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Advances in high frequency materials

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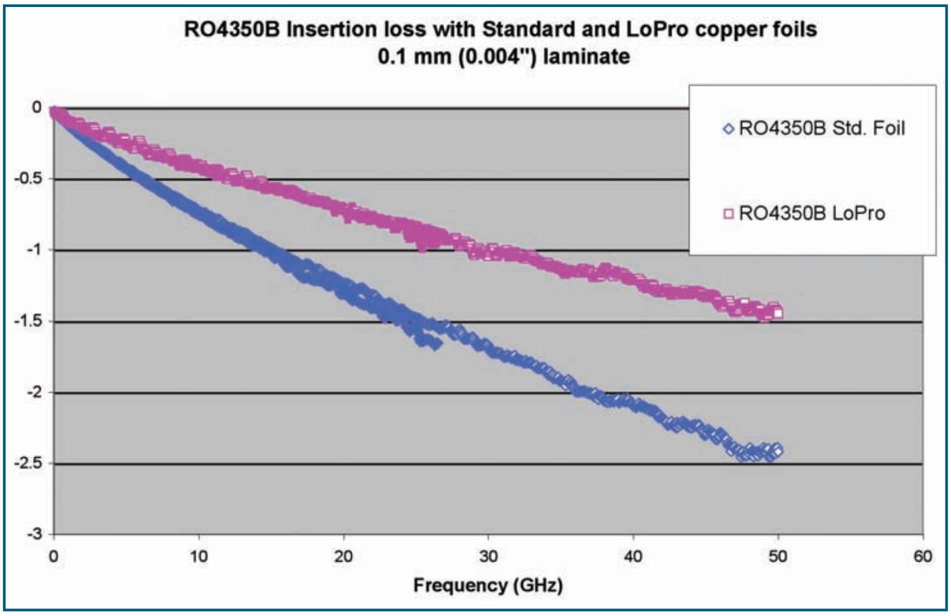
Rogers Corporation has a long history of supporting developments in the field of high frequency materials. Offering products to this market for over 40 years, Rogers is known in the industry as an innovator, the first to offer many new solutions for RF engineers; random glass with PTFE to lower dielectric constant anisotropy due to woven glass (RT/duroid® 5000), temperature stable (electrical/mechanical) PTFE/ceramic filled material (RT/duroid 6002) for high reliability multilayer boards and thermoset/woven glass laminates and prepregs that have created the ability to design RF circuits with FR4 processing practices, to name just a few. This tradition of innovation and performance continues to drive Rogers towards developing the next generation of RF and high speed circuit materials aimed specifically at today's challenges.

Figure 1: Insertion Loss of RO4350B laminate with standard foil and LoPro foil.



Improving circuit losses

The demand for increased mobile broadband data, in particular video, is creating the need for wireless mobile networks with increased data rates, speeds being promoted by developers of WiMAX and LTE networks are in the range of 100 Mbps. Today, high frequency substrates like RO4350B® material are used extensively in the RF portions of the wireless network (base transceiver station, BTS) as well as in high end routers and switches found in the core of the wired network.

Higher data rates are driving the need for faster speeds throughout the network, and along with higher speeds the need for reduced losses in the transmission lines is increasing. To address this particular designer need, Rogers Corporation introduced a new product offering aimed at reducing circuit losses by focusing on improving conductor loss. This new product is called RO4350B™ LoPro™ material. It uses copper with significantly reduced copper roughness as a means to reduce insertion loss. Although smooth copper foils have been available for some time, advances in copper foil treatments were needed in order to achieve adequate peel strength between the foil and the base substrate. These advances now allow the use of smooth copper on RO4350B materials without sacrificing peel strength. The level of improvement is a function of dielectric thickness, frequency and line width, but for a 50 W trace on 0.004" (0.1 mm) dielectric at 20 GHz, the loss is almost cut in half, as can be seen in Figure 1.

E-Band wireless backhaul

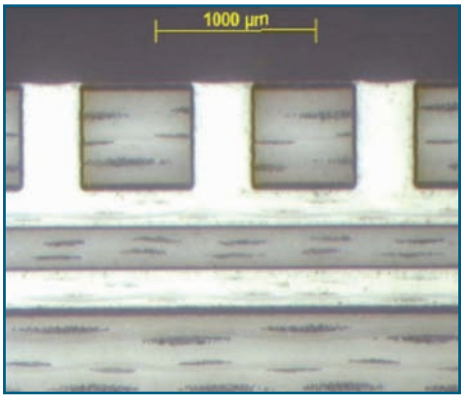
To E or not to E, band that is. E-band wireless backhaul is a hot subject today when it comes to the future of 4G networks (WiMAX/LTE). It is believed that in order for all this mobile broadband data to make its way out of the wireless world and into the wireline world for transmission, microwave backhaul systems will need to operate at E-band or greater (+60 GHz) due to bandwidth limitations in today's sub 40 GHz frequency allocations. Thin dielectrics with low loss are a strong consideration for these applications; some traditional materials for lower frequencies are being evaluated, but a concern regarding the use of woven glass in the matrix of the material (as is common in many high frequency materials) exists — in particular, the periodic nature of the glass weave and how that may impact the dielectric constant of the substrate at the millimeterwave level.

The use of homogeneous materials at these frequencies is gaining momentum, and recent product offerings like ULTRALAM® 3850 provide a solution. ULTRALAM 3850 is unique in that it is a single thermoplastic resin, liquid crystalline polymer (LCP), with a dielectric constant of 2.9 and loss tangent of 0.002 at 10 GHz. (< 0.005 at 90 GHz). This material is available in thicknesses of 0.001" (25 µm), 0.002" (50 µm) and 0.004" (100 µm) making it one of a few select options of high frequency materials with a dielectric thickness less than 0.004".

Improved manufacturing

Long gone are the days where RF designs were solely double sided circuits. Now, more complex designs require RF and high speed digital signals to travel on multiple layers. Higher lamination temperatures are usually needed to laminate these materials. Thermoset RF materials have posed an advantage over PTFE because of their processing similarity to FR 4 and inherent lower processing costs, but limitations in design exist due to the low flow nature of the matched prepregs (RO4350B laminate and RO4450B™ prepreg), in particular fill of blind vias. Increased flow, high frequency RO4450F™ prepreg is now available. Besides having ideal RF performance, this prepreg can now be used to fill blind vias

Figure 2: RO4000 MLB with filled vias using RO4450F prepreg.



(Figure 2 shows an RO4000® multilayer with RO4450F prepreg filled vias). RF engineers now have the flexibility to design complex MLB's with low cost practices commonly found in the FR4 industry.

Defense & Aerospace

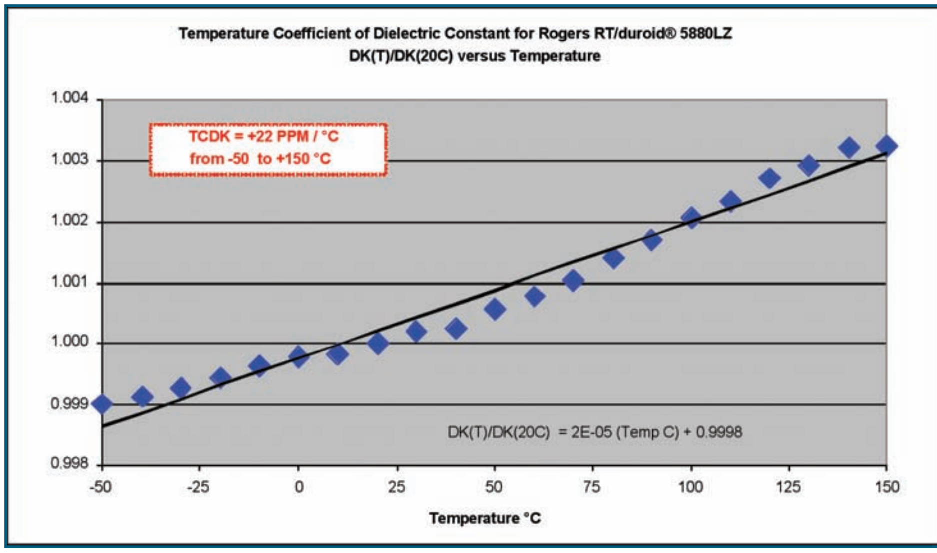
The first market for high frequency circuit board materials was defense and aerospace. Although much is said today about the overall size and growth of the wireless infrastructure market, defense and aerospace continues to be an important market. New materials have been designed that are enabling new technologies to move forward. Airborne radar antennas are becoming more complex and are a greater part of the military's arsenal of tools to monitor the world's hot spots.

To better serve the designer's needs, light weight/low dielectric constant PCB dielectrics are needed. Foam PCB materials have been introduced before but with limited success. Their main drawback was the lack of true circuit board processability, in particular plated through holes. This next generation of products address this problem. RT/duroid 5880LZ material is a low dielectric constant (1.96), lightweight (1.37 g/cm^3) PCB substrate that is plated through hole capable. In addition, with a low value for coefficient of thermal expansion (41.5 ppm/°C, Z-axis) and low thermal coefficient of dielectric constant (+22 ppm/°C), it is well suited for temperature varying environments.

Figure 3 shows the change in dielectric constant of the material with temperature compared to that of PTFE/glass with a dielectric constant of 2.2.

In addition to light weight circuit materials, airborne antennas commonly need thin layers with resistors for use in power distribution networks (combiner/splitters). Resistive layer foils have been available for over two decades, but their use has been hindered by the fact that resistor tolerances can typically exceed 20 percent unless a secondary trimming process is incorporated. Significant improvements to the "as etched" tolerance have been achieved by making slight modifications to the copper base, dielectric and lamination process.

Figure 3: **Temperature Coefficient of Dielectric Constant for RT/duroid 5880 LZ.**



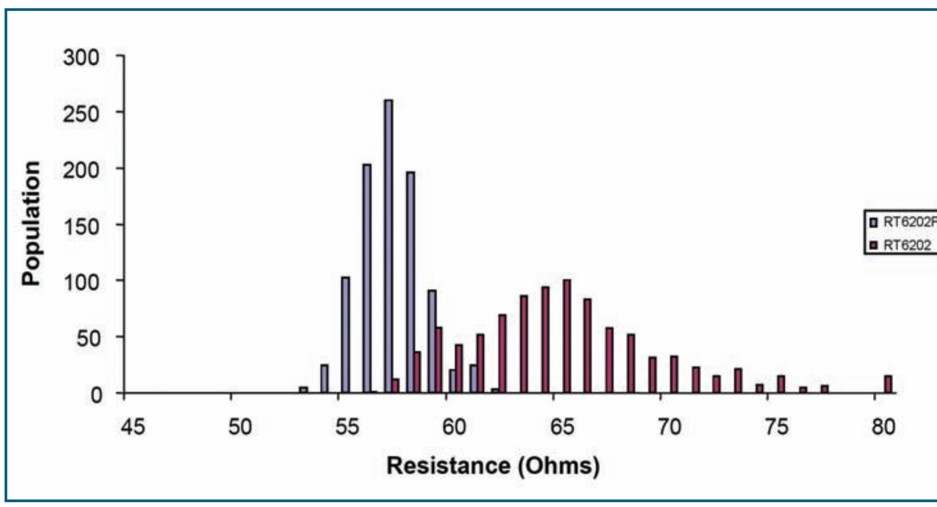


Figure 4: **Improvements in Ohmega Foil resistors on RT/duroid 6202PR versus RT/duroid 6202.**

Designers now have the ability to work with thin, temperature stable dielectrics, achieved through the use of selected filler/resin combinations and tight dimensional tolerances (due to woven glass structures for reinforcement in combination with resistive copper foils) to achieve high level passive integration within a MLB structure.

Conclusion

The world of high frequency materials is going through many changes with new product offerings being tailored to specific market or application needs. Design centers are interfacing more openly with material scientists in order to develop products that enable further technology development. The list of new products to the market discussed herein covers quite a diverse field of applications and market segments. When selecting a material, choose a material supplier that stands behind the products they sell and is willing to work with the customer base to further develop the next generation of materials in a timely fashion.

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