

Fine Ceramics



We wish to be one of the sustainers of the affluent future. Our minute materials can help a big dream come true.



We are pioneers aiming to be the industry leaders. We answer the needs of the age with quality "Only-one" products.

We began developing silicon nitride (Si₃N₄) ceramics in the 1960 s,

and by providing numerous products to industries such as bearings, automobiles, and semiconductors, we have supported the foundations of various industries and the evolution of cutting edge technology. By using rare earth oxides, especially yttria (Y2O3),

as a sintering agent for silicon nitride (Si₃N₄), we succeeded in creating tough fine ceramics. Many highly reliable and high quality products are used in space and aircraft engine bearings and power module boards such as IGBTs, and have received high praise.

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Fine ceramic substrates with high thermal conductivity are becoming indispensable components under the circumstances needs for high power, high integration, slim and lightweight, high frequency and environmental friendliness prevail. We take advantage of one of our core technologies, the grain boundary control of ceramic microstructure, to produce the silicon nitride (Si₃N₄) substrates with the world highest thermal conductivity on a commercial basis.





Typical values for properties of fine ceramics for electronics

ltem		Measuring	U	nit	Silicon nitrides (Si₃N₄)		
		method			TSN-90		
Density		JIS Z8807	RT Mg/m ³		3.35		
σ.	Specificheat	JIS C2141		J/kg•K	650		
Then	Thermal conductivity	JIS R1611		W/m∙K	90		
mal rties	Coefficient of thermal expansion	JIS C2141	RT-500°C	x 10 ⁻⁶ /K	3.4		
Electrical properties	Dielectricstrength	JIS C2110-1	50Hz	kV/mm	25.0		
	Volume resistivity	JIS C2141	RT	Ω·cm	1×10 ¹⁵		
	Dielectric constant	JIS C2141	1MHz		8.0		
	Dielectric factor	JIS C2141	1MHz	tanδx10⁻₄	8.0		
_ 7	3-point bending strength	JIS C2141	RT	МРа	680		
/ech	Fracture toughness	JIS R1607	RT	MPa•m ^{1/2}	6.5		
anica	Young's modulus	JIS R1602	RT	GPa	300		
S	Poisson's ratio	JIS R1602			0.27		
		High thermal conductivity High strength					
	Ν	Substrates for semiconductor assembly Radiator plates (for compression force) Heat sinks					

The values in the table are reference values, not guaranteed values.

Silicon nitride (Si₃N₄) plain substrates

Toshiba Materials' silicon nitride plain substrates utilize material technology and sintering technology cultivated over many years to achieve a dense and fine structure, and have excellent mechanical properties and high thermal conductivity.

Silicon nitride's coefficient of thermal expansion is close to that of Si chips, making it ideal as a substrate for semiconductor mounting, and meeting the diverse needs of our customers.



Standard design

ltam	Unit	Silicon nitride (Si ₃ N ₄)			
item	Onit	TSN-90			
Outerdimensions	mm	MAX 170 x 130			
Outer dimensions	Tolerance	±0.15 (Laser cut)			
Thicknoss	mm	0.32			
THERIESS	Tolerance	±0.05mm			
Warp	mm/mm	0.4% Under (≦50mm)			
Surface area	_	Blast processing (Honing)			

 ${\it Values on the chart are standard \, design \, rule \, and \, not \, guaranteed \, value.}$

 ${\sf Please\,contact\,us\,for\,possibility\,of\,corresponding\,to\,designs\,not\,covered\,in\,above\,chart.}$

Temperature dependency of thermal conductivity and coefficient of thermal expansion



BeO, Al₂O₃ and Si are other companies' products.

In order to meet further needs for highly reliable semiconductor mounting substrates, we were quick to recognize excellent mechanical performances of silicon nitrides. As a result, we have taken the lead in the world in commercializing high thermal conductive silicon nitride insulated substrates for power semiconductors with more than four times thermal conductivity, which had been as low as alumina, while maintaining high strength.

Our high thermal conductive silicon nitride substrates are increasingly being used for PCUs (Power Control Units) of EVs (Electric Vehicles) and HEVs (Hybrid Electric Vehicles).



Comparison of thermal resistance (example)



Comparison of deflection characteristics of plain substrates



Power module model

A current is passed through the Si chip in the figure below, and the temperature rise due to the heat generated by the chip is converted to the thermal resistance value (Δ mV method).



Thermal resistance of silicon nitride substrate of 0.32mm thick is almost equivalent to that of aluminum nitride substrate of 0.635mm thick, which has higher thermal conductivity.



silicon nitride substrate does not crack and bends widely.

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Silicon nitride (Si₃N₄) Active Metal brazed layer Copper (AMC) substrates

We offer all purpose copper plated ceramic substrates by active metal brazing method to meet diversified requirements that have arisen in power module substrates.

Active metal brazed copper (AMC) substrates are made by joining copper circuit plate onto ceramic substrates by brazing. They are suitable for making fine patterned power module circuits with high thermal cycle performance. We offer silicon nitride AMC (SIN-AMC) substrates for the basement ceramic substrates.

AMC substrates are best fit for high power semiconductor module substrates such as power transistor substrates like IGBTs. They directly dissipate heat with sufficient insulation.

[Characteristics of SIN-AMC substrates]

- Simple structure with low thermal resistance. Specifically, thermal resistance of SIN-AMC substrate with the thickness of 0.32mm is almost equivalent to that of ALN-AMC substrate with the thickness of 0.635mm.
- Excellent mechanical strength properties; They have high thermal cycle performance even if the copper circuit is made thick (up to 0.8mm) to lower thermal resistance and increase power output.
- Their high fracture toughness allows direct ultrasonic bonding of electrode terminals onto the copper circuit plate and securing the substrate onto heat sink by rivets.
- $\bullet Coefficient of thermal expansion equivalent to that of ceramics substrates enables direct mounting of Si chips onto the copper circuit plate. \\$
- $\bullet {\sf Highjointstrengthofcoppercircuitplate} \ \bullet {\sf Highvoltageresistance}$

[Applications]

Standard design

• Powertransistor module (IGBT, MOSFET, etc.)

Ceramics	Type of ceramics: Silicon nitride (Si₃N₄)₀ Thermal conductivity 90W/mK (JIS R1611)						
[C] Ceramic thickness (mm)	0.25	0.32	0.635				
Tolerance (mm)	±0.05						
[A,B] Ceramic dimention (mm)	Maximum effective area 90x110 *For ceramics with a thickness of 0.25mm/0.32mm, we may be able to make sizes up to 125mm x 16 so please contact us for details.						
Tolerance (mm)	±0.15 ±0.20						



Cu									
0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60	0.70	0.80
	min.0.5 min.0.7						.0.7	min.1.0	
min.0.4		min.0.5			min.0.7		min.1.0		
mir		1.0.4		min.0.5	min.0.6	min.1.0		min.1.2	
±0.2		±0.3			±0.4		±0.5		
\leq 0.5D (less than 1/2 of the Cu)									
0.2/50 Under									
Rz≦15, (Ra≦6)									
≧9.8kN/m									
Electroless plating Ni / NiAu									
Ni:2~6µm / Ni:2~6µm, Au:0.05~0.1µm									
	UV curing type / Thermosetting type								
5~45μm									
	0.10	0.10 0.15 min.0.4 mir ±0.2 1	0.10 0.15 0.20 min.0.4 min.0.4 ±0.2	0.10 0.15 0.20 0.25 min.0.4 min.0.5 min.0.5 min.0.4 min.0.4 min ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ±0.2 ⊥ ⊥ ⊥	$\begin{tabular}{ c c c c } \hline & & & & & & & & & & & & & & & & & & $	Cu 0.10 0.15 0.20 0.25 0.30 0.40 min.0.5 min.0.5 min.0.5 min.0.6 min.0.6	Cu 0.10 0.15 0.20 0.25 0.30 0.40 0.50 min.0.5 min.0.5 min.0.5 min.0.6 min min.0.4 min.0.4 min.0.5 min.0.6 min ±0.2 ±0.3 ±0.3 ±0.4 ±0.4 ±0.5 ±0.5 ±0.2 ±0.3 ±0.3 ±0.4 ±0.2 ±0.3 ±0.4 ±0.4 ±0.2 ±0.3 ±0.3 ±0.4 min.0.5 min.0.6 min ±0.2 ±0.3 ±0.3 ±0.3 ±0.4 ±0.4 ±0.5 ±0.4 ±0.4 ±0.2 ±0.4 ±0.3 ±0.3 ±0.4<	Cu 0.10 0.15 0.20 0.25 0.30 0.40 0.50 0.60 min.0.5 min.0.7 min.0.4 min.0.5 min.0.6 min.1.0 \pm 0.2 \pm 0.3 \pm 0.6 min.1.0 \pm 0.2 \pm 0.3 \pm 0.4 \pm 0.4 \pm 0.2 \pm 0.3 \pm 0.4 \pm 0.4 Imin.0.5 min.0.6 \pm 0.2 \pm 0.3 \pm 0.4 \pm 0.4 Imin.0.5 min.0.6 \pm 0.2 \pm 0.3 \pm 0.4 \pm 0.4 Imin.0.5 min.0.6 \pm 0.2 \pm 0.3 \pm 0.4 \pm 0.4 Imin.0.5 min.0.6 \pm 0.2 \pm 0.3 \pm 0.4 \pm 0.4 Imin.0.5 min.0.6 Imin.0.5 min.0.6 \pm 0.2 \pm 0.3 \pm 0.4	Cu 0.10 0.15 0.20 0.25 0.30 0.40 0.50 0.60 0.70 min.0.5 min.0.7 min.0.7 min.0.7 min.0.4 min.0.5 min.0.6 min.1.0 min.0.7 min.0.4 min.0.5 min.0.6 min.1.0 min ±0.2 ±0.3 ±0.4 ±0.4 ±0.2 ±0.3 ±0.4 ±0 ±0.2 ±0.3 ±0.4 ±0 ±0.2 ±0.3 ±0.4 ±0 ±0.2/50 Under Electroless plating Ni/Ai ±0 UV curing type / Thermosetting Ni / NiAu UV curing type / Thermosetting type UV curing type / Thermosetting type UV curing type / Thermosetting type 5~45µm

*The value of a table is not a guaranteed performance *Please contact us for possibility of correponding to designs not covered in above chart.

Engineering ceramics Silicon nitride (Si₃N₄) ceramics

Among many ceramic materials, namely zirconia, silicon carbide and alumina, which are known to be used as engineering fine ceramics, we persistently produce silicon nitride ceramics as the only material for engineering ceramics.

We have well understood excellent properties such as high thermal conductivity and high strength of nitride ceramics from early-stages of the research. Then we have developed a grain boundary control technology and applied it to make Silicon nitride ceramics into stable, high-performance, high-functional materials and components.

Silicon nitride ceramics will show their well-balanced mechanical properties under high-speed rotation, high-speed sliding and high vacuum as they have good abrasion resistance, good corrosion resistance, insulation, heat resistance, etc.

We are looking forward to meet customer's diversified requirements with our silicon nitride ceramics.



Typical values for properties of engineering ceramics

Itoms		Measuring		Silicon nitrides (Si₃N₄)			
	items	method		TSN-03	TSN-08	TSN-23	
	Density	JIS Z8807	RT	Mg/m ³	3.23	3.27	3.27
	Hardness	JIS R1601	HV(20kgf)		1,500	1,600	1,500
			RT	MPa	1,000	1,000	900
	bendingstrength	JIS RIGUI	1000°C	MPa	750	900	700
		ASTM C1239	1200°C	MPa	450	850	400
	Conpression strengh		RT	MPa	5,000	4,500	4,000
	Young's modulus	JIS R1602	RT	GPa	308	308	313
and	Poisson's ratio	JIS R1602			0.29 0.29		0.28
thermal	Fracturetoughness	ASTM F2094	RT	$MPa \cdot m^{1/2}$	6~8	6~8	5~7
properties	Specific heat	JIS R1611		J/kg∙K	680 680		680
	Thermalconductivity	JIS R1611		W/m∙K	20	20	25
	Coefficient of thermal expansion	JIS R1618	RT-800°C	x10 ⁻⁶ /K	3.0	3.0	3.0
	Thermalshock temperature dierence		(△Tc)	°C	800	900	700
Electrical	Dielectricstrength	JIS C2110-1	50Hz	kV/mm	>14	>14	>14
properties	Volume resistivity	JIS C2141	RT	Ω·m	>1012	>1012	>1012
Corrosion*	Acid	•			Good	Good	Good
resistance	Alkali				Good	Good	Good
	Fea	itures	High strength Abrasion resistant	Heat resistant Abrasion resistant	Abrasion resistant Corrosion resistant (Electrical corrosion)		
	Recommenda	toryapplications	Bearings Engine parts Mechanical parts	Mechanical parts Refractory tools Heat-resistant and abrasion-resistant parts	Bearings Engine parts		

 ${}^{\star} Corrosion \, resistances \, were \, measured \, under following \, conditions.$

 $Acid;96\ hours immersion\ at\ RT\ in\ 36\% HC\ell, 95\% H_2SO_4\ and\ 60\% HNO_3 \quad Alkali; In\ 5\% NaOH\ and\ 40\% NaOH$

The values in the table are reference values, not guaranteed values.

High performances of silicon nitride ceramics

Silicon nitride (Si₃N₄) Bearing Balls

We offer light-weight, high strength, high rigidty and high abrasion resistant silicon nitride (Si_3N_4) ceramics for structural parts. They are especially fit for bearing balls and applied to various lines of industrial use.



Comparison of properties between silicon nitride (Si₃N₄) ceramics and high carbon chrome bearing steels; and features of ceramic bearings

ltem	Unit	Silicon nitrides	Bearingsteels (SUJ)	Features of ceramic bearings
Thermalresistance	°C	800	180	Heavy-duty bearings under elevated temperature
Density	Mg/m ³	3.24	7.8	$\label{eq:low} Low centrifugal force to rolling balls, causing long life and low temperature rising$
Coefficient of thermal expansion	x10 ⁻⁶ /K	3.0	12.5	Minimum dimensional deviation in inner clearances by temperature rising, causing low vibration and small change in pressurization
Hardness	Hv (20kgf)	1500	750	
Young's modulus	GPa	308	208	Minimum deformation in rolling contact members, causing high rigidness
Poisson's ratio		0.29	0.3	
Corrosion resistance		Good	Notgood	Serviceable under chemical environments including acidic and alkaline solutions
Magnetism		Nonmagnetism	Ferromagnetic material	Minimum rotational fluctuation made by magnetization under strong magnetic field
Electric conductivity		Insulator	Conductor	No electric corrosion especially in generators and motors
Modeofbonding		Covalentbonding	Metallicbonding	Minimum adhesion of contact parts caused by oil film breaking

The values in the table are reference values, not guaranteed values.

Results of load withstanding test for various ceramics



Courtesy of JTEKT Corporation

Silicon nitride (Si₃N₄) ceramics for automobiles

Silicon nitride ceramics, which are lighter than conventional metal parts, have high wear resistance, and have excellent corrosion resistance, were jointly developed in 1987 with Cummins Engine, the largest diesel engine manufacturer in the United States at the time, and it has been adopted for wear-resistant parts of the fuel system of diesel vehicles. Today, it is also used in parts of common rail systems for diesel fuel injection equipment.

Recently, silicon nitride ceramic balls, which have excellent wear resistance, have been adopted as a countermeasure against electrolytic corrosion of bearings used in electric vehicle (EV) motors, and are used as materials that can contribute to environmental problems.

By fusing "product technology" and "material technology" cultivated over 30 years in this way, we will provide products with excellent cost performance.



Bearing of motor for electric vehicle (EV)

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