Advancing Semiconductor Packaging

The Role of LIDE Technology in Enhanced Glass Micro-Processing for More than TGV

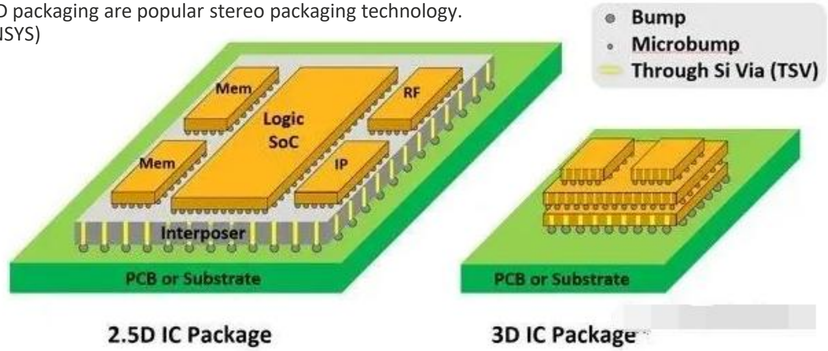
04.03.2025 | Richard Noack

ADVANCED PACKAGING: HETEROGENIOUS INTEGRATION AND GLASS

HETEROGENIOUS INTEGRATION

- More performance per package
- lower power consumption
- reduced costs (less large/expensive silicon elements)
- Supply chain becomes more resilient (combination of different chiplet manufacturers and their strengths)

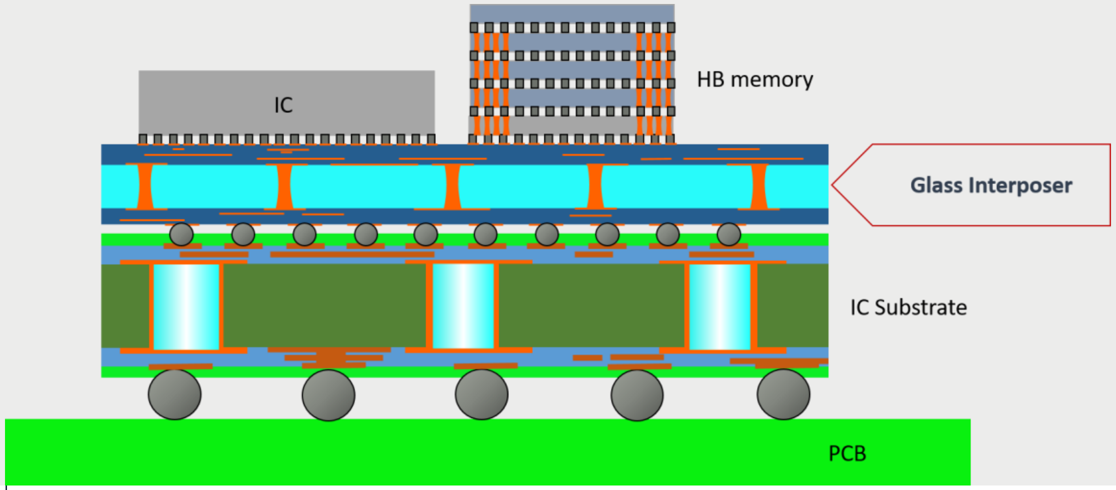
2.5D and 3D packaging are popular stereo packaging technology.
(Source: ANSYS)

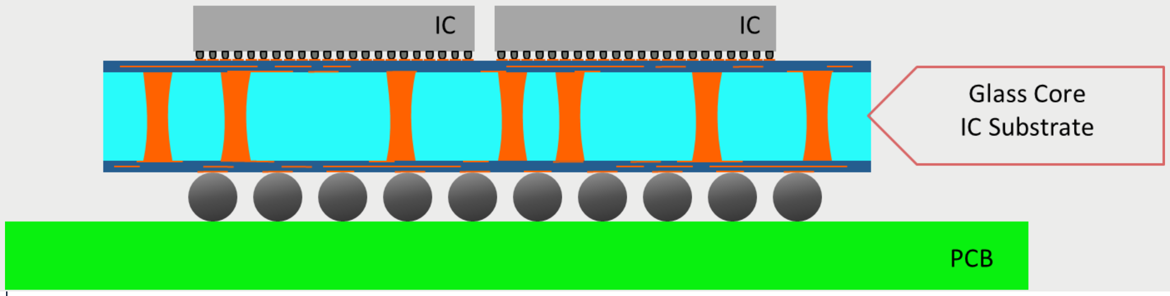


BENEFITS OF GLASS FOR SUBSTRATE AND INTERPOSER

- **Optical**
  - High transparency
  - Low fluorescence
- **Chemical and mechanical**
  - High chemical resistance and chemically inert
  - Isotropic
  - Good mechanical stability
  - Low thermal expansion
  - Tunable coefficient of thermal expansion
- **Electrical**
  - Perfect isolator
  - Low insertion loss
  - Smooth surface enabling fine-line lithography

GLASS SUBSTRATE: GLASS INTERPOSER AND GLASS CORE SUBSTRATE

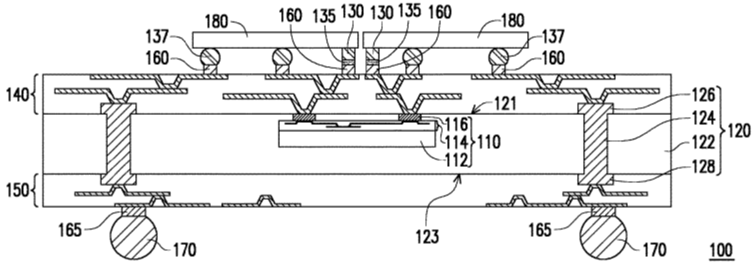


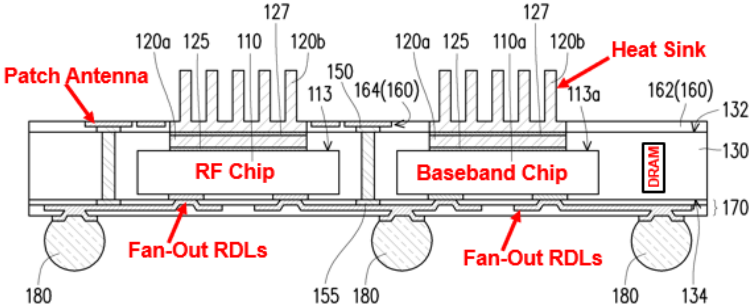


- Glass CTE≈3
- Typical thickness: 400 µm
- Goal: replace costly large area silicon interposer
- Trend towards smaller diameter, thinner substrates
- Highest demand on reliability, cleanliness and process reliability
- Enables scaling to larger packages

- Glass CTE≈7
- Typical thickness: 800 µm
- Core layer must feature higher via densities than organic core to make an additional interposer obsolete
- Enables scaling to larger packages

SUBSTRATE AND MICRO STRUCTURE FOR ADVANCED PACKAGING AND HI





Blind Cavity	Through Cavity	Blind Cavity with Thermal Vias	Through Glass Vias	Glass Substrate

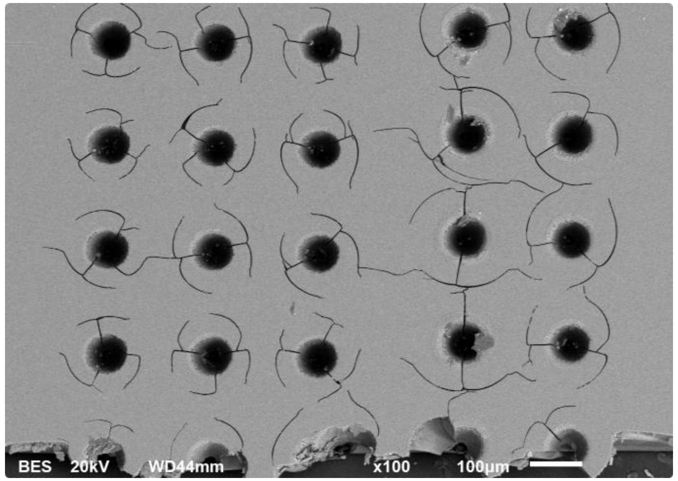
Beside TGV open and closed cavity structures their free combination is required in Advanced Packaging and HI.

MISSING MATURE GLASS PROCESSING METHODS

CONVENTIONAL LASER GLASS PROCESSING

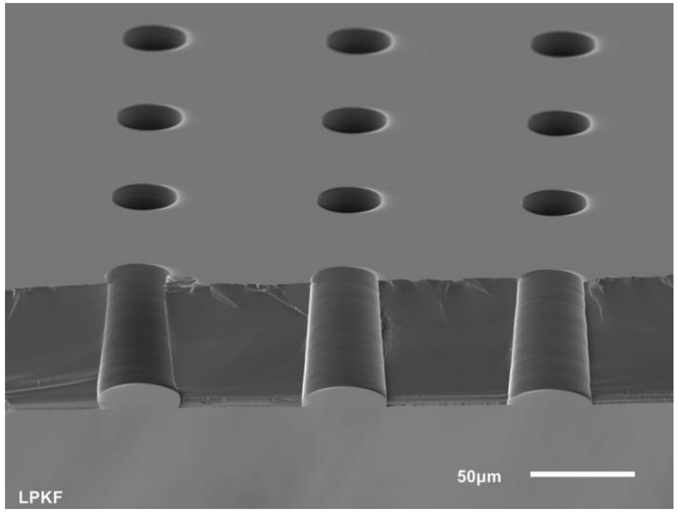
Conventional glass processing limits the application of glass due to:

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



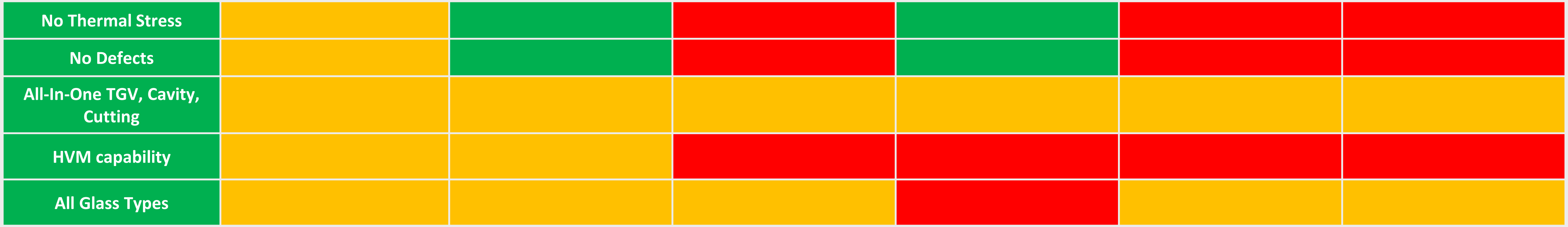
NEEDED PROPERTIES

- Defect free processing
- Highly accurate
- Industrial scalable
- Cost effective
- Glass manufacturer independent
- Downstream process compatible



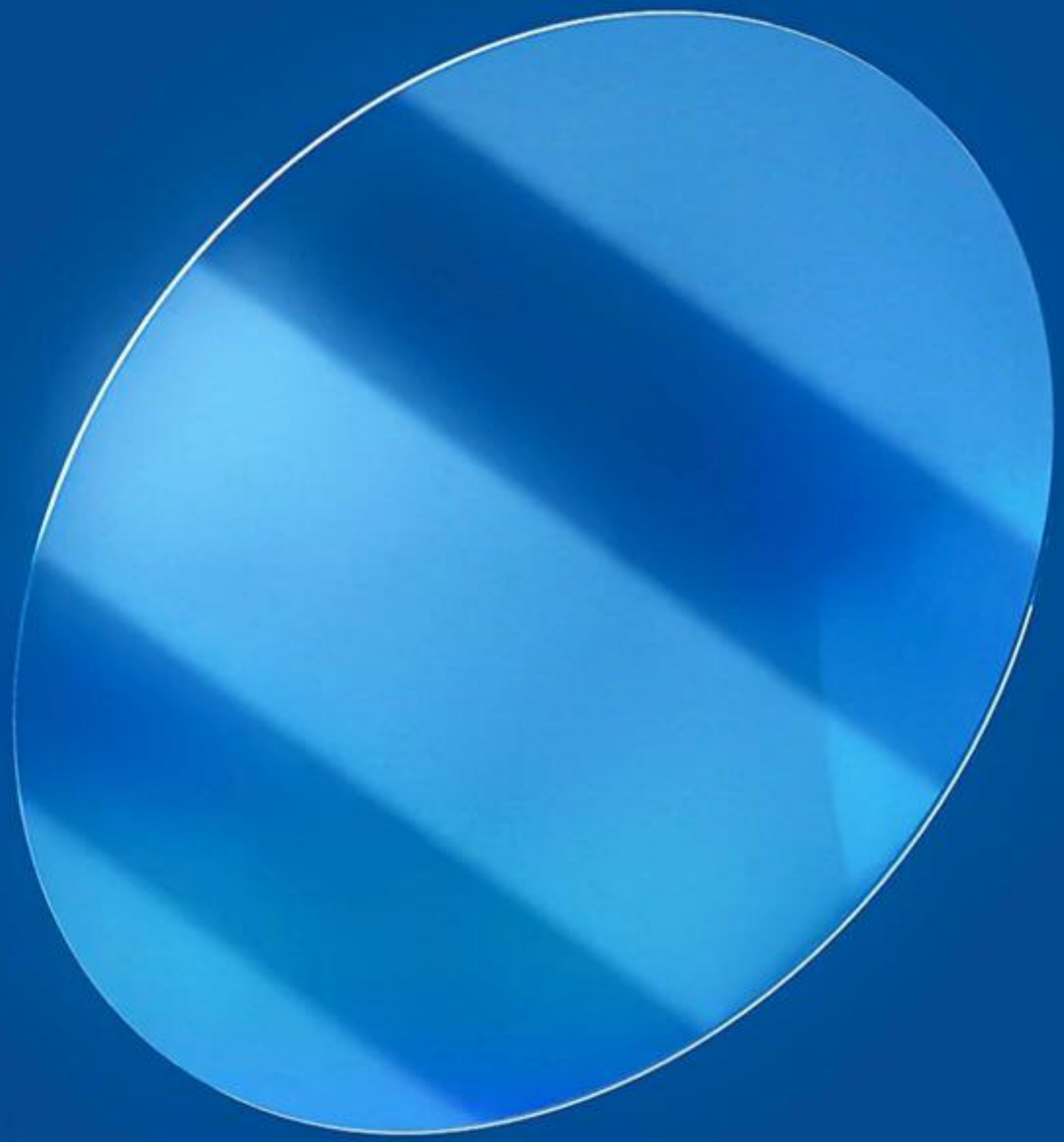
COMPARISON OF DIFFERENT GLASS PROCESSING TECHNOLOGIES

LIDE	Laser + Wet Etch	Lithography + Dry Etch	Laser only	Photo Sensitive Glass	**Hot Pressing**	Mechanical Drilling
Glass	Glass	Glass	Glass	Glass	Glass	Glass
↓	↓	↓	↓	↓	↓	↓
Laser modification	Laser	Mask Lithography	Electrical Discharge	Mask & Expose UV	Hot Pressung	Mechanical Drilling
↓	↓	↓	↓	↓	↓	↓
Wet Etch	Wet Etch	Dry Etch (RIE)	CO_2 Laser	Bake (Form Ceramic)	Etching	Etching (Optional)
↓	↓	↓	↓	↓	↓	↓
Wash	Wash	Strip & Wash	Wash	Etch & Wash	Wash	Wash

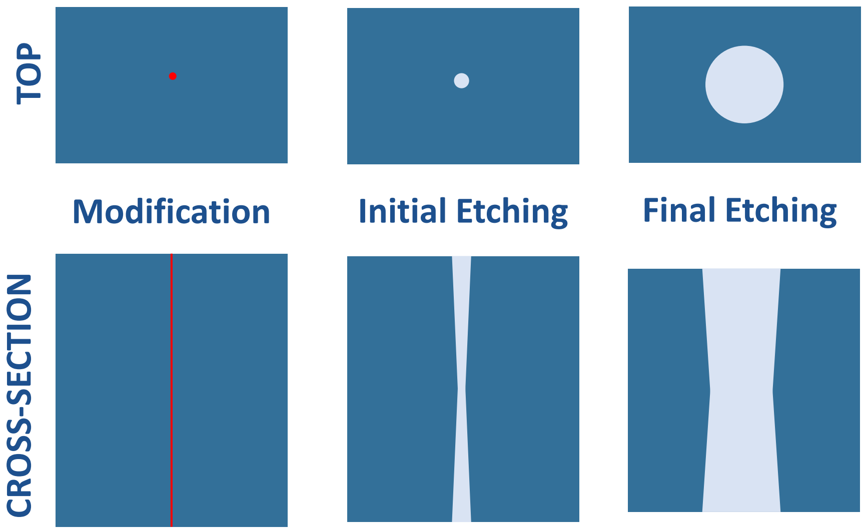


No Thermal Stress	🟨	🟩	🟥	🟩	🟥	🟥
No Defects	🟨	🟩	🟥	🟩	🟥	🟥
All-In-One TGV, Cavity, Cutting	🟨	🟨	🟨	🟨	🟨	🟨
HVM capability	🟨	🟨	🟥	🟥	🟥	🟥
All Glass Types	🟨	🟨	🟨	🟥	🟨	🟨

Technologically LIDE is the superior process to generate microstructures in glass and provides the scalability necessary for HVM.

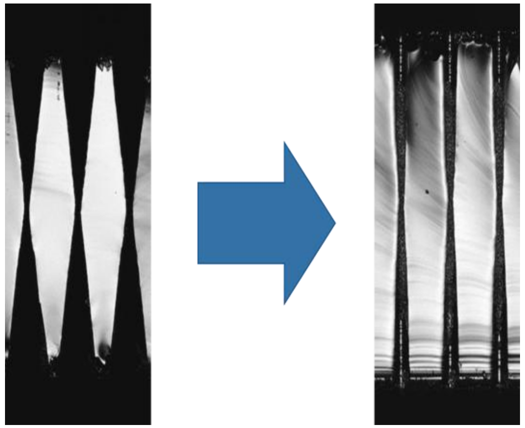


LIDE – LASER INDUCED DEEP ETCHING

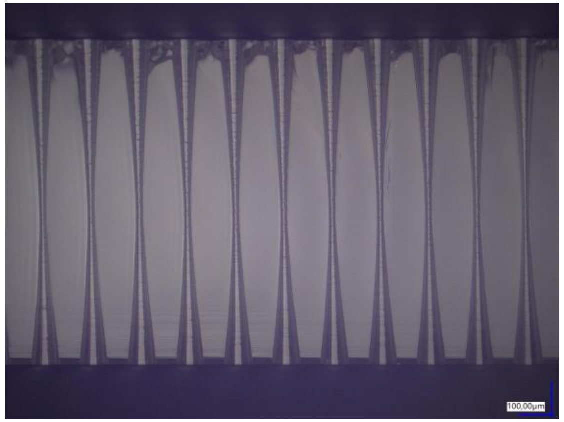


In the **first step**, glass of **up to 1mm** can be structured by a **single laser pulse**. Pulse positioning accuracy is > 5 µm Cp > 1,33.

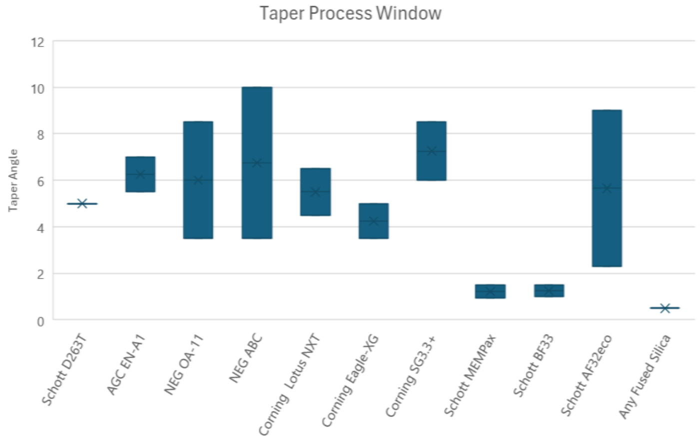
In the **second step**, the laser structured substrates are wet etched. The laser-modified regions display a much higher etch rate than the bulk material **anisotropic etching** along the modification. The result is the formation of hourglass shaped holes with a tunable taper.



Corning SG3.5 same laser parameter different etching conditions



SCHOTT BF33 1000 µm Thickness



LIDE generates highly accurate and defect free microstructures in glass in a cost-effective manner.

TGV SIDEWALL ROUGHNESS IS UNDER INVESTIGATION

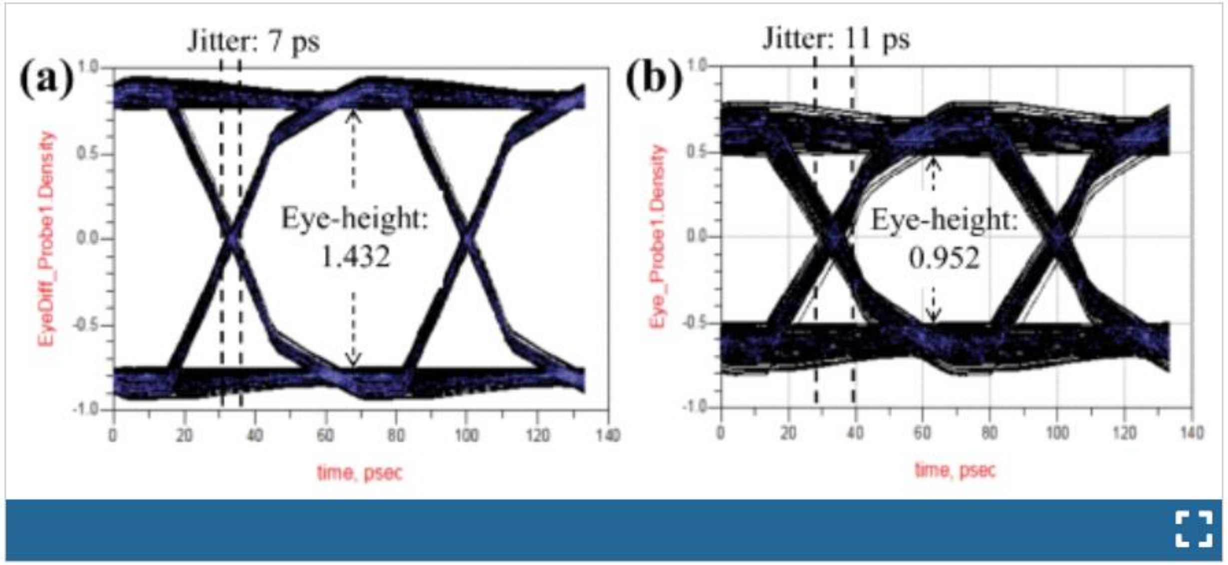


Fig. 2.

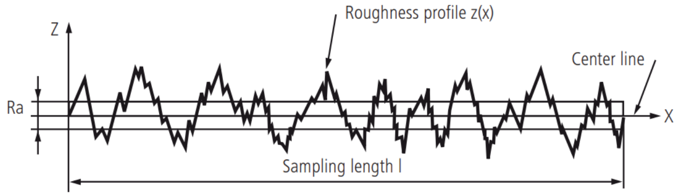
Eye diagrams corresponding to different sidewall roughness simulation results at 15 Gb/s: (a) 0.025 μm and (b) 0.8 μm .

Z. Fang et al., "Derivation and Analysis of a Hemispherical Physical Model and the Correction Factors for the Sidewall Roughness of Through-Glass Vias," in IEEE Transactions on Microwave Theory and Techniques, vol. 72, no. 7, pp. 3908-3919, July 2024

Ra Mean roughness
(DIN EN ISO 4287, ASME B46.1)

Ra is the arithmetic mean average of all ordinate values within the sampling length l.
Ra corresponds to the terms AA (arithmetic average) and CLA (center line average).

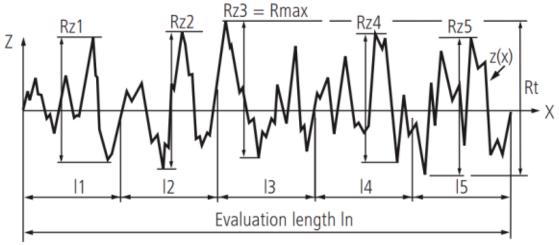
$$Ra = \frac{1}{l}\int_{0}^{l}|z(x)|dx$$



Rz mean roughness depth; roughness depth Rt (DIN EN ISO 4287 ASME B46.1)

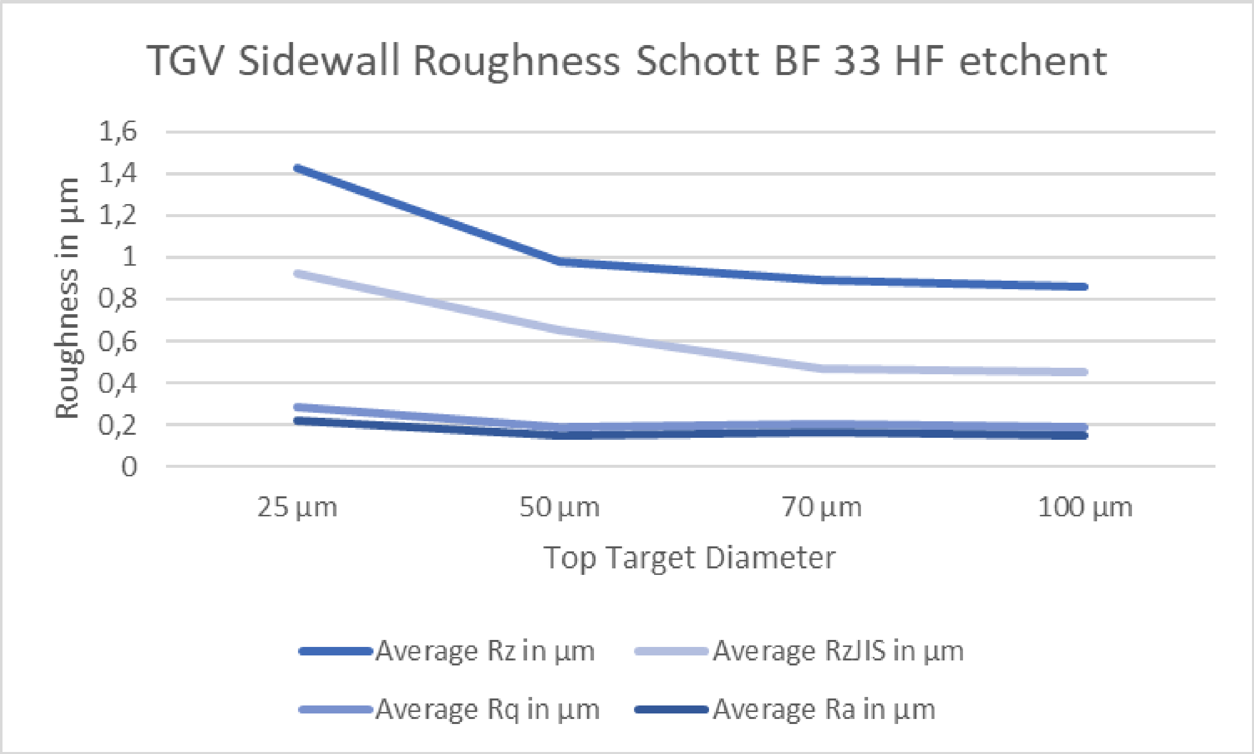
Rz corresponds to the arithmetic average of the single roughness depths of all sampling lengths.

$$Rz = \frac{1}{n}(Rz1 + Rz2 + \ldots + Rzn)$$

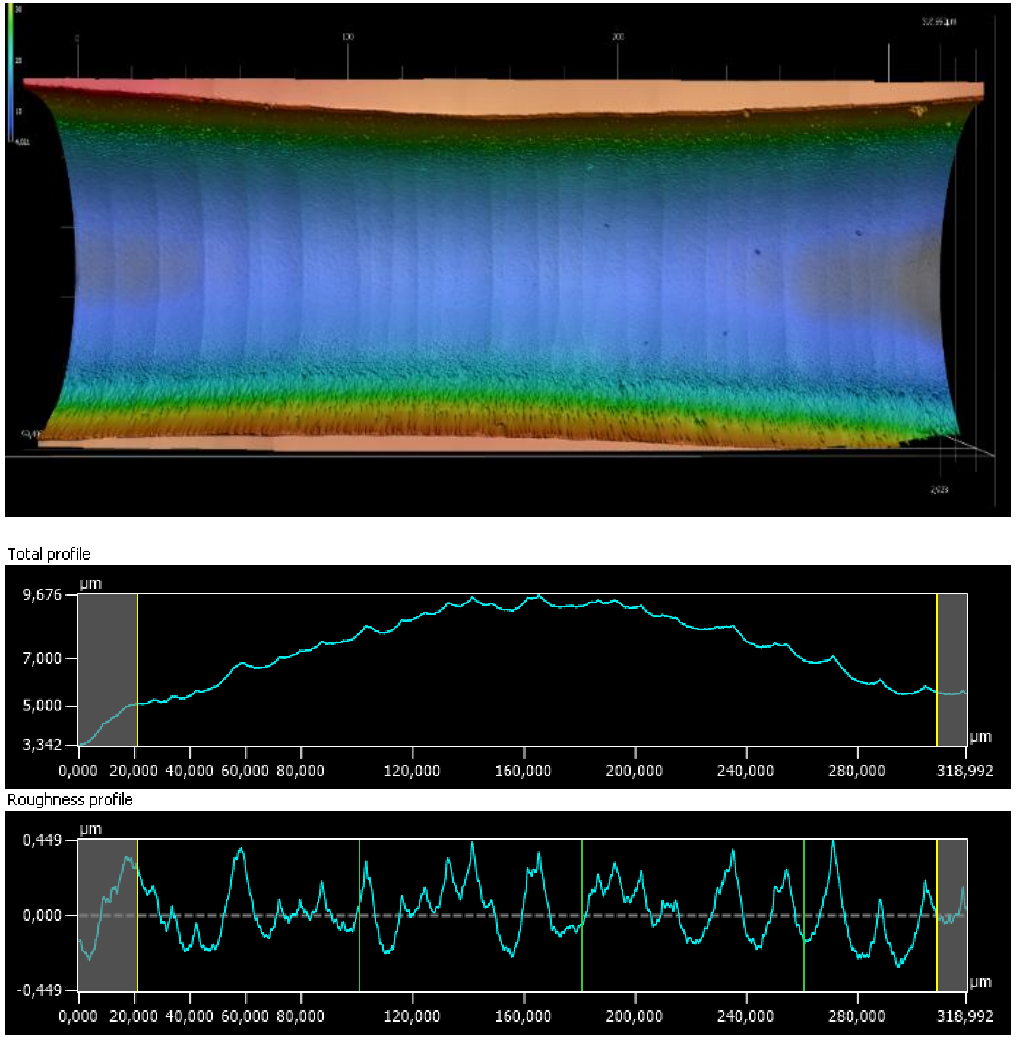


Carl Zeiss – Surface Parameter

THROUGH GLASS VIA SIDEWALL ROUGHNESS DEVELOPMENT

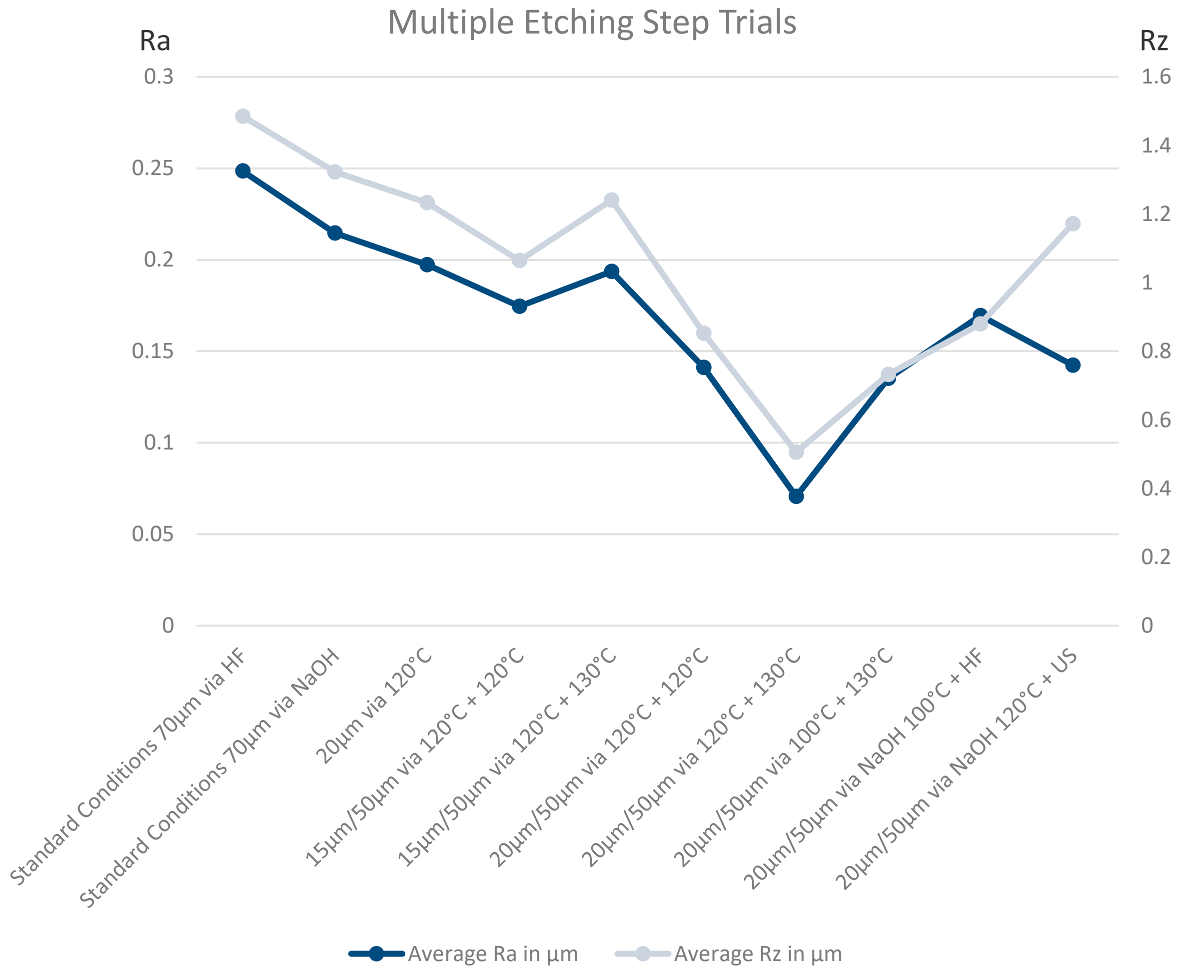


TGV sidewall roughness measurement results for HF etched Schott BF 33

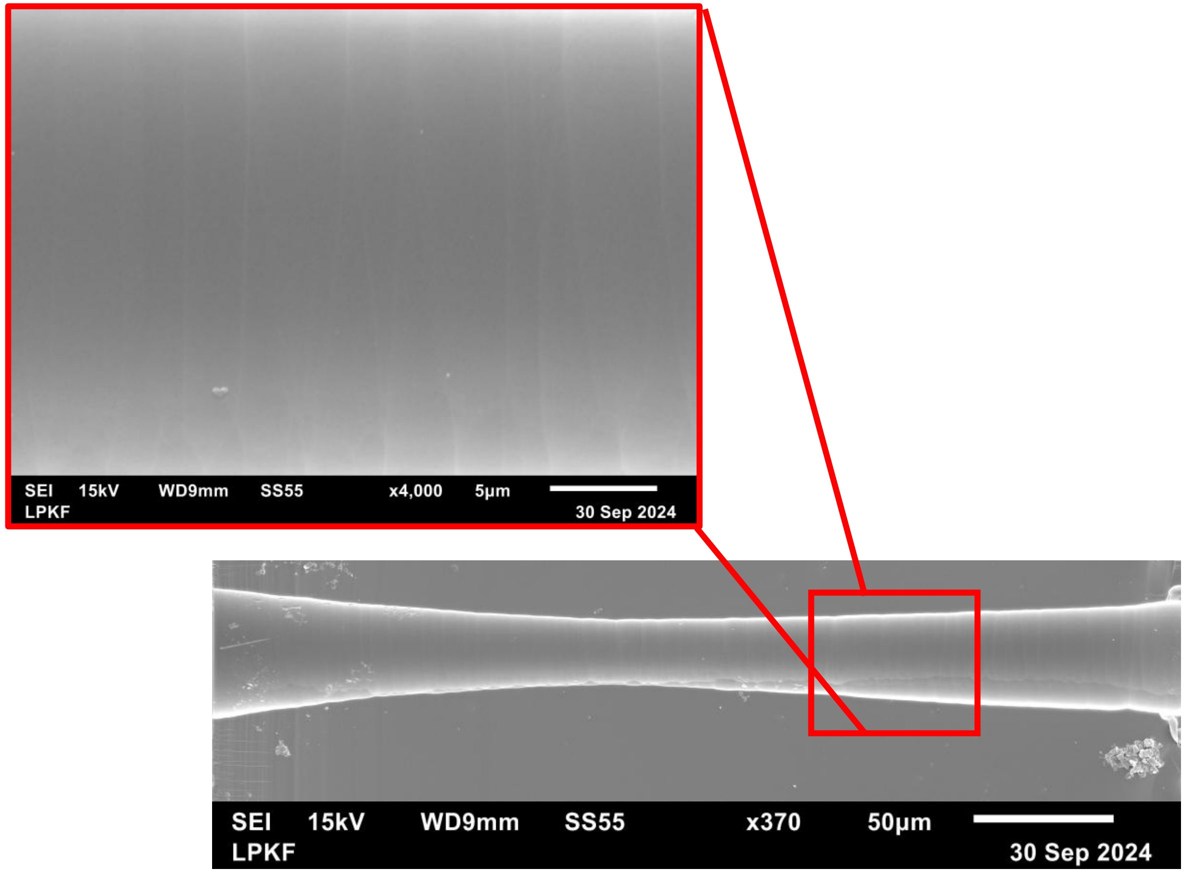


Keyence VK-X3000 WLI 20x cross section image of a TGV produced with LIDE in Schott BF 33 with a top diameter of 100 µm

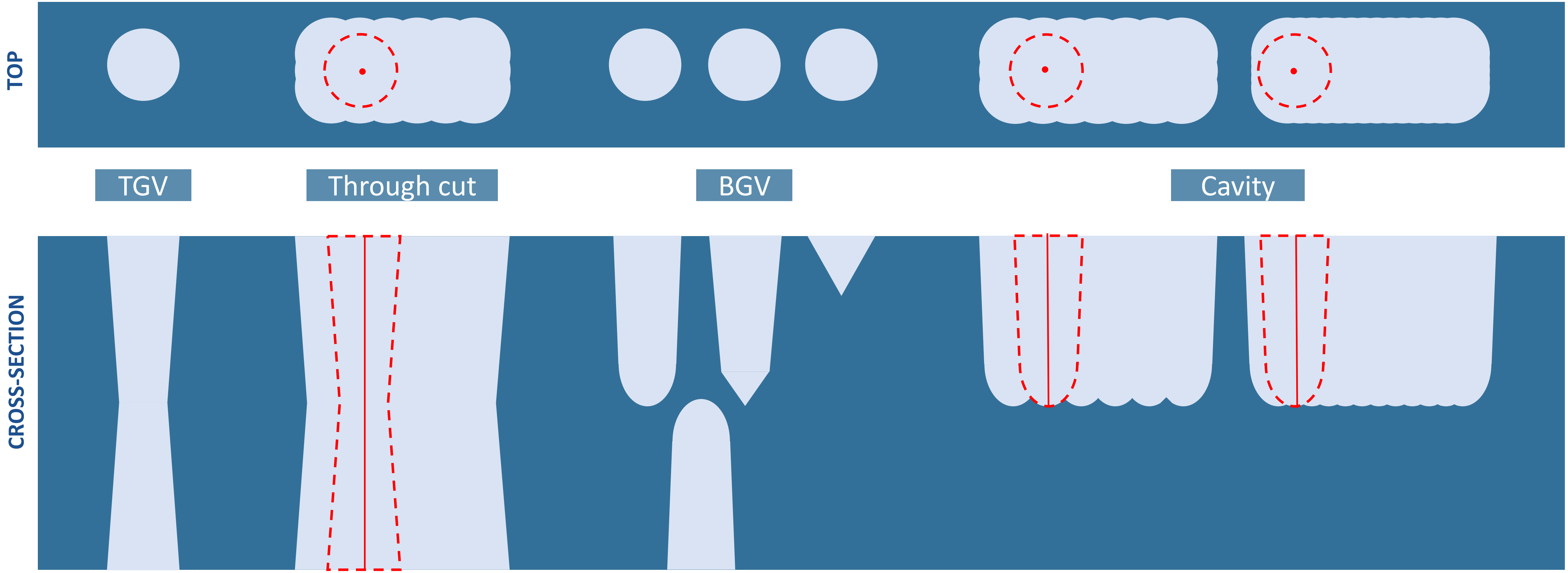
TGV SIDEWALL ROUGHNESS IS A RESULT OF ETCHING CAPABILITIES



SCHOTT AF 32 ECO SEM IMAGE OF A TGV SIDEWALL 20/50 VIA 120°C + 130°C



„MORE THAN TGV“ DEFECT FREE GLASS PROCESSING

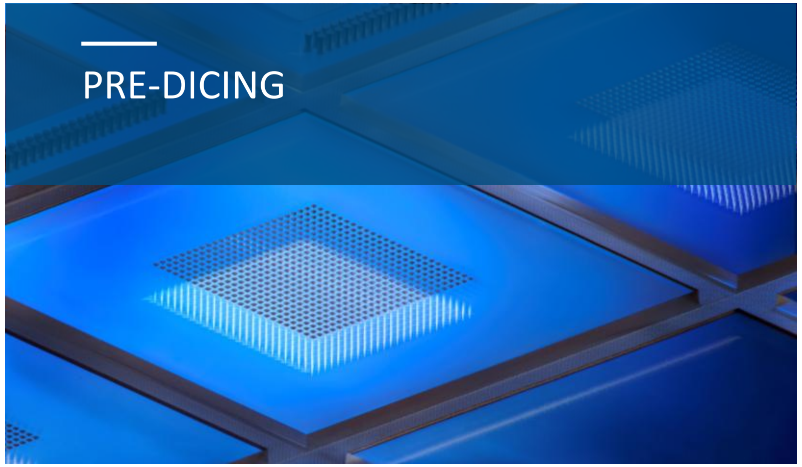


Parameters

TGV	Through cut	BGV	Cavity
Diameter	Surface geometry Surface dimensions	Diameter Depth Taper angle Bottom geometry	Surface geometry Surface dimensions Depth Bottom geometry

MORE THAN TGV

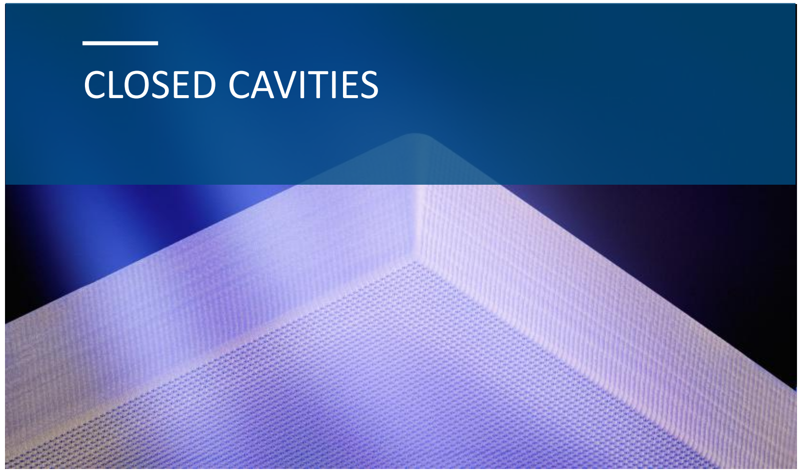
EMBEDDING



PRE-DICING

MICROFLUIDICS

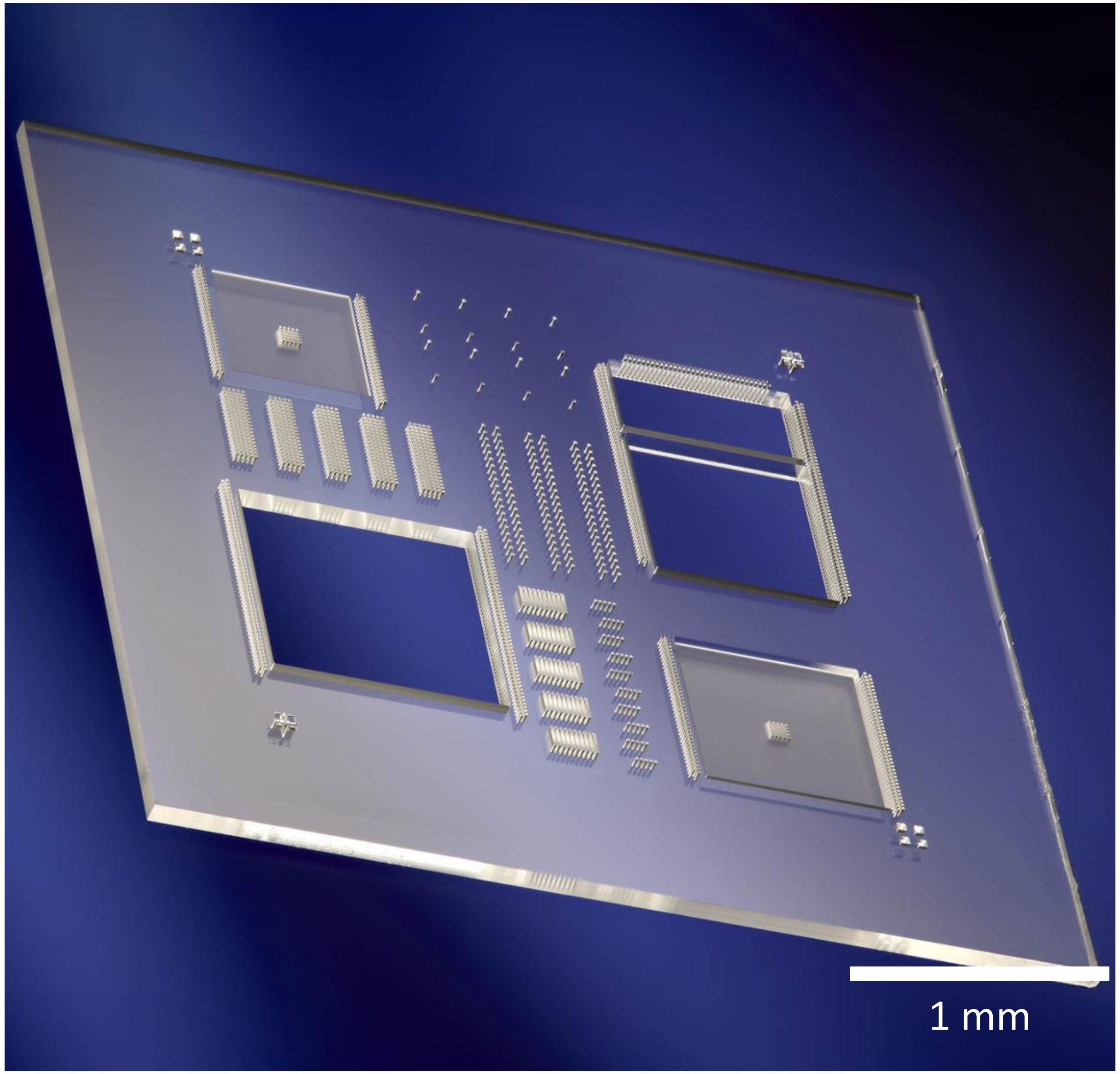
DENSE VIA FORMATION

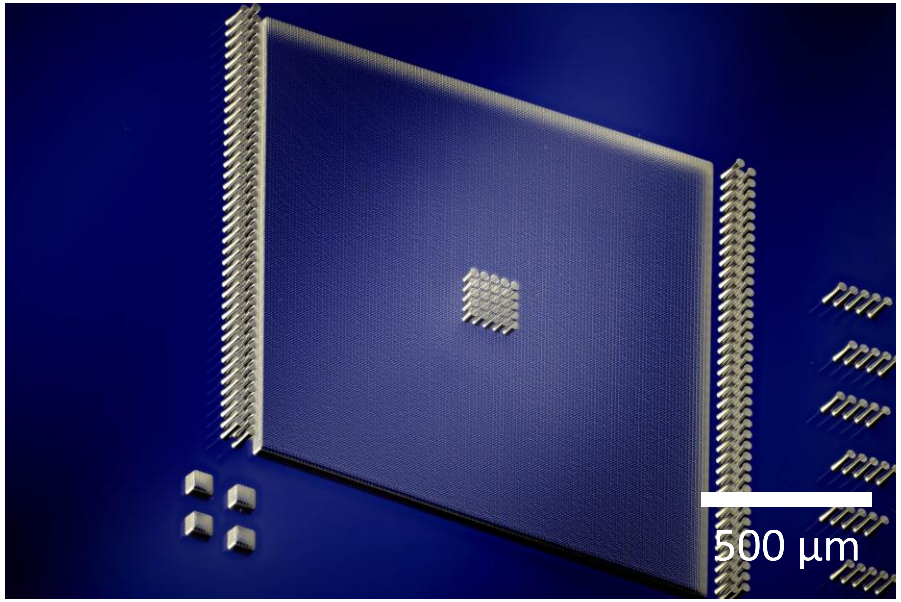


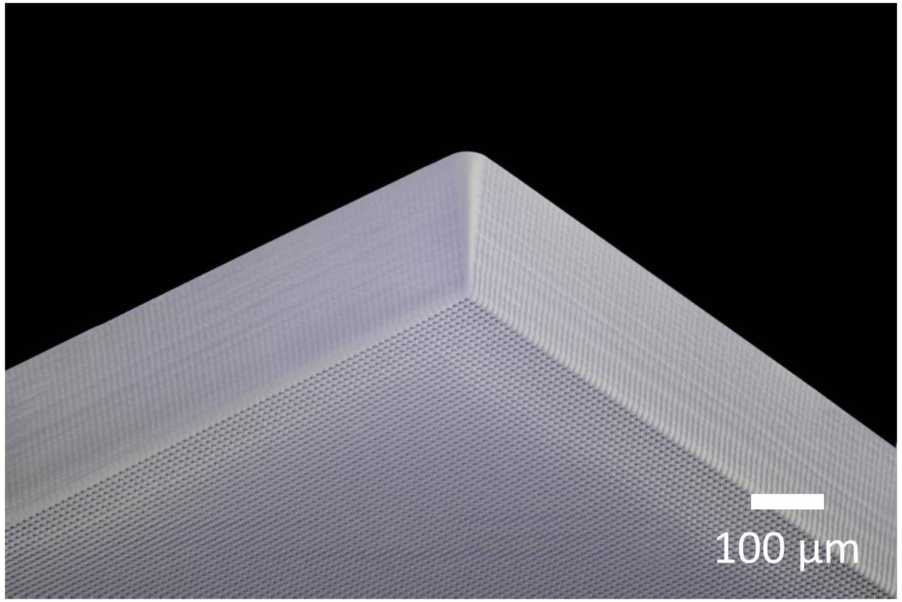
CLOSED CAVITIES

THERMAL MANAGEMENT

ALL IN ONE: TGV, BGV, THROUGHCUTS, CAVITIES

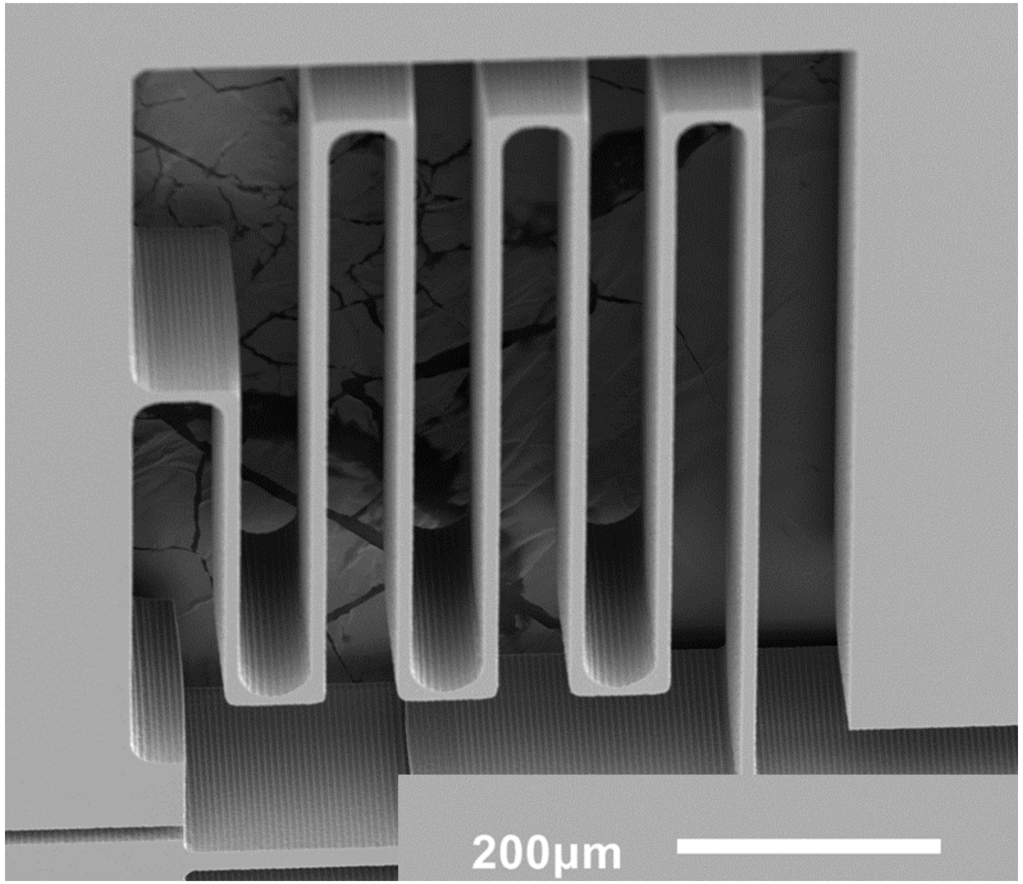


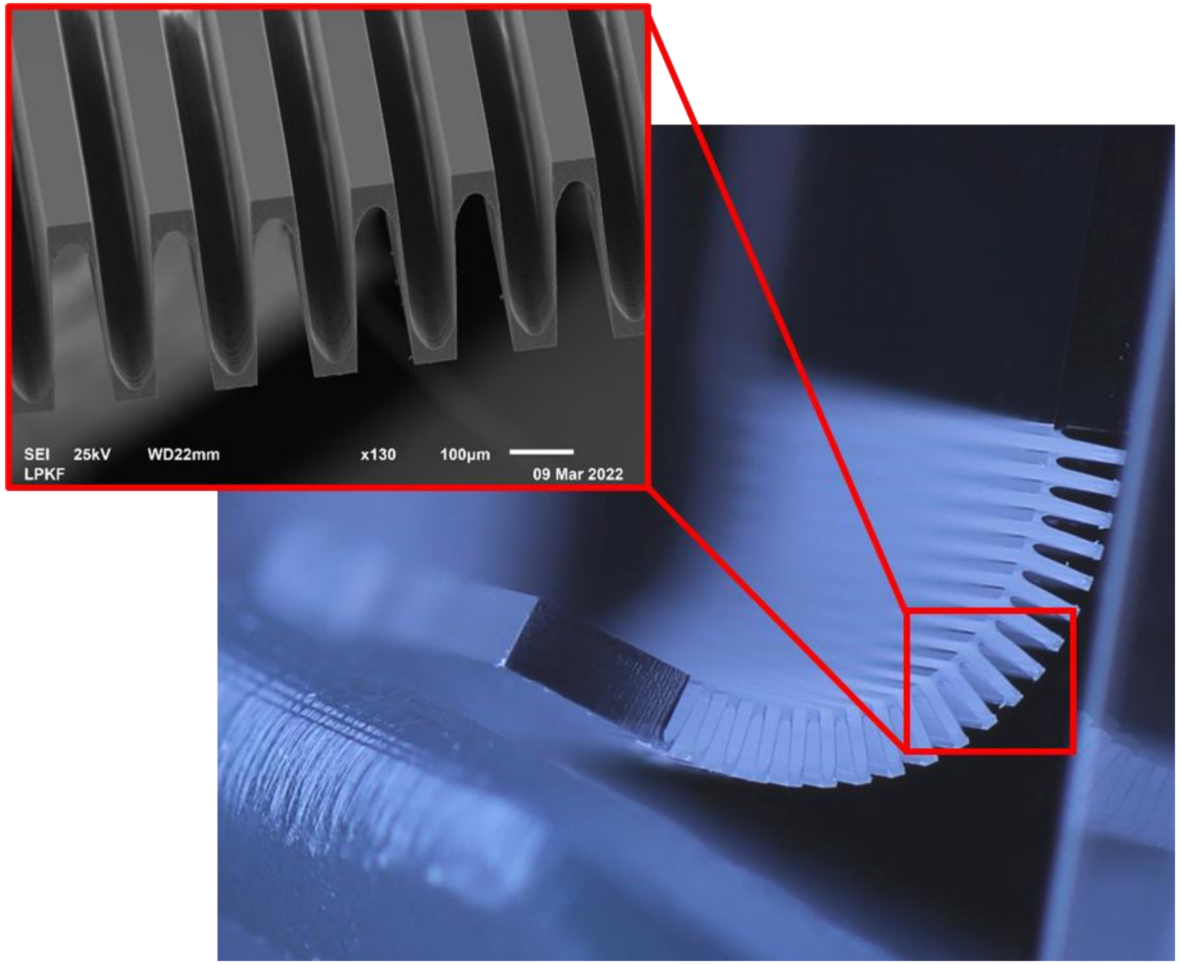




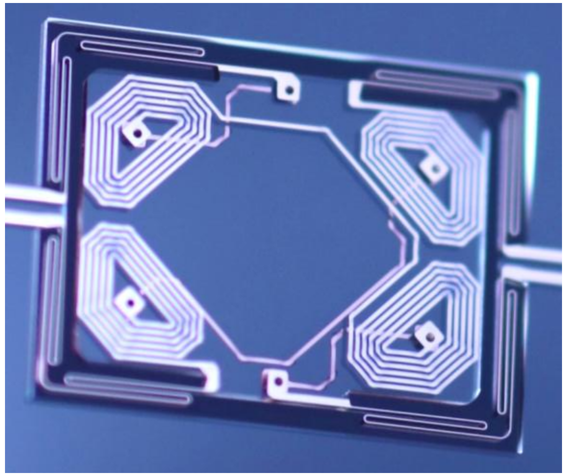
HIGHLY FLEXIBLE MICRO SPRINGS

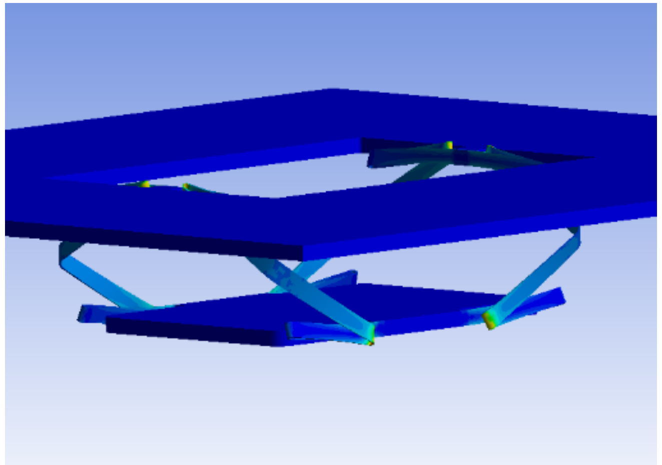
In-plane and out-of-plane meander structures

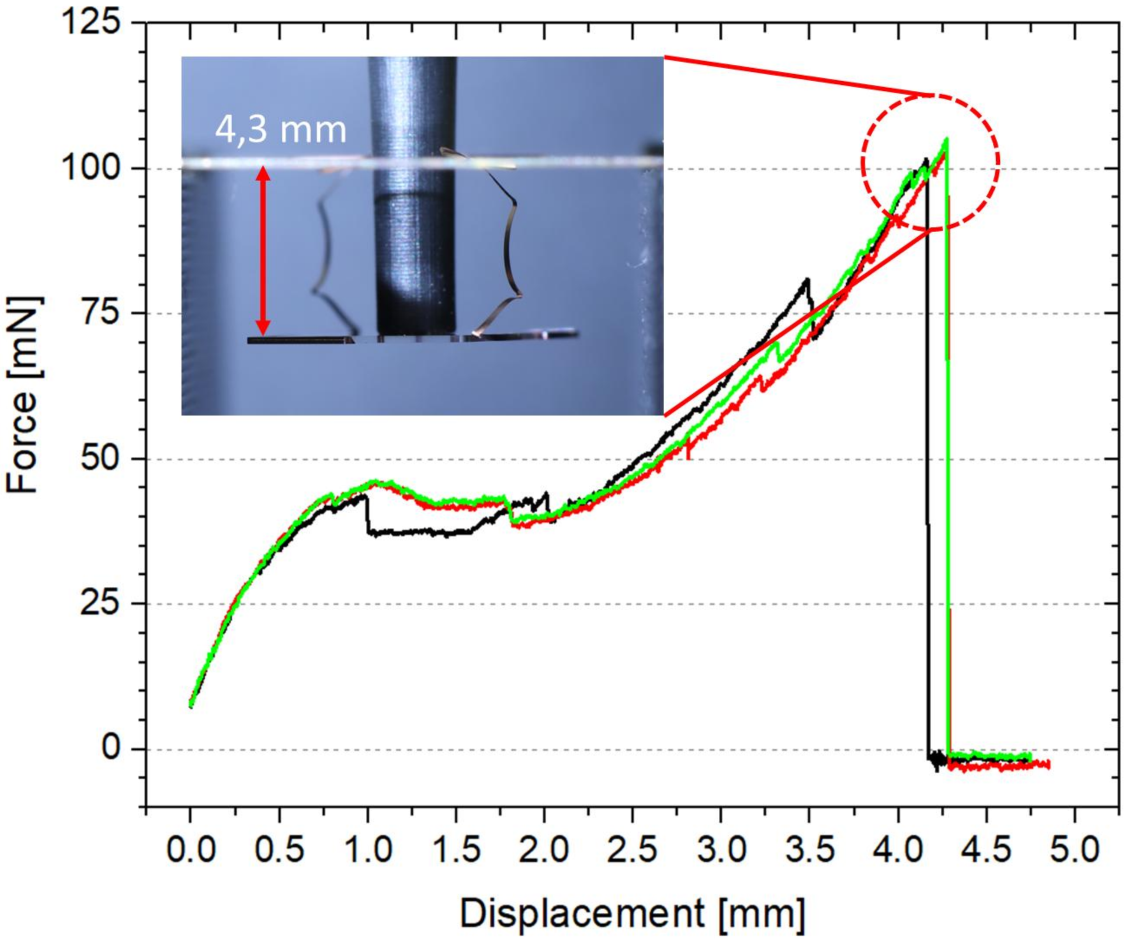




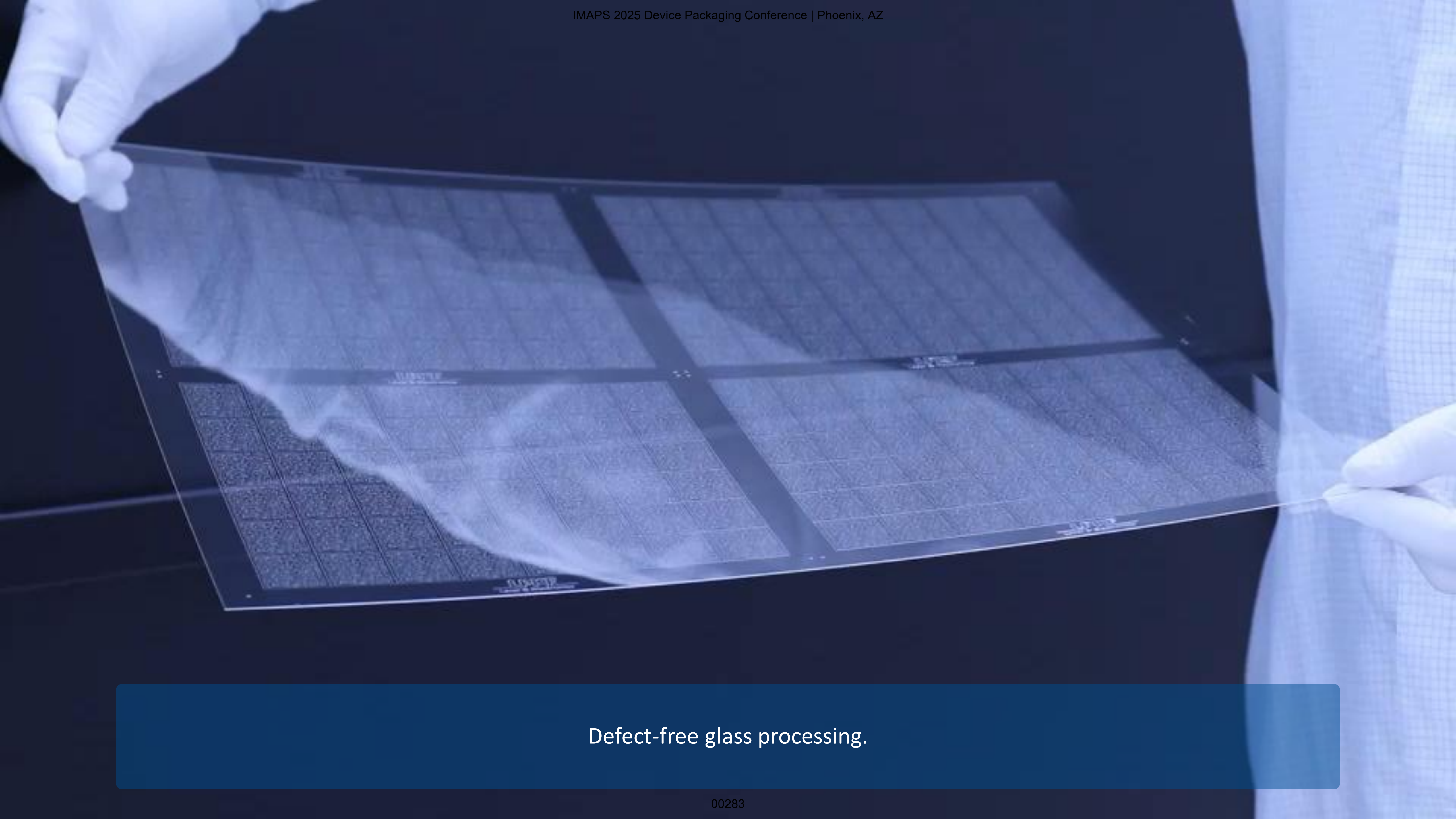
BREAKING STRENGTH





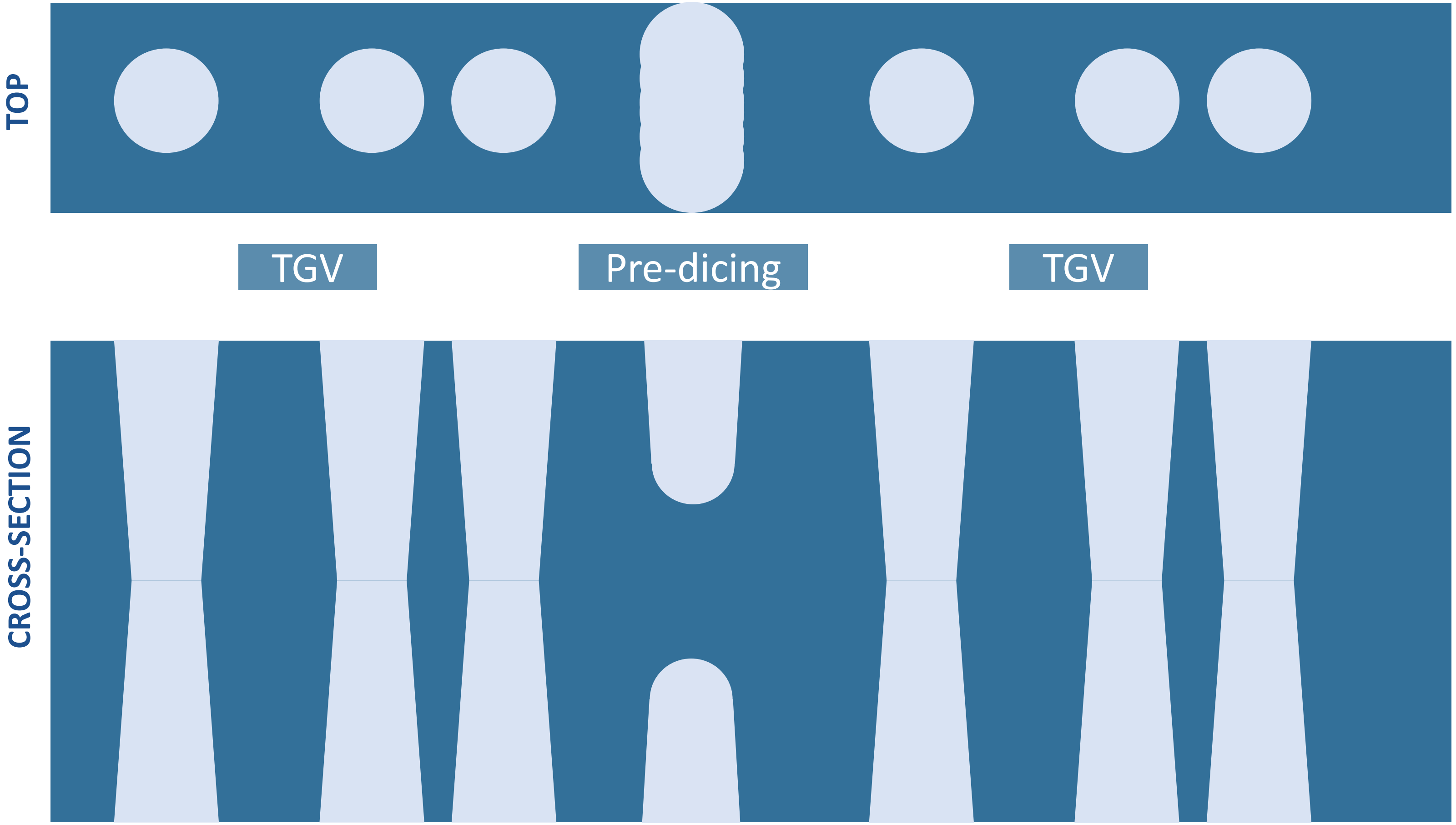


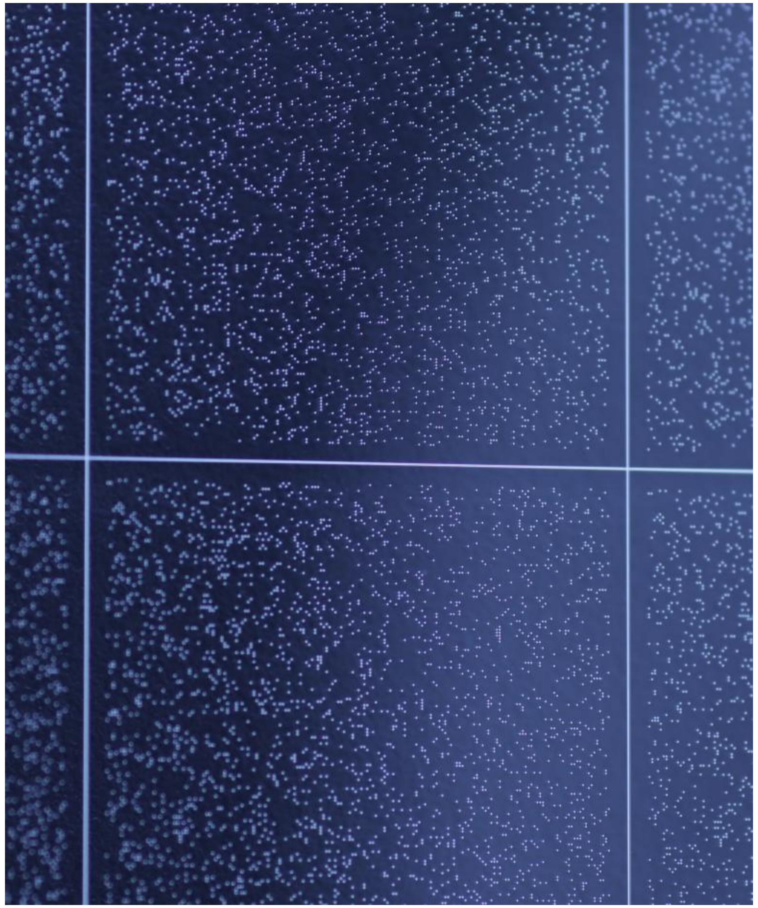
- X-Y-stage (5 mm × 7 mm) with 30 µm × 260 µm string cross-section
- Displacement of microsystem X-Y-stage in Z-direction of 4.3mm
- High repeatability, high breaking strength of ~1 GPa



Defect-free glass processing.

„MORE THAN TGV“



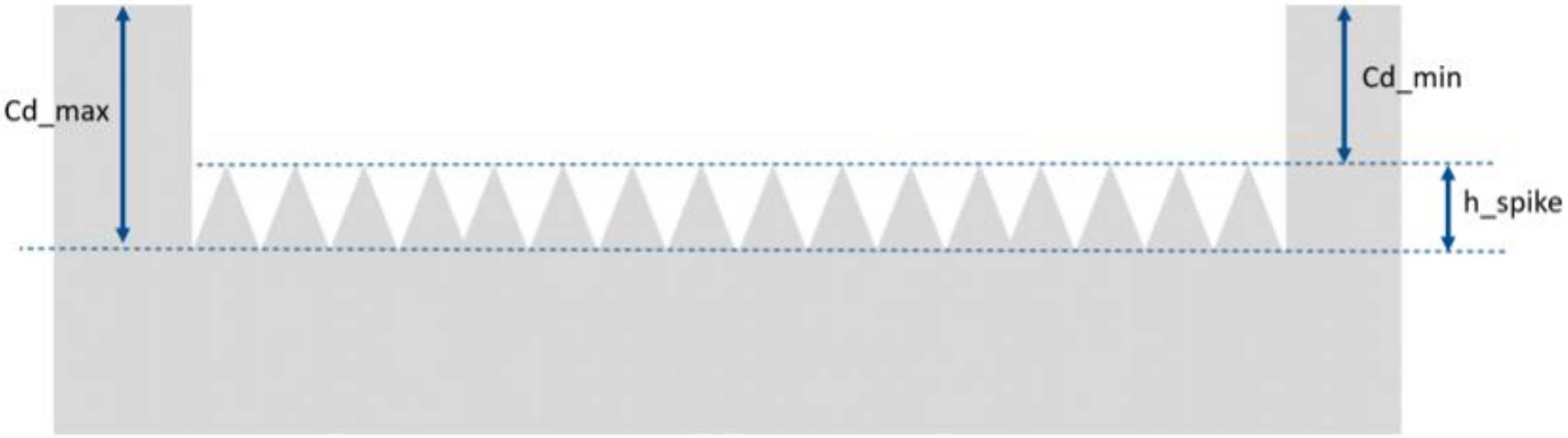


Parameters

- Diameter
- Puls Pitch > 5 µm

- Surface geometry
- Surface dimensions
- Depth
- Bottom geometry

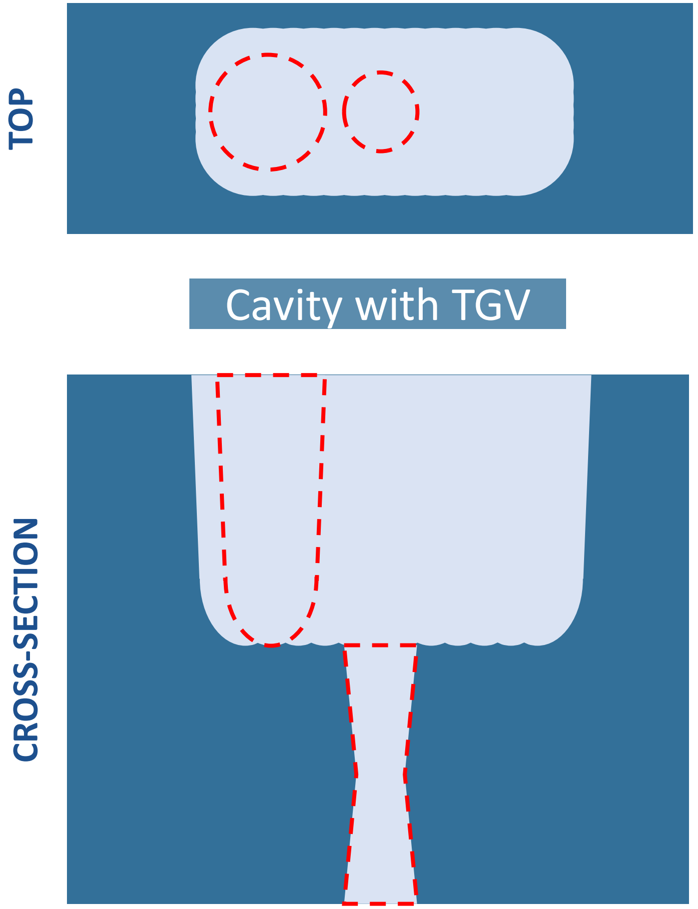
CAVITY BOTTOM CHARACTERISTICS CREATED BY LIDE

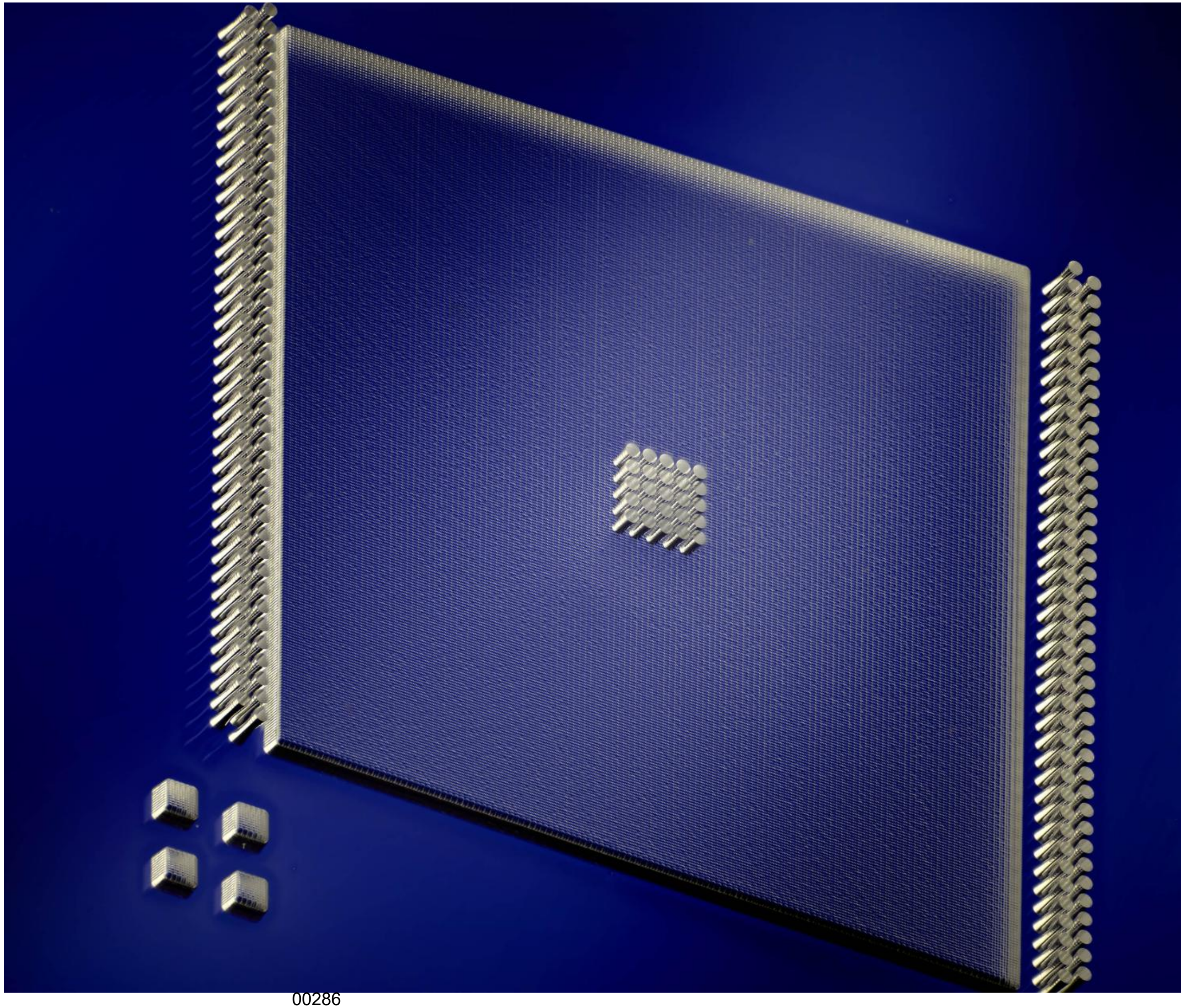


Influencing parameters are:

- Glass type
- Etchrate
- Target TGV top Diameter (etching time)
- Pulse Pitch

„MORE THAN TGV“



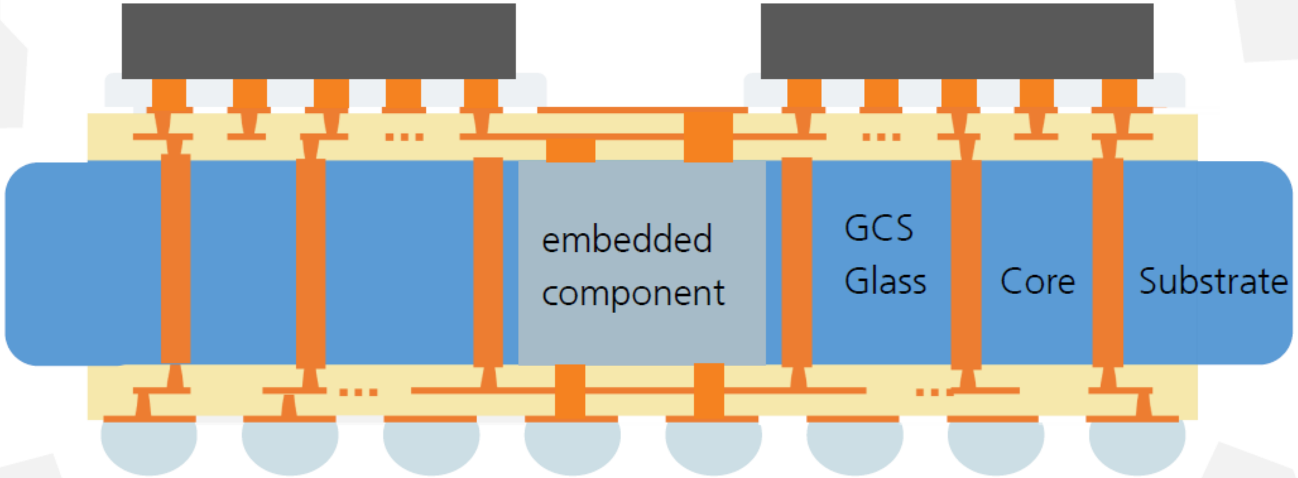


Parameters

- Surface geometry
- Surface dimensions
- Depth
- Bottom geometry
- Diameter

Glas Panel Technology Group (GPTG)

Long term vision



Precise manufacturing on large panel level scale

Progress on TTV, edge
& mechanical stability

economic benefits

homogenious
base material

new / advanced glass types

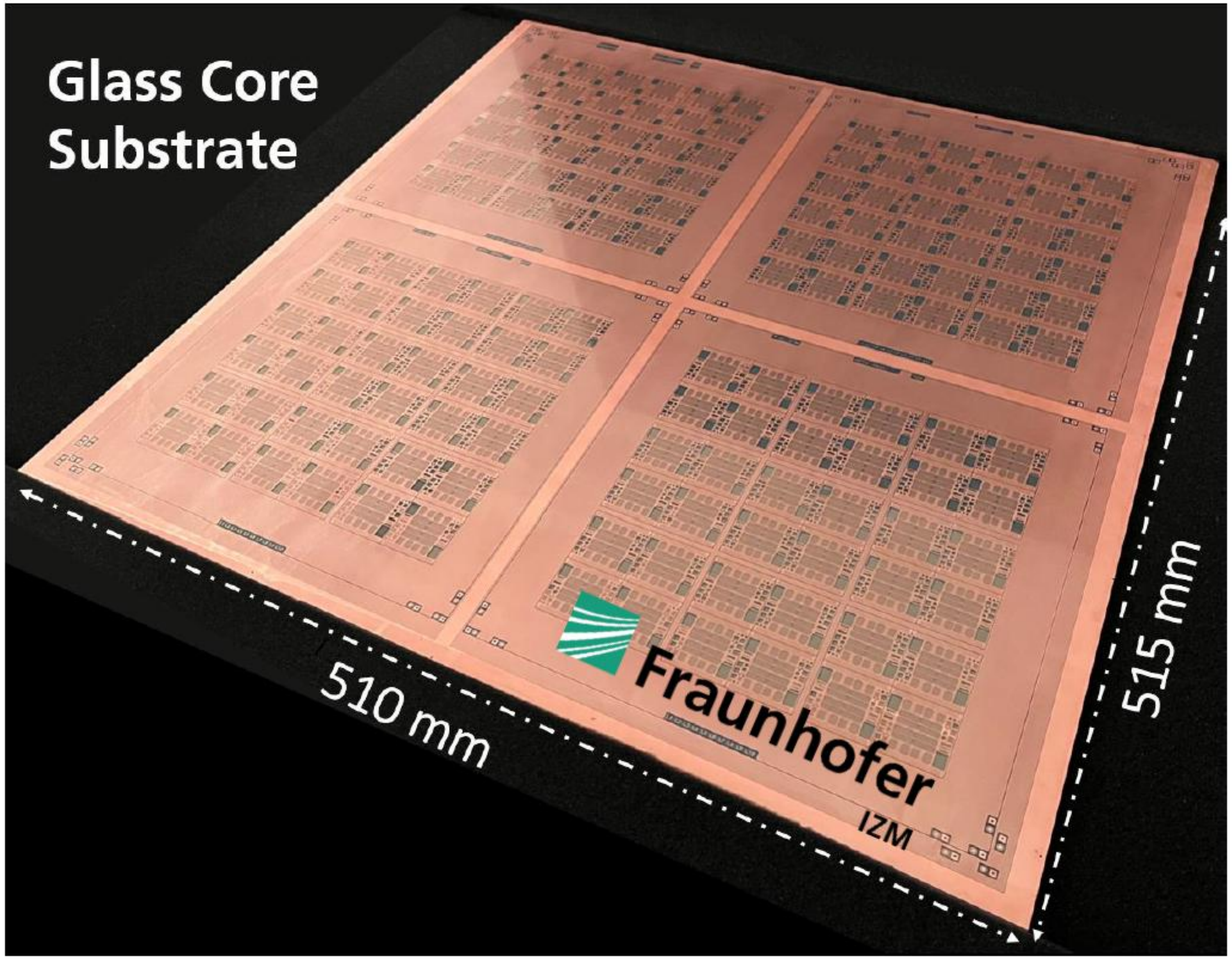
High interconnect density

CVD/PVD/CMP on panel level scale

embedded components

Glas Panel Technology Group (GPTG)

1st demo panel



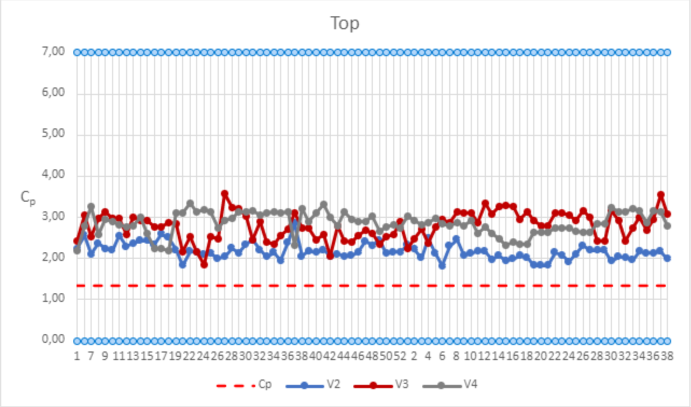
PROCESS CHAIN FOR GLASS CORE SUBSTRATE

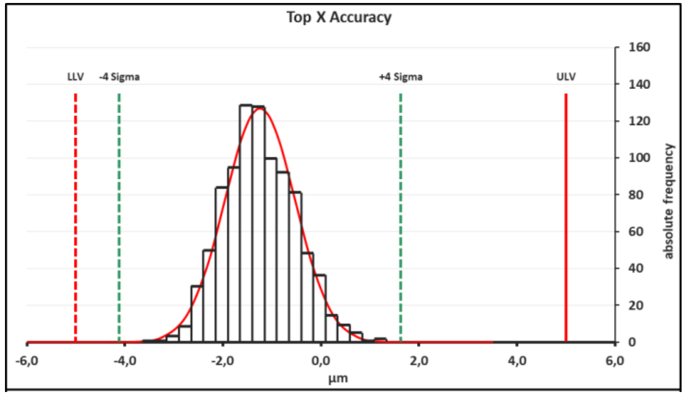
- Glass
- Laser
- Glass Etch
- TGV Metal Seed
- TGV Metal Plate

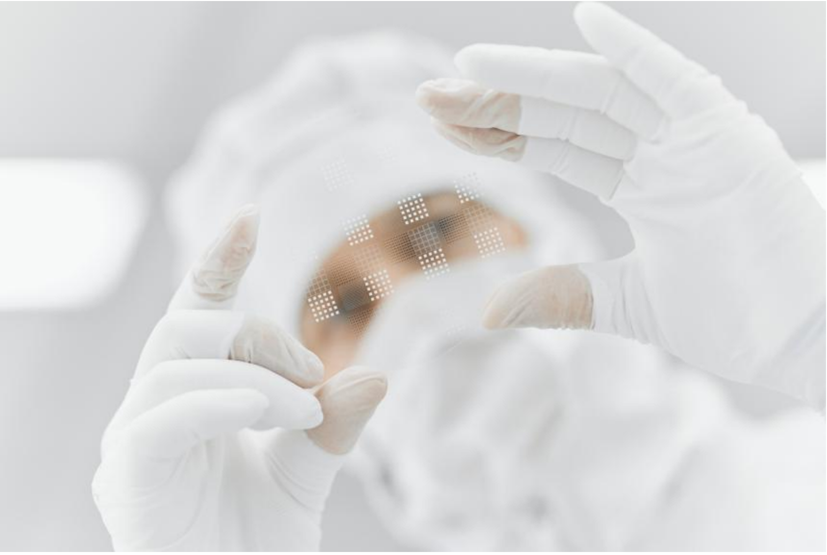
- Dielectric
- Via
- Cu seeding
- Cu plating
- Strip & Etch
- Repair

- Soldermask
- Surface finish
- Electrical test
- Singulation
- Assembly & Underfill
- Reliability testing

LPKF LIDE PROCESS EQUIPMENT: STABILITY BY MATURITY





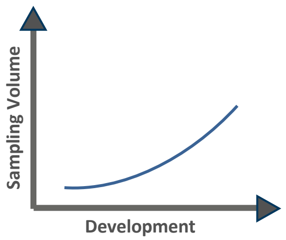


- Long term stability of process and equipment data available
- LPKF operates equipment since 2019 in Vitrion fab ISO 6
- Double digit number of installed tools at customers worldwide
- SEMI compatibility (S2, S8)
- Cleanroom compatibility

Unmatched maturity of LIDE process and process equipment proven by statistics.

REDUCE TIME TO MARKET

CO-DEVELOPMENT AND SAMPLING AT INDUSTRY STANDARD

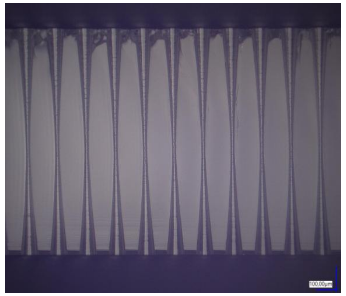
	Development			Scaling
LPKF LIDE Process Equipment	Define Requirements	Permanent innovation in technology, lead to mature technology	Optimizing equipment and process to target application	Scale your internal line with automated tools
Manufacturing Service		Iterative Application Development		Develop and Scale with our Virtual Line

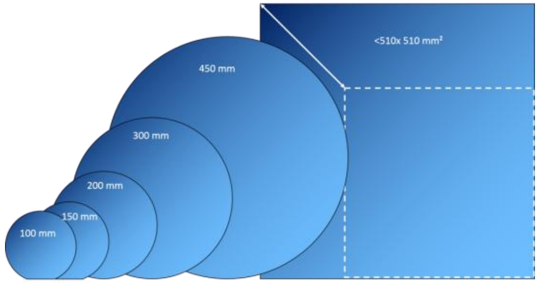
Leverage our expertise and manufacturing capabilities for a faster time to market.

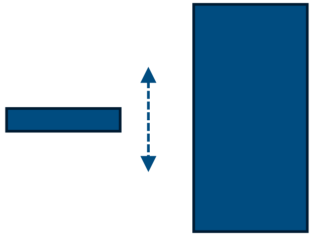
MATURE SUPPLY CHAIN SOLUTION FOR GLASS MICRO-PROCESSING

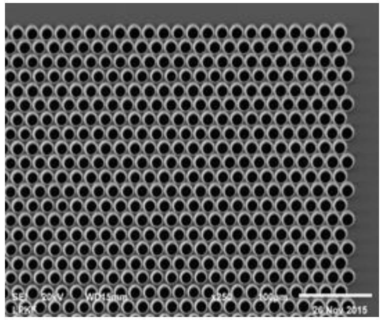
LIDE process enables glass based Advanced Packaging

Glass Type	Wafer Substrate	Panel Substrate	Thickness	Glass Suppliers	Pulse-to-Pulse Pitch
No limitations	4” – 12”	up to 510 mm x 515 mm	0.1 mm – 1.0 mm	All suppliers possible	> 5 µm

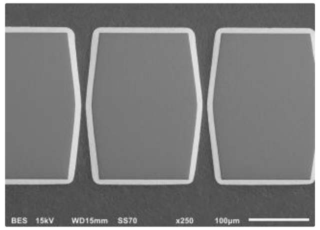


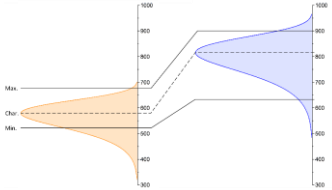


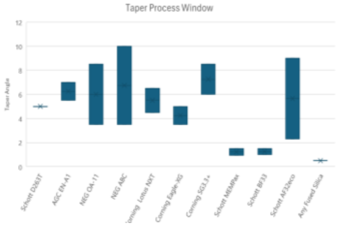


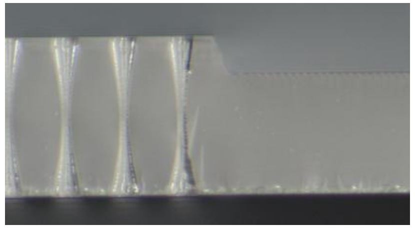


Aspect Ratio	Roughness	Breakstrength	Taper	Drill Rate	More than TGV
1:1 – 1:50	< 0.2 µm	30% improvement	Glass specific process window 0.1° - 30°	5000 TGV/sec**	TGV, Cutting, Cavity









We adapt and qualify extensively to matched all customer and downstream process requirements.

Thank you for your attention.

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