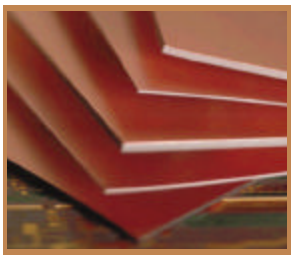

High Frequency
Circuit Materials

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Fabrication Guidelines for RO4000® Series High Frequency Circuit Materials

RO4000® High Frequency Circuit Materials were developed to provide high frequency performance comparable to woven glass PTFE substrates with the ease of fabrication associated with epoxy/glass laminates. RO4000 material is a woven glass reinforced/ceramic filled. thermoset material with a very high glass transition temperature (Tg >280°C). Unlike PTFE based microwave materials, no special through-hole treatments or handling procedures are required. Therefore, RO4000 material circuit processsing and assembly costs are comparable to epoxy/glass laminates.

Some basic guidelines for processing double sided RO4000 panels are provided below. In general, process parameters and procedures used for epoxy/glass boards can be used to process RO4000 boards.

DRILLING:

ENTRY/EXIT MATERIAL:

Entry and exit materials should be flat and rigid to minimize copper burrs. Recommended entry materials include aluminum and rigid composite board (0.010” to 0.025” (0.254 0.635mm). Most conventional exit materials with or without aluminum cladding are suitable.

MAXIMUM STACK HEIGHT:

The thickness of material being drilled should not be greater than 70% of the flute length.This includes the thickness of entry material and penetration into the backer material.
For example:

Flute Length:	0.300” (7.62mm)
Entry Material:	0.015” (0.381mm)
Backer Penetration:	0.030” (0.762mm)
Material Thickness:	0.020” (0.508mm)⇒(0.023”(0.584mm) with 1 oz Cu on 2 sides)

Maximum Stack Height = 0.70 x 0.300”(7.62mm) =

0.210” (5.33mm) (available flute length)
-0.015” (0.381mm) (entry)
-0.030” (0.762mm) (backer penetration)

0.165”(4.19mm) (available for PCBs)

$$\text{Maximum Boards per Stack} = \frac{0.165\text{”} (4.19\text{mm}) \text{ (available for PCBs)}}{0.023\text{”} (0.58\text{mm}) \text{ (thickness per board)}} = 7.2 = 7 \text{ boards/stack (round down)}$$

DRILLING CONDITIONS:
Surface speeds greater than 500 SFM and chip loads less than 0.002" (0.05mm) should be avoided, whenever possible.

Recommended Ranges:

Surface Speed:	300 - 500 SFM (90 to 150 m/mm)
Chip Load:	0.002" - 0.004"/rev. (0.05-0.10mm/rev)
Retract Rate:	500 - 1000 IPM 500 IPM (12.7 m/min) for tool less than 0.0135" (0.343 mm),1000 IPM (25.4m/min) for all others.
Tool Type:	Standard Carbide
Tool life:	2000-3000 hits

Hole quality should be used to determine the effective tool life rather than tool wear. The RO4003 material will yield good hole quality when drilled with bits which are considered worn by epoxy/glass standards. Unlike epoxy/glass, RO4003 material hole roughness does not increase significantly with tool wear. Typical values range from 8-25 um regardless of hit count (evaluated up to 8000 hits). The roughness is directly related to the ceramic filler size and provides topography that is beneficial for hole-wall adhesion. Drilling conditions used for epoxy/glass boards have been found to yield good hole quality with hit counts in excess of 2000.

CALCULATING SPINDLE SPEED AND INFEED:

$$\text{Spindle Speed (RPM)} = \frac{12 \times [\text{Surface Speed (SFM)}]}{\pi \times [\text{Tool Diam. (in.)}]}$$

Feed Rate (IPM) = [Spindle Speed (RPM)] x [Chip Load (in/rev.)]

Example:

Desired Surface Speed:	400 SFM
Desired Chip Load:	0.003"(0.08 mm)/rev.
Tool Diameter:	0.0295"(0.75 mm)

$$\text{Spindle Speed} = \frac{12 \times [400]}{3.14 \times [0.0295]} = 51{,}800 \text{ RPM}$$

Infeed Rate = [51,800] x [0.003] = 155 IPM

***QUICK REFERENCE TABLE*:**

Tool Diameter	Spindle Speed (kRPM)	Infeed Rate (IPM)
0.0100" (0.254mm)*	95.5	190
0.0135" (0.343mm)*	70.7	141
0.0160" (0.406mm)*	95.5	190
0.0197" (0.500mm)*	77.6	190
0.0256" (0.650mm)	60.0	180
0.0258" (0.655mm)	60.0	180
0.0295" (0.749mm)	51.8	155
0.0354" (0.899mm)	43.2	130
0.0394" (1.001mm)	38.8	116
0.0453" (1.151mm)	33.7	101
0.0492" (1.257mm)	31.1	93
0.0531" (1.349mm)	28.8	86
0.0625" (1.588mm)	24.5	74
0.0925" (2.350mm)	16.5	50
0.1250" (3.175mm)	15.0	45

** Conditions stated are tapered from 200sfm and 0.002 chip load up to 400 sfm and 0.003" chip.*

DEBURRING:
RO4000 material can be deburred using conventional nylon brush scrubbers.

COPPER PLATING:
No special treatments are required prior to electroless copper plating. Board should be processed using conventional epoxy/glass procedures. Desmear of drilled holes is not typically required, as the high Tg (280°C+ [536°F]) resin system is not prone to smearing during drill. A standard CF4 plasma cycle or a double pass-through alkaline permanganate can be used to achieve etchback if a three-point interconnect is required.

IMAGING/ETCHING:
Panel surfaces may be mechanically and/or chemically prepared for photoresist. Standard aqueous or semi-aqueous photoresists are recommended. Any of the commercially available copper etchants can be used.

SOLDERMASK:
Any screenable or photoimageable solder masks typically used on epoxy/glass laminates bond very well to the surface of RO4003. Mechanical scrubbing of the exposed dielectric surface prior to solder mask application should be avoided as an "as etched" surface provides for optimum bonding.

HASL and REFLOW:
RO4000 material baking requirements are comparable to epoxy/glass. In general, facilities which do not bake epoxy/glass boards will not need to bake RO4000 boards. For facilities that do bake epoxy/glass as part of their normal process, we recommend at 1-2 hour bake at 250ºF-300ºF (121ºC-149ºC).

Some darkening of the RO4000 materials is expected if boards are baked in an oxygen environment. This is simply surface oxidation and will not impact board performance. If cosmetics are a major concern, boards should be baked under N_2 or vacuum.

***Warning*: RO4003** *does not contain fire retardant(s). We understand boards trapped in an infrared (IR) unit or run at very slow conveyor speeds can reach temperatures well in excess of 700°F (371°C). RO4003 may begin to burn at these high temperatures. Facilities which still use IR reflow units or other equipment which can reach these high temperatures should take the necessary precautions to assure that there are no hazards.*

ROUTING:
RO4000 material can be machined using carbide tools and conditions typically used for epoxy/glass. Copper foil should be etched away from the routing channels to prevent burring.

MAXIMUM STACK HEIGHT:
The maximum stack height should be based on 70% of the actual flute length to allow for debris removal.
Example:

Flute Length:	0.300” x 0.70 =		0.210”(5.33 mm)
Backer Penetration:		–	0.030”(0.762mm)
Max. Stack Height:			0.180”(4.572mm)

TOOL TYPE:
Carbide multifluted spiral chip breakers or diamond cut router bits.

ROUTING CONDITIONS:
Surface speeds below 500 SFM should be used whenever possible to maximize tool life. Tool life is generally greater than 50 linear feet when routing the maximum allowable stack height.

Chip Load:	0.0010-0.0015”(0.0254-0.0381mm)/rev
Surface Speed:	300 - SFM

QUICK REFERENCE TABLE:

Tool Diameter	Spindle Speed	Lateral Feed Rate
1/32	40 k RPM	50 IPM
1/16	25 k RPM	31 IPM
3/32	20 k RPM	25 IPM
1/8	15 k RPM	19 IPM

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ISO 9002 CERTIFIED

Printed in U.S.A

Revised 04/00