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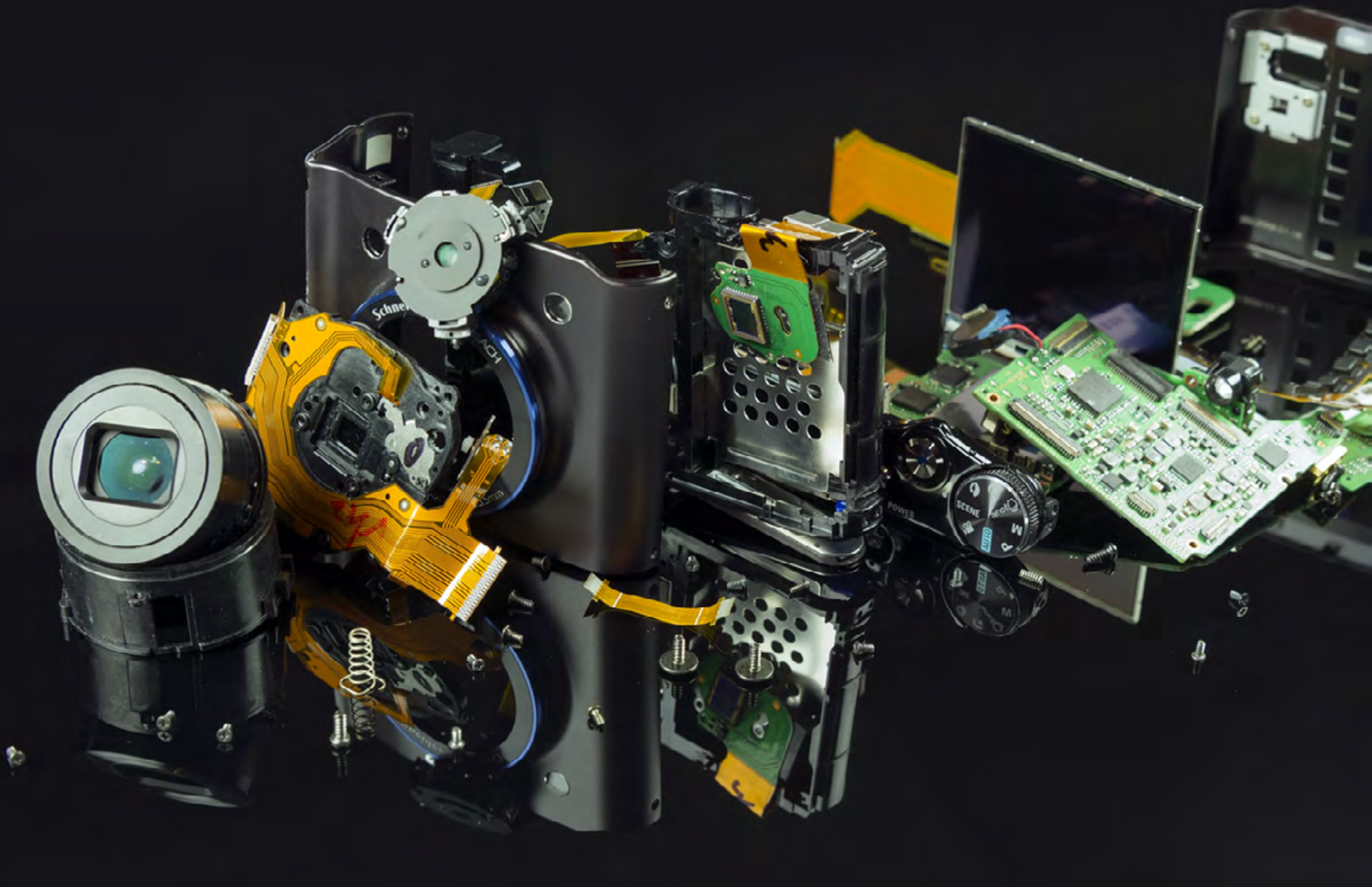

MULTI•BOARD design

Considerations for Comparing Material Data Sheets

Lightning Speed Laminates

by John Coonrod, ROGERS CORPORATION

RF and high-speed digital designers often compare data sheets from different circuit material manufacturers while seeking to find the proper material for their applications. Of course, a careful study comparing the different data sheets is highly recommended. However, when the details of circuit material data sheets are considered, several exceptions could cause confusion among those unfamiliar with this process. Understanding the test methods and their testing conditions for each property is critical in recognizing whether a direct data comparison of two different materials is valid.

To begin with, one common high-frequency circuit material property to consider in most applications is Dk (dielectric constant or relative permittivity). Many PCB designers see Dk as a straightforward property, but when you evaluate the different test methods, conditions and influence the material has on each test method, the results may not be as one would assume.

As an example, the same piece of material can be tested in two different tests and achieve two different Dk values, and both values may be correct. One reason why that statement can be true is since most materials used in the PCB industry are anisotropic, which means that the Dk is not the same on different axes. Some test methods will evaluate the material in the z-axis (thickness axis) only and other test methods will evaluate the x-y plane of the material for the Dk property. When a material is anisotropic, there should be a different Dk in the z-axis than in the x-y plane.

Another example is related to the normal frequency-dependence of the Dk in high frequency materials. As a general statement, an

increase in frequency will cause the Dk to decrease slightly when tested within the microwave range of frequencies or within the lower millimeter-wave range of frequencies. Again, it is possible to test the same material in two different tests, which are using the same test method and get two different answers for Dk and both answers are correct. That can be true due to the frequency-dependence of materials and when using the same test method but at different frequencies, the Dk value should be different.

There are also similar accuracy concerns for comparing data sheets as it relates to dissipation factor (Df). The main concern regarding Df is typically the test methods being compared at different frequencies. Df is frequency-dependent and with an increase in frequency, the Df should increase. Sometimes data sheets will show the Df values at 2 GHz or 2.5 GHz when targeting applications in that frequency range and then other data sheets will report Df for the material when tested at 10 GHz. The Df should be higher at 10 GHz than 2 GHz, so the designer needs to make sure the frequency and test method is the same when comparing Df values for different materials.

The main concern regarding Df is typically the test methods being compared at different frequencies.

Additionally, there are other scenarios to consider for different properties and one example would be the thermal conductivity of a material. There are different test methods for determining the thermal conductivity of the material and when using the same test method, there are different sample preparations which can alter the results of this property. One noteworthy difference for testing thermal conductivity and using the same test method is whether the material is copper clad or if the copper was removed prior to testing. Most materials used in the PCB industry have relatively low thermal conductivity and copper has extremely good thermal conductivity. A common range of thermal conductivity for high-frequency materials is from 0.2 W/m·K to 0.5 W/m·K and copper has about 400 W/ m·K for thermal conductivity. When a material is tested for thermal conductivity and if copper remains on the sample being evaluated, the thermal conductivity test method will report a much higher value than if the sample has the copper removed prior to testing. Since most thermal modeling software requires thermal conductivity values of the raw substrate, it is more appropriate for the test procedure to exclude the influence of the copper during this test.

Another consideration for data sheet comparisons is peel strength and several items can be an issue for fair assessments. One issue that can be a significant concern is the use of one copper type to generate lower insertion loss and a different copper type used to report the peel strength value of the material. It is well known that a copper type which has a smooth surface (at the copper-substrate interface) will have lower insertion loss due to lower conductor loss. However, the smoother copper will typically cause the peel strength to be lower.

Some material suppliers will often use smoother copper to demonstrate better insertion loss performance, while their data sheet will have peel strength values generated from using a copper with a rougher surface. This is usually noted on the data sheet as a footnote next to the peel strength value, which cautions the reader that the peel strength testing was done with a different copper than the copper used for other test methods on the data sheet. **DESIGN007**

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