# Titanium Diboride ( TiB2 ) - Properties and Applications

*From Goodfellow* May 18 2001

**Titanium Diboride ($TiB_2$) is a hard material with high strength and high wear resistance at elevated temperatures. The high density, combined with the high elastic modulus and high compressive strength, have lead ot its use in armour components.**

It is unaffected by most chemical reagents, and has excellent stability and wettability in liquid metals such as zinc and aluminum. This, along with its high electric conductivity, has led to its use in Hall- Héroult cells for aluminum production. It is also used as crucibles for molten metals.

## Background

$TiB_2$ is the most stable of several titanium-boron compounds. The material does not occur in nature but may be synthesised by carbothermal reduction of $TiO_2$ and $B_2O_3$.

As with other largely covalent bonded materials, $TiB_2$ is resistant to sintering and is usually densified by hot pressing or hot isostatic pressing. Pressureless sintering of $TiB_2$ can achieve high densities but liquid forming sintering aids such as iron, chromium and carbon, are required.

## Key Properties

**Table 1.** Typical Physical and mechanical properties of titanium diboride.

| Property | Value |
|---|---|
| Density ($g.cm^{-3}$) | 4.52 |
| Melting Point (°C) | 2970 |
| Modulus of Rupture (MPa) | 410 - 448 |
| Hardness (Knoop) | 1800 |
| Elastic modulus (GPa) | 510 - 575 |
| Poisson's Ratio | 0.1 - 0.15 |
| Volume resistivity (ohm.cm) at 20 °C | $15x10^{-6}$ |
| Thermal conductivity (W/m.K) | 25 |

$TiB_2$ is resistant to oxidation in air up to 1000 °C. It is also resistant to HCl and HF but reacts with $H_2SO_4$ and $HNO_3$. It is readily attacked by alkalis.

Hot pressing of $TiB_2$ (with small additions of metallic or carbide sintering aids) is carried out at 1800 - 1900 °C and achieves close to theoretical density. Pressureless sintering requires higher levels of sintering aids and sintering temperatures in excess of 2000 °C.

## Applications

Due to its high hardness, extreme melting point and chemical inertness, $TiB_2$ is a candidate for a number of applications.

## Ballistic Armour

The combination of high hardness and moderate strength make it attractive for ballistic armour, but its relatively high density and difficulty in forming shaped components make it less attractive for this purpose than some other ceramics.

## Aluminium Smelting

The chemical inertness and good electrical conductivity of $TiB_2$ have led to its use as cathodes in Hall-Heroult cells for primary aluminium smelting. It also finds use as crucibles for handling molten metals and as metal evaporation boats.

## Other Applications

High hardness, moderate strength and good wear resistance make titanium diboride a candidate for use in seals, wear parts and, in composites with other materials and cutting tools.

In combination with other primarily oxide ceramics, $TiB_2$ is used to constitute composite materials in which the presence of the material serves to increase strength and fracture toughness of the matrix.

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- Ceramics - The ceramic materials offered by Goodfellow have been carefully chosen and include both the established as well as more recently developed products.
- Polymers - The range of polymers supplied by Goodfellow is broad and includes both the familiar as well as some of the more unusual or recently developed materials.
- Compounds and Intermetallics - Goodfellow can supply aluminides, borides and silicides as well as other intermetallics and compounds.
- Composites - These are manufactured on a custom-made basis

Some of the materials that Goodfellow can supply are listed below:

| | | |
|---|---|---|
| 347 Stainless Steel | Hafnium Hydride | Regenerated Cellulose |
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| Acetal Polyoxymethylene | Indium Oxide | Rhodium |
| Acrylonitrile Methylacrylate | Indium Tin Oxide | Rubidium |
| Alumina | Iridium | Ruby |

| | | |
|---|---|---|
| Alumina 62/Silica 24/Boria | Iron | Ruthenium |
| 14 Glass | Iron Boride | Saffil Fibre |
| Alumina 70/Silica 28/Boria 2 | Iron Silicide | Sapphire |
| Glass | Lanthanum Fluoride | Scandium |
| Alumina 80/Silica 20 | Lanthanum Hexaboride | Selenium |
| Aluminium | Lanthanum Oxide | Sialon |
| Aluminium Carbide | Leachable Ceramic ( SiO2 | Silica |
| Aluminium Nitride | 50/ZrSiO4 40/Al2O3 10 ) | Silicon |
| Alumino-silicate Glass SiO2 | Lead | Silicon Carbide |
| 57/Al2O3 36/CaO/MgO/BaO | Lead Selenide | Silicon Monoxide |
| Aluminum/Copper MMC's | Liquid Crystal Polyester | Silicon Nitride |
| Antimony | Lithium | Silicone Elastomer |
| Antimony Telluride | Lithium Fluoride | Silver |
| Arsenic | MACOR | Silver / Copper |
| Arsenic Telluride | Magnesium | Silver Chloride |
| Barium | Magnesium Oxide | Silver/Palladium |
| Barium Titanate | Manganese | Silver/Tungsten Metals |
| Beryllia | Manganese Silicide | Sodium |
| Beryllium | Mercury | Sodium Chloride |
| Bismuth | Molybdenum | Stainless Steel 15-7PH |
| Bismuth Telluride | Molybdenum Carbide | Stainless Steel 302 |
| Boron | Molybdenum Diboride | Stainless Steel 304 |
| Boron Carbide | Molybdenum Disilicide | Stainless Steel 310 |
| Boron Nitride | Muscovite Mica | Stainless Steel 316 |
| Brass Alloys | Nanocrystalline Nickel | Stainless Steel 316L |
| Bronze | Neodymium | Stainless Steel 321 |
| Cadmium | Nickel | Stainless Steel 410 |
| Caesium | Nickel Oxide | Strontium Titanate |
| Caesium Iodide | Nickel Silver | Strontium Titanate |
| Calcium | Niobium | Tantalum |
| Calcium Boride | Niobium Boride | Tantalum Boride |
| Calcium Fluoride | Niobium Carbide | Tantalum Carbide |
| Calcium Hydride | Niobium Nitride | Tantalum Silicide |
| Calcium Titanate | Niobium Pentoxide | Teflon PFA |
| Carbon | Niobium Silicide | Thallium |
| Carbon - Vitreous | Nylon | Thorium |
| Carbon/Epoxy Composites | Osmium | Tin |
| Carbon/PEEK Composites | Palladium | Tin Oxide |
| Carbon/Vinylester | PET Polyester | Tin/Silver |

Composites
Carbon-Carbon Composites
Carbon-Diamond
Cellulose Acetate
Cellulose Acetate Butyrate
Cerium
Chromium
Chromium Carbide
Chromium Diboride
Chromium Silicide
Cobalt
Copper / Silver Alloy
Copper Alloys
Copper II Oxide
Copper Selenide
Copper Telluride
Cyclo-olefin Copolymer
Dysprosium
E-CTFE
E-Glass Reinforced Epoxy
Erbium
ETFE
Europium (Eu)
FEP
FKM
Gadolinium
Gadolinium Oxide
Gallium
Germanium
Gold
Gold 82/Nickel 18 Alloy
Gold Germanium Eutectic
Gold/Nickel Au82/Ni18
Gold/Palladium
Gold/Tin
Hafnium
Hafnium Carbide
Hafnium Diboride

Platinum
Platinum 70/Rhodium 30
Platinum 87/Rhodium 13
Platinum 90/Iridium 10
Platinum 90/Rhodium 10
Platinum 92/Tungsten 8
Platinum 94/Rhodium 6
Polyacrylamide/Acrylate
Polyamide/Imide
Polyaramid Materials
Polybenzimidazole
Polybutylene Terephthalate
Polycarbonate Materials
Polychlorotrifluoroethylene
Polyetheretherketone (PEEK)
Polyetherimide (PEI)
Polyethersulphone (PES)
Polyethylene - Carbon Filled
Polyethylene (UHMWPE)
Polyethylene Composites
Polyethylene Naphthalate (PEN)
Polyhydroxybutyrate Biopolymer (PHB)
Polyimide (PI)
Polymethylmethacrylate (PMMA)
Polymethylpentene (TPX)
Polyphenyleneoxide
Polyphenylenesulfide - 40% Glass Fiber Reinforced
Polyphenylsulfone
Polypropylene (PP)
Polystyrene (PS)
Polyvinylfluoride (PVF)
Potassium
PTFE
PVDC

Titanium
Titanium Boride
Titanium Carbide
Titanium Diboride
Titanium Dioxide
Titanium Hydride
Titanium Nitride
Titanium Silicide
Titanium Silicocarbide
Titanium/Palladium Alloys
Tungsten
Tungsten Boride
Tungsten Carbide
Tungsten Carbide 94/Cobalt 6
Tungsten Disulphide
Tungsten Ditelluride
Tungsten Silicide
UPVC
Uranium
Vanadium
Vanadium Carbide
Vanadium Nitride
Vanadium Silicide
Wire Niobium/Titanium
Yttria (Yttrium Oxide)
Yttrium
Zinc
Zinc Arsenide
Zinc Oxide
Zinc Selenide
Zirconia
Zirconium
Zirconium Boride
Zirconium Carbide
Zirconium Hydride
Zirconium Nitride

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