High Aspect Ratio Through Glass Vias

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2. Goals & 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

3. Technical Approach

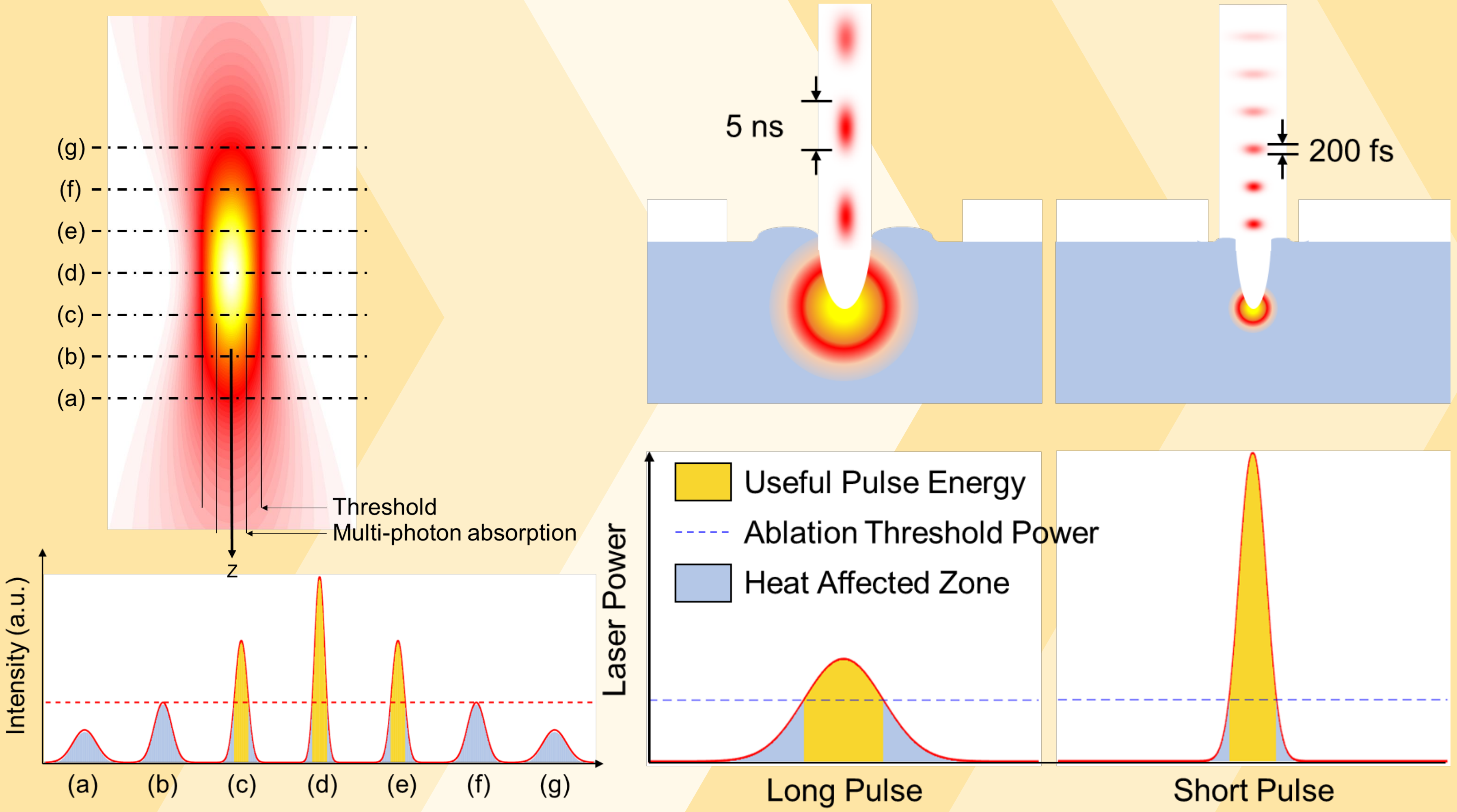
3.1 Femtosecond Laser Micromachining System

- 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

3. Technical Approach

3.2 Basic Principles of Ultra-Short Pulse Laser Ablation

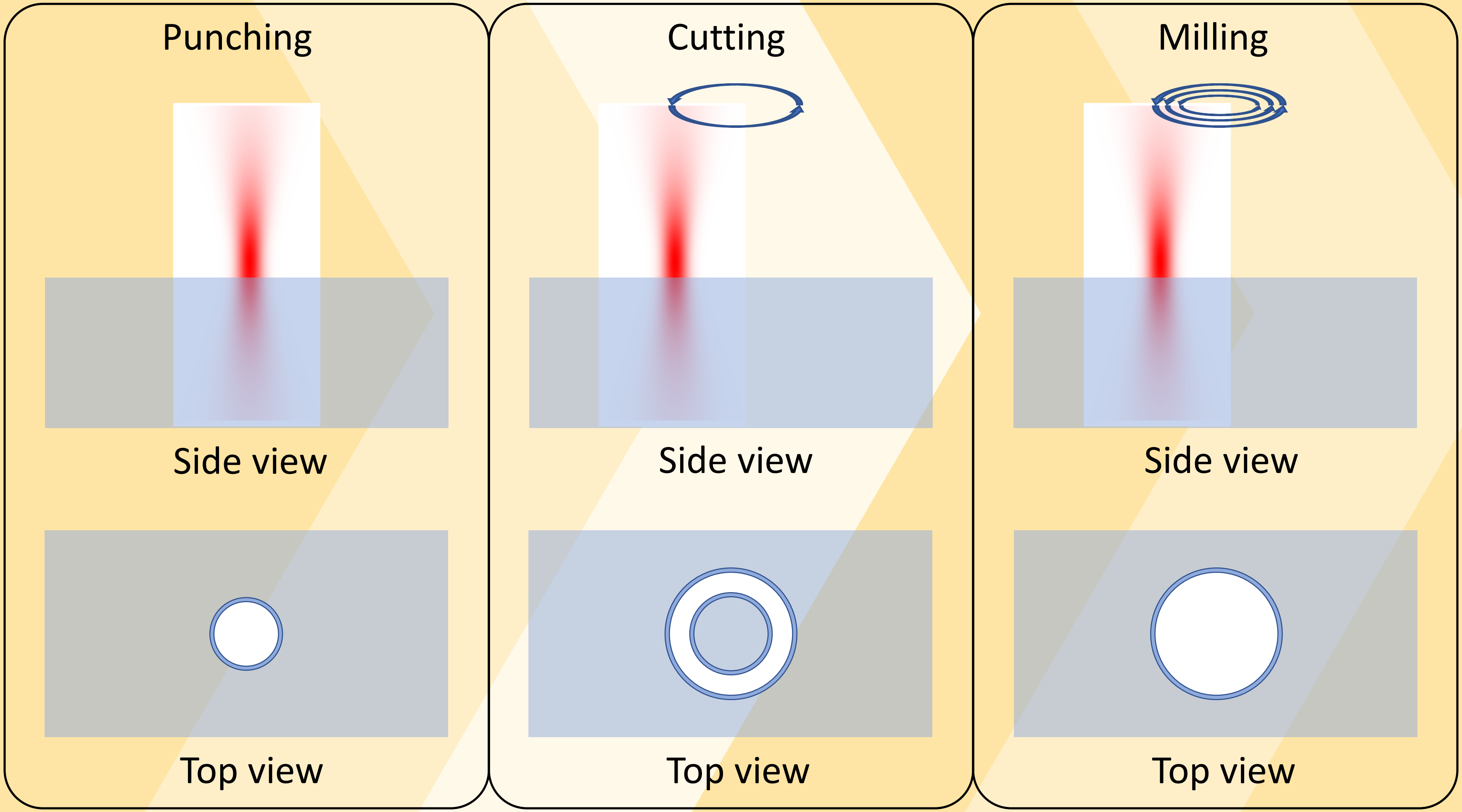
- ❑ Ultra-short pulse (femtosecond) laser ablation



3. Technical Approach

3.3 Laser Ablation on Glass

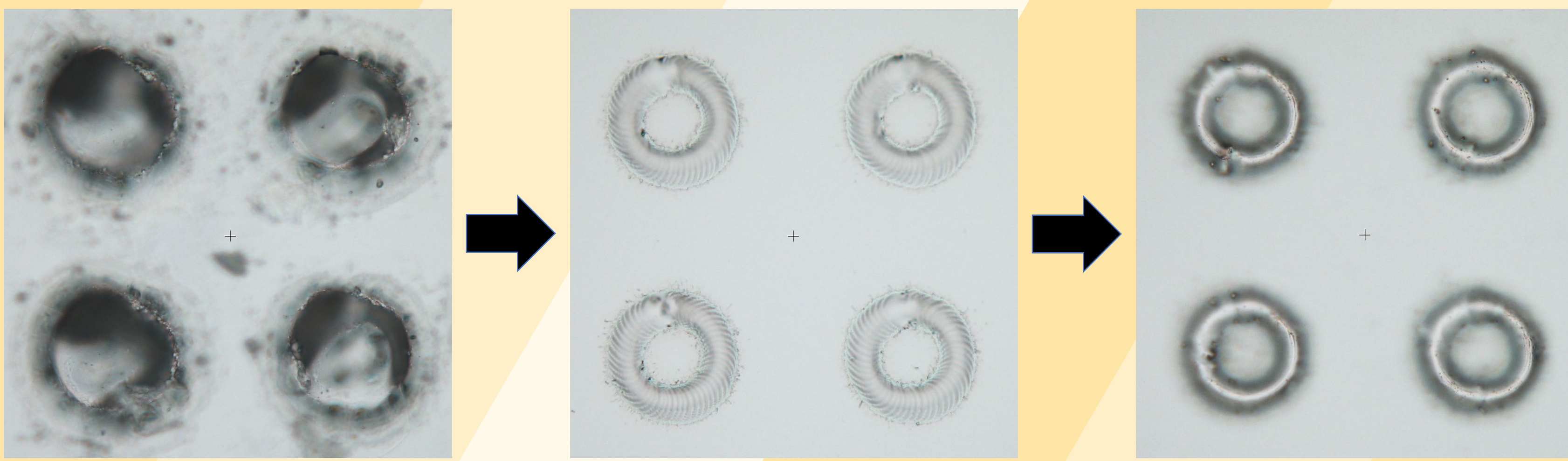
❑ Ultra-short pulse (femtosecond) laser ablation



4. Results & Key Accomplishments

4.1 Process Development

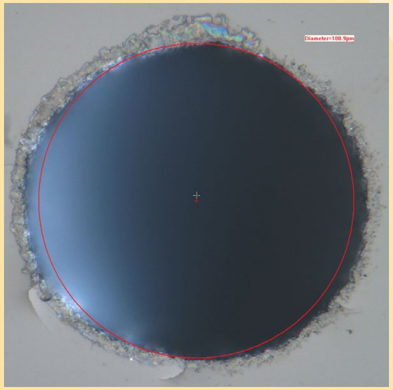
- ❑ Process Development
  - ❑ Incident laser power affects the size of the laser ablation trail
  - ❑ Frequency affects the duration between pulses so that the second pulse won’t be affected by the plasma generated following the first pulse
  - ❑ Frequency and speed together change the overlapping of pulses so that the exposed surface after ablation is smooth



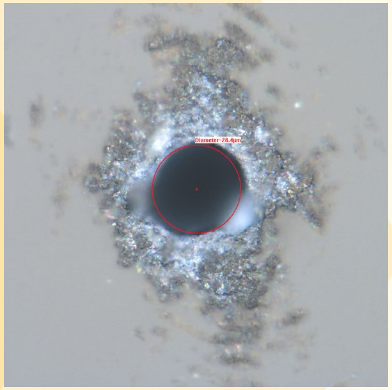
4. Results & Key Accomplishments

4.2 Front Side Drilling

- ❑ Front side drilling
  - ❑ Standard TGV: 100 µm



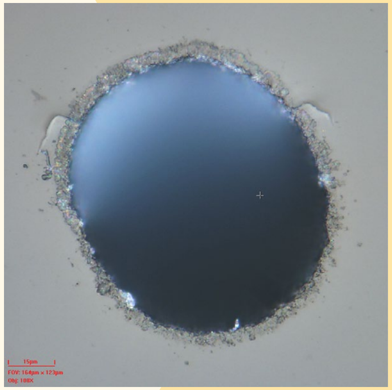
Top opening
100.9 µm



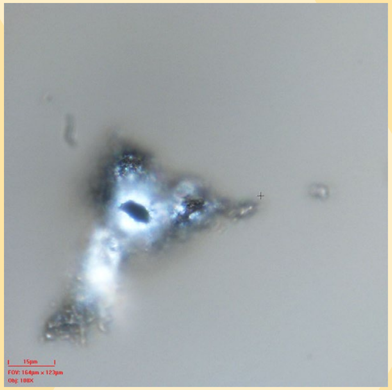
Bottom opening
28.4 µm

- ❑ Moving laser focal plane down while drilling
- ❑ Sidewall angle ~ 83°

  - ❑ Smallest TGV: 80 µm



Front opening
78.8 µm



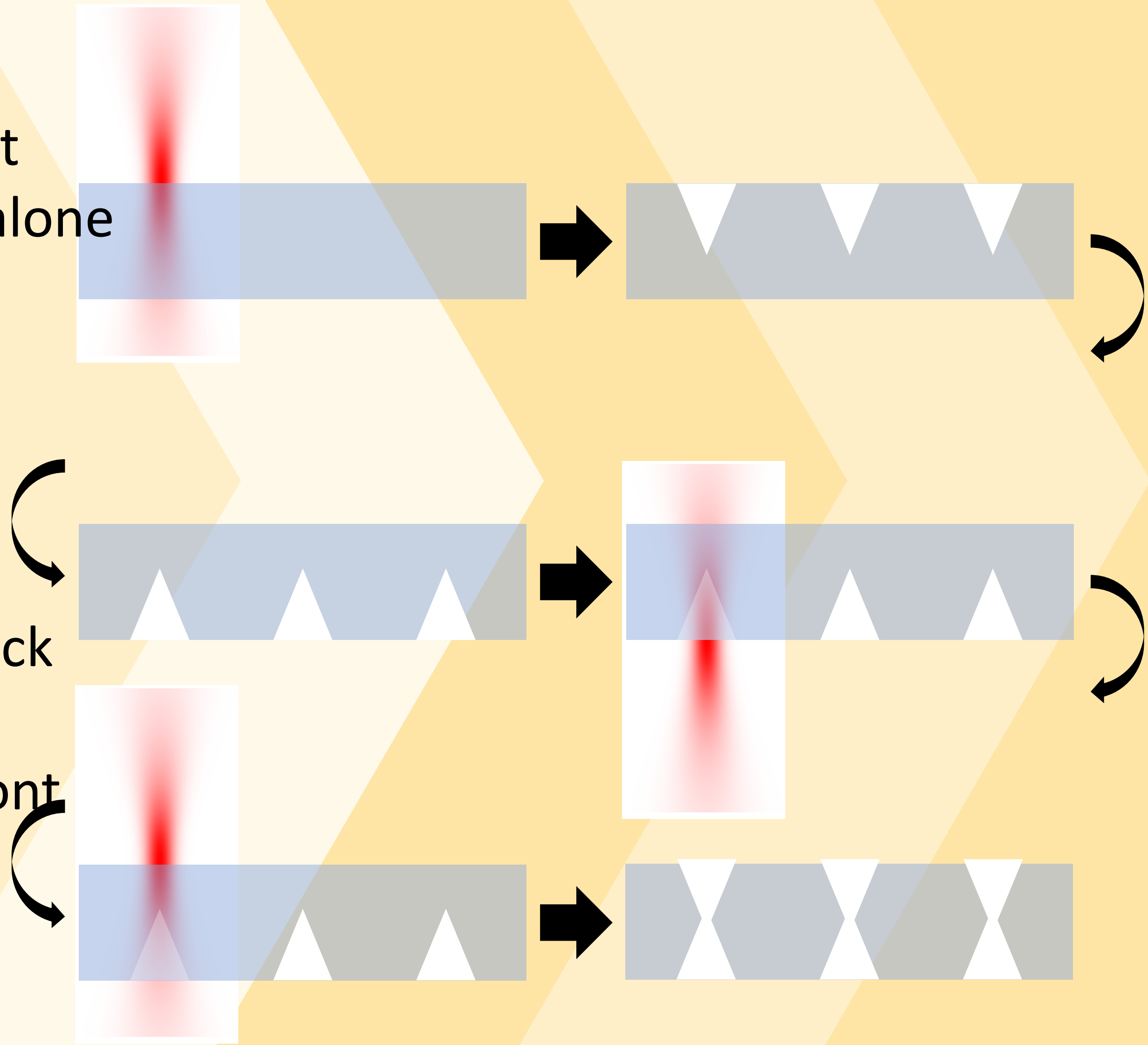
Back opening
10.2 µm

- ❑ Via < 80 µm could NOT be opened by front side drilling due to the taper

4. Results & Key Accomplishments

4.3 Double Side Drilling

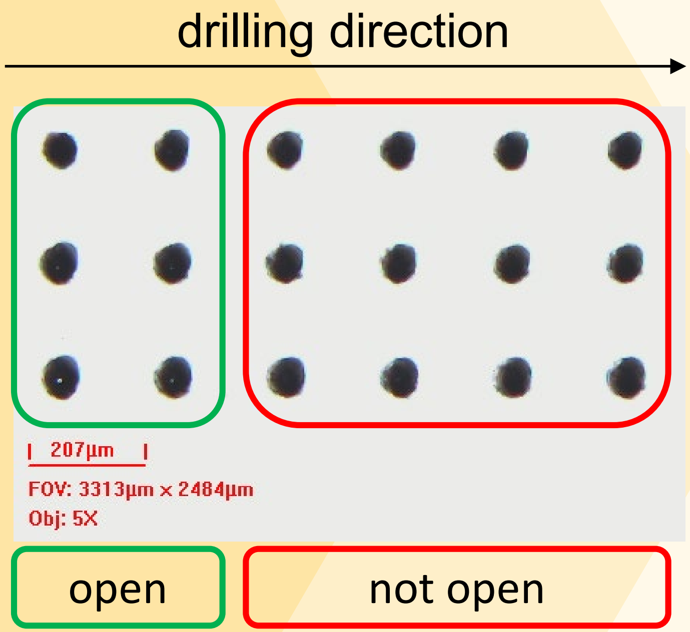
- ❑ Double side drilling
  - ❑ Glass is transparent
  - ❑ Front side drilling alone could not achieve smaller TGVs
- ❑ Process
  - ❑ Front side drilling
  - ❑ Flipping the glass
  - ❑ Focusing on the back for alignment
  - ❑ Focusing on the front for laser ablation
  - ❑ Front side drilling



4. Results & Key Accomplishments

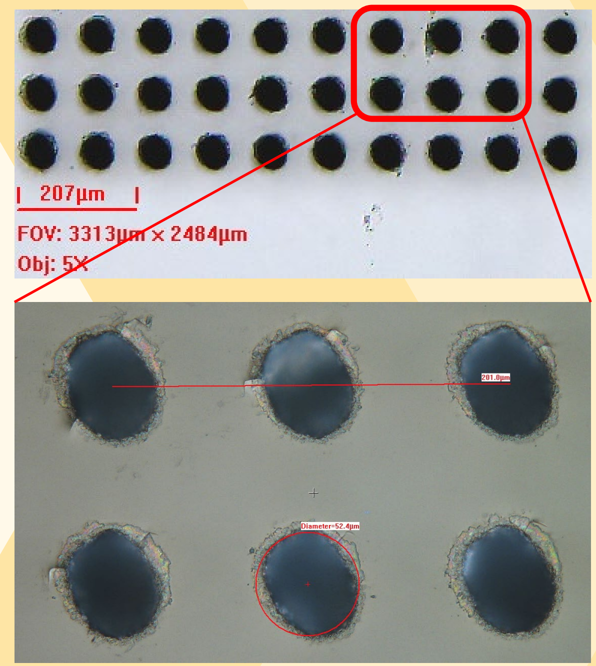
4.3 Double Side Drilling

- 50 µm TGV 200 µm pitch



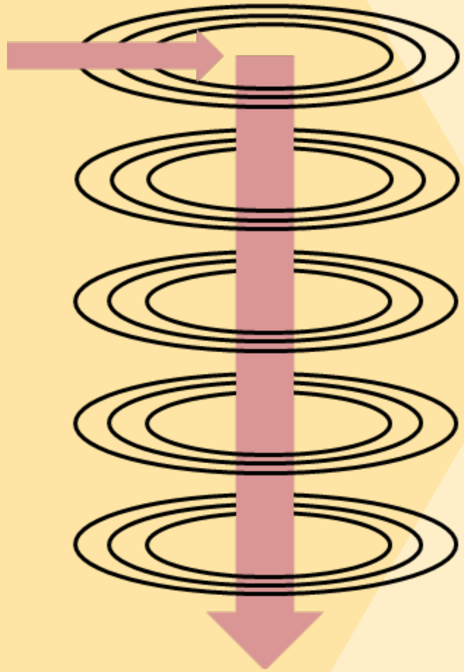
- Via opened due to power fluctuation at the beginning of drilling

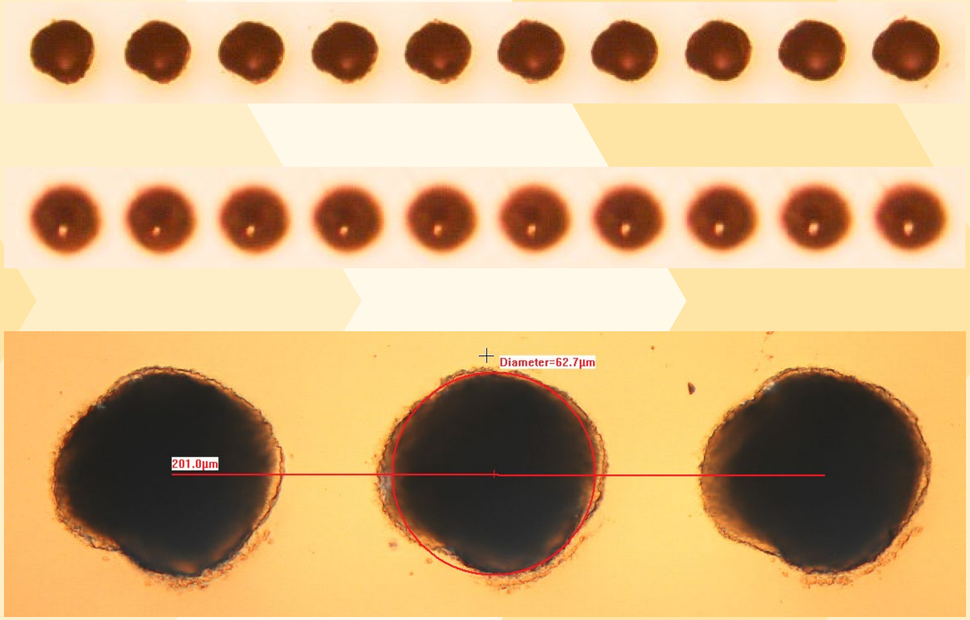
- 50 µm TGV 100 µm pitch



- No opened TGV
- Optimization needed

- ❑ Double side drilling





Top view

Via opening inside the glass

Diameter: 62.7 µm
Pitch: 100 µm

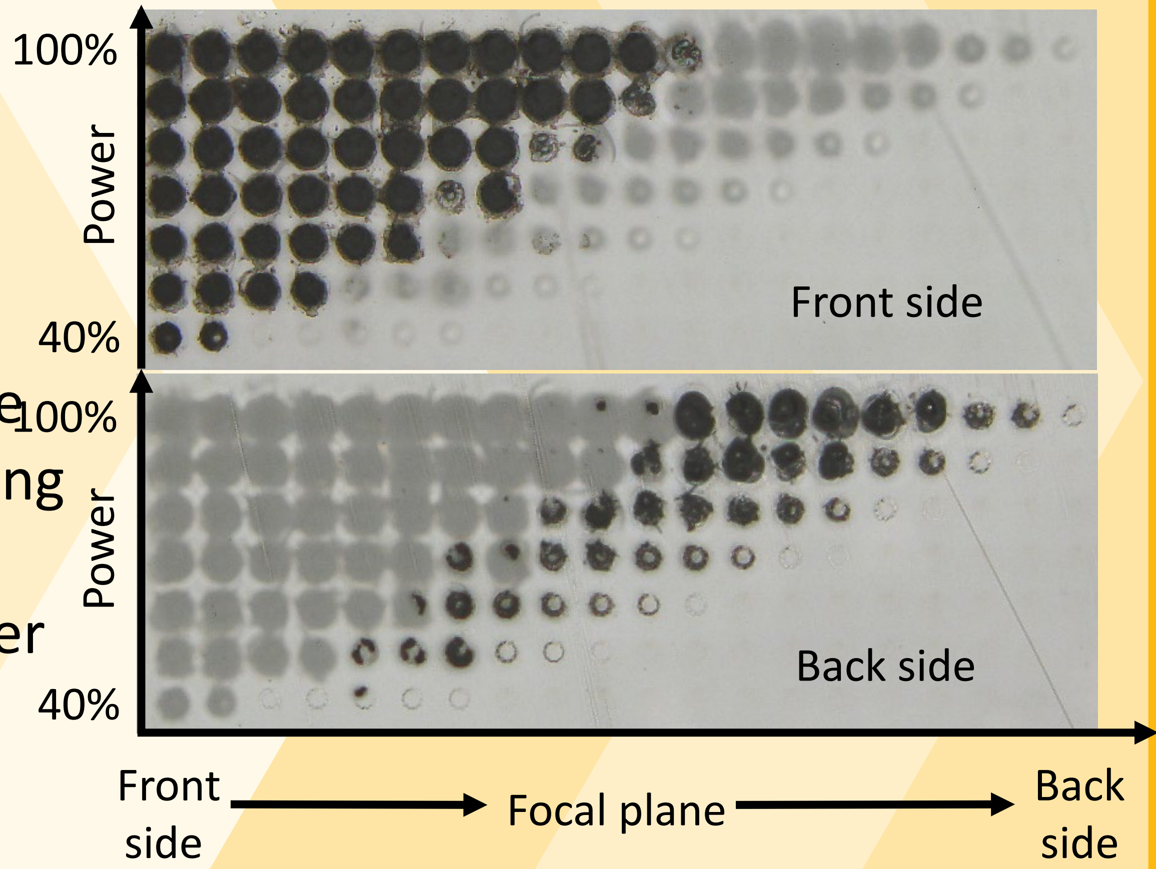
Power increasing as laser focusing deeper into the glass

- ❑ 60 µm TGVs achieved in a 300 µm glass
- ❑ Optimization needed for smaller TGVs

4. Results & Key Accomplishments

4.4 Back Side Drilling

- 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



5. 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