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Thermount® Applications Guidelines

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- Recommendations for Storage, Drying, and Assembly of Printed Wiring Boards Containing Arlon 85NT Substrates
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Why Thermount®?

Thermount® nonwoven aramid reinforcement can be fabricated using existing PWB equipment and "FR-4 type" processes. Cost and yield savings are achievable in imaging and drill areas, and there is no process penalty associated with the improved laminate properties.

Interconnect density on new designs can be increased by using < 0.004" (100µm) lines, <0.010" (250µm) vias and smaller pads. Thinner boards are now possible because of the improved dimensional stability of thin core laminates reinforced with nonwoven aramid and the lower dielectric constant of the composite. The lower dielectric constant also will result in reduced propagation delay in high- speed digital circuitry.

Finally, with nonwoven aramid reinforcement, 25% lighter weight PWBs and MCM-Ls will be available for avionics and portable applications where LCCC, TSOP, DCA, BOA and FP-SMT chip packaging are preferred for their low cost, high reliability and interconnect density potentials. Laser ablated microvias in nonwoven aramid reinforced substrates provide an efficient method of interconnecting high density chips with ultra small holes (<0.010" [250mm]) and stop pads (<0.020" [500mm]). This technology can be produced using standard fabrication processes with minimal equipment investment. By reducing layers in multi- layer PWBs, lowering drilling costs, and increasing real estate for routing lines, laser ablated microvias offer significant cost savings.

THERMOUNT® - FEATURES/BENEFITS

- CTE constrained reinforcement at lower densities than FR-4, CIC or Quartz
- Excellent dimensional stability of the core laminates (or reduced laminate movement (shrinkage) after etch and lamination)
- Low CTE for LCCC (Leadless Ceramic Chip Carrier) SMT Applications
- Lower and more consistent dielectric constant than E-glass
- Smooth surface for finer line
- Adaptable for Sputtering or Vacuum deposition of conductive material
- Random fibers for low abrasion during drilling
- Standard PWB Process at Higher Yields
- Lower density results in reduced weight and cost savings (see Figure 1)
- Laser/Plasma ablatable increases circuit density by way of reduced via hole diameters
- Cost savings over woven aramid (Kevlar@) and wider selection of reinforcement styles

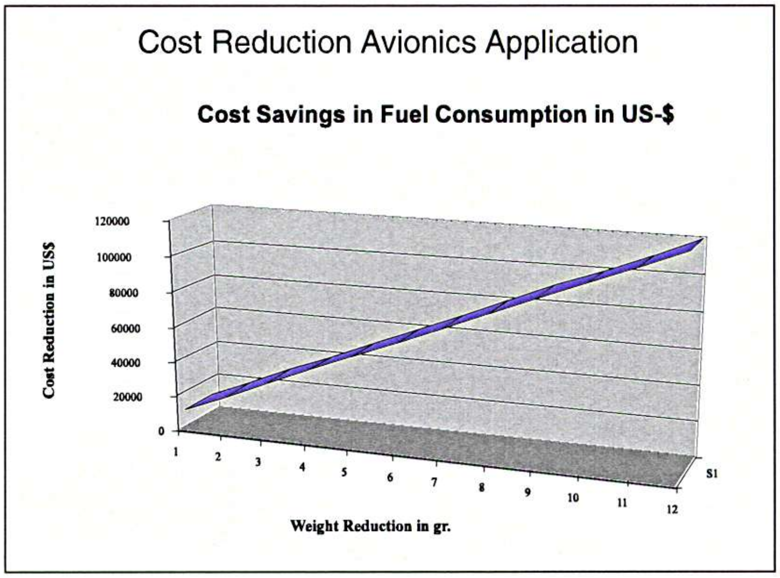

Figure 1

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CONTROLLED CTE

Low in-plane coefficient of thermal expansion reduces strain on chip solder joints during thermal cycling. Layer-to-layer registration is also improved in multilayer printed wiring boards (see Figures 2 and 3).

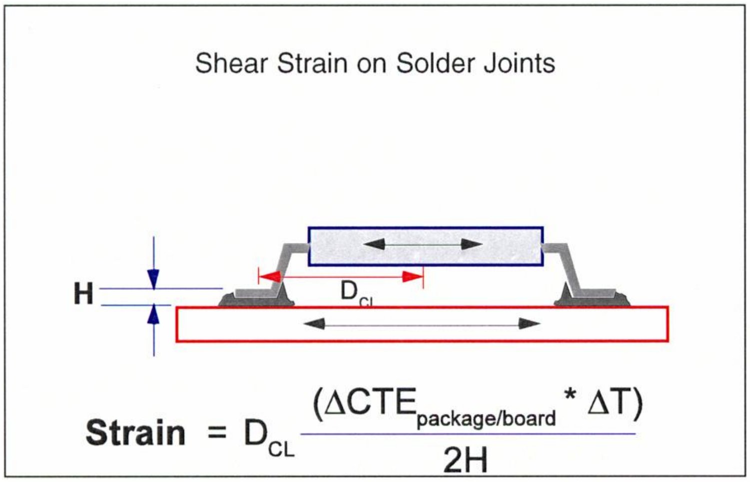


Figure 2

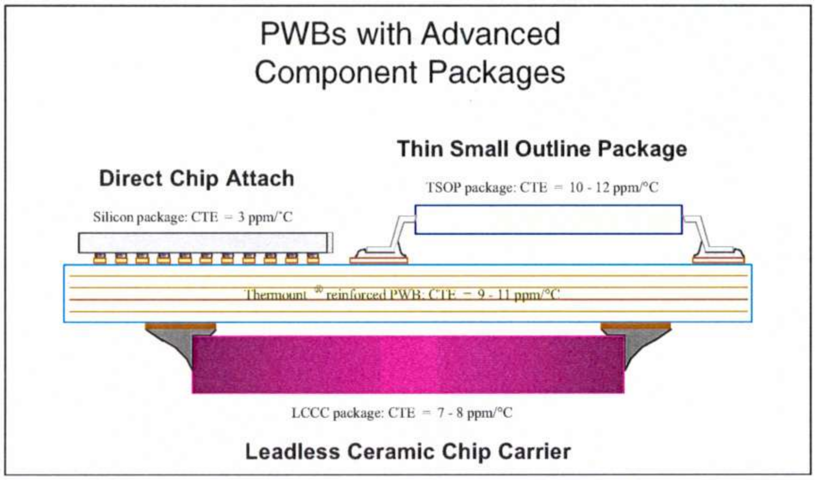


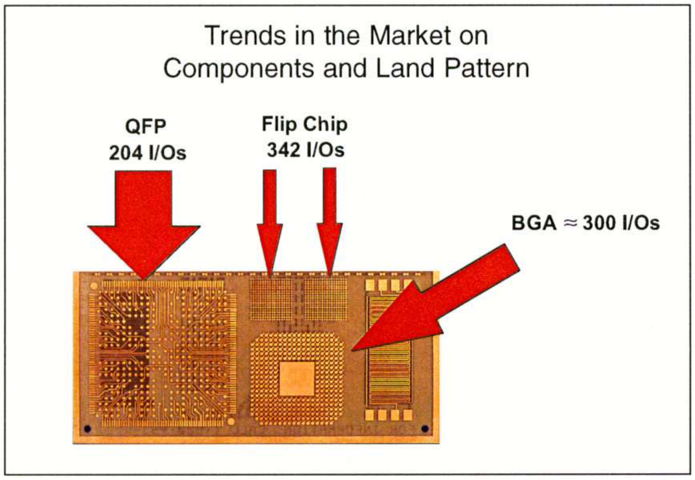
Figure 3

HIGHER DENSITY

Thermount® enables <0.004" (100mm) line widths, <0.010" (250mm) laser-drilled blind rnicrovias and small capture pads. This increases surface area available for higher- density circuitry, and facilitates packaging more interconnect layers in less space.

THINNER AND LIGHTER

Fewer layers mean thinner and lighter PWBs and MCM-Ls, especially important in avionics and portable applications where LCCC, TSOP, DCA and FP-SMT chip pack- aging is preferred for its low cost, high reliability and interconnect density potential (see Figures 4 and 5).



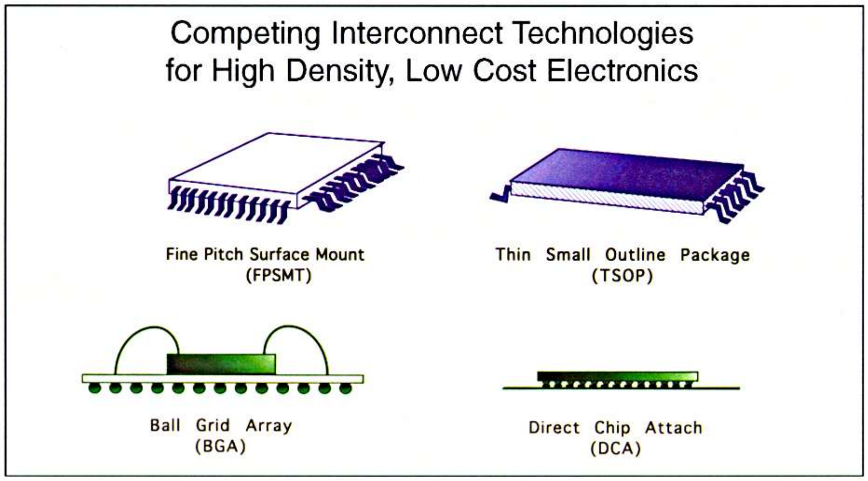


Figure 4
Figure 5

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SUPERIOR DIELECTRICS

The 100% aramid composition of Thermount@ has an inherently lower dielectric constant compared to E-glass and ceramic which enables faster signal propagation and reduced line-to-line and line-to-ground spacing. The dielectric constant is also more linear with variation in resin content (see Figures 6 and 7).

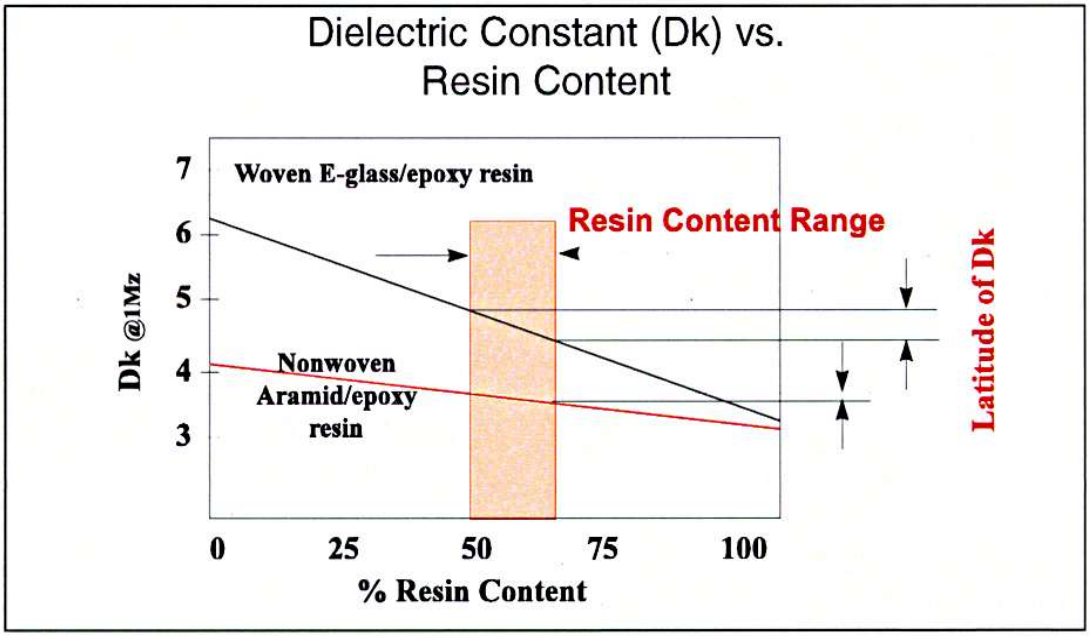

Figure 6

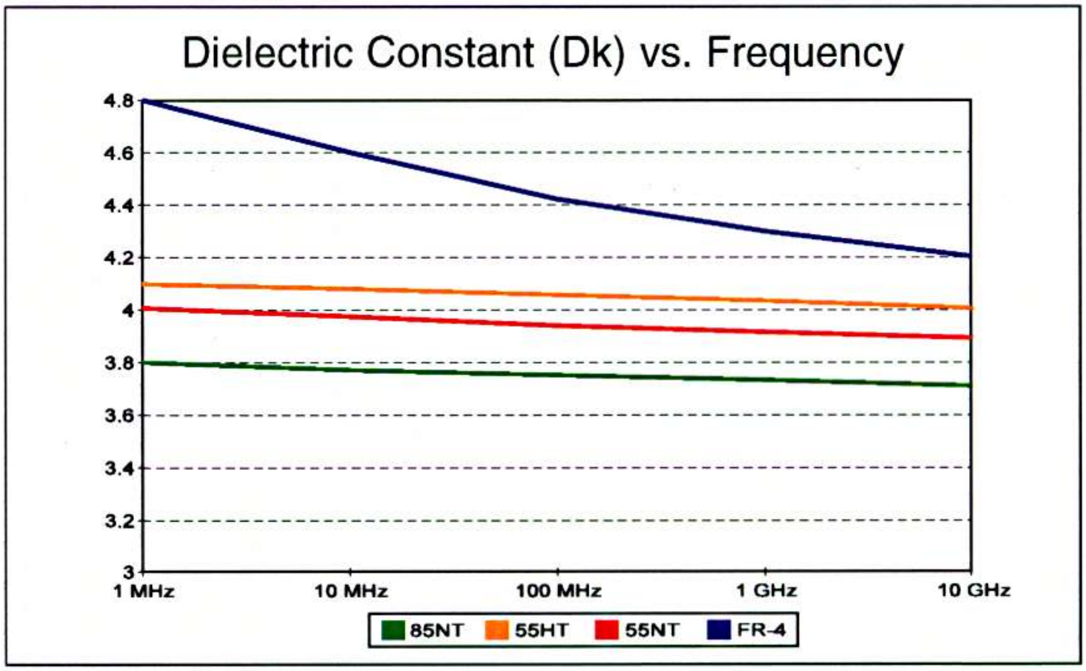

Figure 7

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Thermount® History?

(From Arlon Volume Y2K Newsletter)

Thermount® -- A Retrospective Look at a Revolution in Substrate Technology

Back to the Future

In the summer of 1984, Arlon acquired a small specialty laminator by the name of Howe Industries. An inquisitive Howe product development engineer named Vince Weis was experimenting with combinations of traditional prepreg and non-woven Kevlar® paper in an attempt to produce laminates with reduced coefficient of thermal expansion and smoother laminate surfaces. By allowing resin from the prepreg to saturate the matte Kevlar® during the lamination process it was theoretically possible to avoid the difficulty (then impossibility) of trying to coat the flimsy Kevlar matte. Such a product would, had it been commercialized, have bypassed some of the serious issues with the use of woven Kevlar® fabric and other SMT substrates in multilayer board fabrication. This concept was clearly a few years ahead of its time, but the subsequent commercial development of the Thermount® E-200 series of products by DuPont in the early to mid-1990's finally provided a viable nonwoven aramid platform from which to resolve most of those issues, and yielded us some unexpected bonuses as well.

What is Thermount®?

Thermount® is a nonwoven 100% aramid product derived, according to DuPont, from the base chemistries of both Kevlar® and Nomex®. Provided as a roll of precisely sized high quality aramid paper, it is made with controlled-length high-modulus para-aramid fibers oriented to give it strength for coating and handling as well as balanced X-Y CTE control. It uses meta-aramid as a high performance binder system that holds the fibers together through the rigors of the prepregging process. Thermount® is inherently lightweight (44% less than glass and produces a laminate that is 25% less than FR-4), low in CTE (9-10 ppm/^{o}C), low in dielectric constant (3.8-4.0), high in electrical strength (1500 volts/mil -- remember that Nomex® is used as high-end electrical insulation) and with about half the surface roughness of E-glass reinforced laminates (2200 Angstroms RMS vs 4000 for traditional laminates).

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What About those "Other SMT Alternatives?"

Through the mid to late 1980's and into the early 90's PWB designers, especially at large military or commercial avionics OEM's, were required to use hermetically sealed ceramic chip carriers that provided space and product reliability benefits. They had to select materials from a distinctly suboptimal array of laminate and prepreg technologies, no one of which was entirely satisfactory in cost or performance.

Woven Kevlar® provided very low CTE (in-plane movement as low as 4-6 ppm/°C), but despite the obvious desirability of high Tg in SMT products, nobody was ever successful in coating woven Kevlar® with polyimide resin because of the high water absorption of the system and the poor adhesion of polyimide resin to Kevlar® fibers in woven fabric format. A modified polyimide product, Arlon's 7293, was used with success in certain limited programs, but required specially treated low moisture regain (LMR) Kevlar® and was very expensive. This limited us to high Tg epoxy, which is still used in Arlon's 45NK multifunctional Kevlar® products. Registration of innerlayers in Kevlar® reinforced MLB's was frequently problematic and varied (it still does!) from lot to lot of the woven fabric. Z-direction CTE (CTE_Z) in Epoxy-Kevlar® laminates was high, which limited board thickness in design. Polyimide caps on Kevlar® cores provided some of the benefits of both (improved reworkability for instance) but only aggravated the registration issue.

Woven quartz fabric was touted (briefly) as an option for CTE control that also provided low dielectric constant and loss (3.65 / 0.005 with polyimide resin) and it was compatible with polyimide resin since quartz is a high silica "glass." This provided the desirable high Tg for PTH reliability and was a reasonable compromise in X-Y CTE. There were problems with quartz: it was very expensive, yet because of the brittleness of the quartz fibers, suffered (especially in the early years) from picks and broken filaments which made it of marginal quality for electronics; moreover, pure silica is one of the most abrasive materials known to man and quartz laminates chewed up and spit out drills in 25-50 hits, leading me to speculate about buying stock in one of the drill manufacturers.

The most successful of the alternatives ultimately turned out to be the use of distributed layers of CIC (Copper-Invar-Copper) within an MLB. CIC had a low CTE (4-5 ppm/^{o}C) and a high modulus (19MM psi) and so provided good restraint on the overall CTE of the board. Provided typically in the form of 0.005” polyimide laminate clad with 0.006” CIC both sides, these distributed layers served as power and ground planes as well as to restrain the X-Y movement of the board. This provided a workable system for high reliability military and commercial avionics boards well into the mid-1990’s. It worked! It was widely used! It provided the 3500 to 4000+ thermal cycles (-25 to +140^{o}C) that most aerospace and avionics designers required to ensure adequate in-service life! So why even consider alternatives? If it ain’t broke – don’t fix it, right?

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But CIC is expensive, heavy, and hard to drill and plate. Where through-hole connections to power/ground are not needed, 0.006" CIC requires clearance holes that have to be backfilled with a special hole-fill compound that won't crack or pull away from the hole walls. Obviously if a lower cost, easier to use alternative had been available, designers would have been more than happy to use it.

Enter Thermount®, Stage Left

In the 1989-1991 time period DuPont was perfecting the first commercial version of Thermount®, working with a Fortin development engineer by the name of Vince Weis (yes, the same one and he's long since been back with Arlon in a field technical service and support capacity) to perfect a product that could be handled and coated on traditional prepreg treating equipment. It was not immediately obvious (there was a conservative skepticism and a question about cost-performance benefits by many), but Thermount® was going to represent a revolution in substrate technology that is still in the process of being fully actualized throughout the design community. I won't tell you that the early days of the program were without difficulty, as both Arlon and DuPont learned together, sometimes through painful experience, how to make and use this novel product.

Arlon elected to produce two versions of the product: a high Tg epoxy Thermount® product (55NT) and a polyimide Thermount® based on its second generation 85N polyimide resin. The fact that a polyimide-aramid product not only could be produced, but was manufacturable into PWB's was a breakthrough of serious significance. Still in the future would be the second generation 55RT based on Thermount®RT© with reduced water uptake that would revolutionize the HDI marketplace with a reinforced laser-drillable product that could be processed much like traditional epoxy products.

Nobody likes to be the first to commit a major program to a new material, and it took a sometimes gutsy perception of the future for the Thermount® pioneers in traditionally conservative military/avionics OEM's to make the decision to move forward.

Gene Stannik and his materials team at Loral (now Lockheed-Martin) pushed for the conversion from expensive modified-polyimide on woven Kevlar to 85NT polyimide Thermount® when they realized that they could cut their laminate and prepreg material costs by 75% on the DSMAC guidance system for the Tomahawk Cruise Missile without compromising critical product performance. The Combat Proven Precision Tomahawk is now a mainstay of the U.S. Navy's tactical standoff defense capability – and it's still being made with Arlon's 85NT polyimide Thermount®.

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And in the UK a collaboration between Steve Jones, Technical Director of Manchester Circuits (now part of ViaSystems, Tamworth) and his OEM customers resulted in Thermount® 85NT being designed into a substantial part of the avionics for the European Fighter Aircraft (EFA) and, most recently, into Lucas Aerospace's jet engine control system for Rolls Royce, an application that formerly used heavy and costly CIC. According to Dave Strickley of Lucas some of his SMT designs have exceeded 10,000 thermal cycles without failure (their baseline criterion is 3500-4000 cycles!) and Lucas is designing Thermount® 85NT into all new SMT designs.

Isn't That a Lot of Thermal Cycles for a High Z-Direction CTE Material?

Traditional logic (and finite element modeling used by the design community) says that since the more you constrain the X-Y CTE of a material, the higher will be the Z-direction (out-of-plane) expansion, the number of thermal cycles to failure of PTH's will be reduced as the CTE_Z increases. Yet in the case of 85NT Thermount® this does not hold true. Designers have found that in PTH reliability testing, Arlon's 85NT polyimide Thermount® product gives up to three times more cycles to PTH failure than polyimide-glass laminate (which has a lower CTE_Z and has been used for years in high rel military applications because of its PTH reliability through manufacture and thermal cycling). This level of improvement is counterintuitive, but consistently verified.

The explanation, propounded first by Harry Webb of GEC-Marconi (now retired) will necessitate a rethinking of the use of simple linear Tg and CTE_Z based failure-modeling. Thermount® is extremely uniform in fiber distribution throughout its thickness, having no bundles of fibers surrounded by large volumes of resin that are typical of woven fiberglass products. These fiber bundles intersecting the PTH hole walls are an obvious source of stress concentrations ("stress risers") and since the formation and propagation of cracks in composite materials is almost always related to the concentration of stresses in a system, it is logical that reduction of stress concentration sites would result in reduction in crack formation.

Dimensional Stability and the Large Panel Perplex

A majority of the traditional epoxy-Kevlar® product we have sold in the past has been 12 x 12 or 12 x 18 in size. Attempts to work with larger panels have almost always resulted in difficulty with significant and (worse) inconsistent inner layer misregistration. It is one of the serious downsides of working with woven Kevlar® despite its excellent low CTE_{X-Y}. When I first learned that Thermount® was based on para-aramid fiber technology, I was concerned that this characteristic would carry over to Thermount® products. But was I ever wrong (first time, too)! Thermount® turns out to have among the best registration characteristics of any PWB materials in the market and work with 18 x 24 panels is now commonplace.

In hindsight, that one is easier to explain. Aramid fiber bundles have a lot more stretch to them than glass, and during all the processes of weaving and handling the fabric, it is developing a variety of strains that result in uneven movement as they are partially relieved during lamination. The individual short fibers of Thermount® are not continuous filaments, there is a meta-aramid binder partially isolating the high tensile short fibers from each other and the manufacturing process is a low-tension “papermaking” process. Moreover, because this is a paper product, it is less susceptible to the stresses and strains that to which woven geometry is more inherently during coating and lamination.

All That and Laser Drilling, Too!

There are a lot of new projects that are going to be on 85NT polyimide Thermount® product in the next few years, but the real large volume potential still is in the area of HDI and laser microvia formation using the new 700 Series Thermount® RT© low moisture regain products in Arlon’s 55RT Thermount® laminate and prepreg.

There are still a number of competing material and hole-formation technologies in the area of HDI boards and microvia formation. (I attended a seminar not long ago that made it sound as if resin coated copper already had a lock on it worldwide.) And the guys that sell film materials for photovia formation still see a huge market for their products. They may all be right to some degree, but I personally think that the properties of Thermount® make it the ideal material for microvia HDI boards.

First, it is available as copper-clad laminate in thicknesses as low as 0.002” (.05 mm) so it competes well with resin coated copper or film technologies in terms of available thickness, while having full fiber reinforcement to ensure excellent thickness control and planarity during lamination.

Second, it contains a pseudo-homogeneous microfiber dispersion (the para-aramid) that minimizes the formation and propagation of resin microcracks during processing, a concern that some people have expressed with the use of any pure thermoset resin as a surface microvia layer.

And of course it is easily drilled using fast CO_2 laser drill techniques that permit clean high quality holes to be drilled down to at least layer 3 with precise depth established by copper stop-pads.

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Quo Vadis?

Where is it all headed? What does the crystal ball say about the future of laminate substrates and Thermount® in particular? As a designer of PWB's you are already dealing with "smaller," "faster," and "cheaper." Thermount® based laminates are a tool you can use to make boards thinner and with less layers, yet with higher interconnect density. It has been shown that although the Thermount® laminates are more expensive on a unit basis than FR-4, the finished board costs can be significantly reduced over historical sequential lamination techniques both by reducing total material square footage requirements and eliminating multiple lamination and plating steps. Hybrid glass-epoxy/Thermount® boards are already in production, taking advantage of surface microvia technology with the low cost and reliable processing of FR-4 cores.

We are am "bullish" about Thermount® (although there are those who would say that I am full of bull anyway) for the next seven to ten years as designers take more and more advantage not only of its performance in high rel SMT designs, but also its cost effectiveness and ease of use in HDI designs requiring microvia formation.

Thermount®, Thermount®RT©, Kevlar® and Nomex® are tradenames of the DuPont Company, Wilmington, Delaware

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Thermount® Reinforcement Properties

Physical Properties of Reinforcements

Para-aramid fibers have a high modulus and low axial CTE when compared to other fibers used as reinforcement in printed wiring boards. The CTE of para-aramid fibers is, in fact, negative in the axial direction. When combined with thermoset resins that typically have high CTE in the range of 40-60 ppm/°C, para-ararnid fibers restrain the expansion of the resin when heat is applied to the composite laminate. Para-ararnid fibers have both a low specific gravity and low dielectric constant compared to other printed wiring board reinforcements.

Table 1: Properties of Printed Wiring Board Reinforcements

Reinforcement Materials	Axial Modulus (Gpa)	Axial CTE (ppm/°C)	Specific Gravity	Dielectric Constant (1MHz)
Nonwoven aramid	124	-4.5	1.44	4.0
E-glass	70	5.5	2.54	6.2
S-glass	85	2.6	2.49	4.5
Quartz	70	0.54	2.2	3.8
CIC	140	3.6	8.33	NA

Thermount® is available in three thicknesses, which can be combined to produce laminates ranging from 0.002"-0.060" in thickness.

Table 2: Thermount® Reinforcement, Prepreg, and Laminate Thickness

Thermount® Type	Reinforcement Thickness	Prepreg Pressed Thickness*	Laminate Pressed Thickness*
E210	0.00170" (43µm)	0.0018" (46µm)	0.0020" (51µm)
E220	0.00287" (73µm)	0.0030" (76µm)	0.0032" (81µm)
E230	0.00355" (90µm)	0.0039" (94µm)	0.0039" (99µm)

*Nominal reference thickness at 50% resin content, by weight.

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Laminate & Prepreg Technical Data

Table 1: Typical Properties of Nonwoven Aramid Prepreg

Reinforcement Type (Thermount®)	Basis Weight (oz/yd^2)	Gel Time (sec)	Resin Flow (%)	Volatiles (%)	Resin Content (weight %)	Pressed Thickness (mils/µm)
E210	0.9	150	9	0.7	49	1.8 (46µm)
E220	1.6	150	9	0.7	49	3.0 (76µm)
E230	2.0	150	9	0.7	49	3.7 (94µm)

Laminate Manufacturing

Laminate materials reinforced with nonwoven aramid are pressed under identical conditions as E-glass reinforced laminates. Vacuum presses are ordinarily used for thin core laminate to remove volatiles while operating at a minimum pressure for optimum dimensional stability. Although single ply laminates are permitted and are advantageous in thin board applications, several plies of multiple basis weights can be combined to produce industry standard dielectric thicknesses. High temperature elongation (HTE) Class 3 electrodeposited copper foil is recommended with nonwoven aramid reinforcements to prevent innerlayer cracks in PTH interconnects.

Table 2: Typical Thicknesses of Ninwoven Aramid Laminates

Nominal Thickness	E-Glass Construction	Thermount® Plies			Estimated Thickness(mils)
		E210	E220	E230	
2 mil (51µm)	106	1	0	0	2.0 (51µm)
3 mil (76µm)	1080	0	1	0	3.2 (81µm)
4 mil (102µm)	106/1080	0	0	1	3.9 (99µm)
5 mil (127µm)	106/2313	1	1	0	5.2 (132µm)
6 mil (152µm)	106/2116	1	0	1	5.9 (150µm)
7 mil (178µm)	7628	0	1	1	7.1 (180µm)
8 mil (203µm)	2313/2116	0	0	2	7.8 (198µm)
9 mil (229µm)	2116/2116	1	1	1	9.1 (231µm)
10 mil (254µm)	2116/2116	0	2	1	10.3 (262µm)
11 mil (279µm)	2313/7628	0	1	2	11.0 (279µm)
12 mil (305µm)	1080/7628/1080	0	0	3	11.7 (297µm)

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The dielectric constant of the nonwoven aramid epoxy laminate and prepreg is uniquely consistent across a wide range of resin content. The dielectric constant of epoxy resin (Dk=3.6) and of the reinforcement (Dk=4.0) are so close that designers of printed wiring boards can figure on a nearly constant Dk of 3.9 @ 1 MHz throughout a multilayer layup. This lower dielectric constant also results in potentially thinner boards given the same characteristic impedance and line width goemetry (see Figure 1). The lower Dk of these products can be of particular value in high-speed workstations and wireless applications.

Properties of Nonwoven Aramid Laminate

The following tables and charts summarize important mechanical, electrical, and physical properties of nonwoven aramid laminates. In Table 6, key properties of various high performance laminates are compared.

Table 3: Mechanical Properties of Nonwoven Aramid Laminate

Property	Units	Test Method	1080 E-glass	Nonwoven Aramid
Resin Content	Weight %	Basis weight	50	52
Density	g/cc	Archimedes	1.7	1.34
Cu Peel Strength	pli	1/8" etched	7.1	5.2
Peel (ther. shock)	pli	1/8" etched	6.4	5.5
Solder Float	pass/fail	IPC TM-650	pass	pass
Tg	°C	TMA	129	165
CTE: X (0-100°C)	ppm/°C	TMA	17	8
CTE: Y(0-100°C)	ppm/°C	TMA	19	9
CTE: Z (0-100°C)	ppm/°C	TMA	54	115
Tensile Strength	MPa	ASTM-D-3031	510	252
Tensile Modulus	GPa	ASTM-D-3031	28	14
Flex Strength	MPa	ASTM-D-790	703	267
Flex Modulus	GPa	ASTM-D-790	19	13
Dim. Stability	%	IPC TM-650	0.04	0.02

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Electrical Properties

Table 4: Electrical Properties of Nonwoven Aramid Laminate

Property	Units	Woven E-glass	Nonwoven Aramid
Dielectric Strength	Volts/mil	1665	2081
Dielectric Constant	@ 1MHz	4.6	3.9
Dissipation Factor	@ 1MHz	0.023	0.015
Surface Resistivity			
23°C, 50%RH	ohms/cm^2	2.7E13	1.1E15
35°C, 90%RH	ohms/cm^2	3.8E10	4.0E13
Volume Resistivity			
23°C, 50%RH	ohms/cm^2	3.5E15	1.3E16
35°C, 90%RH	ohms/cm^2	5.0E14	1.1E15
Moisture Insulation Resistance 6 days @ 65°C, 98%RH	ohms/cm^2	2.0E10	7.0E10

Physical Properties

Table 5: Physical Properties of Nonwoven Aramid Laminate

Property	Units	Woven E-glass	Nonwoven Aramid
Water Absorption	%	0.15	0.44
Thermal Conductivity	W/m°K	0.35	0.20
Laminate Smoothness	(Å)	4200	2200
Laser Ablation	After CO$_2$ laser	Molten glass residue	Uniform consistent

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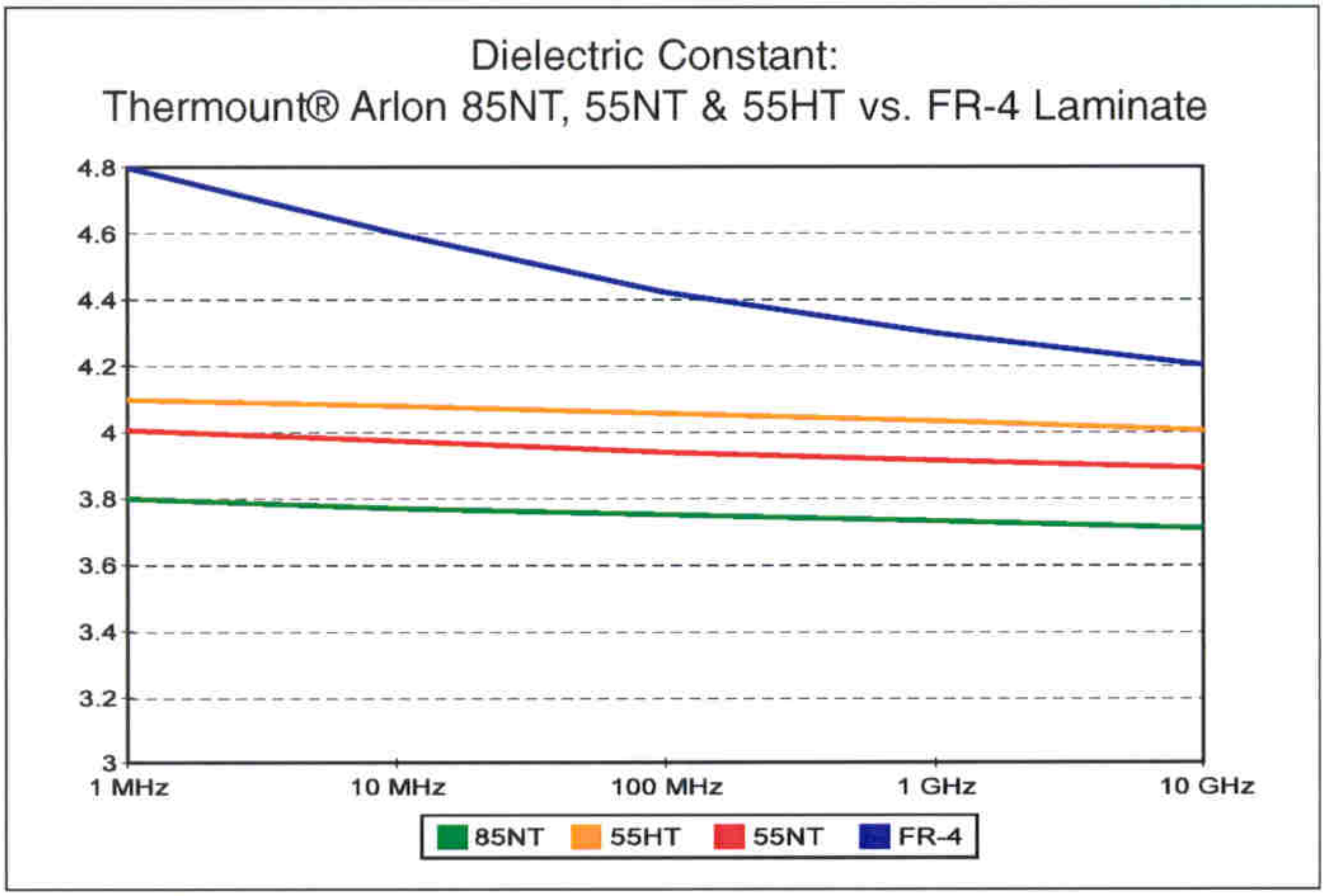

Figure 1

Comparison of Key Properties for High Performance Laminates

Table 6: Key Properties of PWB Substrate Materials

Reinforcement and Resin	Tg (°C)	X-Y CTE (ppm/°C)	Z CTE (ppm/°C)	Dk @ 1 MHz	Dimen. Stability (%)	Water Absorp. (%)	PWB Cost* (vs. FR-4)
Thermount/Epoxy	170	7-9	110	3.9	0.02	0.44	1.5X
Thermount/Polyimide	250	7-9	85	3.6	0.02	0.85	2.2X
E-glass/Epoxy	135	16-18	70	4.6	0.04	0.15	1X
E-glass/Polyimide	250	13-15	45	4.3	0.05	0.35	2X
Woven Kevlar/Epoxy	135	6-8	150	3.9	0.06	0.85	6X
S-glass/Cyanate Ester	230	8-10	40	3.6	0.03	0.08	6X
Quartz/Polyimide	250	6-8	34	4.0	0.04	0.35	9X

*Full cost, including manufacturing costs

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MLB Processing - 55NT 55RT

Fabrication Techniques including Laser Micro-Via Holes in Epoxy Thermount® (55NT & 55RT)

A. PREPREG HANDLING

To prevent moisture absorption and extend shelf life, nonwoven aramid prepreg is typically stored in vacuum-sealed aluminized polyethylene bags at a preferred temperature range of 40-70°F (4-21°C). Prepreg material requirements are specified in IPC-4101 slash sheet 55. Prepreg properties are contained in the product data sheet.

55NT & 55RT prepreg are supplied in vapor barrier vacuum bags to minimize exposure to atmospheric humidity during shipment and storage. Once the original factory supplied bags are opened, a vacuum desiccation cycle of 12 to 16 hours at 29 inches of vacuum is recommended for preparation of the prepreg for lamination. Most plasma chambers can be use for this function by pulling the vacuum and not releasing the gases.

A desiccating chamber containing an adequate supply of fresh desiccant also has shown to effectively remove moisture. However use caution when using a mineral desiccating chamber since the prepreg (resin and aramid fibers) will compete with the desiccant for the moisture already absorbed by the desiccant bed. In either case, it is best to keep nonwoven prepreg in a sealed bag at a low temperature (40-70°F) [4-21°C] for long-term storage. Prepreg once dried must be used within 4 hours within the lay-up area or it will need to be re-dried.

B. INNERLAYER IMAGE PROCESSING

Clearance holes (Laser access holes) are imaged in layer 1 copper foil at the same time as the image is patterned on layer 2, providing optimum front-to-back registration. Developing 0.004" (100µm) clearances in 0.0013" (33µm) photoresist may require two passes through a developer, depending on the spray pressure. If two passes are required to resolve small clearances, the Mylar should be left on layer 2 during the first pass and removed just prior to the second pass.

Flipping the inner layer upside down between the first and second passes will improve developing uniformity.

As received 55RT laminates do not require prebaking, as Tgs are fully developed and do not require stress relief prior to imaging. The preferred method for copper cleaning prior to dryfilm is chemical cleaning.

If the conventional copper cleaning operation prior to dryfilm is mechanical scrubbing, care is needed to ensure the copper is not distorted which could change the dimensional stability or induce warpage problems.

Arlon would recommend test layers with zero artwork compensation to establish dimensional changes. Thermount has shown good registration with compensations of +0.3 mil/inch on inner layers, in both axes.

55NT and 55RT exhibits a much smoother surface than traditional woven glass laminates so improved fine line yields are possible. The material fluoresces to aid contrasting of the signal traces to the substrate during AOI. Tooling holes can be drilled or punched conventionally.

Both epoxy types are compatible with conventional alkaline and cupric chloride etching chemistries as well as aqueous resist strippers. Aramid fibers composites will absorb moisture more readily than E-glass materials, so laminates must be thoroughly dried prior to lamination. We recommend as being critical that all inner layers are baked for a minimum of two hours at 250°F(121°C) prior to lamination. Store the inner layers in a controlled-humidity environment (20-40% RH) after baking and then lay-up the laminate within four hours due to the higher equilibrium regain of aramid fibers compared to glass.

Page 2 >

Inner layers processed with brown oxides and reduced oxides provide good adhesion to 55NT and 55RT prepregs. The multilayer bonder should be selected on compatibility with the resin, and the required lamination temperature. After lamination, the oxide treatment should be chemically removed with sodium persulfate or equivalent microetch to further processing. The oxide treatment, if not completely removed, will absorb, rather than reflect, light during laser ablation, potentially resulting in copper foil damage.

A pre-vacuum of 45 minutes minimum prior to lamination is essential to remove any remaining volatiles. A guide of the pressure levels is given, depending on panel size, in the process profile. This is recommended to compensate for the reduced flow of the prepreg, assuring complete filling of circuit areas. Pressures may need to be increased for more complex designs such as filling of blind vias and plated up copper foil on inner layers. Even at these pressures, inner layers will not distort because of the uniform circumvention strength of the reinforcement.

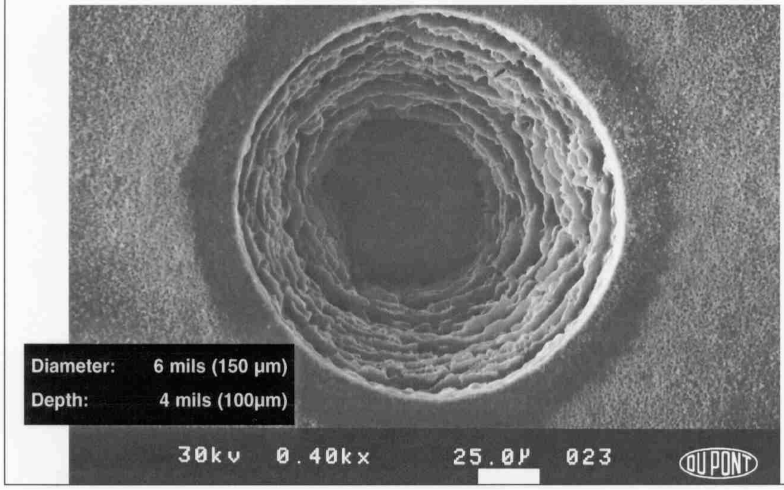
C. LAMINATION OF MULTILAYERS

Innerlayers and prepreg reinforced with nonwoven aramid must be thoroughly dried prior to lamination. Vacuum lamination under 250-400 psi (depending upon panel size) will provide complete encapsulation and removal of air and volatiles. After lamination, the oxide treatment should be chemically removed with sodium persulfate or all equivalent microetch prior to further processing. The oxide treatment, if not completely removed, will absorb, rather than reflect, light during laser ablation, potentially resulting in copper foil damage.

D. CHEMICAL DRILLING

Micro holes between 0.002" (0.051mm) and 0.008" (0.203mm) diameter can be formed in laminates reinforced with Thermount® for buried or blind vias using plasma etching or laser ablation.
Laser processing power should be optimized to produce a hole which is slightly tapered from top to bottom, with no undercut of the clearance copper pad. A perfectly straight hole wall or negative hole wall should be avoided, since it will be difficult to electroplate copper uniformly into the holes without forming plating folds. The connection area on the capture-pad should be at least 50 per cent of the diameter of the surface hole, and should have a minimum diameter of 0.003" (75µm) (see Figures 1 and 2).

Micro Via Hole after Laser Drilling



< Page 1 Page 3 >

Mechanical drilling of larger holes may follow laser drilling using the same panel tooling holes. Offsets should not be added to mechanically drilled holes, otherwise the outerlayer registration will be compromised (see Figure 3).

Compared to woven E-glass materials, nonwoven aramid materials exhibit considerably less primary angle drill wear regardless of the resin system. Studies have shown that more than 90% of the primary angle remains after 4000 hits drilling through a 0.180 inch (4.57mm) 24 layer Thermount(stack, while only 50% of the primary angle remains when drilling through FR4. Because of the smoother laminate surface and softer fibers than E-glass there is less drill wander with small-drilled holes. This results in less breakout and permits smaller annular pads for high density PCB's.

Recommended feeds and speeds for nonwoven aramid boards are based more on the resin system than the reinforcement. For standard size drills (0.025" - 0.250") [0.64mm - 6.4mm], a 1.5-2.5 mil chip load at 350-400 sfm (surface feet per minute) will produce the best hole quality with high Tg resin systems. For small drill (0.008" - 0.024") [0.20-0.61mm], a 0.6-1.2 mil chip load at the maximum spindle RPM (70-110K) is recommended.

Aramid fibers can build up in small diameter drill flutes (0.014" [0.36mm]) when drilling through thick boards or multiple boards stacked 2 or 3 high. Drill breakage may occur during withdrawal if the sheared material does not exit rapidly up the flute. To prevent drill breakage of small diameter drills, one or more of the following modifications should be considered: high strength, thin web carbide drills; reduced stack height; peck drilling; reduced withdrawal rate; high point angle drills; small orifice pressure foot. Do **NOT** use aluminum or aluminum-clad entry or backup matrerials.

Recommendations for 0.0135" (343µm) diameter drill:

1. Feed rate: 60-80 ipm; Spindle speed: 80-100 krpm; retract rate: 500ipm.
2. Narrow web, extended flute drills (approximately 30% longer than the stack height including the entry material and allowance for entry into back-up) for optimum cutting and debris removal.
3. New drills (1000) hits maximum.
4. High vacuum removal of cut debris.
5. Optional: peck drilling at 0.030" per peck will reduce flute packing.
6. Optional: high point angle drills will accelerate debris removal.
7. Optional small orifice pressure foot (0.130" opening in pressure foot).

< Page 2 Page 4 >

E. HOLE AND SURFACE CLEANING

Laser ablation leaves a fine residue of re-deposited resin on the copper capture-pad and the surface copper foil surrounding the clearance hole. This residue must be removed, along with any resin smear generated in the mechanical drilling operation, to ensure good electroless copper adhesion and reliable interconnects.

Plasma is most effective in the removal of this re-deposited residue. A plasma cycle which removes approximately 0.0001"--0.0003" (3-8µm) of hole wall resin is recommended. This should be followed by a high pressure spray water rinse to remove any ash remaining in the hole (see Figure 4).

Permanganate desmear chemistry has also been demonstrated to be an effective method for residue removal after laser processing. Standard process chemistry used for conventional drilled hole cleaning, including a solvent swelling solution and potassium permanganate, will remove laser residues. 'Glass etch' chemistry is not required after permanganate hole cleaning, but is not detrimental to the nonwoven ararnid reinforced hole wall.

Vapor honing has also been used successfully to clean holes after laser ablation. This one step mechanical process removes surface residues and smoothes the laser ablated hole wall. Deburring is not recommended for these small diameter vias.

If a connection is being made to an oxide treated layer, the exposed capture-pads should be stripped of oxide after hole cleaning. The oxide layer can be stripped using sodium persulfate or equivalent chemistry, depending on the type of oxide treatment. The oxide treatment on the capture-pad may be cleaned sufficiently in the pre-clean portion of the electroless line, so no additional cleaning steps may be required.

For hole wall adhesion and etchback to have reliable interconnections plasma and / or permanganate offer the best plated through hole adhesion. Standard desmear and electroless operations can provide excellent copper adhesion and PTH reliability.

< Page 3 Page 5 >

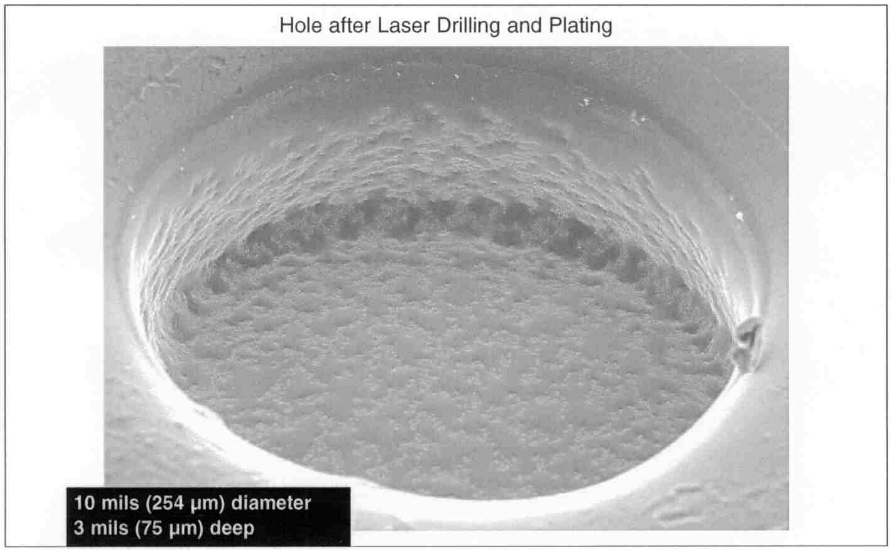
F. ELECTROLESS COPPER PLATING

Standard electroless copper with a minimum thickness of 80 micro-inches (2µm) should be plated in the blind rnicrovias. Vibration systems which increase panel agitation assist in removing air bubbles in micro-vias which can pre- vent full coverage of the holes. To prevent etch-out of vias in subsequent plating processes, 0.0003"-0.0006" (8-15µm) of electrolytic copper strike will improve the reliability and plating distribution in 0.004" (100µm) blind via holes. Tooling holes should be covered prior to electrolytic plating to maintain the proper hole size for artwork tooling. Direct plate systems may offer advantages over traditional electroless copper in catalyzing rnicrovia holes prior to electroplating.

During panel scrubbing prior to photoresist lamination, top-side vias may fill up with pumice, aluminum oxide, or copper particulates, depending on the panel cleaning method. Flipping the panel over after the final rinse and passing it through the final rinse a second time will remove any residue. Standard photo-imaging and developing techniques should be utilized to prepare a pattern plate resist image. Full-build panel plate, followed by print-and-etch processes, may also be used.

G. ELECTROLYTIC PLATING

A minimum of 0.0007" (18µm) of copper plating should be deposited in the blind via holes using standard copper electroplating technology. Rack vibration systems and turbulent solution agitation will assist in removing air bubbles from blind micro-via holes which could prevent uniform plating. To improve the throwing power of the copper electroplating process, lower current density may be required for small micro-via holes. Either tin/lead, tin or nickel/gold may be plated as an etch resist after copper plating (see Figure 5).


Hole after Laser Drilling and Plating

Due to the constraint of the resin in the X and Y planes of 7 to 10 ppm/°C the tradeoff in constrained core materials such as 55RT and 55NT is that the Z-axis expansion is increased over standard materials. Z-axis CTEs of 100 to 130 ppm/°C require attention to plating baths to ensure that plated copper elongations are at least a minimum of 20% elongation and 45,000-55,000 psi tensile strength. Standard electroless copper with a minimum thickness of 80 micro-inches (2µm) should be plated in the blind micro-vias. Vibration systems, which increase panel agitation, assist in removing air bubbles in micro-vias, which can prevent full coverage of the holes. To prevent etch-out of vias in subsequent plating processes, 0.0003"-0.0005" (8-15um) of electrolytic copper strike will improve the reliability and plating distribution in 0.004" (100µm) blind via holes. Tooling holes should be covered prior to electrolytic plating to maintain the proper hole size for the artwork tooling. Direct plate systems may offer advantages over traditional electroless copper in catalyzing micro-via holes prior to electroplating.

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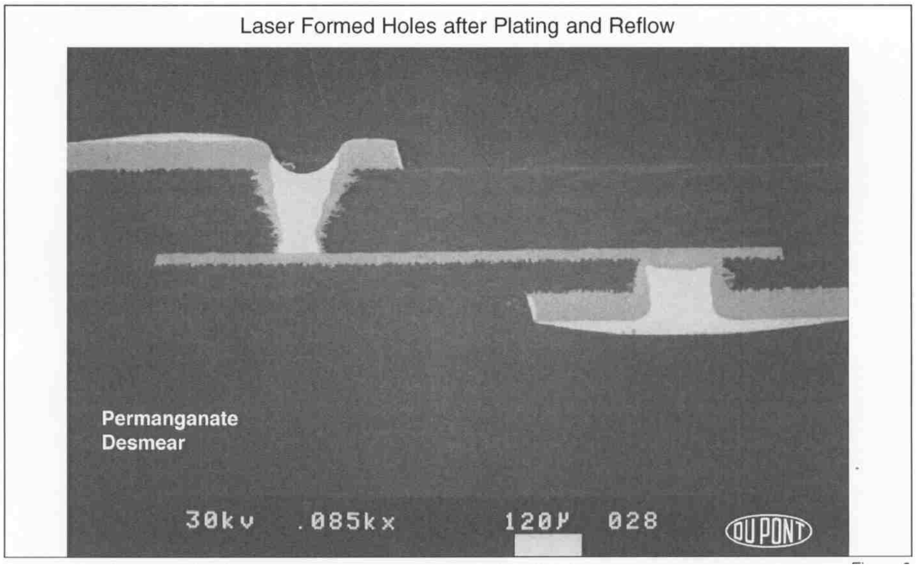
H. FINISHING

Standard photoresist stripping and copper foil etching processes complete outerlayer image formation. If solder is reflowed after etching, the reflowed solder will typically fill the blind rnicrovia, depending on hole diameter and depth (see Figure 6).


Laser Formed Holes after Plating and Reflow

I. PROFILING/ROUTING

As previously mentioned aramid fibers are softer the E-glass, so routing with a continuous cutting edge in a counter-clockwise profile provides a smoother finished edge. A 0.125 inch double fluted end mill type or "chip breaker" style router bit is recommended at a speed of 35,000 rpm and a feed rate of 30ipm. A rigid backing material such as phenolic or FR4 placed on top of the panel stack with a good solid sliding pressure foot will reduce fibrous edges. An outline of the process is given below.

1. Two flute end mill or "chip breaker" style router bit.

2. Vacuum path should be the same width as the end mill diameter.

3. Counter-clockwise profiling

4. Cover the area of the PWB edge with the soldermask material or add a 0.060" copper line around the perimeter and rout through to minimize the tendency for burring.

5. Place a hard material on top of the panel stack to prevent the cut aramid fibers from rolling up (e.g. 0.031" melamine or phenolic drill back-up material or unclad FR-4).

6. Use a sliding pressure foot, which provides sufficient pressure to maintain intimate contact between each panel in the stack during routing.

7. Feed and speed recommendations:

Diameter	Feed	Speed
0.090"-0.125"	30 ipm	35Krpm
0.040"-0.070"	35 ipm	45Krpm

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J. ASSEMBLY PROCESSES

MLB's fabricated from Thermount reinforced material can be processed through standard assembly operations which are used for other MLB's.

MLB parts are compatible with aqueous, semi-aqueous and solvent cleaning systems based on Freon®.

Prior to any assembly process that requires elevated temperature for solder reflow the MLB's should be thoroughly dried. A bake of 250-275°F (121-135°C) for 5 hours is recommended. When there are components present which will be damaged at that temperature, the parts can be dried in a vacuum oven at a lower temperature.

K. SUMMARY OF MICRO-VIA HOLE FABRICATION PROCESS

1. Clean, photo-image, etch, strip resist and oxide inner- layers with clearances in outer layers.
2. Laminate multilayer after drying innerlayers and prepreg as recommended.
3. Remove oxide from outerlayer copper surfaces.
4. Laser ablate blind vias by scanning or point-to-point ablation through copper mask.
5. Mechanically drill through-holes and tooling holes as required.
6. Clean holes using plasma, permanganate or vapor hone processes.
7. Remove oxide treatment from capture-pads if present and inspect.
8. Electroless copper plate.
9. Cover tooling holes and 'flash' copper electroplate, strip; resist and etch copper.
10. Clean, photo-image, copper and solder electroplate, strip resist and etch copper.
11. Bake, follow (or solder strip for HASL) soldermask, legend, rout and test.

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TO: OUR VALUED CUSTOMERS

SUBJ: PROCESSING ARLON's 55NT & 55RT- BFG MULTIFUNCTIONAL THERMOUNT(r)

Arlon is constantly evaluating its products and processing recommendations based on the latest equipment and chemistries used in the manufacturing of Printed Circuit boards. We periodically update our Technical Data Sheets and Process Guides to ensure that our customers have the most current information. We have put together this profile based on successful board processing and should cover all significant aspects through lamination.

* Process innerlayers through develop, etch. and strip using standard industry practices.

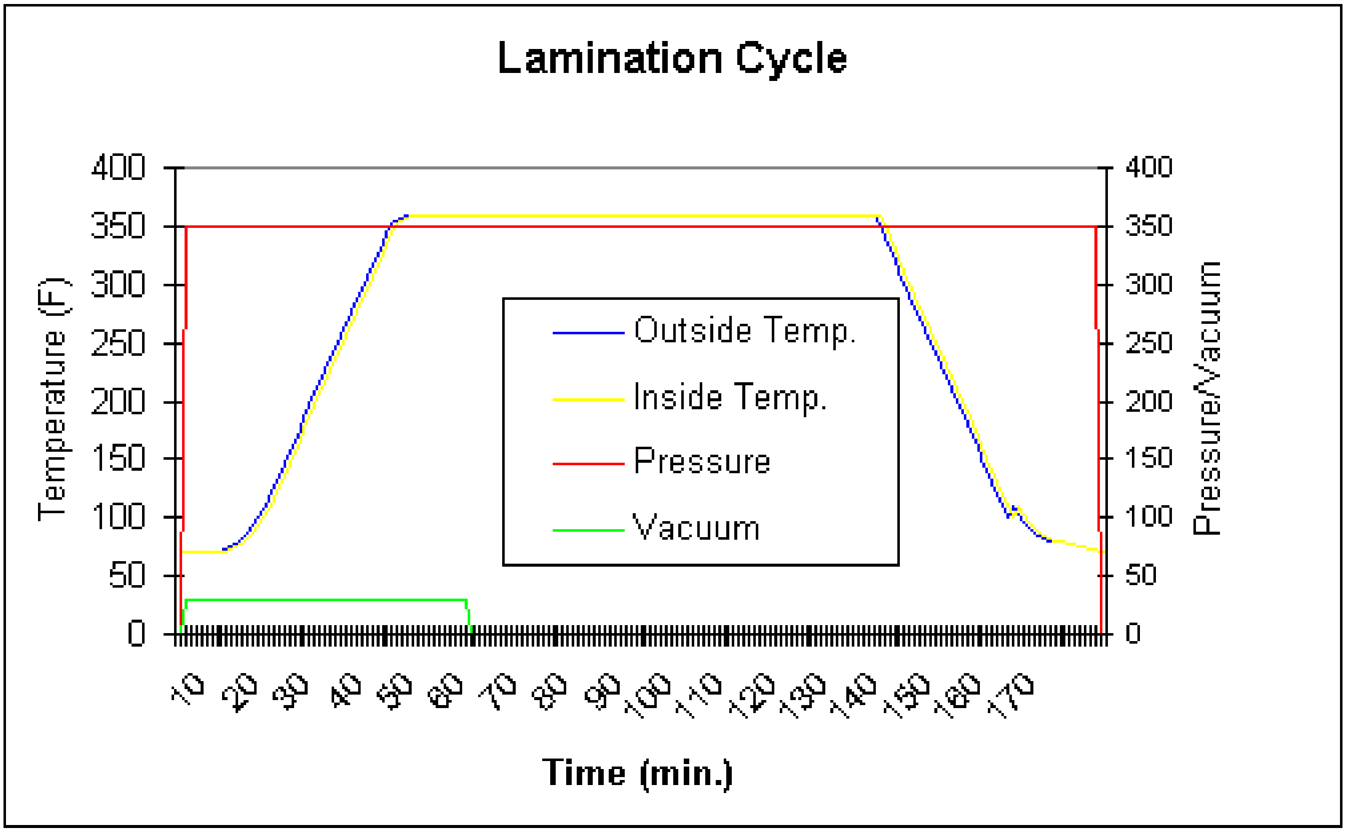
* Use brown oxide on innerlayers. Adjust dwell time in the oxide bath to ensure appropriate coating thickness. Several oxide systems and reduction chemistries have been evaluated and have demonstrated good results. Each chemistry system should be evaluated for compatibility with the process requirements of the nonwoven aramid reinforcement materials used.

* Bake innerlayers-for 2 hours at 225º- 250ºF. immediately Prior to multilayer lay-up

* Vacuum desiccate the prepreg for 12 hours prior to lamination.

* The use of product thermocouples is strongly recommended to monitor al1d control the multilayer lamination cycle. Thermocouples will allow for exact measurement of the product heat rise and allow for tracking of the time and temperatures of product cure.

* See the attached "Process Profile" for specific details of the lamination cycle.



* The final cure should be accomplished in the press at 360°F for 90 minutes.

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PROCESS PROFILE

Customer:____________________________________ DATE:__________________________
Contact:______________________________________ Title:___________________________
MLB -# of layers:______________________________ Size:___________________________
Product Designation: ARLON's 55NT- BFG MULTIFUNCTIONAL THERMOUNT®
MLB Description:____

VACUUM ASSIST HYDRAULIC			TARGET	ACTUAL
MLB Pre-Vac. 45 minute minimum		=	45 min.	____________
Product heat rise from 150º- 250ºF (66º - 121ºC)		=	8-12ºF/min. (4-7ºC/min.)	____________
Full pressure	12 x 18	=	275 PSI	____________
	16 x 18	=	350 PSI	____________
	18 x 24	=	400 PSI	____________
Platen temperature at start of initial cure		=	365ºF (185ºC)	____________
Platen temperature during cure		=	360ºF (182ºC)	____________
Product temperature during cure		=	350ºF (177ºC)	____________
Final cure time		=	90 minutes	____________

AUTOCLAVE

Pressure (chamber)	12 x 18	=	275 PSI	____________
	16 x 18	=	350 PSI	____________
	18 x 24	=	400 PSI	____________
Product heat rise from 150º- 250ºF (66º - 121ºC)		=	8-12ºF/min. (4-7ºC/min.)	____________
Cure Temperature		=	360ºF (182ºC)	____________
Cure time		=	90 min.	____________

* MLB package should be cooled at @ 9º/min. from 365ºF- 250ºF

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Recommendations for Storage, Drying, and Assembly of Printed Wiring Boards Containing Arlon 55NT or 55RT Substrates

INTRODUCTION

ARLON 55NT and 55RT are high Tg, multifunctional epoxy PWB substrates which contain DuPont THERMOUNT® nonwoven aramid reinforcement. THERMOUNT® offers several performance benefits over standard materials: Lowers the in-plane coefficient of thermal expansion (CTE) to 7-9 ppm/ºC for epoxy laminates, depending on resin content; Lowers the dielectric constant to 4.0; Provides excellent dimensional stability (<0.03%); Improves fine feature formation due to its smooth surface; and Enables high speed laser microvia formation. ARLON 55NT and 55RT are both multifunctional epoxy prepreg and laminates reinforced with THERMOUNT®, differing only in resin content (48%RC for 55NT; 54% RC for 55RT).

Aramid fibers and epoxy resin absorb moisture when exposed to high humidity conditions. This moisture, typically in the range of 0.1 - 0.7%, can be removed in 2 - 6 hours using a conventional baking process at temperatures between 110 - 150ºC (230 - 300ºF). It has been demonstrated that 55NT and 55RT PWBs can be assembled and reworked with zero defects when this baking operation immediately precedes assembly processes.

In some cases, companies which assemble components do not have the capability to bake PWBs prior to the assembly process. Moisture removal may be accomplished at the PWB fabrication operation if the PWBs are sealed properly in moisture proof bags, and only removed immediately prior to assembly. Baking at the Fabricator has been shown to be effective with 55NT and 55RT PWBs in high volume assembly operations.

RECOMMENDED DRYING AT THE FABRICATOR

Bake PWBs for a minimum of 4 hours at 235ºF (112ºC), or a maximum of 6 hours at 275ºF (136ºC). Immediately seal PWBs in a metalized Mylar¨ bag within 1 hour of removal from the oven. The time and temperature of the bake depends on the PWB thickness and construction. Thicker PWBs (>0.080” [2.03 mm]) or PWBs with external copper planes should be baked for 6 hours at 275ºF (136ºC).

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Recommended Assembly of 55NT or 55RT Printed Wiring Boards:

Case 1: PWBs are **pre-baked by the Fabricator** and sealed in plastic bags

If metalized/Mylar® bags are opened for PWB inspection or testing, the PWBs should be re-sealed in bags immediately after the work has been accomplished. Based on moisture regain rates of 55NT and 55RT, pre-dried PWBs may be exposed to **85%RH** up to 48 hours prior to standard SMT assembly processes (maximum exposure temperature of 465ºF (240ºC) for 5 minutes). Multiple passes through assembly equipment has not led to failures in 55NT and 55RT PWBs, provided the exposure to high humidity does not exceed 48 hours. If hold times cannot be avoided between assembly processes, store PWBs in a nitrogen dry box until assembly operations can resume. PWBs containing 55NT and 55RT may be exposed to **50%RH** for over 96 hours prior to assembly (see attached moisture regain graphs).

Case 2: PWBs are stored in **uncontrolled environment** without prior drying

Bake PWBs for a minimum of 4 hours at 235ºF (112ºC), or a maximum of 6 hours at 275ºF (136ºC), prior to assembly. Based on moisture regain rates of 55NT and 55RT, PWBs may be exposed to **85%RH** up to 48 hours prior to standard SMT assembly processes (maximum exposure temperature of 465ºF (240ºC) for 5 minutes). Multiple passes through assembly equipment has not led to failures in 55NT and 55RT PWBs, provided the exposure to high humidity does not exceed 48 hours. If hold times cannot be avoided between assembly processes, store PWBs in a nitrogen dry box until assembly operations can resume. PWBs containing 55NT and 55RT may be exposed to **50%RH** for over 96 hours prior to assembly (see attached moisture regain graphs).

Rework and Hand-soldering:

If PWBs have been exposed to **85%RH** for more than 48 hours, the baking operation must be repeated prior to rework or assembly. Bake PWBs for a minimum of 4 hours at 235ºF (112ºC), or a maximum of 6 hours at 275ºF (136ºC), prior to rework or hand-soldering. Soldering iron temperature should not exceed 575ºF (301ºC) for 5 seconds. Soldering irons with a precisely controlled “soldering tip temperature” (e.g. - Metcal) are recommended. PWBs containing 55NT and 55RT may be exposed to **50%RH** for over 96 hours prior to rework or hand-soldering (see attached moisture regain graphs).

When sensitive components which could be damaged by high temperature are being used, a vacuum dry box may be an acceptable alternative to remove moisture. Vacuum desiccate for a minimum of 24 hours at >29” Hg prior to rework. Vacuum drying at room temperature is not as effective as high temperature baking so a small scale test should be conducted prior to processing large volume production quantities.

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Moisture Removal and Regain Graphs for 55NT and 55RT PWBs:

Moisture removal of 55NT and 55RT PWBs will depend on the temperature of the bake, and the thickness and construction of the PWB. Moisture will be removed from PWBs reinforced with 100% Epoxy/THERMOUNT® at different rates than HYBRID constructions that contain some percentage of glass reinforcement. Moisture is removed at a slightly faster rate when PWBs are baked at a higher temperature (see attached moisture removal graphs).

Moisture regain of 55NT and 55RT PWBs will depend on humidity conditions, and the thickness and construction of the PWB. PWBs reinforced with 100% Epoxy/THERMOUNT® will regain moisture at different rates than HYBRID constructions that contain some percentage of glass reinforcement. In general, when a PWB contains over 50% of THERMOUNT® reinforcement, the maximum allowable moisture regain by weight is 0.28% to assure reliable assembly. The time required to regain 0.28% moisture will depend on the humidity level in the storage area (see attached moisture regain graphs).

Typical moisture removal and regain rates are shown in the attached graphs for 100% THERMOUNT®/epoxy PWBs, and HYBRID constructions containing both FR-4 and THERMOUNT®/epoxy.

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The recommendations in this processing guide are intended to transfer our experience with fabrication and assembly of printed wiring boards reinforced with THERMOUNT® nonwoven aramid. This information is based on data generated using ARLON 55NT and 55RT multifunctional epoxy resin with a glass transition temperature of 170ºC (338ºF). Printed wiring boards composed of THERMOUNT® reinforcement and epoxy resin have been successfully fabricated and assembled using these recommendations. Arlon does not, however, guarantee successful results will be obtained using these recommendations because of the diverse combinations of processes and equipment utilized in the printed wiring board industry. In most cases, it is appropriate to follow the specific recommendations of the particular laminate and prepreg supplier.

The information in this guide was prepared as a possible aid when using THERMOUNT® nonwoven aramid reinforcement. Anyone intending to use recommendations contained in this publication concerning equipment, processing techniques and/or products should first be satisfied that the information is suitable for their application and meets all appropriate safety and health standards. Refer to other Arlon publications for safe handling and use instructions before using product. Both manufacturing and end-use technologies may undergo further refinements; therefore, Arlon reserves the right to modify properties and to change current recommendations as additional knowledge and experience are gained. Arlon makes no guarantee of results and assumes no obligation whatsoever in connection with these recommendations. This information is not a license to operate under, or intended to suggest infringement of, any existing patents.

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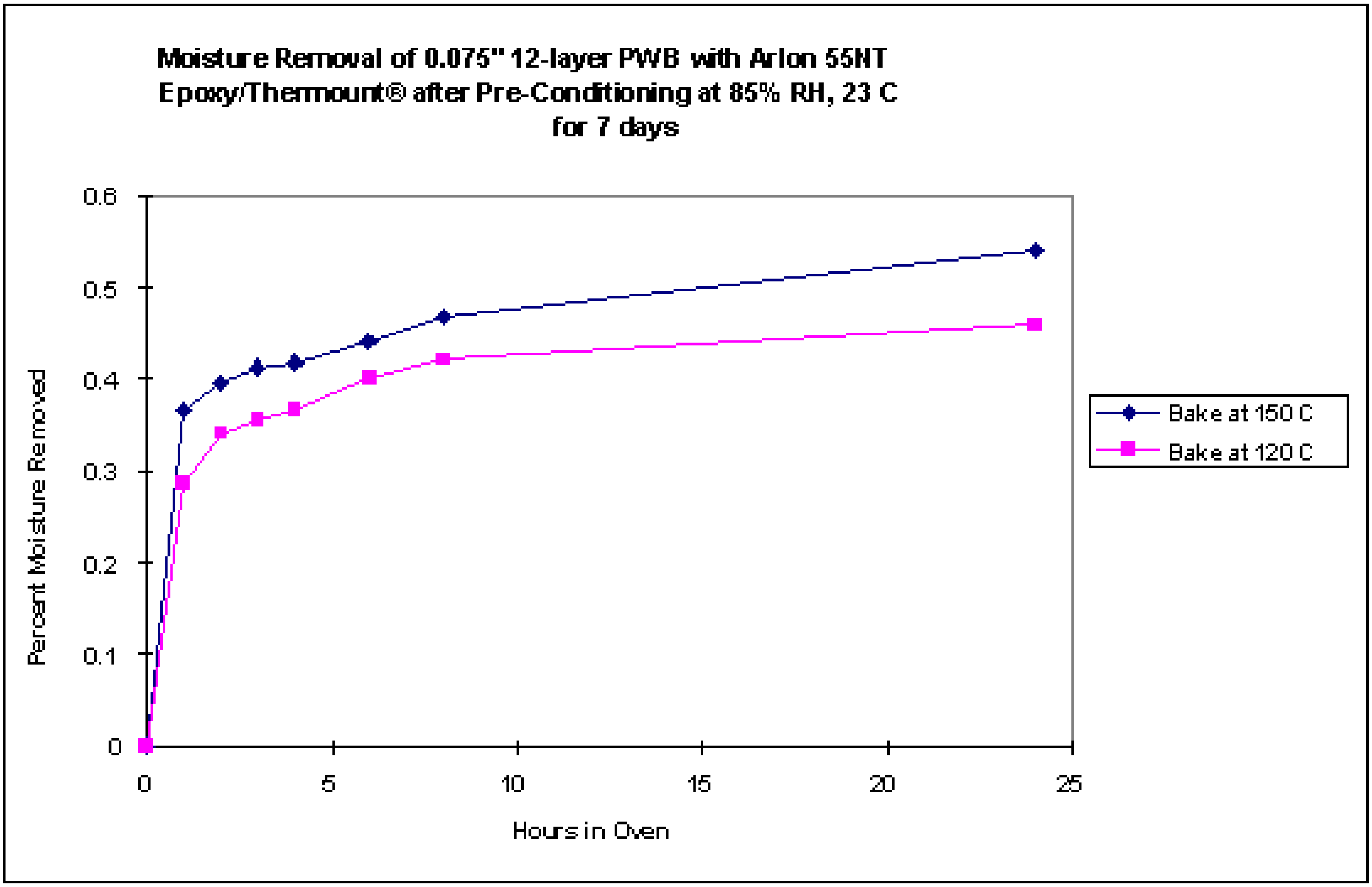
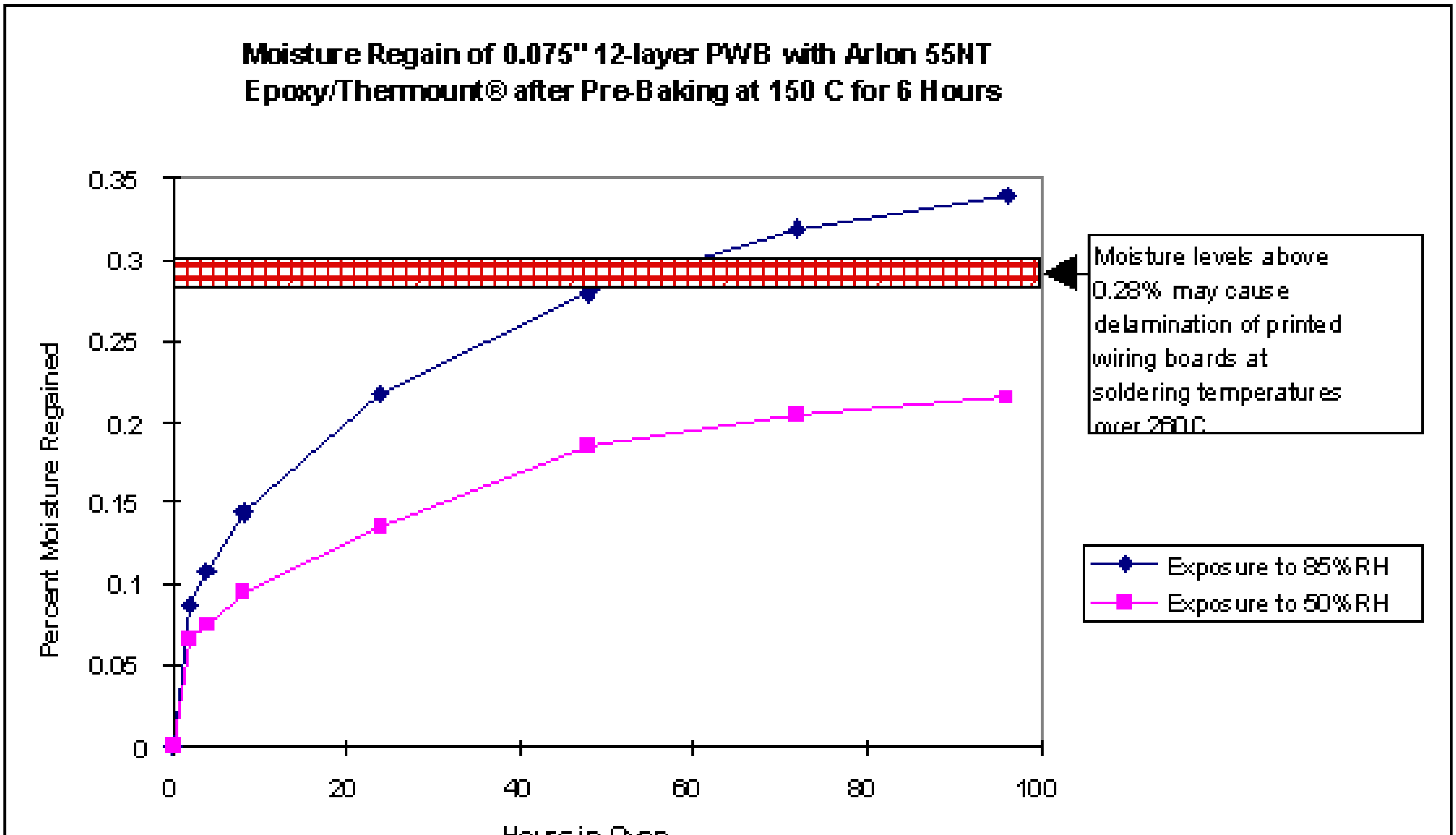
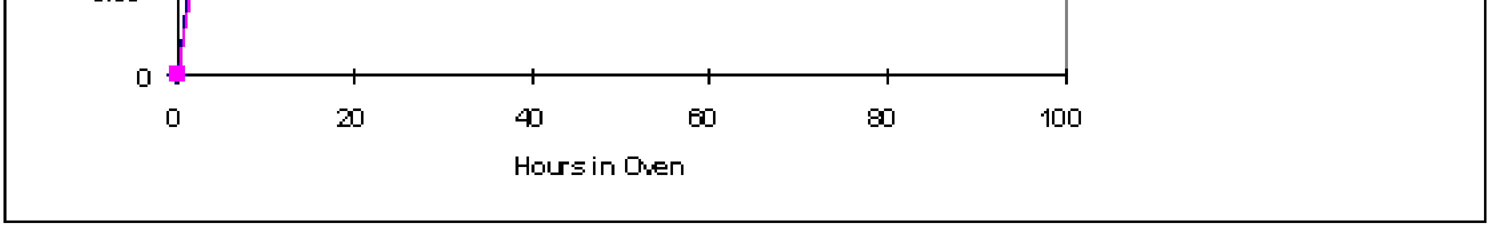




Moisture levels above 0.28% may cause delamination of printed wiring boards at soldering temperatures over 260 C



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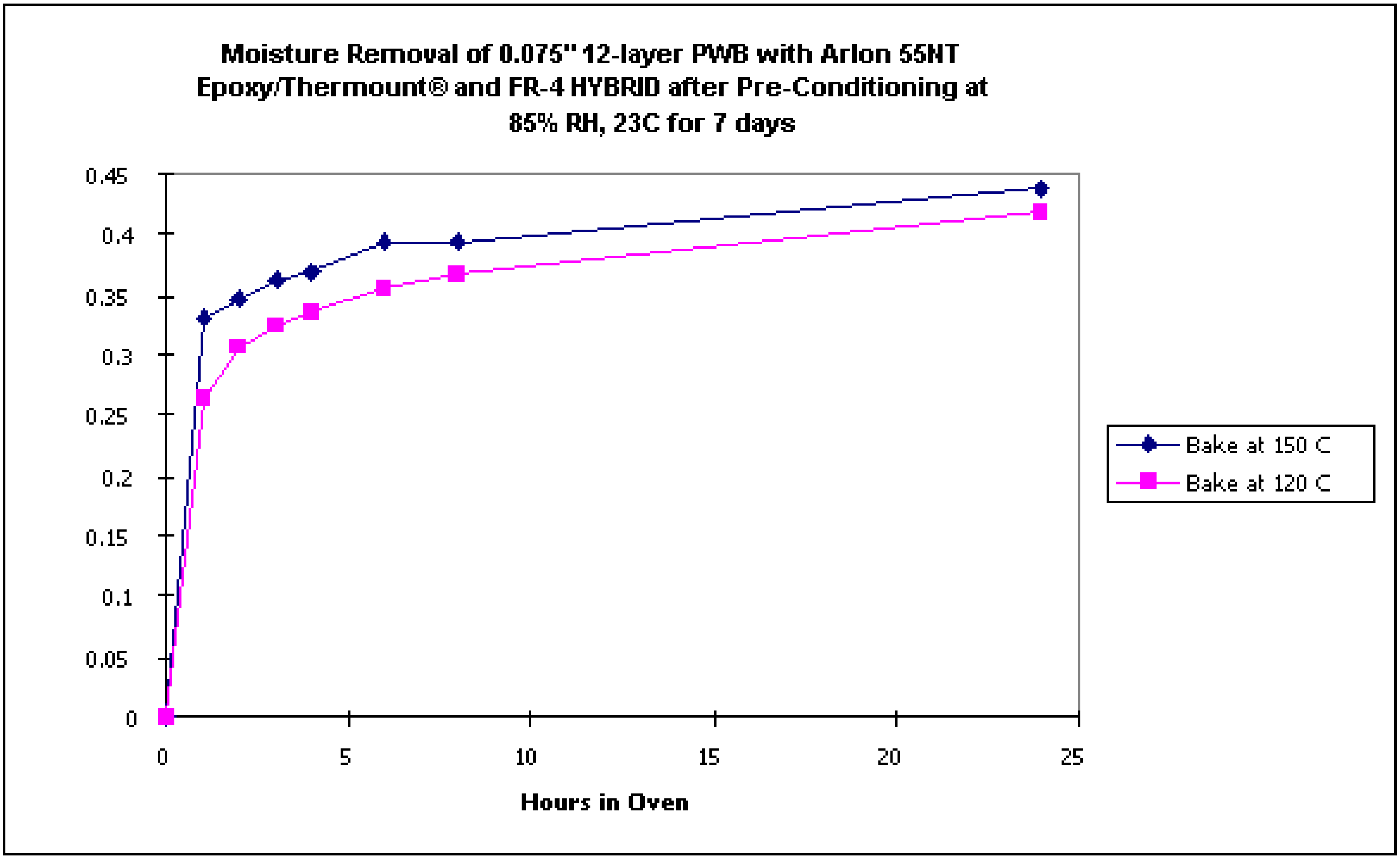
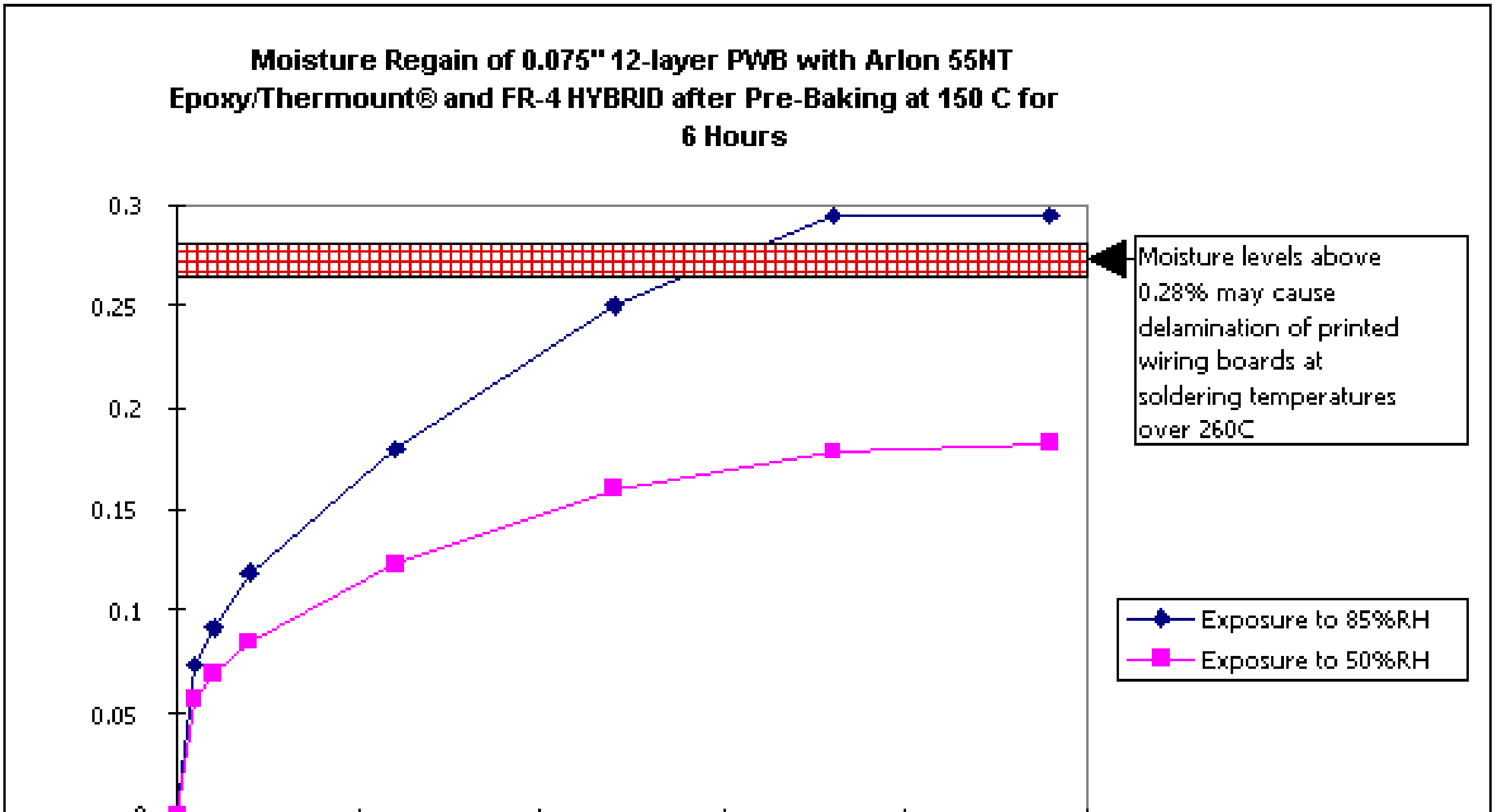
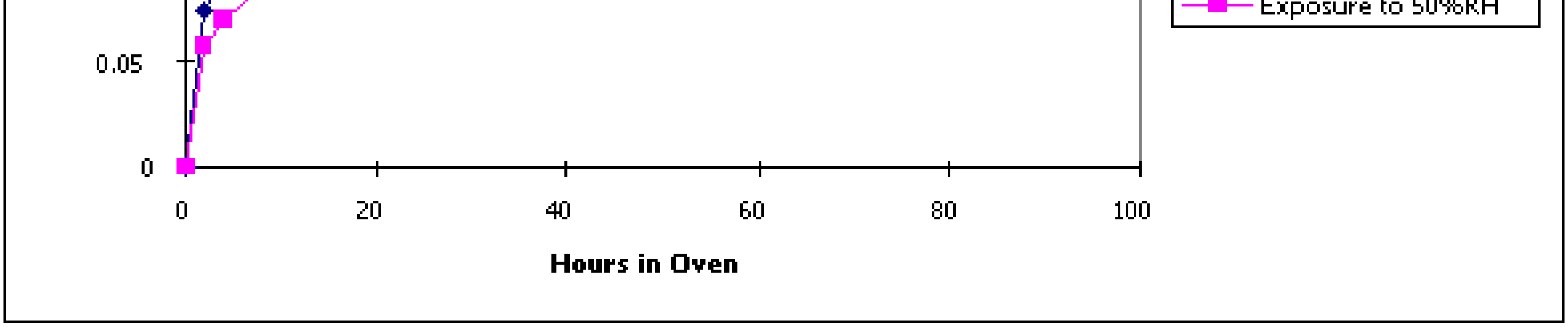

Moisture Removal of 0.075" 12-layer PWB with Arlon 55NT Epoxy/Thermount® and FR-4 HYBRID after Pre-Conditioning at 85% RH, 23C for 7 days


Moisture Regain of 0.075" 12-layer PWB with Arlon 55NT Epoxy/Thermount® and FR-4 HYBRID after Pre-Baking at 150 C for 6 Hours

Moisture levels above 0.28% may cause delamination of printed wiring boards at soldering temperatures over 260C



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Recommendations for Storage, Drying, and Assembly of Printed Wiring Boards Containing Arlon 85NT Substrates

INTRODUCTION

ARLON 85NT is a high Tg, polyimide PWB substrate which contains DuPont THERMOUNT® nonwoven aramid reinforcement. THERMOUNT® offers several performance benefits over standard materials: Lowers the in-plane coefficient of thermal expansion (CTE) to 7-9 ppm/°C for polyimide laminates, depending on resin content; Lowers the dielectric constant to 3.8; Provides excellent dimensional stability (<0.03%); Improves fine feature formation due to its smooth surface; and Enables high speed laser microvia formation. ARLON 85NT is offered as a polyimide prepreg and laminate system reinforced with THERMOUNT®.

Aramid fibers and polyimide resin absorb moisture when exposed to high humidity conditions. This moisture, typically in the range of 0.1 - 0.9%, can be removed in 2 - 6 hours using a conventional baking process at temperatures between 110 - 150°C (230 - 300°F). It has been demonstrated that 85NT PWBs can be assembled and reworked with zero defects when this baking operation immediately precedes assembly processes.

In some cases, companies which assemble components do not have the capability to bake PWBs prior to the assembly process. Moisture removal may be accomplished at the PWB fabrication operation if the PWBs are sealed properly in moisture proof bags, and only removed immediately prior to assembly. Baking at the Fabricator has been shown to be effective with 85NT PWBs production assembly operations.

Recommended Drying at the Fabricator:

Bake PWBs for a minimum of 4 hours at 235°F (112°C), or a maximum of 6 hours at 275°F (136°C). Immediately seal PWBs in a metalized Mylar® bag within 1 hour of removal from the oven. The time and temperature of the bake depends on the PWB thickness and construction. Thicker PWBs (>0.080” [2.03 mm]) or PWBs with external copper planes should be baked for 6 hours at 275°F (136°C).

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Recommended Assembly of 85NT Printed Wiring Boards:

Case 1: PWBs are **pre-baked by the Fabricator** and sealed in plastic bags

If metalized/Mylar® bags are opened for PWB inspection or testing, the PWBs should be re-sealed in bags immediately after the work has been accomplished. Based on moisture regain rates for 85NT, pre-dried PWBs may be exposed to **85%RH** up to 12 hours prior to standard SMT assembly processes (maximum exposure temperature of 465°F (240°C) for 5 minutes). Multiple passes through assembly equipment has not led to failures in 85NT PWBs, provided the exposure to high humidity does not exceed 12 hours. If hold times cannot be avoided between assembly processes, store PWBs in a nitrogen dry box until assembly operations can resume. PWBs containing 85NT may be exposed to **50%RH** for 36 hours prior to assembly (see attached moisture regain graphs).

Case 2: PWBs are stored in **uncontrolled environment** without prior drying

Bake PWBs for a minimum of 4 hours at 235°F (112°C), or a maximum of 6 hours at 275°F (136°C), prior to assembly. Based on moisture regain rates for 85NT, PWBs may be exposed to **85%RH** up to 12 hours prior to standard SMT assembly processes (maximum exposure temperature of 465°F (240°C) for 5 minutes). Multiple passes through assembly equipment has not led to failures in 85NT PWBs, provided the exposure to high humidity does not exceed 12 hours. If hold times cannot be avoided between assembly processes, store PWBs in a nitrogen dry box until assembly operations can resume. PWBs containing 85NT may be exposed to **50%RH** for 36 hours prior to assembly (see attached moisture regain graphs).

Rework and Hand-soldering:

If PWBs have been exposed to **85%RH** for more than 12 hours, the baking operation must be repeated prior to rework or assembly. Bake PWBs for a minimum of 4 hours at 235•F (112•C), or a maximum of 6 hours at 275°F (136°C), prior to rework or hand-soldering. Soldering iron temperature should not exceed 575°F (301°C) for 5 seconds. Soldering irons with a precisely controlled “soldering tip temperature” (e.g. - Metcal) are recommended. PWBs containing 85NT may be exposed to **50%RH** for 36 hours prior to rework or hand-soldering (see attached moisture regain graphs).

When sensitive components which could be damaged by high temperature are being used, a vacuum dry box may be an acceptable alternative to remove moisture. Vacuum desiccate for a minimum of 24 hours at >29” Hg prior to rework. Vacuum drying at room temperature is not as effective as high temperature baking so a small scale test should be conducted prior to processing large volume production quantities.

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Moisture Removal and Regain Graphs for 85NT PWBs:

Moisture removal of 85NT PWBs will depend on the temperature of the bake, and the thickness and construction of the PWB. Moisture will be removed from PWBs reinforced with 100% Polyimide/THERMOUNT® at different rates than HYBRID constructions that contain some percentage of glass reinforcement. Moisture is removed at a slightly faster rate when PWBs are baked at a higher temperature (see attached moisture removal graphs).

Moisture regain of 85NT PWBs will depend on humidity conditions, and the thickness and construction of the PWB. PWBs reinforced with 100% Polyimide/THERMOUNT® will regain moisture at different rates than HYBRID constructions that contain some percentage of glass reinforcement. In general, when a PWB contains over 50% of THERMOUNT® reinforcement, the maximum allowable moisture regain by weight is 0.28% to assure reliable assembly. The time required to regain 0.28% moisture will depend on the humidity level in the storage area (see attached moisture regain graphs).

Typical moisture removal and regain rates are shown in the attached graphs for 100% THERMOUNT®/polyimide PWBs.

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The recommendations in this processing guide are intended to transfer our experience with fabrication and assembly of printed wiring boards reinforced with THERMOUNT® nonwoven aramid. This information is based on data generated using ARLON 85NT polyimide resin with a glass transition temperature of 260°C (500°F by DSC). Printed wiring boards composed of THERMOUNT® reinforcement and polyimide resin have been successfully fabricated and assembled using these recommendations. Arlon does not, however, guarantee successful results will be obtained using these recommendations because of the diverse combinations of processes and equipment utilized in the printed wiring board industry. In most cases, it is appropriate to follow the specific recommendations of the particular laminate and prepreg supplier.

The information in this guide was prepared as a possible aid when using THERMOUNT® nonwoven aramid reinforcement. Anyone intending to use recommendations contained in this publication concerning equipment, processing techniques and/or products should first be satisfied that the information is suitable for their application and meets all appropriate safety and health standards. Refer to other Arlon publications for safe handling and use instructions before using product. Both manufacturing and end-use technologies may undergo further refinements; therefore, Arlon reserves the right to modify properties and to change current recommendations as additional knowledge and experience are gained. Arlon makes no guarantee of results and assumes no obligation whatsoever in connection with these recommendations. This information is not a license to operate under, or intended to suggest infringement of, any existing patents.

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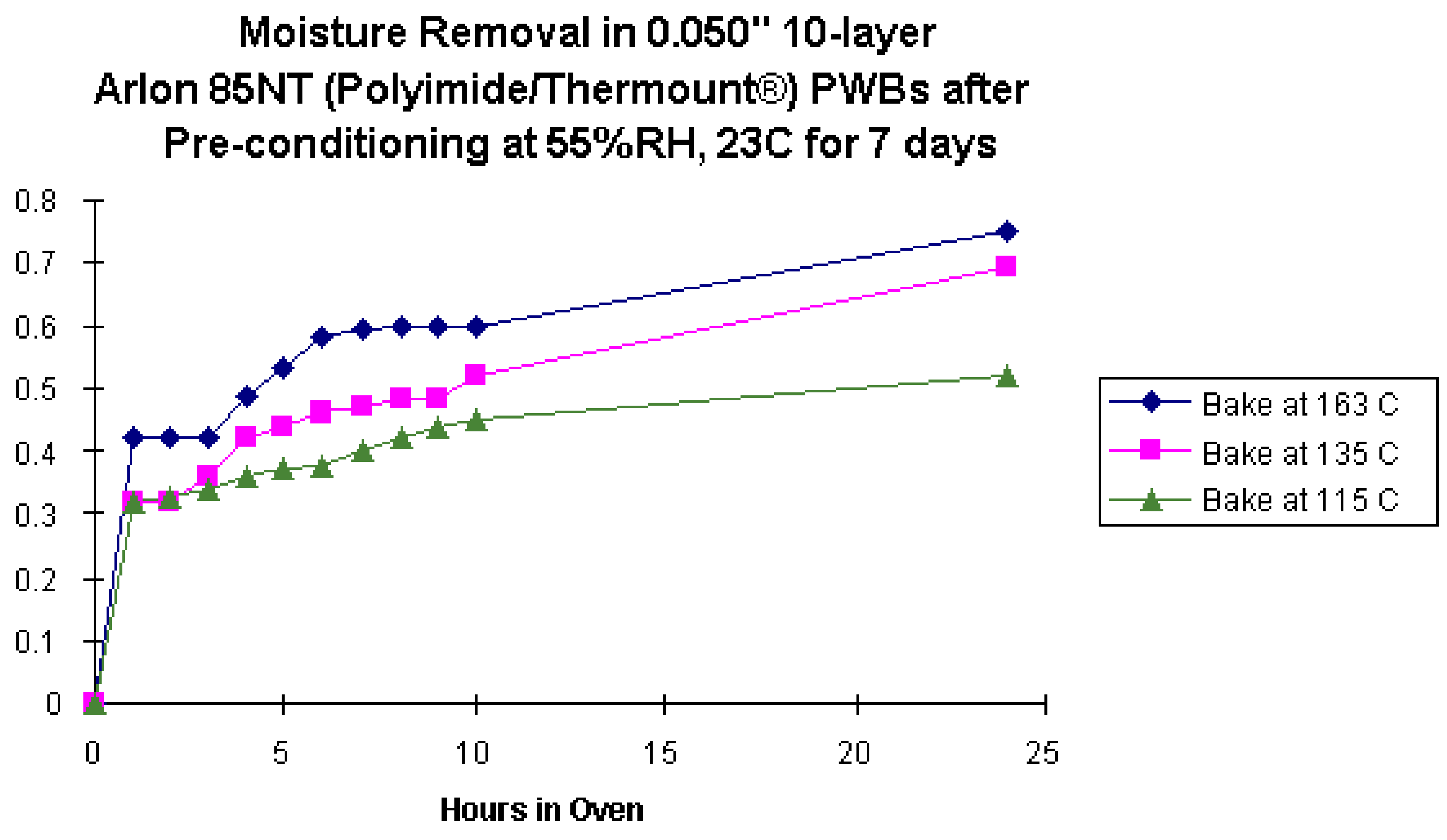
Moisture Removal in 0.050" 10-layer
Arlon 85NT (Polyimide/Thermount®) PWBs after
Pre-conditioning at 55%RH, 23C for 7 days
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
Hours in Oven
Bake at 163 C
Bake at 135 C
Bake at 115 C

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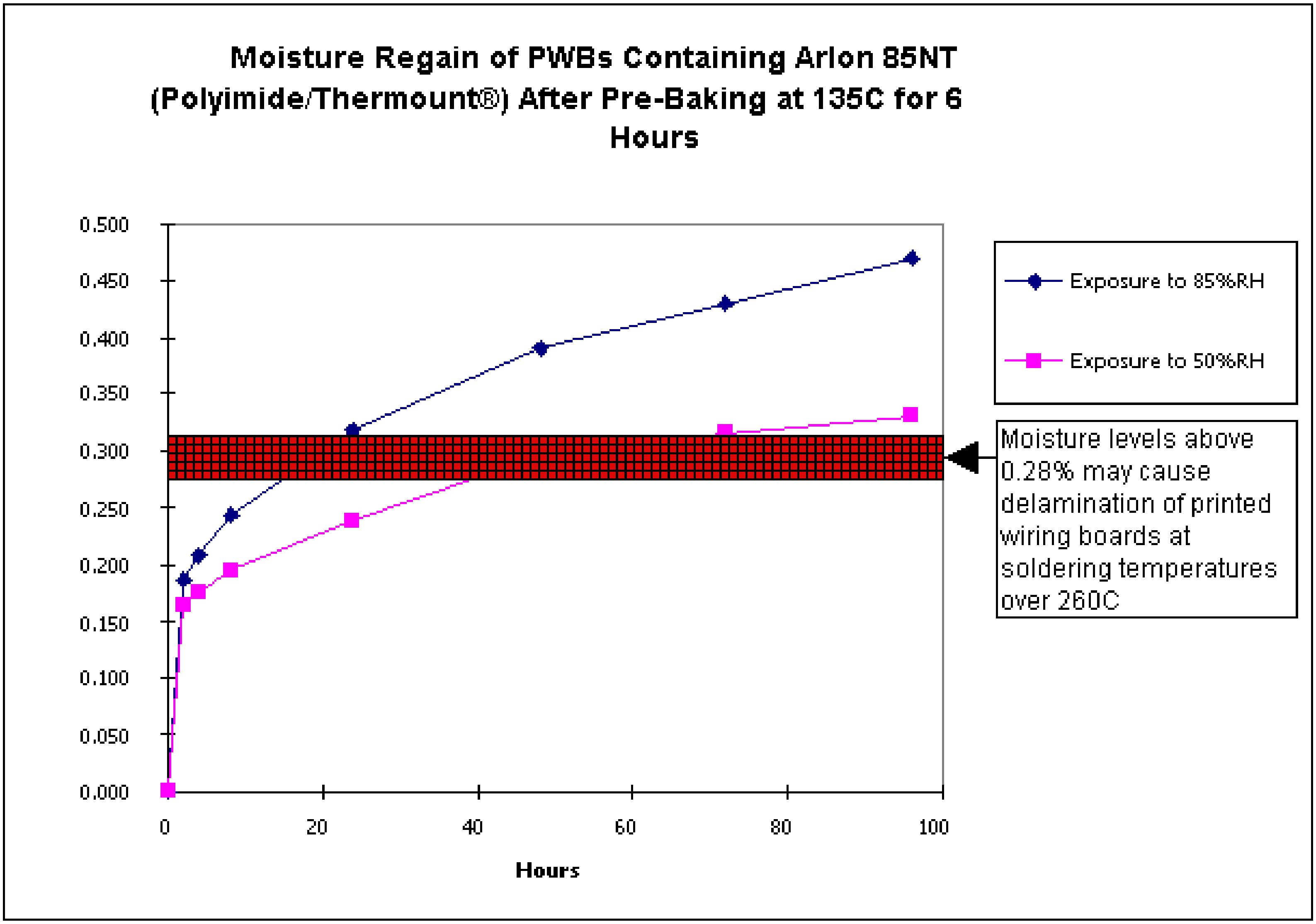

Moisture levels above 0.28% may cause delamination of printed wiring boards at soldering temperatures over 260C

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Comparison of Resin Coated Foil to THERMOUNT® Prepreg and Laminate:

Potential Issues with 2-part (C-stage/B-stage) Resin Coated Foil (RCF):

- RCF has poor thickness uniformity (+/- 15%) after pressing into a multilayer structure, especially over a combination of ground planes and circuitry.

- The copper foil surface of RCF frequently contains resin spots which may result in “excess copper” and shorts between fine line circuitry.

- After lamination to circuitry, the foil surface of RCF contains undulations which.impact photoresist adhesion and potentially lower fine line imaging yields.

- RCF has is a high cost product since it requires a two pass process through treaters at toll-coating operations.

- Non-reinforced resin is more difficult to laser ablate and permanganate clean uniformly, leading to laser formed holes which have rounded side walls. “Lasers cut this material like a hot knife thru butter” according to some CO2 laser manufacturers, making it difficult to control lateral ablation.

- Dielectric thickness between layers 1 and 2 is defined by the “C-stage” resin thickness which is approximately 0.001” - 0.0015”. This thickness is too thin for many impedance applications which use 0.003” - 0.005” line widths.

- RCF can only be used between layer 1 and 2 of a multilayer PWB, so multiple layer via interconnects are not possible without using costly sequential lamination processes. RCF is not available as a dimensionally stable laminate so it is limited to single layer interconnects.

- The dielectric strength of RCF is relatively low since the separation between layers 1 and 2 in a multilayer PWB is only 0.001” - 0.0015”. This thin dielectric has a high potential to fail M&IR tests.

- Non-reinforced epoxy resin is susceptable to cracking during exposure to thermal cycling conditions.

- Non-reinforced epoxy resin has high in-plane CTE of approximately 50 ppm/C, reducing the reliability of SMT component (BGA, CSP, LCCC, DCA, TSOP, etc.) solder joints after thermal cycling.

- The low Tg epoxy resin available from some RCF manufacturers is not suitable for high temperature wire bonding.

- RCF is only available with 17 and 35 micron copper foil. 17 micron foil significantly slows down YAG laser drilling productivity, compared to 9 micron foil. It is more difficult to etch 50 micron lines/spaces on 17 micron foil due to undercut of the etchant, compared to 9 micron foil.

Advantages of THERMOUNT® nonwoven aramid reinforced Laminate and Prepreg in Laser and Plasma Microvia Applications:

F Uniform distribution of organic fiber and resin enables high speed laser ablation

F Enables multiple-layer interconnects without sequential lamination

F Available as both laminate and prepreg, with uniform thickness tolerance, for multilayer structures

F Dimensionally stable nonwoven aramid reinforcement enables use of small stop pads (more space for lines between pads)

F In-plane CTE of PWB is tailorable from 8-16 ppm/°C by varying copper and resin content

F Smooth, flat nonwoven aramid reinforcement increases fine line imaging yields

F Low dielectric constant for high speed electronics

F Compatible with conventional PWB equipment and process sequence, and available from multiple suppliers

ARLON TECHNICAL TIPS

DESIGNING WITH THERMOUNT

Volume 2, Number 3

0.010" H1/H1 Thermount® E220/E230/E220
3 x E220 Prepreg
0.010" H1/H1 Thermount® E220/E230/E220
3 x E220 Prepreg
0.010" H1/H1 Thermount® E220/E230/E220
3 x E220 Prepreg
0.010" H1/H1 Thermount® E220/E230/E220
3 x E220 Prepreg
0.010" H1/H1 Thermount® E220/E230/E220

QUALIFICATION AND PROTOTYPE BOARDS

Qualification boards can be constructed from styles E220 (approximately 3.0 mils per ply) and E230 (approximately 3.5 mils per ply). The diagram shown is a suggested build-up for a 55110 qualification board. (Slight modifications may be needed depending upon individual processing variations to attain final thickness requirements of 0.090" minimum.) Visit other areas on the web site or contact an Arlon Technical Service Representative for additional processing recommendations.

Solvents compatible with THERMOUNT® E200, N710:

1. Ketones

   Methylethyl ketone (MEK)

   Acetone

   Cyclohexanone

2. Solvent containing hydroxyl groups or polyols or their esters

Dowanol PM	1-methoxy-2-propanol
Phenyl Cellosolve	2-phenoxyethanol
Cellosolve Acetate	2-ethoxyethyl acetate
Butyl Cellosolve Acetate	2-butoxyethyl acetate
Cellosolves	2-ethoxy, methoxy, or butoxy ethanol
Downanols	same as cellosolves except based on glycerin instead of ethylene glycol

3. Aromatic and polyaromatic solvents:

   Toluene

   Xylenes

Solvents incompatible with THERMOUNT® E200, N710:

DMF*	Dimethyl formamide
NMP*	N-methyl-2-pyrrolidone

HMPA	Hexamethylphosphoramide
DMAC	Dimethylacetamide
DMSO	Dimethyl sulfoxide (generally, all sulfoxides)
Sulfones	All structures containing sulfone linkages

Notes:

* DMF and NMP at concentrations less than or equal to 5% are compatible with N710

HMPA, DMAC, DMSO, Sulfones: not tested on N710