MOVPE Continuous Flow Growth of Boron Nitride on Sapphire Substrates - Structural Investigations

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The sp^2-BN, like other 2D materials, recently has attracted significant interest. Mainly, because of it possible application for the electronics based on layered materials [1]. BN can also be useful for deep UV optoelectronic devices. Samples investigated in this work were grown in high reactor pressure and high ammonia flow conditions by MOVPE method on sapphire substrates [2]. All samples were characterized by Raman spectroscopy, Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD) methods. For all samples, we find the Raman line around 1369 cm^{-1}, characteristic for the sp^2-BN. Also in each case, XRD 2theta/omega and omega scans in reflection geometry were recorded. From 2theta/omega scan we can get the average distance between BN layers, while omega scan helps us to distinguish epitaxial and polycrystalline like growth. SEM measurements allow us to determine the morphology of the samples top surfaces. Fig. 1 shows the SEM images for two characteristic examples of MOVPE continuous flow growth. The short time growth sample (Fig. 1a) shows characteristic wrinkled morphology of BN layer, generated during cooling after growth [3]. This indicates that we have a BN layer of reasonably uniform thickness with epitaxial quality. Locally randomly-oriented small 3D objects are visible, which are the result of 3D stochastic nucleation. When a growth time is longer, with the applied growth method (high pressure) the 3D growth type prevails and as a result we get inhomogeneous material (Fig. 1b). For both samples, the XRD measurements (2theta/omega and omega scans) show very similar results. That indicates that our samples are basically similar as far as crystalline phase is concern. One has to point out that interplanar spacing deducted from XRD 002 hBN peak also shows the presence of turbostratic phase in both cases. For longer growth time we have a good quality layer on the bottom (like a layer from Fig. 1a) covered with thick 3D material while for short growth time only a good quality layered structure is present.

In our work, we present the role of time growth for the structural quality of BN layers grown in high pressure regime. Understanding and controlling mechanism of 2D/3D growth type seem to be crucial in getting the thick, homogeneous BN layer.

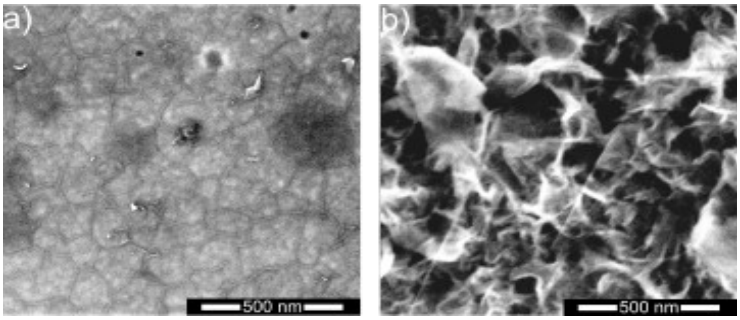

Fig. 1. Scanning Electron Microscopy images of BN layers on sapphire substrates for: a) short, b) long growth time, respectively.

[1] K. S. Novoselov, et al., *Proc. Natl. Acad. Sci. U.S.A*. **102**, 10451 (2005).
[2] Y. Kobayashi, T. Akasaka, J. Cryst. Growth **310,** 5044 (2008).
[3] X.Yang, et al. *J. Cryst. Growth* **482**, 1 (2018).