MACOR® MACHINABLE GLASS CERAMIC

MACOR gives you the performance of a technical ceramic with the versatility of a high performance plastic. MACOR glass ceramic is an outstanding engineering material and is machinable with ordinary metalworking tools.

- It is an excellent electrical insulator
- It has a high maximum use temperature (800°C continuous, 1000°C peak)
- It has a low thermal conductivity and is a useful high temperature insulator
- It is strong and rigid; unlike plastics it does not creep

Making unique components

- Use MACOR and forget about mould costs, firing shrinkage and diamond machining for high tolerance work
- Use MACOR for your products or use it in your production process
- Use MACOR for one component or for many

MACOR is an invaluable material to have 'on the shelf'. It is often quicker and cheaper to make a special part rather than try to find that special item somewhere else. If you do not have your own machining facilities, or your workshop is fully occupied, send your drawing to The Technical Glass Company who can quote for your finished requirements as well as advise on your application and design.

MACOR's unique properties find many varied applications:

- Electronics/semiconductor industry

  Precision coil formers, high voltage insulators
- Laser industry

  Spacers, reflectors and cavities in laser assemblies
- High vacuum industry

  Thermal breaks, coil supports and vacuum feedthroughs
- Aerospace/space industry

  Space Shuttle door and window retaining rings, satellite electrical supports
- Nuclear industry

  Fixtures and reference blocks in power generation units

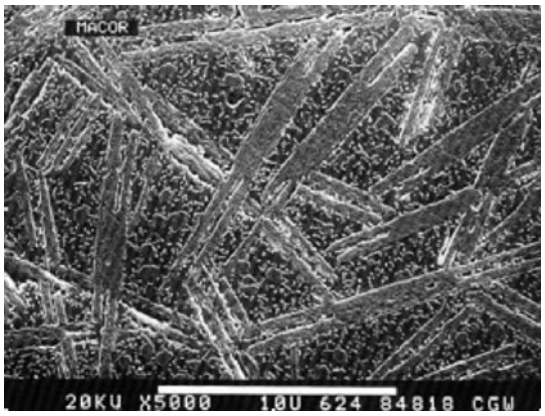
More...

MACOR® MACHINABLE GLASS CERAMIC (Continued)

Composition

MACOR machinable glass ceramic is a white, odourless, porcelain-like (in appearance) material composed of approximately 55% fluorphlogopite mica in a borosilicate glass matrix. It has no known toxic effects ; however, the dust created when machining can be an irritant. Any irritation can be avoided by good housekeeping and appropriate machining techniques. The material contains the following compounds:

Silicon (SiO2)	46%
Magnesium (MgO)	17%
Aluminium (Al_2O_3)	16%
Potassium (K_2O)	10%
Boron (B_2O_3)	7%
Fluorine (F)	4%



Randomly oriented Mica flakes in the microstructure of MACOR are the key to its machinability. (5000x magnification)

More...

MACOR® MACHINABLE GLASS CERAMIC (Continued)

Machining

MACOR can be machined to make precision components but its machining characteristics are different to metals and plastics. MACOR consists of interlocking plate-like mica crystals in a glassy matrix. It is these crystals which stop microscopic fractures at the tool tip from spreading through the material, thus making it machinable in a controlled way. During machining the tool pulverizes and tears the MACOR surface producing a fine powder of crystals and glass. The crystals are so small that, when machined, MACOR has a good surface finish. When machining is complete, the component is cleaned ready for use, no further treatment (e.g. firing) is required.

Setting Up

MACOR machinable glass ceramic is not resilient so, when small or delicate pieces are being machined, make sure that the load is uniformly distributed. Use soft jaws if possible.

It is well worthwhile taking some time to learn how the material behaves during machining. Try some simple tasks such as drilling, turning and milling and you will see how the material machines. This information gives a basis for good machining practice, but do not be afraid to experiment with tools and speeds to obtain the optimum machining performance from your equipment.

MACOR can be machined with high speed steel tools but the use of tungsten carbide tools is highly recommended (ceramic tipped tools are not advised). If the tool squeaks, if the MACOR surface turns greyish through tool wear or if too much force is needed – then stop and sharpen the tool.

As a general rule, machine at lower speeds (keeping the work piece cool) and take smaller depths of cut until you become more confident in machining the material. It is normally the requirement to maintain a surface finish which controls machining speeds. Remember, you are machining a brittle material so always avoid physical shock.

Using Coolant

Although MACOR is a high temperature material, the best machining results are obtained when both the material and tool are kept cool. Water soluble cutting fluids will improve the cutting action, trap and wash away the debris produced during machining and protect machine tools. If the fluid is to be recirculated, the use of a settling tank is recommended. The powder generated during machining is somewhat abrasive and so attention must be given to cleanliness and machine maintenance.

Sawing

Use a carbide grit blade with a 30 m/min band speed, or a diamond or silicon carbide cut-off wheel.

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MACOR® MACHINABLE GLASS CERAMIC (Continued)

Machining (Continued)

Turning

Using carbide tipped tools, suggested turning speeds are around 600 rpm for ø 5mm–10mm rod, reducing to around 400 rpm for ø 25mm rod. Feed rates are 20–30 mm/minute with a depth of cut of 2–4mm for roughing and less than 1mm for finishing.

Side and back rake angle, end and side relief angles should be around 5°. The recommended side cutting edge angle is 15°–45° and the nose radius should be larger than 0.8mm.

Thread cutting can also be done at low spindle speeds, a typical cutting depth is 0.025–0.040mm per pass.

Milling

Typical head speeds are1000–1500 rpm with a chip load of 0.05mm per tooth. Depths of cut are as for turning. Climb milling prevents material being pulled off the edge of the MACOR.

Drilling

For holes up to about ø 5mm a spindle speed of 1000–1500 rpm and a feed rate of 20–30 mm/min. has been found to be effective. Relieve the drill flutes constantly, especially for small diameter holes. Check the sharpness of the drill every 25–50 holes. A slow feed is recommended at the start and finish of each hole. To prevent breakout, use a backing plate or chamfer the hole entrance and exit before drilling through thickness. It is possible to ultrasonically drill MACOR.

Tapping

Make the clearance hole one size larger than that recommended for metal (typically 0.1–0.2mm larger). Chamfer both ends of the hole to prevent chipping. A 4 flute tap is preferable to a 2 flute tap. Run the tap slowly in the same direction (turning the tap back and forth can cause chipping) and flush with water or coolant to remove dust. Wire thread inserts can be used with MACOR.

Grinding and polishing

Diamond grinding wheels give the best results although silicon carbide and alumina wheels can be used. Always use water cooling. Start polishing with a 400 grit silicon carbide, prior to using alumina or cerium oxide powders for the final finish.

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MACOR® MACHINABLE GLASS CERAMIC (Continued)

MACOR MATERIAL PROPERTIES

MECHANICAL PROPERTIES	
Density	2.52 g/cm^3
Porosity	0%
Modulus of elasticity (25°C)	66.9 GPa
Shear modulus (25°C)	25.5 GPa
Modulus of rupture (25°C)	94 MPa
Compressive strength	345 MPa
Poisson's ratio	0.29
Fracture toughness	1.53 MPam$^{0.5}$

THERMAL PROPERTIES	
Coefficient of expansion	-200°C to +25°C: 7.4 x 10 $^{-6}$/°C 25°C to 300°C : 9.3 x 10 $^{-6}$/°C 25°C to 800°C: 12.6 x 10 $^{-6}$/°C
Specific Heat (25°C)	0.79 KJ/kg°C
Thermal conductivity (25°C)	1.46 W/mK
Thermal diffusivity (25°C)	7.3 x 10^{-7} m^2/s
Continuous operating temperature	800°C
Maximum no load temperature	1000°C

ELECTRICAL PROPERTIES	
Dielectric constant (25°C)	@ 1 KHz: 6.03 @ 8.5 GHz: 5.67
Loss tangent (25°C)	@ 1 KHz: 4.7 x 10^{-3} @ 8.5 GHz: 7.1 x 10^{-3}
Dielectric strength (AC avg. 0.3mm thick sample @ 25°C) (DC avg. 0.3mm thick sample @ 25°C)	 9.4 KV/mm 62.4KV/mm
DC volume resistivity (25°C)	>10^{16}Ωcm

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MACOR® MACHINABLE GLASS CERAMIC (Continued)

MACOR MATERIAL PROPERTIES (Continued)

CHEMICAL PROPERTIES				
SOLUTION	TESTS			RESULTS
	pH	Time (Hours)	Temperature (°C)	Weight loss (mg/cm^2) Gravimetric
5% HCl	0.1	24	95	~100
0.002 N HNO_3	2.8	24	96	~0.6
0.1 N $NaHCO_3$	8.4	24	95	~0.3
0.02 N Na_2CO_3	10.9	6	95	~0.1
5% NaOH	13.2	6	95	~10
Resistance to water over time				
H_2O	7.6	24*	95	0.01
		72*	95	0.07
		168*	95	9.4
		72†	95	0.06
		144†	95	0.11

* Water not freshened daily
† Water freshened daily

The above general characteristics of MACOR were derived from laboratory tests performed by Corning, Inc. on sample quantities. The actual characteristics of production batches may vary.

Properties shown are typical values, they are not absolute material properties, and should be used for guidance only. It is recommended that materials and components are tested for their suitability for a specific application.

For more information and advice please discuss your application with our sales staff.

More...

MACOR® MACHINABLE GLASS CERAMIC (Continued)

MACOR STOCK SIZE LIST

Rod: available in lengths of 100mm and 300mm
- 6 mm diameter
- 10 mm diameter
- 15 mm diameter
- 20 mm diameter
- 25 mm diameter
- 30 mm diameter
- 35 mm diameter
- 40 mm diameter

Plate:
- 10 mm x 10 mm x 1 mm thick
- 10 mm x 10 mm x 2 mm thick
- 25 mm x 25 mm x 1 mm thick
- 25 mm x 25 mm x 2 mm thick
- 50 mm x 50 mm x 1 mm thick
- 50 mm x 50 mm x 2 mm thick
- 100 mm x 100 mm x 3 mm thick
- 100 mm x 100 mm x 6 mm thick
- 100 mm x 100 mm x 10 mm thick

Bar:
- 10 mm x 10 mm x 100 mm
- 15 mm x 15 mm x 100 mm
- 20 mm x 20 mm x 100 mm
- 25 mm x 25 mm x 100 mm

Discs:
- 10 mm diameter x 1 mm thick
- 10 mm diameter x 2 mm thick
- 25 mm diameter x 1 mm thick
- 25 mm diameter x 2 mm thick
- 50 mm diameter x 1 mm thick
- 50 mm diameter x 2 mm thick

Special sizes and components:

Other sizes of rod, plate and bar can be supplied on a prompt delivery.

We specialise in the supply of finish machined MACOR components. Let us have your drawing for advice and quotation.