

Coefficient of Thermal Expansion (CTE)

Task Summary: Measure the CTE of sintered Ormet paste over a broad temperature range (-100°C to 200°C). Characterize any non-linearity or glass transition behaviors.

Background: The Ormet 7001 paste material, like all Ormet materials, is comprised of a mixture of metal particles in an organic binder. During thermal processing the alloy particles in the paste melt and react with the copper particles to form a mesh-like alloyed network. Curing of the organic binder requires a longer thermal exposure, but the cure begins simultaneously with the sintering.

As a composite material with the polymer enmeshed with the alloyed metal network, some variations in CTE behavior might be expected over a broad temperature range.

Purpose: The purpose of this task is to characterize the CTE behavior of Ormet material over a broad temperature range and analyze any anomalous behavior.

Scope: The CTE of Ormet 7001, other Ormet reference materials, and other non-Ormet reference materials were obtained and analyzed

Activities: The CTE Ormet 7001 and several other Ormet materials was measured from -100°C temperature to 200°C. Analysis of the CTE was predominantly of fully cured materials, but some underprocessed materials were analyzed as well.

Samples were prepared by drilling 0.25" diameter holes in thick FR4 laminate, taping the backside of the holes shut, filling the holes with the material to be analyzed, drying the filled boards at 95°C to evaporate the solvent, and then curing the paste in a lamination press at 190°C. The samples were carefully pushed out of the molds and polished flat on both surfaces.

The samples were analyzed using a TA Instruments TMA with a quartz probe and platform configuration. The diameter of the quartz probe is roughly equal to that of the sample plug.

The results of the various tests and materials indicate that all were linear. There is no glass transition temperature (T_g). Over the temperature range of 20°C to 150°C Ormet 7001 CTE samples tested 24 to 27 ppm/°C, Ormet 7102 CTE tested at 22 ppm/°C, and Ormet 800 CTE tested at 14 ppm/°C. These CTE numbers compare favorably with copper at 17 ppm/°C and Sn-Pb solders which range from 20 to 29 ppm/°C.

Conclusion: The CTE of all Ormet materials is linear over a broad temperature range and match well with bulk values of the metals from which they are formulated. No discontinuities from a glass transition were observed. The alloyed network dominates any contribution from the polymer binder in the CTE behavior of the material. The polymer binder in the Ormet material has a T_g of at least 80°C according to differential scanning



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calorimetry so the effects of the polymer binder on CTE seem to be negligible. The slight changes in CTE in temperature ranges in excess of 150°C are likely due to changes in the microstructure of the alloyed network as the tin migrates further into the bulk of the copper particles thus changing the overall composition of the intermetallics.