Synthesisand, properties and applications of 2D amorphous carbon & nanoporous graphene foam

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Scalability, Reliability and process compatibility are key challenges in commercializing 2D materials. I will discuss our approach in addressing these challenges for atomically thin amorphous graphene and nonporous graphene foam. I will give two potential for applications.
Atomically thin amorphous thin films are essential for enabling semiconducting device scaling, increase data storage densities. Similarly, such films are expected to boost the performance of supercapacitors performance. Here I will discuss their synthesis, by laser-assisted chemical vapour deposition [1] and spark plasma sintering, respectively [2]. In the first part of my talk I will show, that the excellent physical properties of such stable, free-standing monolayer amorphous carbon are ideal as diffusion barriers in applications such as heated assited magnetic recording and copper interconnects. They can be directly grown on SiO2 and their performance exceeds the 10-years lifetime industry requirement based on time-dependent dielectric breakdown measurements. Furthermore, directly grown MAC on Cu lines with cross section of 80 nm by 200 nm not only preserve device integrity but also leads to 25% reduction in line resistance. In the second part of my talk I will discuss the synthesis of a novel nanoporous graphene foam. This structure is a monolithic, layered composite of 3 carbon allotropes, consisting of a stiff, sp3-rich backbone, covered by a conductive graphite layer, followed by an outermost layer of micropore-rich graphene. This monolithic carbon foam (MCF) hosts a hierarchy of 3D pores, ranging in size and providing high pore accessibility. MCF exhibits electrical conductivity as large as 120 S/cm, exceeding conventional carbon-based electrode performance and a Vickers hardness of over 900 MPa exceeding that of nuclear graphite allowing for a wide range of applications such as energy storage, filtration and catalysis. As a proof of concept, we demonstrate a supercapacitor with ten times longer device life time when compared to commercial devices. Last not but least, I will discuss a new route to synthesize 2D magnetic semiconductors based on interstial doping on black phosphorus with cobolt.

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).