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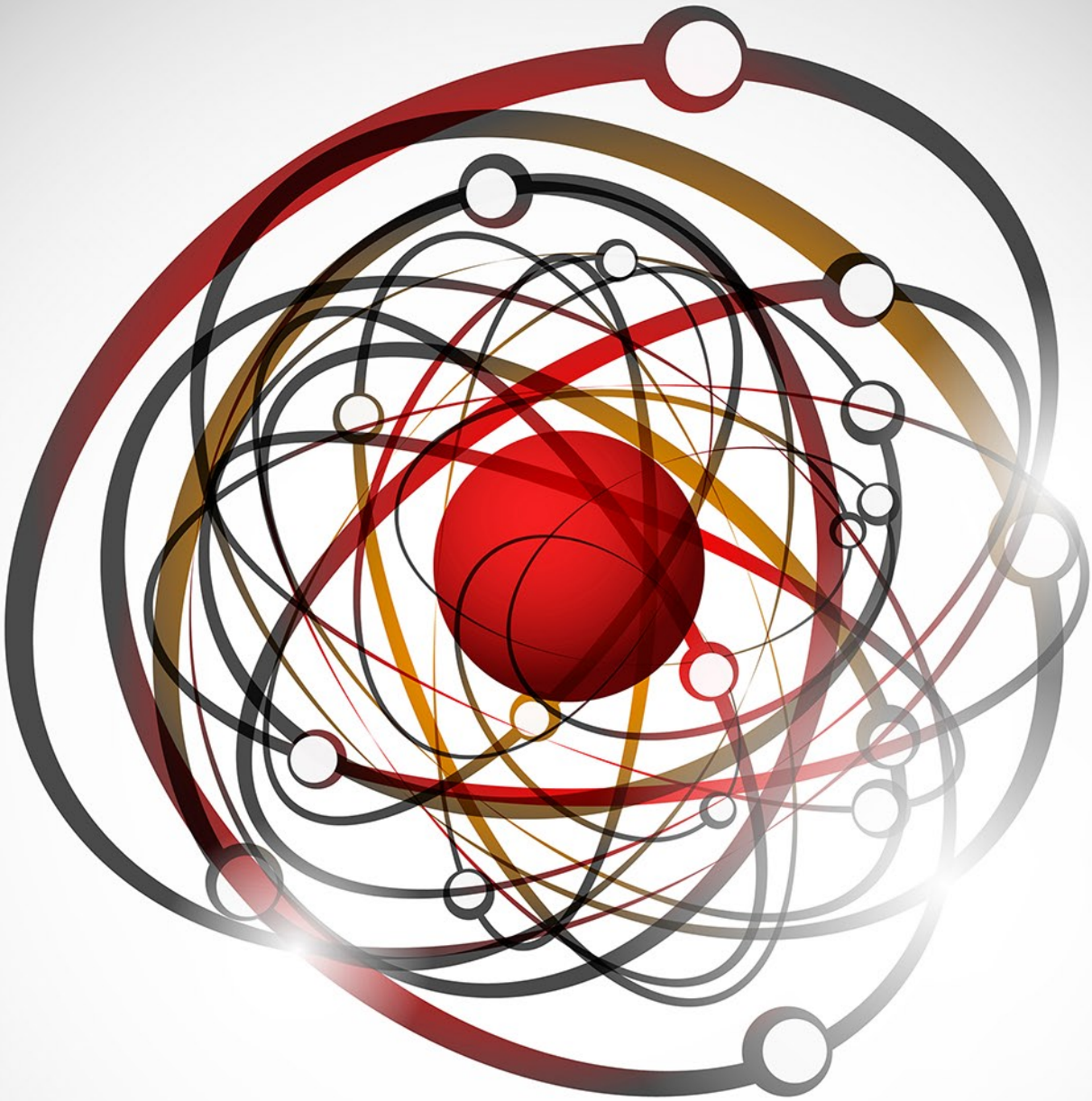

Multilayer PCB Bonding Materials for High-Frequency Applications

by John Coonrod
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When fabricators are choosing a material, they are normally familiar with the bonding materials that are appropriate for their circuit construction. The electrical performance is not always critical, but when it is, the fabricators may not completely understand how the material can impact the material electrical performance. The following is an overview of different bonding materials used in high-frequency multilayer PCB applications.

The materials used to bond high-frequency multilayers may differ greatly in their formulations. Many of these bonding materials are glass-reinforced; however, there are several commonly used bonding materials which are not woven glass-reinforced. The non-reinforced bonding materials are typically a thermoplastic polymer film, however there are some exceptions. Woven glass-reinforced bonding materials are usually thermoset systems and often with special filler to enhance the high frequency performance properties.

The thermoplastic bonding materials are brought to a melt temperature during lamination to achieve adhesion of the layers for the multilayer circuit. These materials can also re-melt after the multilayer has been adhered and re-melting can cause delamination which is why it is typically avoided. The lamination melt temperature and the cautionary re-melt temperatures vary with the type of thermoplastic bonding materials. Some fabricators may not have the equipment necessary to reach these higher temperatures necessary for lamination of a multilayer PCB. The re-melt temperature is typically a concern for the processes following the lamination, which exposes the circuit to elevated temperatures such as soldering.

The following is a list of thermoplastic non-reinforced bonding materials commonly used in multilayer high-frequency PCBs, with their melt and re-melt temperatures: Rogers 3001 (melt=425°F and re-melt=350°F), CuClad 6700 (melt=425°F and re-melt=350°F), and DuPont Teflon FEP (melt=565°F and re-melt=520°F) bonding films.

The re-melt temperature is lower than the initial melt temperature because of delamination concerns. At the re-melt temperature, the material is soft enough to delaminate. At the initial melt temperature during lamination the material is at its lowest viscosity which allows the material to wet-out and flow for good adhesion in the multilayer while held under pressure in the lamination process. From the temperatures of the different materials, it can be seen that using the 3001 or CuClad 6700 bonding materials would be appropriate for a multilayer which is not exposed to elevated temperatures, such as soldering. The DuPont Teflon FEP material can be used for a multilayer that will be subjected to soldering, assuming the soldering temperature is controlled to below the re-melt temperature. However, some fabricators do not have the capability to reach the initial melt temperature.

There is an exception to the thermoplastic non-reinforced bonding materials, and that is Rogers' 2929 bondply, which is non-reinforced, but it is not a thermoplastic. It is a thermoset material. The thermoset material does not have a melt and re-melt temperature, but it has a cure temperature (during lamination) and a decomposition temperature which is to be avoided due to delamination concerns. In the case of the 2929 bondply, the lamination temperature is 475°F and the decomposition temperature is well beyond lead-free soldering temperatures so it is robust to most elevated temperature processing after the multilayer is bonded.

Each of these non-reinforced bonding materials has different electrical properties. The electrical properties for these bonding materials are as follows: Rogers 3001 (Dk=2.3, Df=0.003), CuClad 6700 (Dk=2.3, Df=0.003), DuPont Teflon FEP (Dk=2.1, Df=0.001) and 2929 (Dk=2.9, Df=0.003). The term Dk refers to dielectric constant or ε_r and Df refers to dissipation factor or tan-delta.

There are also woven glass reinforced bonding materials. These are typically a combination of woven glass fiber cloth, resin and some filler. Depending on the formulation, the PCB fabrication parameters for lamination can vary significantly. As a general statement, the prepreg material which is highly loaded with filler will typically have much less lateral flow during lamination. The lack of flow can be good and bad. If the prepreg will be used to build a multilayer with cavities where the prepreg needs to be cut back and not flow into the cavity, then these highly filled prepregs may be a good choice. However, if the inner layers that the prepreg is intended to bond have thicker copper, it is sometimes difficult to get a good lamination with these lower flowing prepregs.

Two woven glass reinforced prepregs which are commonly used in high-frequency fabrication are the RO4450B and RO4450F prepregs (Dk=3.5, Df=0.004). These materials have processing parameters which are relatively similar to FR-4; however, they offer the benefit of very good electrical properties at high frequencies. These materials are highly loaded and will have low lateral flow during lamination. They are a high Tg thermoset materials and very robust to lead free soldering or other elevated processes.

When designing a multilayer PCB for high frequency applications, there are a variety of tradeoffs. The fabrication aspects must be considered along with the electrical performance considerations. It is always highly recommended to contact your material supplier when designing a new multilayer PCB for high-frequency applications so these different tradeoffs can be adequately discussed. **PCBDESIGN**

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