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High Spatial Resolution CL Imaging of ZnO, Bi/ZnO and Sb/ZnO Nanostructures

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Semiconducting ZnO is a promising material for various optical and electrical applications. Due to the ultraviolet light-emitting characteristics of ZnO nanowires, their luminescence properties are an attractive subject of investigation [1]. While Photoluminescence (PL) refers to emission from materials excited by photons, cathodoluminescence (CL) measures the degree of luminescence originated from the decay of electron-hole pairs caused by high energy electron bombardment [2]. CL can be used as a valuable tool to evaluate material properties and high resolution CL imaging can provide spatial information on the electronic properties of nanostructures. Here we report our recent investigation of CL imaging of ZnO, Sb/ZnO and Bi/ZnO nanostructures.

ZnO nanowires were fabricated via a vapor deposition process inside a horizontal quartz tube furnace. Bi/ZnO and Sb/ZnO nanostructures were prepared by introducing metal vapor and deposit them on ZnO nanostructures via the vapor phase transport process. JEOL JXA-8530F hyper probe, consisting of a field-emission scanning electron microscope equipped with five wavelength dispersive spectrometers and a CL detector of panchromatic type, collecting signals in the wavelength range of 200 nm to 900 nm. This instrument can provide a spatial resolution of 3 nm in the secondary electron and backscattered electron imaging mode.

Fig.1 shows high magnification backscattered electron image (a) and the corresponding CL image (b) of ZnO nanowires. Analyses of many CL images showed that when the diameter of ZnO nanowires is below about 30 nm the CL signals were hardly detectable. Preliminary investigation suggests that the signal reduction may not just originate from the smaller emission volume. Further study of this phenomenon is under way. Fig. 2 (a) is a BSE image of the synthesized Bi/ZnO nanostructure; the brighter contrast represents the bismuth oxide phase. Fig. 2 (b) is the corresponding CL image, revealing that the two oxides provide a similar integrated CL signal. Figures 2(c) and 2(d) show a BSE image and a CL image of the Sb/ZnO nanostructures, respectively. The relatively low CL intensity of the antimony oxide microwires (compared to ZnO nanowires) suggests that CL imaging can be used to investigate the CL emission properties of mixed (Sb)ZnO nanoscale structures. Detailed analyses of the local CL emission from various nanostructures will be discussed [3].

References:

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[2] YM. Oh *et al*, Nano Lett **7** (2007) p.3681.
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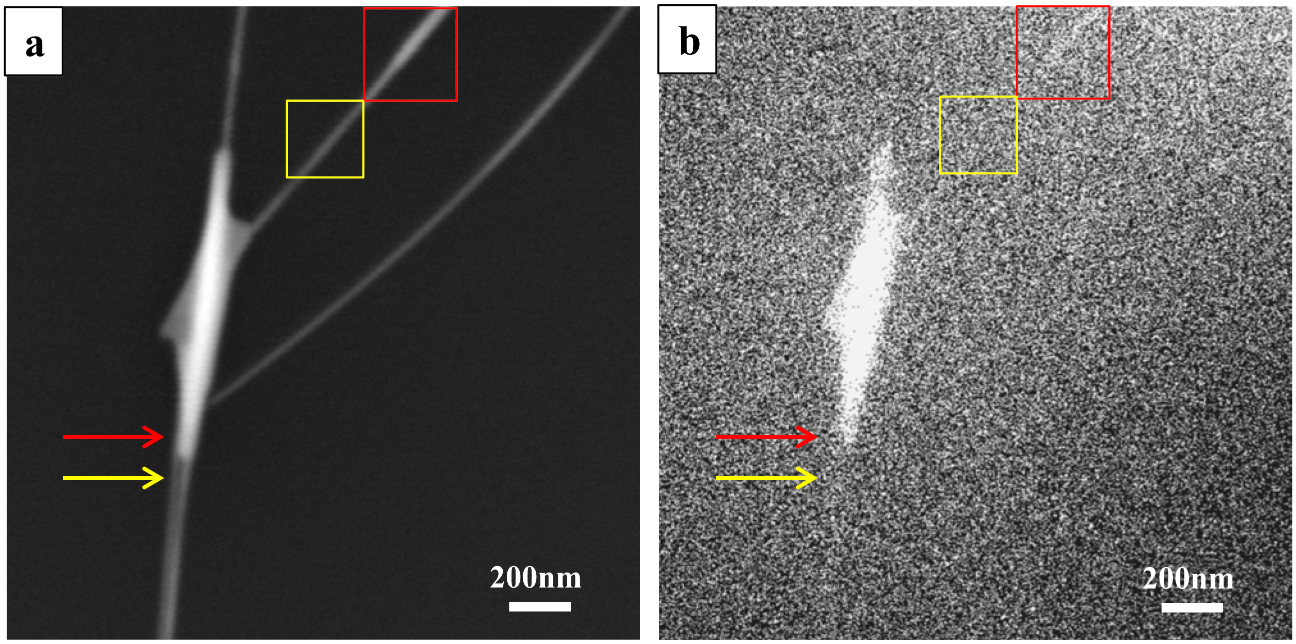

Fig.1. High resolution backscattered electron image (a) and the corresponding CL image (b) of ZnO nanowires. The squares and arrows represent the CL signals of different locations with different diameters of the ZnO nanowires. Note the non-observable CL signal when the diameter of the ZnO nanowires is smaller than about 30 nm in diameter (from red square to yellow one).

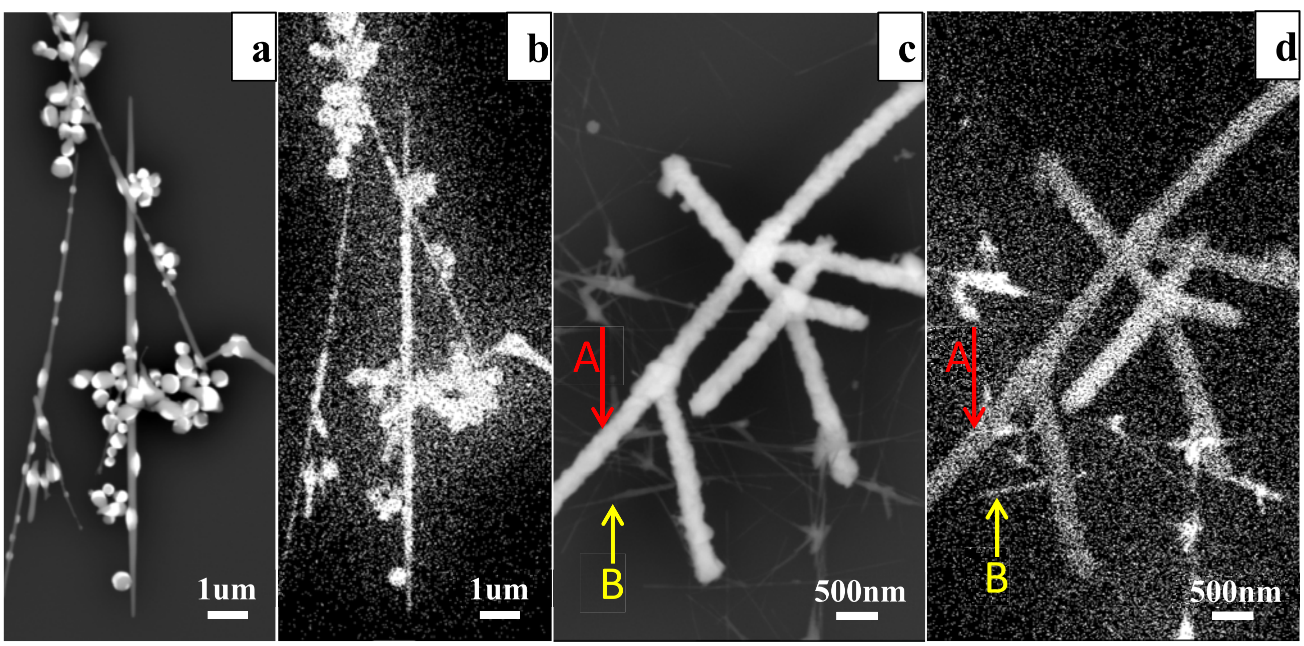

Fig.2. BSE image of Bi/ZnO nanostructures (a), clearly showing the spatial distribution of the ZnO and β-Bi_2O_3 phases; the corresponding CL image (b) does not show any intensity variations across the two different phases. BSE (c) and CL (d) images of Sb/ZnO nanostructures show significantly reduced CL emission from the corrugated antimony oxide microwires.

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