Surface materials engineering

Ultrafast laser processing: new advances for display manufacturing

HEF GROUPE

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Introduction to Abrisa Technologies and the HEF Group

HEF Group

Since 1953,
70 years of expertise in surface material engineering.

3200 employees (worldwide)
650 in France

317 M€
Revenue - 2022

66%
Of the equity is owned by employees & 34% by the founders

200+
patents

90 Industrial sites
in **21** countries

55 M€
investments in 2023

6500clients

TRIBOLOGY

Study of phenomena linked to solids in dynamic interaction. Understanding of friction and wear mechanisms.

PHOTONICS

Study of phenomena linked to the interaction between light and matter. Understanding of surfaces and optical interfaces.

HYDROGEN

Fabrication, transport, storage and exploitation of hydrogen : electrolysis, compression, fuel cells, hydrogen engine.

HEF close to its customers all over the world

We strive to provide our customers the best response, service, technology and expertise, with consistent international quality standards.

HEF Group USA Footprint

- ❑ Springfield, OH – US HQ
- ❑ Kennebunk, ME
- ❑ Montreal, Canada
- ❑ Denver, NC (Calico Coatings) JV
- ❑ Kearney, NE
- ❑ Chattanooga, TN
- ❑ Phoenix, AZ (TS WEST) JV
- ❑ Benton Harbor, MI (Tech Nickel)
- ❑ Los Angles, CA (ABRISA)

- ★ Liquid Nitriding
- ★ Liquid Nitriding + PVD/DLC Coatings
- ★ PVD/DLC Coatings + Phosphating + PTFE/FEP Coatings
- ★ Liquid Nitriding + Nickel Plating
- ★ Optical Coatings & Technical Glass

About Abrisa Technologies

Abrisa Technologies – Your Total Solution Partner

Abrisa Industrial Glass (AIG), Santa Paula, CA – ISO Cert
This 100,000+ sq. ft. manufacturing facility is dedicated to solution-based, industrial flat glass manufacturing, products and services, including screen-printing, etching, cutting and edging, CNC machining, higher level assembly, and more.

ZC&R Coatings for Optics (ZC&R), Torrance, CA – ISO Cert
This 21,000 sq. ft. manufacturing facility offers custom and OEM precision coating solutions for optical thin film products. ZC&R's PVD and ION-assist depositions provide a wide range of standard and custom coatings to meet our customer's ever evolving needs.

https://abrisatechnologies.com/

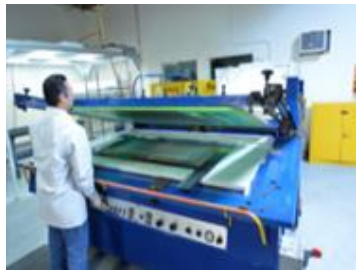
Abrisa Facilities

Abrisa Industrial Glass (AIG)

- 100,000+ sq. ft. manufacturing facility in Santa Paula, CA
- Quality Management System ISO 9001:2015 Certified
- Class 10,000, clean rooms, ITAR approved



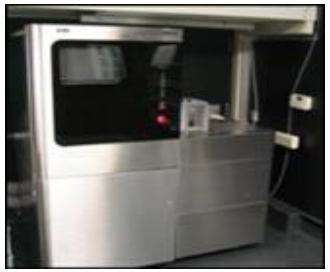




ZC&R Coatings for Optics (ZC&R)

- 21,000+ sq. ft. manufacturing facility in Torrance, CA
- Class 100, 1,000, and 10,000 clean rooms, ITAR approved
- Quality Management System ISO 9001:2015 Certified
- 13 Coating chambers of various sizes, large (73”) and medium (64”) chambers
- Ultrasonic Wafer Cleaning and Environmental Test Chamber



Your Total Solution Partner

Single Point Accountability

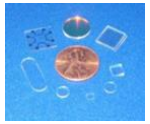
Supplier partnerships

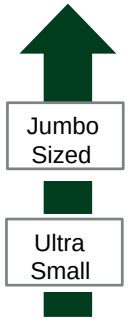
- Large offering of specialty glass sourced through key long-term supplier partnerships
- Extensive knowledge of glass substrates and properties
- Special rights to select brands of raw and specialty coated and processed glass

SCHOTT AGC CORNING

Precision fabrication

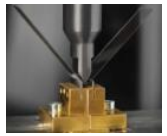
- High volume cutting, shaping, seaming, grinding, polishing and CNC machining
- Industry leading range of glass sizes that can be processed from meters down to 0.1mm thick





Specialized Glass Processing

- HIE™ strengthening: imparts high damage resistance to thin aluminosilicates for low profile devices
- Chemical strengthening: enhanced durability with minimal optical distortion
- Heat tempering: creates stronger, safer and more durable glass

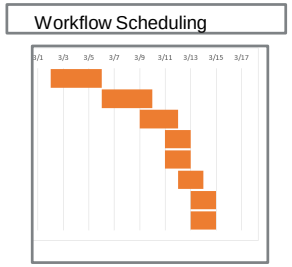


Customized Coatings and Graphics

- Transparent conductive IMITO
- Low loss wide angle anti-reflection
- Selective signal filters and mirrors
- Heat and chemical protection
- Ultra-thin wafer coatings
- Deadfront and PMS matched graphics
- Electrical connectivity bus bars
- Damage, smudge and water resistance
- Optical, safety, aesthetic films and gaskets

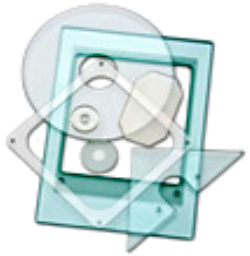
Program management

- Solutions engineering
- Concept to production
- Value-added assembly
- Inspection and verification
- Certification and testing
- Inventory management
- Special packaging

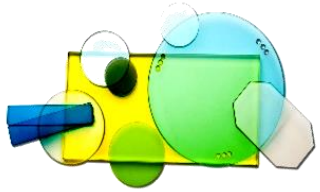


Abrisa Technologies capabilities

HIE™ Glass



Fabrication



Coatings

Graphics

Protection

Films

Abrisa Technologies' broad scope of design and manufacturing capabilities, vertical integration, and single-point accountability allows you to put your trust in one company for supply chain simplicity, convenience, reduced cost of ownership, and delivery of verified and certified product(s) every time.

- **Float & Specialty HIE™ Glasses in mm to meter sizes**
- **Specializing in Ultra-Thin Glass – as low as 0.1 mm Boro & Aluminosilicates**
- **Fabrication for Shape & Features to Your Specific Needs**
- **Chemical or Heat Strengthening for Damage Resistance**
- **Coatings for Filtering, Throughput Reflection & Conductivity**
- **Screen Printing for Electrical Connectivity, Branding & Displays**
- **Value-Added Assembly Films, Chemistry, ID Marking**

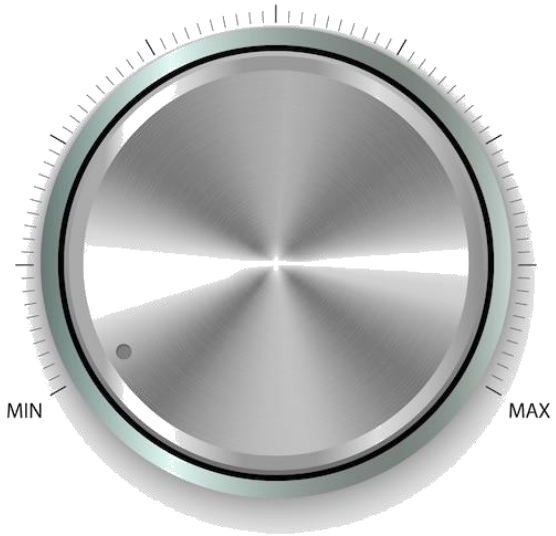
Abrisa Technologies in the display market

Display – Digital, Immersive & Interactive Displays

- Damage Resistant HIE™ Thin & Ultra-Thin Aluminosilicates
- Hidden LCD Mirrors, Dead Front Graphics
- Sunlight Readable Coatings & UV/IR Blockers
- Near-to-Eye Display Partial Transmitters
- Ultra-Thin, Lightweight & Flexible Glass

Ultrafast laser processing

Lasers parameters



Wavelength (UV – IR)

Pulse duration (fs to CW)

Repetition rate (up to GHz)

Pulse energy (nJ to J)

Spot size (down to few µm)

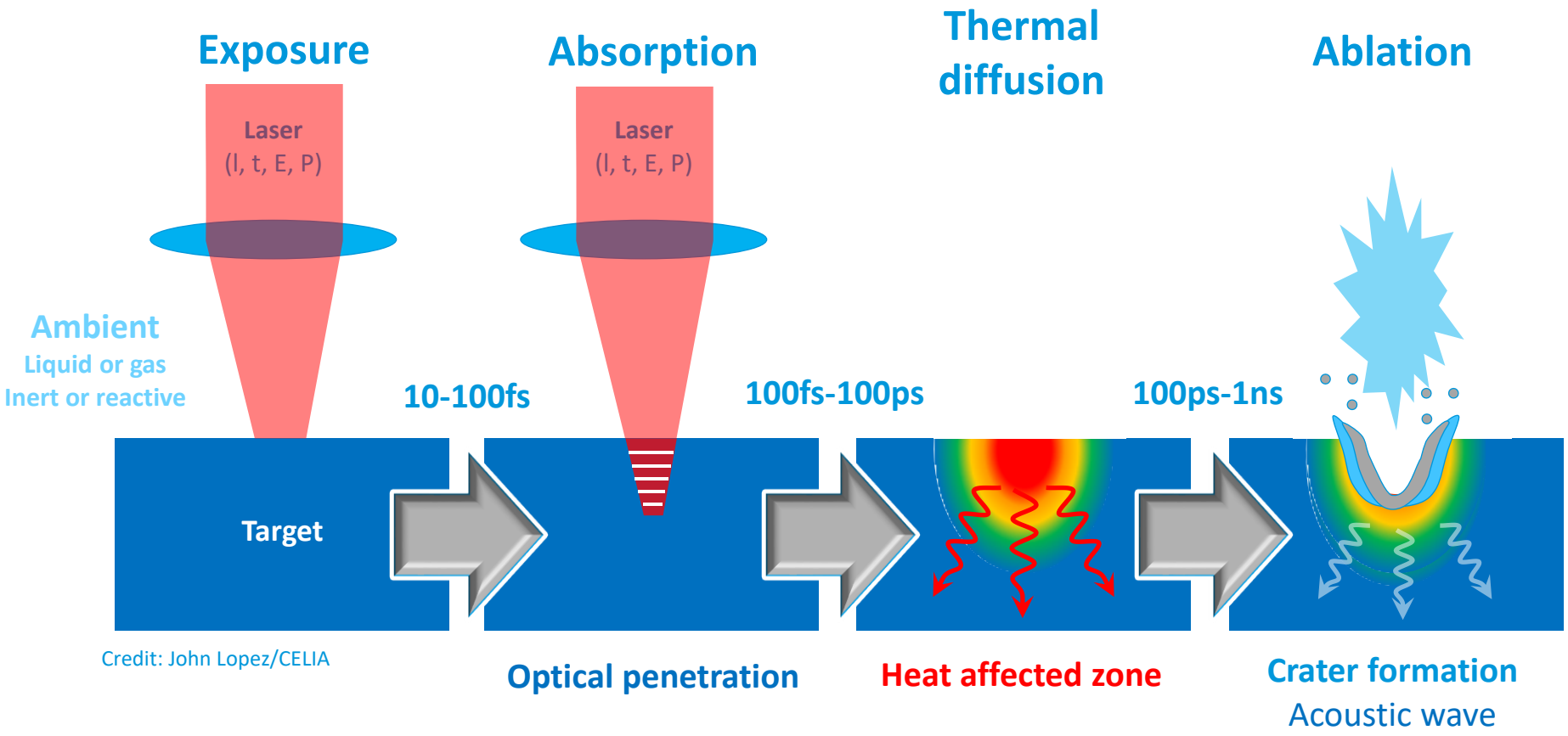
Spot shape

Polarization

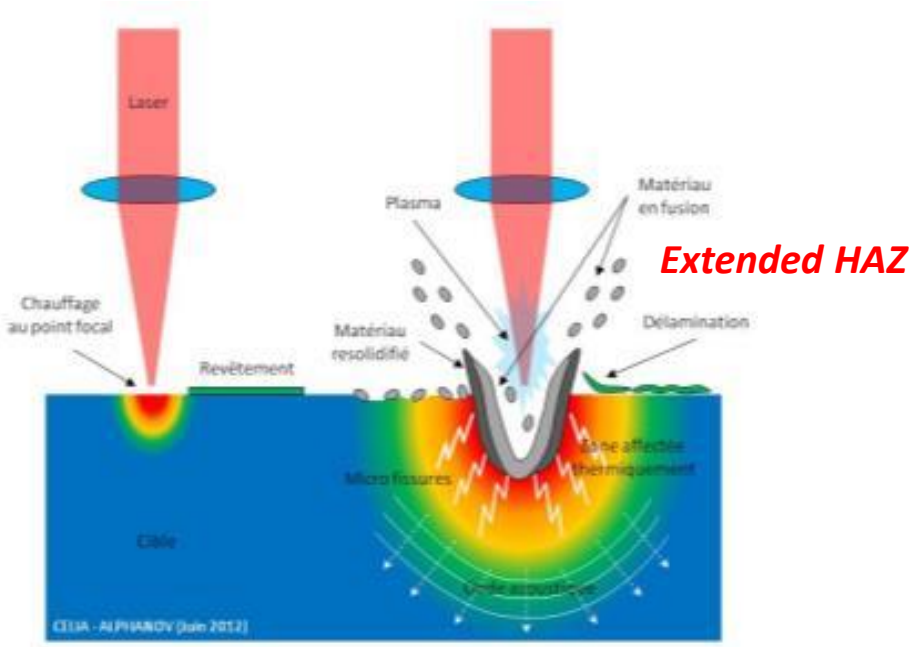
Laser processing

Laser ablation : decomposition of the material under the effect of intense laser radiation

Ablation threshold : energy threshold beyond which there is ablation



Laser-matter interaction process



Extended HAZ

Thermal process

Wavelength: IR -> UV
Pulse duration: cw -> ns
Material : all

Absorption

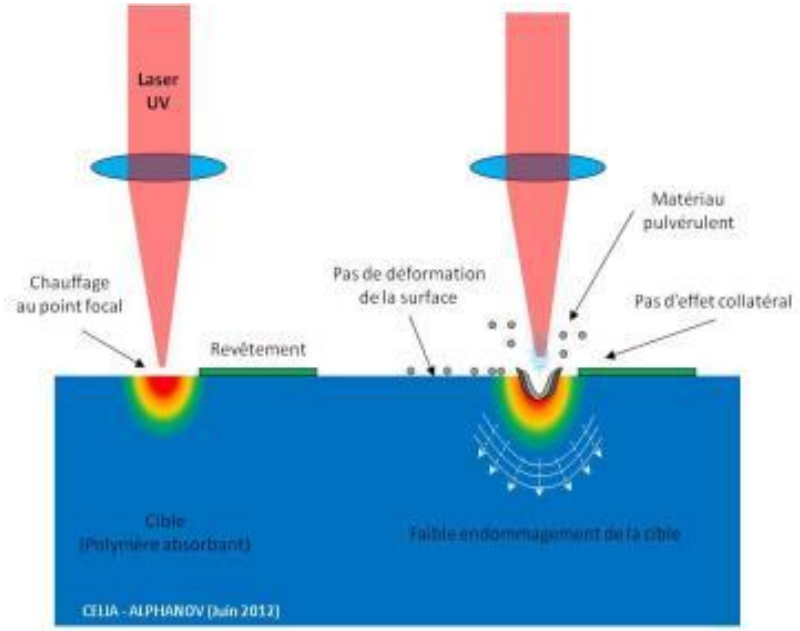


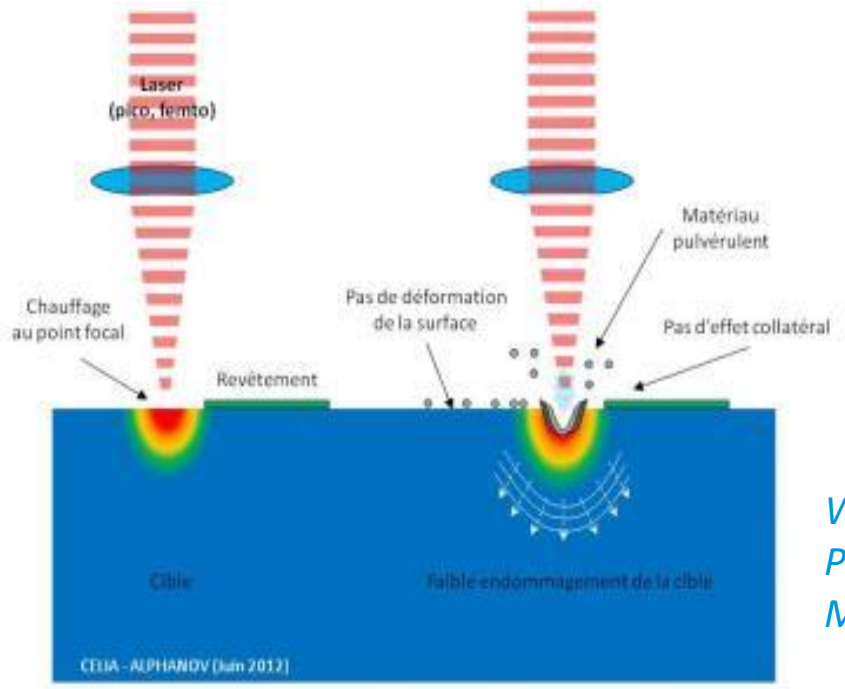
Photo ablation

Wavelength: UV
Pulse duration : ns
Material : polymer

Absorption

Laser-matter interaction process

Pulse duration << heat diffusion time
Small HAZ



Ultrashort process

Wavelength : IR -> UV
Pulse duration : 5 ps -> 10 fs
Material : all

Thermal effects in laser ablation

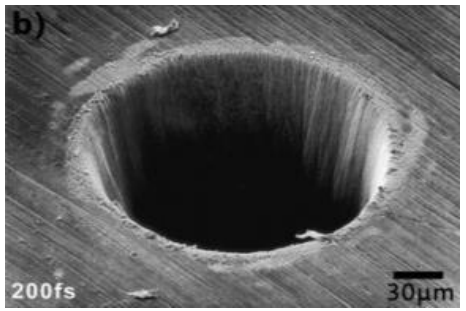
Low ablation rates
Little to no HAZ
High precision
All materials

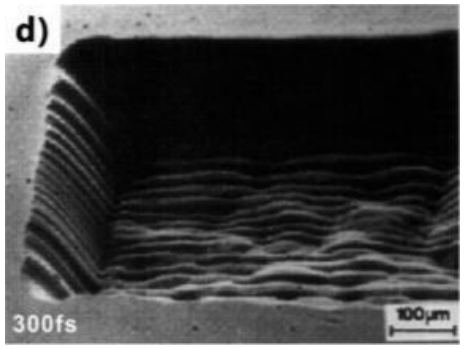
Pulse duration

High ablation rates
Large HAZ

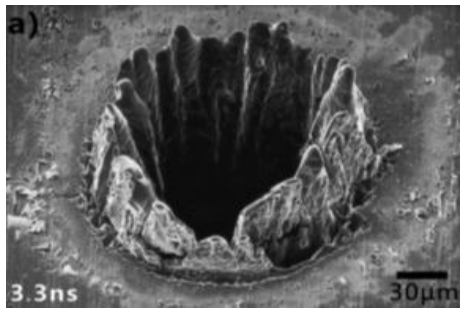
Thermal effects / defects

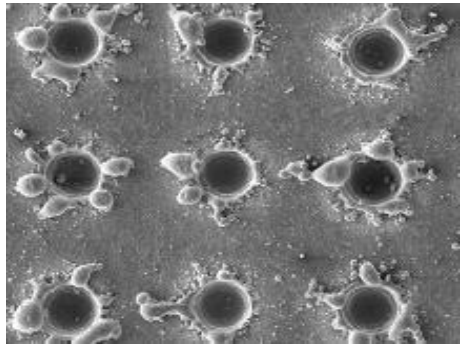
Femtosecond (fs)



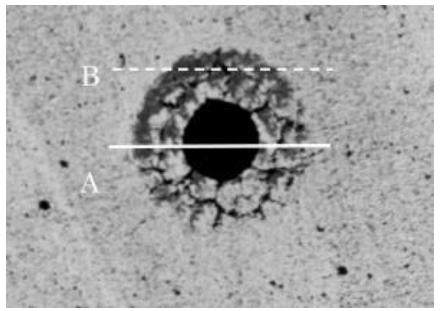


Nanosecond (ns)





Continuous laser (CW)



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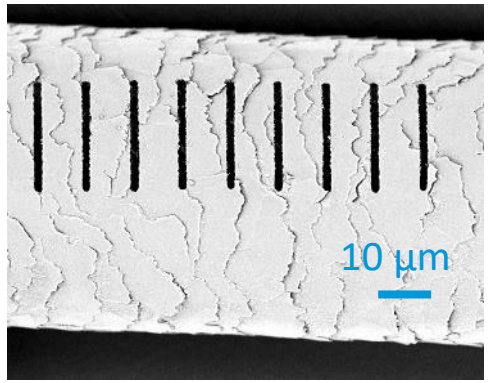
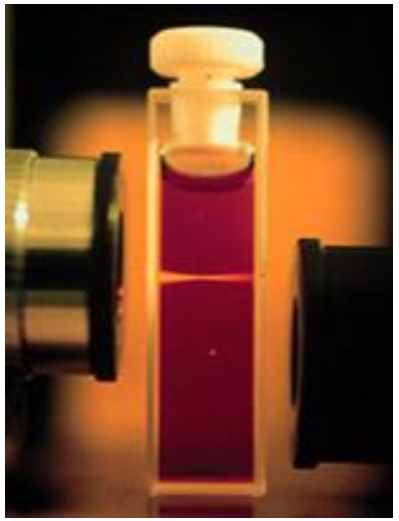
Advantages of ultrafast laser processing

Ultrafast : Dt < ~10ps

- Fast
- Precise
- Flexible
- Non contact
- No consumables
- No pre- or post-treatment
- Maintains structural integrity (no cracks)
- Edge finish suitable for many applications
- Higher yields than traditional scribe-and-break processing





Credit: Brad Amos, MRC, Laboratory of Molecular Biology, Cambridge

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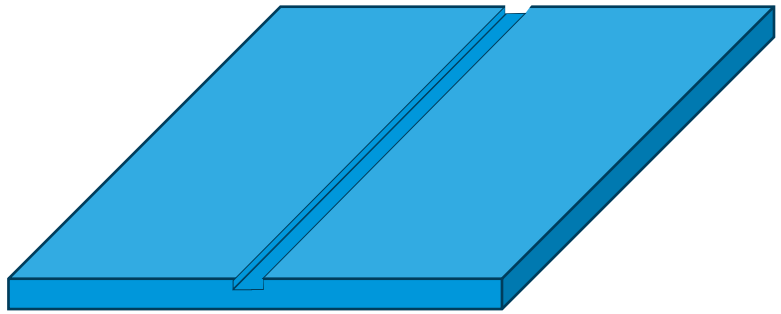
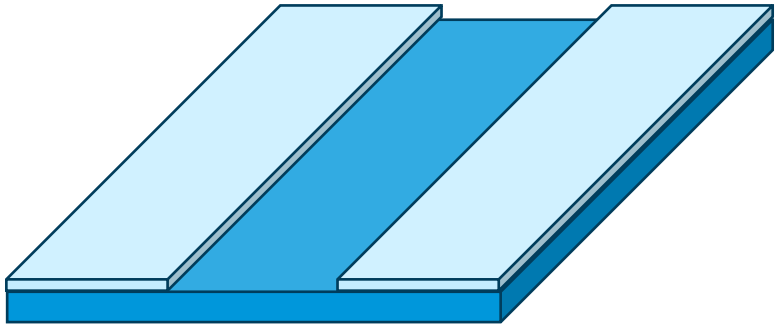
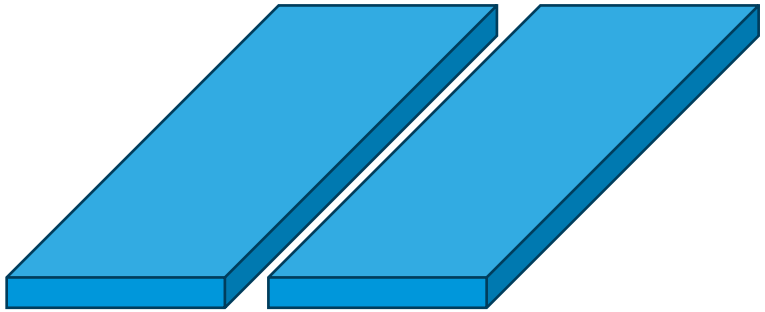
Ultrafast lasers: a Swiss knife in micromachining



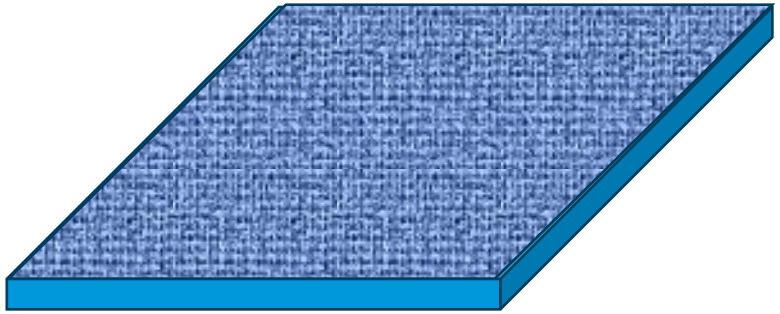
Engraving



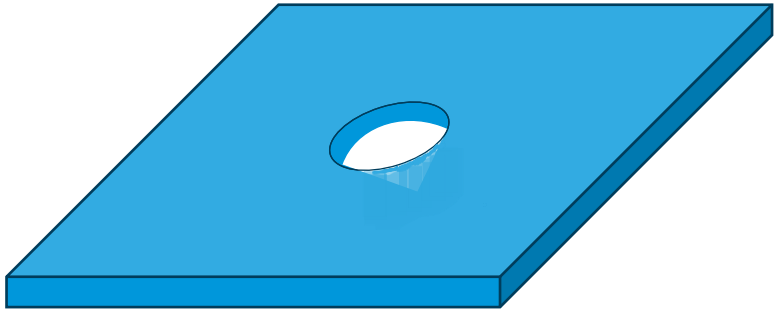
Selective ablation



Cutting



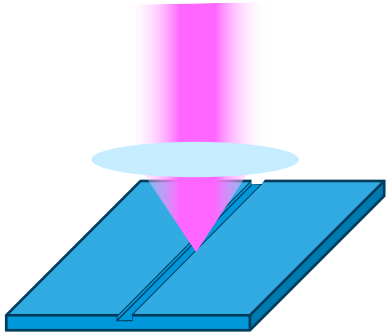
Surface texturation



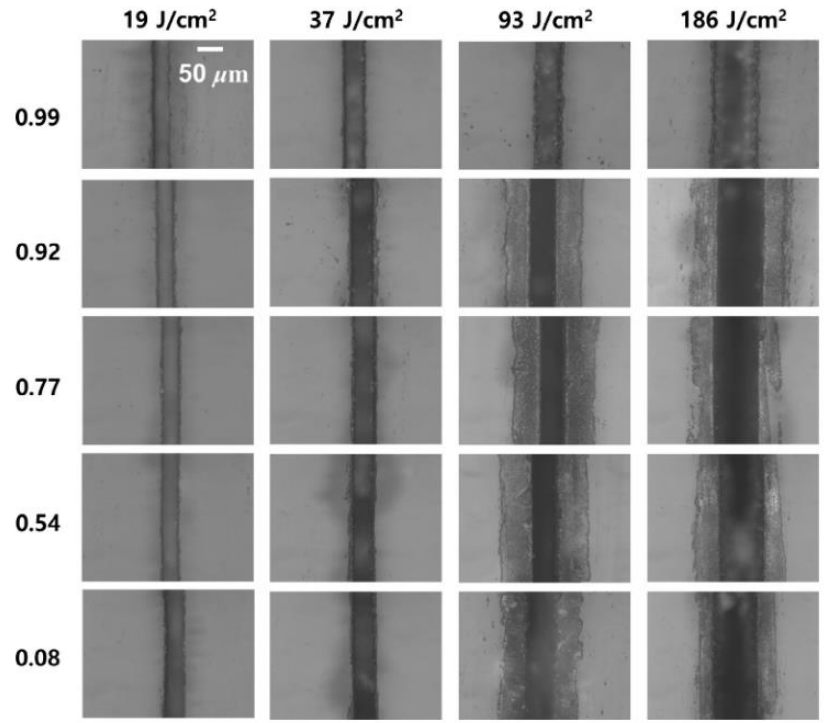
Laser hole drilling

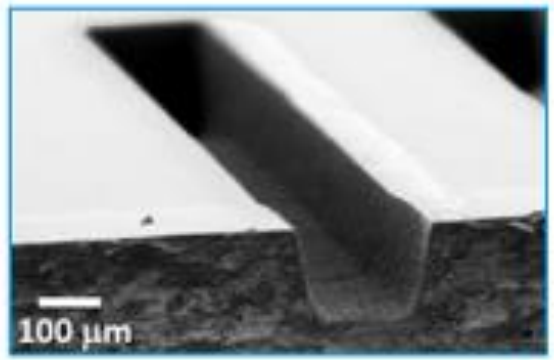
Engraving

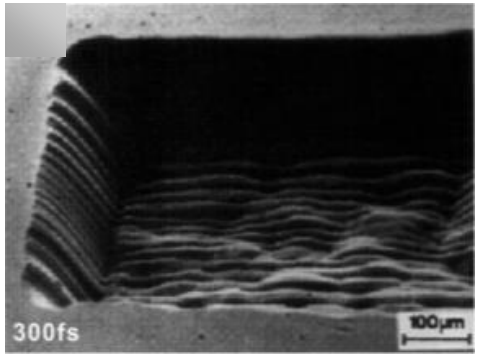
Material is ablated from the surface

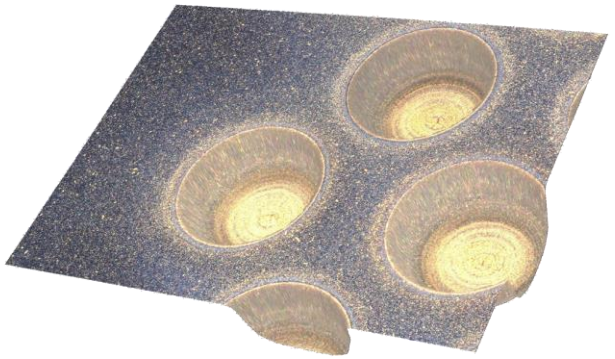


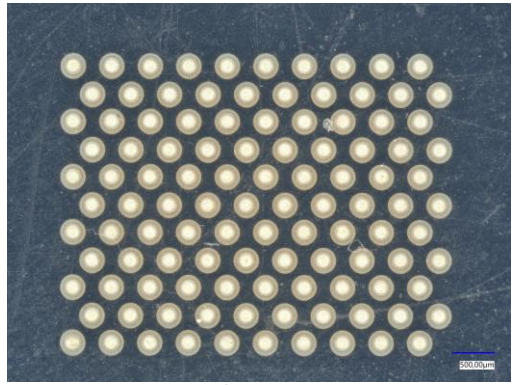
Laser parameters are
finely tuned for cut quality











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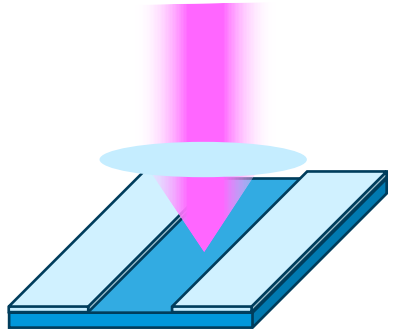
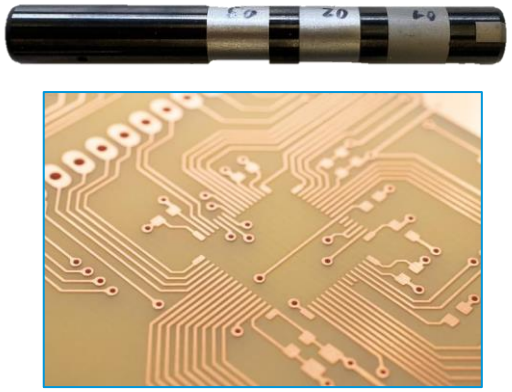
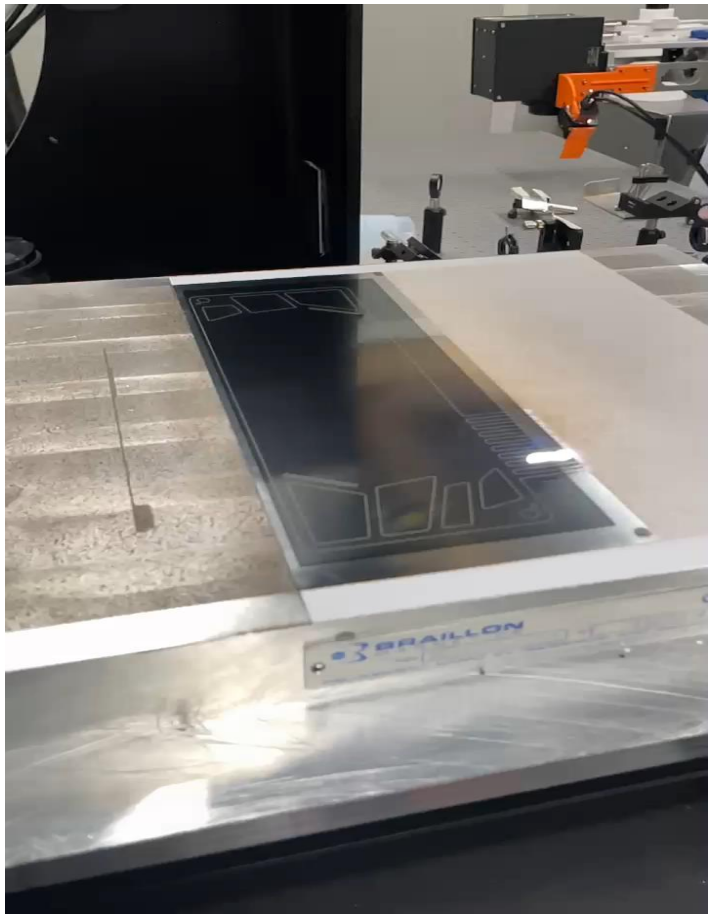
Selective ablation (de-coating)

Material is ablated from the surface leaving the substrate intact



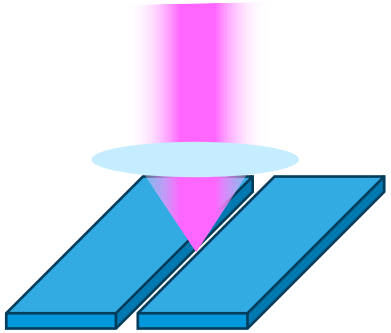
Works best when top layer and substrate have very different ablation thresholds



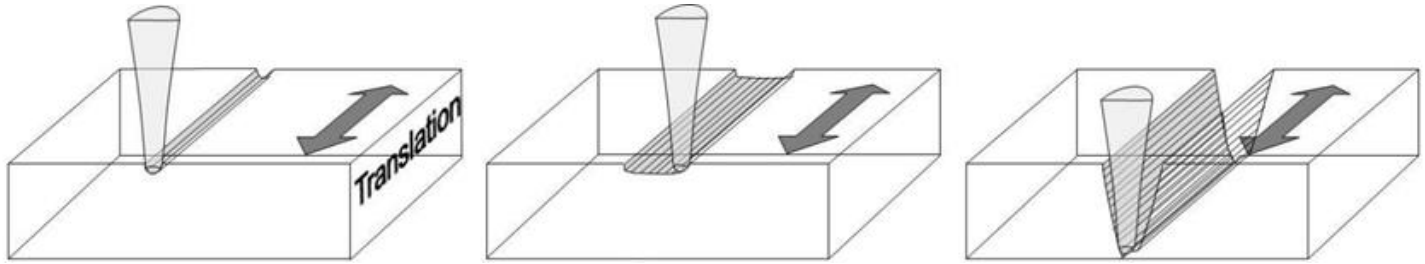


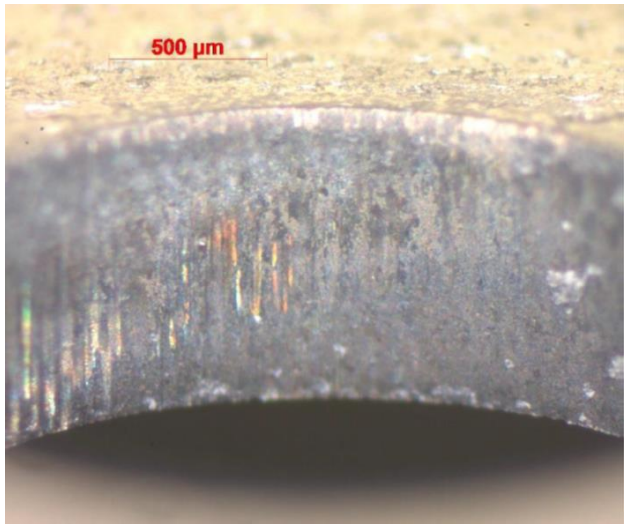
Laser cutting (by ablation)

Material is ablated down to the bottom surface

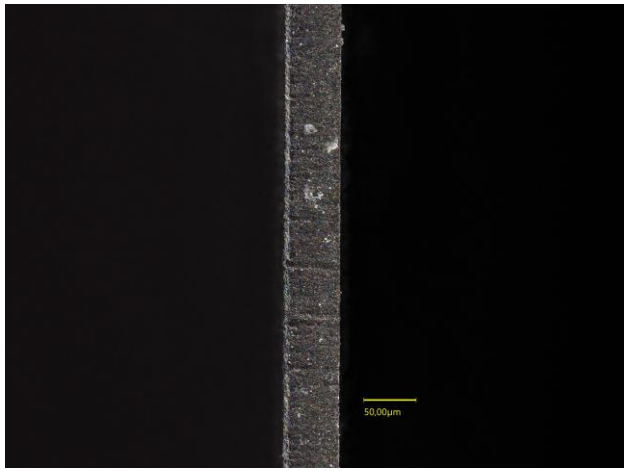


Best used for very thin samples when conventional mechanical cutting can’t work





1-mm Nickel sheet



50µm metal sheet, Ra = 0.1µm

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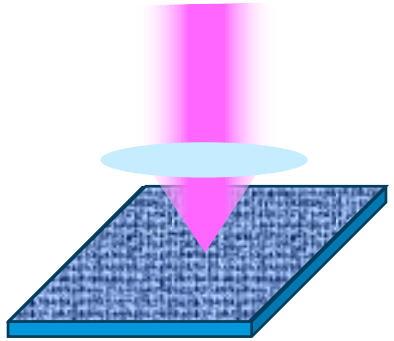
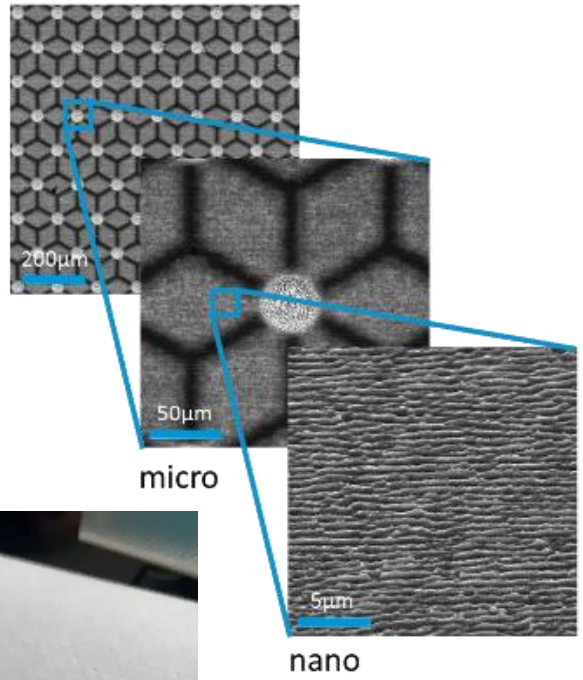
Surface texturation

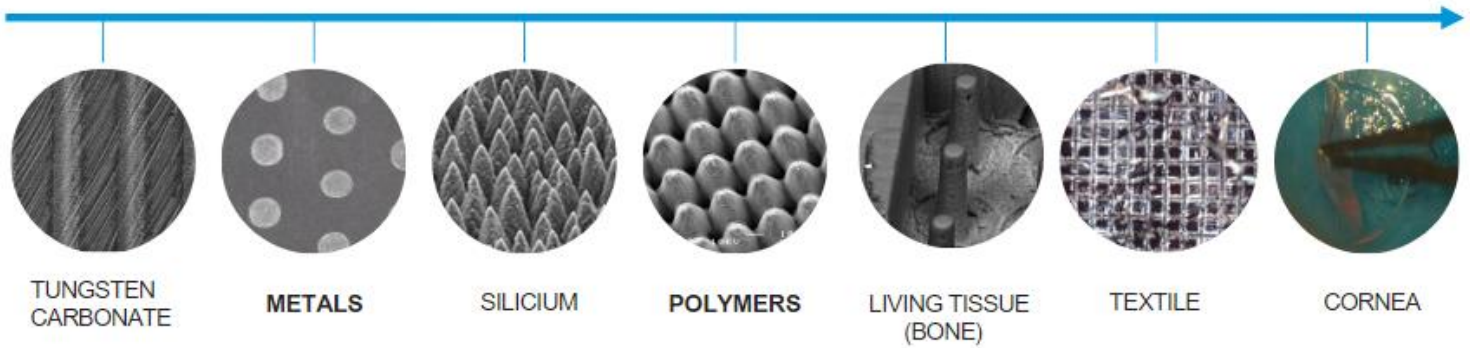


Possibility of combining micrometric and nanometric surface structuring to obtain multi-scale texturations.



From the hardest to the most delicate

From a few nm to several hundred µm



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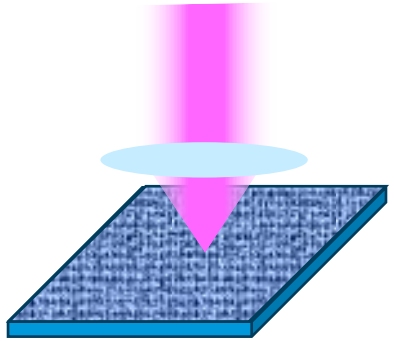
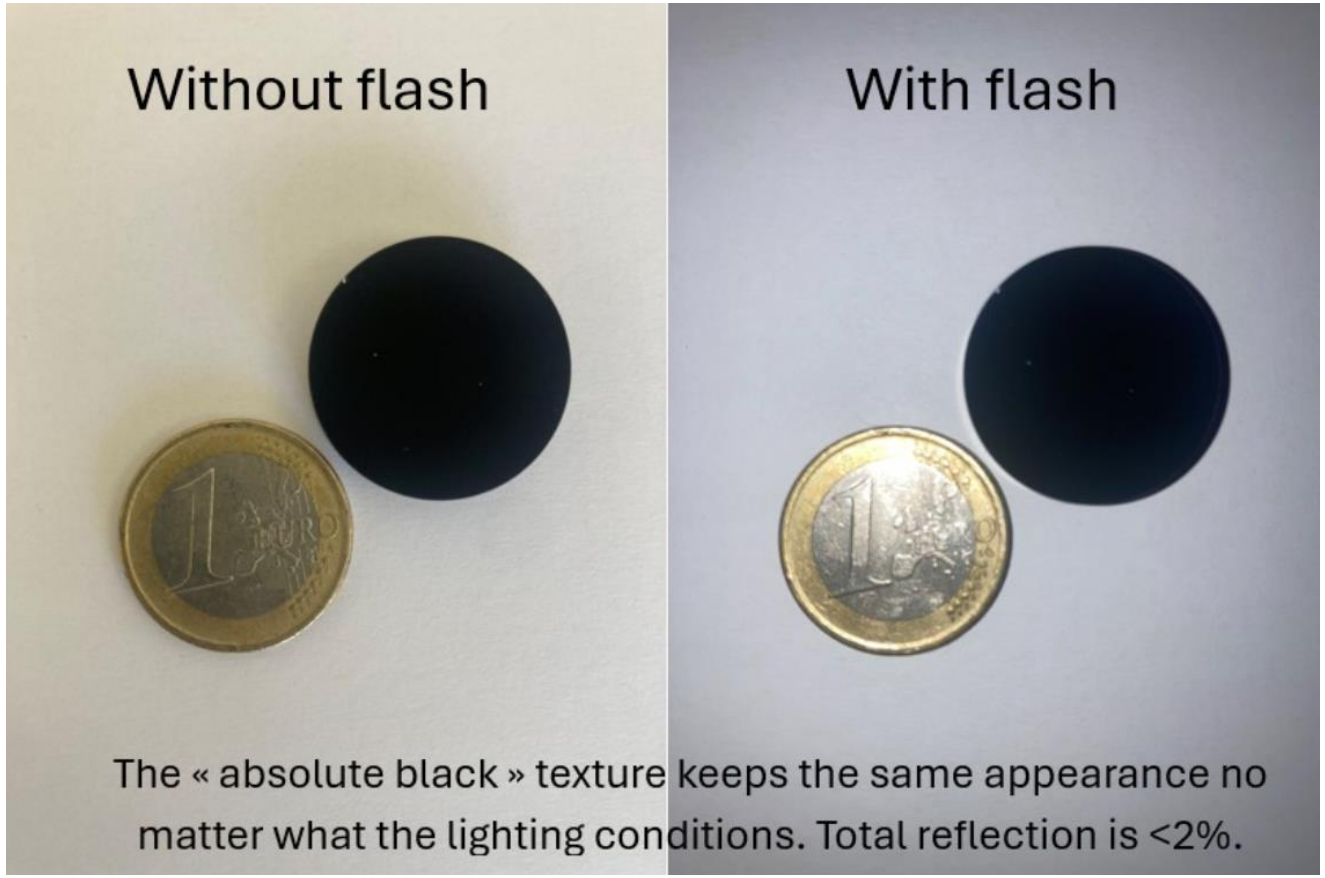
Surface texturation / Absolute black

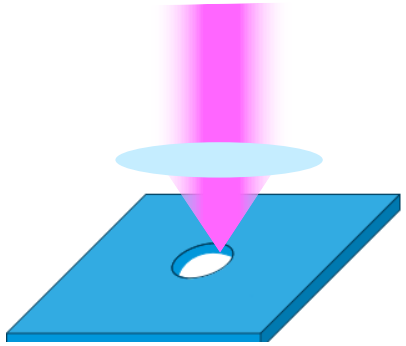


Laser texturation enables « absolute black » coloring on any metallic surface for blocking stray light and unwanted reflection

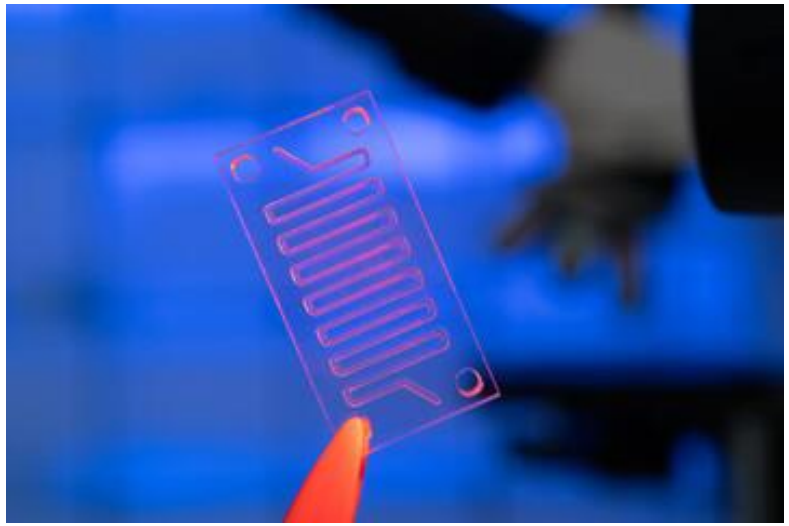


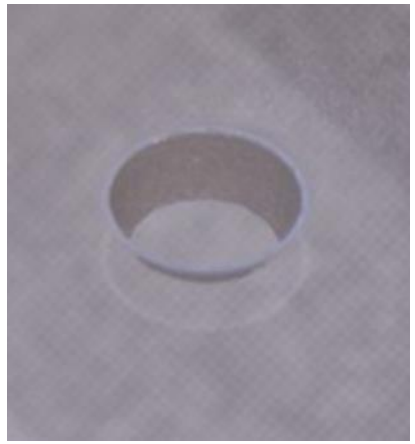
Laser hole drilling

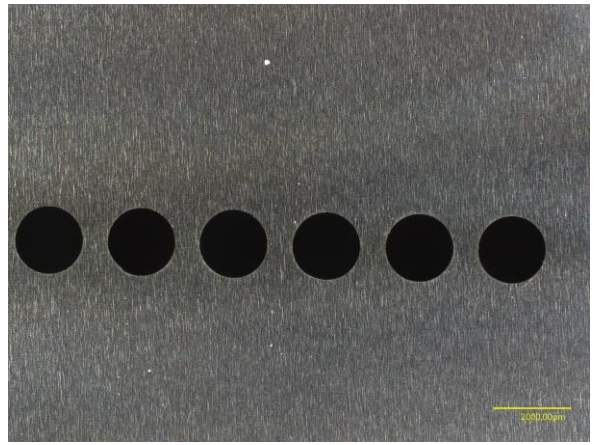
Material is ablated down to the bottom surface



Direct drilling (single-shot) → Fast but limited depth and taper
Percussion drilling (multiple) → High aspect ratio, but small diameter only
Trepanning (~cutting) → Large diameter, no taper but slow







Ultrafast laser processing for the display industry

Ultrafast lasers for display manufacturing

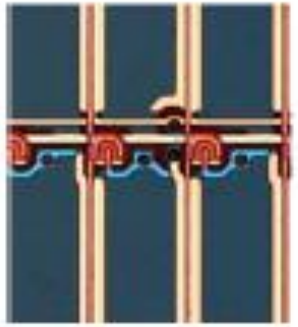
3 main applications :

- Repair process
- Hole In Active Area (HIAA) process
- Cutting process on flexible or foldable OLED

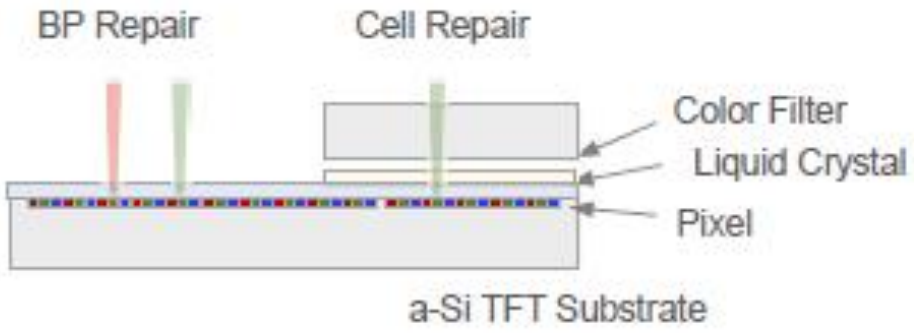
Repair process – controlled energy deposition on the defect

LCD

Thickness to remove : 0.1 ~ 0.5um
Target Layer : Metal, ITO, Color Filter
Laser : Nano (IR, Green, UV) ~ 5W



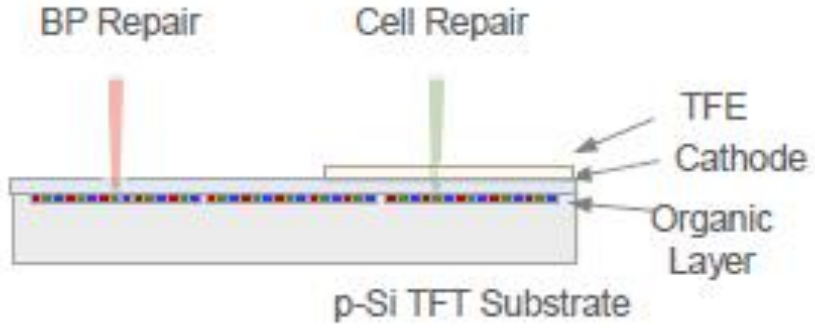
<200 ppi



OLED

Thickness to remove : 0.1 ~ 0.5um
Target Layer : Metal, Oxide, OC ※ Overcoat
Laser : Femto (IR 5W, Green, DUV 2W)

> 300 ppi



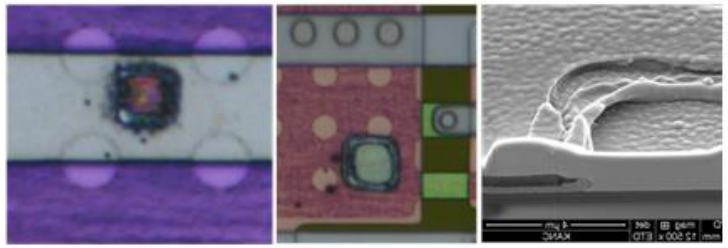
Credit: Amplitude Lasers

HEF GROUPE

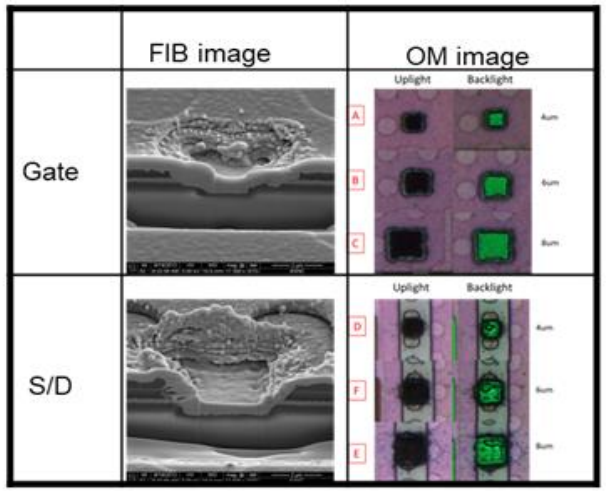
Repair process

Typical repair processes

☐ **Point shot**

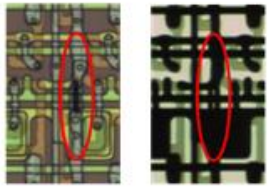


S/D remove @S/D+Gate+p-Si | Gate remove @Gate+p-Si | S/D remove @S/D+Gate/p-Si

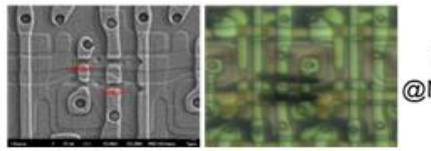


☐ **Scan shot**

Line cutting (fuselective ablation)

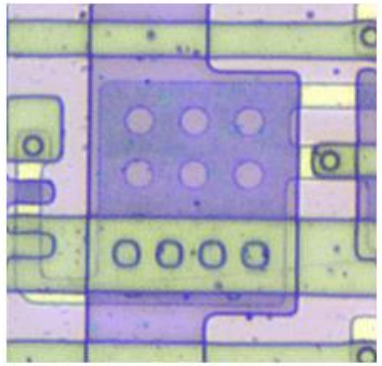


Line cutting (selective ablation)



Metal remove @Metal+Gate+p-Si

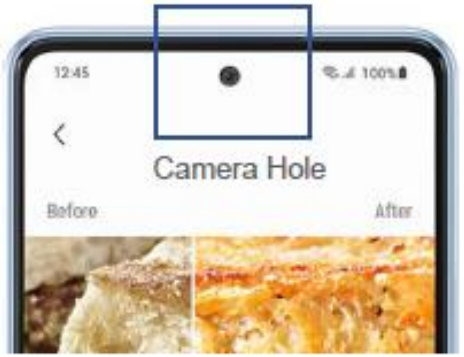
☐ **Block removal**



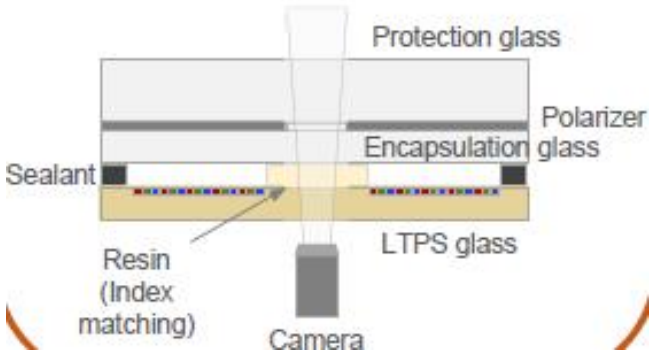
Credit: Amplitude Lasers

Hole In Active Area (HIAA) process

Rigid OLED
Etching
Laser : Femto, GR 10W

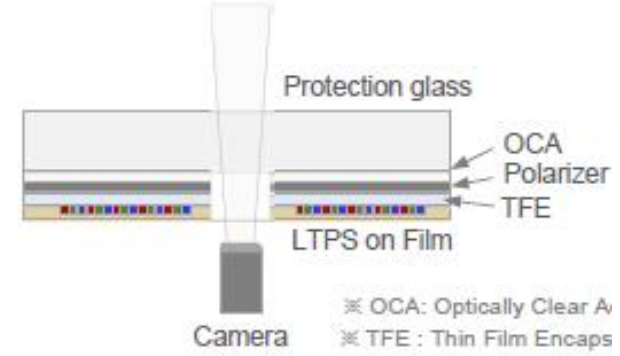


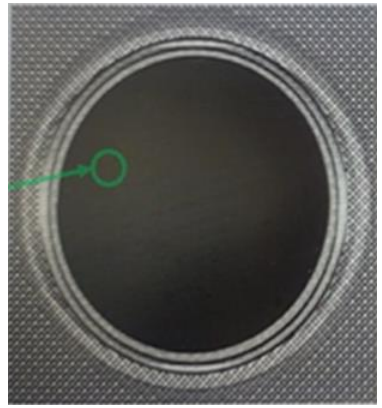
HIAA
※ Hole In Active Area

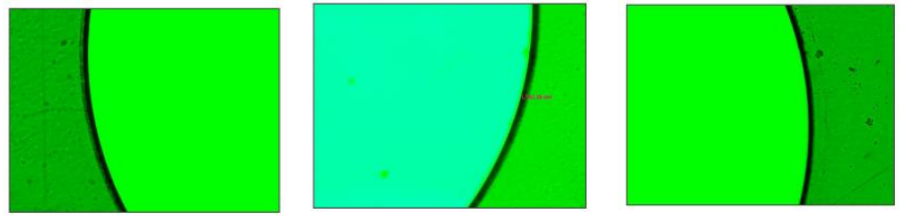


Flexible OLED
Through Hole Cut
Laser : Femto, UV 30W

HIAA
※ Hole In Active Area







- ✓ No Burr
- ✓ No delamination
- ✓ No microcracking
- ✓ Low HAZ

Credit: Amplitude Lasers

Cutting process on flexible or foldable OLED

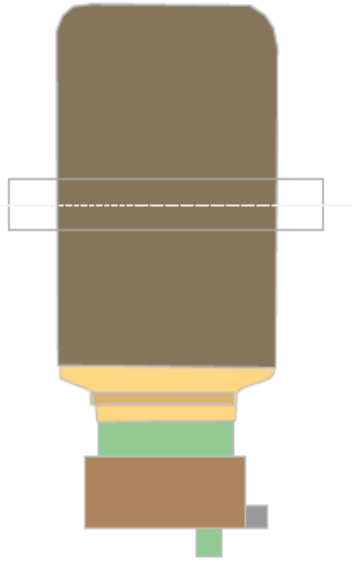
Flexible OLED

Thickness to remove: 600 ~ 800µm
Target layer: Polymeric Films
(PI/PSA/Pol/PET etc.)
Laser: Pico or Femto UV 30W

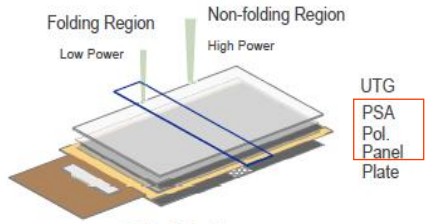
Shape Cut

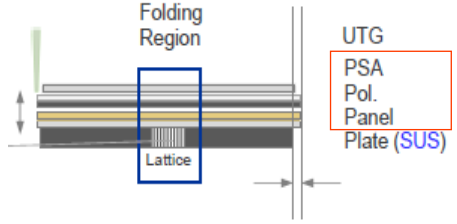
Foldable OLED

Thickness to remove: 500 ~ 600µm
Target layer: Polymeric Films
(PI/PSA/Pol/PET etc.)
Laser: Femto UV 30W



Shape Cut





※ Dead Space : HAZ + Align Offset + etc.

- ✓ No Burr
- ✓ No delamination
- ✓ No microcracking
- ✓ HAZ around 15µm
- ✓ Typical cutting speed: 50 to 100mm/s
- ✓ Typical time per panel: 8 seconds

Credit: Amplitude Lasers

HEF GROUPE

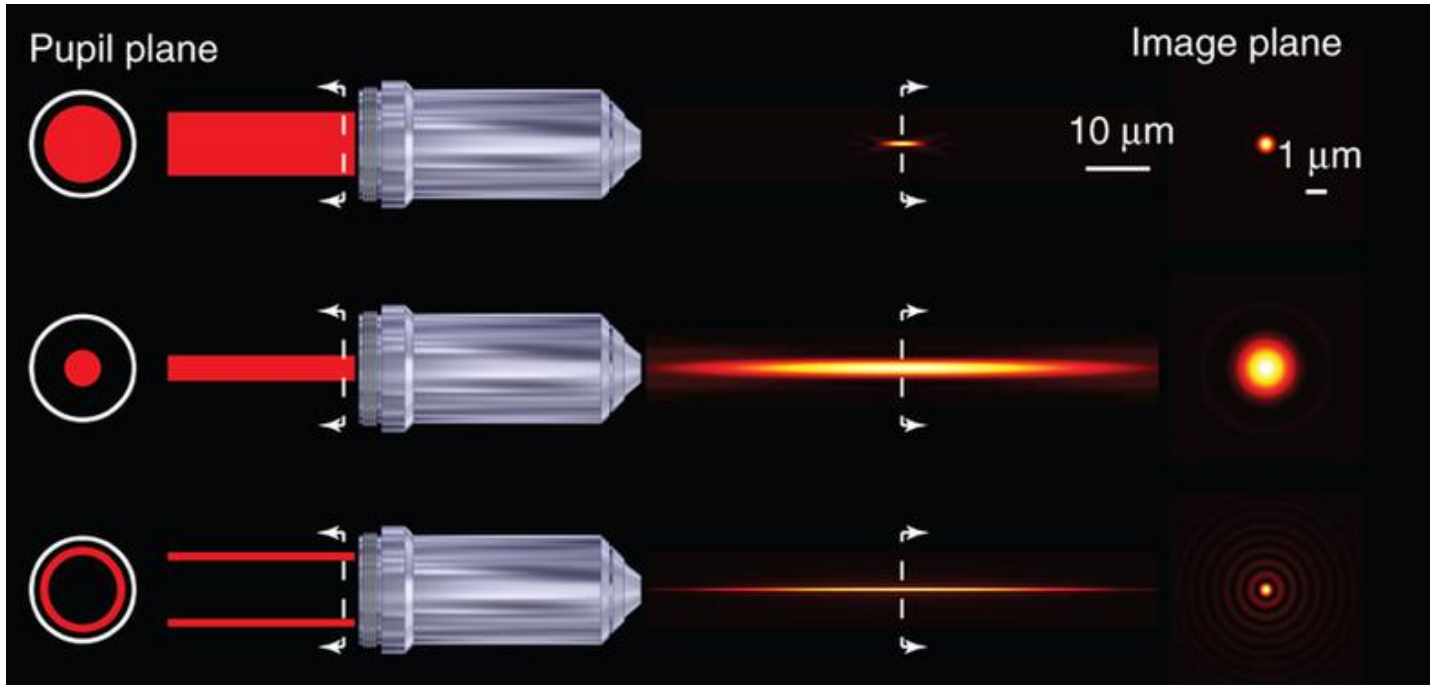
Beam shaping for glass cutting

Incoming Beam Profile

Beam focusing with a lens/objective

Focus

- Gaussian w/ Large diameter
- Gaussian w/ Small diameter
- Bessel (collimated)



- **Small** spot size
- **Short** Depth-of-field

- **Large** spot size
- **Long** DOF

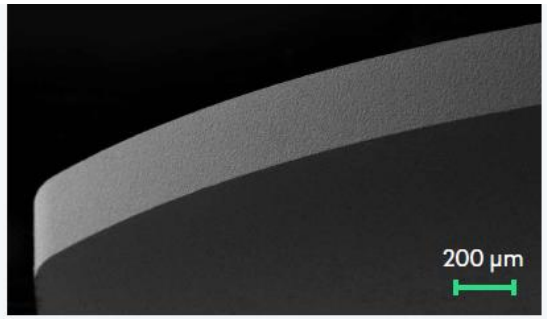
- **Small** spot size
- **Long** DOF
- « Filament beam »

Gao *et al*., DOI:10.1038/nprot.2014.087 (**2020**)

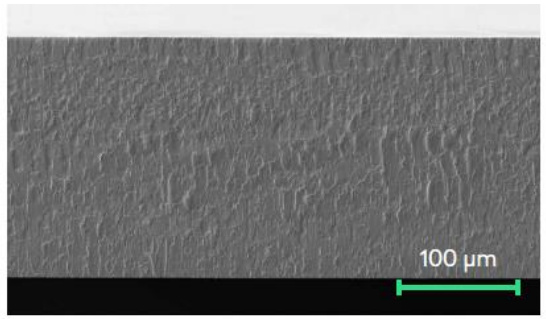
HEF GROUPE

Beam shaping

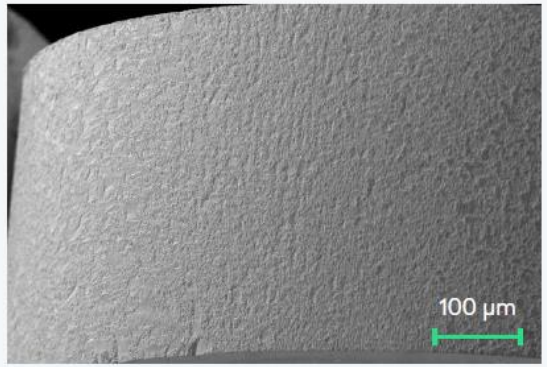
Best commercial cut quality available
Quasi-bessel beams:



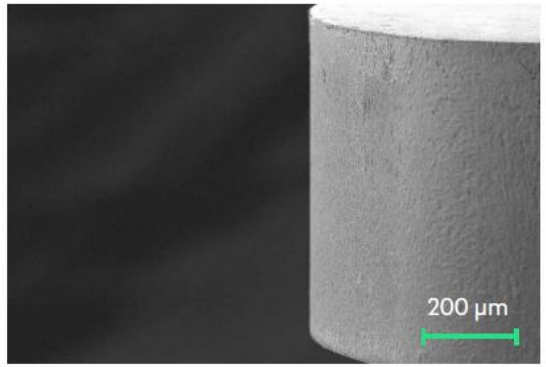
D263T glass, thickness 300 µm



Fused silica glass, thickness 250 µm



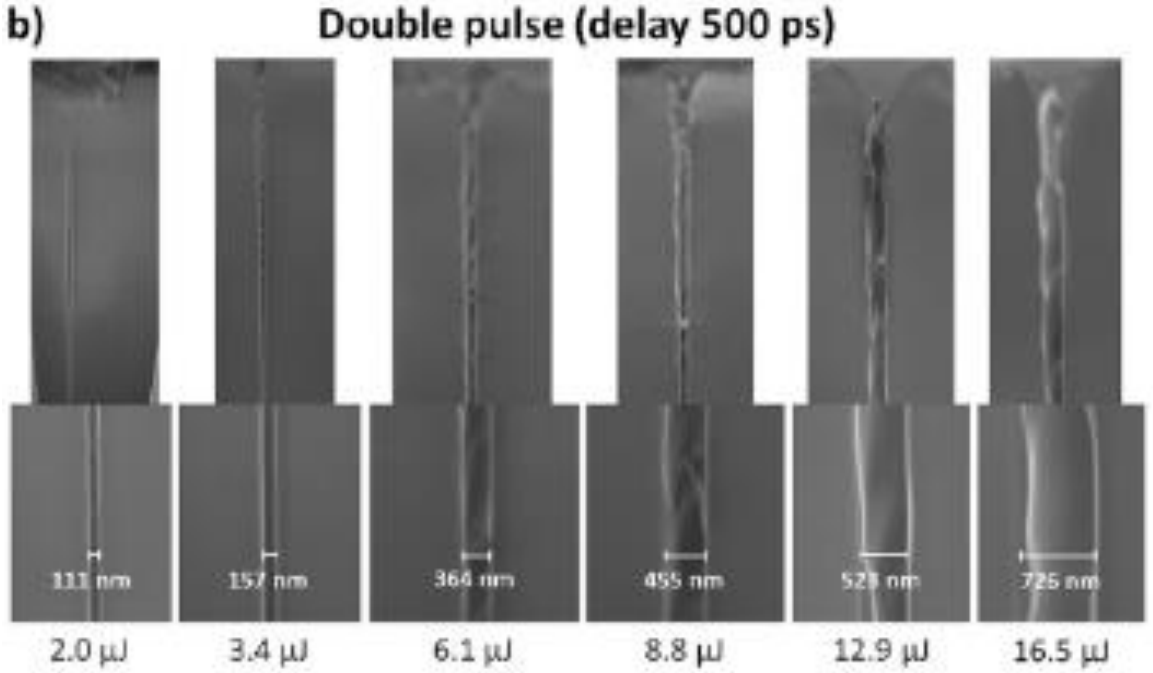
Sapphire, thickness 400 µm



Sapphire, thickness 700 µm

Credit: WOP

Multi-pulses technologies for drilling
100 µm long Microcanals on BK7



Credit: FemtoST

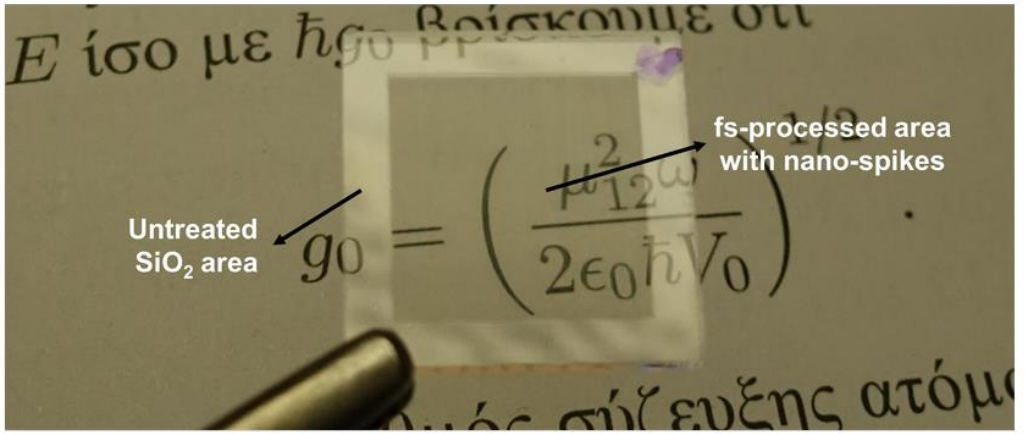
Source: 10.1515/nanoph-2020-0457 (**2021**), FEMTO-ST

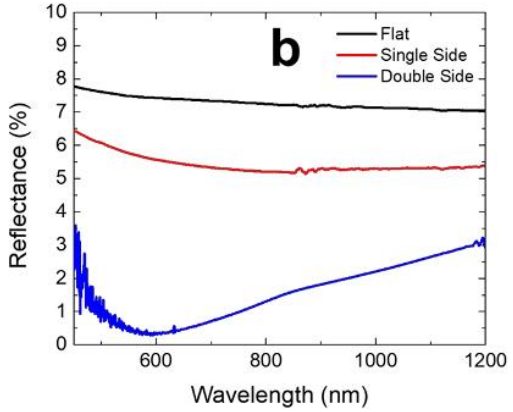
Thin glass cutting

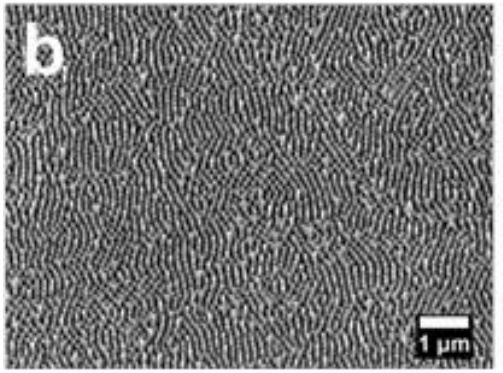
Volume modification + chemical etching

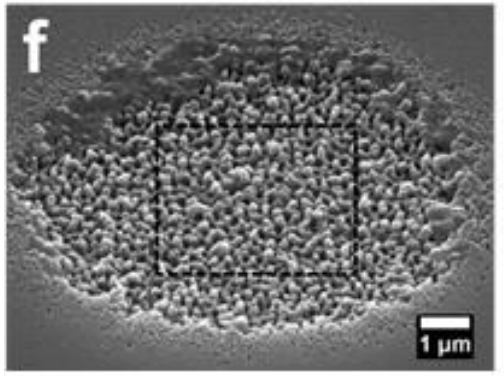
- Freeform in glass

Credit: Femtoprint



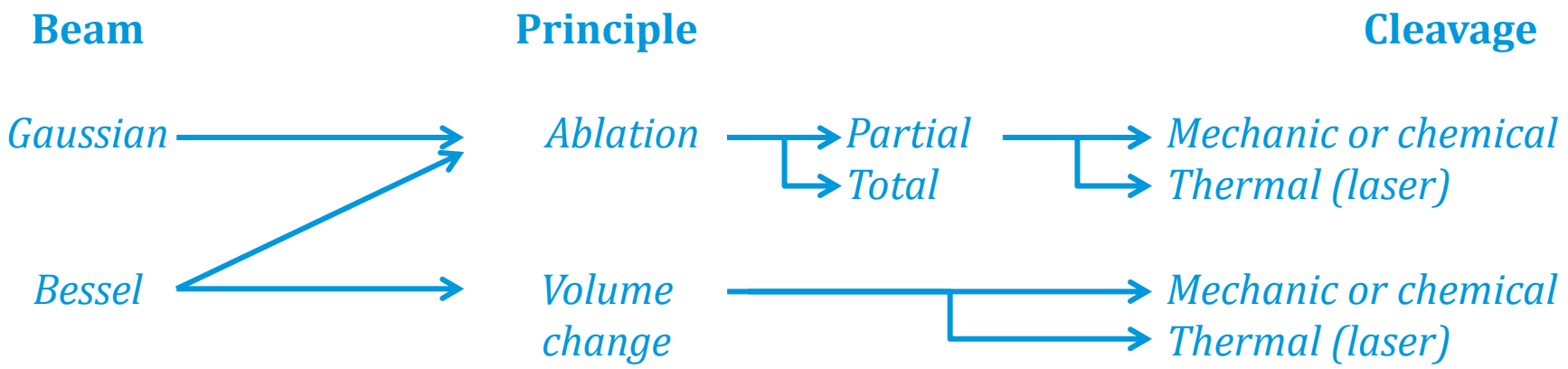


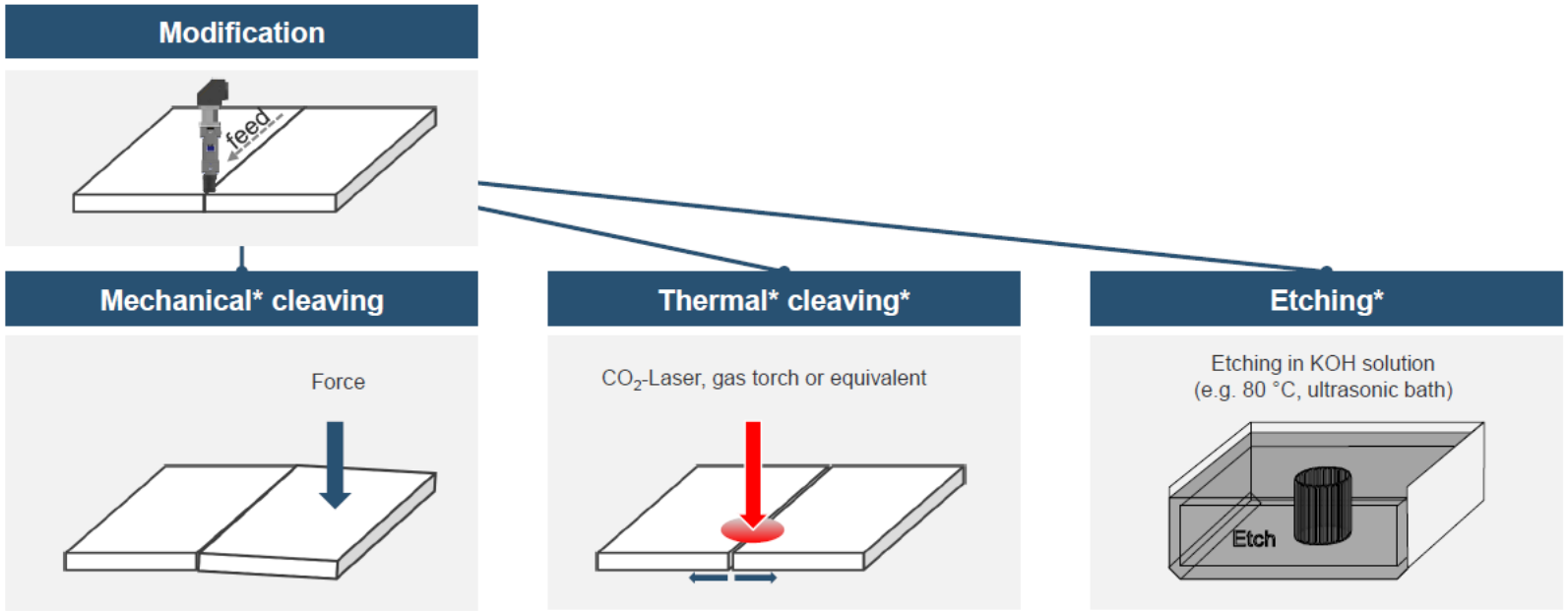




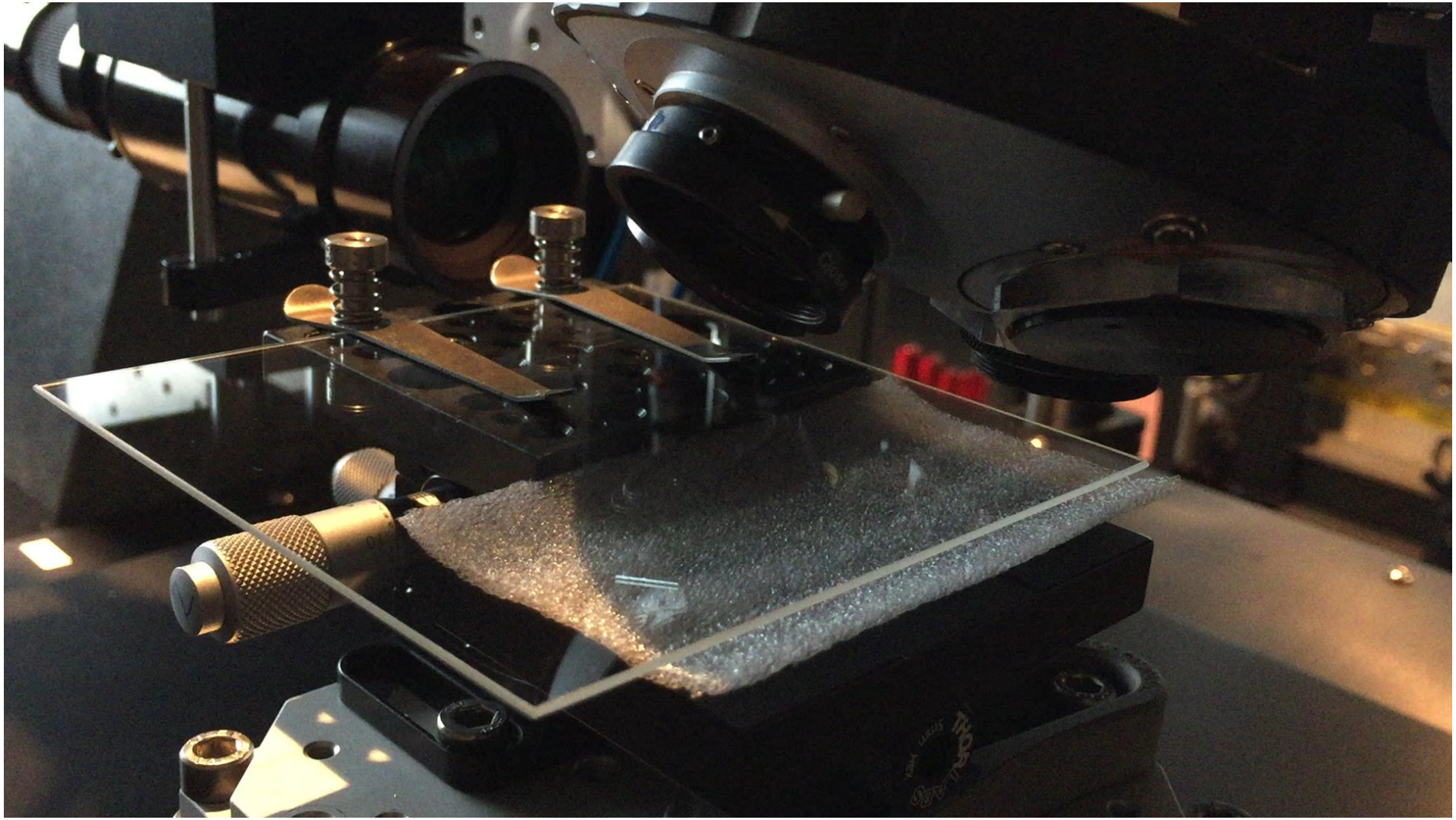
Surface functionalization:
Fs-Laser AR coating
(high LIDT)

Thin glass cutting





Thin glass cutting

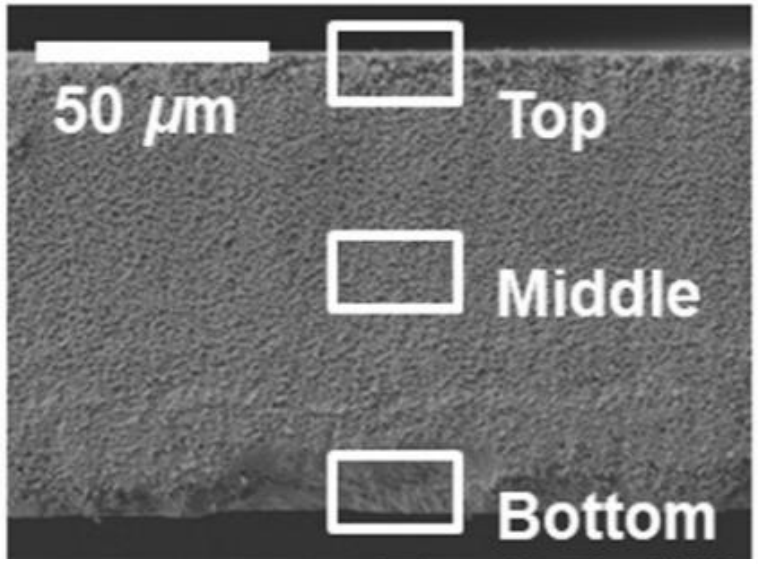


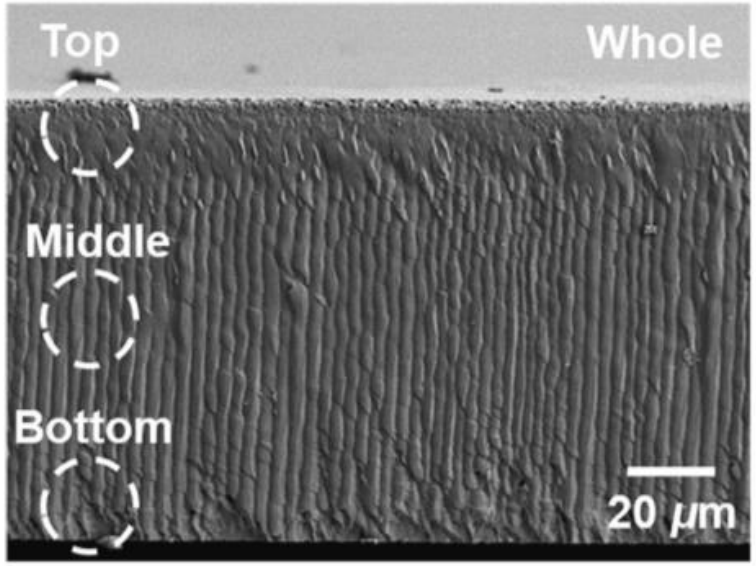
Credit: ALPhANOV/CELIA (John Lopez)

Thin glass cutting

	Ablation (gaussian)	Volume change (Bessel)
Kerf (cut line width)	~30 µm	1-5 µm
Defaults	Chipping (10 – 30 µm) « Heat Affected Zone » <30 µm	Chipping (~µm) Line shape<3 µm
Cutting speed	10-500 $mm.s^{-1}$ Strong dependence on thickness	200-1000 $mm.s^{-1}$ Very low dependence on thickness
Wall roughness	High	Low
Dust	Lots = cleaning	A few chips = no cleaning
Material strength after cutting	160 MPa*	350 MPa*

*edge strength, back side, credit: POSTECH





Abrisa Technologies: One-stop-shop provider for display solutions

Semi-Transparent Mirrors for Hidden Displays

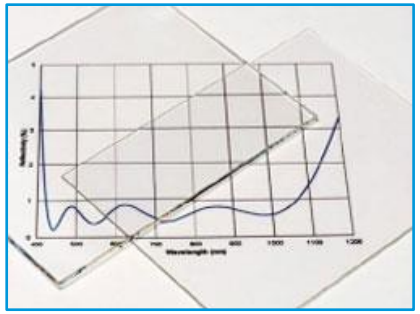
Total Solutions for Ready-to-Install Enhancement Glass

Large 84” Diagonal HI-OD™ Screen Printed Display Glass Solutions

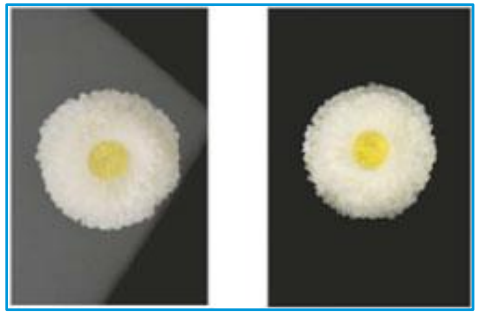
CleanVue™ Pro Oleophobic & Hydrophobic Coating Solutions

Dead Front Panels for Backlit User Interfaces

Vehicular Information Display & Interface Applications



Sensor & Scanner window Solutions

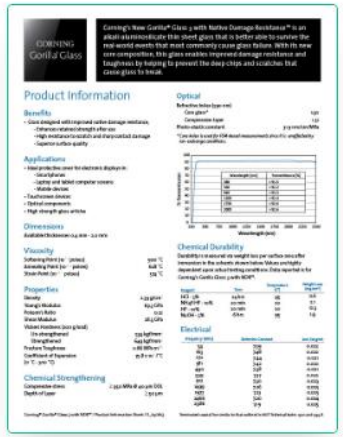


Low Reflection & Non-Glare Glass Solutions

HEF GROUPE

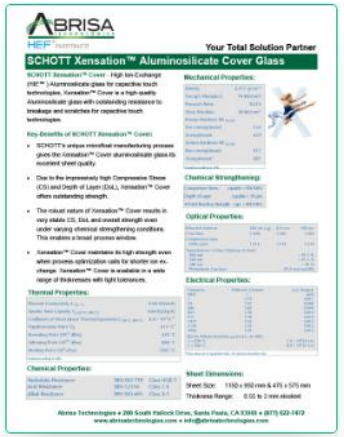
More application notes on our website !

AGC Dragontrail™ Chemically

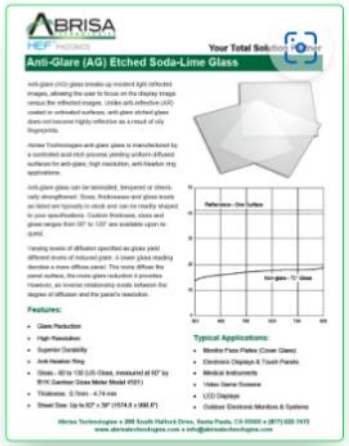


Corning® Gorilla® Glass

SCHOTT AS 87 eco Ultra-Thin

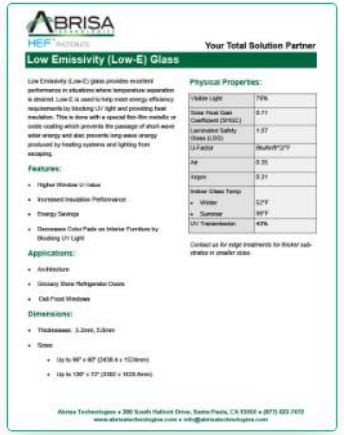


SCHOTT Xensation®

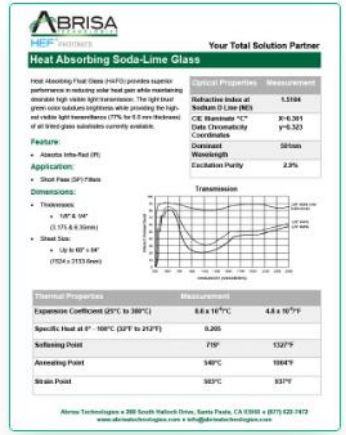


Etched Anti-Glare Soda-Lime Glass

Patterned Glass for Light Control



Low Emissivity (Low E) Soda-Lime Glass



Heat Absorbing Float Glass

Thank you for your attention !

THANK YOU FOR YOUR ATTENTION

Contact information :

azoubir@hef.group

https://abrisatechnologies.com/

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