Concurrent Magnesium and Hydrogen Intercalation in Epitaxial Graphene

Patrick Rondomanski[1]*, Anushka Bansal[1], Chengye Dong[1], Autumn Heltman[2], Ke Wang[3], Joshua A. Robinson[1,4], Qi Li[2], Joan M. Redwing[1,4]

*lead presenter: par40@psu.edu
[1] Department of Materials Science & Engineering, The Pennsylvania State University, USA
[2] Department of Physics, The Pennsylvania State University, USA
[3] Materials Research Institute, The Pennsylvania State University, USA
[4] 2D Crystal Consortium Materials Innovation Platform, Materials Research Institute, The Pennsylvania State University, USA

It is well known that the properties of graphene can be altered by intercalation of an atomic or molecular species between or beneath graphene layers. Hydrogenation of epitaxially grown graphene can decouple the graphene buffer layer from the underlying SiC substrate, creating hydrogen intercalated quasi-freestanding epitaxial graphene (H-QFSEG). Prior studies have attempted to answer the question of whether the hydrogen in H-QFSEG can subsequently be replaced by other intercalants. Lithium, for example, was intercalated into H-QFSEG and is believed to coexist with the H atoms, whereas Ca is thought to replace the H, and Mg intercalation is allegedly inhibited by the H atoms [1,2]. However, detailed studies of the co-intercalation process have not yet been carried out. In our study we demonstrate that Mg will intercalate into monolayer H-QFSEG, making a combination magnesium and hydrogen intercalated quasi-freestanding epitaxial graphene (Mg-H-QFSEG), but it is unstable and changes over time. Instability of the material is best evidenced by x-ray photoelectron spectroscopy (XPS) of the C 1s and Si 2p, where it is observed that a peak shift toward lower energies appears over time for the respective SiC peaks. This is indicative of a change in the bonding of the material between the graphene and SiC that isn't seen in magnesium intercalated quasi-freestanding epitaxial graphene (Mg-QFSEG). While difficult to measure H, the instability of the material is a direct result of the presence of both Mg and H beneath the graphene and supports the idea that an intercalating material can coexist with intercalated H. Additionally, Raman spectroscopy indicates the free-standing nature of graphene remains after Mg intercalation as indicated by the presence of the 2D peak.

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