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Pushing the Limits of Cathodoluminescence Signal Detection: Analyzing 2D Materials

Anas Mouti[1,2], Ritesh Sachan[1], Andrew R. Lupini[1], Matthew F. Chisholm[1], Stephen Pennycook[3]

[1.] Oak Ridge National Laboratory, Materials Science and Technology Division, Oak Ridge, TN
[2.] University of Kentucky, Chemistry department, Lexington, KY
[3.] National University of Singapore, Department of Materials Science and Engineering, Singapore

We report in this communication the analysis of hexa-BN atomic layers by cathodoluminescence in a scanning transmission electron microscope (STEM-CL). Both polychromatic imaging and light spectroscopy were performed varying thicknesses of BN, down to a few monolayers. Previous studies have reported spatially resolved structural and optical properties of BN flakes [1] ; our ultimate goal in this study is to collect useful data from a single monolayer, which would be the thinnest possible sample. We are conducting the research on a custom CL system that we have built and integrated onto a VG 601 STEM, equipped with an aberration corrector to increase probe current at higher magnifications. System characteristics include 2 str collection angle, 360-1000nm wavelength spectroscopy range, and 180-900nm photomultiplier detection range. We report success in collecting spectra and polychromatic images from samples as thin as 5-6 monolayers. In Fig.1, (a) is the ADF picture of the edge of a BN flake, and A it's thinnest region, (b) is the corresponding polychromatic CL image, showing that signal is clearly collected from A. Fig. 1(c) is a high resolution image of A taken with a Nion UltraSTEM 100, from which it can be deducted that the thickness is about 5 monolayers. Finally, (c) is a CL spectrum acquired from the 5 monolayers.

We discuss practical challenges such as beam damage with dose and acceleration voltage, and ways to improve the signal-to-noise ratio. We finally study the evolution of emission energy and intensity with different thicknesses.

Our current research includes studying monolayers, and their interactions with dopants and plasmonic particles.

References:

[1] Bourrelier et al. ACS Photonics 2014, 1, 857−862

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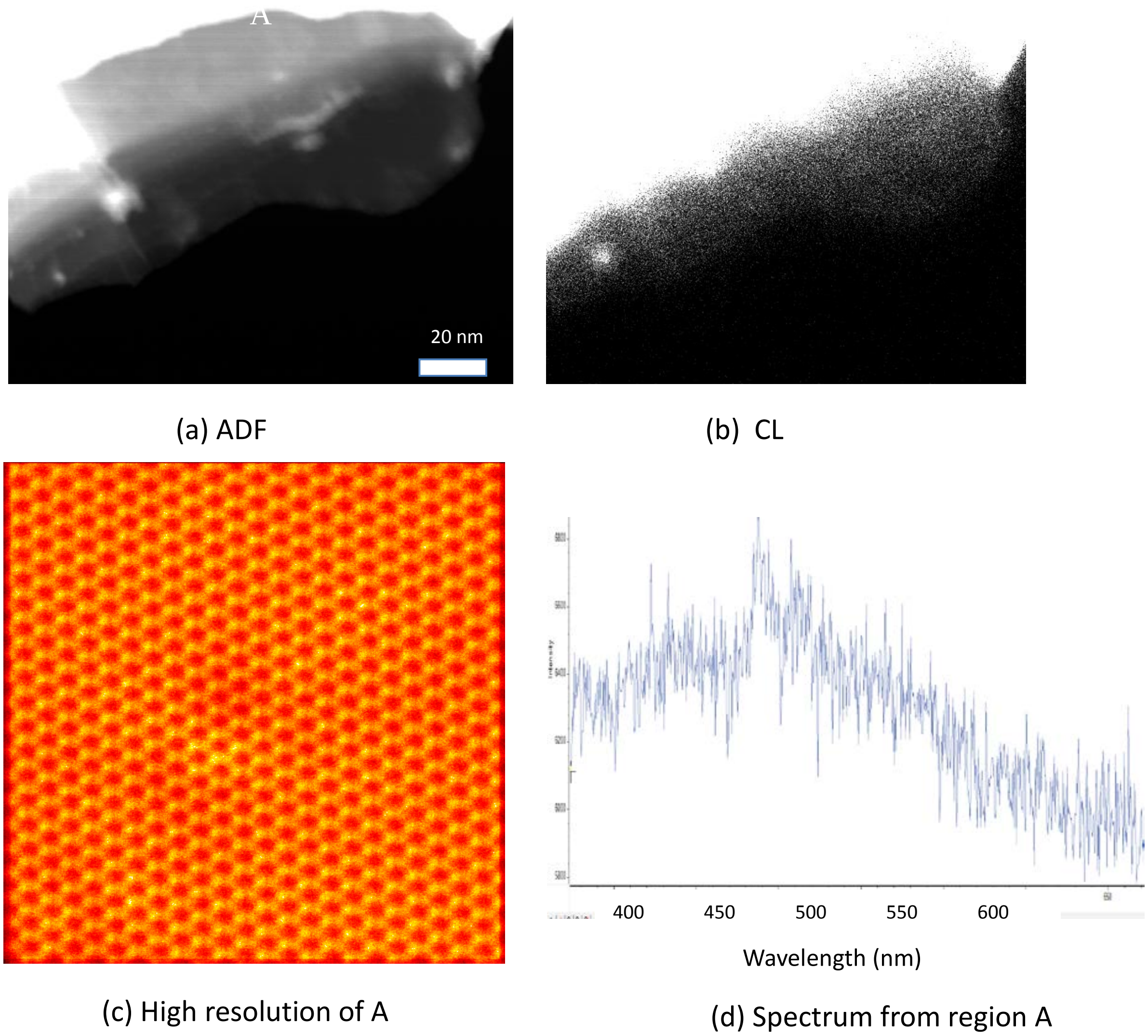

Figure 1: (a) Annular Dark Field (ADF) image of the edge of a BN flake, and (b) it's corresponding CL image, signal is detected from the thinnest area A of the flake. From the high resolution image of A in (c) it can be determined that A is about 5 monolayers thick. Finally, (d) is a spectrum acquired from A.