Ormet Circuits, Inc.

Ultimate Tensile Strength

Task Summary: Determine the ultimate tensile strength of sintered Ormet 7001 paste through standardized experimental methods.

Background: Ormet 7001 paste is composed of discrete metal particles in an organic binder. During thermal processing, the alloy particles within the paste melt and react with the copper particles and any adjacent solderable surface to form an alloyed network structure. The organic binder cures around the metallic web as it is formed and reinforces it.

In microvia applications, the Ormet 7001 will be sandwiched between copper pads and cured within a multilayer laminate structure. During subsequent thermal exposure, the multilayer laminate structure will expand disproportionately to the sintered Ormet and the metal circuits. This expansion may place significant tensile strain on the sintered paste in the microvias.

Purpose: The purpose of this task is to determine the ultimate tensile strength of Ormet paste sintered between copper surfaces.

Scope: The tensile pull test methods used to determine the ultimate tensile strength of the sintered Ormet 7001 were based on JEDEC Standard No. 22, Test Method B109: Flip Chip Tensile Pull. In JEDEC 22:B109, the tensile strength of the solder joints between a die and board are measured by affixing the die to the board with solder in the usual manner and then affixing a pull stud with low-temperature-setting epoxy to the back side of the die such that the pin is perpendicular to the die surface. This test method, with some modification, was determined to be the closest fit to the application in which the Ormet 7001 paste will be used. A few iterations of the test were necessary to perfect the test method and obtain meaningful data.

Activities: Three iterations of the experiment were performed over which the modifications to JEDEC 22:B109 were perfected.

In the initial round of experiments three individual samples were prepared to determine an appropriate size of paste deposit for the test. A square deposit 0.5" per side on copper-clad FR4 gave a reading in a useful scale and was straightforward to create. In the second round of experiments, ten 0.25 sq. in. samples were prepared in a row, dried, and then mated with an identical row of ten. The two strips of copper-clad FR4 with mated Ormet deposits were then placed into the lamination press to sinter the material. Upon removal from the press it was noted that the booking materials used in the lamination cycle had created high pressure areas at the center of each deposit. Further, the shearing blade used to divide the samples subjected the samples to a significant amount of torque that may have compromised their strength. When the pins were affixed and the samples pulled, the tensile strength values did not correlate with the initial experiment.
In the third set of experiments, the samples were prepared as follows:

1. Two 2” x 10” pieces of double-sided copper-clad laminate were sheared from a panel.
2. The copper surfaces were abraded lightly with 400 grit sandpaper until uniformly shiny.
3. On each of the laminate strips, ten 0.25 sq. in. squares were defined using clear plastic tape (approximately 2 mil in thickness).
4. Ormet 7001 was doctor bladed into each of the 20 squares until a thin, uniform coating covered the area of each square.
5. The tape was removed and the laminate strips were placed in a 95°C oven for 30 minutes to evaporate the solvent in the paste.
6. The two laminate strips were aligned so that opposing squares were directly mated.
7. The laminate-Ormet-Ormet-laminate sandwich was loaded into a hot press (370°F/ 188°C) with a release sheet on the bottom and release sheets plus Pacopads on top.
8. The temperature in the press was reduced to 350°F (177°C) and the sandwich was cured for one hour.
9. Pull pins were affixed to the top of the strip and perpendicular to the face of the laminate using Defcon epoxy cured at 150°C for 30 minutes.
10. The laminate strip construction was singulated with a band saw to produce ten identical samples.
11. The samples were pulled using a Del-Tron pull test machine.

For all of the samples the failure mode was within the Ormet material. The tensile strength results of the third set of experiments ranged from 302 to 416 PSI.

Conclusion: The tensile strength results obtained were surprisingly low. For comparison, the tensile strength of electrolytic copper is 43,511 PSI (CRC) and 50-50 Sn-Pb solder bulk tensile strength is 6,090 PSI (CRC). As a composite material, the tensile strength of Ormet was anticipated to be lower than a pure metal, but the magnitude of the difference was very surprising.

The reason for the low values is unknown; however, it is possible that mating the two coatings after drying did not create a representative bulk structure. In that case, the measurements presented here are more indicative of adhesion between Ormet layers after drying rather than a true measure of bulk tensile strength.

In 1997 Boeing tested a similar Ormet material for a packaged component attach application (ref. ECTC proceedings 1997). The Ormet material was evaluated against several different solder and conventional conductive adhesive materials. Although tensile strength was not measured, the Ormet material performed on par with the solders and was far superior to the conductive adhesive materials in drop testing from several feet.