Arlon Materials for Electronics
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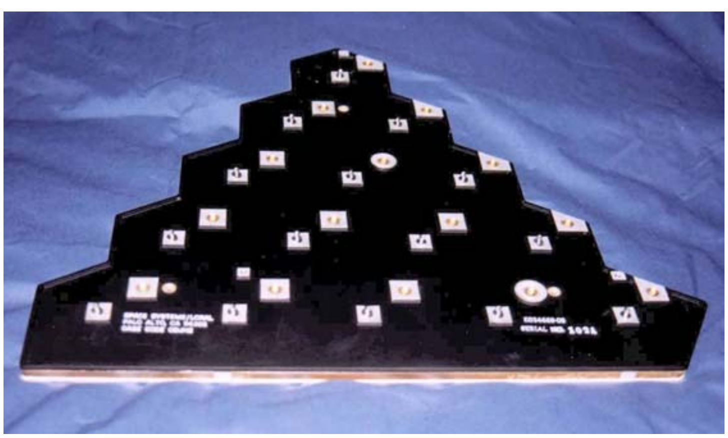
PTFE Multilayers -- The Future is Now!

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 may involve multiple sequential laminations and think about the effect of those 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.

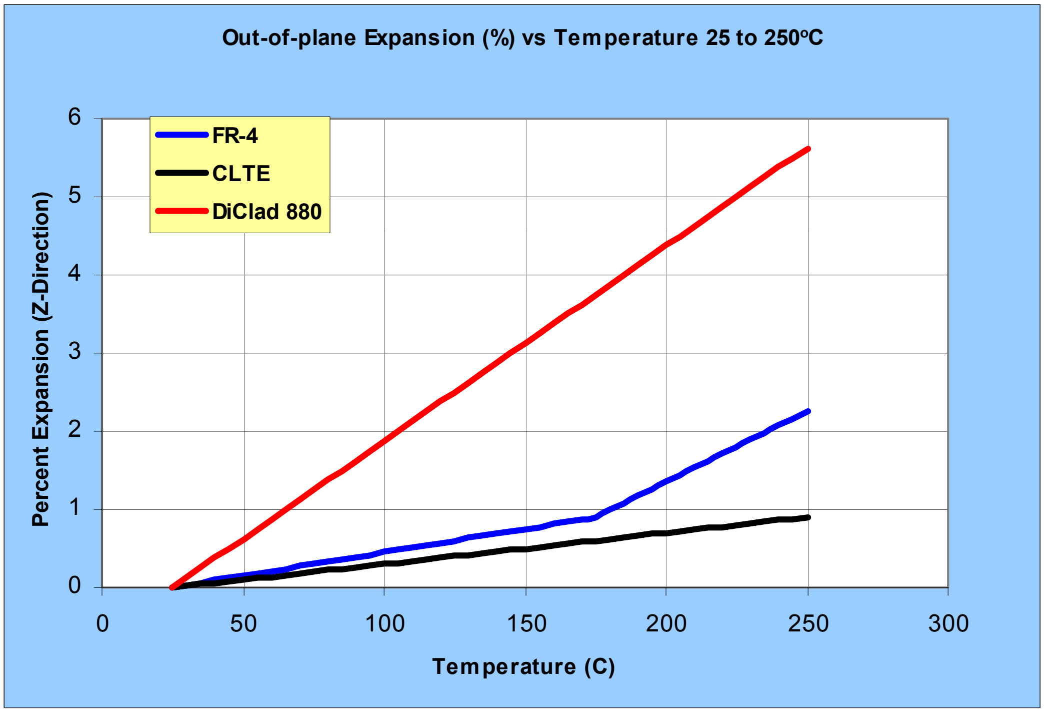
High layer count low dielectric constant/low loss multilayer boards are being considered for increasingly more applications, from probe cards for testing IC's to large backplanes or motherboards for optical-digital interface systems doing high gigabit per second data handling. More and more the electrical 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) = < 35 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/^{o}C. Consider multifunctional FR-4, with a CTE(Z) of 60 ppm/^{o}C below the Tg and 180 ppm/^{o}C above the Tg and assume a multifunctional system with Tg of 180^{o}C. It's total expansion between room temperature and 250^{o}C is 22000 ppm or 2.2%. The total expansion of CLTE at 40 ppm/ ^{o}C from room temperature to 250^{o}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.

No Flow -- or "Mo Flo"?

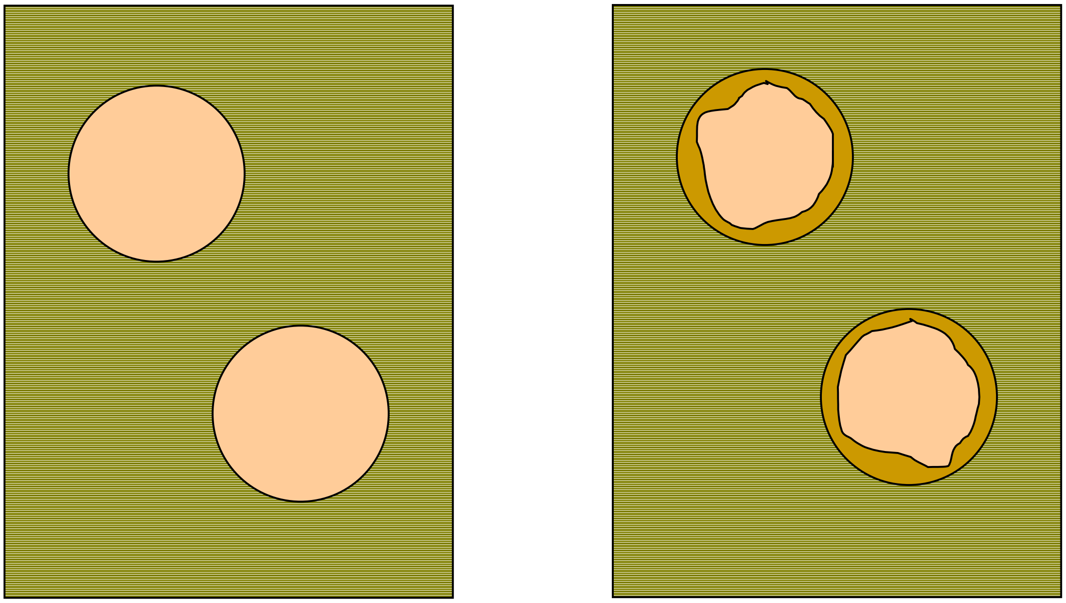
The term "No Flow Prepreg" has become part of the lexicon of the printed circuit industry, a term which in effect has created a great deal of confusion about what "No Flow" is or should be, and how to measure it. No matter what material you use, some amount of flow is necessary to permit wet out of surfaces to be bonded, and/or to fill inner layer circuitry associated with rigid-flex products.

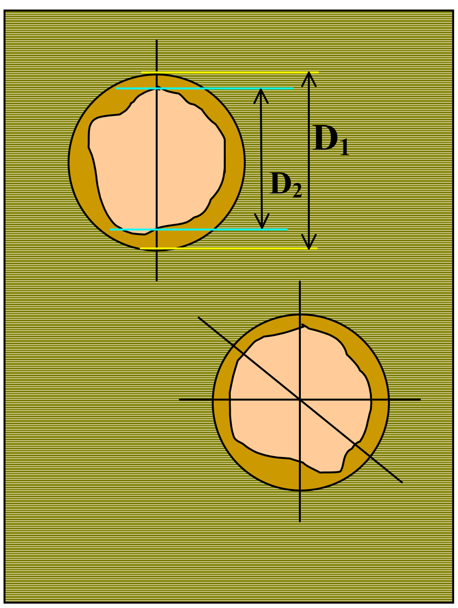
There are two major areas in which so-called No Flow materials are used: first, to adhere heat sinks of various kinds and shapes to printed wiring boards; and second, to act as a bonding material in rigid flex circuits to bond various layers together internally without flowing out to fill cutouts or interfere at the junction of the rigid and the flexible portions of the circuit. In both cases enough flow is needed to create a bond, fill circuitry if appropriate, but not so much that cutouts are filled in or excess flow is experienced.

For heat sink bonding the closer we can come to "No Flow" the better, since cutouts intended for device attachment often can't tolerate any resin flow. Rheologically this means that we have to find ways to make sure that, while the resin melts and bonds to working surfaces, it does NOT flow laterally any more than is absolutely necessary to flush out air at the edge of the panel. A typical melt viscosity for a No-Flow material may be anywhere from 6000 to 30,000 poise -- while a standard epoxy prepreg might by comparison have a melt viscosity of as low as 600 poise. That's the order of magnitude of the difference between the flow of warm honey and the flow of cold putty. For heat sink applications, the preference is to be in the range of 30,000+ cps.

How we measure flow that is that low is problematic since traditional methods of measuring flow such as the IPC TM-650 2.3.17 4" x 4" flow test, are not suitable for materials whose lateral flow needs to be measured in thousandths of an inch. With apologies to those of you who are old enough to remember, or who grew up on a farm somewhere, the test of choice for measuring No Flow materials is the IPC TM-650 2.3.17.2 test, also known affectionately as the "Two Hole" Test.

In the Two Hole flow test two 1-inch diameter holes are punched with a precision die in a stack of prepreg and the stack is pressed under controlled conditions. As the resin flows into the hole, it reduces the hole diameter and that diameter reduction is quoted as the flow value. Measurement is made with an optical comparator (see picture). For No-Flow systems we normally talk about diameter reductions, for example a typical value for our 47N No Flow is 50-80 mils (0.050" to 0.080"). This is illustrated in the diagrams below.





1. Two 1" diameter Holes are cut in the material
2. Material is pressed at controlled pressure/temp
3. Measure Diameter Reduction in 3 locations
4. “Flow" is measured as Mils of Diameter Reduction: i.e. 50-80 = 0.050" to 0.080" reduction in diameter after flow into the cutouts

In the case of Rigid-Flex circuitry, while flow remains important, it is often necessary to have a little more flow than for heat sink bonding to allow for the filling of inner layer circuitry. To account for the variability in process from design to design and even from shop to shop, we have developed multiple flow ranges for some of our products.

Did you know that Arlon has the most extensive line of No-Flow (and Low Flow) products on the marketplace? Well check it out for yourself. As the TV pitchmen say, "But wait, that's not all…"

	Tg (°C)	**Glass Styles**	**Flow Grades**	**Product Notes**
37N Polyimide	**200**	**106, 1080**	**30-60 60-90 80-120 "6%"**	**6% is standard IPC-4101 4x4 Flow Test**
38N Polyimide	**210**	**106, 1080**	**90-130**	**Rheology Modified**
47N Epoxy	**130**	**106,1080**	**30-90 50-120**	**Modified FR-4**
49N Epoxy	**180**	**106, 1080**	**30-90 50-120**	**Multifunctional**
99N Epoxy	**180**	**106**	**100-150**	**Thermal Conductive (1.2 W/m-K)**

Selecting the right No Flow or Low Flow prepreg is easy: simply consult with an Arlon technical representative to discuss your application and requirements and we can help you select the proper product for your process and application.

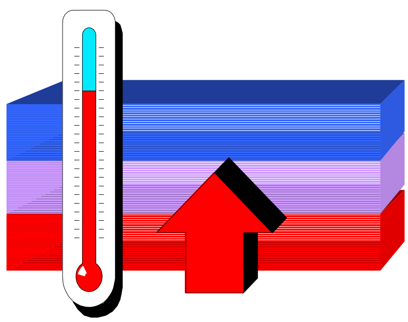
In general the following guidelines will help you toward selection of the right family of products:

1.) If you are doing heat sink bonding, the 47N product is the most widely used and lowest cost of the product line. It combined a reasonable Tg (130°C) with very robust processing parameters, allowing cures at as low as 100 psi and 300°F (although we recommend higher temperature for more complete cure).

2.) If you are doing epoxy rigid-flex, and especially if you are using adhesiveless flex and want a high temperature system, 49N is a 170°C product that is widely used in rigid flex products.

3.) If you are doing polyimide rigid-flex, then either 37N or 38N will be your material of choice. While 37N is our largest selling polyimide low flow material, 38N is compounded with additional flow restrictor and a less sensitive cure accelerator to provide a little extra open time without more flow. Your own process will determine which of these two materials is optimal for you.

In addition to the current wide range of standard product, Arlon has recently introduced a thermally conductive No-Flow Product with thermal conductivity 1.2 W/m-K, four times the thermal conductivity of conventional No-Flow materials. This product, called 99N, provides the potential to move heat out of a board and into a heat sink several times faster than conventional prepregs whose conductivity is on the order of 0.25 W/m-K.



Whatever your application for No-Flow (or Mo-Flo) materials may be, an Arlon Sales Engineer can help you select the right material from Arlon's family of precision-engineered No-Flow and Low Flow products. Call us today. Need something a little bit different? Perhaps Arlon's development group is already working on something to solve your specific problem. If so, call your Sales Engineer, or Chet Guiles, Director of New Business Development, at 909 987-9533 and we can discuss your application in detail.

Meet Arlon People

Please join us in welcoming Jack Frankosky to Arlon as OEM Marketing Engineer. Jack is located at the Bear, Delaware facility, where Microwave Materials are manufactured, however, his responsibilities extend across both microwave materials and high performance laminate and pre-preg materials (manufactured in Rancho Cucamonga, CA). Joining our marketing group, Jack will focus on the design segment, working primarily with OEMs. Prior returning to Arlon, he held product development and management responsibilities in Advanced Dielectric Products and Medical Electronics groups at W.L.Gore & Associates. Earlier, he had worked for Arlon in Bear, DE as a Product Engineer and Applications/Technical Service Engineer in the Microwave Materials business. Jack's background is in Chemical Engineering and Materials Science, with a Bachelor's of Science in Chemical Engineering in 1986 from the University of Delaware in Newark. He and his family live in Landenberg, Pennsylvania.

Congratulations are in order for our newly promoted of Director of Engineering for Arlon's Materials for Electronics Division -- Keith St. John. In his new position Keith has responsibility for Process Engineering and Facilities Engineering for the Microwave Materials and Silicone Technologies product lines at our Bear, DE manufacturing facility. Keith came to Arlon in 1994 as a process engineer for Silicone Technologies Division and joined Microwave Materials in May 2002. Prior to joining Arlon, he worked at Warner Lambert as a Product Development Engineer developing extrusion processes for biodegradable polymers. Keith received his BS in Chemical Engineering in 1992 from Drexel University, and currently resides in Aston, PA.

Some Final Notes…

It is interesting to hear some senior electronics industry guru's say that the technology business is posed for a rebound starting in the forth quarter of 2002, but that wireless (translate that into 3G cellular telephone service) was still perhaps a year away in terms of recovery. To me that still says that the "killer app" for 3G has not been identified, and those of us in the materials business at the bottom of the food chain need you guys to go out there and find that magic application – NOW! Drop us a note and share your ideas on the "Killer App" that will make 3rd Generation Wireless with 10 GB/sec data transmission rates a "necessity" for the average user. I'll publish the "Top Ten List" of best suggestions (with or without attribution) in the next newsletter.

Those of you interested in "Green" materials will be interested in checking out the Proceedings of the recent SMTA meeting in Chicago. Arlon's own Dr. Ousama Najjar presented an excellent technical paper on our new 65GT Halogen and Antimony free epoxy nonwoven aramid reinforced laminate and prepreg product line. There has been considerable renewed interest in environmentally friendly technology of late after a lull that appears to have been related to the economic downturn of the last year, and 65GT is designed specifically to provide a "green" HDI material that is optimized for surface laser microvia formation.

On a more personal closing note, I am pleased to be able to pass along the fact that after a year long Internet research study (called LaughLab) by a British psychology professor, the "funniest joke in the world" has been quasi-officially identified. Unfortunately this joke involves hunters, shooting and sudden death and may be too intense for some of our younger readers. (If you go to any good search engine – I use Google -- and search for "Associated Press" and "World's Funniest Joke" you'll find several sites where you can find it.) The AP also identified the following, which we are happy to share with our readers, as the world's second funniest joke:

"Sherlock Holmes and Dr. Watson go on a camping trip. After a good dinner and a bottle of wine, they retire for the night, and go to sleep. Some hours later, Holmes wakes up and nudges his faithful friend.

"'Watson, look up at the sky and tell me what you see.

"'I see millions and millions of stars, Holmes,' replies Watson.

"'And what do you deduce from that?'

Watson ponders for a minute.

"'Well, astronomically, it tells me that there are millions of galaxies and potentially billions of planets. Astrologically, I observe that Saturn is in Leo. Horologically, I deduce that the time is approximately a quarter past three. Meteorologically, I suspect

that we will have a beautiful day tomorrow. Theologically, I can see that God is all powerful, and that we are a small and insignificant part of the universe. What does it tell you, Holmes?'

"Holmes is silent for a moment. 'Watson, you idiot!" he says. 'Someone has stolen our tent!"'

Chet Guiles
Arlon