Material Witness
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Beating the Heat –
Practical Considerations in Using Tc Materials for PWB’s

It’s one thing to know you have to reduce the temperature at active devices mounted on a PWB and another altogether to do so while maintaining a “normal” manufacturing and assembly process for circuit boards. In our previous discussion of thermally conductive materials (“Beating the Heat – A Nonmathematical Introduction to Thermal Properties”) we summarized some of the important properties of laminates and prepregs that would be ideal for such applications: high thermal conductivity (at least 1 W/m-K, and preferably higher), minimum thickness, and the ability to flow and fill the interface to minimize thermal impedance. This time we will talk about some of the practical issues involved.

There are two different applications of thermally conductive prepregs: 1.) Use as interface bonding layers between a PWB and a heatsink; and 2.) Use as part of a total thermally conductive package in which the entire PWB is composed of thermally conductive materials.

In the use of thermally conductive prepregs (whether standard or so-called “Low Flow”) as bond layers between a PWB and a heat sink, the critical issues will be (in addition to thermal conductivity) bond to both the aluminum and the PWB, and the completeness of the wetting to both surfaces to minimize thermal resistance due to any trapped air, imperfect mating of the surfaces, etc. Rheologically, highly thermally conductive materials will be different than standard unfilled FR-4 in that they will have substantially higher minimum melt viscosities by at least an order of magnitude (10,000 to 15,000 poise vs about 1000 poise), as the chart below indicates.

In practical terms this will mean that to achieve optimum bonding and complete wetting to the bonding surfaces, pressures used will tend to be higher than for an equivalent unfilled conventional epoxy system. The actual pressures used will depend on how much unevenness there is between the heat sink and the board, whether there are circuits on the underside of the board that also have to be filled, etc. If there will be cutouts in the heat sink, the pressure used will have to be balanced so as not to fill cutout areas while still achieving an acceptable fill and bond. Bonding a filled system to the aluminum heat sink and the PWB requires that both surfaces be clean, and that the aluminum preferably be sandblasted or abraded and any grease or fingerprint residue be removed (wiping with dry isopropyl alcohol is normally a good way to do a final clean and dry of the aluminum bonding surface. Lap shear
testing for bond to aluminum has indicated that values of 750 psi or greater will ensure a good bond that will resist normal thermal cycling or shock.

These same considerations will be present to some degree with bonding layers together with prepreg in an all-conductive MLB. Because these materials tend to be highly filled and have reduced flow (higher minimum melt viscosity) they will take more effort in filling circuitry on inner layers, and especially in filling vias or clearance holes in heavy metal inner layers. Here again, additional pressure and a higher rate of heatup will help to get more flow from any given system, but it may be necessary to pre-fill clearances in very thick metal layers or in thicker board sections with high aspect ratio vias, such as in complex sequentially laminated PWB's.

Interlam inarbonds in highly filled materials will not be as great as with unfilled epoxy, and this should not normally present any major problem. Avoid the old standby of trying to peel them apart by inserting an X-acto knife at the edge and twisting. The ability to force layers apart does not indicate unacceptable bond. When polyimides were first introduced during the late Jurassic Period (when I first joined this industry) there was concern about interlaminar bond because it was possible to peel multilayer boards apart, whereas it was nearly impossible with standard epoxies. Accepting that this is a difference rather than a defect is an important step in moving forward with thermally conductive technology today, as it was for polyimides 30 years ago.

You will not be able to drill as many holes in a board with a highly filled system as with an unfilled FR-4. While every effort is made to use filler materials that are as nonabrasive as possible, our objective is increased thermal conductivity and we need to use materials of a type and quantity such that the product will fulfill that necessary condition. Conditions that work well for filled materials and give optimum drill life usually include slower drill surface speeds (<300 sfm) and reduced infeeds (under 1 mil chipload). Your supplier’s technical service reps will have experience with all these variables, and can make suggestions to get the most out of your processes.

For many board shops whose business has been almost exclusively FR-4 for many years, these materials will seem to be “process-unfriendly,” but everybody else will have the same issues, so in the end the marketplace will decide which applications really require improved thermal conductivity, and will be willing to pay any material or process premium to get the needed properties. Clearly in such applications as power conversion, high intensity LED lighting and the like, that thermal requirement is already well established. It remains to the PWB design and fabrication process chain to determine the right materials and optimal processing.

Until next time, this is the “Material Witness,” signing off.