Molecular Modification of PCB Substrates for Fine Line Patterning: Demonstration of High Peel Strength, Low Surface Roughness and HAST Survivability of Molecular Modified Surfaces

S. Shi, T. Wei, Z. Liu, W. Liu, B. Lita, C. Rhodine and W. Kuhr*

ZettaCore, Inc., 369 Inverness Drive, Suite 350, Englewood, CO 80220 USA

The present work describes the formation of a molecular adhesion layer for smooth epoxy substrates to facilitate the electroless deposition and electroplating of copper. Molecules are attached to smooth PCB substrates via a thermally-induced reaction of the molecular species with the substrate surface, after which the molecule-coated substrate is washed to remove the excess, un-reacted molecules. The high affinity of the molecule-modified surface for metal ions facilitates electroless plating of the copper, which is then used as a seed layer to electroplate larger quantities of copper utilizing conventional procedures.

A porphyrin molecule was attached to the epoxy on the substrate surface. The formation of a molecular layer on the epoxy surface was identified by LDTOF mass spectrometry and characterized more quantitatively by fluorescence and/or UV absorbance spectroscopy. Once the molecular layer is formed on a smooth (unroughened) epoxy substrate as described above, the molecule-treated substrate was subjected to a standard electroless Cu deposition process. The electroless copper film thus formed could not be removed in a tape peel test, while copper on an untreated control sample showed no adhesion. After subsequent electroplating, the resulting Cu film could be peeled from the surface (peel strength > 0.6 kg/cm) and the substrate surface roughness was less than 0.2 um for the molecule-coated smooth surface. The exposed epoxy substrate was examined with fluorescence spectroscopy to determine the extent of molecule coverage. The molecule coverage, proportional to the fluorescence signal, increases with increase in attachment concentration. There is essentially no change in the molecule coverage post electroless plating process, indicating that the molecular layer formed on the epoxy substrate is robust enough to survive the harsh chemical environment of electroless plating.

Additional peel testing was used to determine the adhesion strength of the plated Cu layer before and after preconditioning, reflow and HAST evaluations (3x reflow @ 260^{o}C (JEDEC Level 3) HAST: 96 hr @ 130^{o}C/85%RH). These surfaces showed better performance than conventionally roughened and desmeared samples (>0.6 kg/cm) when the peel strength was monitored following reflow and HAST testing. This was accomplished while maintaining a smooth surface at the epoxy – copper interface, so as to enable fine line patterning of copper traces on a conventional epoxy substrate.