

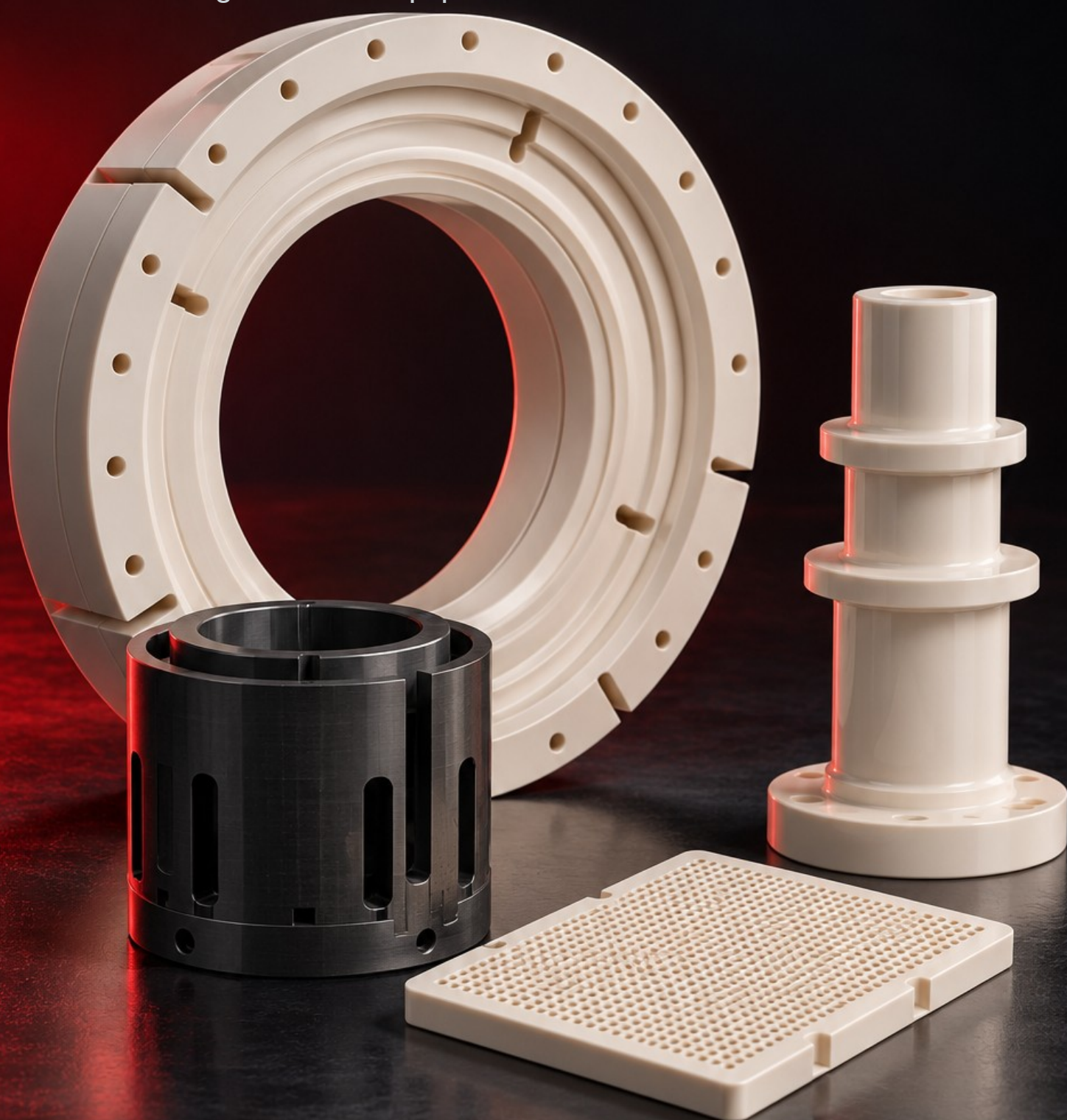


Great Ceramic
Making Great Ceramic

COMPANY &
ENGINEERING GUIDE

PRECISION CERAMICS

For demanding industrial equipment



Precision ceramic component concepts

Advanced ceramics. From prototype to production.

ENGLISH EDITION / 2026

great-ceramic.com

Advanced ceramics. Engineered around your component

Great Ceramic supplies custom ceramic components for electrical insulation, thermal management, wear resistance and demanding operating conditions.

Our work connects material selection, precision manufacturing and application support. From the first sample to repeat production, we focus on the features that determine how your component performs.

- 01

Materials matched to the application

Oxides, nitrides, carbides and machinable glass ceramics for different thermal, electrical and mechanical duties.
- 02

Precision where the part needs it

Machining, grinding, laser processing and joining support complex geometry and critical working surfaces.
- 03

A clear route from sample to supply

Material, drawing revision, inspection requirements and delivery scope come together in the project specification.

YOUR GUIDE

Company & markets	03–06	Services & capability data	07–16
Applications & material profiles	17–33	Design knowledge & contact	34–42

The capacity behind a precision component



Ceramic manufacturing and machining



Since 2013

ADVANCED CERAMICS EXPERIENCE

11

CERAMIC MATERIAL OPTIONS

Prototype to Production

CUSTOM COMPONENT SUPPLY

650

CUSTOMERS SERVED / CUMULATIVE

Manufacturing advanced ceramics since 2013

Great Ceramic supplies custom ceramic components for equipment manufacturers worldwide. Our Shenzhen operation combines material selection, precision machining and finishing with project support, from development samples to repeat production.

The process behind a precision component



Precision ceramic machining

Material to interface

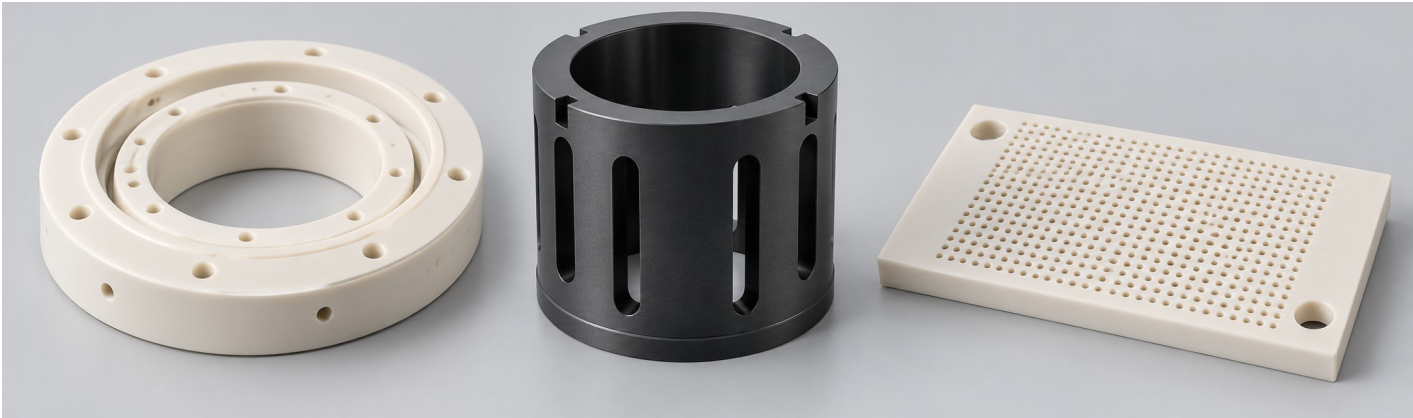
GEOMETRY
SURFACE
FUNCTION

Our manufacturing capabilities connect the material blank to the finished interface. Each route balances geometry, surface requirements and production volume.

Manufacturing capability	Role in the finished part
CNC machining	Profiles, holes, slots and relationships between faces
Precision grinding	Flatness, thickness, bores and mating diameters
Lapping and polishing	Sealing faces and controlled contact surfaces
Laser processing	Substrate profiles, apertures, grooves and snap lines
Forming and sintering	Blanks and near-net shapes for repeat geometry
Metallization and brazing	Coated interfaces and ceramic-to-metal assemblies

One component specification across the route

Built for international industrial buyers



Complex ceramic geometries for equipment integration

38

EXPORT DESTINATIONS
CUMULATIVE

240

ACTIVE CUSTOMERS

1,800

ANNUAL PRODUCTION
WORK ORDERS

Active customers and annual work orders: September 2025–August 2026.

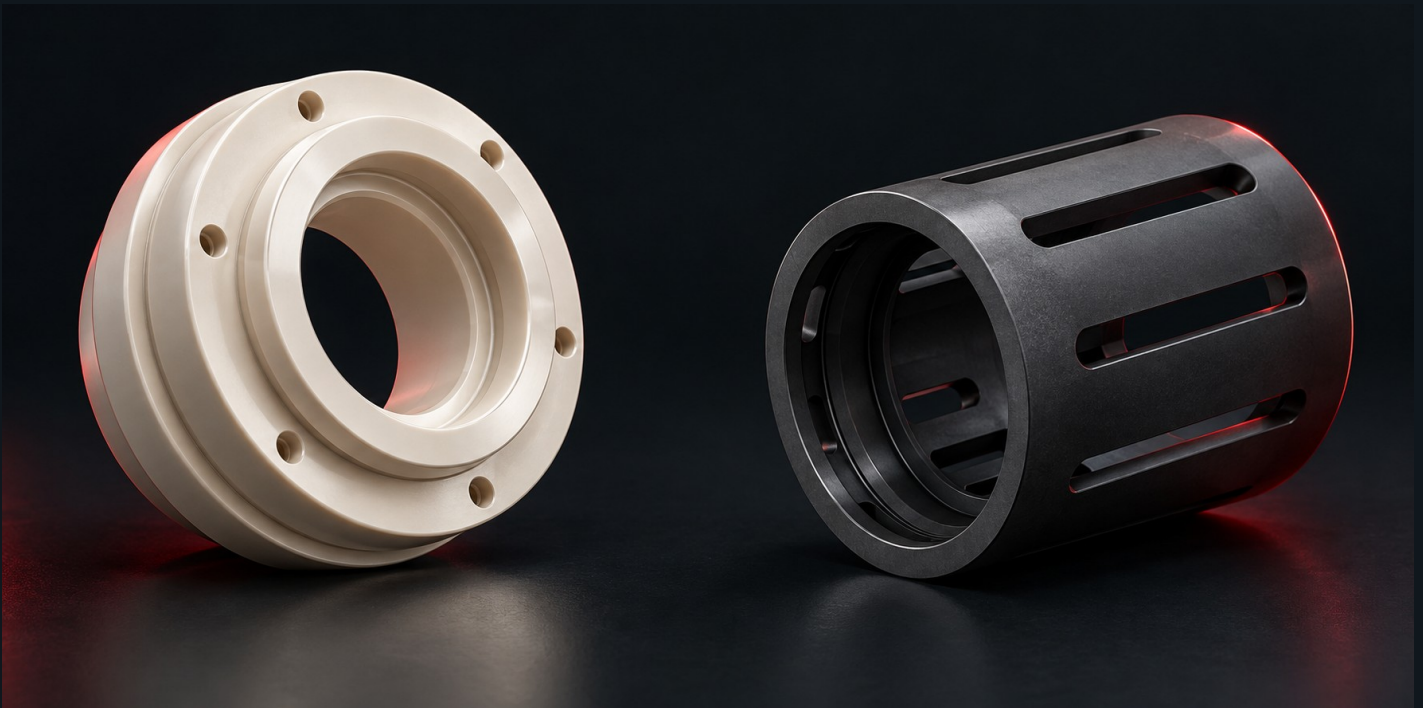
Market	Typical component requirements
Semiconductor & electronics	Process fixtures, insulating parts and thermal substrates
Industrial machinery & automation	Guides, sleeves, locating parts and wear surfaces
Chemical processing, oil & gas	Seal rings, valve parts and process-resistant components
Instruments, medical & aerospace equipment	Precision supports, insulation and thermal stability

Application review, samples and repeat supply, with inspection and delivery requirements defined for each order.

Industry suitability and qualification depend on the component and its intended use.

The interface defines the part

Rings and seats. Sleeves and guides. Plates, insulators and complex housings.



Precision ceramic component concepts

Stepped rings

Locating shoulders, contact faces and controlled edges.

Slotted housings

Slots, thin sections and access to internal features.

Components for critical working interfaces

Rings, sleeves, substrates, insulating supports and complex housings are supplied in material grades and finishes matched to each design.

Custom components are manufactured to the agreed material grade and drawing.

Complex geometry, controlled critical features



±0.005

mm

**CNC machining
tolerance capability**

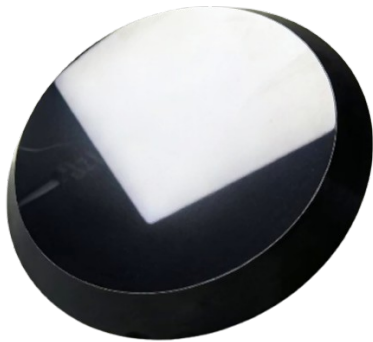
Subject to material,
feature and geometry

CNC machining combines tool access, fixturing and diamond tooling to produce holes, slots, profiles and multiple functional faces in technical ceramics.

Feature	Engineering review	Why it matters
Multi-face geometry	Datum scheme and machining access	Relationships between assembled features
Holes, slots and recesses	Tool reach, depth and edge distance	Machinability and edge integrity
Precision fits	Local tolerance and finishing route	Fit without unnecessary cost
Thin or fragile features	Support during cutting and handling	Reduced risk of local damage

Four- and five-axis machining. Achievable tolerance depends on material, feature size, geometry and inspection method.

Precision finishing for fits, contact and sealing



**Fit
Contact
Sealing**

Grinding, lapping and polishing refine the dimensions and surfaces that control fit, sealing and contact. Size, form and edge integrity are considered together.

Process	Tolerance*	Surface finish*	Typical features
Surface grinding / polishing	± 0.002 mm	Ra 0.02 μm	Flat faces and plates
ID / OD / cylindrical grinding	± 0.002 mm	Ra 0.02 μm	Shafts, bores and sleeves
Centerless grinding / polishing	± 0.001 mm	Ra <0.02 μm	Rod and pin diameters
Fine grinding / lapping	± 0.001 mm	Ra <0.02 μm	Sealing and contact faces

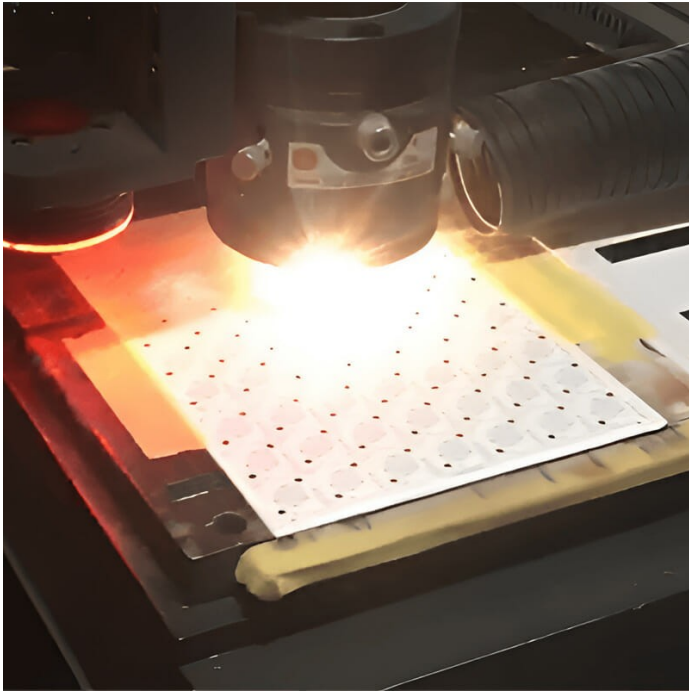
Surface quality defined by function

Inspection covers the specified datum, finish, measurement direction and edge condition.

*Capability references. Final tolerances and surface finish depend on material, size, geometry and measurement conditions.

Thin substrates.

Precise profiles and apertures



Laser processing



Laser-processed AlN substrates

Cut profiles, holes, grooves and snap lines in ceramic substrates. The review combines thickness, spacing and finished-edge quality with the required geometry.

Processing envelope	Reference value
Maximum working area	250 × 250 mm
Maximum thickness: alumina / AlN / zirconia	2.0 / 3.0 / 1.0 mm
Minimum aperture / hole-to-edge distance	0.02 / 0.2 mm

Capability depends on material, thickness and feature geometry. Full dimensional tolerances follow on p. 10.

Laser cutting

thickness-dependent tolerances

Dimensional control depends on substrate thickness and the feature being processed. The following ranges support the specification of profiles, holes, snap lines and finished edges.

Dimensions in mm. T = substrate thickness.

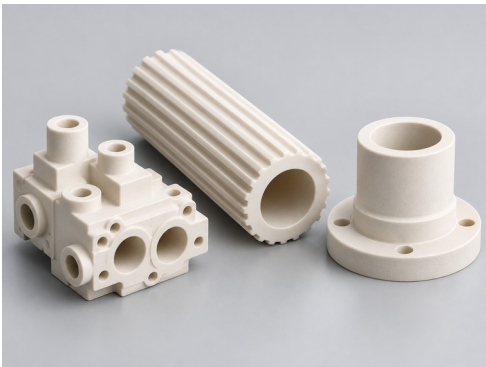
Feature / thickness range	General	Precision
Length: $T \leq 0.645$	+0.20 / -0.05	+0.15 / -0.05
Length: $0.635 < T \leq 1.0$	+0.25 / -0.10	+0.20 / -0.05
Length: $1.0 < T \leq 1.2$	+0.30 / -0.10	+0.25 / -0.10
Thickness	$\pm 10\%$; min ± 0.05	$\pm 7\%$; min ± 0.05
Snap-line or hole-to-hole spacing	± 0.05	± 0.05
Hole diameter: $T \leq 0.645$	± 0.075	± 0.05
Hole diameter: $T > 0.635$	± 0.10	± 0.075
Edge to snap-line / hole: $T \leq 0.645$	+0.15 / -0.05	+0.15 / -0.05
Edge distance: $0.635 < T \leq 1.0$	+0.20 / -0.05	+0.20 / -0.05
Edge distance: $1.0 < T \leq 1.2$	+0.25 / -0.10	+0.25 / -0.10
Overall camber	0.3%; min 0.05	0.25%; min 0.05
Parallelism / perpendicularity	0.3% of long edge	0.2% of long edge

At $T = 0.635\text{--}0.645$ mm, the applicable tolerance band is confirmed during technical review. Capability limits are evaluated together with material and geometry.

Forming routes for geometry and production volume

A machined blank may suit an early prototype. For repeat geometry, a forming route can reduce the stock and machining needed. Critical interfaces can still be finished after sintering.

Forming route	Part or volume fit	Review before tooling
Injection molding (CIM)	Small, complex repeat components	Wall transitions, ejection and shrinkage
Extrusion	Tubes, rods and continuous sections	Cross-section and straightness
Hot die casting	Intricate small near-net shapes	Release, detail and distortion
Isostatic pressing	Uniform blanks and larger stock shapes	Blank allowance and final machining
Dry pressing	Simpler shapes for repeat quantities	Press direction and thickness

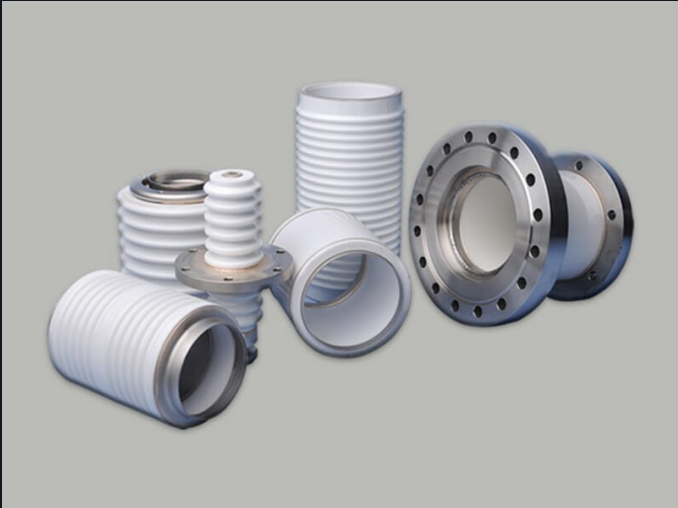


Ceramic preform concepts

From formed blank to finished component

The process route combines forming and sintering with finishing where required. Functional interfaces receive the machining, grinding or polishing specified by the drawing.

Metallized ceramics and ceramic-to-metal assemblies



Metallized surfaces

Metallized ceramics provide surfaces for electrical connection and joining. Coating, masking and plating follow the component specification.

Brazed assemblies

Brazed assemblies combine ceramic performance with metal mounting and connection features. Joint design considers expansion, temperature and sealing.

Metallized surfaces	Brazed assemblies
Metallization route and coating stack	Ceramic and metal grades
Plating: nickel, gold, silver or tin as applicable	Joint gap, geometry and assembly datums
Coating thickness and masked boundaries	Leak / strength method and acceptance limit
Adhesion and surface preparation	Thermal cycle and operating environment

Substrate properties and joining capabilities follow on pp. 13–14.

Metallized alumina substrate properties

The table below applies to the listed metallized-alumina series. These values are distinct from the general alumina data on p. 23.

Property / test condition	96%*	97%	99%	99.6%
Al ₂ O ₃ content (%)	≥95*	≥97	≥99	≥99.6
Listed size range (mm)	0.5–500	0.5–500	0.5–500	0.5–500
Listed best accuracy (mm)	0.01	0.01	0.01	0.01
Density (g/cm ³)	≥3.67	≥3.70	≥3.85	≥3.90
Flexural strength, 25°C (MPa)	≥300	≥300	≥350	≥400
Thermal conductivity (W/m·K)	10–20	10–20	15–21	15–21
CTE, 20–500°C (10 ⁻⁶ /°C)	7.36	6.9	6.9	6.9
Dielectric constant, 1 MHz / 20°C	9.1	9.5	9.8	10
DC breakdown strength (kV/mm)	≥30	≥35	≥25	≥25
Volume resistivity, 100°C (Ω·cm)	≥10 ¹⁴	≥10 ¹⁴	≥10 ¹⁴	≥10 ¹⁴

The order specification defines the substrate composition and coating requirements.

Coating definition

Mark metallized areas, masking, plating material, layer thickness and adhesion criteria on the drawing.

Joining capabilities for integrated assemblies

Ceramic-to-metal assemblies combine electrical or thermal functions with metal mounting and connection features. The joint design addresses expansion mismatch, operating conditions and the required seal.

Process / characteristic	Capability reference
Mo–Mn metallization firing	Approximately 1,500°C, reducing H ₂ /N ₂ atmosphere
Typical brazing temperature	750–1,000°C
Typical joint strength	>150 MPa; material and joint dependent
Reported best hermeticity	Down to 10 ⁻¹¹ Pa·m ³ /s; test conditions apply
Vacuum / controlled-atmosphere brazing	Up to 2,200°F
Joint clearance control	±0.001 in

Joint design

Ceramic, metal, filler, clearance and coating form one assembly specification.

Acceptance

Leak rate, joint strength and thermal cycling require an agreed test method and acceptance limit.

Reference capabilities vary with material and joint design. Test conditions and achievable values are confirmed for the specified assembly.

From the first sample to repeat production

We support one-off development components, small batches and ongoing supply. Prototypes provide a route to evaluate fit, manufacturing features and application performance before the design enters repeat production.

Project requirement	Capability / approach
Quantity	One-off parts to 2,000+ pieces
Dimensional tolerance	± 0.05 to ± 0.002 mm, depending on the feature and process
Quotation	Based on the drawing, material, quantity and delivery requirements
Production schedule	Confirmed for the material, geometry and finishing route
Repeat supply	Approved drawing revision, inspection scope and delivery plan

- 01

Technical review

Material, geometry, critical features and process route.
- 02

Sample evaluation

Dimensional inspection and application testing.
- 03

Production release

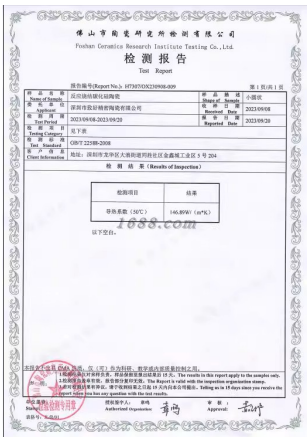
Confirmed drawing, acceptance requirements and delivery scope.

New tooling, material preparation and specialist processes may affect minimum quantity and lead time.

Quality defined at the component level

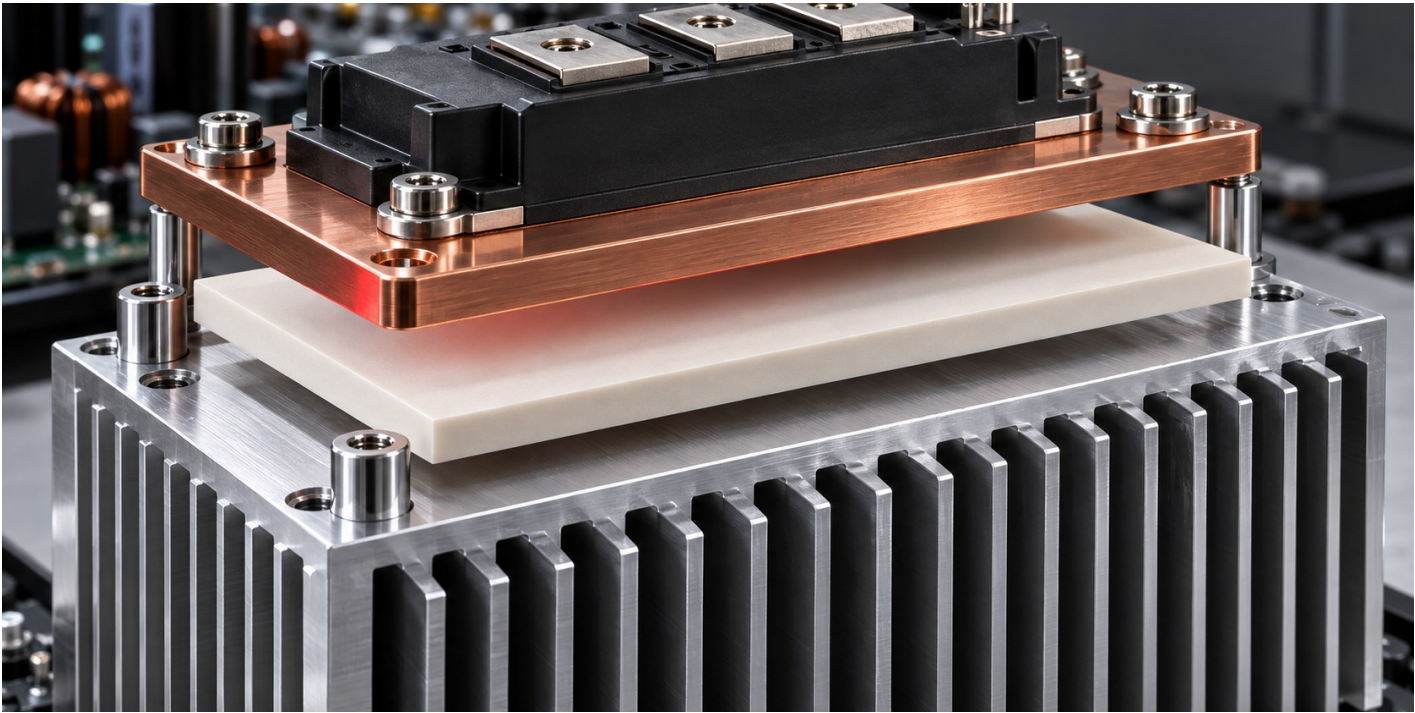
Our project review connects the drawing to the material, inspection scope and delivery requirements. This gives engineering, production and incoming inspection a common basis for acceptance.

Requirement	Control and documentation
Material identity	Supplier grade, applicable specification and batch documentation
Critical dimensions	Drawing revision, datums, feature controls and inspection method
Functional surfaces	Roughness, flatness, edges and appearance criteria
Sample approval	Assembly or application test, result and drawing changes
Release and delivery	Report scope, sampling, marking and protective packaging



Certificate validity is subject to surveillance. Current documentation is available for supplier qualification.

Ceramics for thermal and electrical performance



Power module thermal-stack concept

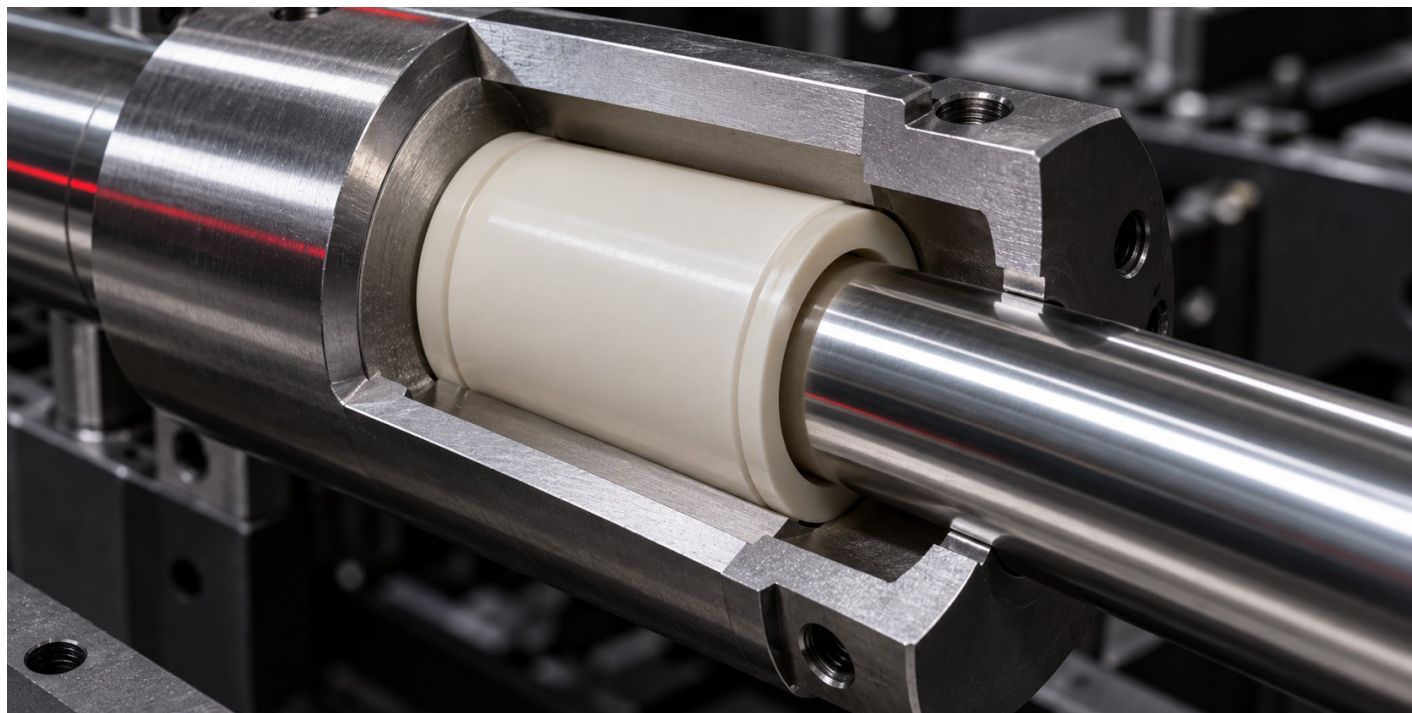
Thermal substrates and insulating interfaces

For power electronics, laser packages and semiconductor equipment, the ceramic may have to transfer heat while separating electrical functions. Review the complete mounting stack.

Part / function	Material direction	Validate on the assembly
Thermal substrate / heat spreader	AlN-170 / 200 / 230	Temperature rise, isolation and flatness
Insulating support / process fixture	Alumina or qualified grade	Position, cleanliness and service temperature
Sealed electrical interface	Metallized ceramic / brazed assembly	Leak test, insulation and thermal cycling

Application example. Material data: pp. 23–24. Thermal and assembly guidance: pp. 37–39.

Wear-resistant components for motion and process equipment



Cutaway of a guide-sleeve concept

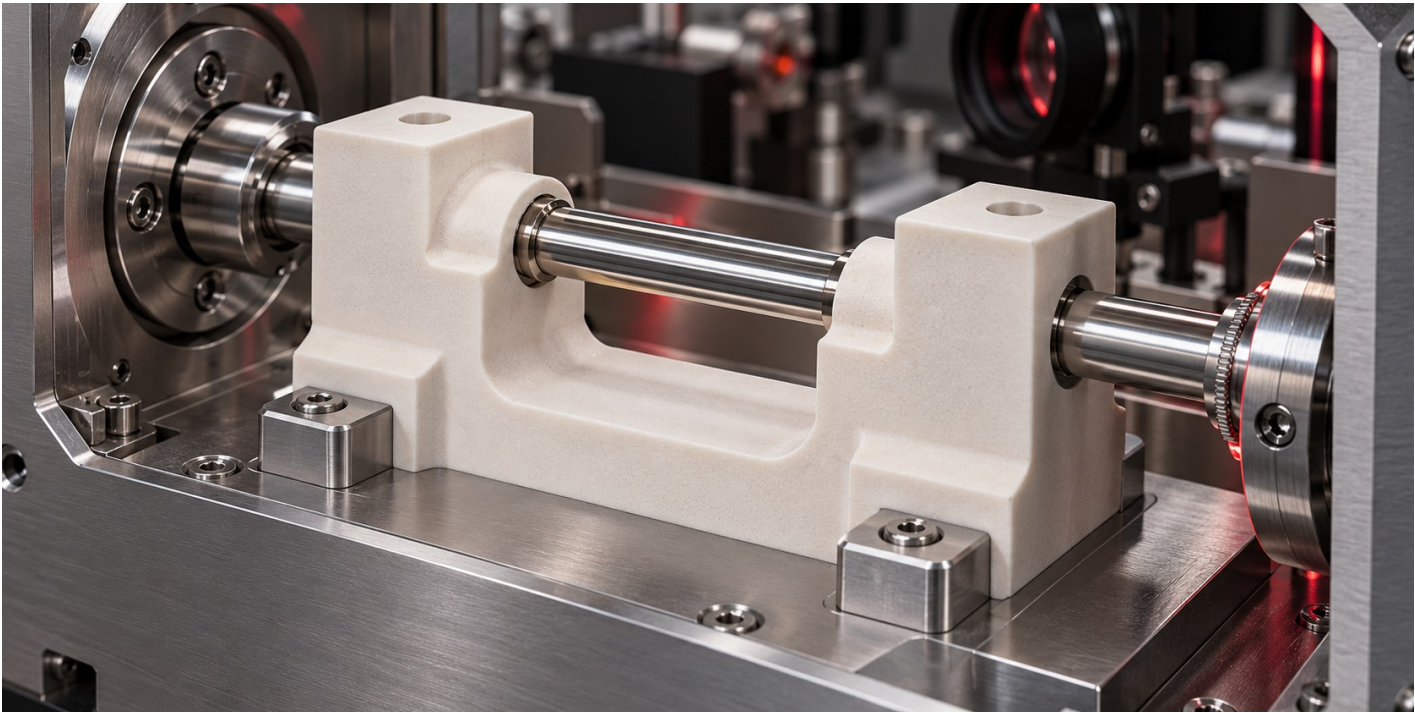
Guides, sleeves, seals and wear surfaces

In automation, pumps, valves and process equipment, a hard material is only one part of the answer. Mating material, pressure, lubrication, alignment and particles determine the wear mechanism.

Part / market	Material direction	Define the trial
Shaft / sleeve / guide: machinery	Zirconia, alumina, ZTA	Fit, contact finish and wear rate
Seal / valve seat: chemical, oil & gas	SiC or qualified oxide grade	Medium, pressure and sealing behavior
Roller / motion element: equipment	Silicon nitride	Contact load, lubrication and duty cycle

Application example. Material choice depends on the actual medium, load, lubrication and duty cycle.

Precision for instruments and demanding equipment



Instrument-fixture assembly concept

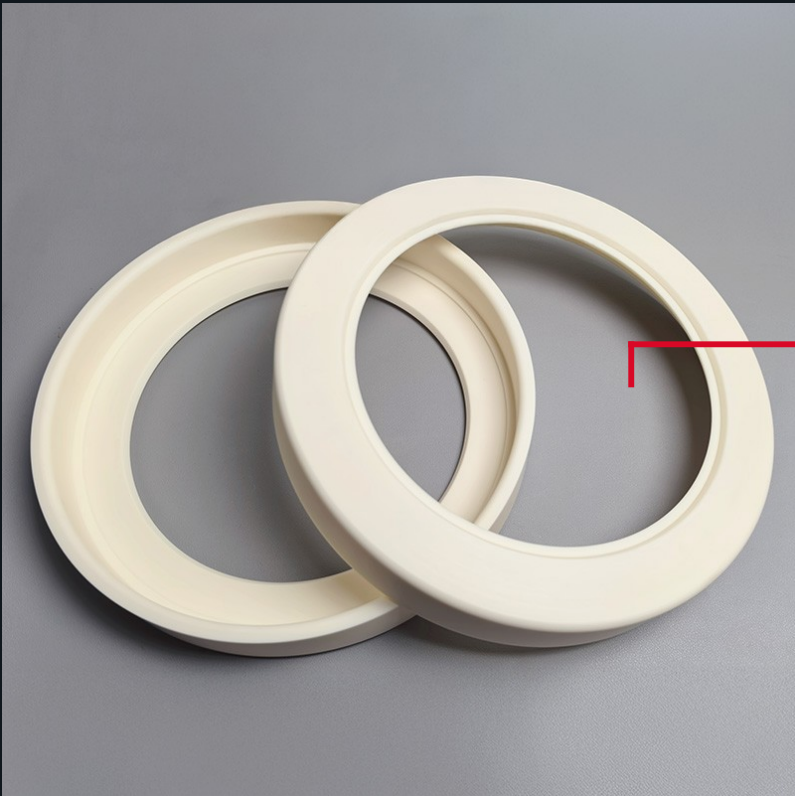
Complex fixtures and insulating structures

Laboratory, medical-device and aerospace equipment can combine small features, electrical isolation and thermal movement. Prototype the geometry, then verify the complete service conditions.

Part / function	Material direction	Review and validate
Instrument bracket / coil former	MGC or alumina	Tool access, fit and electrical clearance
Hot fixture / process support	BN or suitable oxide grade	Atmosphere, contamination and temperature cycle
Precision locating / wear part	Zirconia or silicon nitride	Load, vibration and interface stability

Application example. Medical and aerospace requirements, including qualification and sterilization, are assessed for the intended use.

A ring is more than two diameters



Stepped ceramic ring geometry

Locating diameter

A controlled locating diameter establishes the position and fit of the mating part.

Annular shoulder

The shoulder can locate, seal or support a mating part. Form and finish follow the intended function.

Edges and transitions

Controlled chamfers and edge quality help protect the part during handling and assembly.

Before the sample	What the review must establish
Operating conditions	Temperature cycle, medium, load and the mating material
Critical characteristics	Material grade, datum, size, form and surface condition
Acceptance	Dimensional record plus a relevant fit or functional test

Illustrative design considerations for a stepped ceramic ring. Final characteristics follow the component drawing.

START WITH YOUR PART

Send the drawing. Tell us what must work.

Share a dimensioned PDF and a 3D model if available, the operating conditions, quantity and required delivery date. Mark the critical fit, contact, thermal or electrical features.

Discuss the grade, process route and acceptance requirements.

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Continue into the engineering reference

Materials & grades 22–33

Design & application knowledge 34–41 Contact 42

Materials for demanding component requirements

This reference covers eleven material profiles with grade descriptions and performance data. Select a candidate by its operating duty, then check the actual grade and test conditions.

Primary design need	Candidate families	Pages
Electrical insulation and wear	Alumina	23
Heat transfer with electrical isolation	AlN; specialist BeO applications	24 / 27
High-temperature process tooling	BN and composite BN	25–26
Intricate insulating prototypes	Machinable glass ceramic	28
Strength and thermal cycling	Silicon nitride	29
Abrasive or chemical process duty	Silicon carbide	30
Mechanical interfaces and wear	Y-PSZ, ZTA and Mg-PSZ	31–33

A family name is not a complete specification

Grade, processing route, direction, temperature and test method affect the values. A material that performs well in one condition may behave differently in your assembly.

Typical values support preliminary selection. They are not guaranteed component acceptance limits.

Alumina

Al₂O₃ / THE VERSATILE WORKHORSE

A practical starting point for electrical insulation, abrasion resistance and stable structural support. Alumina suits everything from a simple spacer to a precision process component.



Material and component forms

GRADES & CHARACTERISTICS

95%, 99% and 99.5% alumina are compared below. Additional options include 96%~99.9% and black alumina, with specifications confirmed for the selected grade.

Typical parts: insulators, spacers, rings, plates, substrates and wear guides.

Property / test condition	95%	99%	99.5%
Density (g/cm ³)	3.7	3.85	3.9
Hardness (GPa)	13.7	15.2	15.7
Compressive strength (MPa)	2,000	2,160	2,350
Flexural strength (MPa)	280	310	350
Fracture toughness (MPa·√m)	3–4	3–4	4.5
Young's modulus (GPa)	320	360	370
Max. temperature, no load (°C)	1,650	1,650	1,650
Thermal conductivity, 20°C (W/m·K)	24	29	32
CTE, 20–400°C (10 ⁻⁶ /°C)	7–8	7–8	7–8
Dielectric constant, 1 MHz	9.4	9.9	9.9
Dielectric strength (10 ⁶ V/m)	15	15	15
Volume resistivity, 25°C (Ω·cm)	>10 ¹⁴	>10 ¹⁴	>10 ¹⁴

The table applies only to the stated 95%, 99% and 99.5% grades. Other purities and black alumina require their own grade specification.

Aluminum nitride

AlN / THERMAL MANAGEMENT

Move heat away from power devices while maintaining electrical isolation. AlN is a useful candidate when the thermal path through the ceramic is a significant part of the assembly resistance.



Material and component forms

GRADES & CHARACTERISTICS

AlN-170: economical thermal substrates. AlN-200: increased heat spreading for demanding modules. AlN-230: the highest-conductivity grade listed. BN+AlN composite: a separate machinable composite option; request its own data sheet.

Typical parts: power substrates, heat spreaders, laser supports and insulating thermal components.

Property / test condition	AlN-170	AlN-200	AlN-230
Thermal conductivity (W/m·K)	≥170	≥200	≥230
Flexural strength (MPa)	300–400	350–450	350–450
CTE (10 ⁻⁶ /K)	~4.5	~4.5	~4.5
Dielectric strength (kV/mm)	>15	>15	>15
Volume resistivity (Ω·cm)	>10 ¹⁴	>10 ¹⁴	>10 ¹⁴
Max. temperature, inert gas (°C)	≥1,000	≥1,000	≥1,000
Oxygen content (wt%)	0.5–1.0	≤0.5	≤0.3

Specify flatness, surface finish, metallization area and the complete mounting stack. A higher conductivity grade alone does not guarantee a cooler device.

Conductivity is grade specific; the test temperature must be confirmed in the grade specification. Assembly thermal resistance also depends on thickness, contact and interfaces.

Boron nitride

BN / PURE GRADES

Machinable, electrically insulating BN supports high-temperature and clean process applications. Atmosphere and material direction matter: a BN grade for a furnace fixture is not automatically a substitute for a deposition crucible.



Material and component forms

GRADES & CHARACTERISTICS

GCBN-HBN1: standard hexagonal BN. GCBN-HBN2: higher-purity hexagonal BN. GCBN-PBN: pyrolytic BN for high-purity process components. PBN properties can be direction dependent.

Typical parts: crucibles, nozzles, furnace supports, insulating blocks and process fixtures.

Property / condition	HBN1	HBN2	PBN
BN purity (%)	≥99	≥99.5	≥99.99
Density (g/cm ³)	2.0–2.3	≥2.0	1.95–2.22
Oxygen content (%)	0.46	<0.3	<0.1
Flexural strength (MPa)	38	40–50	80
Compressive strength (MPa)	110–150	120–160	Not stated
CTE (10 ⁻⁶ /K)	2.0–2.8	2.0–2.5	2.0 (a); 2.6 (c)
Thermal conductivity (W/m·K)	30–50	50	82.3 at 200°C
Thermal conductivity, 900°C (W/m·K)	Not stated	Not stated	55.3
Max. in air (°C)	900	900	Not specified
Max. in vacuum / inert gas (°C)	2,100 / 2,300	2,100 / 2,300	See note
Volume resistivity (Ω·cm)	>10 ¹⁴	>10 ¹⁴	10 ¹⁵

PBN is listed at 2,000+°C without an atmosphere definition; confirm the intended service condition. HBN temperature limits differ greatly between air, vacuum and inert gas.

Composite boron nitride

BN / SIX ENGINEERED COMPOSITE GRADES

Composite grades adjust strength, thermal conduction and wear behavior by combining BN with another ceramic phase. Select the named composition before comparing the numbers.



Boron nitride component form

GRADES & CHARACTERISTICS

GCBN-B: BN+Zr+Al. GCBN-C: BN+SiC. GCBN-D: BN+ZrO₂. GCBN-E: BN+AlN. GCBN-S2 and S3: BN+Si₃N₄, with different mechanical properties.

Selection cue: GCBN-E emphasizes heat conduction; S2/S3 offer higher listed strength. Evaluate chemical compatibility and process cleanliness separately.

Property	B	C	D	E	S2	S3
Density (g/cm³)	2.25–2.35	2.40–2.50	2.8–2.9	2.8–2.9	2.55–2.65	2.75–2.85
Flexural strength (MPa)	65	85	115	120	220	320
Compressive strength (MPa)	110	130	225	220	420	480
CTE (10 ⁻⁶ /K)	2.0	2.8	3.5	2.8	2.7	2.7
Thermal conductivity (W/m·K)	30	30	20	80	40	40
Max. in air (°C)	1,000	1,000	1,000	1,000	1,000	1,000
Max. vacuum / inert gas (°C)	1,800	1,800	1,800	1,800	1,800	1,800
Volume resistivity (Ω·cm)	>10 ¹³	>10 ¹²	>10 ¹²	>10 ¹³	>10 ¹³	>10 ¹³

Column names use the GCBN- prefix. Conductivity and strength require confirmation of test temperature in the current grade data sheet.

Beryllium oxide

BeO / SPECIALIST THERMAL INSULATION

BeO combines heat conduction with electrical insulation for selected RF, microwave and thermal-management applications. Material selection must include the full manufacturing and handling route.



Material and component forms

GRADES & CHARACTERISTICS

B97: baseline BeO. B99: increased thermal and dielectric performance. B99.5: higher purity and thermal performance. BeO attenuators require a separate component specification.

Typical parts: RF heat spreaders, insulating substrates and dedicated microwave components.

Property / test condition	B97	B99	B99.5
Density (g/cm³)	≥2.85	≥2.85	≥2.88
Flexural strength (MPa)	≥170	≥200	≥200
Thermal conductivity, 25°C (W/m·K)	≥200	≥260	≥285
Thermal conductivity, 100°C (W/m·K)	≥160	≥190	≥200
CTE, 25–500°C (10 ⁻⁶ /K)	7–8.5	7–8	7–8
Dielectric constant, 1 MHz	6.9 ±0.4	6.6 ±0.2	6.6 ±0.2
Dielectric constant, ~10 GHz	6.9 ±0.4	6.9 ±0.2	6.8 ±0.2
Dielectric loss, 1 MHz	≤0.0004	≤0.0004	≤0.0004
Dielectric loss, ~10 GHz	≤0.0008	≤0.0006	≤0.0004
DC breakdown strength (kV/mm)	≥15	≥30	≥40
Grain size (µm)	12–30	10–20	10–20

Specialist handling: BeO dust presents a serious inhalation hazard. Do not machine or grind outside an approved specialist process with appropriate exposure controls. Follow the material SDS.

Machinable glass ceramic

MGC / COMPLEX SHAPES FROM STOCK

MGC is useful for intricate insulating fixtures, prototypes and small batches where machining access and quick design iteration matter. It can support holes, slots and threads without a dedicated forming tool.



Material and component forms

GRADES & CHARACTERISTICS

MGC supports complex insulating geometry machined from stock. MACOR® appears as a separate reference material for comparison; the two materials are not specified as interchangeable.

Typical parts: coil formers, laboratory fixtures, insulating brackets and complex prototype components.

Property / test condition	MGC	MACOR® reference
Density (g/cm³)	2.48	2.52
Hardness (GPa)	2.0	2.5
Compressive strength (MPa)	508	345
Flexural strength (MPa)	91.5	94
Young’s modulus (GPa)	65	66.9
Max. temperature, no load (°C)	800	800
Thermal conductivity, 20°C (W/m·K)	1.71	1.46
CTE, 25–200°C (10 ⁻⁶ /°C)	7.38	9.3
Dielectric constant, 1 MHz	5.7	6.03
AC dielectric strength (kV/mm)	43.4	45
Volume resistivity, 25°C (Ω·cm)	>10 ¹⁶	>10 ¹⁷

MGC and MACOR® are separate materials. Confirm supplier, grade and test conditions for the intended application. MACOR® is a registered trademark of Corning Incorporated.

Silicon nitride

Si_3N_4 / STRENGTH AND THERMAL SHOCK

Silicon nitride combines relatively low density with strength and thermal-shock resistance. Consider it for demanding motion components, wear interfaces and thermally cycled tooling.



Material and component forms

GRADES & CHARACTERISTICS

GPSN: gas-pressure-sintered silicon nitride. HPSN: hot-pressed silicon nitride. HTCSNS: a high-conductivity grade for thermal substrate applications.

Typical parts: bearing elements, locating pins, rollers, nozzles, crucibles and ceramic tooling.

Property / test condition	GPSN	HPSN	HTCSNS
Density (g/cm ³)	3.2	3.3	3.25
Hardness (GPa)	15	16	15
Compressive strength (MPa)	2,500	3,000	2,500
Flexural strength (MPa)	700	900	600–800
Fracture toughness (MPa·√m)	5–7	6–8	6–7
Young's modulus (GPa)	300	300	300–320
Max. temperature, no load (°C)	1,100	1,300	1,100
Thermal conductivity, 25°C (W/m·K)	15–20	20–25	80–100
CTE, 40–400°C (10 ⁻⁶ /°C)	3.0	3.1	3.0
Water-quench thermal shock ΔT (°C)	550	800	Not stated
Dielectric constant, 1 MHz	6–8	8	7.8
Volume resistivity, 25°C (Ω·cm)	>10 ¹⁴	>10 ¹⁴	>10 ¹⁴

Thermal-shock values depend on test geometry and method. Grade selection must consider the actual component, heating rate and operating cycle.

Silicon carbide

SiC / WEAR AND PROCESS DUTY

SiC is a strong candidate for abrasive and chemically demanding process conditions. Seals, sleeves and valve components benefit from its hardness, while the exact grade determines the usable service envelope.



Material and component forms

GRADES & CHARACTERISTICS

SSiC: pressureless-sintered silicon carbide. SiSiC: silicon-infiltrated, reaction-bonded silicon carbide. Evaluate the silicon-containing phase when assessing temperature and chemical exposure.

Typical parts: mechanical seal rings, pump sleeves, valve seats, wear plates and spray nozzles.

Property / test condition	SSiC	SiSiC
Density (g/cm ³)	3.15	3.02
Apparent porosity (%)	≤0.1	≤0.1
Hardness (GPa)	22	22
Compressive strength (MPa)	2,600	2,600
Flexural strength (MPa)	400	250
Young's modulus (GPa)	410	330
Listed maximum temperature (°C)	1,400	1,000
Thermal conductivity (W/m·K)	100–120*	45 at 1,200°C
CTE (10 ⁻⁶ /°C)	4.0	4.5

*The SSiC conductivity test temperature is not stated. The two conductivity values are not a like-for-like comparison. Maximum-temperature atmospheres and loads are also unspecified.

Zirconia

Y-PSZ / TOUGH MECHANICAL INTERFACES

Yttria-stabilized zirconia supports highly finished mechanical interfaces, wear components and compact structural parts. Its low thermal conductivity can also help limit heat transfer through a component.



Material and component forms

GRADES & CHARACTERISTICS

Y-PSZ is the zirconia grade in the table. Mg-PSZ and ZTA have separate profiles. ATZ is alumina-toughened zirconia, a different composite option requiring its own specification.

Typical parts: shafts, sleeves, guides, pins, valves and polished wear surfaces.

Property / test condition	Y-PSZ
Density (g/cm ³)	6.05
Hardness (GPa)	12.5
Compressive strength (MPa)	2,100
Flexural strength (MPa)	850
Fracture toughness (MPa·√m)	4–5
Young's modulus (GPa)	200
Max. temperature, no load (°C)	1,000
Thermal conductivity, 25°C (W/m·K)	2.0
CTE, 20–400°C (10 ⁻⁶ /°C)	10
Water-quench thermal shock ΔT (°C)	300
Dielectric constant, 1 MHz	30
Volume resistivity, 25°C / 500°C (Ω·cm)	>10 ¹³ / >10 ³

Zirconia's electrical resistance is strongly temperature dependent. Evaluate the service-temperature data, surface condition and assembly geometry for insulation applications.

Zirconia-toughened alumina

ZTA / A COMPOSITE FOR WEAR AND STRUCTURE

ZTA combines an alumina matrix with a zirconia phase. It offers a useful route when wear resistance, stiffness and structural reliability must be considered together.



Material and component forms

GRADES & CHARACTERISTICS

ZTA combines an alumina matrix with zirconia. It differs from ATZ, which uses a zirconia matrix. The table describes the ZTA grade in this range.

Typical parts: bushings, rings, wear components, locating features and structural supports.

Property / test condition	ZTA
Density (g/cm ³)	4.1–4.38
Hardness (GPa)	15
Compressive strength (MPa)	2,350
Flexural strength (MPa)	700
Fracture toughness (MPa·√m)	3.5
Young's modulus (GPa)	310
Poisson's ratio	0.26
Max. temperature, no load (°C)	1,500
Thermal conductivity, 25°C (W/m·K)	20
CTE, 40–400°C (10 ⁻⁶ /°C)	8
Water-quench thermal shock ΔT (°C)	300
Dielectric constant, 1 MHz	10.2

Properties are grade specific. Compare toughness and wear under the intended conditions when choosing between composites and single-phase ceramics.

Magnesia-stabilized zirconia

Mg-PSZ / MSZ

Mg-PSZ combines mechanical strength with toughness for loaded components, thermal cycling and process equipment. Material selection depends on the exact stabilization system and service conditions.



Material and component forms

GRADES & CHARACTERISTICS

Mg-PSZ, also called MSZ, is a magnesia-stabilized zirconia. The table describes the MSZ grade presented here; other zirconia grades have different properties.

Typical parts: pump elements, valve components, sleeves and mechanically loaded process parts.

Property / test condition	MSZ
Density (g/cm ³)	5.7
Flexural strength (MPa)	500
Compressive strength (MPa)	2,500
Young's modulus (GPa)	250
Fracture toughness (MPa·√m)	6–7
Weibull modulus	12
Vickers hardness (HV0.5)	1,100
CTE (10 ⁻⁶ /K)	10
Thermal conductivity (W/m·K)	3
Water-quench thermal shock ΔT (°C)	450
Volume resistivity, 20°C (Ω·cm)	>10 ¹⁴

Typical MSZ grade data for preliminary selection. The current grade specification defines design values and operating-temperature limits.

Select the material by the dominant duty

Begin with the failure mode you need to prevent. Then eliminate grades that cannot satisfy the secondary conditions.

Primary need	Start the discussion with	Check before committing
Electrical isolation	Alumina, MGC, AlN; selected BN grades	Temperature, voltage, humidity, creepage and contamination
Heat removal	AlN; specialist BeO where appropriate	Thickness, contact resistance, mounting and process controls
Sliding wear / polished contact	Zirconia, alumina, Si ₃ N ₄ , ZTA	Load, mating material, lubrication, debris and finish
Abrasive / corrosive flow	SiC; selected alumina or zirconia grades	Exact medium, concentration, particles, temperature and pressure
Thermal cycling / hot fixtures	Si ₃ N ₄ , BN and other qualified grades	Atmosphere, rate of change, gradient, mounting and geometry
Intricate insulating prototype	MGC; selected machinable BN grades	Strength, edge sensitivity, service temperature and final volume

Compare complete material/process combinations

An easily machined grade may simplify the first design. A different grade or forming route may become more economical as duty and volume are confirmed.

Geometry designed for manufacture and assembly

Ceramics combine useful functional properties with limited tolerance for concentrated tensile stress and impact. Geometry, tool access and support deserve attention early.

Design feature	Practical approach	Clarify on the drawing
Corners and transitions	Use suitable radii and gradual section changes where the function allows.	Radius, access and functional keep-out areas
Thin walls and long features	Consider clamping, machining, transport and assembly loads.	Minimum section and acceptable local deflection
Holes and deep recesses	Review depth, tool access and how the feature will be inspected.	Diameter, depth, position and edge distance
Edges and openings	Protect critical edges from chipping in production and handling.	Chamfer and maximum permitted chips
Precision interfaces	Concentrate tight requirements on the functional features.	Datum, fit, form and surface finish
Threads and fasteners	Check wall thickness and contact stress; consider suitable metal interfaces.	Thread definition, tightening and support

There is no single minimum wall, radius or hole size for all ceramics. Review the named grade, geometry and manufacturing route.

Tolerance, finish and inspection belong together

A precise drawing defines how the component will be used and how conformity will be measured. Tightening every dimension is rarely the best way to improve the assembly.

Drawing item	Useful instruction	Why it matters
Datums & functional fits	Name the locating faces, axes and mating dimensions	The inspection setup should reflect the assembly
Geometric control	Define flatness, parallelism, roundness or position where needed	Size tolerance alone does not control geometry
Surface texture	Specify the functional face, parameter and measurement rule	Ra alone may not describe sealing or sliding performance
Edges & visual condition	Agree chamfer, chip and scratch limits by surface	Appearance rules should follow part function
Inspection scope	Set critical features, sampling and report requirements	The delivered evidence matches the receiving decision
Revision control	Identify material, drawing revision and approved deviations	Repeat orders remain tied to the accepted specification

Put the tightest requirement where it earns its cost

Reserve precision finishing for functional datums and interfaces. Separate as-formed and finished surfaces, with suitable allowances elsewhere.

The interface can matter as much as the material

For a uniform ceramic layer, thermal resistance is approximately $R = t / (k \times A)$. The complete assembly also includes contact and interface resistances.

WORKED EXAMPLE

30 × 30 mm plate / 1.0 mm thickness

AlN-170

0.00654 K/W

AlN-200

0.00556 K/W

AlN-230

0.00483 K/W

Calculated bulk-layer resistance using $k = 170 / 200 / 230 \text{ W/m}\cdot\text{K}$. This is not a measured module result.

01 Control the contact path

Specify flatness, surface finish, mounting pressure and the interface material. Do not use ceramic conductivity as a proxy for the whole assembly.

02 Allow for differential expansion

Compare ceramic and metal expansion over the operating range. Review clearance, restraint and temperature gradients.

03 Protect the part during assembly

Use clean, supported contact surfaces. Avoid impact, point loading and forcing a ceramic part into a mismatched fit.

Simplified one-dimensional calculation; constant conductivity and uniform heat flow are assumed. Actual heat paths and interfaces require validation.

Temperature, expansion and electrical isolation

Material data are an input to the design. Geometry, contacts, atmosphere and service temperature determine how the finished assembly behaves.

Expansion is a joint-design problem

A first estimate is $\Delta L = \alpha \times L \times \Delta T$. Different materials in the same assembly may expand by different amounts. Allow for movement and restraint at the interface.

ILLUSTRATIVE EXPANSION CALCULATION

$$\alpha = 8 \times 10^{-6}/\text{K} \quad / \quad L = 50 \text{ mm} \quad / \quad \Delta T = 200 \text{ K}$$

$$\Delta L = 0.08 \text{ mm}$$

Electrical isolation changes with service conditions

Room-temperature resistivity does not establish hot-service insulation. Check operating temperature, humidity, surface contamination, voltage waveform, spacing and the agreed electrical test.

Temperature limit and thermal shock

A listed maximum use temperature does not describe the safe heating rate or temperature gradient for your part.

Simplified expansion example for discussion. Material coefficients, geometry and the complete assembly require validation.

Protect the component in assembly and service

01 Support loads and avoid point contact

Use stable locating surfaces and controlled clamping. Check contact stress where metal hardware presses against the ceramic.

02 Plan the temperature cycle

Consider atmosphere, heating rate, temperature gradients and differential expansion. Validate a representative operating cycle.

03 Check the complete chemical exposure

Include process fluids, cleaning agents, concentration, temperature and contaminants. A broad chemical-resistance label is insufficient.

04 Protect precision edges and surfaces

Keep parts separated in transit and handling. Define acceptable chips and scratches; inspect critical features before assembly.

05 Keep BN clean and dry

Use clean tools and controlled storage. Match the BN grade to the atmosphere and avoid unreviewed oxidizing exposure at high temperature.

06 Route BeO through specialist controls

Dust-generating machining or grinding requires an approved specialist process and appropriate exposure controls. Follow the SDS and site procedures.

Application-specific instructions and material SDS take precedence over this general design guide.

How to read a ceramic data sheet

Term	What it helps you understand	What it does not guarantee
Hardness	Resistance to local indentation and a clue to wear behavior	Impact survival or wear life in every contact pair
Flexural strength	Strength in a specified bending test	An allowable design stress for any shape or defect population
Fracture toughness	Resistance to crack propagation	Immunity to chipping, impact or poor assembly
Thermal conductivity k	How readily heat passes through the material	The thermal resistance of the full mounted assembly
CTE α	Thermal expansion per degree of temperature change	Joint survival with a metal of different expansion
Volume resistivity	Resistance to current through the bulk at a stated temperature	Surface insulation under contamination or moisture
Dielectric strength	Breakdown behavior for a specified test setup	A permitted working voltage without geometry and safety margins
Maximum use temperature	A published limit under the stated conditions	Thermal shock tolerance, load capacity or life at that limit

BEFORE YOU COMPARE TWO NUMBERS

Match grade, units, temperature, atmosphere, test direction and test method. Request clarification when any of these are missing.

Material data and component acceptance

Reference	What it does tell you	What still needs definition
Flexural strength	A test-specimen strength under a defined method	Part geometry, defects, load path and safety margin
Thermal conductivity	Material heat conduction at a given condition	Temperature, direction, thickness and interfaces
Thermal-shock value	Performance in the stated thermal-shock test	Real heating rate, geometry, restraint and cycle
Dielectric strength / resistivity	Electrical behavior under test conditions	Frequency, temperature, moisture and surface
Maximum temperature	A published boundary under its stated condition	Atmosphere, mechanical load, duration and life
Size tolerance	Allowable variation of a measured dimension	Datum, geometric controls and measurement method

A complete component specification

Exact grade and revision. Critical feature and datum. Inspection method and sampling. Application validation and acceptance.

BeO requires specialist dust controls. BN temperature limits depend on atmosphere. SiC is not a default electrical insulator. Review the material-specific notes before selection.

Bring the drawing. Define the next step

A new design, a difficult interface or an existing part to improve: start with the component and its operating requirements.

Send with your inquiry	Why it helps
2D drawing + STEP / IGES model	Revision, dimensions, datums and tool access
Material grade or application duty	A grounded material and process discussion
Critical features and acceptance	Inspection scope and the sample objective
Quantity, schedule and delivery location	Quotation and production planning
Reports, marking and packaging	Clear requirements at receipt

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