OPTICAL PROPERTIES OF INDIVIDUAL BORON NITRIDE NANOTUBES

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Stability of boron nitride nanotubes has been theoretically predicted in 1994 whereas first syntheses of multiwall and of singlewall nanotubes have been achieved in 1995 and 1996 respectively. Similarly to carbon nanotubes, they are composed of rolled up hexagonal boron nitride (hBN) sheets. According to calculations, BN nanotubes are all wide band gap semiconductors and their band gap value should not depend much on their diameters and chirality. They are also expected to emit strongly in the UV range because of excitonic recombinations. Preliminary optical absorption experiments performed on BN-SWNT synthesized by a laser vaporization technique [1] have confirmed the existence of a large gap close to 6 eV [2, 3].

As it has been experimentally demonstrated for the related bulk material hBN, stronger excitonic effects than in carbon nanotubes should occur in BN nanotubes. The excitons involved in these materials are expected to be localized excitons of very large binding energy (quasi-Frenkel excitons). Such effects have not been experimentally demonstrated yet for BN nanotubes especially because of a lack of pure samples.

In our study, optical properties of multi-wall BN nanotubes are investigated with luminescence and excitation spectroscopies. Cathodoluminescence spectroscopy and imaging of individual BN nanotubes of diameters ranging from 30 nm to 110 nm have been undertaken. The results are compared with photoluminescence experiments at various temperatures (from 5 K to 300 K) on the same macroscopic sample. These experiments show that BN nanotubes are strong UV emitters at about 230 nm (Figure 1). Photoluminescence excitation experiments on the same sample further confirm the interpretation of the UV emission as due to excitonic recombinations. The precise nature of the luminescence bands are interpreted in comparison with hBN (Figure 2). This study gives experimental evidences that the optical properties of BN nanotubes are dominated by large binding energy excitons. The nature of the excitons will be discussed comparatively in hBn and in the nanotubes.

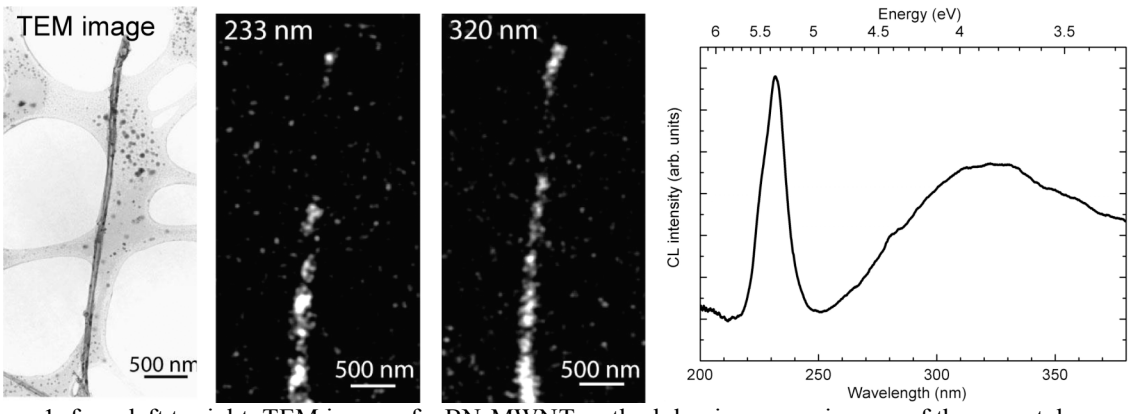

Figure 1, from left to right: TEM image of a BN-MWNT, cathodoluminescence images of the same tube recordd at 233 and 320 nm respectively and cathodoluminescence spectrum of the same tube exhibiting two emission

bands, one centred on 320 nm and related to impurities and vacancies and the second one at 230 nm related to gap and dominated by excitons [4].

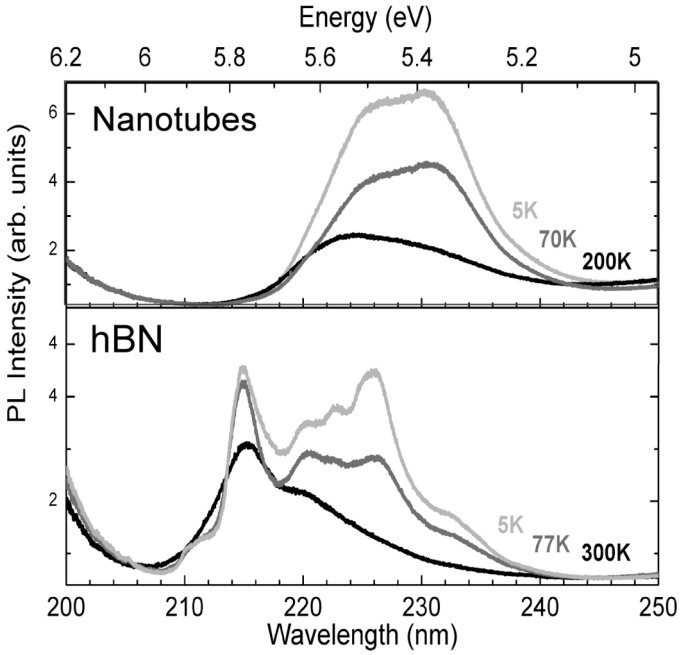

Figure 2: Photoluminescence spectra recorded on BN-MWNT (top) and on hBN crystallites (bottom) for varaible temperatures, showing the excitonic band associated with the gap. In hBN, the band displays free and bound excitons, the latter being trapped on structure defects of the crystallite [5, 6] . In the nanotube sample, the band is red-shifted. This red-shift has been shown to be due to non radiative free excitons [7].

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