

PROCESSING OF NANOMATERIALS IN THE C-B-N SYSTEM

Raj N. Singh

Energy and Materials Engineering, University of Cincinnati, Cincinnati, OH 45221-0012, USA

Introduction

Materials in the C-B-N ternary system have extraordinary properties such as Diamond and cubic-BN [1]. Nanotubes (NTs) belonging to this system have also attracted a significant attention for applications in nanoelectronics, medicine, energy systems, and reinforced-composites because of their potential for rendering unusual properties. The discovery of carbon nanotubes (CNTs) has generated intense experimental and theoretical interests but their applicability have been limited by their small length and variable/anisotropic properties that are dependent on the number of tube walls, tube diameter and chirality. In contrast, boron nitride nanostructured materials, an III-V compound with similar hexagonal structure to graphite, have more uniform electronic properties with a larger band gap (~5.8eV) than the CNTs. Besides, boron nitride nanotube (BNNT) is a unique tubular material combining ultimate strength, stable dielectric properties and transparency. In contrast to the aligned CNT, boron nitride nanotubes with 3-D network architectures are expected to impart their unique 1-D properties into 3-D thereby opening new possibilities for their applications. In this regard recent research performed in our microwave-enhanced CVD growth system has demonstrated successful growth of 3-D BNNT networks, which presents the opportunity for novel applications of BNNTs as sensors for high

temperature environments. Our research group has done research work on synthesizing novel nanostructured materials in the C-B-N system such as diamond, cubic- and hexagonal-BN, and boron [1-3]. Specifically, our research work on nanostructured diamond and BNNTs will be presented and discussed.

Experimental

Nanostructured diamond thin films and 3-D BNNTs were synthesized in a MPCVD system reported elsewhere, employing methane, hydrogen and argon or diborane (B_2H_6 -5 vol% diluted in H_2), ammonia (NH_3) and hydrogen (H_2) as the gas precursors, respectively. More details can be found in [1-3]. In the case of BNNTs a Ni catalyst thin film with varied thickness (2-20 nm) was deposited on the oxidized Si (111) substrate by electron beam evaporation. The substrate was placed on a sample holder in the reaction chamber. Then, the substrate was heated to 800 °C and H_2 plasma was initially created at 15 torr, 600W, and 800 °C. Then, the H_2 was partially replaced by NH_3 . Diborane gas was finally introduced into the reactor for deposition at a microwave power of 800 W. The deposited nanocrystalline diamond thin films and BNNTs were examined by SEM (Scanning Electron Microscope) and TEM (Transmission Electron Microscope), Raman spectroscopy and SAD (Selected Area Diffraction).

Results and Discussions

Figure 1-a shows synthesis of nanocrystalline diamond thin film of grain size < 100 nm and smooth morphology. Similarly, growth of BNNTs with interweaved 3-D nanostructures are found on 2nm Ni film coated oxidized Si (111) substrates as shown in Fig. 1-b with diameters around 10-50 nm and lengths over 10 micrometers. In addition, nano-junctions

of different shapes (Y-junction, star network, etc) are also observed as shown in Fig. 1-b. Further TEM observation revealed the detailed morphology of the obtained hollow nanotubes. They appear either in a bundle with a width close to 50 nm, or as a single tube with a diameter around 10-20 nm. The SAD pattern was taken on the bundle of nanotubes indicating a textured hexagonal structure.

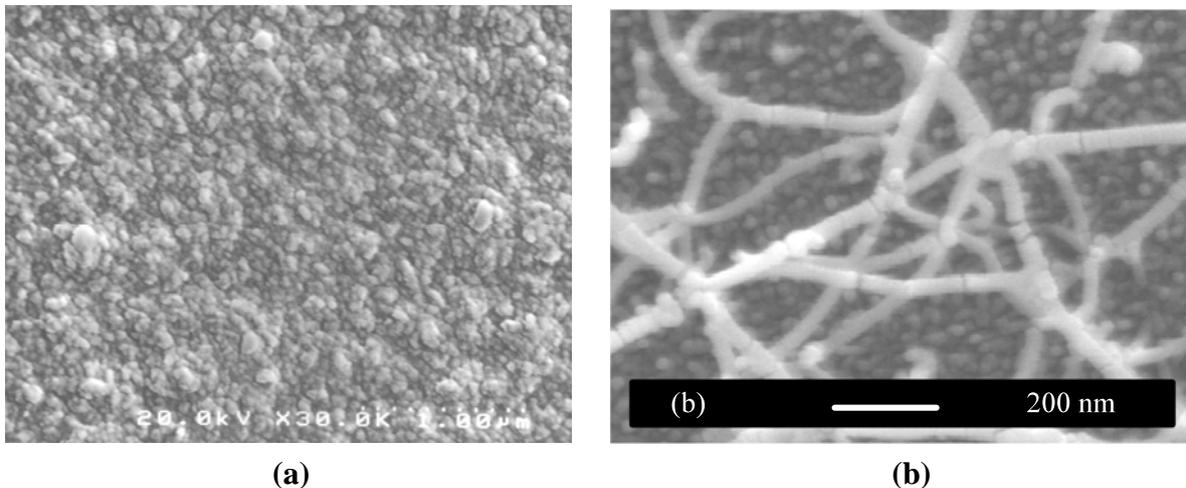


Figure 1. SEM images of (a) nanocrystalline diamond and (b) BNNTs.

Conclusions

Nanocrystalline diamond thin films and 3-D boron nitride nanotubes were synthesized at a low substrate temperature (800 °C) through a microwave plasma CVD process. The electrical properties and growth mechanism of these nanostructured materials were investigated.

References

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