Functionalizing epitaxial graphene on SiC(0001) by intercalation and nanostructuring

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Wafer scale epitaxial graphene (EG) grown on Silicon Carbide (SiC) is regarded as a suitable candidate for carbon based electronics. An important basis for using its outstanding electronic properties is the well-known technique of decoupling epitaxial graphene from the SiC substrate by intercalation [1]. Yet, intercalation can also serve to functionalize the electronic structure of graphene in a variety of directions, accompanied by the development of a defined two-dimensional (2D) interface structure. Au and Ag intercalation generate a highly ordered graphene/intercalant/substrate system with a noticeable charge transfer to the graphene, and many-body interactions renormalizing its π-bands [2,3]. A sharp 2D band structure can be resolved in angle-resolved photoemission spectroscopy (ARPES) for the interface layer revealing a metal-insulator transition in the monolayer limit of the noble metal. On the other hand, Pb intercalation leads to an essentially charge neutral quasi-free graphene layer, while the Pb interlayer develops its own 2D metallic band structure [4,5].

High doping regimes can be reached by the intercalation of rare earth elements. As a result, the Van-Hove singularity (VHS) of the π*-band reaches the Fermi level [6]. The doping is accompanied by a strong flattening of the band at the Fermi level, which is attributed to strong electron-electron interaction. By a combination of Yb intercalation and K adsorption, the EG layer can be n-doped even past the VHS. Thereby a Lifshitz transition is completed, where the Fermi surface topology changes from two electron pockets into a giant hole pocket [6]. Crossing the VHS in this way allows access to potential exotic phases where unconventional superconductivity or charge and spin density waves are predicted.

By starting with a patterned SiC surface with mesas and trenches of 200 nm periodicity, EG nanoribbons (GNRs) can be grown on the mesa facets. High-resolution ARPES demonstrates the 1-dimensional behaviour of graphene on these facets: while the whole facet has a width of about 40 nm, it contains an array of mini-GNRs (≈ 2 nm wide) separated by nano-basal stripes. The subbands of these mini-ribbons reveal a sharp distribution of ribbon widths of around 18 dimers [7]. On the mesas, a conventional graphene buffer layer develops. By H-intercalation, both graphene types, on mesa and facet, are decoupled and transform into a single two-dimensional graphene sheet rolling over the mesa structures. Due to the different surface terminations of the basal and vicinal SiC surfaces, different types of charge carriers are locally induced into the graphene layer leading to two symmetrically n- and p-doped phases. Thus, a regular array of of graphene pn-junctions develops [8].

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