Boron Nitride Nanotubes Using Ammonia by Triple Thermal Plasma

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Abstract: In this work, boron nitride nanotubes (BNNTs) were synthesized by adding hydrogen (H_2) and ammonia (NH_3) in the triple thermal plasma system. In addition, we examined the effect of hydrogen and ammonia on the impurity in BNNTs. NH_3 could promote the growth of BNNTs and reduce B impurity. It is attributed to the low decomposition temperature and molecular structure of NH_3

1. Introduction

Hydrogen is mainly injected into the synthesis of BNNTs by thermal plasma [1, 2]. Hydrogen increases the reactivity of B atoms and inhibits the recombination of N atoms. B-N-H intermediates are formed in this process, and those species are effectively reformed into BNNTs. However, the incorrect addition of hydrogen causes intermediates to become impurities in the synthesized BNNTs. Synthesized BNNTs usually contain B, hexagonal, and turborastic boron nitride (h-BN/t-BN, respectively) as impurities [3]. These impurities require purification because they cause defects when BNNTs are applied.

In this work, we synthesized BNNTs using H_2 and NH_3 as H resources. The effect of each reactant gas on the formation of intermediates and impurities was investigated.

2. Methods

BNNTs were synthesized in a DC triple-thermal plasma system. The plasma forming gas was injected into each torch at a flow rate of Ar 4 LPM and N_2 8 LPM. h-BN was introduced at a rate of 0.6 g/min using a powder feeder. In each experiment, the reactant gas (H_2 or NH_3) was injected into the top of the reactor at the same flow rate of 10 LPM.

The synthesis experiment was performed at a fixed current of 100 A and a power of 21 kW. The synthesized BNNTs were collected on three mesh filters and characterized by microscopy, spectroscopic, and thermal analysis.

3. Results and Discussion

FE-SEM images of the synthesized BNNTs show that NH_3-BNNTs have a larger diameter and more walls than H_2-BNNTs. Non-tubular particles surrounding the surface of BNNTs are considered impurities. H_2-BNNTs contain more particles larger than NH_3-BNNTs.

The derivative thermogravimetric (DTG) curves in Figure 2 show different mass gain rates for each BNNTs. The mass gain is attributed to the oxidation of B into B_2O_3 from 500 ℃, and the mass gain rate increases. The high mass increase rate of H_2-BNNTs in the oxidation region of B means that the amount of B is relatively large.

These suggest that more B-N-H intermediates are formed in NH_3-BNNTs than in H_2-BNNTs.

4. Conclusion

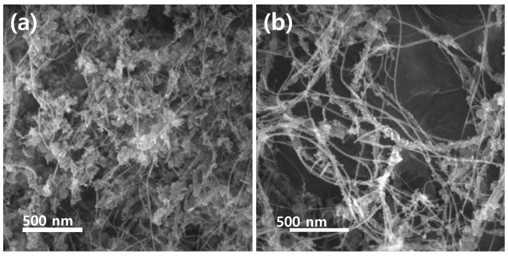

Fig. 1. FE-SEM images of (a) H_2-BNNTs and (b) NH_3-BNNTs

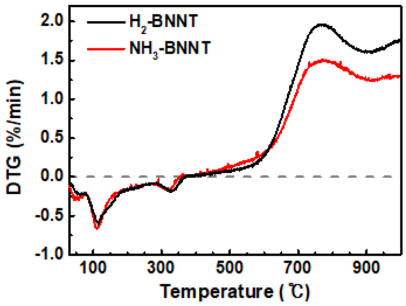

Fig. 2. DTG graphs of synthesized BNNTs

NH_3-BNNTs have a higher average diameter and lower B content. NH_3 has a lower decomposition temperature than H_2. In addition, NH_3 is decomposed into NH radicals required for intermediate synthesis. In BNNTs synthesis, NH_3 provides sufficient NH radicals to enable the growth of BNNTs and reduce the amount of B impurities.

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References

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