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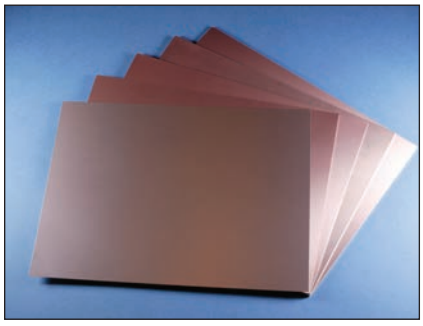

New Laminates Enable 79 GHz Technology Advancements

Rogers Corp.
Chandler, Ariz.

Millimeter wave (mmWave) applications are looming large on the horizon, from increased use in automotive electronic systems, including automated steering and collision avoidance, to providing bandwidth so severely needed for improved data throughput and video performance in fifth generation (5G) wireless communications systems. But first, new techniques must be developed to affordably fabricate circuits, devices and components for use above 30 GHz. RO3003™ laminates from Rogers Corp. is a circuit board material that provides that much-needed combination of performance and affordability to help bolster current and emerging mmWave applications.

RO3003 laminates are already well established as a circuit material of choice for mmWave automotive sensors and radar systems through 79 GHz because of outstanding performance and material characteristics well suited to those higher frequencies. These ceramic-filled PTFE laminates exhibit a dielectric constant (Dk) of 3.00 in the z-direction (thickness) measured at 10 GHz, with a tightly controlled tolerance of ±0.04. They are affordable because they can be transformed into high frequency circuits using standard PTFE circuit board processing techniques.

The performance of these materials is good at mmWave frequencies because of various material features and characteristics. For example, RO3003 laminates offer low insertion loss (especially with rolled-copper conductors), even at 79 GHz. The material has low coefficient of thermal expansion (CTE), low moisture absorption, low thermal coefficient of dielectric constant (TCDk) and low dissipation factor. Since the material does not rely on glass reinforcement, there is no concern for performance degradation due to glass weave effects. This combination of factors adds up to a circuit material that is well suited for mmWave applications and can be processed with affordable circuit fabrication techniques.

The low CTE of RO3003 laminates contributes to high printed circuit board (PCB) reliability, especially for circuits using plated-through holes (PTH). Higher CTE values indicate a

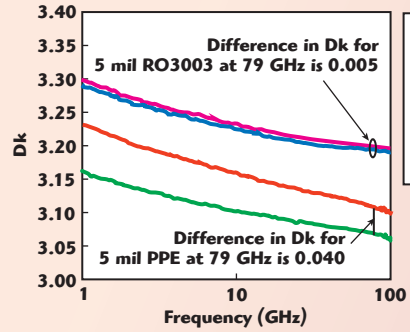

Fig. 1 PPE thermoset circuit materials can lack stability of dielectric constant (Dk) with changing temperature and humidity conditions compared to RO3003.

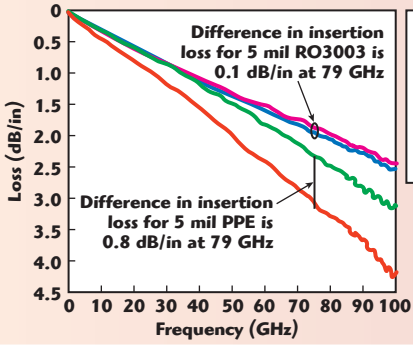

Fig. 2 The insertion loss of RO3003 laminate is considerably less and more stable with temperature and humidity at 79 GHz compared to PPE thermoset material.

dielectric material that will expand and contract more as temperatures change, rather than a conductor such as copper, and result in mechanical stresses of the conductor on the substrate and in PTHs over wide temperature ranges. A laminate with CTE of 70 ppm/°C or less is considered good, with an ideal number closer to 17 ppm/°C to match the CTE of copper. RO3003 laminate features CTE values of 17, 16 and 25 for the x, y and z axes, respectively, which are all closely matched to the 17 ppm/°C of copper, yielding excellent reliability of PTHs and other circuit features. Having three-axis CTEs so closely matched to copper is one reason why RO3003 laminate has been used extensively in multilayer PCBs (and their PTH interconnections) for so many years with such good results.

Low moisture absorption is an important trait for high frequency circuit board materials since the Dk of water (≈80) absorbed into the material increases its Dk and dissipation factor. Circuit materials exposed to high humidity environments can absorb water and suffer variations in phase response and insertion loss. When tested at mmWave frequencies, RO3003 laminate fared well compared to a new polyphenylene ether (PPE) thermoset material developed for high frequency use (see Figures 1 and 2). The materials were compared at room temperature (+25°C) and 50 percent relative humidity (RH) and then at elevated temperature (+85°C) and 85 percent RH. In both cases, the RO3003 laminate outperformed the PPE circuit material.

Another important circuit material parameter to consider for mmWave applications is TCDk, which is a measure of how much a material's Dk will change with temperature. For example, the TCDk of RO3003 is -3 ppm/°C. While a value of 0 would be ideal, this TCDk for RO3003 is an extremely low value and less than 50 ppm/°C as an absolute value. It indicates minimal change in the material's Dk over its operating temperature range for stable electrical performance, even in hostile environmental conditions faced by many automotive mmWave applications.

Wavelengths decrease with increasing frequency and wavelengths at mmWave frequencies are extremely small, requiring small circuit features. At 79 GHz, for example, and using 5 mil thick circuit material with Dk of about 3, a 50 Ω microstrip transmission line will have a wavelength of about 0.095" or 2.413 mm. A quarter-wavelength 0.024" or 0.603 mm at 79 GHz can cause unwanted resonances and some glass-reinforced laminates may employ glass cloth with features within this dimensional range, resulting in performance problems at mmWave frequencies. Known as the glass-weave effect, such circuit materials can suffer areas with variations in Dk that result in impedance and phase variations in a circuit at mmWave frequencies. The effect is typically exhibited as a circuit-to-circuit variation. RO3003 laminate does not employ glass reinforcement and therefore suffers no glass-weave effect.

RO3003 material features outstanding Dk consistency with tight Dk tolerance for excellent repeatability of circuit performance from board to board. Such consistency not only supports predictable circuit performance at mmWave frequencies but also enables the use of commercial computer simulation software for designing circuits at those higher frequencies, with results that closely match actual measurements of fabricated circuits.

In addition, RO3003 laminate has very low dissipation factor which contributes to the low loss characteristics. The dissipation factor of RO3003 is 0.001 when tested at 10 GHz using a clamped stripline test per IPC-TM-650 2.5.5.5c. The different material characteristics of RO3003 combine in a circuit material well-suited for mmWave circuits, especially in automotive applications where environmental conditions, such as wide temperature ranges, can be quite challenging to the reliable and consistent performance of such high frequency circuits.

VENDORVIEW

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