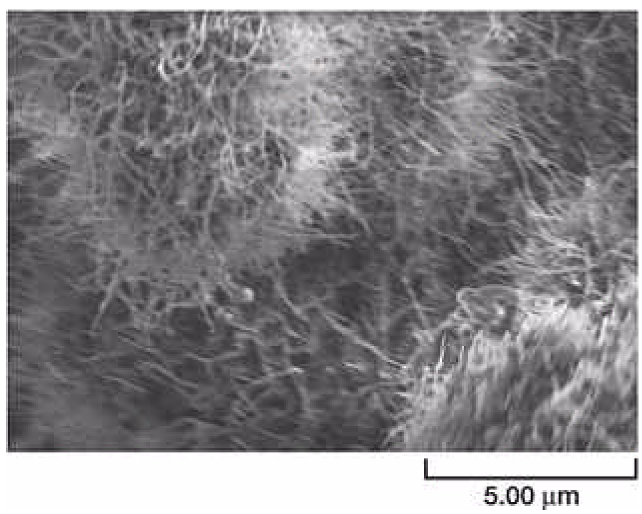
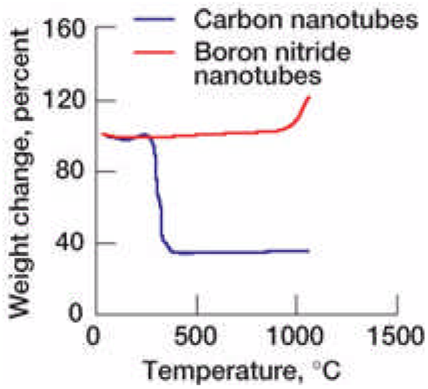
Boron Nitride Nanotubes Synthesized by Pressurized Reactive Milling Process

Nanotubes, because of their very high strength, are attractive as reinforcement materials for ceramic matrix composites (CMCs). Recently there has been considerable interest in developing and applying carbon nanotubes for both electronic and structural applications. Although carbon nanotubes can be used to reinforce composites, they oxidize at high temperatures and, therefore, may not be suitable for ceramic composites. Boron nitride, because it has a higher oxidation resistance than carbon, could be a potential reinforcement material for ceramic composites. Although boron nitride nanotubes (BN-nT) are known to be structurally similar to carbon nanotubes, they have not undergone the same extensive scrutiny that carbon nanotubes have experienced in recent years. This has been due to the difficulty in synthesizing this material rather than lack of interest in the material. We expect that BN-nTs will maintain the high strength of carbon nanotubes while offering superior performance for the high-temperature and/or corrosive applications of interest to NASA.



As-produced boron nitride nanotubes.
Structure of a batch of as-produced BN nanotubes prior to any subsequent cleaning step.

At the NASA Glenn Research of preparing BN-nTs were investigated and compared. These include the arc jet process, the reactive milling process, and chemical vapor deposition. The most successful was a pressurized reactive milling process that synthesizes BN-nTs of reasonable quantities. Batch sizes of 6 g with over 90-percent yield have been successfully prepared by this method. The photomicrograph shows the as-synthesized BN-nTs. The temperature stability of these BN-nTs in air is significantly higher than that for commercially available carbon nanotubes, as shown in the graph. The carbon nanotubes lose weight rapidly at 400 °C because the carbon is oxidized. On the other hand, BN-nTs are stable in air up to 1000 °C, demonstrating the superior performance of the BN-nT. BN-nTs are currently being incorporated into composites to provide high-strength behavior at high temperatures.



Superior temperature stability of boron nitride nanotubes in air relative to carbon nanotubes from weight loss data (thermogravimetric analysis).
Improved stability of boron nitride relative to carbon nanotubes in air at temperatures up 100 °C.

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