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ROGERS CORPORATION
Advanced Circuit Materials

Preliminary Data Sheet
Antenna Grade Laminates

Rogers' Antenna Grade Materials

RO4500™ Series Cost Performance Antenna Grade Laminates

A new line of cost/performance materials from Rogers Corporation. These laminates are specifically engineered and manufactured to meet the specific demands of the antenna markets.

Typical Applications

- Cellular infrastructure base station antennas
- WiMAX antenna networks

RO4533™, RO4534™, AND RO4535™ Laminates

FEATURES	BENEFITS
Loss range (0.0020 to 0.0037)	Wide range of application use
Dk range (3.3 to 3.5)	
Low PIM response	
Thermoset resin system	Compatible with standard PCB fabrication
Excellent dimensional stability	Greater yield on larger panels sizes
Uniform mechanical properties	Robust handing and long life in use with thin materials
High thermal conductivity	Improved power handling

RO4500™ Series High Frequency Laminates extend the capabilities of the successful RO4000® product series into antenna applications. This ceramic-filled, glass-reinforced hydrocarbon based material set provides the controlled dielectric constant, low loss performance and excellent passive intermodulation response required for mobile infrastructure microstrip antenna applications.

As with all RO4000 High Frequency Laminates, RO4500 laminates are fully compatible with conventional FR4 and high temperature lead free solder processing. These laminates do not require special treatment needed on traditional PTFE-based laminates for plated through hole preparation. This product series is an affordable alternative to more conventional antenna technologies, thus allowing designers to maximize the price and performance of their antennas. Moreover, these materials are available halogen-free to meet the most stringent "green" standards, or with our RoHS-compliant flame-retardant technology for applications requiring UL94 V-0 certification.

The resin systems of RO4500 dielectric materials are designed to provide the necessary properties for ideal antenna performance. The coefficients of thermal expansion (CTEs) in both the X and Y directions are similar to that of copper. The good CTE match reduces stresses in the printed circuit board antenna. The typical glass transition temperature of RO4500 materials exceeds 280°C (536°F), leading to a low z-axis CTE and excellent plated through hole reliability. These properties, in combination with a dimensional stability value of less than 0.05%, make RO4500 laminates an excellent candidate for printed circuit antenna applications. RO4500 materials also provide increased thermal conductivity over equivalent PTFE/woven glass materials, allowing for design of antennas with increased power handling capability.

In addition to these excellent thermo-mechanical properties, RO4500 laminates embody electrical characteristics that antenna designers need. The laminates have a dielectric constant (Dk) ranging from 3.3 to 3.5 (±0.08) and a loss tangent (Df) of 0.0020 to 0.0037 measured at 2.5 GHz. These values allow antenna designers to realize substantial gain values while minimizing signal loss. Materials are available with demonstrated low PIM performance, with values better than –155 dBC using two 43 dBm swept tones at 1900 MHz.

Prolonged exposure in an oxidative environment may cause changes to the dielectric properties of hydrocarbon based materials. The rate of change increases at higher temperatures and is highly dependent on the circuit design. Although Rogers' high frequency materials have been used successfully in innumerable applications and reports of oxidation resulting in performance problems are extremely rare, Rogers recommends that the customer evaluate each material and design combination to determine fitness for use over the entire life of the end product.

Product	Dielectric Constant @10 GHz	Dissipation Factor (tan δ) @ 2.5 GHz /10 GHz	Dielectric Strength V/mil	Dimensional Stability mm/m	Coefficient of Thermal Expansion ppm/°C			Tg °C	Thermal Conductivity W/m/°K	Density gm/ cm3	Peel Strength N/mm	PIM (1) dBc range	UL
RO4533™	3.3 ± 0.08	0.0020 / 0.0025	>500	<0.2	13	11	37	>280	0.6	1.8	0.9	150-160	N/A
RO4534™	3.4 ± 0.08	0.0022 / 0.0027	>500	<0.3	11	14	46	>280	0.6	1.8	1.0	150-160	N/A
RO4535™	3.5 ± 0.08	0.0032 / 0.0037	>500	<0.5	14	16	35	>280	0.6	1.9	0.9	N/A	V0(2)
Direction	**Z**	**Z**	**Z**	**X,Y**	**X**	**Y**	**Z**						
Condition	**10 GHz 23°C**	**10 GHz 23°C**	**0.51mm**	**after etch**	**-55 to 288°C**			**A**	**100°C**	**23°C**	**1 oz. EDC post solder float**	**Reflected 43 dBm swept tones**	**UL 94**
Test Method	**IPC-TM-650 2.5.5.5**	**IPC-TM-650 2.5.5.5**	**IPC-TM-650 2.5.6.2**	**IPC-TM- 650 2.4.39A**	**IPC-TM-650 2.4.41**			**IPC-TM-650 2.4.24**	**ASTM F433**	**ASTM D792**	**IPC-TM-650 2.4.8**	**Summitek 1900b PIM Analyzer**	

Ordering Information:
Laminate Thickness and Copper Foil Options:

Product	30 (0.762)	40 (1.016)	60 (1.524)
RO4533	● ▲	● ▲	● ▲
RO4534	32 (0.813) ● ▲	● ▲	● ▲
RO4535	●	●	●

Standard Panel Sizes:
24"X18" (610 X 457 mm)
48"X36"(1.224 X 0.915 m)
Additional thicknesses and panel sizes are available up to 50" X 110" (Untrimmed)

Copper Cladding:

Standard EDC:
● 1/2 oz (17mm), 1 oz (35 μm)

Reverse Treated EDC for PIM Sensitive Applications:
▲ 1/2 oz (17mm), 1 oz (35 μm)

For most applications the standard EDC foil should be used. When PIM and insersion loss is critical, the reverse-treat copper should be considered. Rogers' uses a proprietary surface modifier to bond reverse-treat foils to RO4000 laminates.

(1) PIM Performance is heavily influenced by the copper choice. PIM values provided are based on testing of reverse-treat electrode-postied copper foils. Typical PIM rating on standard EDC foils are ≤ -145 dBm. Refer to the laminate thickness and copper option table for material options.
(2) UL94 V-0 certification in process; not certified by UL.

Typical values are a representation of an average value for the population of the property.
For specification values contact Rogers Corporation.

RoHS Compliant

Processing and Fabrication Guidelines:

RO4500 materials are available with a reverse treat copper foil treated in a Rogers Corporation proprietary process. This unique construction reduces conductor loss and enhances PIM performance while utilizing the proven electrical and thermo-mechanical dielectric properties of the RO4000 resin system. RO4500 materials are not intended for multilayer use.

SURFACE PRE-CLEAN

The edges of panels with Reverse-Treated copper foil may show signs of surface oxidation. It is recommended that the panels go through a micro-etch prior to processing to remove the oxidation.

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)Þ(0.023”(0.584mm)
with 1 oz Cu on 2 sides)	

Maximum
Stack = 0.70 x 0.300”(7.62mm) =   0.210” (5.33mm) (available flute length)
Height   -0.015” (0.381mm) (entry)
                                                         -0.030” (0.762mm) (backer penetration)
                                                          0.165”(4.19mm) (available for PCBs)

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

The information contained in this data sheet and processing guide is intended to assist you in designing with Rogers’ circuit materials and prepreg. It is not intended to and does not create any warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose or that the results shown on this data sheet and processing guide will be achieved by a user for a particular purpose. The user is responsible for determining the suitability of Rogers’ circuit materials and prepreg for each application.

DRILLING CONDITIONS:

Surface speeds greater than 500 SFM and chip loads less than 0.002" (0.05mm) should be avoided whenever possible. People using small diameter drills (>0.0135") need to go below a 0.002" chip load to avoid random breakage of drill bits.

Recommended Ranges:

Surface Speed:	300 - 500 SFM (90 to 150 m/mm)
Chip Load:	0.002" - 0.004"/rev. (0.05-0.10 mm/rev)
Retract Rate:	500 - 1000 IPM 500 IPM (12.7 m/min) for tool less than 0.0135" (0.343 mm),1000 IPM (25.4 m/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 RO4500 material will yield good hole quality when drilled with bits which are considered worn by epoxy/glass standards. Unlike epoxy/glass, RO4500 material hole roughness does not increase significantly with tool wear. Typical values range from 8-25 mm 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:

RO4500 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. Resin can be removed using a standard CF4/O2 plasma cycle or a double pass through an alkaline permanganate process should smear result from aggressive drilling practices.

IMAGING/ETCHING:

Panel surfaces may be mechanically and/or chemically prepared for photoresist. Standard aqueous or semiaqueous 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 RO4500 material. 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:

RO4500 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 a 1-2 hour bake at 250°F-300°F (121°C-149°C).

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Warning: RO4533, and RO4534 material 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). These RO4500 materials may begin to burn at these high temperatures. Facilities which 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.

SHELF LIFE:

Rogers' High Frequency copper clad laminates, not etched material, can be stored indefinitely under ambient room temperatures (55-85°F, 13-30°C) and humidity levels. At room temperature, the dielectric materials are inert to high humidity. However, metal claddings such as copper can be oxidized during exposure to high humidity. Standard PWB pre-exposure cleaning procedures can readily remove traces of corrosion from properly stored materials.

ROUTING:

RO4500 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 fl ute 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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The information in this data sheet is intended to assist you in designing with Rogers' circuit material laminates. It is not intended to and does not create any warranties express or implied, including any warranty of merchantability or fitness for a particular purpose or that the results shown on this data sheet will be achieved by a user for a particular purpose. The user should determine the suitability of Rogers' circuit material laminates for each application.

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