Glass Substrates for High Density Electrical and Optical Interconnect

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High density electronics packaging using flip chip assembly requires substrates with matching feature sizes for interconnect to semiconductor devices. However, limitations of organic substrate materials, such as dimensional instability during manufacture and difference in coefficient of thermal expansion (CTE) to Si, have led manufacturers to look at alternatives that can better meet the needs of future applications. There has been much interest in the use of Si as a substrate material, however there are disadvantages due to its inherent semiconducting properties. A potential alternative material is glass and this project has investigated the use of thin (<100µm thick) glass sheets to manufacture multilayer substrates able to support high density electrical and optical interconnect. By using glass with a CTE that is matched to silicon it is expected that there will be reduced stresses in the solder joints of flipchip assemblies caused by thermal excursions. A glass substrate will also enable more accurate machining of microvias due to its high dimensional stability and allow "viewing" of target capture pads on buried layers. Furthermore, glass is electrically insulating and offers the opportunity for the efficient transmission of light for optical interconnect.

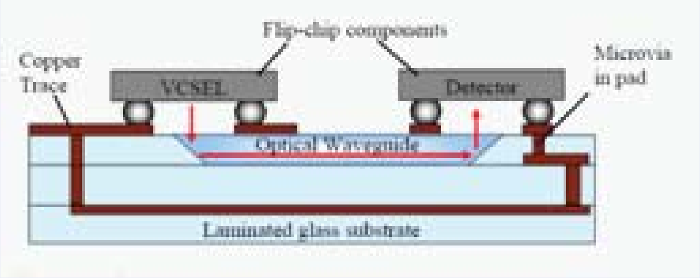

Figure 1 shows a schematic view of the proposed multilayer glass substrate.

The project has involved three key areas of research; laser machining to produce vias and grooves/tracks, metallisation to form electrically conductive interconnects, glass lamination to create multilayer structures.

A KrF Excimer laser (248nm) has been used to machine microvias (fig. 2) and process optimisation has been implemented to :

Reduce debris
Reduce hole taper
Control microcracking

Laser machining has also been used to create grooves in the glass and to roughen the surface to enhance the adhesion and direct the deposition of electroless copper and nickel tracks.

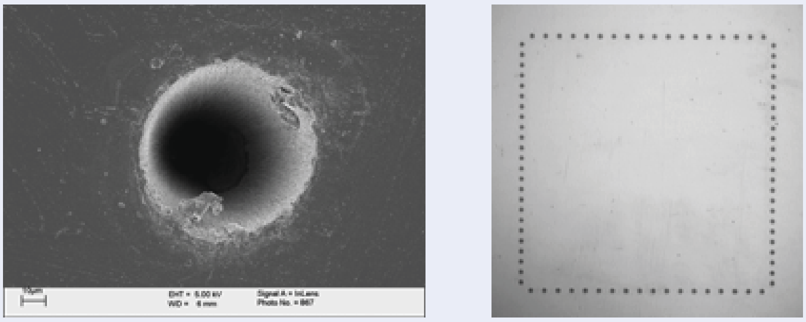

Fig 2: 75µm diameter microvia in glass and a peripheral array of microvias at 225 and 300µm pitch.

Glass metallisation represents a significant challenge due to the poor level of adhesion to the smooth surface. Electroless copper has been used as it is low cost and widely used in PCB manufacture. Coatings have been deposited uniformly over the plain glass surface and methods to improve the adhesion have been examined, leading to the identification of the failure interface location. However, the best adhesion has been found on the laser machined glass surface, enabling circuit patterns to be created (fig 3).

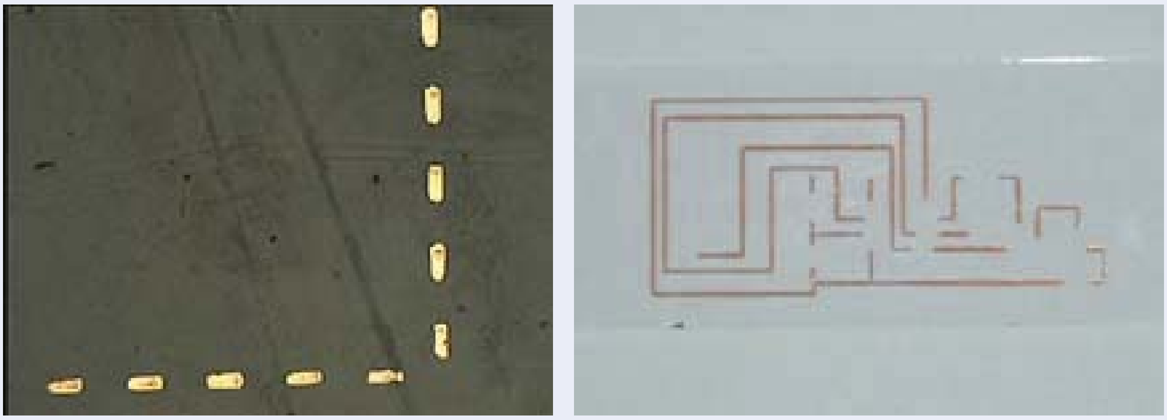

Fig 3: Electroless copper deposition on laser machined glass: (a) tracks approximately 200µm long for a flip chip pattern; (b) large scale circuit.

The lamination of several glass sheets together is necessary to complete the entire structure. Pressure assisted low temperature bonding is one approach. Through appropriate cleaning regimes it has been possible to join glass sheets using temperatures of 200 to 300oC and pressures of 1 to 4 MPa. Fatigue testing (fig 4) has been used to evaluate the bonded area and identify the presence of microcracks. An alternative method of bonding using an intermediate material has also been investigated.

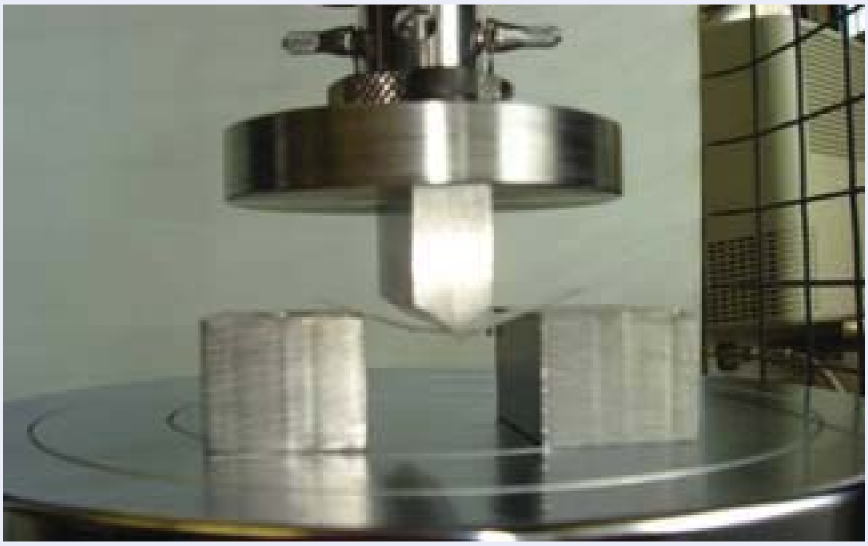

Fig 4: Fatigue testing of laminated glass sheets.