

# Boron Nitride: Properties, Production and Applications

**Boron nitride (BN)** is a heat and chemical resistant crystalline compound with refractory properties composed of boron and nitride. Because it exists in multiple polymorphs, BN has evolved as a highly useful compound, finding its purpose in a wide range of industries and applications.

Here, you will learn about:

- The properties of Boron nitride
- The production process and forms of Boron nitride
- The applications of Boron nitride

## Boron nitride properties

The substance is composed of hexagonal structures that appear in crystalline form and is usually compared to graphite. It may come in the form of a flat lattice or a cubic structure, both of which retain the chemical and heat resistance that boron nitride is known for.

- **Heat and chemical resistance:** The compound has a melting point of 2,973°C and a thermal expansion coefficient significantly above that of diamond. Its hexagonal form resists decomposition even when exposed to 1000°C in ambient air. Boron nitride doesn't dissolve in common acids.
- **Thermal conductivity:** At 1700 to 2000 W/mK, boron nitride has a thermal conductivity that is comparable with that of graphene, a similarly hexagon-latticed compound but made up of carbon atoms.
- **Lubricating property:** Boron nitride has the ability to boost the coefficient of friction of lubricating oil, while reducing the potential for wear.
- **Density:** Depending on its form, its density ranges from 2.1 to 3.5 g/cm<sup>3</sup>.

## Production and processing

Boron nitride is synthesized via the reaction of a boron precursor (either boric acid or boron trioxide) with a nitrogen-containing reagent (urea or ammonia) under a nitrogen atmosphere.

This reaction yields amorphous boron nitride containing trace amounts of boron trioxide impurities, which may be further purified by evaporation via heating above 1500°C.

The versatility of boron nitride as a compound is evident in the number of forms and polymorphs that occur in the real world:

## Forms of boron nitride

### Hexagonal

This form of boron nitride has the highest number of applications, because of its high lubricating property, electrical conductivity, and thermal stability.

### Cubic

The cubic form of BN possesses significantly high electrical resistivity and thermal conductivity like diamond. It doesn't dissolve in steel components, thereby making it a good abrasive material.

### Amorphous

The non-crystalline form of boron nitride is comparable to amorphous carbon in terms of structure and properties.

### Atomically thin

Despite its ultra-thin property, this BN polymorph is characterised by high thermal conductivity, increased surface adsorption, and good dielectric properties.

### Nanotube

As one of the rising developments in recent times, nanotube technology has been given a boost with the use of boron nitride. This rolled-up form of hexagonal BN is similar to carbon nanotubes in terms of structure. However, BN nanotubes have higher electrical insulation as well as better resistance to heat and chemical reactions.

## Applications of boron nitride

### Lubricant

The hexagonal form of boron nitride is used as lubricant for paints, cosmetics, pencil lead, and cement for dental applications. Its lubricating property occurs even in the absence of gas or water molecules within the compound layers, thereby making it a good component for vacuum systems.

Compared to graphite, BN has significantly better chemical stability and electrical conductivity.

### **Equipment in high-heat environments**

Its exceptional resistance to heat lends the compound to a wide variety of applications involving extremely high temperatures. Hexagonal boron nitride is being used to improve the lubricating properties of rubber, plastic, alloys, and ceramics.

In the case of plastics, inclusion of a BN component provides lower thermal expansion. It may also be integrated into semiconductor substrates and microwave oven windows.

Boron nitride is an effective component of reaction vessels and crucibles because of its thermochemical properties.

### **Semiconductor industry**

With a bandgap ranging from 4.5 to 6.4 eV, boron nitride is an excellent wide-gap semiconductor material. Its intrinsic thermal and dielectric properties make it a suitable substrate in developing metal-oxide-semiconductor field-effect transistors (MOSFETs) and semiconductors.

### **Abrasive and cutting implements**

Due to the physical properties of cubic boron nitride, this polymorph is used as abrasive material for nickel, iron, and selected alloys in conditions where diamond was not found to be suitable (such as under extreme heat). Its cubic BN form is incorporated in cutting-tool bits and grinding equipment.