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Laser Drillable Prepreg Alternative to Coated Copper for HDI Applications

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Abstract
There is a contingent in the industry that feels reinforced substrates are needed to meet the performance requirements of HDI microvia technology. Concerns that non-reinforced resin coated foils, or non-woven substrates, may not provide the thickness control and predictability of movement and reliability needed to meet the next generation of infrastructure board designs, which must include microvias. Conventional woven glass offerings used for prepregs which have been fabricated using laser drilling technologies have yielded inferior hole wall quality and require higher pulse counts making them an undesirable alternative to some.

Development of a laser drillable glass fabric has given new hope to conventional prepregs, offering a better fit to all attributes desired in materials for HDI microvia applications. Clean hole quality at fewer pulses than conventional glass fabric, better dimensional performance, dielectric yield control, reduced cracking, ease of handling and storage and availability make the new generation of laser drillable prepregs an attractive alternative where supported substrates are desired.

This paper will discuss the attributes and short falls of laser drillable prepregs in comparison to other material types commonly used in HDI applications.

Resin Coated Copper Foil

Resin coated copper foil, while providing fast drilling and good hole quality, carries with it limitations and restrictions.

The nature of the material itself, unsupported resin coated on the treatment side of copper foil, required that special considerations be made in the development of the product. Special resin systems had to be incorporated to allow converting and handling without excessive cracking. Such resins, while compatible and capable of linking to materials made with standard FR-4 resin chemistries, may not be the same, resulting in a mixed package in the final board. Product offerings are generally limited to 140 ^{o}C to 170 ^{o}C Tg range FR-4 materials. Often, these resin chemistries require special storage conditions to extend shelf life.

In applications where thicker outer dielectrics and good thickness control for impedance requirements is needed, resin coated copper foil attractiveness drops very quickly. A double pass coating, which results in a C-stage/B-stage coated copper, can help achieve thicker dielectric requirements with an element of thickness control and guarantee a minimum insulation layer contributed by the C-stage film but still limits the resin available to flow to fill features and vias as may be required by the overall board build-up.

Dimensional stability and predictability in non-sequential builds also becomes a major concern as lines and spaces become tighter and registration is increasingly important. Resin coated foil is also susceptible to more prominent image transfer to the outer copper, which can cause off contact resist application resulting in imaging defects in outerlayer processing, especially where fine work is prevalent.

Conventional Prepregs

As HDI boards become thicker and designs more complex with tighter trace work, the move towards reinforced materials will grow. While glass reinforced prepregs address the structural and design flexibility issues of resin coated copper foil, conventional prepregs made with standard fabrics present performance issues of their own.

Industry standard 106, 1080 and 2113 fabrics using essentially an oval filament bundle, have weaves that exhibit very distinct glass rich and resin rich areas when coated (see Figure 1). These areas create non-homogeneity in the substrate that results in a varied degree of ablation in localized areas in the laser drilling process. The glass rich areas can also be difficult to laser drill cleanly and require a higher number of pulses to achieve the desired depth.

Standard prepreg has been used out of necessity, but better alternative is needed.

Improved Laser Drillable Prepregs

Development of glass technology in which glass fabric manufacturers use various techniques to flatten and spread the yarn bundles has resulted in a woven glass fabric that is topographically flatter and more even in glass yarn distribution across the area of the fabric. This is evident in the comparison between Figure 1 and Figure 2.

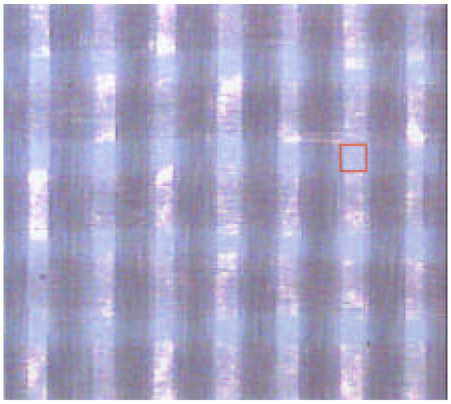

Figure 1 - Conventional 2113 Fabric

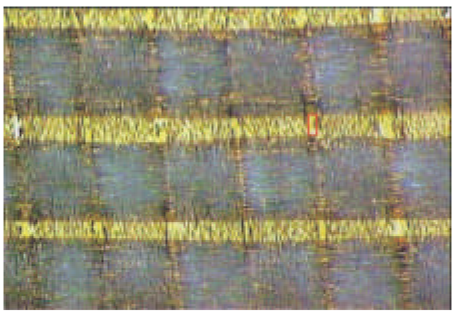

Figure 2 - Laser Drillable 3113 Fabric

Prepreg made with these flatter fabrics results in a more homogeneous substrate. The distinct areas of glass rich, or resin rich make-up, are minimized in the X-Y plane. The flatness of the bundles also minimize the "glass thick" points where the bundles overlap, which typically require a greater number of pulses to drill through. The benefit of the homogeneous substrate extrapolates across the board as a more consistent drilling parameter can be applied not being concerned with drilling effectiveness, hole-to-hole, due to significant differences in glass-to-resin ratio in localized areas.

Table 1 provides a general comparison between relevant attributes of resin coated copper foil, conventional prepreg, and prepreg made with improved laser drillable fabric. Pulse counts, though not as low as with resin coated copper foil, are reduced appreciably for the laser drillable prepreg over conventional prepregs, with a better resultant hole.

Benefits over resin coated copper include the elimination of cracking through the unsupported resin, better dimensional performance due to the glass contribution in the dielectric, reduction of image transfer and a controllable insulation spacing between the outer foil and Layer 2/Layer N-1.

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Table 1 - Relative Properties of Laser Drillable Materials

Property	Resin Coated Copper Foil	Conventional Glass Reinforced Prepreg	Improved Laser Drillable Prepreg
Dielectric Construction	--	1-3 Ply	1-3 Ply
Laser Drilling Speed (500 Hz CO_2 Laser)			
50 micron dielectric 80 micron dielectric	1-3 pulses 2-5 pulses	4-5 pulses 6-8 pulses	3-4 pulses 5-6 pulses
Hole Geometry/Plate-ability	++	+	+++
Resin Cracking	Possible	No	No
Image Transfer	+	++	+++
Plasma Capability	Yes	No	No
Dimensional Stability	+	++	+++
Thermal Expansion X, Y	+	++	+++
Thickness Control	+	++	+++
Surface Smoothness	+++	+	++

Figures 4 and 6 show the hole quality achievable with the improved laser drillable 1080 prepreg equivalent versus standard 1080 shown in Figures 3 and 5. The hole quality and angle is much improved. The visible planes of resin-glass-resin in the Z-axis allow for more controlled ablation down through the material.

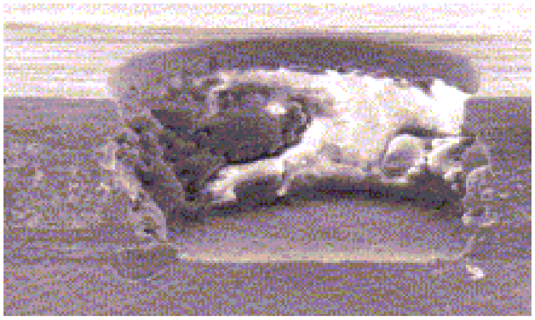

Figure 3 - Conventional 1080 Fabric 500X

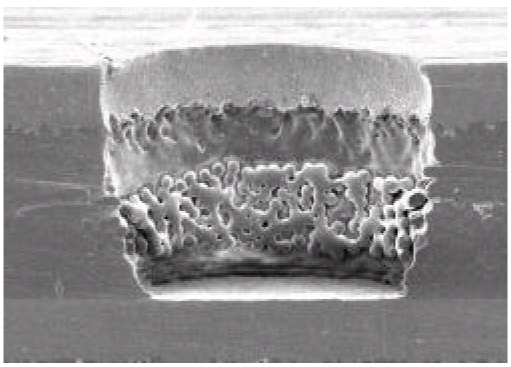

Figure 4 - Laser Drillable 1080 Fabric 500X

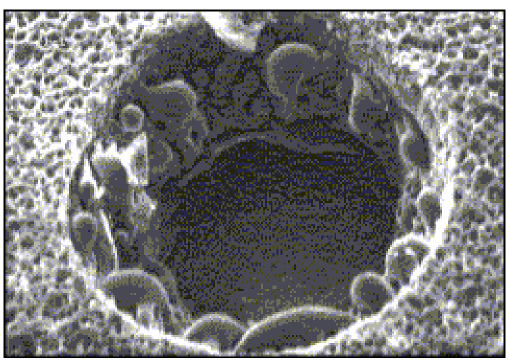

Figure 5 - Conventional 1080 Fabric 600X

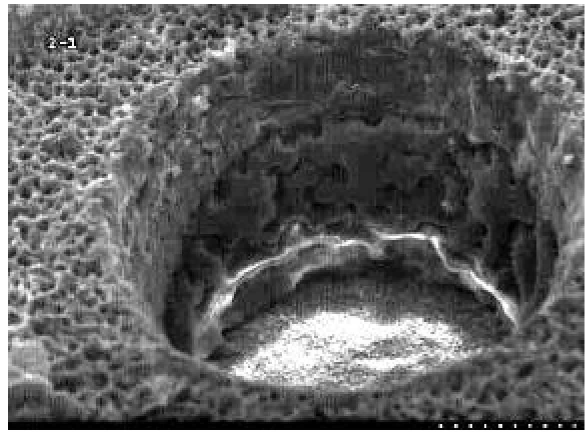

Figure 6 - Laser Drillable 1080 Prepreg 600X

Figure 7 shows a finished plated microvia drilled through an enhanced laser drillable prepreg dielectric. The absence of protruding glass filaments allows a clean, evenly plated hole comparable to that achievable with resin-coated foil.

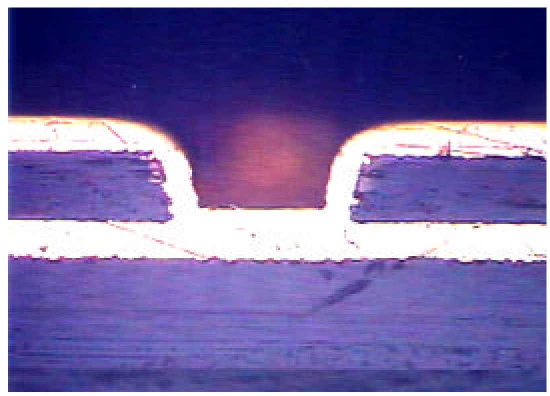

Figure 7 - Plated Hole

A clear advantage of laser drillable prepreg over coated copper foil is the flexibility in design and application. Fabrics are currently available from several suppliers, in fabric weights comparable to 106, 1065, 1080, and 2113 and heavier, providing design flexibility from 0.002 inches and increasing to virtually any target dielectric thickness needed. Dry glass weights typically run 10-20% higher than their conventional counterparts resulting in a slightly higher thickness yield for a given resin content. Resin contents for prepregs can be calculated to address resin availability needed to fill image features and buried vias in sub-assemblies while satisfying the necessary dielectric properties. The various styles of laser drillable prepregs can be laid-up as single ply or multiple ply constructions, as with standard relamination prepreg, to achieve the overall thickness and thickness control as desired for impedance-controlled work. The flexibility to design a product for specific performance requirements is greatly enhanced.

Another distinct advantage that this emerging technology carries with it is the ability to produce prepreg from any resin system currently offered. These enhanced fabrics can be finished by the glass weaver with the proper resin compatible finish chemistry and impregnated in the laminate manufacturers standard prepreg treating operation. This attribute provides the board manufacturer the reliability of a pure package with respect to resin chemistry. Laser drillable prepregs are manufactured to the same melt rheology profile as standard prepregs of the same resin type, thus the same press cycles can be employed in the relamination process. All material attributes, thermal characteristics, composite coefficient of thermal expansion (CTE) properties and inter-laminar bond integrity are predictable and familiar to the user.

With these attributes, laser drillable prepregs fall more readily into the category of standard materials. Storage conditions and shelf life are equivalent to the conventional prepregs made from like resin systems. Cost offset is minimal over standard products and significantly advantageous over resin coated foil and other available supported materials for HDI applications. UL approval is simplified as the listing falls under existing listings. Lead times and minimum purchase volume requirements are also favorably impacted.

Conclusion

Enhanced laser drillable prepregs offer a cost effective solution to the increasingly complex demands of HDI designs. The shortcomings of resin coated copper foil are well addressed in a design flexible product, which falls readily into the category of a standard material and provides greater ease in application and processing.

References

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