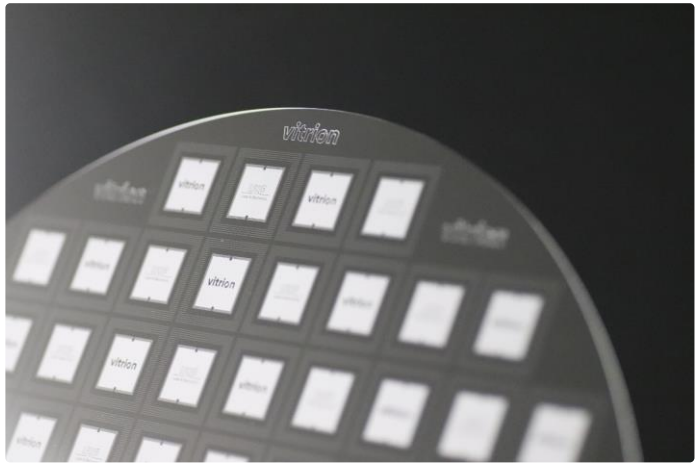
New Possibilities for Glass in Microsystems Technology

Dr.-Ing. Christian Kelb

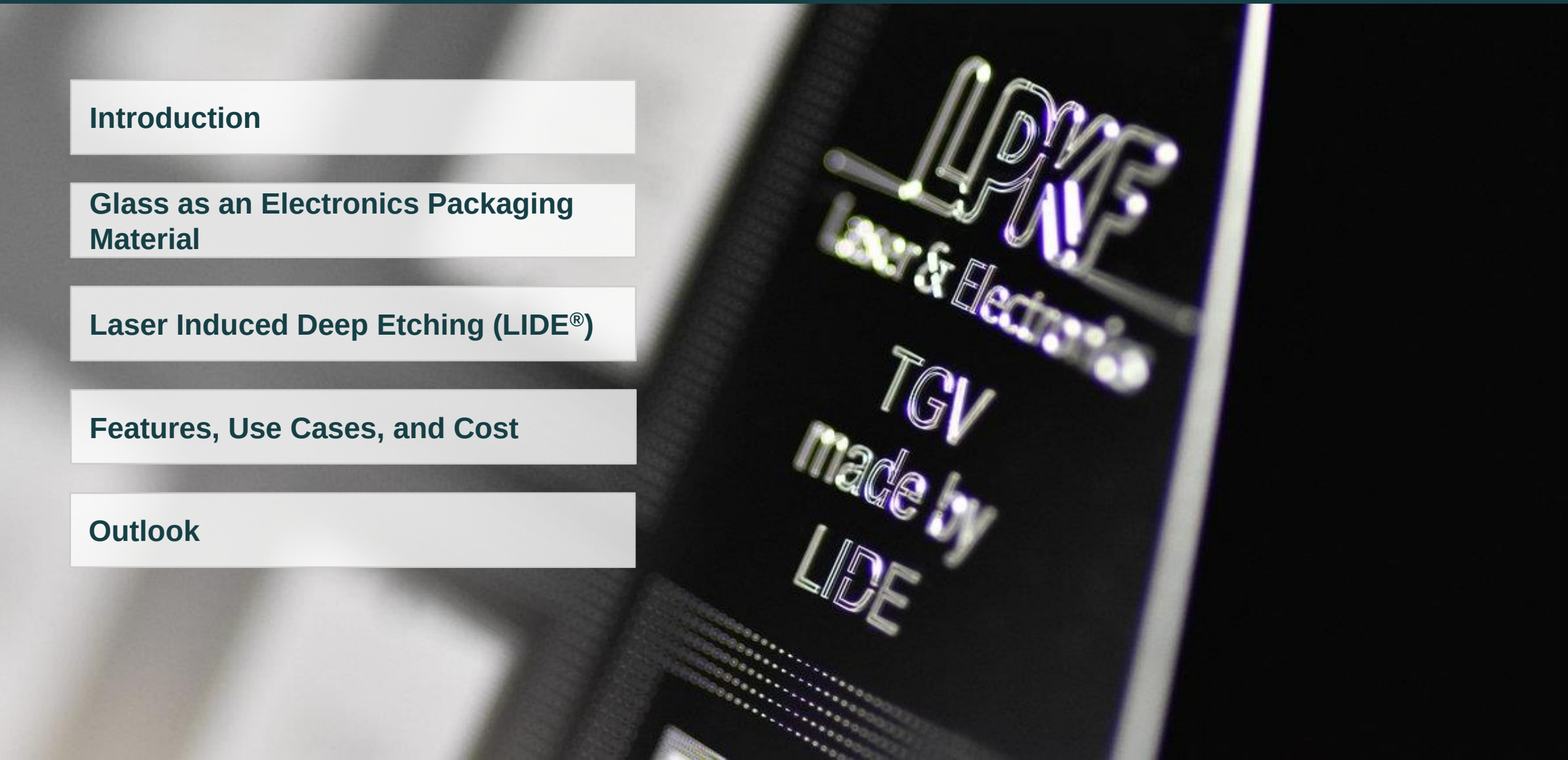
Project Manager & Process Development Engineer

LPKF Laser & Electronics AG



Agenda

- Introduction
- Glass as an Electronics Packaging Material
- Laser Induced Deep Etching (LIDE®)
- Features, Use Cases, and Cost
- Outlook

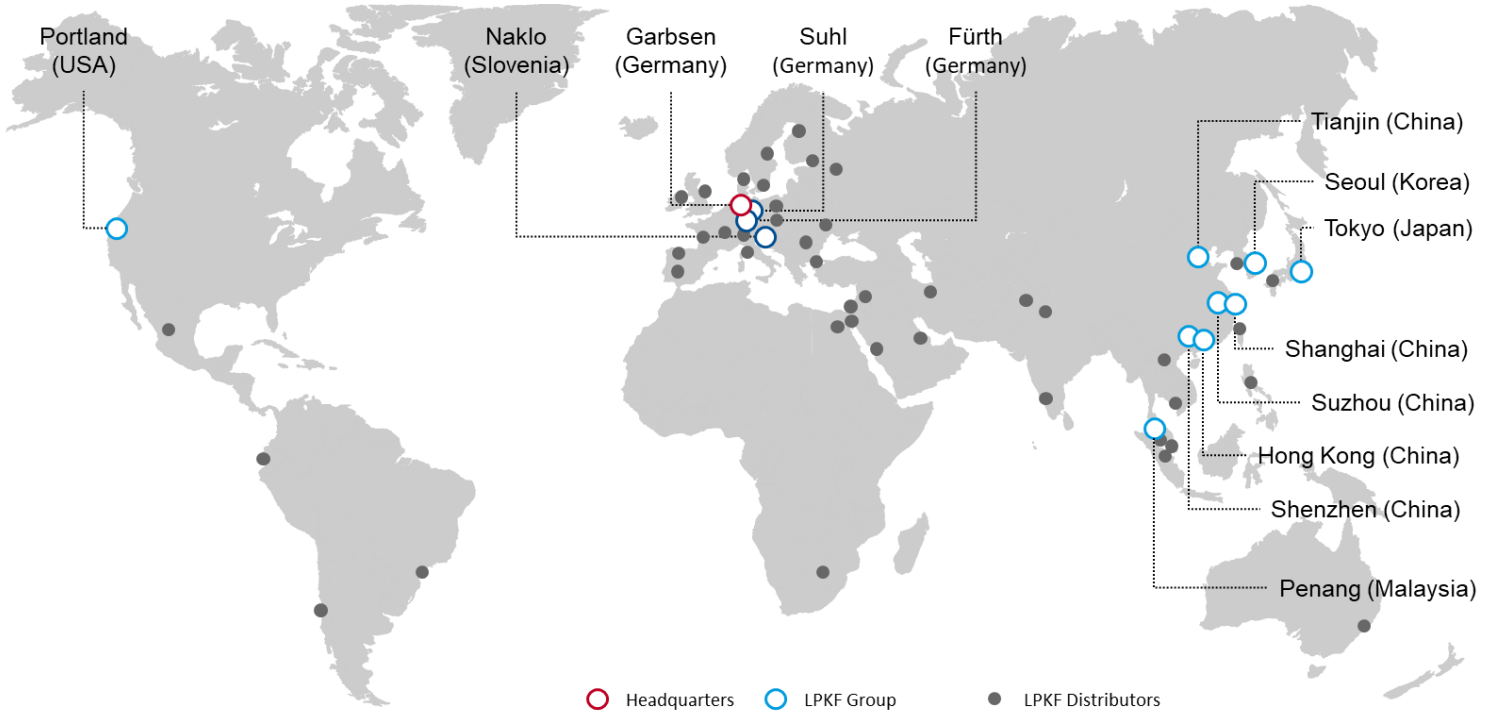


Company Introduction

LPKF Laser & Electronics AG

- Headquarters in Garbsen, Germany
- Founded in 1976
- Revenue in 2021: EUR 94 Million
- Approx. 750 employees worldwide

LPKF
Laser & Electronics



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Glass as an Electronics Packaging Material

- Low-cost
- Unique properties
  - Tunable CTE

	Fused Silica	Borosilicate	Alumino-silicate	Silicon
CTE	0.5	3.3	8.7	2.5
E (GPa)	72	64	74	160
ρ (Ω.m)	10^{16}	10^{8}	10^{12}	10^{-2}
Dk	3.8	5.9	6.7	12
Df	< 0.0004	30	170	150

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Glass as an Electronics Packaging Material

- Low-cost
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  - Great mechanical properties

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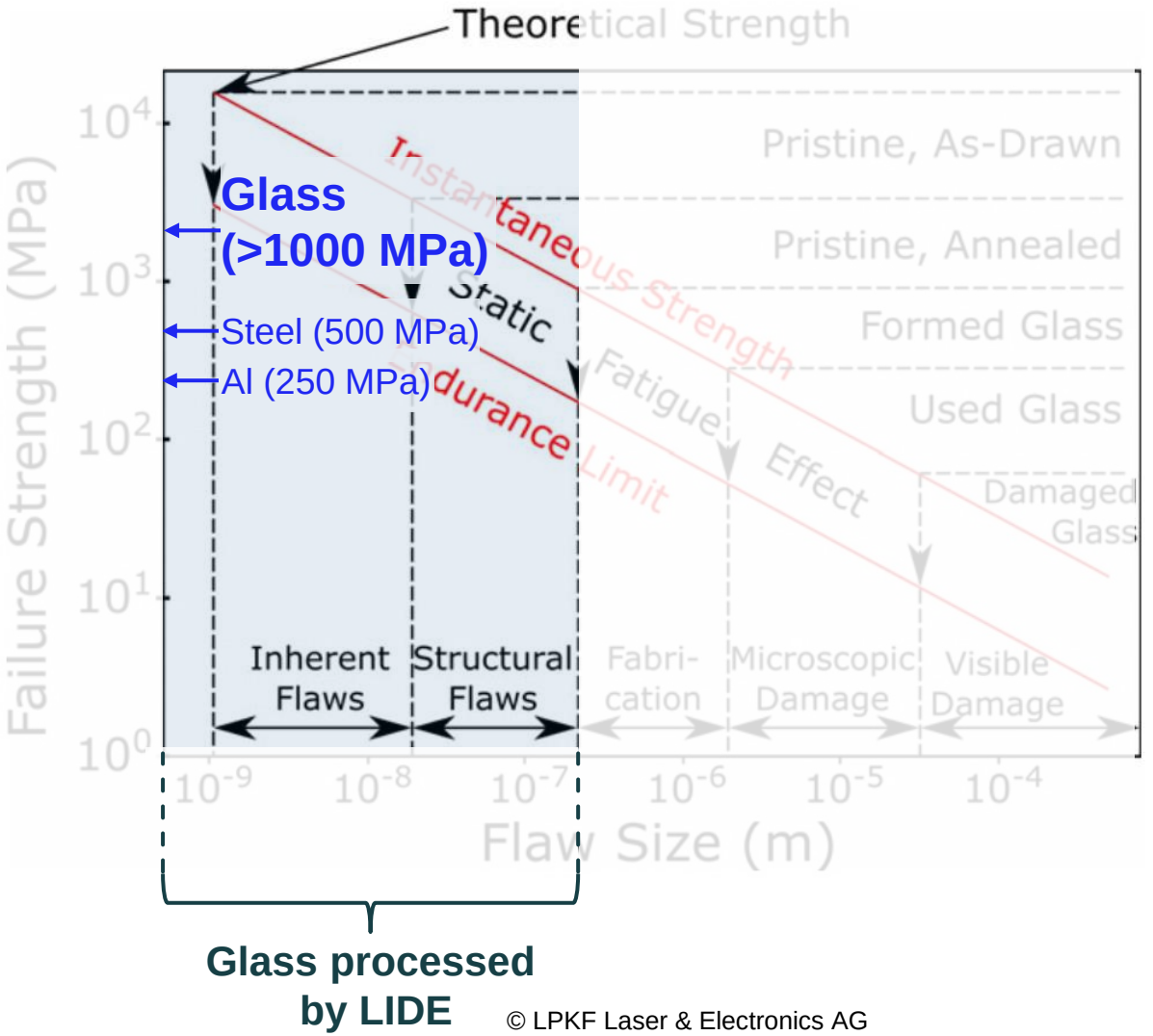
Glass as an Electronics Packaging Material

- Low-cost
- Unique properties
  - Tunable CTE
  - Great mechanical properties

- The break strength of glass can vary across multiple orders of magnitude
- Measured break strength depends on the surface quality, rather than the material
- Flawless glass is an incredibly powerful engineering material



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Glass as an Electronics Packaging Material

- Low-cost
- Unique properties
  - Tunable CTE
  - Great mechanical properties
  - Excellent electrical insulator

	Fused Silica	Borosilicate	Alumino-silicate	Silicon
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Glass as an Electronics Packaging Material

- Low-cost
- Unique properties
  - Tunable CTE
  - Great mechanical properties
  - Excellent electrical insulator
  - Excellent RF properties

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Df	< 0.0004	30	172	150

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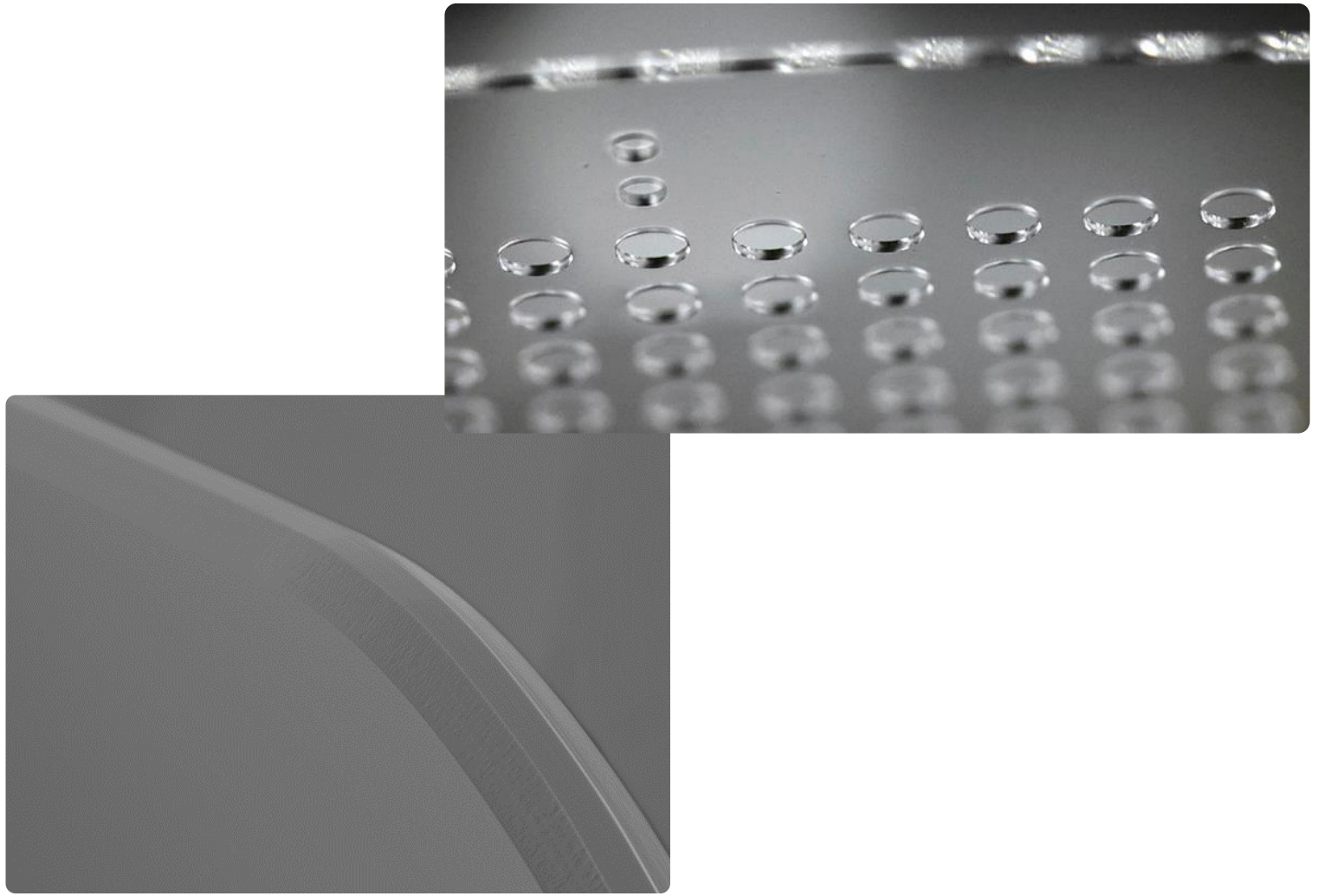
Glass as an Electronics Packaging Material

- Low-cost
- Unique properties
  - Tunable CTE
  - Great mechanical properties
  - Excellent electrical insulator
  - Excellent RF properties
  - Optically transparent
  - Outstanding haptic impression



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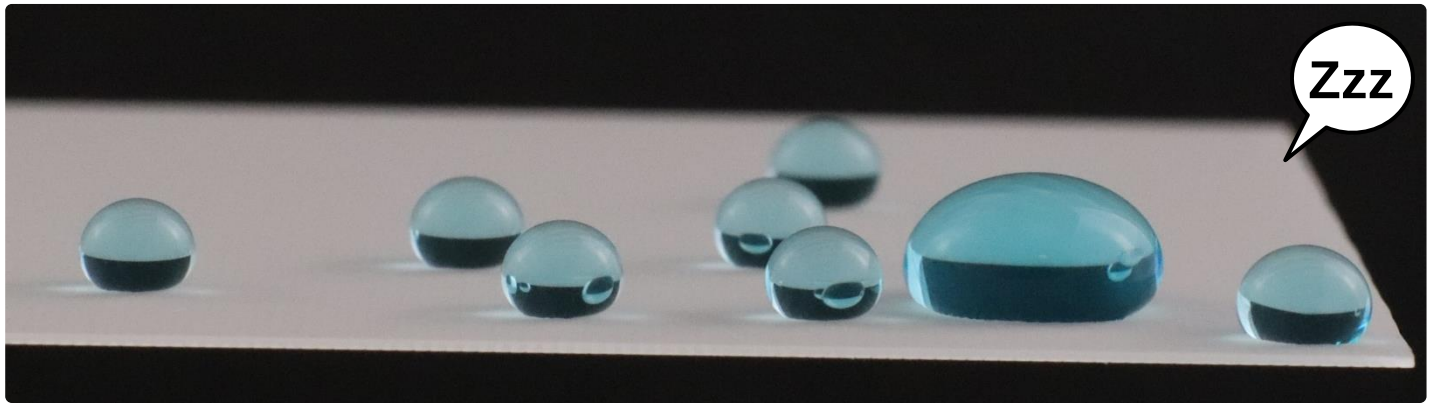
Glass as an Electronics Packaging Material

- Low-cost
- Unique properties
  - Tunable CTE
  - Great mechanical properties
  - Excellent electrical insulator
  - Excellent RF properties
  - Optically transparent
  - Outstanding haptic impression
  - Thermally stable
  - Chemically inert



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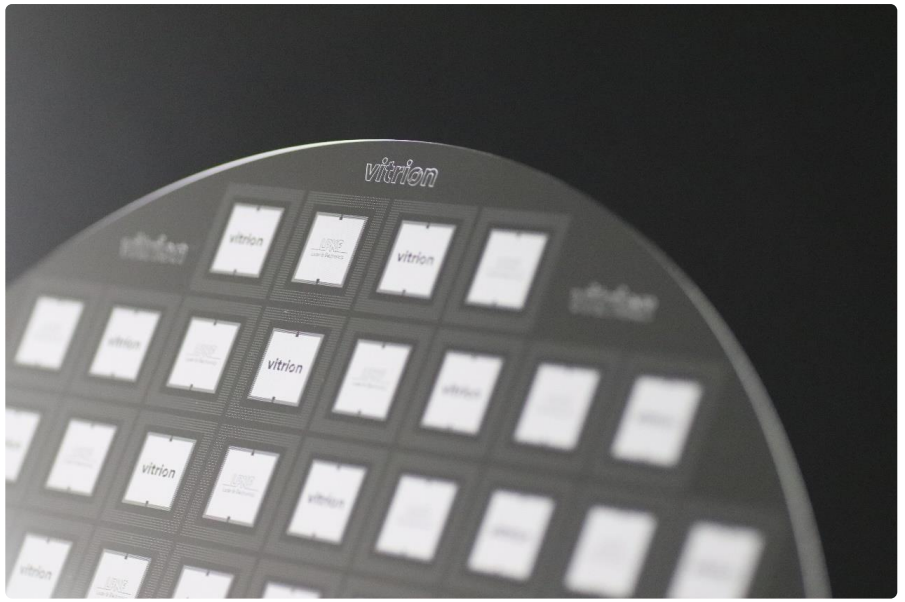
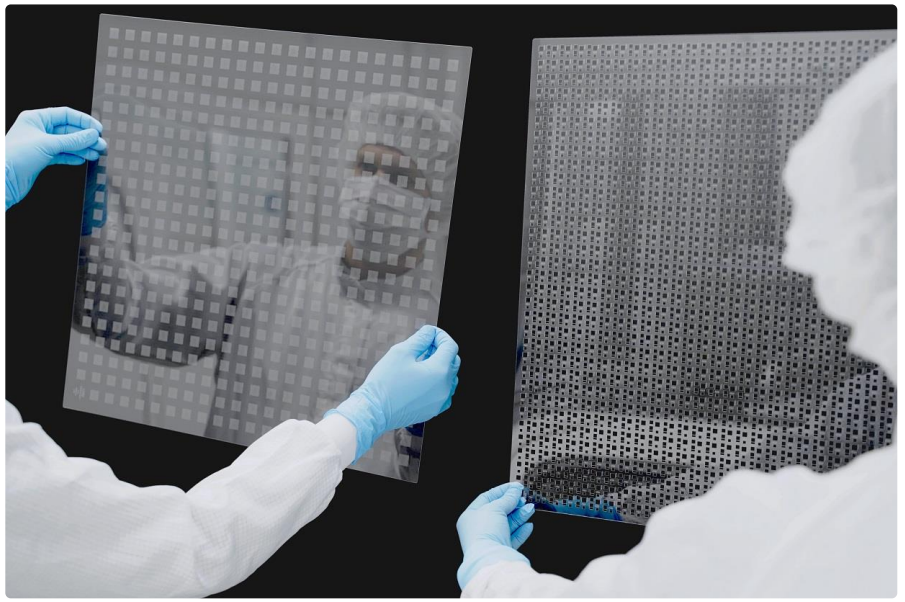
Glass as an Electronics Packaging Material

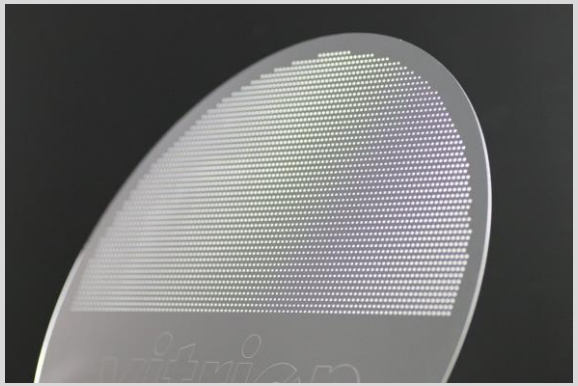
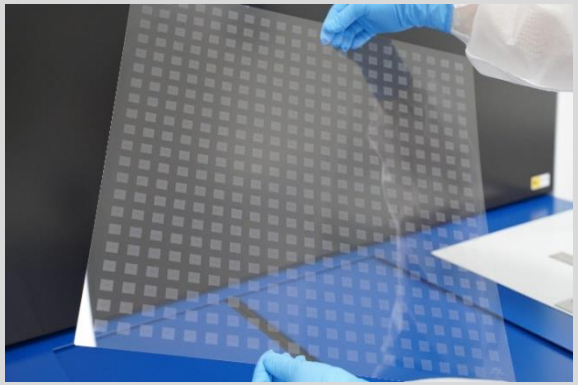
Glass is the **ideal** substrate for micro electronics packaging:

- Low-cost
- Tunable coefficient of thermal expansion (CTE)
- High strength/weight ratio
- Low total thickness variation
- Electrically insulant
- Excellent RF properties
- High temperature stability
- Homogeneous and isotropic material properties





Status of Glass in Electronics Packaging

	Wafer Level Packaging	Panel Level Packaging
Current Applications of Glass	▪ Limited HVM usage ▪ Low sophisticated applications e.g. capping	▪ Not in HVM yet ▪ Through glass vias (TGV) mandatory
		

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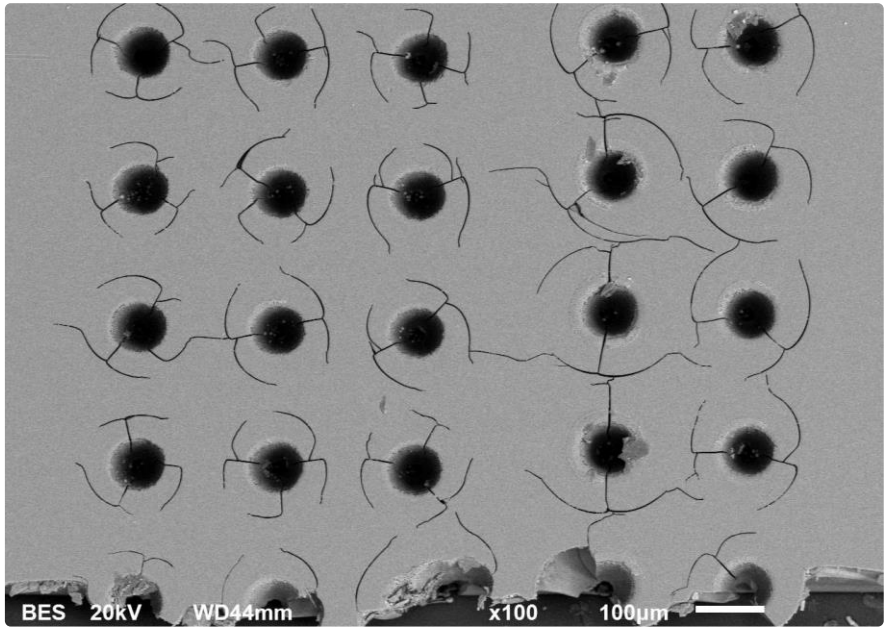
Status of Glass in Electronics Packaging

Conventional glass processing limits the application of glass due to:

- (Micro) cracks
- Chipping
- Thermally induced stress
- Low accuracy
- Low reproducibility and yield
- Debris and vapours
- Limited aspect-ratios



Glass is an uniquely interesting material, but current processing methods prevents it from realizing its full potential

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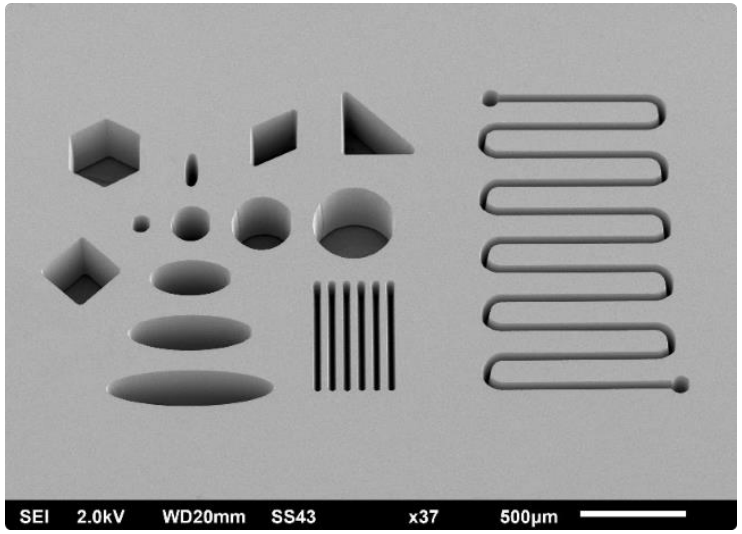
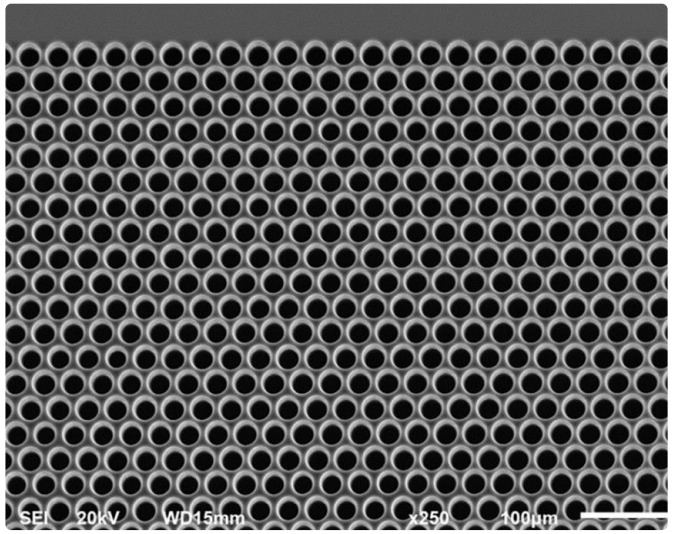
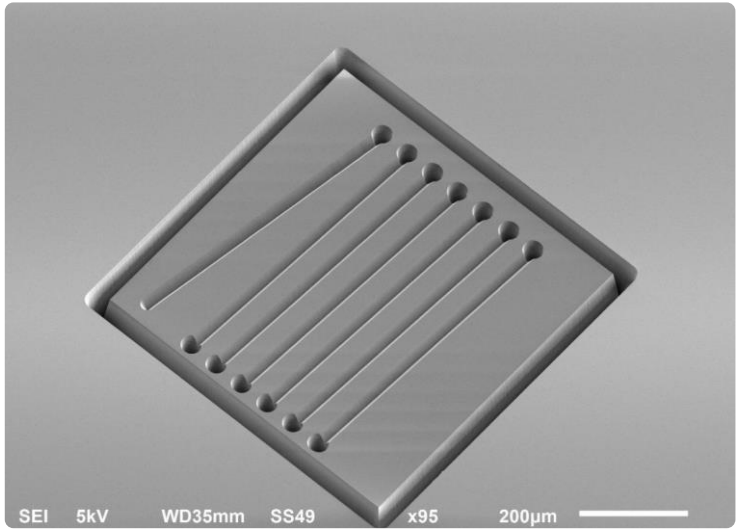
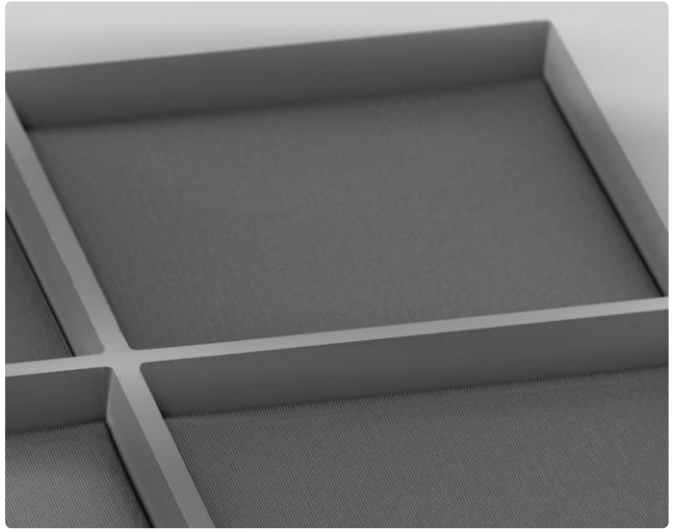
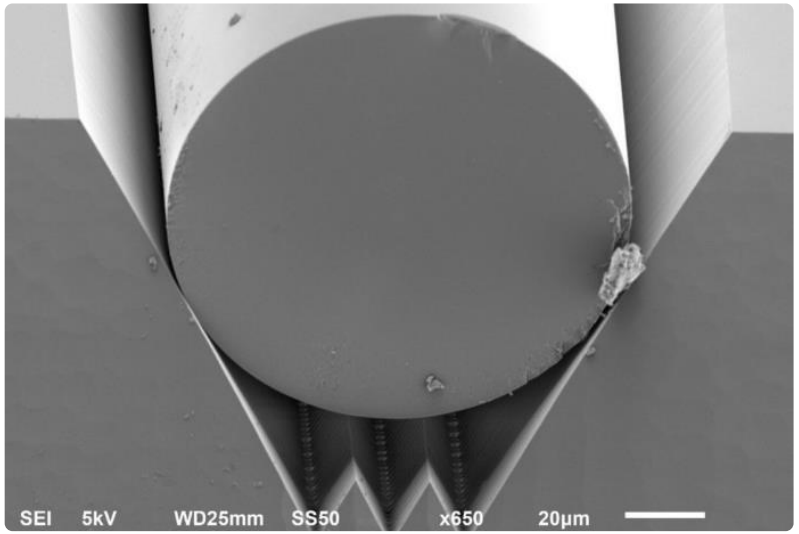
Solution: Laser Induced Deep Etching (LIDE®)











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Solution: Laser Induced Deep Etching (LIDE®)

	Conventional glass processing	LIDE®
(Micro) cracks	Yes	None
Chipping	Yes	None
Thermally induced Stress	Yes	None
Precision & Accuracy	Low	Single-digit micrometer
Reproducibility	Low	Very high
Debris	Yes	None
Maximum aspect-ratio	Up to 1:4	Up to 1:50

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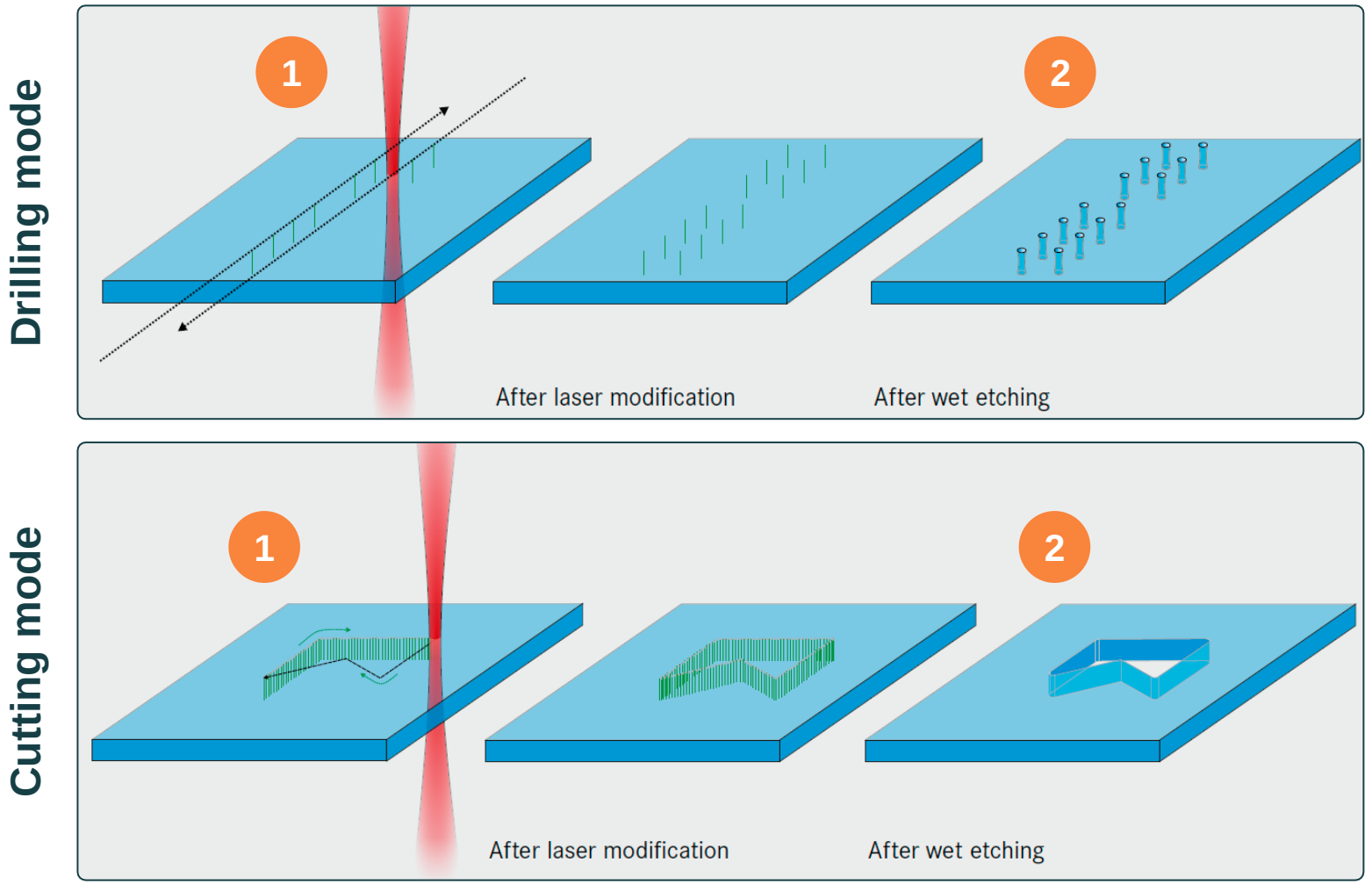
Laser Induced Deep Etching (LIDE®)

Two-Step Process

1. Laser patterning
2. Wet-Etching*

*Glass substrate undergoes a slight decrease in thickness



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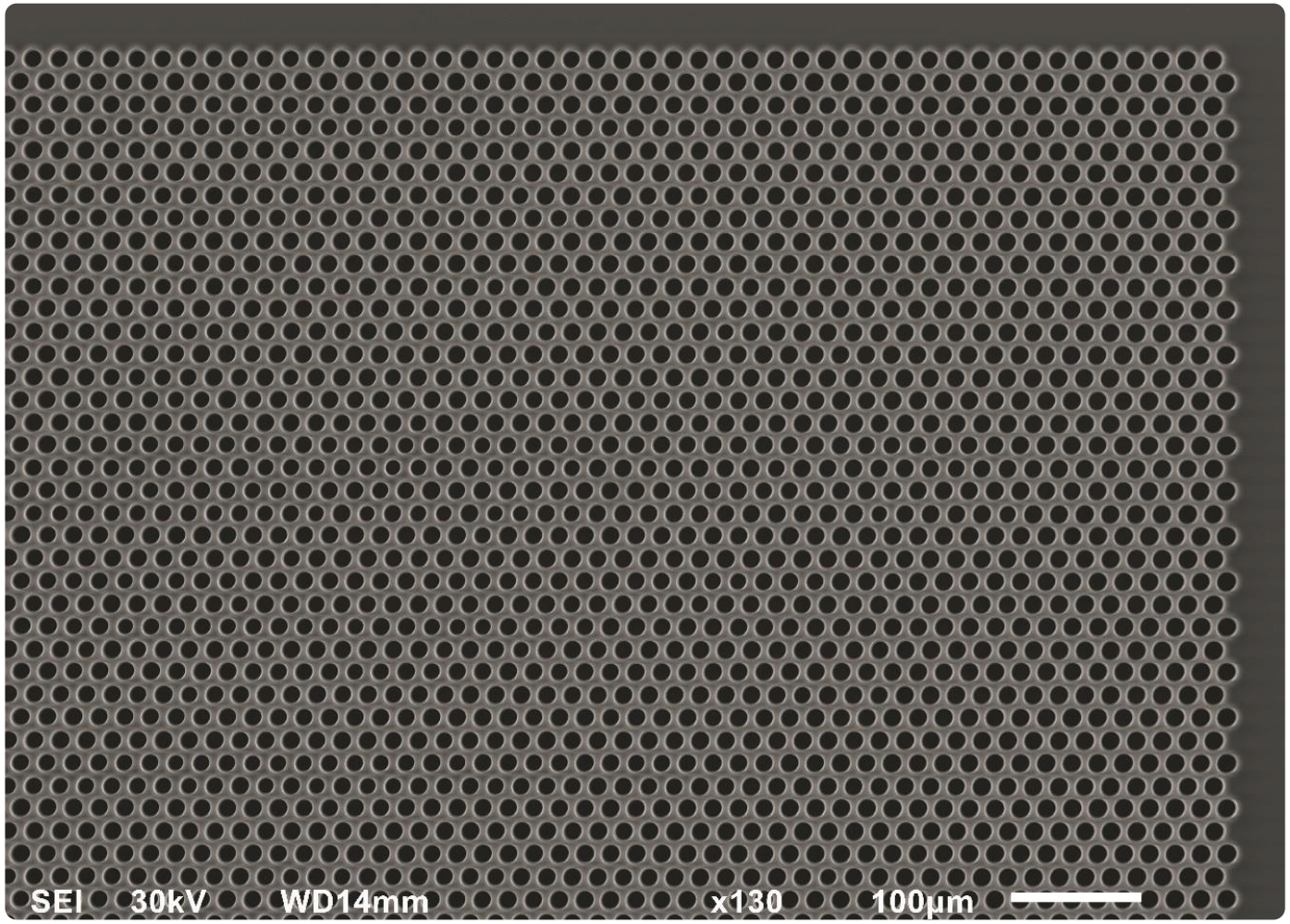
Through Glass Vias (TGV)

TGV – key enabling feature

1. Micro-hole formation (by LIDE)
2. Metallization

- Micro-hole qualification criteria
  - Positional Accuracy
  - Dimensional Accuracy
  - Sidewall Roughness



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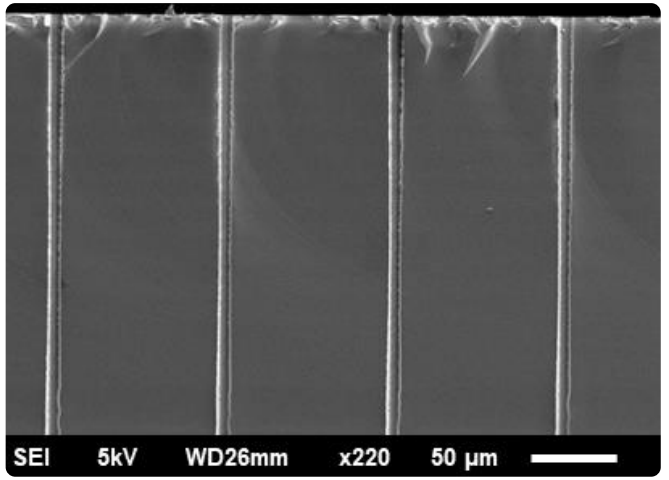
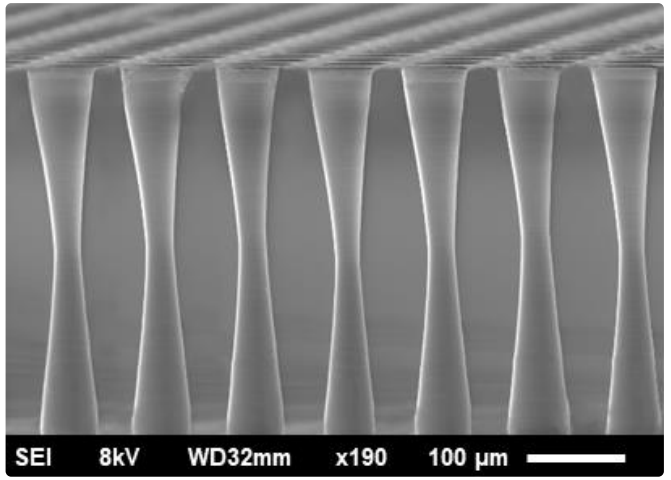
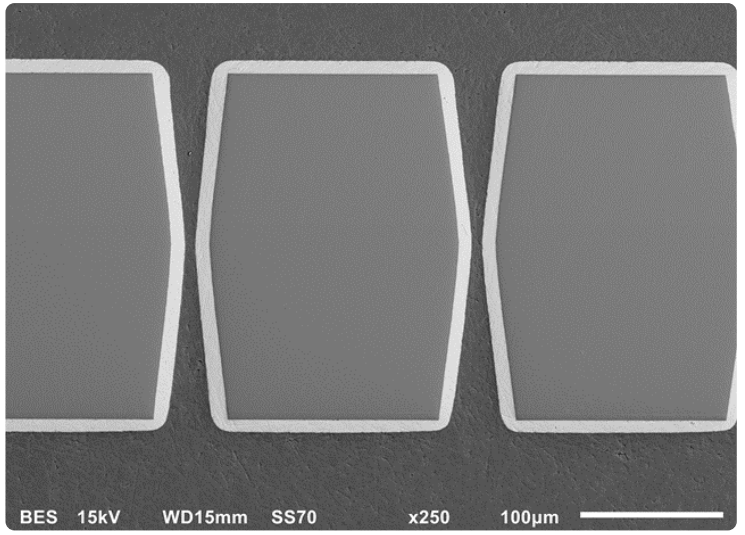
Micro-holes for Through Glass Vias (TGV) made with LIDE®

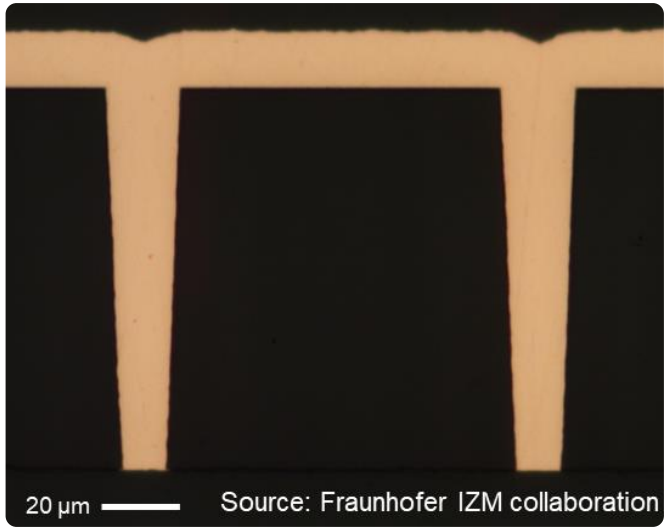
Key aspects

- Defect-free
- Hourglass- and “V”-shaped TGV
- Aspect-ratios: typical 1:10 (max. 1:50)
- Glass thickness: up to 1 mm
- TGV diameter (typical): 10 – 100 µm
- Positional accuracy: ± 5 µm, Cp > 1.33
- Sidewall roughness: ~300 nm









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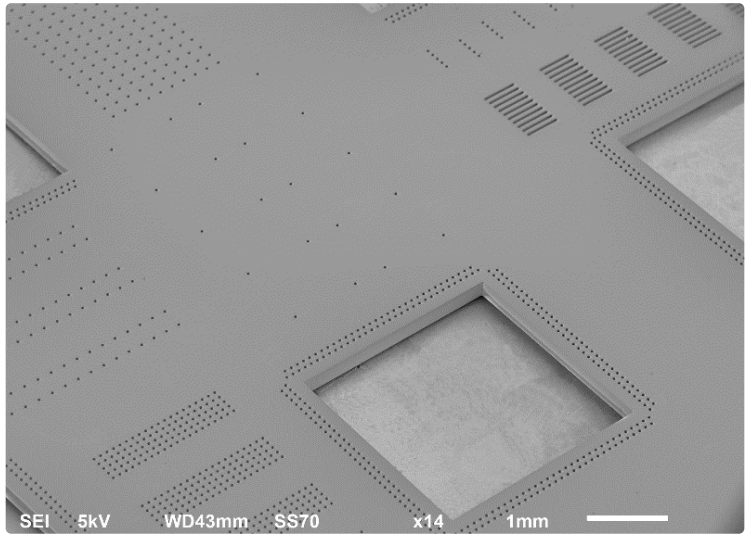
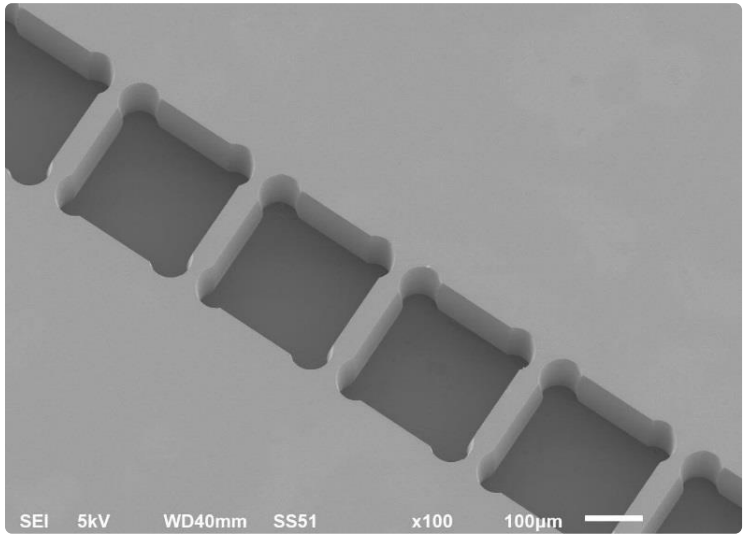
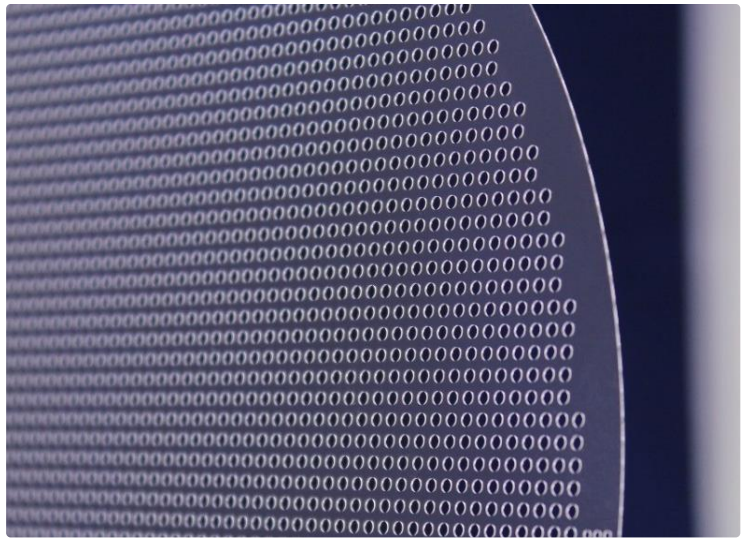
Open Cavities made with LIDE®

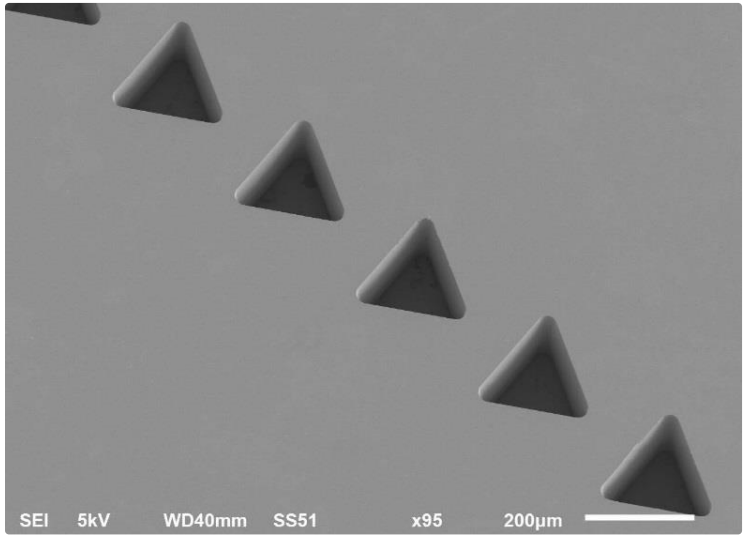
Key aspects

- Using cutting mode
- Any shape, any size
- Corner radius > 5 µm
- Glass thickness: up to 1 mm
- Creation of TGV or other features in the same step possible
- Accuracy: ± 5 µm, Cp > 1.33









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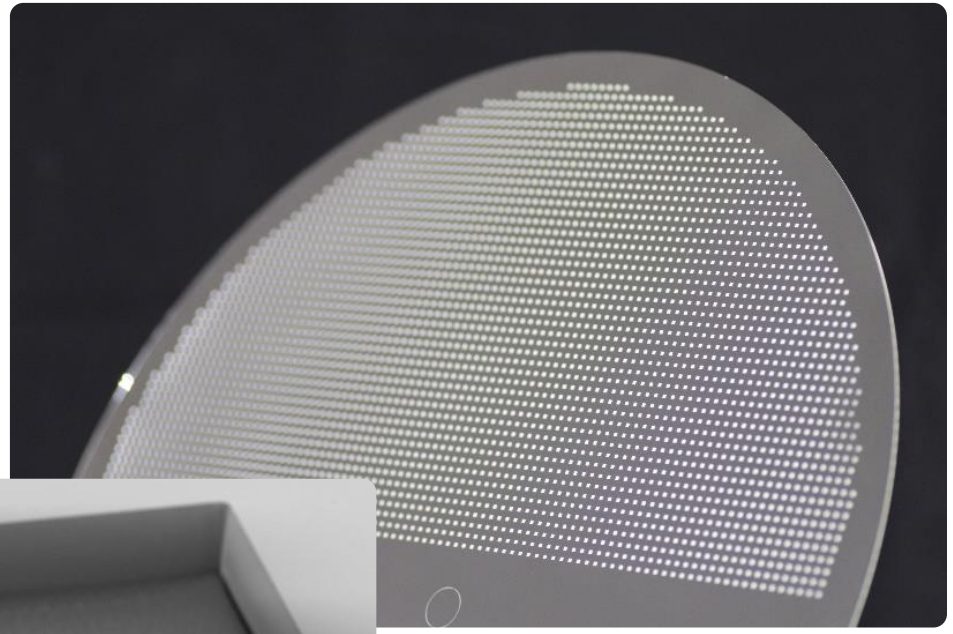
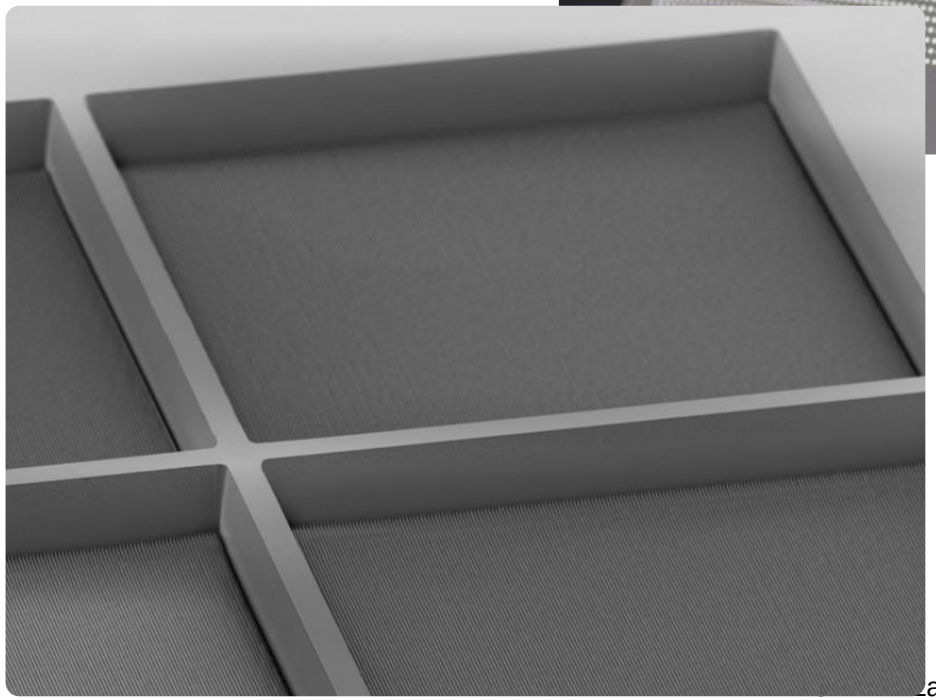
Closed Cavities made with LIDE®

Key aspects

- Using raster scanning mode
- Any shape, any size
- Corner radius > 5 µm
- Glass thickness: up to 1 mm
- Creation of TGV or other features in the same step possible
- Cavity depth: < 300 µm typical
- TGV at the bottom of the cavity possible
- Accuracy: ± 5 µm, Cp > 1.33





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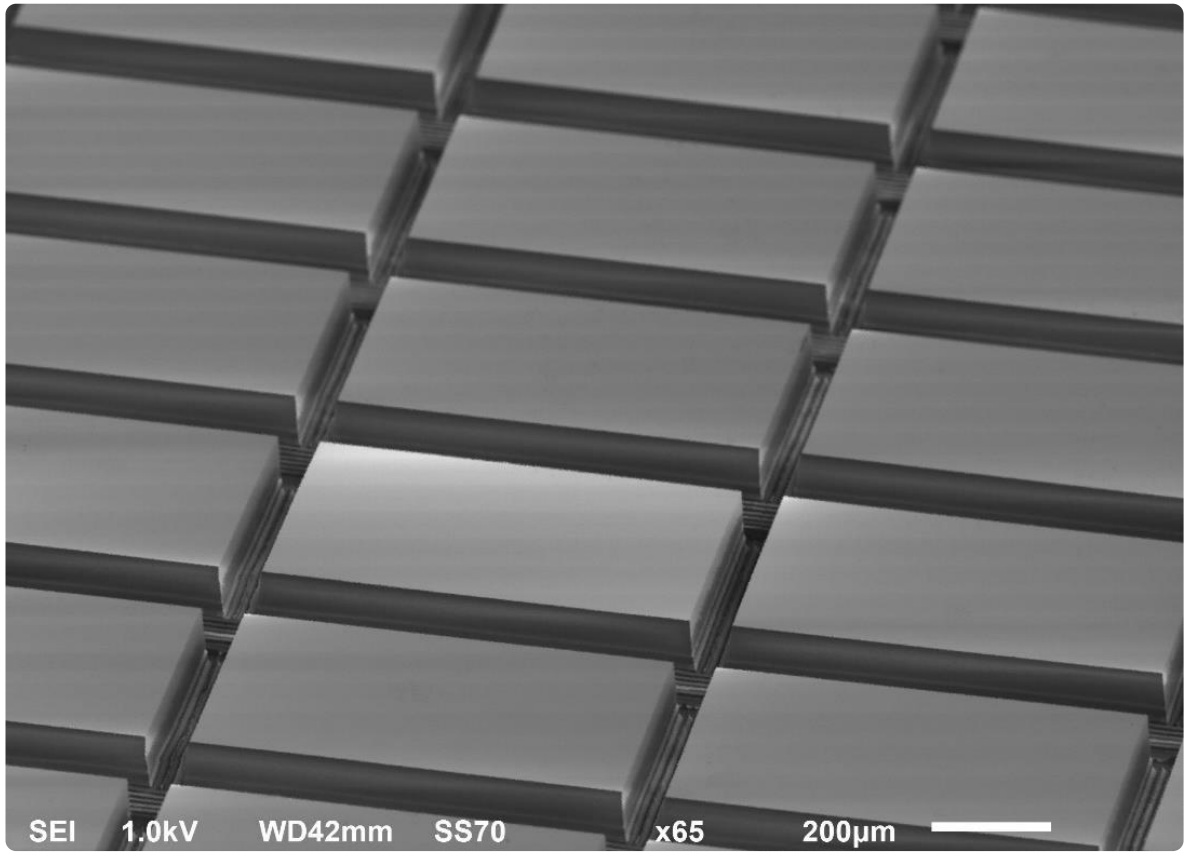
Glass Dicing Before Grinding

Key aspects

- Half-cut dicing streets made by LIDE
- Glass thickness: up to 500 µm
- Creation of TGV or other features in the same step possible
- Dicing streets width > 10 µm
- Accuracy: ± 5 µm, Cp > 1.33



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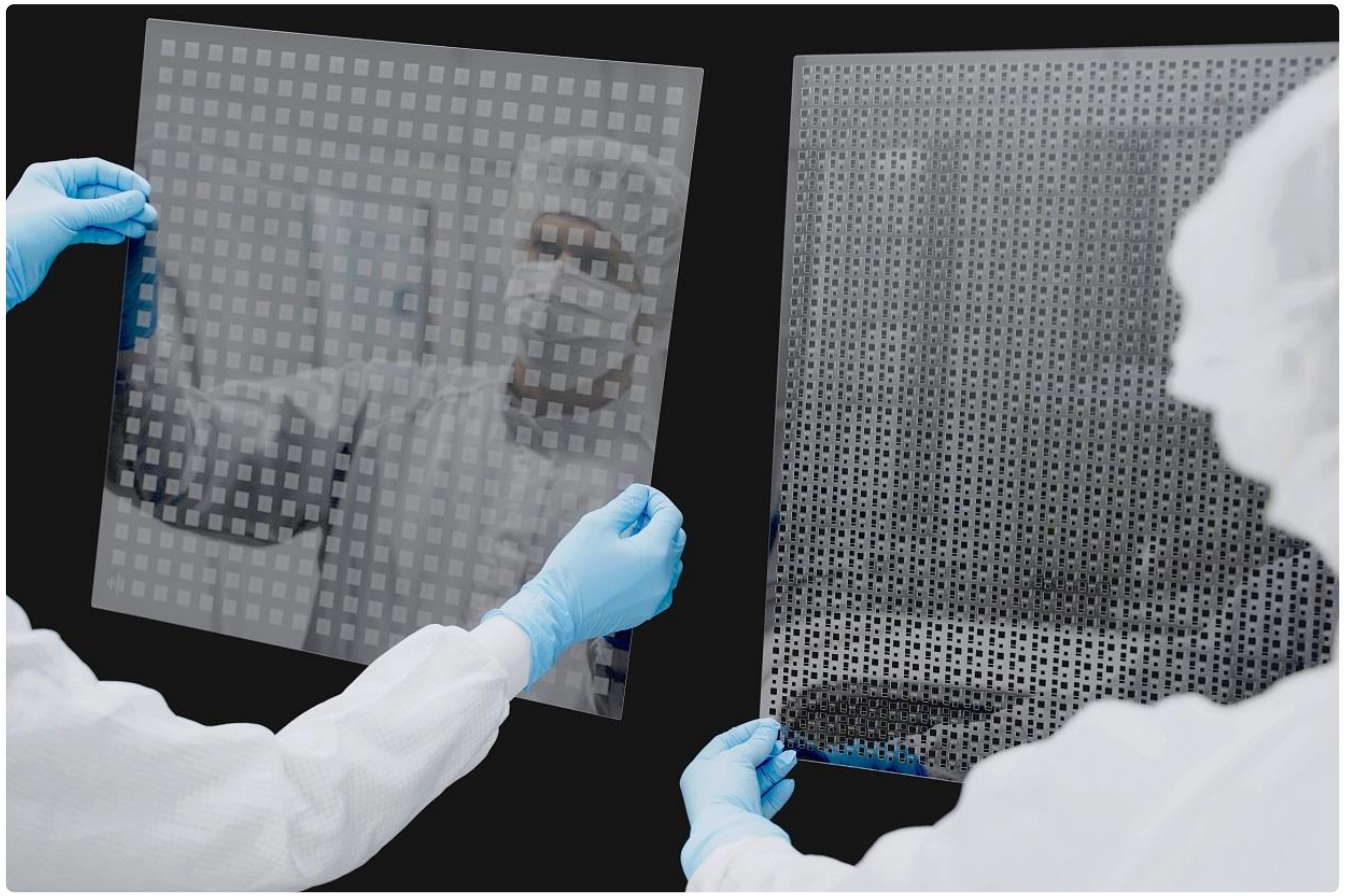
Laser Induced Deep Etching (LIDE®)

Key aspects

- Defect-free
- Any glass, any vendor
- Wafer format: any up to 12” (300 mm)
- Panel format: any up to 510 mm x 515 mm
- Aspect-ratios: typical 1:10 (max. 1:50)
- Glass thickness: up to 1 mm
- Smallest feature size: 10 µm



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Cost of LIDE®

- LIDE throughput and, consequently, cost, depends on the layout (design to manufacturing)
- For high-quality, defect-free, high accuracy micro features, LIDE is the technology with the lowest manufacturing cost
- LIDE enables the widespread use of glass as a core material in new applications and as a substitute for others, in all industries

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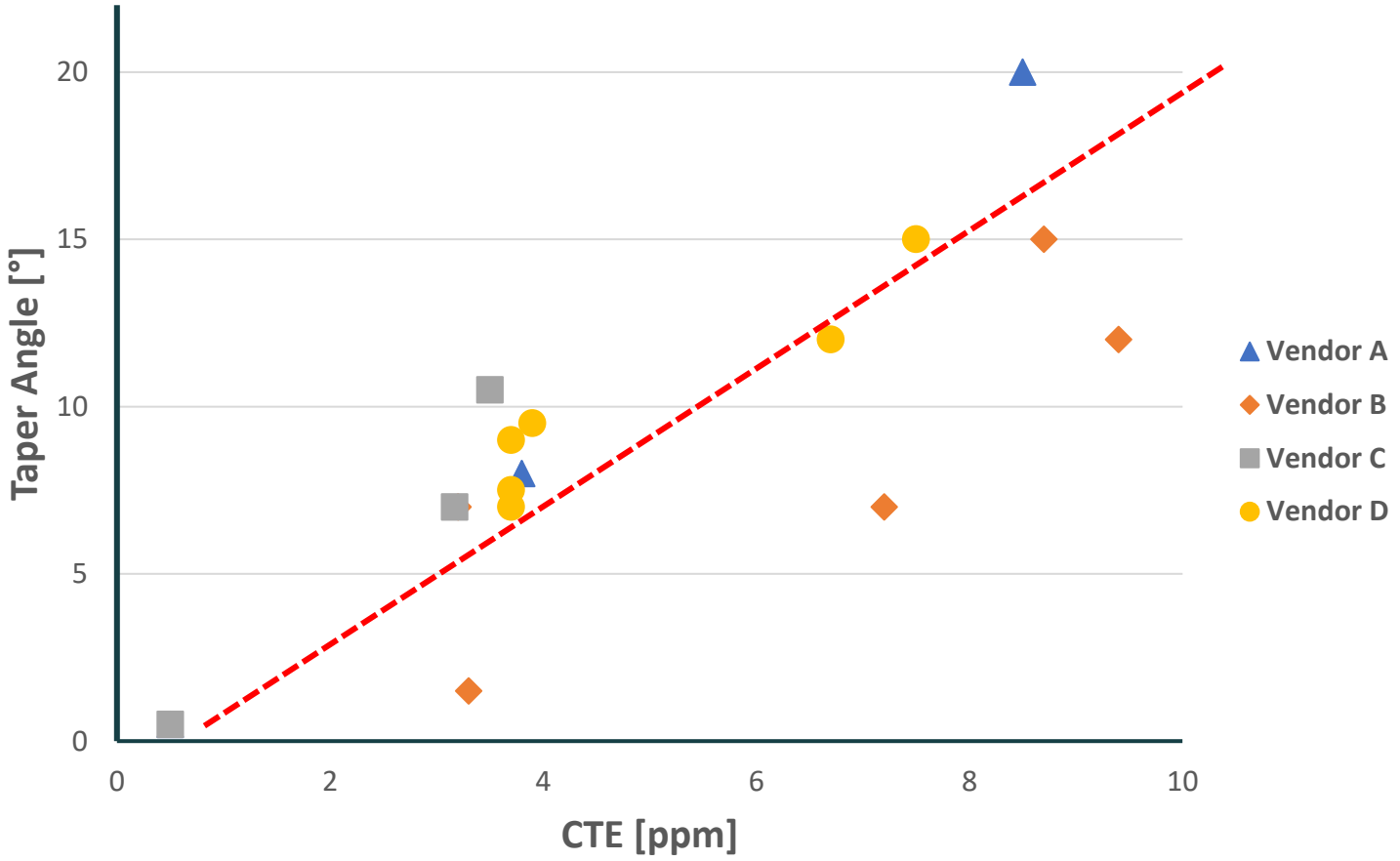
Outlook for LIDE®

Today:

All glass types can be processed, however, there's a correlation between the taper angle and the CTE of the glass



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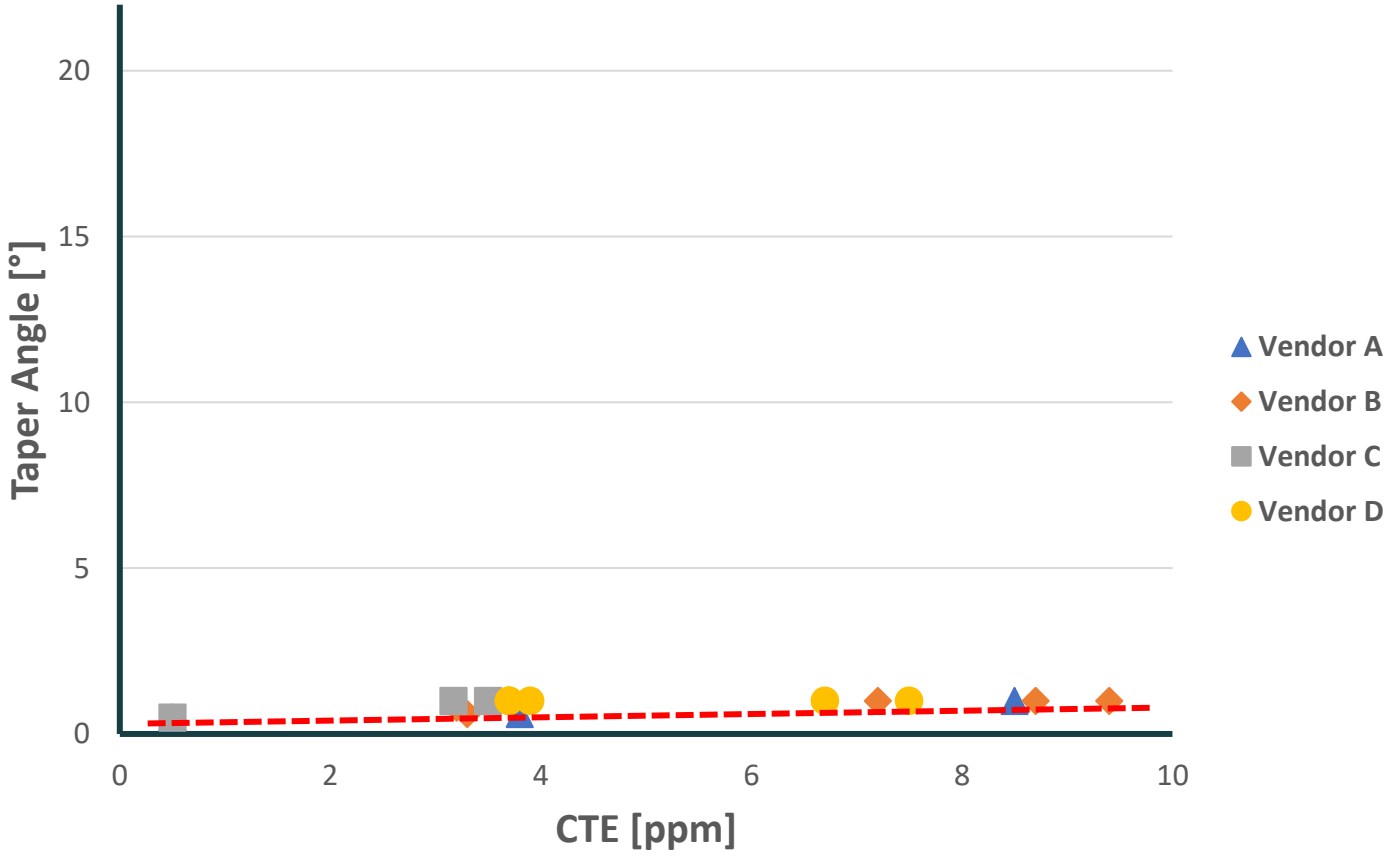
Outlook for LIDE®

Soon:

~1° taper angle possible for any glass type

“Any glass, any vendor, any taper angle”



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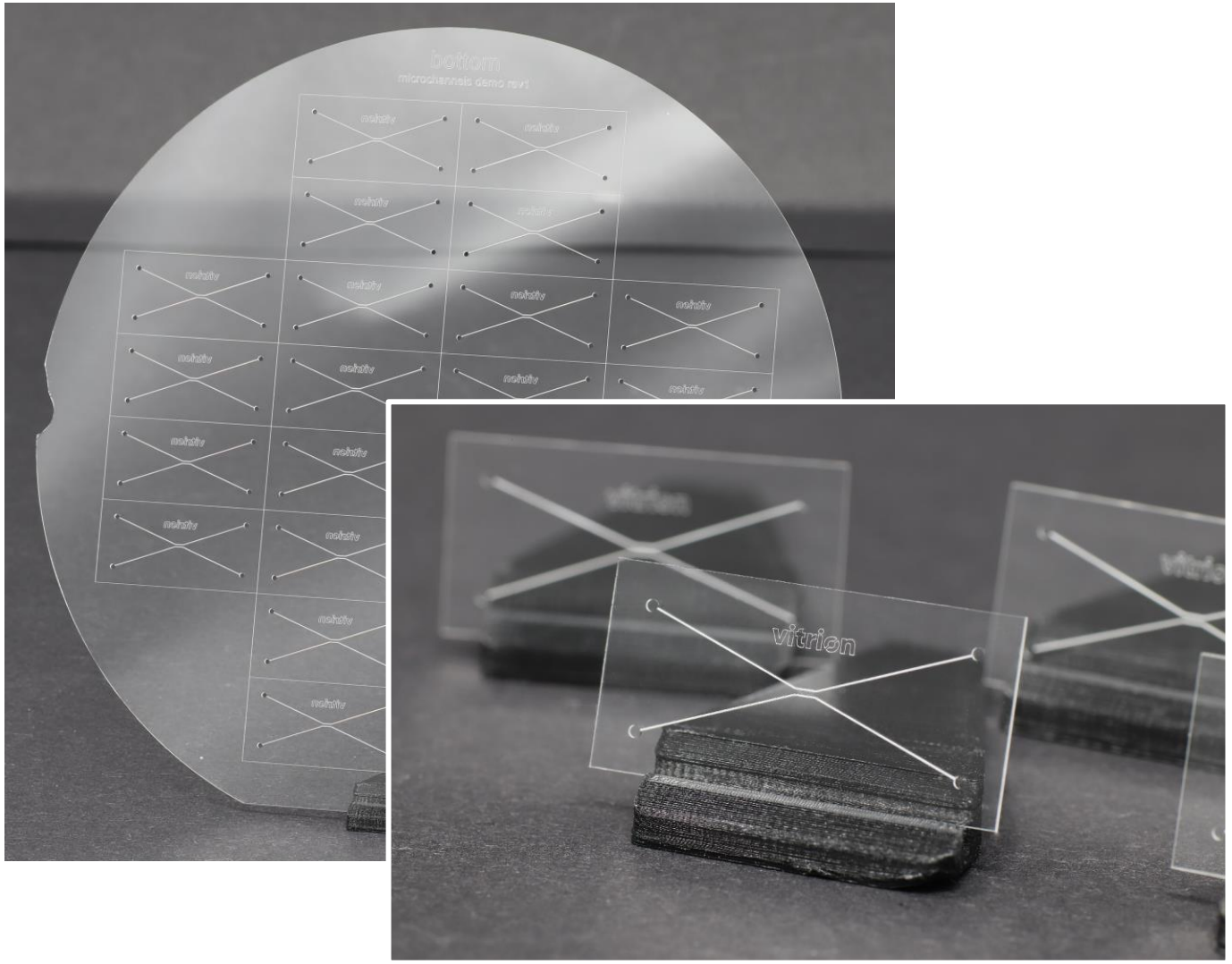
Outlook for LIDE ®

Already established:

- Small-volume PDMS Bonding as R&D tool and for low-cost applications

Soon:

- Glass Fusion Bonding for high-spec applications



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LIDE® technology – Business Model

LIDE

Laser Induced Deep Etching

Foundry Service

LIDE Laser Tools

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