How to use the polymer-derived ceramics route for the synthesis of boron nitride-based nanomaterials

Catherine Journet[1]
Camille Maestre[1,2], Yangdi Li[1,2], Boitumelo Matsoso[1], Wenjun Hao[1], Victor Vuillet-a-Ciles[1], Vincent Garnier[2], Philippe Steyer[2], Bérangère Toury[1], Catherine Marichy[1]
1 Laboratoire des Multimatériaux et Interfaces (LMI), UMR CNRS 5615, Univ. Lyon, Université Claude Bernard Lyon 1, F-69622 Villeurbanne, France
2 UCBL, CNRS, MATEIS, UMR 5510, Université de Lyon, INSA Lyon, 7 avenue Jean Capelle, Villeurbanne 69621 CEDEX, France
catherine.journet@univ-lyon1.fr

Hexagonal boron nitride (hBN) occupies a special place in the vast world of 2D materials, due to its excellent thermal, chemical, mechanical, and dielectric properties that make it a promising candidate for many revolutionary applications, especially for optoelectronic devices. However, it is now well established that the optical, electronic, and transport properties of these systems are highly dependent on the chemical purity and crystallinity of the hBN used, which in turn are highly dependent on the synthesis approach used.
For several years, we have been developing a polymer-derived ceramics (PDCs) synthesis route that allows the elaboration of ceramics with tailored textural and structural properties.[1] PDCs consists in synthesizing a molecular precursor and then polycondensing it into an inorganic polymer that can be shaped before ceramization. One of the main advantages is that from molecular or preceramic polymer precursors, it is possible to produce specific shapes, including fibers, films, or ceramic composites, which cannot be easily obtained by conventional powder technology.
Here, we demonstrate the value of the PDCs route for the synthesis of hBN.[2] Single crystal growth of hBN at relatively low temperature and atmospheric pressure is successfully achieved from a borazine precursor using the PDCs route alone.[3] Furthermore, by coupling PDCs with a sintering technique from the same preceramic polymer, it is possible to increase the crystal size to a few millimeters (Figure 1).[4] The resulting pure hBN single crystals can then be exfoliated into hBN nanosheets. Finally, by combining PDCs with atomic layer deposition (ALD), functional hBN nano-/heterostructures are successfully synthesized from highly structured sensitive templates, making this ALD process a promising alternative for the fabrication of functional hBN nanostructures.[5]

References

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Figures

Figure 1: Optical image of a few millimeters side hBN crystal