Synthesis of large h-BN single crystals suitable for exfoliation

Catherine Journet
Yangdi Li, Vincent Garnier, Philippe Steyer, Bérangère Toury

Laboratoire des Multimatériaux et Interfaces, CNRS, UMR 5615, University of Lyon, F-69622, Villeurbanne, France.
Laboratoire Matériaux Ingénierie et Science, UMR CNRS 5510, INSA de Lyon, France

catherine.journet@univ-lyon1.fr

Prompted by the rising star of graphene, 2D nanomaterials are now a hot issue in the scientific world. Among them, the h-BN nanosheet (BNNS), consisting of thin atomic layers made of B and N atoms covalently bounded, is particularly relevant. Actually, BNNS has shown to be an excellent gate dielectric support for graphene and other two-dimensional materials owing to its atomically smooth surface, high thermal conductivity and stability combined with high mechanical strength. Compared with conventional SiO_2 substrate, lattice matching and absence of dangling bonds make BNNS and graphene excellent pairing materials and give incentive to develop various Van der Waals hetero-structures. However, it has to be pointed out that such applications cannot be put into use without high purity large BNNSs.
In order to achieve high quality and large BNNSs, we propose novel synthesis ways by the Polymer Derived Ceramics (PDCs) route involving polyborazylene as precursor, combined with sintering techniques [1]. These promising approaches allow synthesizing pure and well-crystallized h-BN single crystals, which can be easily exfoliated into BNNSs with lateral size over hundreds microns [2]. Here we present recent investigations on how to optimize processes, considering the influences of both sintering temperature (1200°C to 1950°C) and crystallization promoter ratio (0 to 10 wt %) on h-BN. Structural studies were led by TEM and Raman spectroscopy. Both methods evidence a very high crystalline quality attested by the FWHM value, $7cm^{-1}$, as one of the best reported in literature. More original characterizations were carried out by cathodoluminescence and XPS to prove the high BNNSs purity from both structural and chemical point of view. As a final application purpose, further physical measurements have confirmed that derived BNNSs exhibit an interesting dielectric constant of 3.9 associated with a dielectric strength of 0.53 V/nm.

References

[1] S. Yuan, S. Linas, C. Journet, P. Steyer, V. Garnier, G. Bonnefont, A. Brioude, B. Toury, Sci. Rep., 6 (2016) 20388
[2] Y. Li, V. Garnier, C. Journet, J. Barjon, A. Loiseau,I. Stenger, A. Plaud, B. Toury, P. Steyer, Nanotechnology, 30 (2019) 035604

Figures

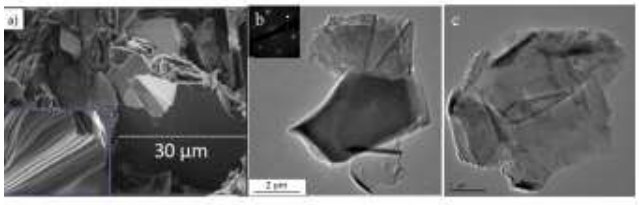

Figure 1: (a) as-obtained h-BN pellet, (b) h-BN flake, (c) h-BN nanosheet