Synthesis, properties and applications of free-standing monolayer amorphous carbon & nanoporous graphene foam

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Environmental stability, synthesis cost and process compatibility are key challenges in commercializing 2D materials. I will discuss our approach in addressing these challenges for atomically thin amorphous carbon and nonporous graphene foam and their potential for applications.
Bulk amorphous materials have been studied extensively and are used widely. Amorphous thin films are for example essential for enabling device scaling, increase data storage densities and improve energy storage capacities. Yet their atomic arrangement remains an open issue. Although they are generally believed to be Zachariasen continuous random networks, recent experimental evidence favours the competing crystallite model in the case of amorphous silicon. In two-dimensional materials, however, the corresponding questions remain unanswered. Here I will discuss the synthesis, by laser-assisted chemical vapour deposition of centimetre-scale, free-standing, continuous and stable monolayer amorphous carbon, topologically distinct from disordered graphene [1]. Unlike in bulk materials, the structure of monolayer amorphous carbon can be determined by atomic-resolution imaging. Extensive characterization by Raman and X-ray spectroscopy and transmission electron microscopy reveals the complete absence of long-range periodicity and a threefold-coordinated structure with a wide distribution of bond lengths, bond angles, and five-, six-, seven- and eight-member rings. Direct measurements confirm that it is insulating, with resistivity values similar to those of boron nitride grown by chemical vapour deposition. Free-standing monolayer amorphous carbon is surprisingly stable and deforms to a high breaking strength, without crack propagation from the point of fracture. The excellent physical properties of this stable, free-standing monolayer amorphous carbon could prove useful for permeation and diffusion barriers in applications such as magnetic recording devices, copper interconnects and flexible electronics.

In the second part of my talk I will discuss the synthesis of nanoporous graphene foam, its properties and potential for supercapacitor applications.

REFERENCES

[1] Synthesis and properties of free-standing monolayer amorphous carbon; Chee-Tat Toh, Hongji Zhang, Junhao Lin, Alexander S. Mayorov, Yun-Peng Wang, Carlo M. Orofeo, Darim Badur Ferry, Henrik Andersen, Nurbek Kakenov, Zenglong Guo, Irfan Haider Abidi, Hunter Sims, Kazu Suenaga, Sokrates T. Pantelides & Barbaros Özyilmaz ; Nature (Jan 2020).

FIGURES

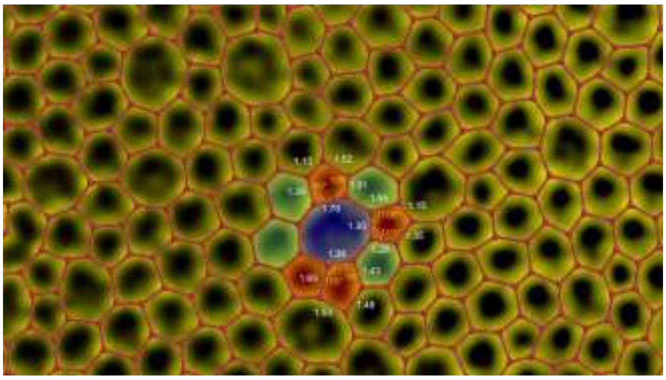

Figure 1: Atomic structure of MAC from TEM. Monochromated HRTEM image of MAC. The image contrast is inverted and false-coloured for better
visibility. Colour overlay is added for identification of pentagons (red), heptagons/octagons (blue) and strained hexagons (purple for individual
hexagons; green for crystallite regions) that are omnipresent. Crystallites (regions of green hexagons) separate the regions with non-hexagons.