

# NITRIDE CERAMICS

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The following groups of materials relate Nitride ceramics:

- ▣ **Silicon Nitride**
- ▣ **Gas Pressure Sintered Silicon Nitride (GPSSN)**
- ▣ **Low Pressure Sintered Silicon Nitride (SSN)**
- ▣ **Hot Pressed Silicon Nitride (HPSN)**
- ▣ **Reaction Bonded Silicon Nitride (RBSN)**
- ▣ **Aluminum Nitride**
- ▣ **Silicon Aluminum Oxynitride (SIALON)**
- ▣ **Properties of some nitride ceramics**

## Silicon Nitride

Silicon Nitride ( $\text{Si}_3\text{N}_4$ ) is the most important nitride ceramic.

Silicon Nitride ceramics are produced from a mixture of fine sub-micron powder of Silicon Nitride and binders (oxides). The powder is compacted and then sintered at  $3400^\circ\text{F}$  ( $1870^\circ\text{C}$ ).

## Gas Pressure Sintered Silicon Nitride (GPSSN)

In order to prevent decomposition of Silicon Nitride sintering is conducted in the atmosphere of Nitrogen under increased pressure (up to 100 atm.).

## Low Pressure Sintered Silicon Nitride (SSN)

If sintering is conducted under normal nitrogen pressure some of Silicon Nitride decomposes forming metallic silicon (Si).

The process is simpler and more cost effective than GPSSN, but the resulted materials possess lower mechanical strength.

## Hot Pressed Silicon Nitride (HPSN)

Uniaxial (die) pressing or Isostatic pressing techniques under pressure up to 2000 atm. are used for manufacturing dense high strength Silicon Nitride parts.

The process application is limited by its relatively high cost.

## Reaction Bonded Silicon Nitride (RBSN)

Reaction Bonded Silicon Nitride ceramics are produced from metallic silicon powder by sintering it in nitrogen atmosphere at  $2550^\circ\text{F}$  ( $1400^\circ\text{C}$ ).

Silicon Nitride forms as a result of chemical reaction between metallic silicon and gaseous nitrogen.

The material is characterized by low density and low oxidation resistance due to high open porosity.

The main advantage of the method is low volume change (low shrinkage) of the sintered parts.

The following characteristics are typical for Silicon Nitride ceramics:

- ☐ High fracture toughness;
- ☐ High mechanical strength and hardness even at high temperatures;
- ☐ Good creep resistance;
- ☐ High thermal shock resistance;
- ☐ High wear resistance;
- ☐ Low coefficient of thermal expansion;
- ☐ Good chemical and oxidation resistance;
- ☐ Low wettability by molten metals.

Silicon Nitride ceramics are used for manufacturing cutting tools, turbine blades, bearing balls and rollers, kiln furniture, valves and turbocharger rotors for engines, glow plugs, molten metals tools, melting crucibles, thermocouple protection tubes.

## Aluminum Nitride

Aluminum Nitride (AlN) ceramics are produced by sintering of Aluminum Nitride powder with or without binders.

The materials possess high thermal conductivity and good dielectric properties.

Aluminum Nitride easily oxidizes at the temperatures above 1300°F (700°C), therefore it is not used in high temperature applications.

The general fields of application of Aluminum Nitride ceramics are electronics and electrical engineering.

The following characteristics are typical for Aluminum Nitride ceramics:

- ☐ Very high thermal conductivity;
- ☐ Thermal expansion similar to silicon;
- ☐ Good dielectric properties;
- ☐ Good corrosion resistance;
- ☐ Stability in semiconductor processing atmospheres.

Silicon Nitride ceramics are used for manufacturing substrates for semiconductors, housing and heat sinks, power transistors bases, IC packages, microwave device packages.

## Silicon Aluminum Oxynitride (SIALON)

Silicon Aluminum Oxynitride ceramics are produced from a mixture of Silicon Nitride powder and Aluminum Oxide powder.

The properties of the material are similar to those of pure Silicon Nitride ceramic but the sintering temperature is lower.

Silicon Aluminum Oxynitride possesses low wettability by non-ferrous molten metals, therefore is used in metallurgical applications.

It is also used for cutting tools due to its high toughness.

## Properties of some nitride ceramics

- Sintered Silicon Nitride ceramic (SSN)
- Hot Pressed Silicon Nitride (HPSN)
- Reaction Bonded Silicon Nitride (RBSN)
- Aluminum Nitride (AlN)

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