Looking for a defect in a (millimetre-sized) h-BN stack

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Hexagonal boron nitride (hBN) thin film deposition processes can now achieve wafer-scale coverage, yet self-standing hexagonal boron nitride crystals provide exfoliated nanosheets (BNNS) of unrivalled purity and crystal quality which are still preferred for fundamental applications. Defect-free BNNS favour the expression of adjacent 2D materials properties and present interesting intrinsic properties such as hyperbolic phonon polariton (HPhP) propagation.

In order to obtain high quality and large size BNNSs, we propose a specific process for bulk hBN synthesis at moderate pressure and high temperature. [1,2] The millimetre-sized hBN crystals produced by this method (Figure 1 a)) have demonstrated state-of-the-art crystalline quality (Figure 1 b)) and optical (Figure 1 c)) properties. [2] Our work aims at understanding hBN crystal growth in order to provide BNNSs with controlled properties. Indeed, finely controlling doping and/or defect generation is required to tune hBN properties without altering the properties of adjacent 2D materials.

G-FET encapsulated in BNNSs exfoliated from our crystals show an electron temperature much higher compared to similar devices made with HPHT hBN while maintaining a high carrier mobility (up to 85 000 cm²/Vs at room temperature). [3] This high mobility confirms the BNNS crystalline quality whereas the suppression of radiative cooling induced by HPhP damping or backscattering is a sign of diffuse defects. Our crystals are thus promising for studying doping effects in high quality hBN.

On the basis of these results, we investigate the defect generation from a synthesis and characterization point of view.

References

[1] Y. Li et al. ACS Applied Nano Materials 3, 1508-1515 (2020).
[2] C. Maestre et al., 2D Mat. 9, 035008 (2022).
[3] A. Schmitt et al. PRB 16, L161104 (2023).

Figures

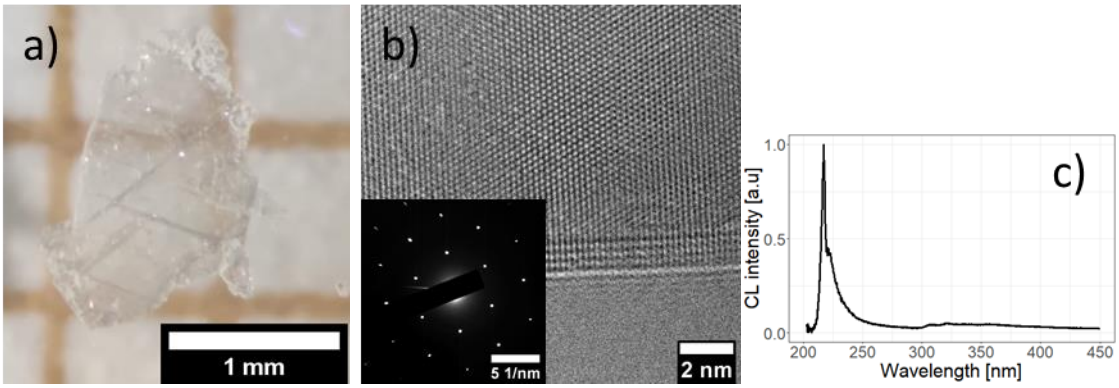

Figure 1: Description of the millimetre-sized hBN crystals we produce. a) Optical micrograph of a representative crystal; b) HRTEM image of an exfoliated BNNS showing a highly organized hexagonal structure, also probed by SAED (insert); c) cathodoluminescence spectrum dominated by hBN's intrinsic emission at 215 nm.