May 2004 Presentation & Plant Tour Meeting Review

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A well received presentation was provided by Fred Hickman, VP of OEM Marketing and Technology for Park/Nelco, on May 20th, 2004 at the Embassy Suites in Anaheim, CA. Immediately following Fred's Presentation we met up at Park Nelco's Facility on 1411 Orangethorpe Avenue in Fullerton, CA. where we experienced a very impressive tour of their facility.

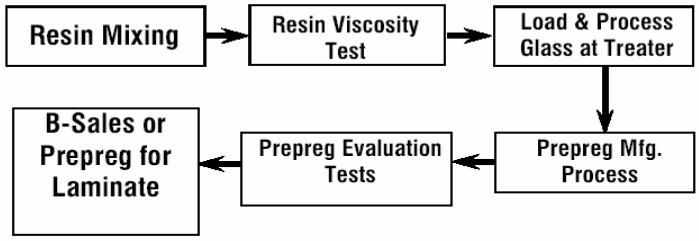
The presentation began with an overview of the Park-Nelco organization, which has 3 facilities located in the America's and 3 facilities located in Europe and Asia. This was followed by covering the technology drivers for Park-Nelco, which are *higher signal transfer rates, broader dielectric material sets* (new resin chemistries & focus on manufacturability and signal integrity), *lower Cu tooth profile, different etch techniques, tighter impedance control, changes in signal routing, optoelectronic integration, thinner dielectrics, embedded passives, IC densification, Alternative IC Packaging, HDI Technology, Pb free, Br free, P free, Cd free, Hg free, ozone depleting substances, polybrominated aromatics, Ni free, improved thermal stability, enhanced shock resistance, CAF resistance, improved IST performance, improved buried via filling, enhanced integrity of electroplated Cu, & minimum PWB performance change during useful product life.* This is quite the laundry list of technology drivers and for many it is all greek, but for those of us doing Circuit & PCB design it all has meaning and it is a welcome sight. All of the these technology drivers will lead to materials with higher speed and lower loss, hybrid & mixed dielectric, halogen free or leadless solder capability, CTE enhanced, tighter thickness controls, CAF resistant, buried capacitance, and laser drillable glass.

Fred then covered the various Park-Nelco part numbers all of which can be correlated to the IPC 4101 specification. This was followed with coverage of new Park Nelco part numbers that meet Lead Free requirements. These new part numbers are N4000-11 (180°C Tg Phenolic Cured Epoxy), N4000-12 (190°C Tg High Speed Low Loss Epoxy), & 4000-13 (N4000-13 210°C Tg High Speed Low Loss Epoxy). The resin for these materials have been modified so that they are now able to withstand multiple reflows at 260^{0}C, and there will be no increase in cost for these materials. This is good news for a lot of us, since previously it was thought that PCB material costs would increase dramatically when moving to a lead free process.

Fred then provided a quick overview in Pre-Pregs and Laminate manufacturing, which all starts with the treating process. The resin material is heat cured and thermosetting (Epoxy, Polyimide, BT, CE). The resin is specially formulated for electronics and is very pure, which is required for good insulation. Solvents are used during the mixing process to ease treating and control viscosity. The Resin is mixed, catalyzed, and aged (to ensure proper viscosity) in stainless steel mixing containers. After mixing the resin is carefully tested for proper viscosity.

There are three stages to resin curing, which are **A-Stage** *(Liquid resin that is mixed and catalyzed, but not cured)*, **B-Stage** *(A-Stage resin is heated and partially cured during the treating process (prepreg). Resin becomes dry to the touch.)*, and **C-Stage** *(B-Stage resin on the prepreg is fully cured during the pressing process).* Once the resin is ready the Glass is loaded and ready for processing at the Treater. Various woven glass styles and thicknesses are treated. The glass is unwound and fed into the front of the treater. This process coats the glass with the A-Stage Liquid Resin. Temperature, speed, tension & cleanliness are very important controls for proper treating. Pre-preg is formed in the treater by curing the **A-Stage** resin after it is coated on the glass cloth. This curing process occurs in a large oven, which is integrated with the Treater system. Pre-preg is a **B-Stage** product that is dry to the touch. The speed and heat curing process is dependant on glass styles and resin type. The prepreg is then wound into rolls or cut into sheets as it comes off the machine. During and after the treater process the pre-preg is tested for key product characteristics.

TREATING PROCESS OVER-



One of these key characteristics that is tested is the Tg (glass transition temperature) of the material. The glass transition temperature or Tg of a polymer is the temperature at which a polymer transitions from a glassy to rubbery state upon heating and reflects the degree of polymer chain motion. When below the Tg the motion of polymer chains is restricted and materials are usually hard and glassy. When above the Tg, polymer chain motion is increased and amorphous polymer regions are tough and rubbery. In practice, the transition from glass to rubber does not occur at a single temperature, but rather over a temperature range and the magnitude of this range typically indicates the relative homogeneity of the polymer system. During the glass-to-rubber transition, a number of physical property changes also occur. Some of the important polymer properties that change with Tg include modulus, thermal expansion coefficient, heat capacity, refractive index, and dielectric properties. These properties that are most frequently measured to determine the Tg of polymers. There are several tests that are used for testing the Tg. Probably the most common method used to determine the glass transition temperature of polymers is to measure the change in specific heat capacity by Differential Scanning Calorimetry (DSC). With this technique, sample and reference cells of a DSC instrument are maintained at approximately the same programmed temperature by varying the power to electric heaters. The difference in power supplied to the two cells is a measure of the rate of energy change and heat capacity of the sample. In contrast, Thermal Mechanical Analysis (TMA), an alternative method to determine Tg, measures dimensional changes during heating and/or cooling, and the glass transition is indicated by a shift in the rate of thermal expansion of the sample. It is important to understand that the glass transition temperatures measured by these and

LOADING GLASS

other tests will often differ since the test conditions and the measured properties associated with the Tg are different. Thermal Mechanical Analysis also is used to measure the resistance of laminates to elevated temperatures, particularly temperatures associated with soldering operations. In this test, copper clad samples are heated to and held at a desired temperature until a sudden and irreversible expansion indicative of a delamination occurs. The time at temperature until this catastrophic failure occurs is taken as the limit of a sample's thermal resistance. This test is referred to as time to delamination and is typically performed at 260°C and higher temperatures indicative of soldering operations.

Now that we all have a better understanding of Tg we can better understand why Tg is so important. The higher your Tg the lower your CTE (Coefficient of Thermal Expansion), which is a good thing; however, the more expensive the material. These various Tg tests can also be used to keep your board shop honest. If you are having bow and twist issues then these are excellent tests to perform to verify that your PCB has been properly laminated.

The diagram below provides a good visual of what the treater process looks like, although it does not do this massive and expensive machine justice. The rolled or cut **B-Stage** material can now be sold for customer use, or the sheets can be processed to create copper clad laminate. The lay-up, set-up and copper process are all done in a clean room since it is critical to eliminate all forms of contaminates. If there are contaminates or foreign inclusions found in the laminate then there will be issues with it's electrical characteristics. Specially treated copper foil is used for the copper clad process and is shown below. The B-Stage material and the copper foil are sheeted and laid up in large lamination racks between large stainless steel call plates. Then the material is laminated similar to a PCB lamination process. The laminate systems used by Park-Nelco are very large, fully enclosed and vacuum sealed systems. A flow chart of the laminate & prepreg technology and a diagram of the laminate and prepreg process are shown below.

At the completion of the presentation we all headed over to Park-Nelco's facility where we received a wonderfully guided tour of the facility. The diagrams shown in this article do not do their facility justice as the processing machines were very large and fully automated. The handling systems for the copper sheeting process were incredible and Park-Nelco management stated that they have had little to no down time since they were installed over 2 years ago. The tour was definitely one of our more interesting tours. Park-Nelco's facility was very impressive, especially the automated handling system.

A special thanks goes to Fred Hickman and Jim Hartzell for a wonderful presentation on laminate technology and for opening up their facility to the SMTA group. We really enjoyed it! Thank You! For those of you who missed this meeting you missed a good one, but it is not too late! Park-Nelco would be willing to provide a tour to you as well if you just give Jim Hartzell a call at (714) 870-2257. A copy of their presentation can also be found at:

http://www.laocsmta.org/archive/May_2004_Park_Nelco_Technology_Roadmap_Presentation.pdf