High Aspect Ratio Through Glass Vias (TGVs)

Faculty:
Dr. Fuhan Liu
Dr. Mohanalingam Kathaperumal
Prof. Madhavan Swaminathan
Prof. Rao R. Tummala

Student:
Rui Zhang
Outline

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Goals and Objectives

- The objective of this research is to investigate and develop high aspect ratio and small opening through glass vias with low surface roughness for high density interconnects for 2.5D and RF applications.

- The goal is to fabricate high quality high throughput TGVs with aspect ratios larger than 2:1 (up to 10:1) in 300 µm glass.
Technical Approach

- Ultra-short pulse (femtosecond) laser ablation

- OPTEC Femtosecond Laser Micro-machining System
  - Max Power: 4 W
  - Wavelength: 1.03 µm
  - Minimum Pulse Duration: 221 fs
  - Effective on polymer, copper, steel, FR-4, silicon, glass, etc.

- Parameters to be optimized
  - Power, frequency, repetition, speed, drilling mode
  - Glass: 300 µm AGC glass
Technical Approach (cont.)

- Ultra-short pulse (femtosecond) laser ablation
Technical Approach (cont.)

- Ultra-short pulse (femtosecond) laser ablation
Results & Key Accomplishments

- Front side drilling
  - Standard TGV: 100 µm
  - Top opening: 100.9 µm
  - Bottom opening: 28.4 µm
  - Front opening: 78.8 µm
  - Back opening: 10.2 µm
- Smallest TGV: 80 µm
- Via < 80 µm could NOT be opened by front side drilling due to the taper
- Moving laser focal plane down while drilling
- Sidewall angle ~ 83°
Results & Key Accomplishments (cont.)

- Double side drilling
  - Glass is transparent
  - Front side drilling alone could not achieve smaller TGVs

- Process
  - Front side drilling
  - Flipping the glass
  - Focusing on the back for alignment
  - Focusing on the front for laser ablation
  - Front side drilling
Results & Key Accomplishments (cont.)

- Double side drilling

  - Power increasing as laser focusing deeper into the glass

  - 60 µm TGVs achieved in a 300 µm glass
  - Optimization needed for smaller TGVs
Results & Key Accomplishments (cont.)

- Back side drilling
  - Glass is transparent
  - Focusing on the back side of the glass and drilling upwards are possible
  - Compared to front side drilling, back side drilling avoids laser power diffusion from the taper
  - Extremely challenging
  - Optimization needed
Comparison with Prior Art

- 60 µm TGVs with 100 µm pitch in 300 µm glass, comparable to state-of-the-art laser drilling TGVs
  - Mechanical: 4:1 and rough
  - Chemical: 10:1 and slow
  - Thermal: 7:1 on special glass
  - Hybrid: 3:1

- Near Infrared laser enables back side drilling and aspect ratio could be improved further than the current value (AR 5:1) with further optimization
### Schedule

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Summary

- Process optimization for laser ablation with minimum heat affected zone and debris
- 80 µm TGVs using front side drilling achieved
- 60 µm TGVs using double side drilling achieved

Future work
- Shape profile characterization
- Optimization of back side drilling
- Copper plating of high AR TGVs