

3M Advanced Materials Division

3M™ Silicon Nitride

Introduction

Ceradyne, Inc., a 3M company, offers a complete family of silicon nitride materials ideal for demanding applications in a wide variety of industries, from automotive and aerospace to oil and gas. 3M™ Silicon Nitride is a lightweight, high-strength ceramic material used as an alternative to stainless steel, super alloys, tungsten carbides and first-generation ceramics such as Al_2O_3 and ZrO_2 .

3M silicon nitride materials and components, with the exception of sintered silicon nitride, are produced at fully dedicated manufacturing plants in the U.S., using unique compositions and processing techniques. Our proven, high-volume manufacturing processes yield cost-effective, precision engineered components that consistently receive high performance ratings. Our rigid process controls allow components to be produced to net or near-net shape, thereby eliminating or reducing the need for diamond grinding. Components requiring close tolerances can be finish machined in our fully equipped precision diamond grinding facilities.

Features and Benefits

- Light weight (60% lighter than steel)
- Extremely high hardness
- Contact fatigue resistance
- Excellent fracture toughness

- Superior thermal shock behavior
- Exceptional wear resistance
- High dielectric strength
- Tribological compatibility with metals – low coefficient of friction
- Excellent high temperature oxidation resistance
- High chemical corrosion resistance

Grades of 3M™ Silicon Nitride

3M™ Silicon Nitride 147-1B is a reaction bonded, high-purity (>98%) grade of silicon nitride. It is a lower-cost alternative to fully dense silicon nitride grades and has a density of approximately 70-80% of theoretical. It offers excellent thermal shock resistance and outstanding compatibility with non-ferrous molten metals. 3M silicon nitride 147-1B can be manufactured to close tolerances without the need for diamond grinding.

3M™ Silicon Nitride 147-31N is a sintered, reaction bonded material which is fully dense and produced via Ceradyne's proprietary gas pressure sintering process. These ceramics feature a unique, pore-free microstructure of interlocking needle-shaped grains. This microstructure toughens the silicon nitride by a crack-deflection process similar to that found in composite materials. The result is a monolithic silicon nitride with high hardness and fracture toughness. 3M silicon nitride 147-31N can be produced in cost-effective, complex net shapes.



3M™ Silicon Nitride Components

3M™ Sintered Silicon Nitride is a sintered grade of silicon nitride. This material is produced at the 3M Kempten, Germany facility and is formed using iso-pressing. The primary applications are long tubes such as thermocouple protection tubes and heat riser tubes, both used in the aluminum and non-ferrous alloy industries. This material has excellent temperature response, is unaffected by corrosion, and is gas tight.

Key Features and Applications

Product	Key Features	Applications
3M™ Silicon Nitride 147-1B	High purity Net shape fabrication	Industrial applications Electrical insulators Sputtering targets
3M™ Silicon Nitride 147-31N	Strength Hertzian contact strength Structural reliability Net shape fabrication	Automotive components Bearings Wear components
3M™ Sintered Silicon Nitride	Excellent temperature response Gas tight	Thermocouple protection tubes Low pressure riser tubes

Typical Physical Properties

(Not for specification purposes)

Property	3M™ Silicon Nitride		
	147-1B	147-31N	Sintered Si ₃ N ₄
Process	Reaction Bonded	Sinter Reaction Bonded	Sintered (iso-pressing)
Purity (%)	>98.0	92.0	87.3
Density (g/cc)	2.3	3.2	>3.24
% Theoretical Density	70	98.5	99.5

Mechanical Characteristics

(Not for specification purposes)

Property	3M™ Silicon Nitride		
	147-1B	147-31N	Sintered Si ₃ N ₄
Flexural Strength (MPa)	190	800	800
Weibull Modulus	10	15–50	15
Elastic Modulus (GPa)	175	310	300
Poisson's Ratio	0.21	0.27	0.28
Hardness HV (5) kg/mm ²	800	1450	1530
Fracture Toughness (MPam ^{1/2})	2.5	6.0	7.0

Thermal Properties

(Not for specification purposes)

Property	3M™ Silicon Nitride		
	147-1B	147-31N	Sintered Si ₃ N ₄
Thermal Conductivity (W/mK) @ 25°C	6	26	27
Coefficient of thermal expansion (10 ⁻⁶ /K) 25°C –1000°C	2.9	2.9	3.2

Electrical Properties

(Not for specification purposes)

Property	3M™ Silicon Nitride		
	147-1B	147-31N	Sintered Si ₃ N ₄
Dielectric Constant	-	8	-
Electrical Resistivity (Ωcm)	10 ¹⁴	>10 ¹⁴	>10 ¹²

3M™ Silicon Nitride 147-1B and 3M™ Silicon Nitride 147-31N are manufactured and sold by Ceradyne, Inc., a 3M company.

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