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2011 REVIEW
STEPPING BACK IN TIME

2011 MATERIAL HIGHLIGHTS

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SUMMARY

As high-speed digital applications are stretching to faster data rates, the need for a circuit material to bridge the gap between FR-4 and very low loss PCB materials has become evident. The year 2011 has been a good year for the progression of this type of PCB technology and has set the stage for 2012 to be even better.

Looking back over 2011, several technical issues regarding PCBs and the materials used come to mind. Most of these are very interesting and will likely facilitate the technology to come. Some of the more obvious issues for 2011 were thermal management improvements, PCB design modeling enhancements and the blending of high-speed digital and microwave technologies.

Thermal management concerns are nothing new. As technology evolves, these issues become more critical. Some of the new GaN microwave-power amplifier chips introduced in 2011 have very impressive electrical performance; however, they also generate high levels of heat—some more than 200°C in normal operation. More of these chips will be found in PCB power amplifier applications in the future and thermal management will be very important to understand. Most, if not all, PCB configurations with these chips will be directly mounted to the heat sink, although the heat emanating from the chip leads onto the PCB traces can be significant. Having a PCB material with a high thermal conductivity property will allow this heat to spread and not be focused at a specific point. Also, a laminate with high thermal conductivity will increase the heat flow path from the PCB traces to the heat sink, improving thermal management. The Rogers RT/duroid® 6035HTC laminate was introduced to the market a few years ago and in 2011 sales of this product increased in response to thermal management needs. Where most PCB laminates have a thermal conductivity value of about 0.25 W/m/K, the RT/duroid 6035HTC material is more than 5X this number at 1.44 W/m/K. The material also has very low loss (dissipation factor = 0.0013). This translates to less heat generated at RF frequencies.

Another topic which advanced in 2011 was electrical modeling of PCB structures; more specifically, microwave and RF modeling of PCB structures. The advances in the electromagnetic (EM) modeling software continue to be remarkable. Nonetheless, one limit to them is knowing the correct

properties of the PCB material used within an EM model. The dielectric constant (Dk) of the substrate needs to be accurately known and this value can vary somewhat with frequency or even the construction of the laminate. It has been found and demonstrated that thin laminates can have an altered Dk value in certain circuit configurations due to the effects of copper surface roughness. Additionally, the performance of some PCB microwave structures can be impacted by the Dk of the material in the x-y plane of the laminate, and strides in understanding these values regarding a variety of material have been made in 2011. The design Dk is the Dk value which is best used for circuit design and modeling, as compared to other Dk values sometimes found on datasheets which reference a test method that may or may not be appropriate for circuit design.

I mostly deal with RF/microwave/millimeter-wave applications. However, from some exposure to high-speed digital, I found there are similar concerns, as well as many differences. Microwave designers typically think in terms of wavelength, wave propagation, insertion loss and frequency domain characteristics. On the other hand, high-speed digital designers generally think in terms of rise time, propagation delay, crosstalk and time domain concerns.

It seems that over time these two technologies are merging to some degree. For decades, the microwave designers have known about dispersion and the many different aspects of insertion. There are some in the high-speed digital design community who are also very aware of these issues, but as a generalization, most have only recently began to explore these concerns in depth. The concern for copper roughness is getting significant attention as it relates to insertion loss, as is the impact of dispersion and insertion loss on the eye diagram for very high-speed digital applications.

Rogers Corporation has made laminates used in the RF/microwave/millimeter-wave PCB applications for many years. These materials are considered low loss and typically have extremely low dispersion. The standard FR-4 circuit materials that have been used in the PCB industry for several years are considered high loss and come with relatively high dispersion. As high-speed digital applications are stretching to faster data rates, the need for a circuit material to bridge the gap between FR-4 and very low loss PCB materials has become evident.

The year 2011 has been a good year for the progression of PCB technology and has set the stage for 2012 to be even better.

The Rogers Corporation Design Dk paper and many other useful references can be found on the Technology Support Hub at http://www.rogerscorp.com/acm. **PCB**

John Coonrod is a Market Development Engineer for Rogers Corporation, Advanced Circuit Materials Division. John has 23 years of experience in the Printed Circuit Board industry. About half of this time was spent in the Flexible Printed Circuit Board industry doing circuit design, applications, processing and materials engineering. The past ten years have been spent supporting circuit fabrication, providing application support and conducting electrical characterization studies of High Frequency Rigid Printed Circuit Board materials made by Rogers. John has a Bachelor of Science, Electrical Engineering degree from Arizona State University.