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MATERIALS

Key Factors Influencing Laminate Material Selection for Today's PCBs

by Steve Iketani and Brian Nelson

High-Frequency Laminates for Hybrid Multilayer PCBs

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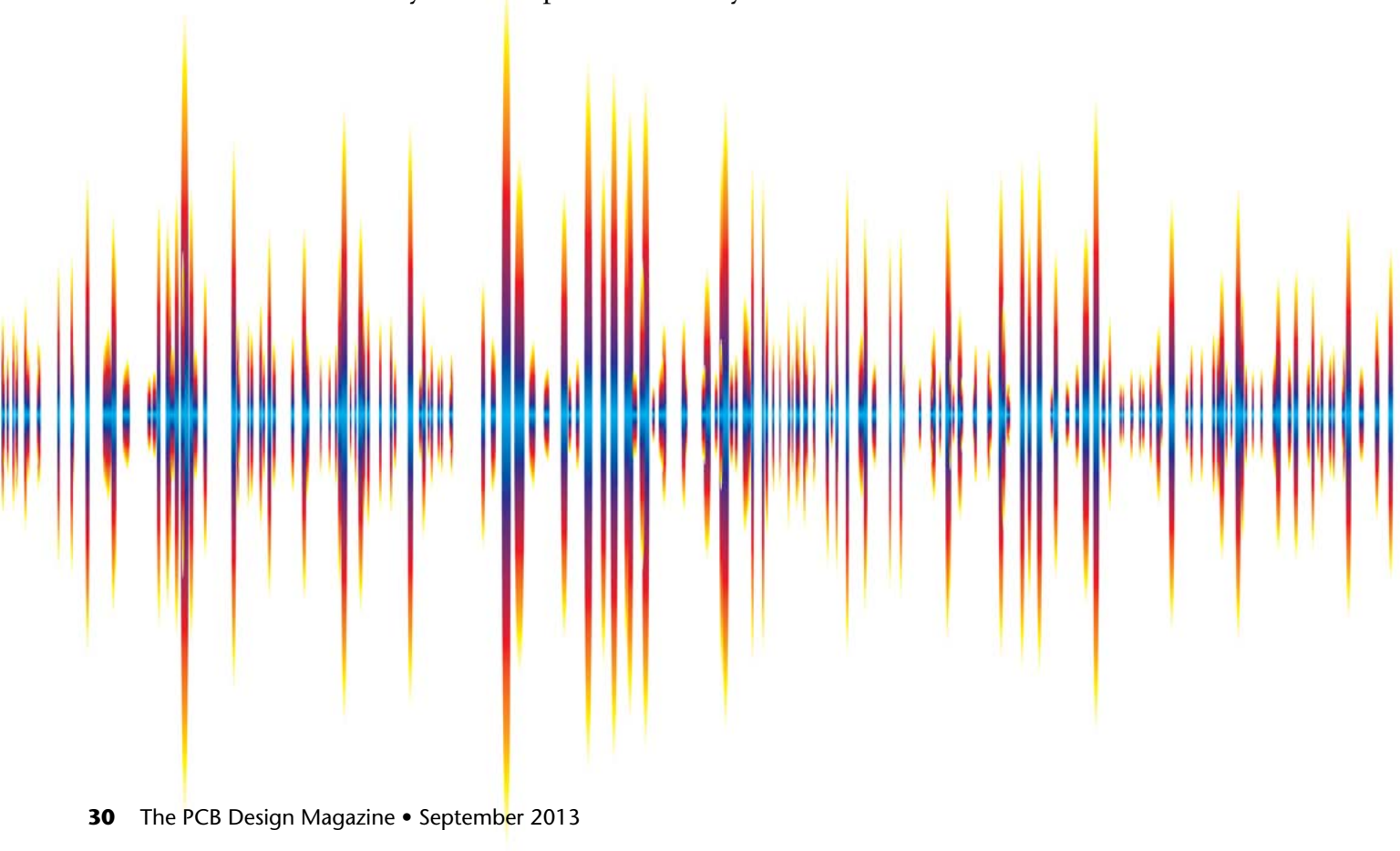
A hybrid multilayer is a PCB construction that uses dissimilar materials. Reasons for using dissimilar materials include: improving reliability, reducing cost, optimizing electrical performance, and improving manufacturability. For the past several years, hybrid multilayer PCB construction has flourished in the arena of high-frequency RF applications.

Multilayer reliability concerns are often related to the coefficient of thermal expansion (CTE) of the circuit material. Some laminates that display excellent electrical performance at high frequencies also have high CTE values. These laminates are often non-filled PTFE-based substrates that have a very low dissipation factor (tangent delta), low dielectric constant, and very good electrical performance at microwave and millimeter-wave frequencies. However, the high CTE of these laminates can cause problems when the PCB undergoes thermal cycling, such as soldering.

A high-CTE laminate grows at a different rate than the copper during elevated thermal exposure, and this difference can cause delamination of the copper-to-substrate interfaces. Also, when a PTFE-based circuit reaches elevated temperatures, it will expand and put stress on the plated through-hole (PTH) vias, which may in turn cause them to fracture. It is typically desired to have a substrate with a CTE simi-



HIGH-FREQUENCY LAMINATES FOR HYBRID MULTILAYER PCBS *continues*

lar to that of copper, which is approximately 17 ppm/°C. But some PTFE substrates have a CTE in the range of 200 ppm/°C or more.

Nowadays, most multilayer constructions perform multiple electrical functions. With some multilayer circuits, only a few copper layers are considered electrically critical for high-frequency performance, while the rest are not critical. These circuits could use PTFE-based laminates for high-performance layers, and a low-CTE material in the remainder of the board. Combining the high-CTE and low-CTE materials will yield a hybrid multilayer with a composite CTE that can be acceptable for thermal reliability and good electrical performance.

Some hybrid multilayer PCBs use dissimilar materials specifically for cost reasons. Most high-frequency laminates cost more than FR-4; however, they are typically compatible for circuit fabrication. A word of caution regarding using hybrids for cost reduction: Even though the material costs are very different, if fabrication is made more difficult due to the combination of these dissimilar materials, some cost savings may be mitigated. The supplier of high-frequency materials should be involved in planning these hybrids, because these companies typically know which materials are compatible.

Hybrids are often used in coupler applications; they help improve the performance of the coupler. High-frequency materials with very different dielectric constant (Dk) values can be used to improve the coupling coefficient. A quick example is a four-layer stripline broadside coupler, with the same low-Dk laminate type used for the top and bottom layers. The circuit uses a material with a high Dk value for the layer that separates the coupling elements of layers 2 and 3. This combination can help tune the design for specific coupling values as well as other enhanced coupler properties.

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The combination laminates with different Dk values have been used in antenna multilayer hybrids in order to optimize the performance of the antenna. Typically, a thick laminate with a low Dk is used for the radiating element of a PCB antenna. It is often not optimum for the feed line that transfers energy to the antenna radiating element to use this same material because the feed line will lose some energy due to radiation loss before it reaches the antenna elements. In this case, a multilayer hybrid is used where the feed line is a buried signal layer in a stripline configuration using a low-loss material. The stripline configuration will not allow radiation loss. A PTH via is used to get the energy from the feed line to the antenna element on the outside layer of the hybrid. Many times the outside layer for the antenna radiating element will be of a different Dk than the inner layer feed line to optimize each circuit feature's performance.

Hybrid multilayer PCBs can offer improved manufacturability, because certain materials offer better drill life, simpler processing for PTH preparation, and shorter lamination cycles, as well as causing less debris during laser ablation, etc. When the desire is to improve manufacturing by using hybrids, there are many issues to consider for each material. Typically, a very thorough study is needed to assess compatibility issues and yields, as well as true improvements to the fabrication process. **PCBDESIGN**

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