

Silicon nitride ceramics

While there are many kinds of engineering fine ceramics materials-zirconia, silicon carbide and alumina, to name just a few-Toshiba devotes all its resources and attention to superior silicon-nitride ceramic materials and components.

Silicon nitride is a very well balanced material, able to meet diverse needs: our ceramics are suitable for use in high-temperature, vacuum, clean, chemical and ultra-high-speed environments.

Materials line-up

			Silicon Nitride (Si ₃ N ₄)					
			TSN-03	TSN-05	TSN-10	TSN-15	TSN-20	
Density		Mg/m ³	3.22	3.20	3.22	3.17	3.22	
Mechanical Prop.	Hardness	Hv(500g)	1,500	1,400	1,400	1,500	1,400	
	Bending	room temp	MPa	900	700	800	900	700
		1000°C		750	600	700	750	550
	JIS1601	1200°C		450	400	400	450	350
	3-point bend			4,000	3,200	3,200	3,500	3,200
	compression	R.T.	MPa	290	290	290	290	290
Young's modulus	R.T.	GPa	0.27	0.27	0.27	0.27	0.27	
Poisson's ratio			6~7	5~6	6~7	6~7	5~6	
Fracture toughness	K _{IC}	MPa·m ^{1/2}	680	680	680	670	670	
Thermal	Specific heat	J/kg·K	20	22	20	28	20	
	Conductivity	W/m·K	3.4	3.4	3.4	3.4	3.4	
	Expansion	RT-800°C	X10 ⁻⁶ /°C	800	600	600	600	600
	Critical diff. temp	(ΔT _c)	°C	800	800	600	600	600
	Max. util.temp		°C	>14	>14	>14	>14	>14
Electrical	Insulate	50Hz	kV/mm	>10 ¹²	>10 ¹²	>10 ¹²	>10 ¹²	>10 ¹²
	Volume Resistance	25°C						
		500°C						
	Dielectric const.	1MHz						
tan δ	1MHz	tan δ x10 ⁻⁴						
Corrosion*	Acid		good	fair	good	excellent	fair	
	Alkali		good	fair	good	good	fair	
	Molten glass		good	good	good	good	good	
	Molten metal			excellent	good	good	good	good
Advantages			high strength abrasion resistant corrosion resistant	heat resistant abrasion resistant corrosion resistant	abrasion resistant high strength	corrosion resistant high strength abrasion resistant	abrasion resistant	
Recommend Main Application			bearings engine parts machine parts abrasion resistance parts	machine parts thermal resistant jig	engine parts abrasion resist parts	bearings chemical equipment abrasion resist parts	machine parts abrasion resistance parts	

* Corrosion test conditions

acid : 36%HCl, 95%H₂SO₄, 60%HNO₃; R.T., 96Hr dipping
glass: molten soda lime glass dipping

alkali: 5%NaOH, 40%NaOH dip ping
metal: molten Zn, Sn, Al dip ping

Silicon nitride ceramic bearing

Toshiba, working with Koyo Seiko Co., Ltd., achieved commercialization of silicon-nitride ceramic bearings in 1984. The many advantages enjoyed by ceramic bearings-heat and corrosion resistance, light weight, high degree of insulation and non-magnetism-soon earned their incorporation in ultra-high-speed rotation, heat-treatment furnaces, chemical production equipment,

semiconductor equipment and other applications.

The quality of our ceramic bearings was confirmed by NASA approval in 1995, and they are now used as the ball bearings of the Space Shuttle's turbo-molecular pump. Another recent application is as the bearings in the spindle motor found in HDD.



■ Features of TOSHIBA fine ceramic bearings and comparison with steel bearings

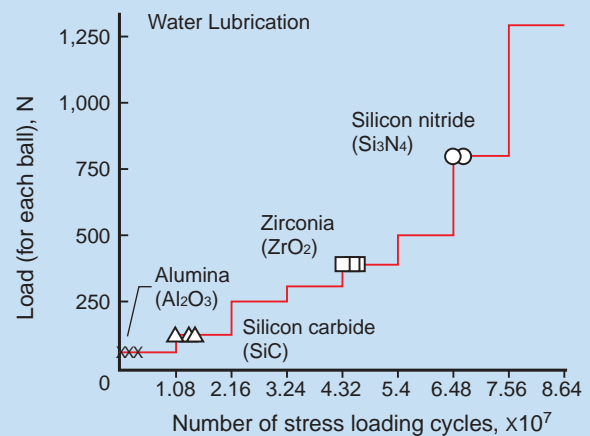
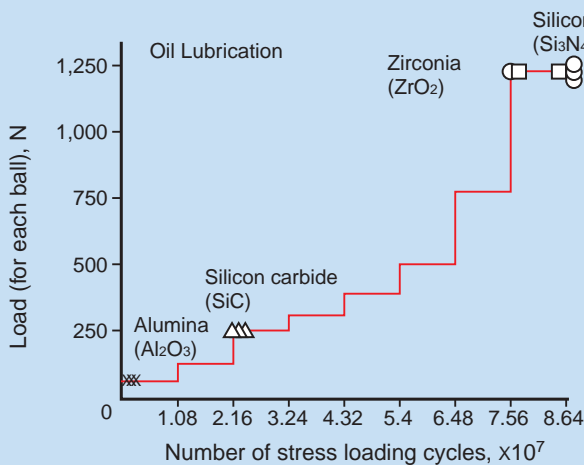
Item	Unit	Ceramic Material (Si ₃ N ₄)	Steel Bearings (SUJ)	Advantages of Ceramic Bearings
Heat Resistance	°C	800	180	Higher load durability maintained in high-temperature ranges
Density	Mg/m ³	3.2	7.8	Reduction of centrifugal force induced by rolling elements (balls or rollers) → Increased service life and restricted increase in temperature
Thermal Expansion		3.2x10 ⁻⁶	12.5x10 ⁻⁶	Smaller change of internal clearance caused by temperature rise → Reduced vibration, small change of preload
Hardness	HV	1500	750	Smaller change of deformation at rolling contact point → High rigidity
Young's Modulus	GPa	320	208	
Poisson's Ratio		0.29	0.3	
Corrosion Resistance		good	poor	Can be used in acid solutions, alkali environments, and other special environments
Magnetism		non-magnetic	ferro-magnetic	Smaller speed fluctuation caused by magnetism in intense magnetic field
Electric Conductivity		insulator	conductor	Eliminates electric pitting (applicable to electric motors, etc.)
Bonding of raw material		covalent	metallic	Minimized seizure (or cohesion) at contact points, usually resulting from discontinued oil film

Withstand load test for various types of ceramic materials

(Offered by Koyoseiko)

• Test Condition

	Oil Lubrication	Water Lubrication
Lubricant	Spindle Oil	City Water
Material to be mated	3/8 inch high carbon chrome bearing steel (SUJ2) balls	3/8 inch silicon nitride (Si ₃ N ₄) balls
Load	Increase of load in stages at every 1.08X10 ⁷ cycles	
Rotation Speed	1200rpm	

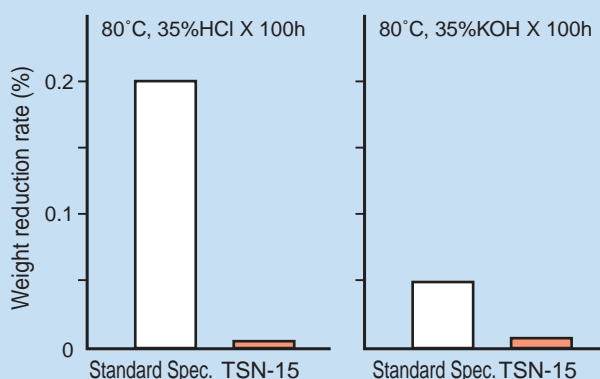


Corrosion Resistance of Ceramic Bearings (TSN-15)

(Offered by Koyoseiko)

Weight reduction rate and bending strength reduction rate of ceramic material after corrosion resistance test

• Weight reduction rate after immersion



• Bending strength reduction rate after immersion

