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IMAPS DEVICE PACKAGING CONFERENCE 2025

HIGH-THROUGHPUT FABRICATION OF GLASS MICRO-VIAS THROUGH A DIRECT LASER ABLATION PROCESS UTILIZING A DOE AND AN OPTIMIZED KRF EXCIMER LASER

March 4th, 2025

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Outline

1. Gigaphoton Company Overview
2. Introduction - Trends in semiconductor
3. Glass micro-via fabrication using a KrF excimer laser
4. TGV productivity enhancement by simultaneous processing
5. Discussion [Corning]: Potentials of KrF excimer & DOE technology
6. Summary

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1. Company overview Gigaphoton

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Gigaphoton corporate overview

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Company name	Gigaphoton Inc.
Business	Development, manufacturing, sale and services of excimer laser used for lithography tools in semiconductor manufacturing and for other uses, and Extreme Ultra-Violet lightsources
Established	2000/8/1
Capital	5 Billion Yen
Stockholders	Komatsu Ltd.
Head Quarters	400 Yokokurashinden, Oyama-shi, Tochigi-ken 323-8558, Japan
President &CEO	Tatsuo Enami
Employees	1,361 (as of March 31, 2024)

Gigaphoton product portfolio

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Lineup

Lightsources for lithography

KrF
G60K

ArF dry
GT45A

ArF immersion
GT66A

Advanced Packaging

KrF
G300K

Gas Recycle System

hTGM
GR10K

Data products

EUV Lightsource

Gigaphoton's business is development, manufacturing, and sales of **lightsource** used in semiconductor manufacturing.

- ✓ Excimer laser DUV lightsource for lithography
- ✓ Excimer laser DUV lightsource for advanced packaging
- ✓ EUV lightsource for inspection

Gigaphoton worldwide operations

HQ is in Japan; branches in USA, Europe, Taiwan, Korea , China, Singapore

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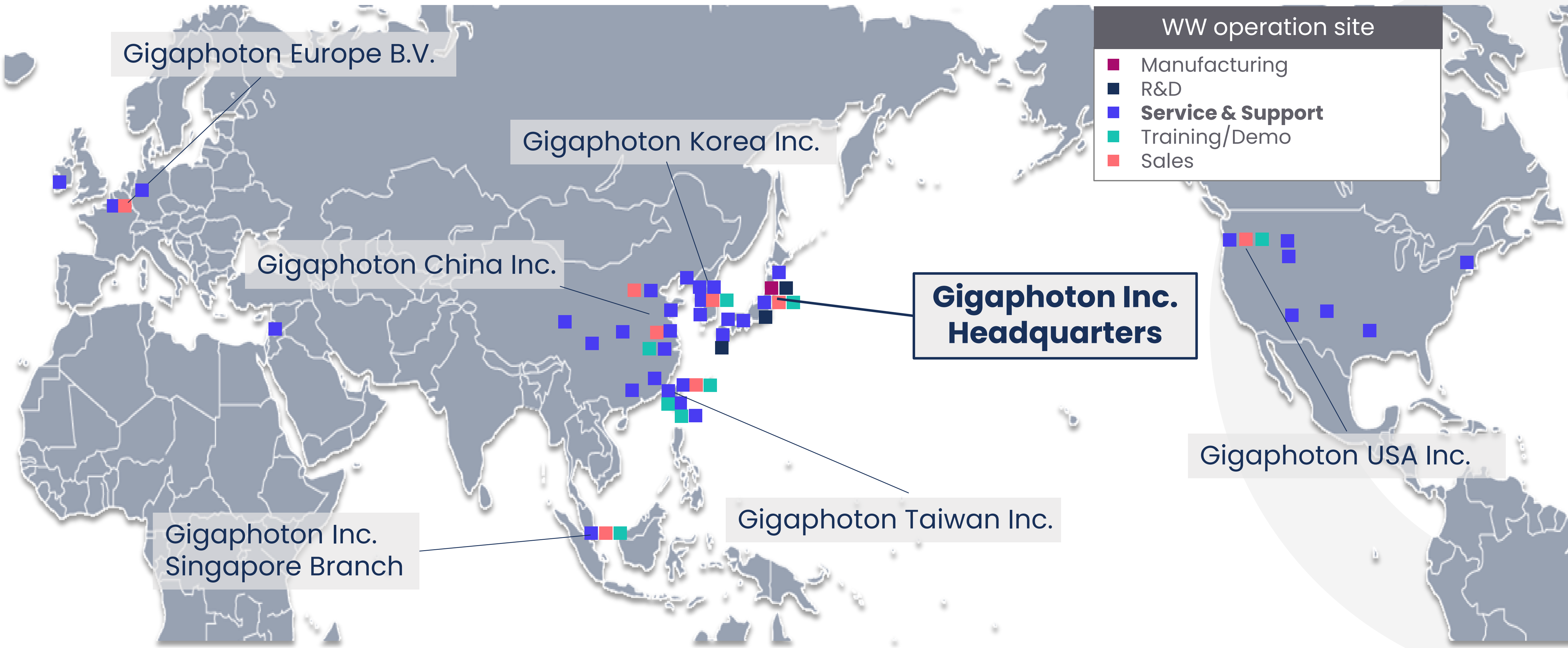

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Gigaphoton has shipped 2,000 Excimer laser light source

2000 Units Shipment

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Gigaphoton Excimer laser light source for material processing

■ Product

Gigaphoton has developed the **G300K** and **GT600K** commercial lasers for material processing.

■ Key performance metrics

- Short wavelength (248 nm)
- High power (300 W, 600 W)
- High frequency (4000 Hz, 6000 Hz)

Model	**G300K**	**GT600K**
Wavelength (nm)	248	248
Output light power (W)	300	600
Output light energy (mJ/pulse)	75	100
Output light repetition frequency (Hz)	4000	6000
Body size (mm) $W \times D \times H$	1975 x 800 x 1950	2800 x 820 x 2120
Body weight (kg)	1600	3400

In this study, we used a GT600K as DUV light source.

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2. Introduction

Emerging of chiplet design

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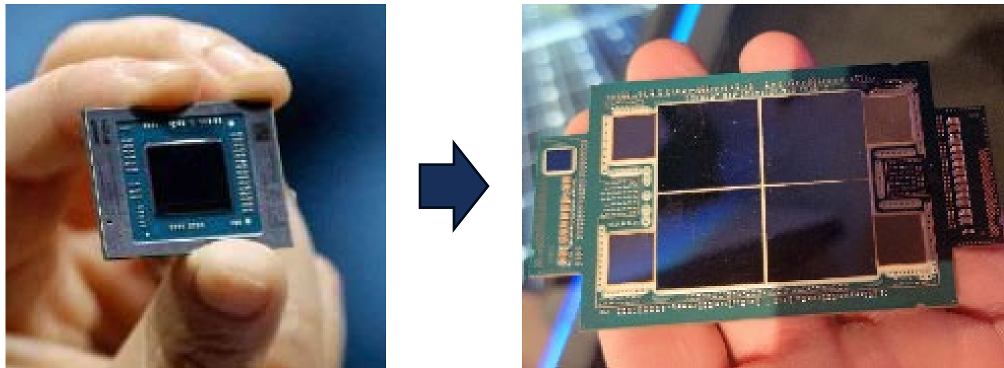
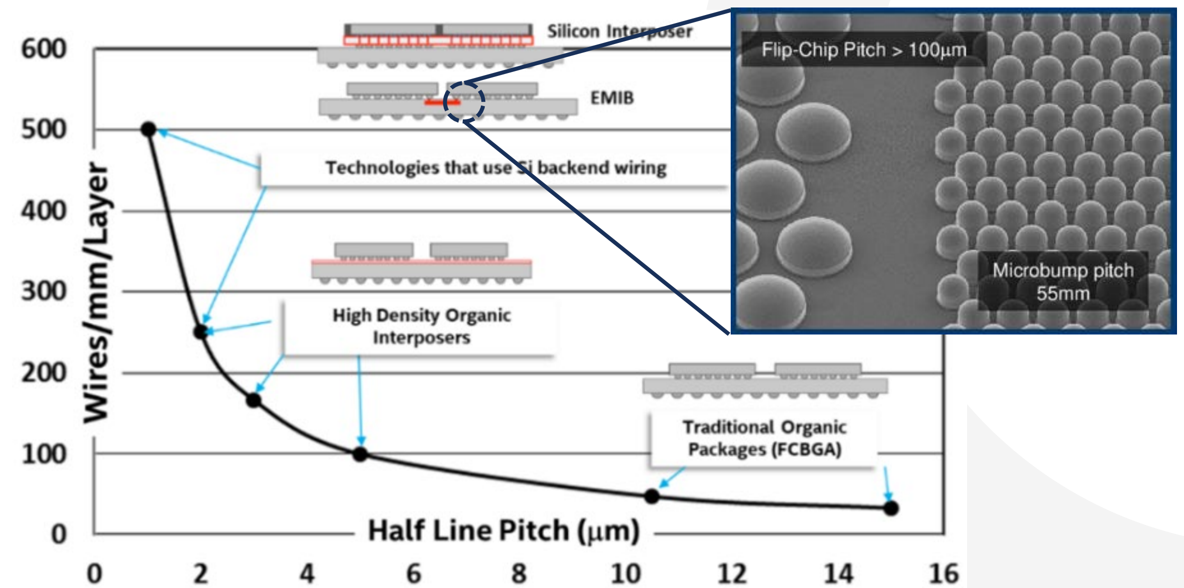
Chip design architecture is transitioning from a monolithic design to chiplet designs.
This transition requires high signal bandwidth and densely wired interconnections between the chips.

Transition from Monolithic to Chiplet Architecture



Interconnect density
for different advanced package architecture



Source: Intel

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Interconnection technologies

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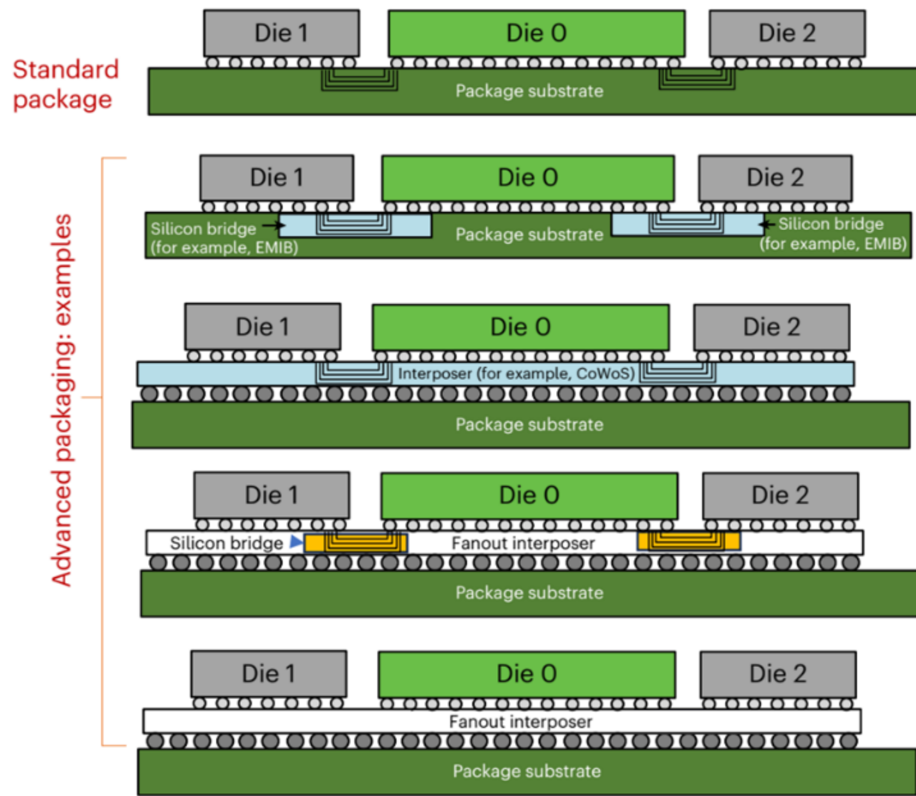
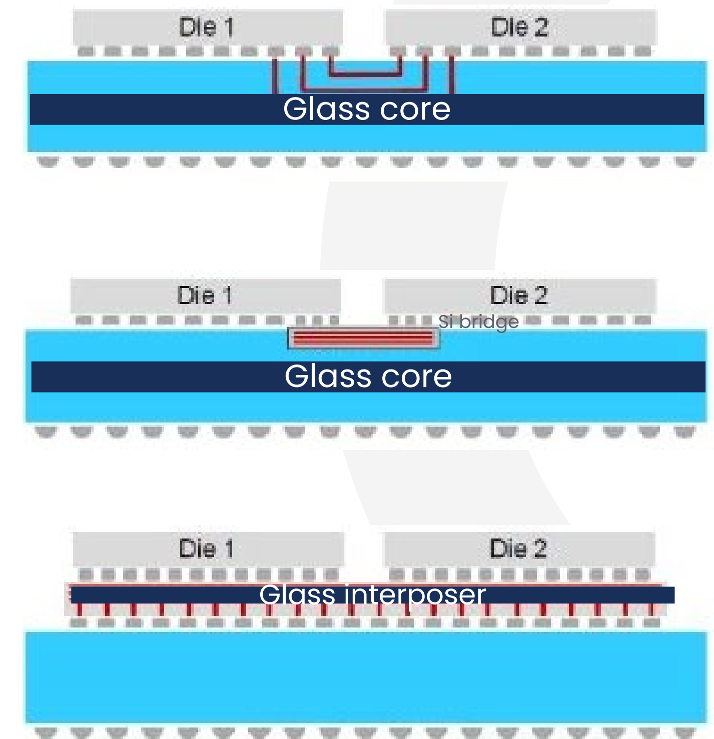
The semiconductor packaging architecture and materials also need improvement.

Glass is a promising material enabling larger form factor package with high-density interconnect



Ref: "High-performance, power-efficient three-dimensional system-in-package designs with universal chiplet interconnect express", Nature Electronics 2024

Large body
Finer I/O pitch
Finer RDL L/S



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Benefits to use Glass as a substrate material

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Glass Core Benefits

		Scaling Enabled by Glass Core	Product Value
1	Feature Scaling	<5/5um Line/Space & <100um TGV* pitch	Reduce metal layer count and/or package size OR add more function/cores
2	Bump Pitch Scaling	Enables D2D bump pitch <36u on substrate and core bump pitch <80um	Reduced die area/power and increased interconnect density
3	More SI Content / Larger Package Size	Enables 50% larger die complex area in same package, >8x reticle Si and package size up to 240x240 mm	Enables scaling of die area complex and package size in HPC
4	High Speed I/O	Smooth Cu + Ultra-low loss dielectric + TGV pitch	Scaling to 448G without the complexity and cost of transitioning to optical**
5	Power Delivery	Advanced IPD	Improved Performance

*Through Glass Via

** With Organic Substrate

*Based on internal analysis of Intel products and projections of future Intel products

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3. Glass micro-via fabrication using a KrF excimer laser

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Applicability of KrF excimer lasers to glass micro-via processing

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Gigaphoton demonstrated high-aspect-ratio glass micro-via fabrication using a KrF excimer laser.

Glass material: Non-alkali glass SG3.4 (Corning)
1100 µm thickness

Light source: KrF excimer laser GT600K (Gigaphoton)

Results:

Aspect ratio : more than 50

Glass thickness : more than 1 mm

No etching needed to penetrate

Suitable for glass microvia fabrication for semiconductor advanced packaging.

Side view

1100 µm

Hole diameter 20 µm
Hole pitch 50 µm

Aspect ratio 55 (=1100/20)

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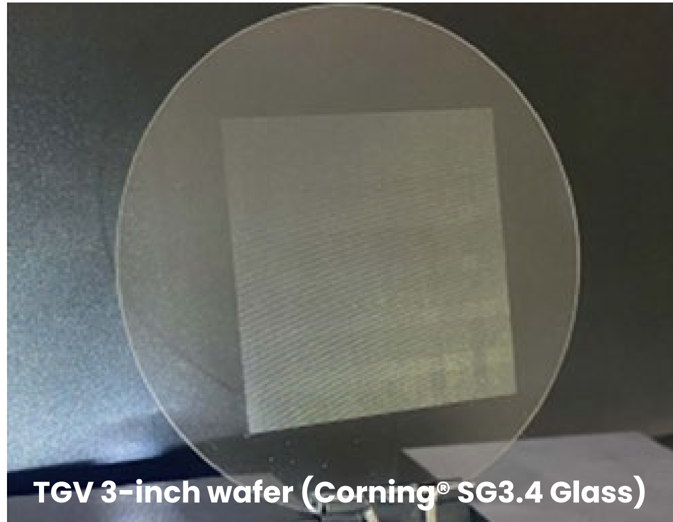
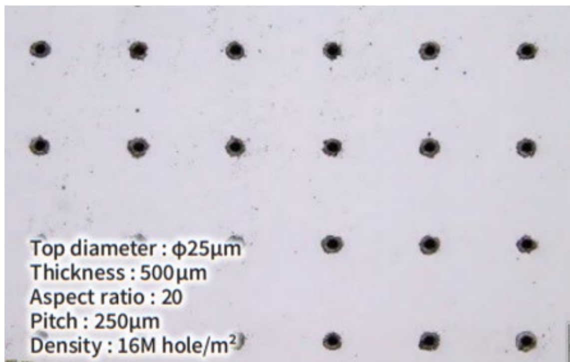
Gigaphoton demonstrates KrF excimer laser ability to fabricate glass micro-via processing





Laser irradiation condition	Condition #1	Condition #2	Condition #3
Top view			
Side view	Top:25μm 500μmt Bottom:11μm	Top:25μm Bottom:16μm	Top:25μm Bottom:33μm
Magnification of side view close to bottom surface	Tapered profile	(Straight) profile	Reverse-tapered profile

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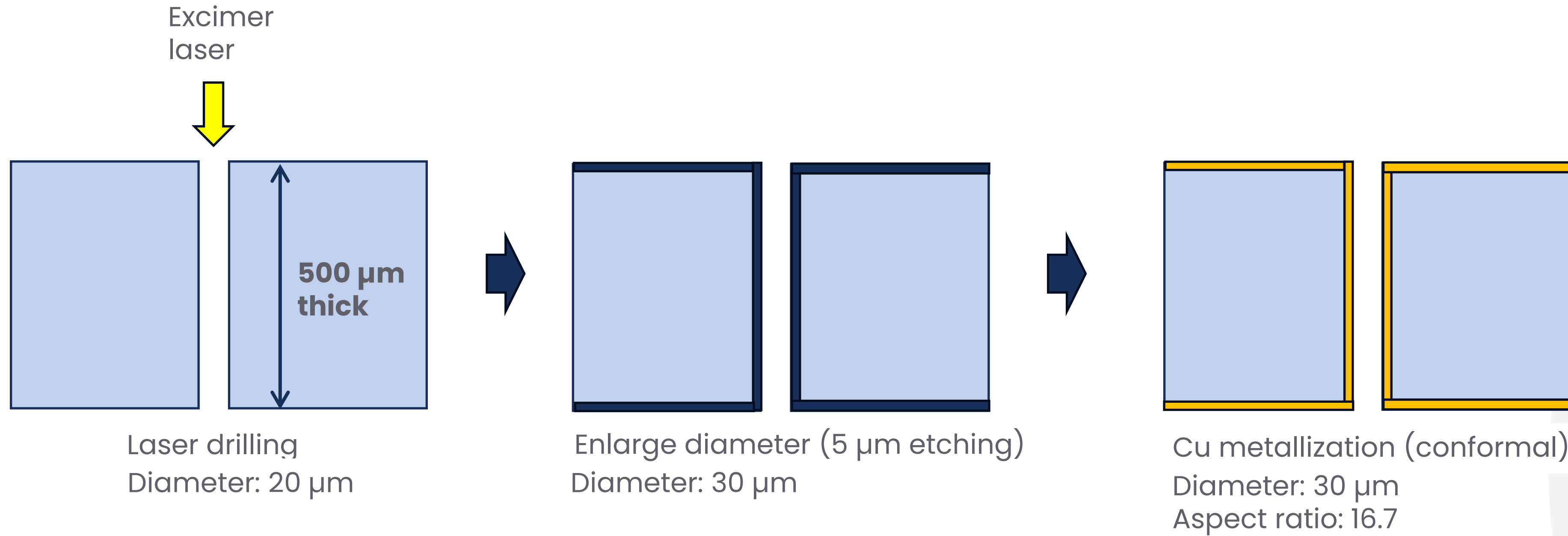
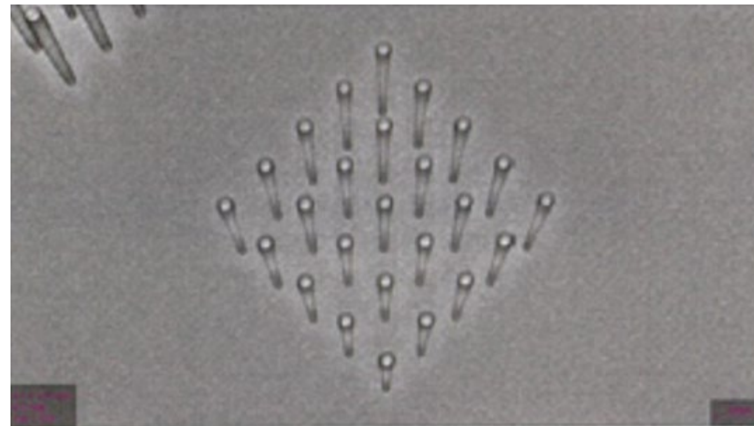
Glass micro-via metallization test results





Plating: Provided by Koto electric

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4. TGV productivity enhancement by simultaneous processing

New glass drilling optical system to improve productivity

Gigaphoton has co-developed the diffractive optical element (DOE) for short wavelength light of excimer laser and the DOE optical system with our suppliers. The DOE optical system is suitable for micro-via fabrication using high-fluence substrate (e.g., glass) drilling and can drastically improve the efficiency of the laser drilling process.

Optical System	Diagram of Optical system	Target material
Conventional System (Mask Projection)	Excimer laser → Homogenizer (η > 0.9) → Illuminator (η > 0.9) → Mask (η < 0.05) → Projection (η > 0.9) → Target; Total η <0.04	Suitable for low-fluence material drilling (e.g., ABF, other resins)
Developing System (DOE Imaging)	Excimer laser → Beam formation (η > 0.7) → DOE (η > 0.7) → Projection (η > 0.9) → Target; Total η > 0.5	Suitable for High fluence material drilling(e.g., Glass, Silicon)

Developed diffractive optical element (DOE) for DUV light

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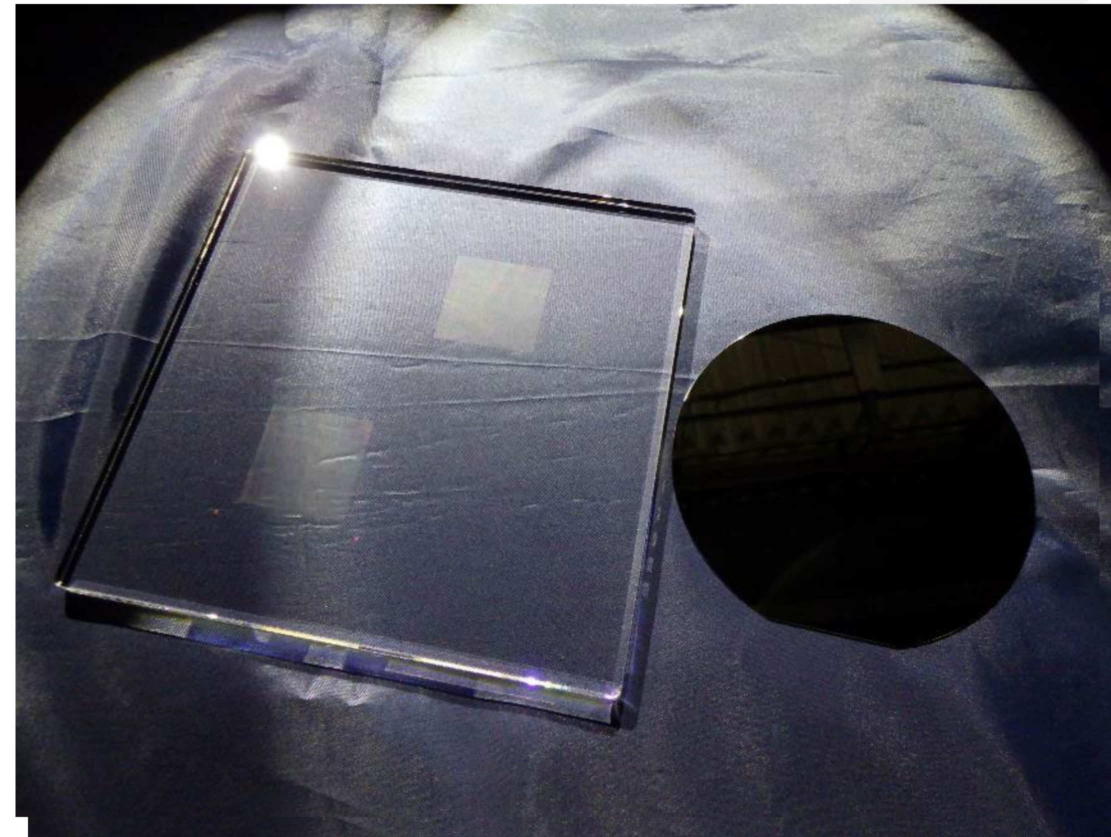
Photo of DOE for DUV light

Photo of DOE and 4″ wafer



Innovative glass micro-via processing: Achieving high throughput with OPS and DOE

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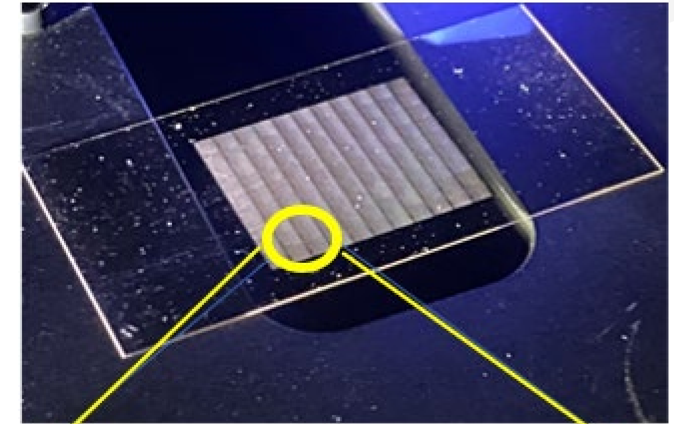

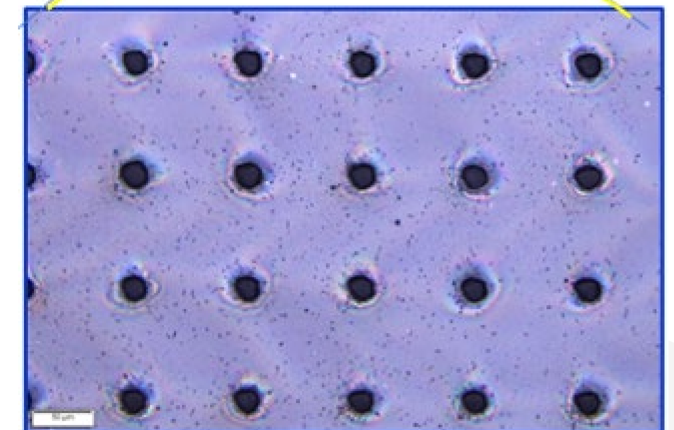

Fabricated 20 μm diameter TGV

High-throughput glass micro-via processing: Achieving 1,237 TGVs per second

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We have demonstrated high productivity in TGV fabrication, achieving 22,275 TGVs in 18 s (which is equivalent to 1,237 TGVs/s).

Process	Condition
Laser frequency (Hz)	4,000
Pulse width (ns TIS)	130
Hole diameter (μm)	20
Glass material	Corning® SG3.4
Glass thickness (μm)	100

High-throughput fabrication of glass micro-vias through a direct laser ablation process utilizing a DOE and an optimized KrF excimer laser

Discussion: Potentials of KrF excimer & DOE technology

Dr. Junro Yoon
Program Manager
Corning Advanced Optics

March 4th, 2025

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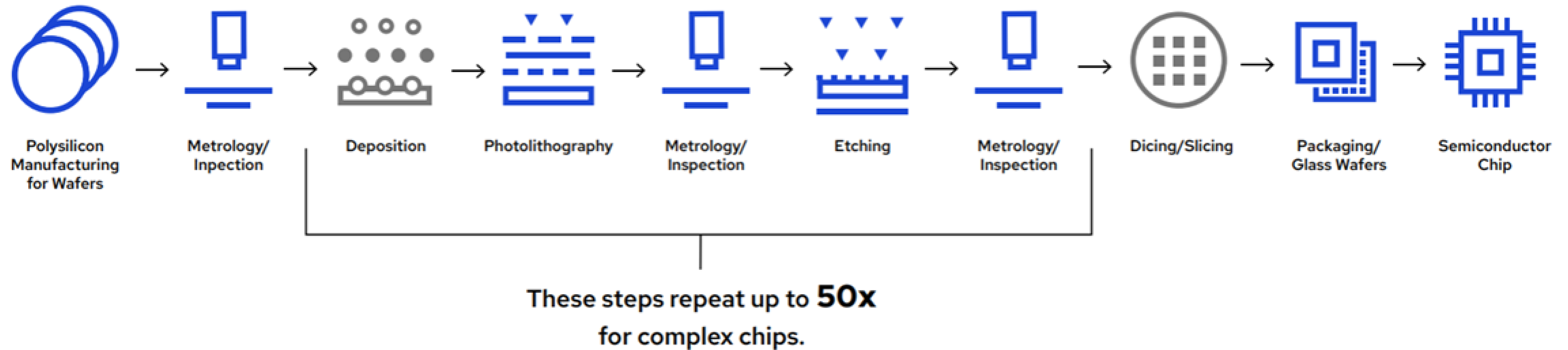
Introduction to Corning

How Does Corning Contribute to Chip industry? We Support Nearly Every Step



Enabled by Corning

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Introduction to Corning

What Corning Makes: Semiconductor Technologies & Solutions

Lithography

Corning enables this crucial step for DUV and EUV lithography through laser optics, mirrors, and photomasks made with *durable* calcium fluoride, Corning® HPFS® Fused Silica and Corning® ULE® Ultra-Low Expansion materials.

Semiconductor Materials

Optical Materials

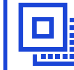
Laser Optics

Inspection & Metrology

Corning precision optical assemblies and advanced metrology instruments precisely measure flatness and other dimensional characteristics critical to yield.

Metrology Instruments

Precision Optics



Packaging & Wafers

Corning glass solutions for advanced packaging enable modern chip manufacturing. Our glass solutions are used in wafer thinning, fan-out packaging, and advanced 3D packaging.

Advanced Packaging Solutions

Optical Glass Solutions

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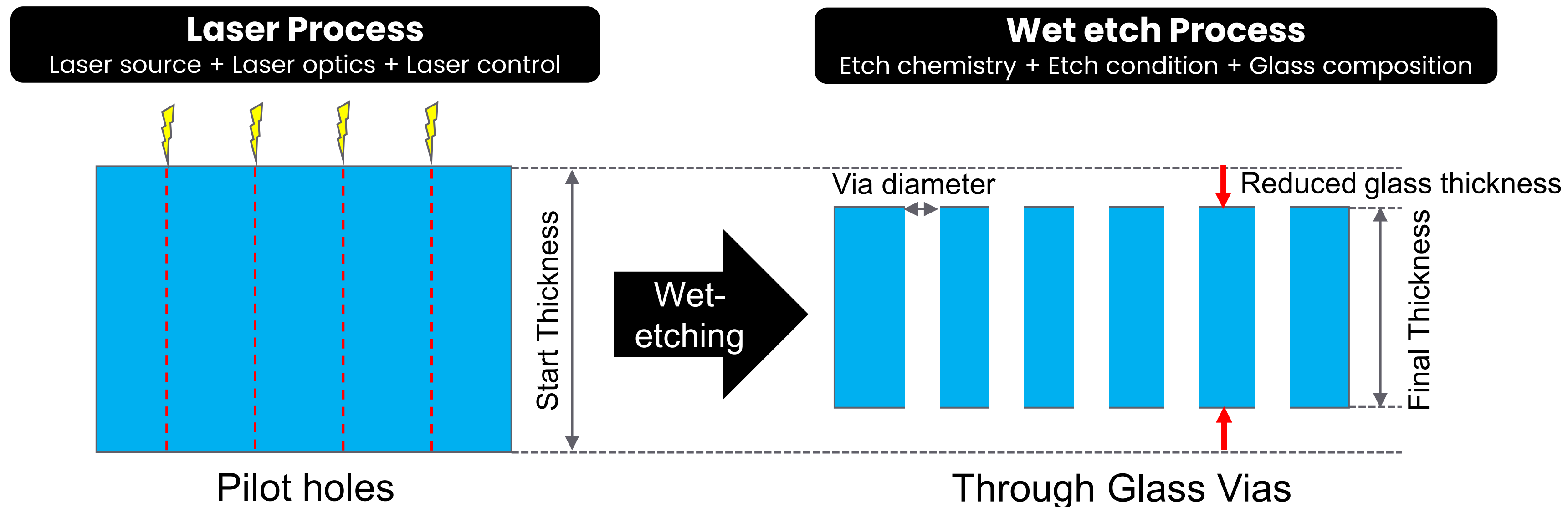
Discussion

Majority of TGV process today use laser + wet-etching

- Laser process forms pilot holes
- Etch enlarges the pilot holes
- Final glass thickness is reduced during etch if surface is not protected



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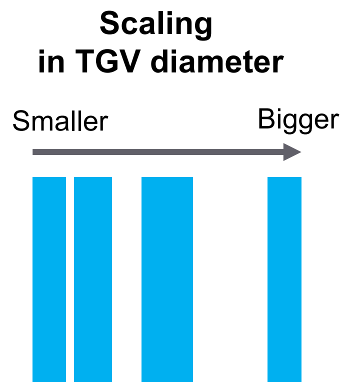
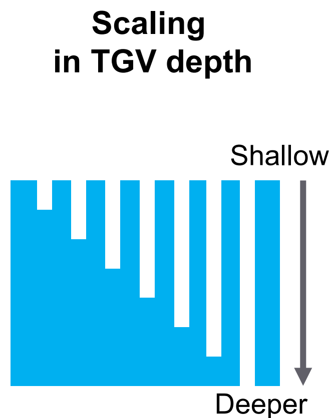
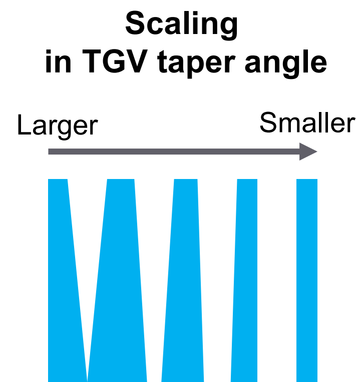
Discussion

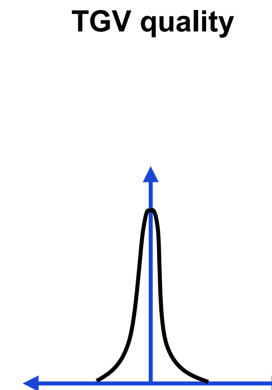
The industry is looking for scalable, good quality, and low-cost TGV technology

- **Scaling in TGV dimension**
  - Glass core is expected to replace organic substrate and interposer in various applications
  - Scaling in diameter, pitch, taper angle, and depth (aspect ratio) is necessary
- **Good TGV quality**
  - Uniformity & Reliability
- **Low total cost of ownership**









Low Total Cost of Ownership

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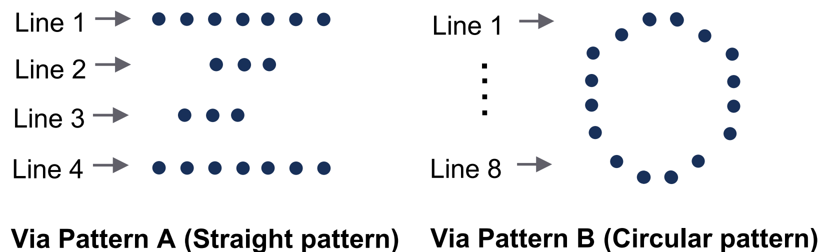
Discussion

How can we make TGV process time less dependent on pattern design?

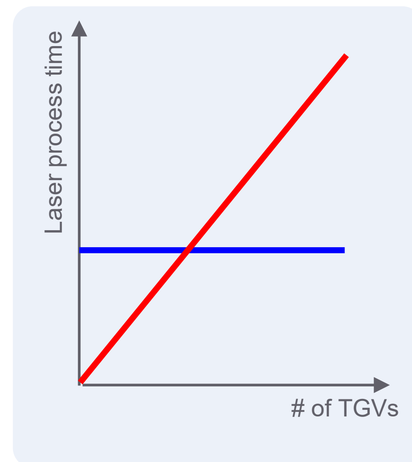
- With current TGV laser technology, laser process time is affected by number of TGVs & pattern complexity
- Variable laser process time per pattern design can increase complexity of TGV production
- Can we make laser drilling more like lithography?

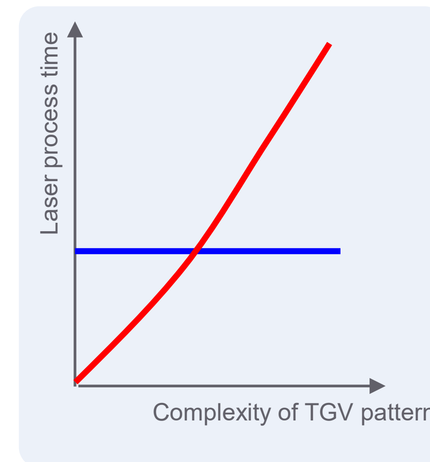


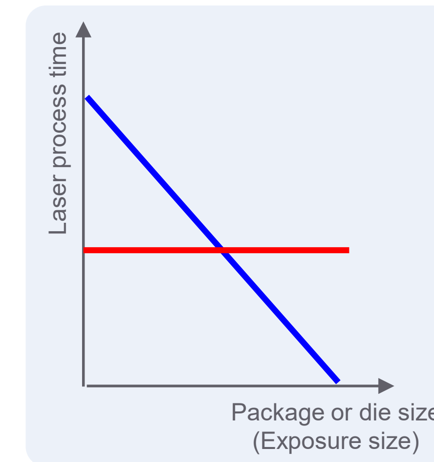
Via Pattern A (Straight pattern) **Via Pattern B (Circular pattern)**

Via Pattern	Via #	Lines	Laser Time*
Pattern A	50K	4	4 min
Pattern B	100K	8	16 min
Ratio	2.0x	2.0x	4.0x

*It excludes loading/unloading, log-in & out, process check







Ideal laser technology
Laser technologies currently used

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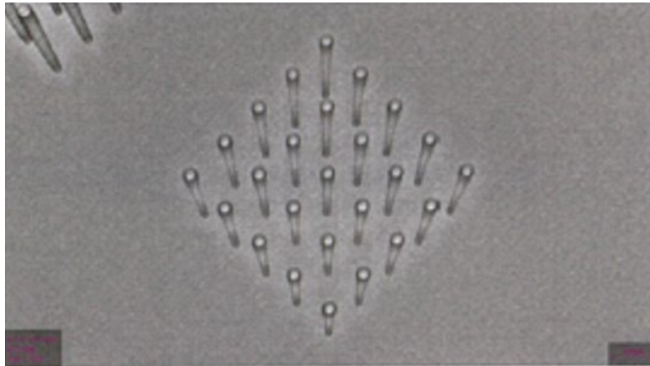
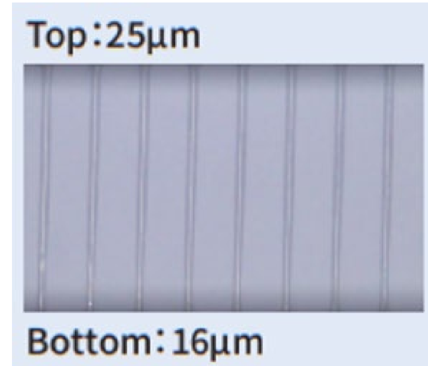
Discussion

Potentials of KrF excimer and DOE technology

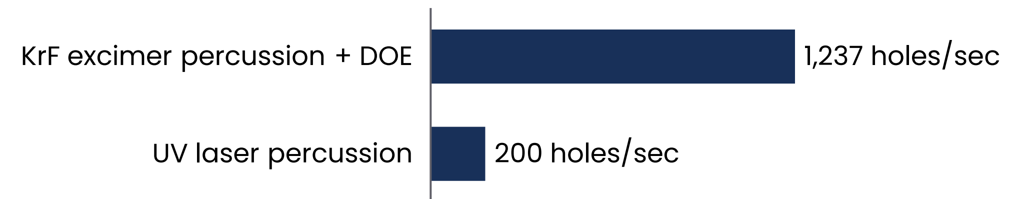
Potential Benefits

- KrF excimer laser has the capability to facilitate high aspect ratio TGV in thick glass
- Diffractive Optic Elements increases percussion laser drilling throughput





Aspect ratio > 10:1
in Corning® SG 3.4 glass



6x increase in productivity

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Summary

Summary

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- Advanced packaging demands innovation in materials and its process technology
- Dimensional stability and tunable attributes of glass enables larger form factor package with high density interconnect
- Scalable, good quality, and low-cost TGV technology is critical to commercialize glass core substrates and glass interposers
- Advanced laser drilling process using Gigaphoton's excimer laser and diffractive optic elements (DOE) successfully demonstrated high processing rate exceeding 1000 holes per second on 100 μm-thick Corning® SG3.4 Glass.
- Gigaphoton also tested this technology on 500 μm-thick 75mm diameter Corning® SG3.4 Glass wafers. Further study on 1000 μm-thick glass is in progress.

Acknowledgements

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- This presentation is based on results obtained from a project, JPNP20017, subsidized by the New Energy and Industrial Technology Development Organization (NEDO) Japan.

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Thank you very much for your attention

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