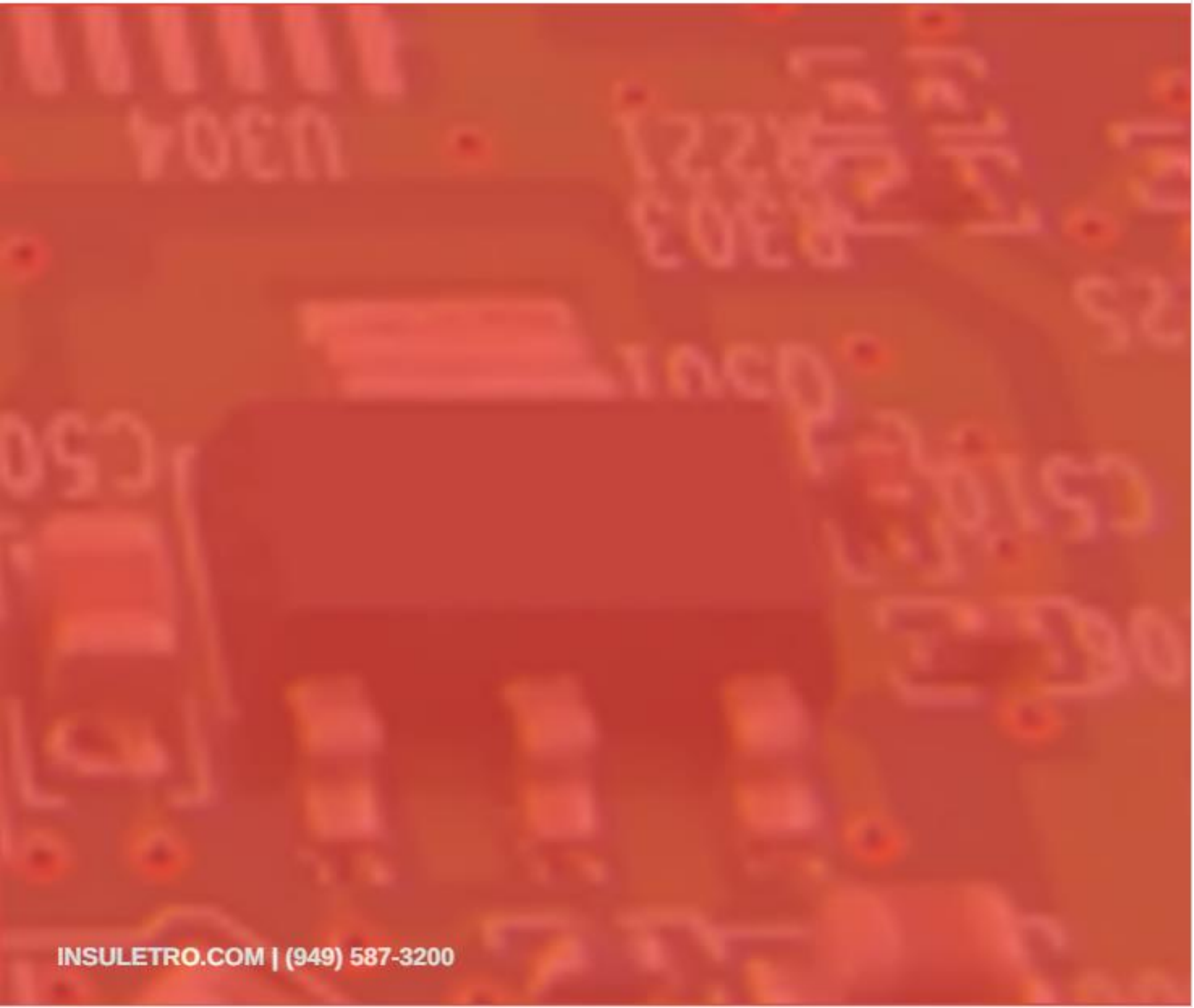
FILMS FOR IMPROVED RELIABILITY IN RIGID PRINTED CIRCUIT BOARDS

Author: Chris Hunrath, Insulectro Vice President of Technology



INSULETRO.COM | (949) 587-3200

TABLE OF CONTENTS

ABSTRACT

The Printed Circuit Board industry has been dominated by fiberglass cloth-based materials for many years. Good reasons include cost, as well as thermal and mechanical stability. Glass fabric provides a substrate for manufacturing where the resin of choice is applied and then “dried” for use in the PCB manufacturing process. The fabric also supports cutting and handling of the uncured product.

Technically, PCB materials are composites (heterogeneous solids containing two or more materials that are combined where each retains its characteristic properties). The glass provides mechanical and thermal stability as well as dielectric spacing. The resin enhances the mechanical and dielectric properties and provides a bonding function.

Over the history of printed circuit boards, many different resin systems have been developed, driven by the ever-increasing need for better electrical and thermal performance.

In some cases, mixing of resin types is used to balance cost and electrical performance, but these structures still typically use glass fabric as a foundation.

New high performance resin systems are almost always applied to the same glass cloth that has been used for decades. While some of the properties are improved, limitations from the glass tend to carry over to the newer resins systems.

INTRODUCTION

Films and liquid dielectric materials are not new to the industry. Films have been used extensively in flexible circuits including printed electronics. Liquids have found use in HDI (high density interconnect) structures. RCC (resin coated copper) is a film of sort where some of the same resins coated on glass cloth are instead coated onto copper foil. Copper clad films have been used to create embedded passive components (capacitors).

Polymers used for flex circuits include polyimide, epoxy, acrylic and polyester films. These films offer a variety of properties such as flexibility, roll to roll processing and in some cases low cost.

While flex films do what they do well, they do have certain limitations. For example, you would not want to mount a BGA to an unsupported flexible substrate. Also, ingredients used to improve flex performance often result in a companion reduction in thermal stability and even electrical performance.

RCC has been used as a stand-alone dielectric as well as a cap layer on more traditional PCB structures. The polymers used here tend to resemble the same ones already used in fiberglass cloth prepregs. This has the benefit of being familiar to the industry but does not offer performance improvements.

A NEW APPROACH

Improvements in polymer chemistries in the composites industry have opened the possibility to have the benefits of glass fabric without the drawbacks. Controlled dielectric spacing, low neat resin CTE and better breakdown voltage performance are all possible. In addition, many resin systems give up transmission line performance (Dk, Df) due to the glass reinforcement. This is not the case with a film that does not contain glass fabric.

Laminar composites based on high performance films can be used alone or in combination with more traditional glass-based materials.

Like using different glass reinforced resin systems in the same PCB stack-up, adding films in specific layers provide some unique benefits to the structure. These laminar composites solve some technical and reliability challenges that were difficult or impossible before.

Pad cratering has become more common as the industry transitions to more and more lead-free solder. Higher solder temperatures, higher modulus solder joints and temperature resistant but brittle resin systems increase the risk of fractures under the pad. (Figures 1&2)

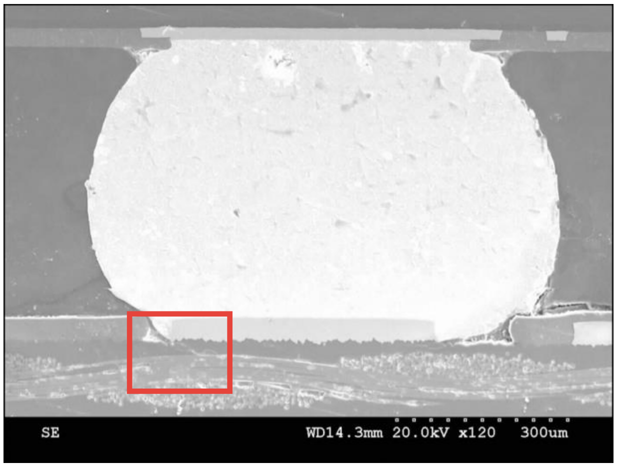


Figure 1

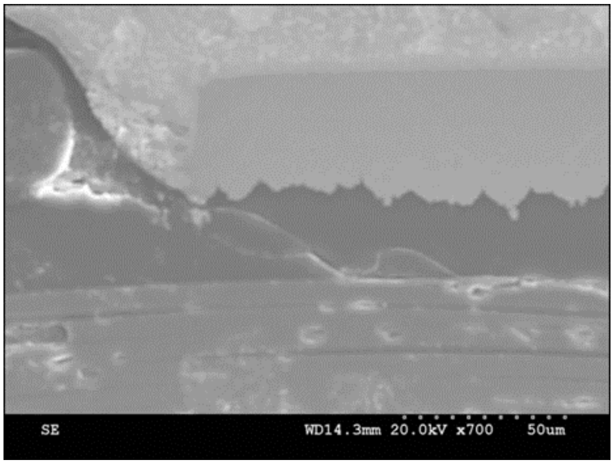


Figure 2

A pad crater resistant structure may be built using a fracture-resistant film on the surface layer. This layer is in direct contact with the copper pad, preventing fractures starting or reaching the copper trace or via.

The high performance (modified) film has a combination of properties to balance modulus and elongation to produce a product that is between a rigid and flex PCB material. (Figure 3)

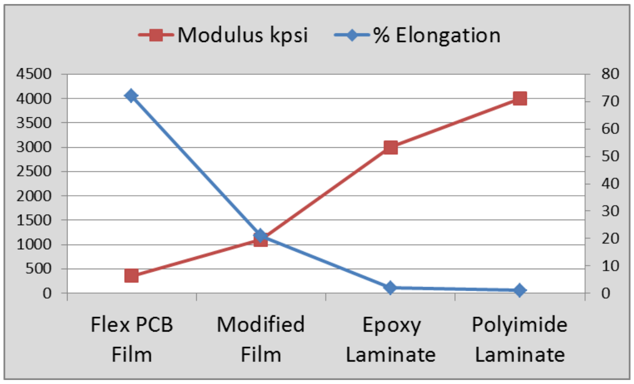


Figure 3

When used as a cap layer (figure 4), it becomes the interface between the copper pad and the rest of the PCB. The more pliant cap layer will prevent or block fractures and protect copper connections (traces) to the pad.

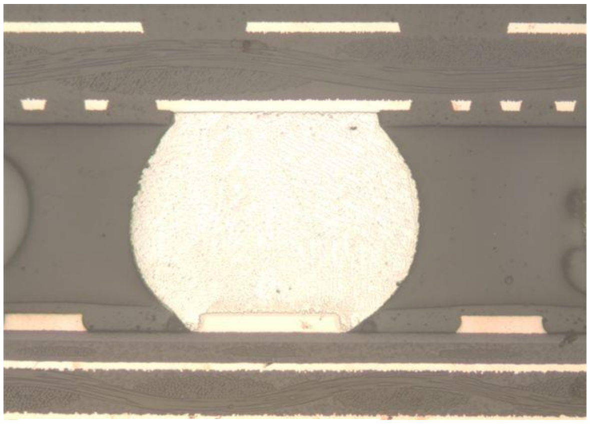


Figure 4

In addition to the fracture resistant properties, the neat (non-fabric reinforced) resin CTE is close to copper metal, Tg is in excess of 300°C and the Td is over 500°C.

A material with these properties has an extremely high cure temperature. This makes use of this type of polymer as a bonding film impractical in the PCB shop but adding an already cured film can be used for pad crater resistance, stacked via HDI structures and more.

FILMS FOR HDI STRUCTURES

RCC has been used for both a surface layer of blind vias, and 2 to 3 layers of stacked vias for some time. These layers do not contain glass cloth. This provides some processing and even transmission line benefits but lacks the CTE and z-axis spacing control of the glass. As the drive to increase layer count and thickness reduction continues, the reliability of this structure is challenged. Lead free assembly adds to the problem.

The use of a high Tg, low CTE, c-stage film creates some new possibilities when used with a high flow b-stage bonding layer. The high temperature c-stage performs many of the same functions as the fiberglass. In addition to reducing CTE and controlling z-axis spacing, cured films like this have a very good track record with dielectric withstanding voltage over glass reinforced systems.

Combining the two films into a laminar composite, yields the benefits of the high temperature film, while using conventional PCB laminating and curing temperatures.

Very reliable 12 micron copper to copper spacing is possible. Figure 5 shows a via through the c-stage layer over the internal copper pad, the b-stage resin bonds the c-stage and fills the sides of the internal pad.

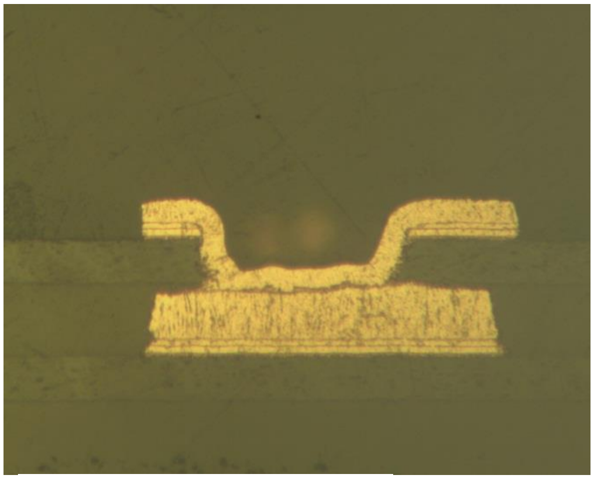


Figure 5

In figure 6, this 12 micron spacing has a dielectric that withstands over 1500 volts. In addition, removing the glass fabric lowers the Dk of the structure, making thinner spacing with the same impedance possible.

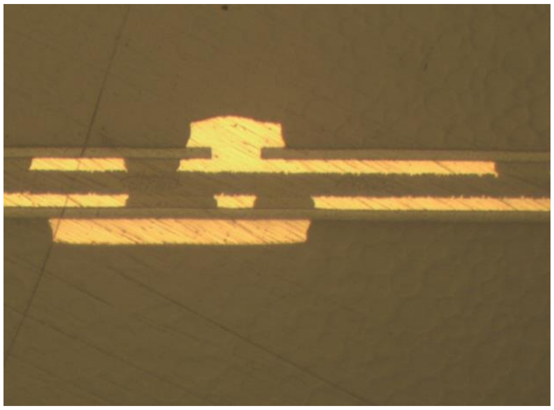


Figure 6

NEW B STAGE RESIN

Using a high temperature c-stage film creates some new opportunities for bonding films. Because the c-stage guarantees the z-axis copper to copper spacing, the b-stage can have a low melt viscosity. Also, all of the resin may be used for fill (instead of wetting glass fabric) so it can be used to fill large and/or deep structures. Figure 7 shows a 25 mil wide by 50 mil deep via filled with resin from the b-stage bonding film.

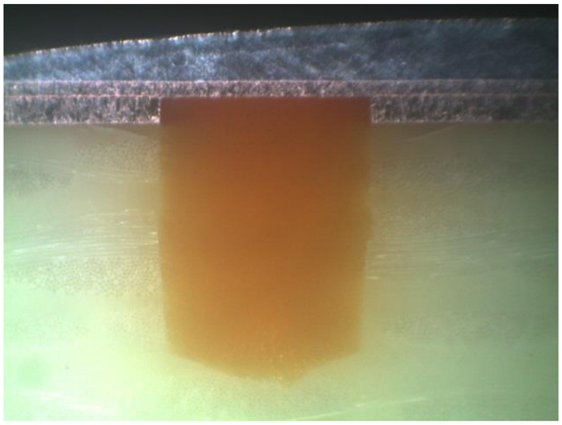


Figure 7

New epoxy technologies allow for comparatively low, neat resin CTE (60 ppm/°C) without the use of a filler. While fillers offer a CTE benefit, they tend to agglomerate (collect) along circuits when used with a high flow resin system. Collection of too much filler in one spot can cause many problems including CAF, electrical performance variations and bond failure.

CONCLUSION

New polymers from the widespread composites industry have produced some materials with great potential. As technology advances, new demands will be placed on the PCB structure. Creating and using these new films will both solve some of the existing challenges and make new types of circuits possible.