

## MACOR<sup>®</sup> MACHINABLE GLASS CERAMIC - MACHINING INFORMATION

### Machining

MACOR<sup>®</sup> can be machined to make precision components but its machining characteristics are different to metals and plastics. MACOR<sup>®</sup> 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<sup>®</sup> surface producing a fine powder of crystals and glass. The crystals are so small that, when machined, MACOR<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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.

More...

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## MACOR<sup>®</sup> MACHINABLE GLASS CERAMIC – MACHINING INFORMATION (Continued)

### Turning

Using carbide tipped tools, suggested turning speeds are around 600 rpm for  $\varnothing$  5mm–10mm rod, reducing to around 400 rpm for  $\varnothing$  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 are 1000–1500 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<sup>®</sup>.

### Drilling

For holes up to about  $\varnothing$  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<sup>®</sup>.

### 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<sup>®</sup>.

### 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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