Research Project

**Glass Interposer Metallization**  
*Interfacial Adhesion Studies of Ultra-Small Copper Vias in Glass Substrates*

Research Objectives

Due to its favorable intrinsic mechanical and electrical properties, glass makes for an ideal substrate for low-cost, high-performance interposers. Metallization of Cu traces and through-package-vias (TPVs) directly to glass, however, remains a challenge due to their different chemical structures. The object of this research is to explore copper to smooth glass adhesion mechanisms and demonstrate reliable metallized through-via structures.

Unique Approach

Adhesion promoters are required in depositing Cu on glass with sufficient adhesion. There are two primary mechanisms for adhesion: mechanical (anchoring) and chemical (valence forces). From glass manufacturing and electrical performance standpoints, the latter is the preferred method. Drawing influence from previously demonstrated thin, stable metal oxides as adhesive layers such as Ti or Cr (Fig. 1), this work aims to develop novel chemical adhesion layers that can conform to the high aspect ratios found in TPVs.

![Schematic of metallized glass TPV structure.](image)

Interdisciplinary Research

In addition to being a materials science issue, the chemical, electrical, and mechanical aspects must also be considered in fulfilling the objective of this research. A variety of chemical characterization tools such as XPS, EDS, and SIMS are used to analyze material interfaces. Structures are subjected to thermo-mechanical reliability testing in the form of thermal cycle testing. Electrical performance measurements are also necessary.

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<th>Challenge</th>
<th>Research to Address Challenges</th>
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<td><strong>Materials Science and Chemistry</strong></td>
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<tr>
<td>• Chemical adhesion: achieve target Cu-Metal Oxide-Glass interfaces</td>
<td>• Model, design, and develop a process for thermodynamically stable interfaces with good adhesion</td>
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<td>• Mechanical anchoring: achieve Cu-Metal Oxide-Glass with 3D connectivity</td>
<td>• Optimize chemistry to achieve desired material microstructure</td>
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<td><strong>Fabrication Processes</strong></td>
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<td>• Conformal and scalable deposition</td>
<td>• Explore processes utilizing dip, spray, and spin-coating</td>
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Results
Various metallization approaches were investigated: electroless, sputtering, and sol-gel. While electroless Cu can be deposited directly on glass, the required glass surface roughness is order of hundreds of nanometers (Fig. 2); in addition to increasing electrical loss due to the skin effect, it is unfavorable from a glass manufacturing standpoint to roughen glass. As expected, the other methods showed better adhesive performance since they utilize chemical bonding rather than mechanical bonding. For example, sputtering Ti/Cu resulted in high peel strength values after 1000 thermal shock cycles (Fig. 3) [1].

![Ra = 1.3 nm](image1)
![Ra = 19 nm](image2)
![Ra = 46 nm](image3)
![Ra = 559 nm](image4)

Fig. 2. Tape test results of electroless Cu on roughened glass.

![Fig. 3. Peel strength of sputtered Ti/Cu on smooth glass before and after 1000 thermal shock cycles.](image5)