Protection of graphene against helium-ion-induced damage by h-BN encapsulation

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The novel helium ion microscope (HIM) has received wide-spread attention for milling and structuring of graphene and other sensitive materials[1]. While a HIM is a popular and versatile tool for structuring graphene, the interaction of the helium ions with graphene is still poorly understood. So far, damage induced by the ions to unprotected graphene precluded nanofabrication of graphene devices by focused helium ion beams.

Here, we investigate helium-ion-induced defects in graphene that is encapsulated between h-BN flakes. A comparison is made between 4 different sandwich configurations to clearly elucidate the roles of the primary ions and the environment on defect formation. Raman measurements reveal a high tolerance of the h-BN encapsulated graphene to the helium ion beam, in particular a well-preserved sp^2 structure at a dose of 10^{16} ions/cm^2, see Fig 1a.

We conclude that the presence of interstitials in the sandwich structure facilitates self-healing of the encapsulated graphene, thereby reducing the total damage by the primary ions. In addition, the presence of the h-BN layer precludes the formation of oxide defects by preventing oxygen incorporation from the atmosphere or SiO_2 substrate.

Finally, we fabricate a graphene device with one-dimensional contacts to study the charge transport[2]. The beam-induced substitution of carbon atoms by nitrogen atoms make graphene n-doped, which could be essential to realize graphene-based p-n junction devices, see Fig. 1b.

[1] Ahmed N. Abbas et al., ACS Nano, **8** , 1538–1546 (2014).

[2] L. Wang et al., Science, **342**, 614-617 (2013).

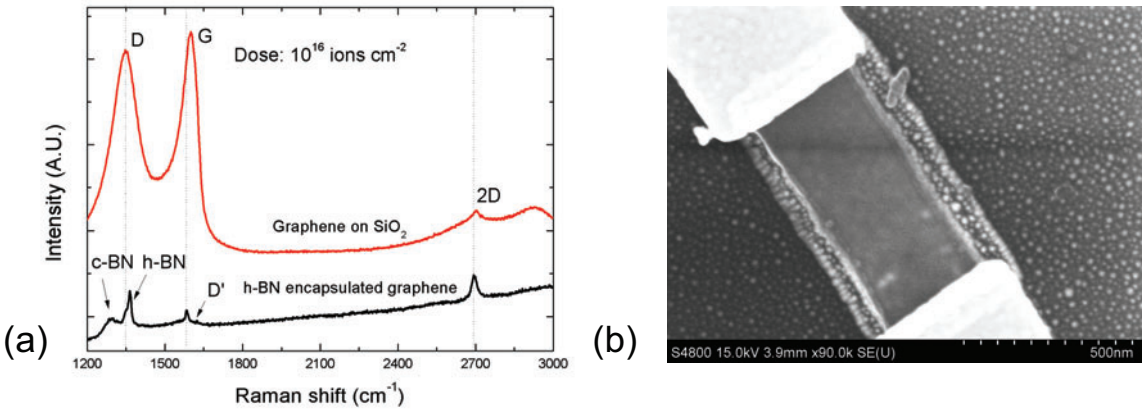

Figure 1: (a) Raman spectra comparison of the graphene on SiO_2 with the h-BN encapsulated graphene at a dose of 10^{16} ions/cm^2, (b) graphene device with one-dimensional contacts.