Ormet Circuits, Inc.

Viscosity Study of Ormet 7001

Task Summary: Determine the usable range of viscosity (percent metal loading) for Ormet 7001 in screen print deposition.

Background: Ormet 7001 was designed for application into 4-10 mil diameter drilled/laser ablated via using a temporary, conformal mask and doctor blade technique. The current specification of 300 kcps was selected as an appropriate viscosity for this type of deposition technique. An optimization that characterizes multiple aspects of what constitutes a good fill would be useful for establishing a range of workable viscosity. By using the organic pre-mixture as the diluent and the metal pre-mixture as the thickener an optimum mix ratio can be determined without excess solvent dilution or introduction of foreign particles. A simple serpentine pattern test card will magnify deposition issues that might be more difficult to differentiate in a small via. A test card with an array of via holes will allow evaluation of manufacturing ease-of-use. The best, acceptable and not acceptable ranges can be determined for each of these characteristics, and then combined to determine an overall ranking of mix ratios.

Purpose: The purpose of the activities in this task is to determine which viscosity range produces optimum manufacturability.

Scope: This task was limited to the evaluation of Ormet 7001 in the viscosity range of 100-1500 kcps, using only the metal and organic pre-mixtures to change the viscosity of the material.

Activities: Starting from a standard batch of Ormet 7001 with a viscosity of 304 kcps, organic pre-mixture and metal pre-mixture were added to produce samples with viscosities ranging from 94 kcps to 1300 kcps. Each of the samples was deposited into the standard DN410 test card with serpentine patterns recessed into the polymer dielectric. Each sample was deposited into via holes mechanically drilled into pre-preg with a conformal Mylar mask. The procedure for filling and processing each of the paste samples was as follows:

1. A bead of material was laid down and 4 squeegee strokes (back-and-forth) were used to deposit the material into the recessed features (via and serpentines).
2. The test vehicles were dried in a box oven for 15 minutes at 95°C
3. The test vehicles were rotated 90° offset of their original filling position and two squeegee strokes were used to top-off the deposit.
4. The Mylar mask was pulled off of the test vehicles with via holes.
5. The test vehicles were dried in a box oven at 95°C for 30 minutes

The ease of use of each of the paste samples was noted and the test vehicles underwent an extensive visual analysis under the microscope. The results of these analyses are as follows:

Viscosity (kcps)	Application notes	Test vehicle observations		
		Ink appearance after drying	DN410 Trench card	Via Hole
96	➢ Too thin to work with – messy ➢ Less residue ➢ Poor filling ➢ Squeegee speed increased ➢ Ink bleed	Wet/glossy	Traces not level and have a dip in center	➢ Substantial tails of Ormet from bleeding into voids in pre-preg near the holes ➢ Air bubbles on underside
208	➢ Similar to standard ➢ Squeegee speed increased slightly ➢ Less residue than standard	Slightly wet	Appeared similar to standard	➢ Less bleeding but still some tails ➢ More air bubbles on underside than 96 kcps
304	Standard	Pink		
496	➢ Felt thicker ➢ Squeegee speed slowed ➢ Workable	Frosty pink	➢ Better fill ➢ More ink in traces ➢ Less shrinkage	➢ Slightly domed ➢ Less bleed ➢ Air bubbles on top and bottom
704	➢ Felt much thicker ➢ Squeegee speed way down ➢ More residue on surface ➢ Difficult to keep bead rolling	Very frosty	➢ Surface of traces less uniform and smooth ➢ Build up on trailing edge of squeegee	➢ Very little bleed ➢ Large holes uniform and packed, but smaller holes lose ink ‘chunks’ when Mylar is pulled ➢ Large air bubbles on underside
1,300	➢ Ink very thick and dry ➢ Bead tends to stick to squeegee and not roll ➢ Leaves voids and requires additional passes ➢ Very slow squeegee speed needed	Extremely frosty and dry	➢ Surface has orange peel type roughness ➢ Considerable ink build up on squeegee trailing edge traces ➢ More residue on surface ➢ Fill is less consistent	➢ Excellent edge definition ➢ No bleeding or tails ➢ Substantial air bubbles on underside

Conclusion: Viscosities below 200 kcps seem to be out of the workable range because they are too runny to create a well-defined bead. A well-defined bead is necessary to produce a controlled and consistent fill. Viscosities in excess of 1,000 kcps are also outside the useable range because the bead has a tendency to skip as it is drawn across the

surface and the ink does not settle resulting in substantial air bubble entrapment on the underside of the hole. That said, the very high viscosity material did exhibit the best feature definition inside the via hole. It did not exhibit bleeding issues. Given a different deposition method, the use of a very highly metal-loaded formulation might be advantageous for consistent performance. For the current stencil-print-type deposition scheme, a viscosity range from 200-500 kcps seems to provide an optimum balance of characteristics – particularly for an automated operation. There is therefore no incentive to change the current specification for viscosity of the 7001 material.