

Advanced Circuit Materials

RO4000® Series High Frequency Circuit Materials



Features:	Benefits:
RO4000® materials are reinforced hydrocarbon/ceramic laminates	<ul style="list-style-type: none"> Designed for performance sensitive, high volume applications
Low dielectric tolerance and low loss	<ul style="list-style-type: none"> Excellent electrical performance Allows applications with higher operating frequencies Ideal for broadband applications
Stable electrical properties vs. frequency	<ul style="list-style-type: none"> Controlled impedance transmission lines
Lead-free process compatible	<ul style="list-style-type: none"> No blistering or delamination
Low Z-axis expansion	<ul style="list-style-type: none"> Reliable plated through holes
Low in-plane expansion coefficient	<ul style="list-style-type: none"> Remains stable over an entire range of circuit processing temperatures
Volume manufacturing process	<ul style="list-style-type: none"> RO4000 laminates can be fabricated using standard glass epoxy processes Competitively priced
Typical Applications:	
<ul style="list-style-type: none"> Cellular Base Station Antennas and Power Amplifiers 	
<ul style="list-style-type: none"> RF Identification Tags 	
<ul style="list-style-type: none"> Automotive Radar and Sensors 	
<ul style="list-style-type: none"> LNB's for Direct Broadcast Satellites 	

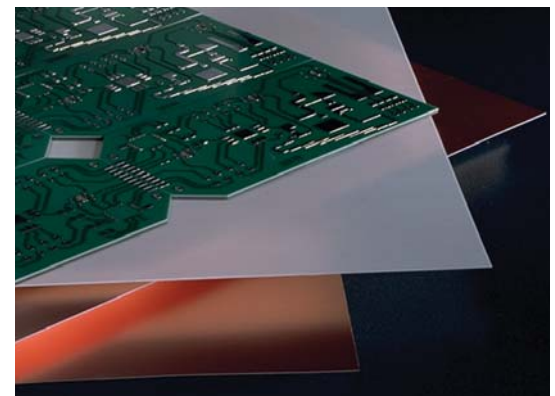
RO4000® hydrocarbon ceramic laminates are designed to offer superior high frequency performance and low cost circuit fabrication. The result is a low loss material which can be fabricated using standard epoxy/glass (FR-4) processes offered at competitive prices.

The selection of laminates typically available to designers is significantly reduced once operational frequencies increase to 500 MHz and above. RO4000 material possesses the properties needed by designers of RF microwave circuits and matching networks and controlled impedance transmission lines. Low dielectric loss allows RO4000 series material to be used in many applications where higher operating frequencies limit the use of conventional circuit board laminates. The temperature coefficient of dielectric constant is among the lowest of any circuit board material (Chart 1), and the dielectric constant is stable over a broad frequency range (Chart 2). This makes it an ideal substrate for broadband applications.

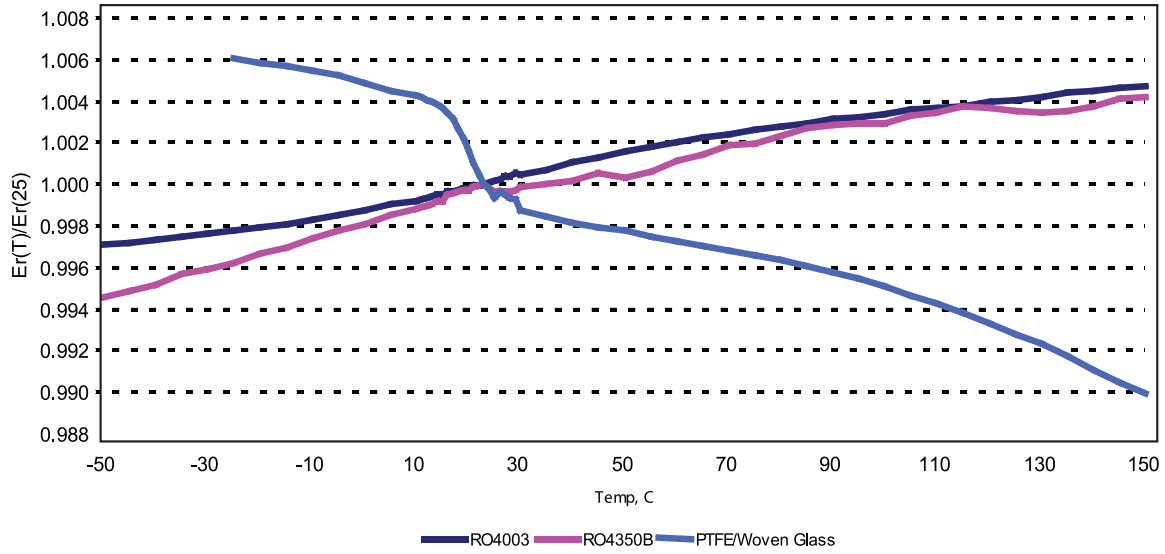
RO4000 material's thermal coefficient of expansion (CTE) provides several key benefits to the circuit designer. The expansion coefficient of RO4000 material is similar to that of copper which allows the material to exhibit excellent dimensional stability, a property needed for mixed dielectric multilayer boards constructions. The low Z-axis CTE of RO4000 laminates provides reliable plated through-hole quality, even in severe thermal shock applications. RO4000 series material has a Tg of >280°C (536°F) so its expansion characteristics remain stable over the entire range of circuit processing temperatures.

RO4000 series laminates can easily be fabricated into printed circuit boards using standard FR-4 circuit board processing techniques. Unlike PTFE based high performance materials, RO4000 series laminates do not require specialized via preparation processes such as sodium etch. This material is a rigid, thermoset laminate that is capable of being processed by automated handling systems and scrubbing equipment used for copper surface preparation.

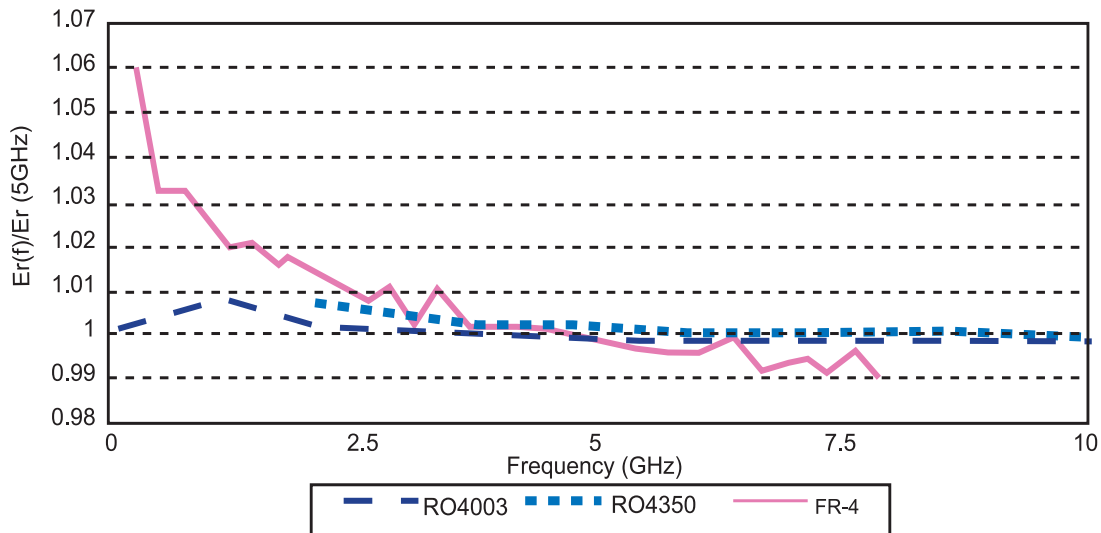
RO4003™ laminates are currently offered in various configurations utilizing both 1080 and 1674 glass fabric styles, with all configurations meeting the same laminate electrical performance specification. Specifically designed as a drop-in replacement for the RO4003C™ material, RO4350B™ laminates utilize RoHS compliant flame-retardant technology for applications requiring UL 94V-0 certification. These materials conform to the requirements of IPC-4103, slash sheet /10 for RO4003C and /11 for RO4350B materials.



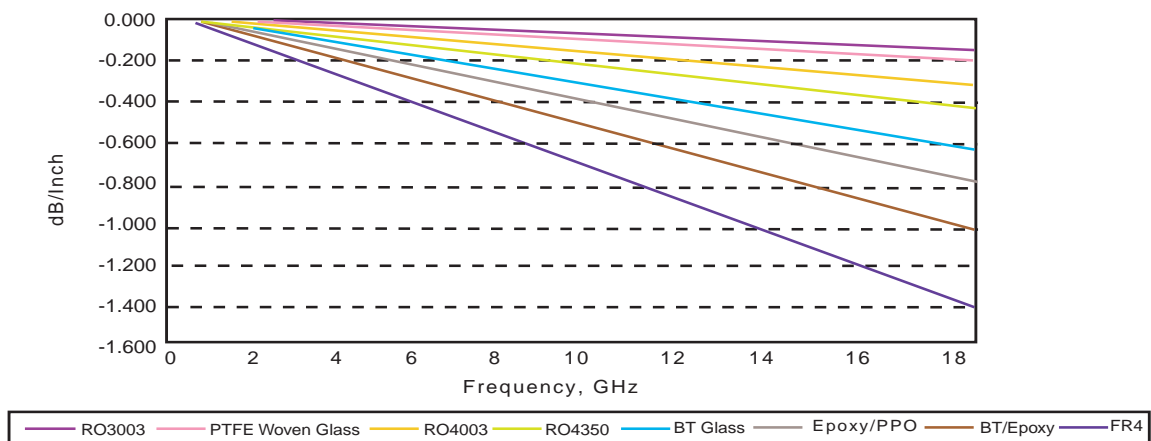
**Chart 1. RO4000® Series Materials
Dielectric Constant vs. Temperature**



**Chart 2: RO4000 Series Materials
Dielectric Constant vs. Frequency**



**Chart 3: Microstrip Insertion Loss
(0.030" Dielectric Thickness)**



Property	Typical Value		Direction	Units	Condition	Test Method
	RO4003C	RO4350B				
Dielectric Constant, ϵ_r (Process specification)	3.38 ± 0.05	⁽¹⁾ 3.48 ± 0.05	Z	--	10 GHz/23°C	IPC-TM-650 2.5.5.5 ⁽²⁾ Clamped Stripline
⁽³⁾ Dielectric Constant, ϵ_r (Recommended for use in circuit design)	3.55	3.66	Z	--	FSR/23°C	IPC-TM-650 2.5.5.6 Full Sheet Resonance
Dissipation Factor tan, δ	0.0027 0.0021	0.0037 0.0031	Z	--	10 GHz/23°C 2.5 GHz/23°C	IPC-TM-650 2.5.5.5
Thermal Coefficient of ϵ_r	+40	+50	Z	ppm/°C	-50°C to 150°C	IPC-TM-650 2.5.5.5
Volume Resistivity	1.7 X 10 ¹⁰	1.2 X 10 ¹⁰		M Ω •cm	COND A	IPC-TM-650 2.5.17.1
Surface Resistivity	4.2 X 10 ⁹	5.7 X 10 ⁹		M Ω	COND A	IPC-TM-650 2.5.17.1
Electrical Strength	31.2 (780)	31.2 (780)	Z	KV/mm (V/mil)	0.51mm (0.020")	IPC-TM-650 2.5.6.2
Tensile Modulus	26,889 (3900)	11,473 (1664)	Y	MPa (kpsi)	RT	ASTM D638
Tensile Strength	141 (20.4)	175 (25.4)	Y	MPa (kpsi)	RT	ASTM D638
Flexural Strength	276 (40)	255 (37)		MPa (kpsi)		IPC-TM-650 2.4.4
Dimensional Stability	<0.3	<0.5	X,Y	mm/m (mils/inch)	after etch +E2/150°C	IPC-TM-650 2.4.39A
Coefficient of Thermal Expansion	11 14 46	14 16 35	X Y Z	ppm/°C	-55 to 288°C	IPC-TM-650 2.1.41
Tg	>280	>280		°C DSC	A	IPC-TM-650 2.4.24
Td	425	390		°C TGA		ASTM D3850
Thermal Conductivity	0.71	0.69		W/m/°K	80°C	ASTM C518
Moisture Absorption	0.06	0.06		%	48 hrs immersion 0.060" sample Temperature 50°C	ASTM D570
Density	1.79	1.86		gm/cm ³	23°C	ASTM D792
Copper Peel Strength	1.05 (6.0)	0.88 (5.0)		N/mm (pli)	after solder float 1 oz. EDC Foil	IPC-TM-650 2.4.8
Flammability	N/A	⁽⁴⁾ V-0				UL 94
Lead-Free Process Compatible	Yes	Yes				

- (1) Dielectric constant typical value does not apply to 0.004" (0.101mm) laminates. Dielectric constant specification value for 0.004" RO4350B material is 3.33 ± 0.05.
- (2) The IPC clamped stripline method can potentially lower the actual dielectric constant due to presence of airgaps between the laminates under test and the resonator card. Dielectric constant in practice may be higher than the values listed.
- (3) The design Dk is an average number from several different tested lots of material and on the most common thickness/s. If more detailed information is required please contact Rogers Corporation. Refer to Rogers' technical paper "Dielectric Properties of High Frequency Materials" available at <http://www.rogerscorp.com/acm>
- (4) ** Note on 94V-0 ** RO4350B LoPro™ laminates do not share the same UL designation as standard RO4350B laminates. A separate UL qualification may be necessary.

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

RO4000 LoPro laminate uses a modified version of RO4000 resin system to bond reverse treated foil. Values shown above are RO4000 laminates with out the addition of the LoPro resin. For double-sided board, the LoPro foil results in a thickness increase of approximately 0.0007" (0.018mm) and the DK is approximately 2.4. Therefore, effective DK is highly dependent on core thickness.

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.

Standard Thickness	Standard Panel Size	Standard Copper Cladding
RO4003C: 0.008" (0.203mm), 0.012 (0.305mm), 0.016" (0.406mm), 0.020" (0.508mm) 0.032" (0.813mm), 0.060" (1.524mm) RO4350B: *0.004" (0.101mm), 0.0066" (0.168mm) 0.010" (0.254mm), 0.0133" (0.338mm), 0.0166" (0.422mm), 0.020" (0.508mm), 0.030" (0.762mm), 0.060" (1.524mm) Material clad with LoPro foil add .0007" (0.018mm) to dielectric thickness	12" X 18" (305 X457 mm) 24" X 18" (610 X 457 mm) 24" X 36" (610 X 915 mm) 48" X 36" (1.224 m X 915 mm) *0.004" material is not available in panel sizes larger than 24"x18" (610 X 457mm).	½ oz. (17µm), 1 oz. (35µm) and 2 oz. (70µm) electrodeposited copper foil . LoPro Reverse Treated EDC for PIM Sensitive Applications: ½ oz (17µm), 1 oz (35 µm) Note: LoPro EDC foil adds .00035" to the panel thickness per side.

World Class Performance

Rogers Corporation (NYSE:ROG), headquartered in Rogers, Conn., is a global technology leader in the development and manufacture of high performance, specialty material-based products for a variety of applications in diverse markets including: portable communications, communications infrastructure, computer and office equipment, consumer products, ground transportation, aerospace and defense. In an ever-changing world, where product design and manufacturing often take place on different sides of the planet, Rogers has the global reach to meet customer needs. Rogers operates facilities in the United States, Europe and Asia. The world runs better with Rogers.®

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