Towards epitaxial graphene-based quantum materials

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2D heterostructures as well as nanostructures of 2D materials are intensively studied and discussed as emergent quantum materials for future technologies. Epitaxial 2D systems are of interest here because interfaces and edges can be manipulated in manifold ways. Using epitaxial graphene on insulating SiC(0001) substrates as an example, we demonstrate the potential of edge termination and proximity coupling using nanostructuring and intercalation.

In contrast to CNTs, for graphene nanoribbons (GNR) the edges play a crucial role, but at the same time offer the possibility for further functionalization. Moreover, large-area and scalable GNR arrays can be fabricated directly on SiC substrates. Thereby, the width and edge topology of the GNRs are tunable and defined by the SiC-mesas and allow growing gapped armchair and ballistic zigzag GNRs due to confinement and hybridization of the edges, respectively [1,2].

A step further in complexity involves combining different two-dimensional (2D) materials to fabricate graphene with novel properties, i.e. spin-orbit coupling or superconductivity. Possibly driven by the manifold of monolayer Pb structures on Si surfaces, intercalation of Pb into the interlayer of graphene and SiC has attracted recently a lot of attention. We were now able to show, that the quasi 10-fold periodicity is rather a grain boundary effect. The formation of the domain grain boundaries comes along with a rotation of the Pb-induced supercell. The number of Pb atoms nicely match the number of Si adatoms and allows for a perfect compensation of surface dangling bonds giving rise to quasi-charge-neutral graphene. Moreover, after intercalation of Pb multilayer structures plumbene honeycomb lattices are formed, which are rotated by with respect to graphene. Along with this twist, a proximity-induced modulation of the hopping parameter in graphene opens a band gap of around 30 meV at the Fermi energy, giving rise to a metal-insulator transition [3-5].

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