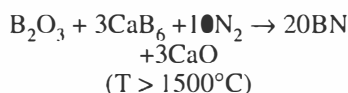
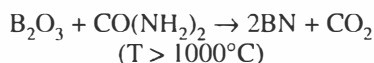
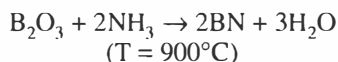


**BORON NITRIDE (BN).** BN is a synthetic ceramic material that occurs in two modifications. One is the hexagonal BN ( $\alpha$ -BN) that shows a graphite-like layer structure. However, In contrast to graphite, BN shows a white color, thus it is often called "white graphite." The other is the dense cubic BN ( $\beta$ -BN) with a structure similar to that of diamond.

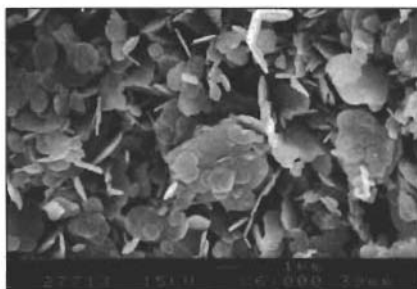
BN was first prepared on a large-scale basis by Union Carbide and Carborundum in the 1950s. Today, the following three general reactions are used for the synthesis of a-BN using boron oxide (or boric acid) and a nitrogen-containing compound:



The resulting BN contains 92–95% BN and 5–5%  $\text{B}_2\text{O}_3$ . If desired the remaining  $\text{B}_2\text{O}_3$  can be evaporated in a second step at temperatures  $>1500^\circ\text{C}$  in order to achieve BN concentration  $>98\%$ .

BN production figures are not listed separately in statistical reports; however, we estimate the 1999 production for the western world of about 300–350 metric tons. Production figures will be similar for 2000 with a slight increase possible. Also, there is a BN production in the Commonwealth of Independent States (CIS) and China, but no reliable production data are available.

Companies involved in the production of BN include Advanced Ceramic Corp. (formerly Union Carbide) and Carborundum Co. in the United States; Boride Ceramics & Composites (owned by Sintec Keramik GmbH & Co. KG, Germany) in the United Kingdom; Elektroschmelzwerk Kempten and H. C. Starck GmbH & Co. KG in Germany; and Denki Kagaku Kogyo, Kawasaki Steel Corp., Shin-Etsu



SEM micrograph (secondary electron image) illustrating the plate-like particles of boron nitride powder.

Chemical Co. Ltd. and Showa Denko KK in Japan.

Prices for hexagonal BN range from ~\$75–120/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. Although a large demand for BN exists at present, no large price increases are to be expected in the near future.

For ceramic applications, the hexagonal modification is used because of its outstanding chemical, thermal and electrical properties. It finds application in the metallurgical field because of its good non-wetting behavior against metallic melts. Further applications are high-temperature solid lubricants because of its layer lattice and thermal conductor/electrical insulator in electronic applications. Large quantities of BN are used for the production of engineering ceramics like brake rings for horizontal continuous steel casting and  $\text{TiB}_2/\text{BN}$  composites used as evaporator boats for vacuum metallization.

Other applications include those in the field of cosmetics, as catalysts and as a starting material for the production of cubic BN. Due to its extreme hardness, second to diamond, cubic  $\beta$ -BN is used as a hard material.

The good non-wetting behavior as well as the good high-temperature lubrication make BN an ideal release and parting agent for the production of aluminum and magnesium castings as well as glass forming and superplastic forming of titanium sheets for aerospace applications. In these applications BN is used as a dispersion in a carrier (water or alcohol) blended with

refractory binders, that are applied like wall paint. Such coatings are produced by Advanced Ceramic Corp., Carborundum Co. and ZYP Coatings Inc. in the United States and by Elektroschmelzwerk Kempten and Büro für angewandte Mineralogie in Germany.

Stephan Rudolph  
Büro für angewandte Mineralogie

**CALCIUM ALUMINATE CEMENT (CAC)** is a type of hydraulic binder that has been in commercial existence since 1908. At that time a patent was granted for a manufacturing process by which bauxite and limestone were fused in a reverberatory furnace to form the hydraulic mineral  $\text{CaAl}_2\text{O}_4$ . This mineral, monocalcium aluminate, is the principal reactive phase in all CACs.

The annual production quantity of CAC is minor in comparison to Portland cement (OPC). CAC and OPC are similar in that they are principally both composed of hydraulic minerals. In CAC these minerals are calcium aluminates, and in OPC they are calcium silicates.

The typical applications for these two binders, however, are quite different. While OPC is used in all types of construction work, CAC has unique properties that distinguish it from these applications:

- High temperature resistance and refractory performance;
- Rapid strength development;
- Resistance to chemically aggressive environments;
- Ability to accelerate the normal chemical reactions of OPC.

Today, CACs are manufactured by either a fusion or a sintering process. Typical starting raw materials are a source of  $\text{Al}_2\text{O}_3$  and  $\text{CaO}$  and can include limestone, lime, bauxite and calcined alumina. The resulting clinker is then processed and ground to cement fineness in ball mills resulting in a finished product of fine powder.

The principal reactive phase in all CACs is monocalcium aluminate ( $\text{CaAl}_2\text{O}_4$ ) and is generally present in quantities of at least 40%. The high-