Selenium intercalation of graphene on SiC(0001)

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Intercalation of different atomic species is a powerful method of stabilising a thin layer of material at the interface of graphene and SiC. A variety of elements have already been successfully intercalated, with each of them influencing the electronic properties of the decoupled graphene. For example, the intercalation of hydrogen results in a p-type doping of the graphene [1], whereas decoupling with copper leads to electron doped graphene [2]. Depending on the number of atoms present at the interface, the intercalation with gold [3] or bismuth [4,5] can lead to n-type or p-type doping of the graphene.

However, intercalation not only manipulates the properties of graphene, but also enables the synthesis of novel phases of two-dimensional (2D) materials that would otherwise be unstable. For example, a 2D lead layer can form at the interface where the intercalated atoms arrange in either (1×1) [6] or (10×10) [7–9] periodicity. In both cases, the intercalant compensates the spontaneous polarisation of the SiC substrate, resulting in a doping of the lead layer and charge neutrality of the decoupled graphene layer above.

In this project we investigated the intercalation of selenium at the interface between the zeroth layer graphene (ZLG) and the SiC. The intercalation process was carried out in a two-zone tube furnace containing two individually heatable zones, with $SnSe_2$ acting as the selenium precursor. X-ray photoelectron spectroscopy (XPS) and angle-resolved photoelectron spectroscopy (ARPES) revealed the successful formation of a p-doped quasi-freestanding graphene with selenium atoms present at the interface as well as on top of the non-intercalated ZLG. Similar observations were made for the intercalation of sulfur [10]. However, in contrast to sulfur-intercalated graphene, an additional annealing in UHV at elevated temperatures caused the selenium atoms to evaporate from the surface without further decoupling of the ZLG. Upon annealing, a new component Se* appeared in the Se core levels (see Fig. 1), corresponding to atoms at the graphene/ SiC interface, and the hole doping of the decoupled graphene layer was increased. Low-energy electron microscopy (LEEM) could potentially help to elucidate the origin of the two different selenium intercalation species.

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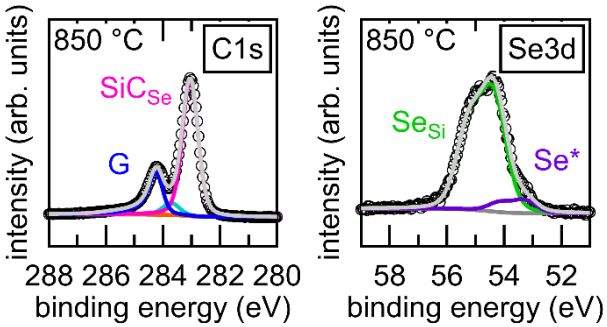

Fig. 1: C1s and Se3d core level of a partially intercalated ZLG sample after annealing at 850°C in UHV