Boron Nitride

Hexagonal boron nitride (α-BN) is a white, talclike synthetic ceramic material with outstanding properties. It is a high-temperature solid lubricant, good dielectric and good thermal conductor. It also has high electrical resistivity. Furthermore, boron nitride is chemically inert and not wetted by many metal melts or silicate and salt melts.

BN is stable in air to 1000°C and under vacuum up to 1400°C. It can be used in argon-gas atmosphere to 2200°C and nitrogen-gas atmosphere to 2400°C.

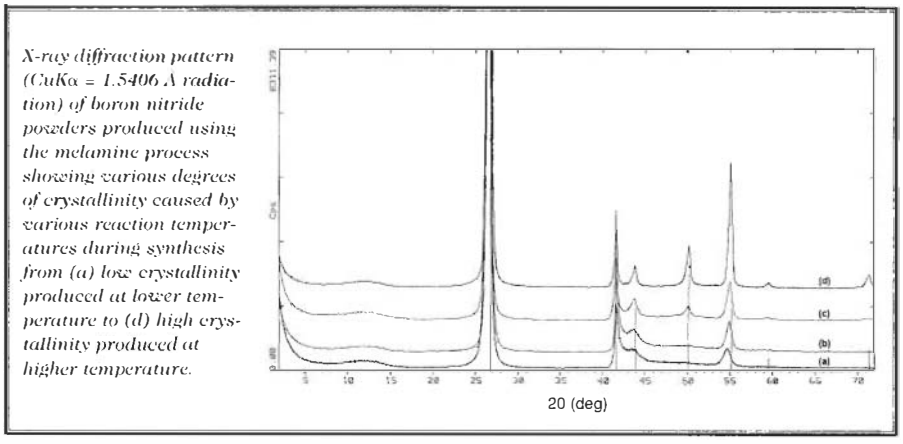
BN was first prepared in 1842 by reacting boric acid with potassium cyanide. Commercial production began during the 1950s by Carborundum Co. and Union Carbide Corp.

The following synthesis routes are currently used for commercial production:

- Reaction of boric oxide with melamine, according to $3B_2O_3 + C_3H_6N_6 \rightarrow 6BN + 3CO_2 + 3H_2O$ (melamine process).
- Reaction of boric oxide with ammonia, using tricalcium phosphate as a carrier, according to $B_2O_3 + 2NH_3 \rightarrow 2BN + 3H_2O$ (trical process).
- Exothermic reaction of boric oxide with magnesium in the presence of nitrogen gas, according to $B_2O_3 + 3Mg + N_2 \rightarrow 2BN + 3MgO$ (SHS process, i.e., self-propagating high-temperature synthesis).

The resulting BN is well crystallized in the hexagonal structure, and it contains 1–10 μm platelets having a thickness of 0.1–0.5 μm. The crystallinity, however, is influenced by the temperature at which the synthesis takes place.

BN is available as a powder with concentrations as low as 92% for



X-ray diffraction pattern (CuKα = 1.5406 Å radiation) of boron nitride powders produced using the melamine process showing various degrees of crystallinity caused by various reaction temperatures during synthesis from (a) low crystallinity produced at lower temperature to (d) high crystallinity produced at higher temperature.

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refractory purposes to >98.5% for ceramic applications. High-purity grades are >99.5%.

Companies involved in the production of BN include Advanced Ceramic Corp. (formerly Union Carbide) and Saint-Gobain Advanced Ceramics Corp. Boron Nitride (formerly Carborundum Corp. Boron Nitride) in the United States; Sintec Keramik UK (formerly Boride Ceramics & Composites and owned by Sintec Keramik GmbH & Co. KG, Germany) in the United Kingdom; SHS Cerámicas in Spain; Wacker Chemical (formerly Elektroschmelzwerk Kempten) and H.C. Starck GmbH & Co. KG in Germany; and Denki Kagaku Kogyo, Kawasaki Steel Corp., Shin-Etsu Chemical Co. Ltd. and Showa Denko KK in Japan.

Prices for hexagonal BN range from ~$80 to 120/kg for standard qualities depending on purity of BN, and may reach prices up to $200–400/kg for high-purity and tailor-made grades. Because some producers have increased their production during recent years to overcome past shortages, prices are not expected to increase considerably in the near future.

Boron nitride shapes are produced using hot isostatic pressing of boron nitride powder with calcium borate glass as a binder. Large quantities of boron nitride are used for the production of engineering ceramics, such as brake rings for horizontal continuous steel casting and TiB_2/BN composites used as evaporator boats for vacuum metallization. Other applications include cosmetics, catalysts and starting materials for the production of α-BN. Because of its extreme hardness, second to diamond, cubic β-BN is used as a hard material.

Good nonwetting behavior as well as good high-temperature lubrication characteristics make boron nitride an excellent release and parting agent for the production of aluminum and magnesium castings. It also is used in glass forming and superplastic forming of titanium sheets for aerospace applications. In these applications, boron nitride is used as a dispersion in a carrier (water or alcohol) blended with refractory binders that are applied similar to wall paint. Such coatings are produced by Advanced Ceramic Corp., Saint-Gobain Advanced Ceramics Corp. Boron Nitride and ZYP Coatings Inc. in the United States and by Wacker Ceramics and Büro für angewandte Mineralogie in Germany.

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