Advances in selfstanding hBN crystal synthesis via the PDC route

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Whether used as a substrate or as an active layer, high quality 2D hexagonal boron nitride (hBN) holds great promise for future research applications, especially in optoelectronics. Vapor-phase processes such as Chemical Vapor Deposition can achieve large scale coverage, but selfstanding hexagonal boron nitride crystals provide exfoliated nanosheets (BNNS) of unrivalled purity and crystal quality which are still preferred for demanding applications. In order to obtain high quality and large size BNNSs, we propose a synthesis route coupling the Polymer Derived Ceramics (PDCs) process with a sintering step. [1,2] The hBN obtained by this method has already demonstrated a very high crystalline quality attested by a Raman FWHM value of 7.6 cm^{-1}, one of the best reported in literature to date. [2] Our study aims at understanding the mechanisms of hBN crystal growth and the generation of crystalline defects in order to better control the synthesis and to provide hBN with the desired quality.

X-ray tomography and SEM observations (Figure 1b and 1c) provide insights into nucleation and growth orientation. To search for defects in the crystal, its optical (see Figure 1a) and electrical properties are explored. BNNSs exfoliated from these crystals have been used to fabricate metal-hBN-metal capacitor devices to measure the dielectric constant and the breakdown electric field of hBN, which were found to be 3.136 and 0.64 $V.nm^{-1}$ respectively [3], *i.e* very close to the theoretical values. Such routine functional measurements allow the assessment of the overall crystal quality and prove to be a powerful tool for the optimization of the process parameters.

These BNNSs have also been used to encapsulate Transition Metal Dichalcogenides (TMDs). Such van der Waals heterostructures have been tested by optical spectroscopy. The photoluminescence widths of WSe_2 and $MoSe_2$ neutral exciton lines at 4K were measured within the 2-3 meV range [2], while non-encapsulated TMD monolayers exhibit photoluminescence linewidths of a few tens of meV. These results demonstrate that these BNNSs are relevant for future electronic and opto-electronic applications.

References
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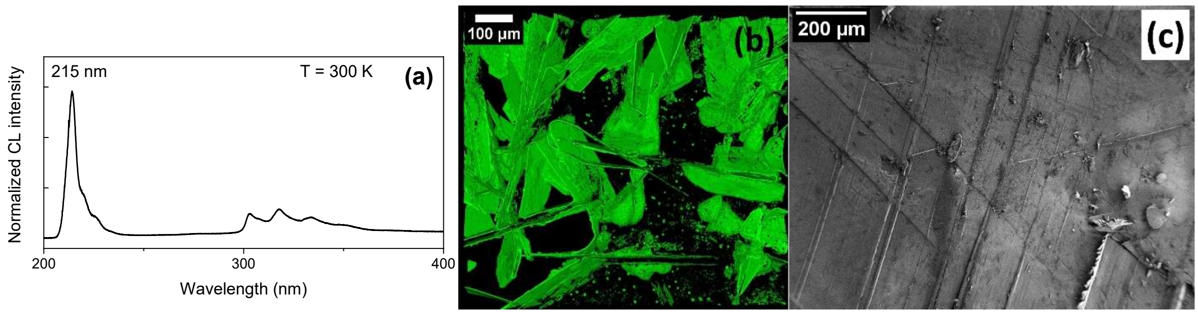

Figure 1: (a) Cathodoluminescence measurement of a PDC hBN crystal [2]; (b) 3D extracted view of entangled crystals inside the as-obtained ingot from X-ray tomography; (c) low magnification SEM view of the crystal surface

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