TA Instruments

Thermal Analysis & Rheology

THERMAL SOLUTIONS

Measurement of the Degree of Cure of Discrete Wired Circuit Boards

PROBLEM

In a discrete wired circuit board, the signal wiring layer is formed by ultrasonic bonding of an insulated wire in a precise pattern onto an adhesive coated substrate. The adhesive is subsequently cured both to secure the wires in place and to develop final properties. The wiring layer is then encapsulated, usually with an epoxy prepreg. Since obtaining and verifying the proper cure of these materials is critical to the end-use performance and reliability of the circuits, the manufacturers are interested in a rapid cure evaluation technique.

SOLUTION

Measurement of the glass transition temperature (Tg) using differential scanning calorimetry (DSC) provides a convenient means of monitoring the degree of cure in thermosets, based on the heat capacity step change (ΔCp) which occurs at the Tg. However, in many high performance multilayer and discrete wired circuits, the samples are very thick, often contain several different materials, and the ΔCp at the Tg of these materials is small and difficult to quantify. Hence, the DSC of a discrete wired circuit (Figure 1) shows a single, broad Tg, not the individual Tg's of the adhesive and prepreg used in the circuit

Fortunately, complementary thermal analysis techniques such as TMA and DMA are useful alternatives in this situation. As seen in Figure 2, when the same sample is analyzed using TMA, two transitions are detected. Even though the Tg of the adhesive is difficult to detect in the expansion curve, the Tg is observed as a small increase in the first derivative, or expansion coefficient curve. The Tg of the prepreg is observed as the second, larger increase

Figure 1. DSC (Discrete Wired Circuit Board)

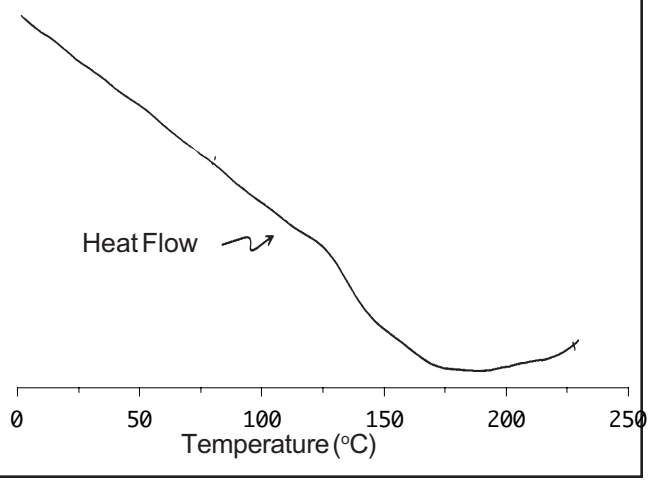
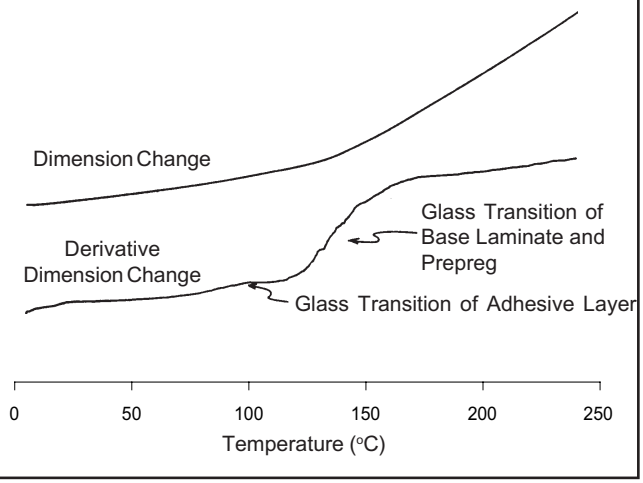


Figure 2. TMA (Discrete Wired Circuit Board)



in the expansion coefficient curve. Unfortunately, the TMA Tg's are difficult to quantify precisely by extrapolation from the expansion curve.

DMA, on the other hand, shows both transitions more clearly (Figure 3). The loss peak of the adhesive layer is easily observed at 120°C, even though it makes up only about 5% of the total sample thickness. The Tg of the prepreg is seen at 166°C. The DMA of a complex discrete wired circuit board (Figure 4) shows the ability of the technique to detect multiple Tg's. In this case, five transitions are observed within a single circuit.

Although DSC, TMA, and DMA can be used for Tg evaluation, DMA is generally the most sensitive technique.

Figure 3. DMA (Discrete Wired Circuit Board)

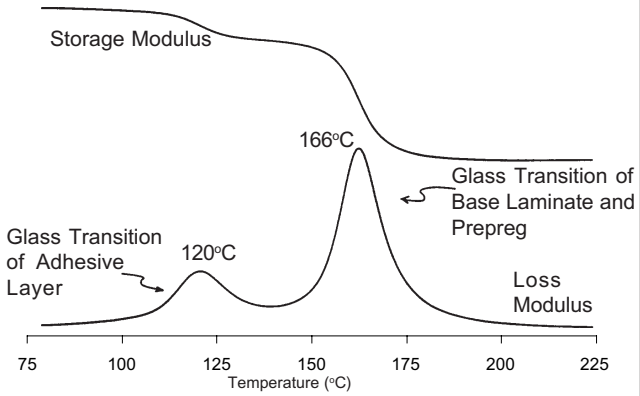
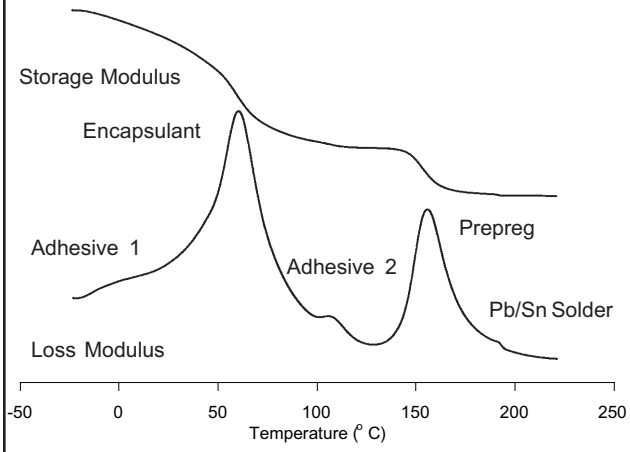


Figure 4. DMA (Discrete Wired Circuit Board)



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