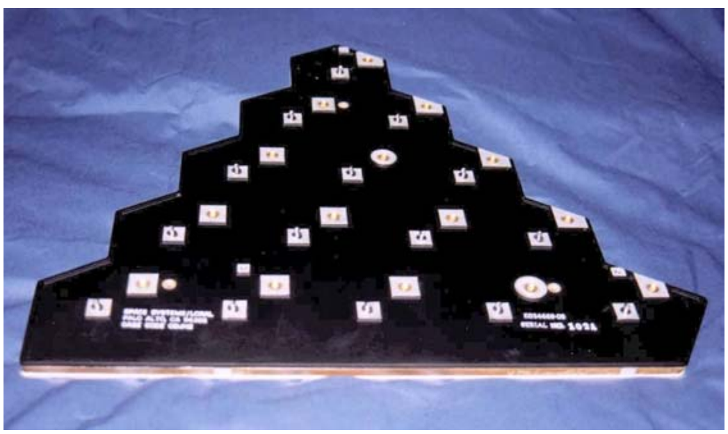
Arlon

Application Notes

# PTFE Multilayers -- The Future is Now!

Does the idea of a 1.5" thick 68 layer 18" x 24" PTFE blind and buried via multilayer board with mixed bonding materials leave you quivering with fear?  This is not a hypothetical instance -- the beam-forming antenna



network for the Globalstar satellite system had several such monster boards in each bird!  The photographs below, courtesy of Tyco Printed Circuit Group and Space Systems Loral, show one of the large modules,  the S-Array -- that was later assembled to make the final beam forming antenna -- and a typical cross section of a Globalstar board.  The raw material cost alone in such a board would make a nice down payment on a house in Malibu, and the selling price of the final board could run into the hundreds of thousands of dollars.  If that wasn't enough by itself, consider that this is involves multiple sequential laminations and think about the effect of multiplied yield values.  Until recently it is quite possible that your laminate sales rep would be twirling his mustache while tying you to the railroad tracks, and cynically telling you that ***nobody*** has a PTFE product that can be multilayered like ***that***.

While PTFE has always been recognized as providing the ultimate in electrical properties at high frequencies, it has frequently been the source of streaks of blue language when it came to trying to proceduralize the multilayer process, both in terms of dimensional stability (translate: "registration") and high z-direction expansion. In most cases this has led to not entirely satisfactory compromises, either requiring the use of materials with less than acceptable electrical properties, or cumbersome and expensive processing that still left doubt as to the reliability of the PTH's.

High layer count low dielectric constant/low loss multilayer boards are being considered for increasingly more applications, from probe cards for testing IC's to large backplanes or motherboards for optical-digital interface systems doing high gigabit per second data handling. More and more the electrical properties of the materials being used in multilayer boards have to be matched with mechanical properties that will accommodate the need for small closely spaced thru holes with reduced pad diameters, which by the way also means high aspect ratios in the plated holes.

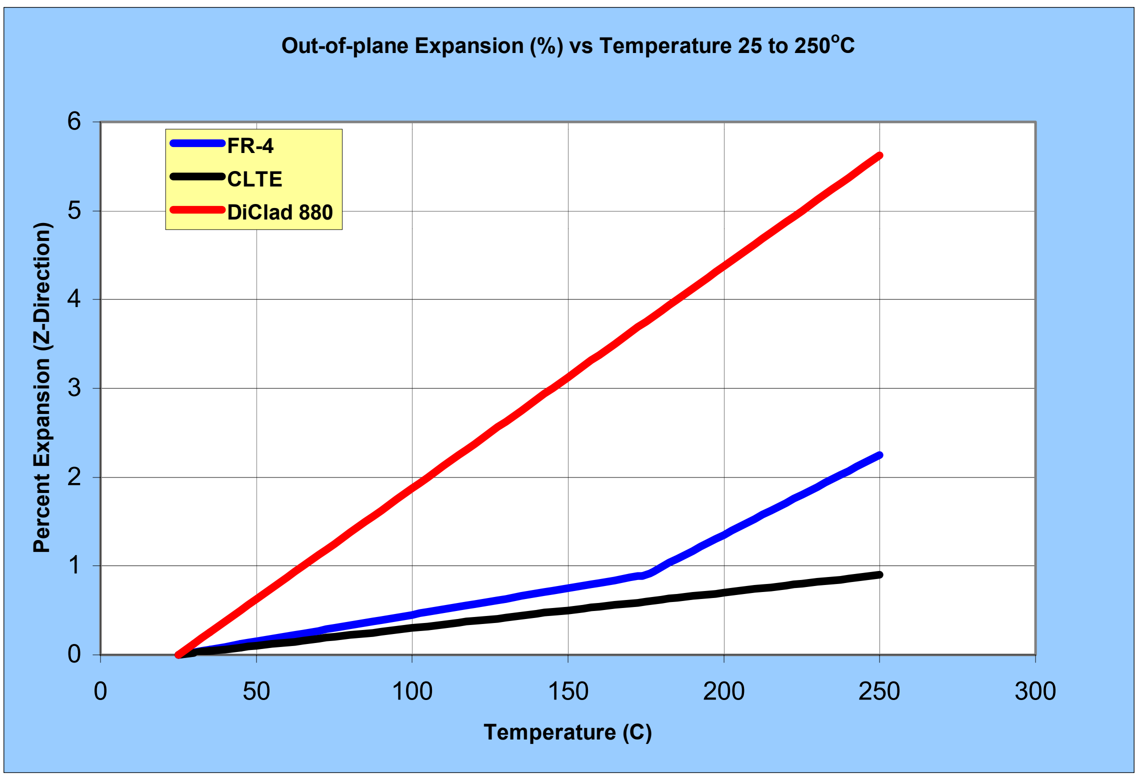
Enter CLTE, Stage Left, to the Rescue!

Arlon's CLTE material, a woven glass reinforced ceramic-filled PTFE product can also be supplied with an electrically matched bonding sheet, CLTE-P, for multilayering, or used with any of a number of other available bonding materials, seems to be the optimal material for multilayering. A quick look at several important properties of CLTE will show why that's the case:

Er = 2.94
Loss = 0.0025
CTEr (Thermal Coefficient of Dielectric Constant) is flat from -20 to +140$^{o}$C
CTE(X,Y) = 10,12
CTE(Z) = < 40 ppm/$^{o}$C (under 1% total from 25$^{o}$C to 250$^{o}$C)
Water Absorption = 0.04%
Thermal Conductivity = 0.5 W/m-K

Perhaps the most important consideration from the standpoint of building multilayer PWB's is the out of plane CTE (Coefficient of Thermal Expansion) of 40 ppm/°C. Consider multifunctional FR-4, with a CTE(Z) of 60 ppm/°C below the Tg and 180 ppm/°C above the Tg and assume a multifunctional system with Tg of 180°C. It's total expansion between room temperature and 250°C is 22000 ppm or 2.2%. The total expansion of CLTE at 40 ppm/ °C from room temperature to 250°C is 9000 ppm or 0.9%. In simple terms CLTE will cause less stress on a plated through hole than a high temp epoxy system, while providing the benefits of PTFE and a stable dielectric constant over temperature.

With most PTFE systems, including most of Arlon's other products, it is necessary to perform bonding of multilayer systems using a bonding film




whose dielectric properties are not the same as the material being bonded. These might include thermoplastic Fluoropolymer bonding films such as Arlon's CuClad 6250 or 6700, or may even involve use of FR-4. Not so with CLTE. The CLTE-P prepreg, although made from a lower melting point polymer to permit bonding without remelting the CLTE itself, precisely matches the Er, loss and CTE(Z) of the laminate material.

From the graph you can see that even if you bond your layers together with FR-4 (which will have an impact on the dielectric properties, but which can be done at conventional lamination process parameters) the total Z-direction expansion will always be less than that of the FR-4 alone. A number of variations on multilayering of RF and microwave boards are in common usage including the use of multilayerable materials such as Arlon's 25N and 25FR, the use of PTFE surface layers over a multilayer FR-4 signal distribution board and combinations of the above.

In the future new materials with more conventional epoxy processing will likely be available but if you need a high performance ML board built today, and Z-axis expansion is critical – you have a material that can do the job right now in CLTE! Your Arlon salesperson (who wears a white hat and will help untie you from those railroad tracks) would be happy to help you select the right CLTE (or CLTE-LC, a full featured reduced cost version of the product available in most thicknesses over 0.010") products for your particular application.