Growth of selfstanding h-BN crystals: hunting for crystal defects and contamination

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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 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. [1] 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 (Figure 1a) provide insights into nucleation and growth orientation. To search for defects in the crystal, its optical and electrical properties are explored (see Figure 1b and c). 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. These BNNSs have also been used to encapsulate Transition Metal Dichalcogenides (TMDs) 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] which is comparable to the results obtained with the highest quality hBN. All these results demonstrate that the BNNSs are relevant for future electronic and opto-electronic applications.

References

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Figures

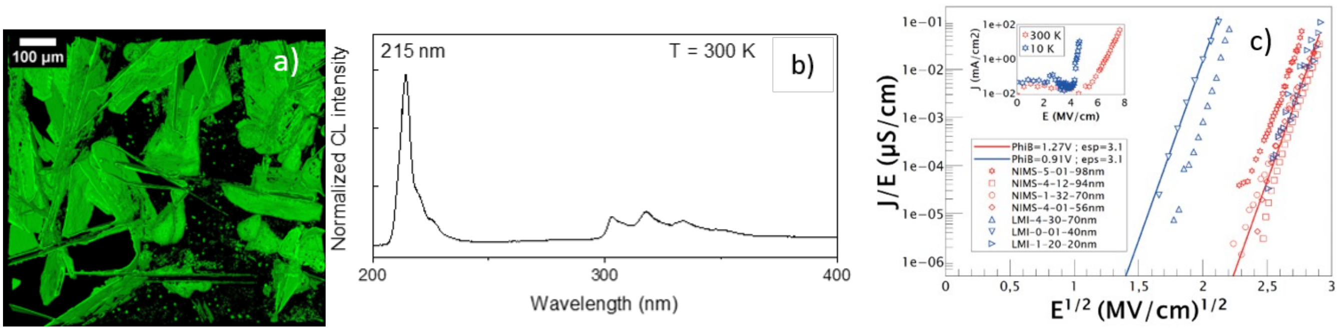

Figure 1: (a) X-ray tomography 3D extracted view of entangled crystals inside the as-obtained ingot; (b) Cathodoluminescence measurement of a PDC hBN crystal [2]; (c) Frenkel-Pool plot of the high field hBN conductivity, exfoliated crystals from LMI and NIMS [3].