The synthesis of BN-nanostructures from borates of alkali and alkaline-earth metals

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Abstract

Extraordinary mechanical strength and chemical inertness of boron nitride nanotubes (BNNTs) make them an attractive material for reinforcement of advanced plastics, ceramics or metals for innovative applications in aerospace, automobile and other industries. Deterrent to a wide technological use of BNNTs is their poor availability on the market. Nowadays only a few laboratories around the world have reported on the synthesis of BNNTs with different qualities in tens of grams per hour yields. Lack of practical models for the BNNTs' nucleation and growth is a bottleneck for their high yield synthesis. In our previous work [1] the influence of lithium oxide on reaction of boron oxide with ammonia was investigated. Obtained results suggested that lithium borates play a key role in BNNTs growth. To shed a new light on these phenomena we have studied an influence of alkali and alkaline-earth oxides (MeO_x) on reaction of boron oxide with ammonia. Reactions of oxide mixtures $(M_2O/MO) \cdot nB_2O_3$, where M_2O and MO are alkali and alkaline-earth oxides respectively have been explored for a molar ratio n=0,5-5 in a temperature range of 900-1250^oC. It was found that various BN-nanostructures like nanoparticles, graphene-like flakes, nanotubes, and nanofibers grow dependently on borate composition and temperature. High quality straight and well-structured BNNTs with a diameter of 30-80 nm (fig. 1) have been obtained with a high yield from Li, Mg, Ca borates in a certain range of their compositions and temperatures. Na and K borates produced exclusively BN nanoflakes in a whole studied composition and temperature ranges (fig. 2). A model for BN nanostructures nucleation and growth from borates is proposed. The obtained results are the basis for creating a highly scalable method for BN-nanostructures synthesis.

References

[1] Andrei T. Matveev, Konstantin L. Firestein, Alexander E. Steinman, Andrey M. Kovalskii, Oleg I. Lebedev, Dmitry V. Shtansky, Dmitri Golberg. Boron nitride nanotube growth via boron oxide assisted chemical vapor transport-deposition process using $LiNO_3$ as a promoter. Nano Res. Available on-line 08 Apr 2015.

Figures

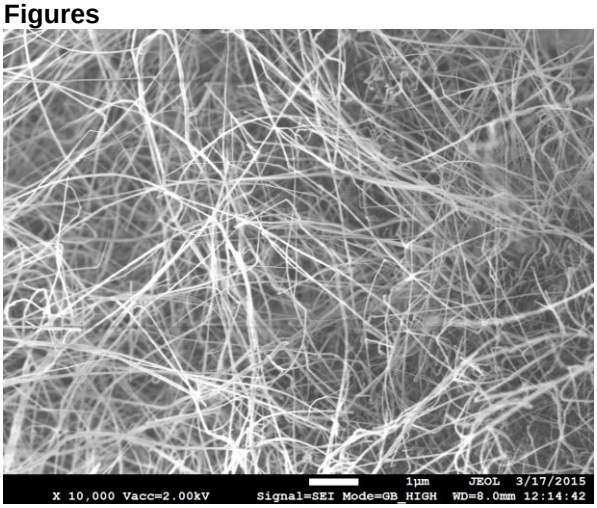

Figure 1 BNNTs grown from Mg borate

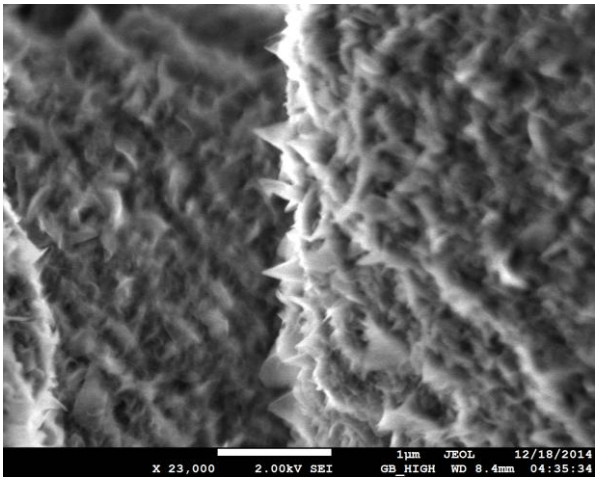

Figure 2 BN nanoflakes grown from Na borate