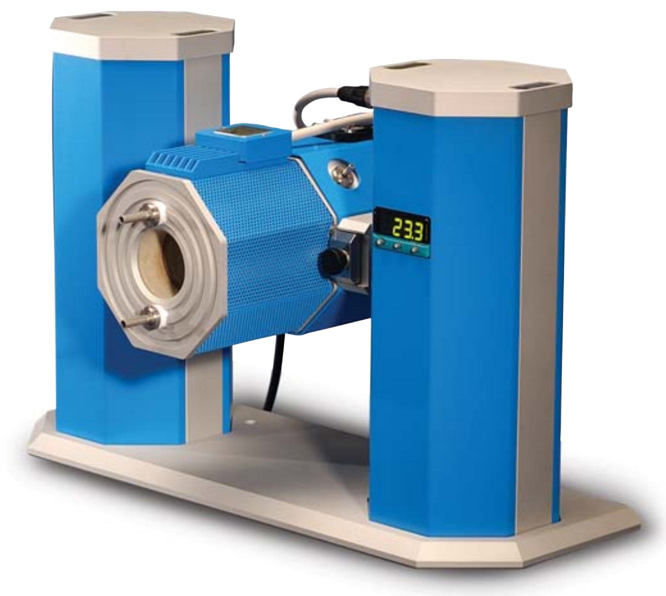
APPLICATION NOTE

THERMAL ANALYSIS

Multifrequency Analysis of Epoxy Based PCB (Printed Circuit Board)



Summary

This application note demonstrates the ability of DMA to characterize the mechanical properties of an epoxy based printed circuit board (PCB) using a PerkinElmer® DMA 8000. The modulus of the PCB is measured providing an important parameter for the manufacturer. In addition, the glass transition temperature is accurately measured, which gives information about the viable temperature range in which the material can be used.

Introduction

Dynamic Mechanical Analysis (DMA) is one of the most appropriate methods to investigate relaxation events. The stiffness of the material is also measured which can have an impact on the utility of the material in the real world. The glass transition (Tg) is a key process in any material, and can be observed with ease by DMA. Three Point Bending geometry is considered the most suitable geometry when an accurate modulus is required. As there is no "clamping" of the sample, the influence of the instrument on the measurement is at a minimum.

DMA works by applying an oscillating force to the material and the resultant displacement of the sample is measured. From this, the stiffness can be determined and the modulus and tan δ can be calculated. Tan δ is the ratio of the loss modulus to the storage modulus. By measuring the phase lag in the displacement compared to the applied force it is possible to determine the damping properties of the material. Tan δ is plotted against temperature and glass transition is normally observed as a peak since the material will absorb energy as it passes through the glass transition.

The interest in measuring physical properties of PCBs has increased in recent years as the industry prepares for the use of lead-free solder in manufacture. European legislation dictates that electrical equipment sold after mid-2006 should not contain any lead soldering. This challenge has resulted in new materials being investigated in the manufacture of PCBs. Both the stiffness (and modulus) of the material at different temperatures and the glass transition temperature are crucial parameters for any material used as an electrical component.

Experimental

Temperature scan of PCB.

The sample was mounted in the 3-Point Bending clamps and cooled to -150 °C prior to starting the DMA experiment.

Equipment	Experimental Conditions	
DMA 8000 1L Dewar	Sample:	Epoxy based PCB
	Geometry:	3-Point Bending
	Dimensions:	17.5 (l) x 6 (w) x 1.5 (t) mm
	Temperature:	-150 °C to 250 °C at 3 °C min^{-1}
	Frequency:	0.1, 1.0 and 10.0 Hz

Results and conclusion

Figure 1 shows the glass transition of this material as a peak in the tan δ and a drop in modulus. A clear frequency dependence is seen confirming the transition as a relaxation. The modulus of the material before and after this transition is relatively constant at approximately 2.3 x 1010 and 5.0 x 109 Pa respectively. The glass transition temperature, as defined by the peak in the tan δ, is shown to be between 142.6 °C and 151.8 °C depending on the frequency.

These data were collected from a starting temperature of -150 °C. By increasing the scale of the lower temperature data it is possible to observe another relaxation event (as shown in Figure 2). This β transition is clearly a relaxation as a frequency dependence is seen in both the modulus and tan δ data. This demonstrates that DMA is an excellent technique to monitor these lower temperature transitions.

By selecting 3-Point Bending as the geometry of choice, it has been possible to demonstrate that an accurate modulus can be obtained for this epoxy based PCB material. The glass transition temperature can be easily characterized as well. In addition, a β relaxation is identified due to the sensitivity of DMA to observing this type of event. The instrument used for this experiment can go as low as -190 °C so even lower temperature transitions can be observed with ease.

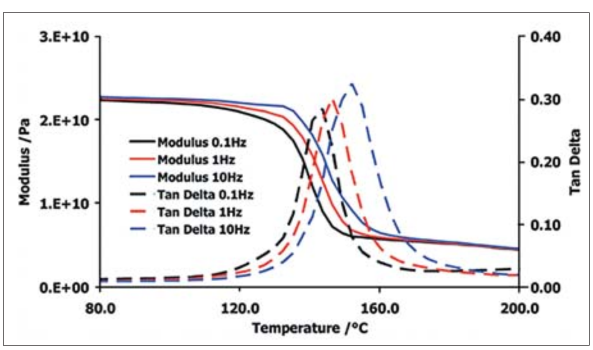


Figure 1. Glass transition as a peak in tan δ and drop in modulus.

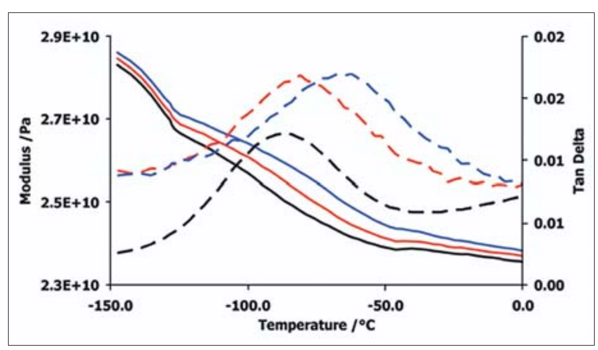


Figure 2. Relaxation observed at low temperature.

PerkinElmer Life and Analytical Sciences
710 Bridgeport Avenue
Shelton, CT 06484-4794 USA
Phone: (800) 762-4000 or
(+1) 203-925-4602
www.perkinelmer.com

For a complete listing of our global offices, visit www.perkinelmer.com/lasoffices

007771_11 Printed in USA