

RO4000® Series High Frequency Circuit Materials

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). For reduced insertion loss, LoPro™ foil is available (Chart 3). 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 multi-layer 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.



Data Sheet

FEATURES AND BENEFITS:

RO4000 materials are reinforced hydrocarbon/ceramic laminates - not PTFE

- Designed for performance sensitive, high volume applications

Low dielectric tolerance and low loss

- Excellent electrical performance
- Allows applications with higher operating frequencies
- Ideal for broadband applications

Stable electrical properties vs. frequency

- Controlled impedance transmission lines
- Repeatable design of filters

Low thermal coefficient of dielectric constant

- Excellent dimensional stability

Low Z-axis expansion

- Reliable plated through holes

Low in-plane expansion coefficient

- Remains stable over an entire range of circuit processing temperatures

Volume manufacturing process

- RO4000 laminates can be fabricated using standard glass epoxy processes
- Competitively priced

SOME TYPICAL APPLICATIONS:

- Cellular Base Station Antennas and Power Amplifiers
- RF Identification Tags
- Automotive Radar and Sensors
- LNB's for Direct Broadcast Satellites





Chart 1: RO4000 Series Materials Dielectric Constant vs. Temperature

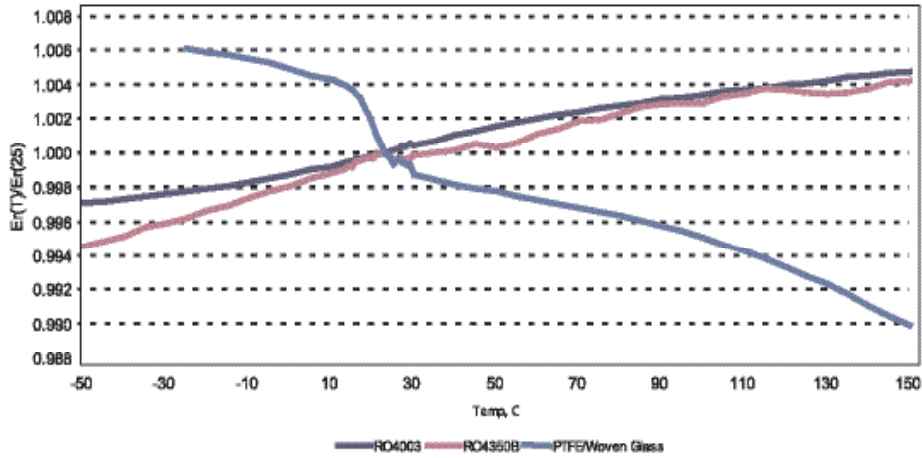


Chart 2: RO4000 Series Materials Dielectric Constant vs. Frequency

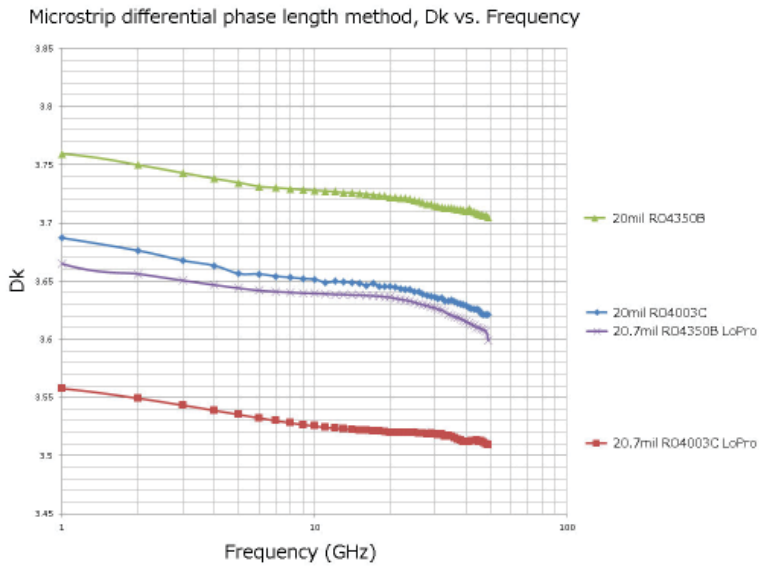
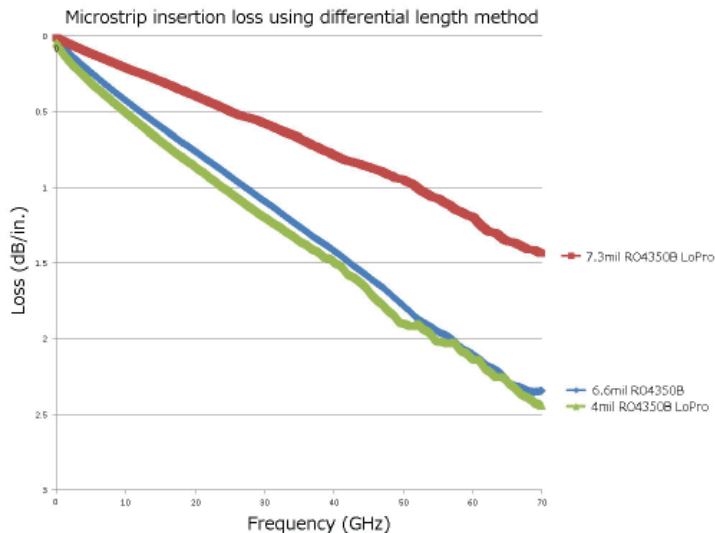


Chart 3: Microstrip Insertion Loss



| Property | Typical Value | | Direction | Units | Condition | Test Method |
|---|----------------------------------|-----------------------------------|-------------|---------------------|---|--|
| | RO4003C | RO4350B | | | | |
| Dielectric Constant, ϵ_r , Process | 3.38 ± 0.05 | ⁽²⁾ 3.48 ± 0.05 | Z | -- | 10 GHz/23°C | IPC-TM-650 2.5.5.5 Clamped Stripline |
| ⁽⁴⁾ Dielectric Constant, ϵ_r , Design | 3.55 | 3.66 | Z | -- | 8 to 40 GHz | Differential Phase Length Method |
| 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 | 19,650 (2,850) 19,450 (2,821) | 16,767 (2,432) 14,153, (2,053) | X Y | MPa (ksi) | RT | ASTM D638 |
| Tensile Strength | 139 (20.2) 100 (14.5) | 203 (29.5) 130 (18.9) | X Y | MPa (ksi) | 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 | 10 12 32 | X Y Z | ppm/°C | -55 to 288°C | IPC-TM-650 2.4.41 |
| 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 | ⁽³⁾ V-0 | | | | UL 94 |
| Lead-Free Process Compatible | Yes | Yes | | | | |

NOTES:

- (1) 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 or refer to Rogers' technical papers in the Rogers Technology Support Hub available at <http://www.rogerscorp.com/acm/technology>.
- (2) 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.
- (3) 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 the RO4000 resin system to bond reverse treated foil. Values shown above are RO4000 laminates without the addition of the LoPro resin. For double-sided boards, the LoPro foil results in a thickness increase of approximately 0.0007" (18µm) and the Dk is approximately 2.4. The Dk decreases by about 0.1 as the core thickness decreases from 0.020" to 0.004.

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) | 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) | ½ oz. (17µm) electrodeposited copper foil (.5ED/.5ED) |
| 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) | *0.004" (0.101mm) material is not available in panel sizes larger than 24"x18" (610 X 457mm) | 1 oz. (35µm) electrodeposited copper foil (1ED/1ED) |
| | | 2 oz. (70µm) electrodeposited copper foil (2ED/2ED) |
| | | PIM Sensitive Applications: |
| | | ½ oz (17µm) LoPro Reverse Treated EDC (.5TC/.5TC) |
| Note: Material clad with LoPro foil add 0.0007" (0.018mm) to dielectric thickness | | 1 oz (35µm) LoPro Reverse Treated EDC (1TC/1TC) |

The information in this data sheet is intended to assist you in designing with Rogers' circuit materials. 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 materials for each application.