics and superconductivity. The resulting atomic and electronic properties as well as the dynamics of the corresponding intercalation and desorption processes are characterized using various surface science techniques.

Au intercalation yields two phases of different carrier type in SiC based graphene [4]. With the improved preparation quality of our furnace grown graphene layers, we retrieve a highly ordered graphene/intercalant/substrate system as demonstrated by periodic replicas of the graphene p-bands in angle-resolved photoemission spectroscopy (ARPES). High resolution ARPES experiments reveal a significant renormalization of the graphene bands due to a strong electron-plasmaron interaction which can be used to estimate the tunability of graphene's dielectric constant due to the intercalation. A sharp 2D band structure of its own can be resolved for the gold layer.

By intercalation of lanthanide elements, in this case Gadolinium, extremely high doping levels can be reached. As a result, the Van-Hove singularity in the p-band structure at the M-point of pristine graphene is shifted towards the Fermi level so that spectral weight appears in ARPES along the KMK-line. Thus, the intercalation's influence on the electronic structure of the graphene can be viewed as a topological transition from a situation with 2 hole pockets to one electron pocket. The doping is accompanied by a strong bending of the bands in the vicinity of the Fermi energy, which we attribute to a combination of hybridization with the Gd orbitals and electron-electron interaction. Additionally strong electron-phonon coupling is observed. We speculate that the high density of states at the Fermi level may potentially allow to access superconductivity in graphene.

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