

The image features a white background with a red logo at the top left. Below the logo is a horizontal band of various halftone patterns, including a world map, a grid, and a diamond pattern. The right side of the image is dominated by a large, vertical halftone pattern of circular dots. A dark grey rectangular area is positioned in the lower-left quadrant, containing white text.

microrelleus

**EPIC ONLINE TECH. MEETING
ON MOULDED OPTICS**

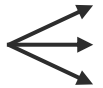
Femtosecond laser - High accuracy laser micro-processing



LIGHTING APPLICATIONS

- 1) Who we are
- 2) Femtosecond laser technology
- 3) Mould microstructuring for lighting
- 4) Mould texturing for lighting

Who we are

- Service provider for industry  Industrial engraving
Laser texturing
Laser microstructuring
- Company creation: 1983 (Pantograph → Die-Sinking EDM → CNC Milling → Laser)
- Facilities in Barcelona – Spain
- 2013: nanosecond laser in 5 axis
- **2016: femtosecond laser service in 5 axis**

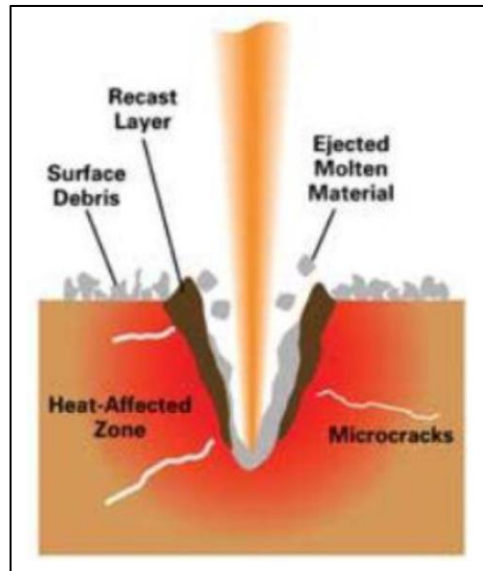


Technology - What a femtosecond laser is?

Ultra-short pulse duration laser (almost no thermal effect over the material)

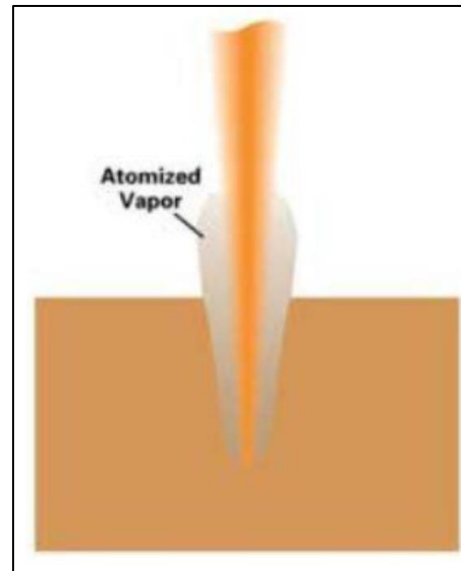
Nanosecond laser (10^{-9} sec)

- Heat affected zone
- Burr



Femtosecond laser (10^{-15} sec)

- “Cold” ablation
- Absolutely burr-free



Femtosecond laser beam diameter:
from $\varnothing 50\mu\text{m}$ down to $\varnothing 15\mu\text{m}$

FEMTOSECOND LASER ENGRAVING ON MOULD INSERTS FOR LIGHTING:

Microstructuring:

Microstructures and freeform micro-optics in the tempered steel inserts

Benefits: smaller details in a conventional mould → new design and functional possibilities

Texturing:

Texture inserts to achieve different properties

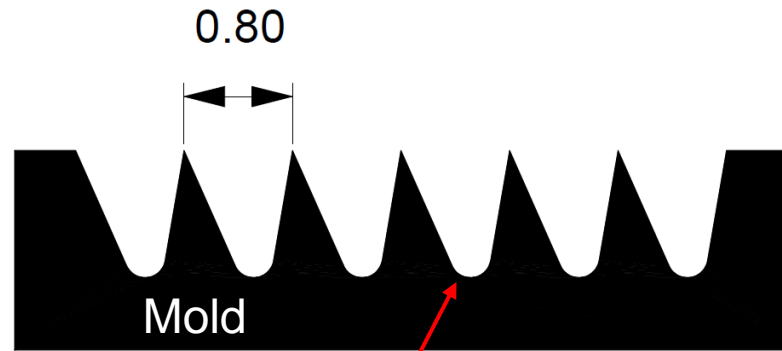
Benefits: controlled process, repeatability, homogeneous and stable results. New possibilities

Mould microstructuring for lighting

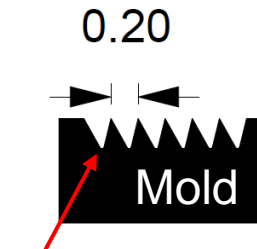
Because of the “cold ablation” of the laser, we can engrave microstructures on mould

- Absolutely burr-free
- Very good tolerances
- High quality surface finishing
- With very sharp edges

Minimum size comparison between tool and femtosecond laser machining:



RADIUS USING TOOL R 0,15mm



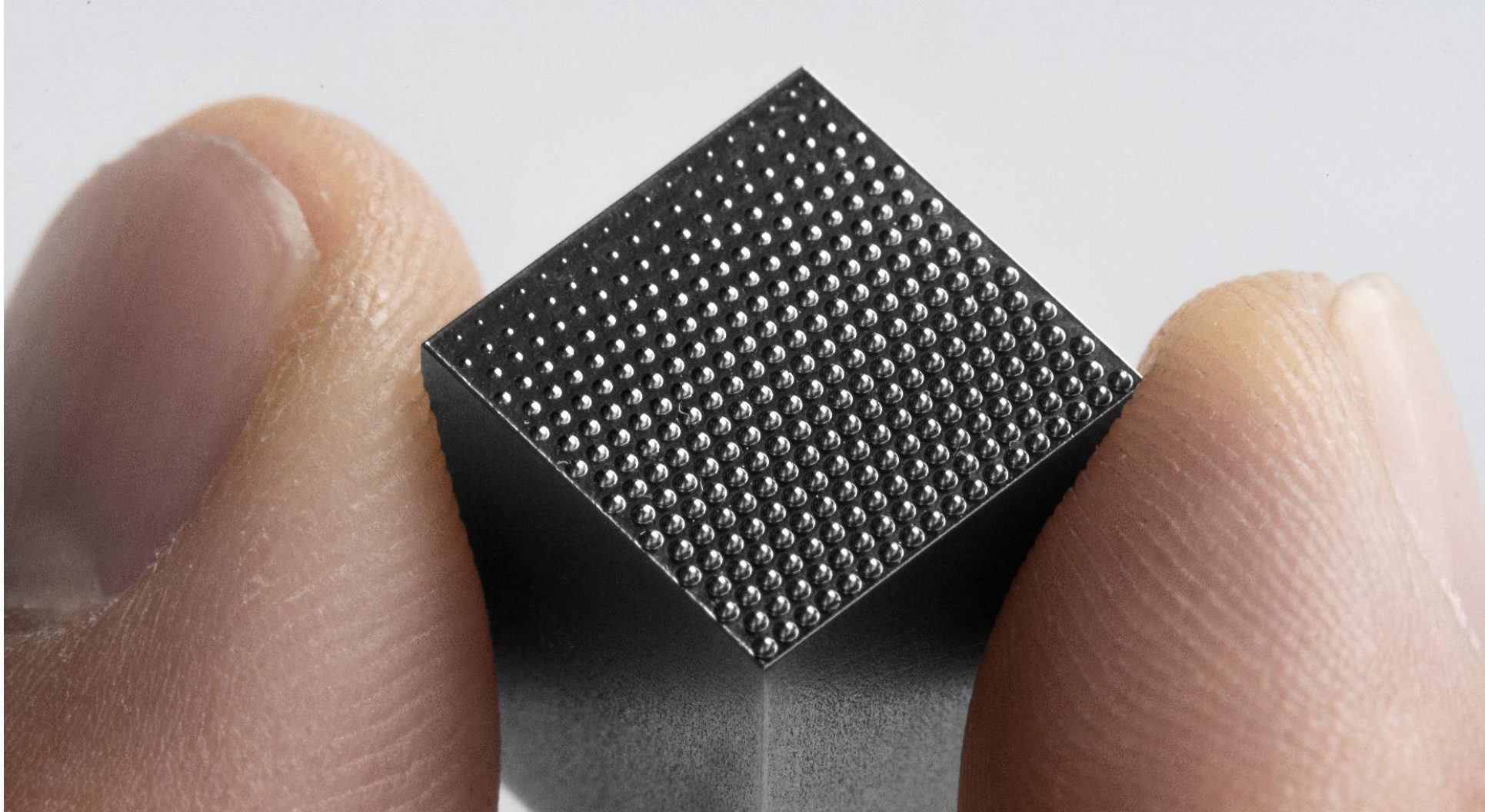
RADIUS FEMTOSECOND LASER R 0,015mm

**LIMITLESS DESIGN
POSSIBILITIES!**
We can engrave
freeform micro-optics
and microstructures
on mould inserts

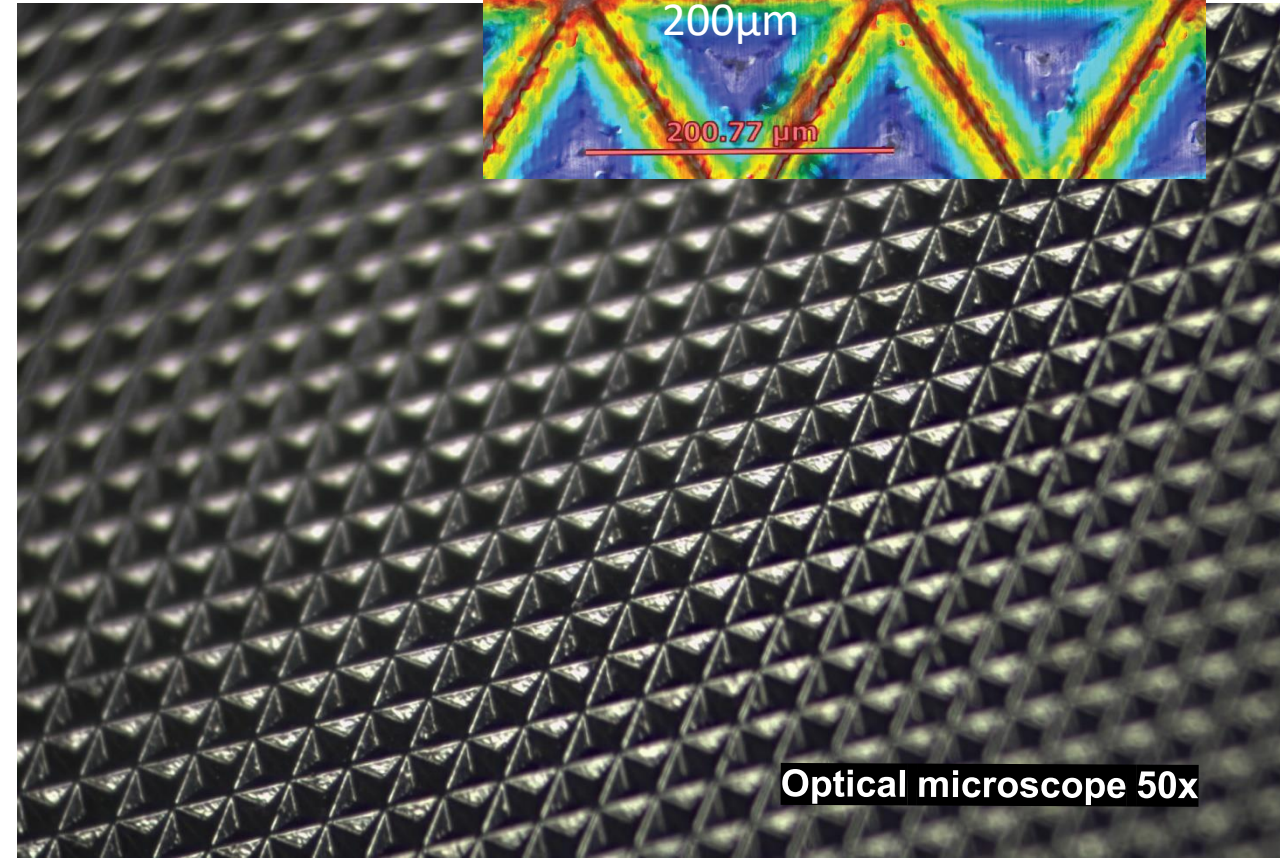
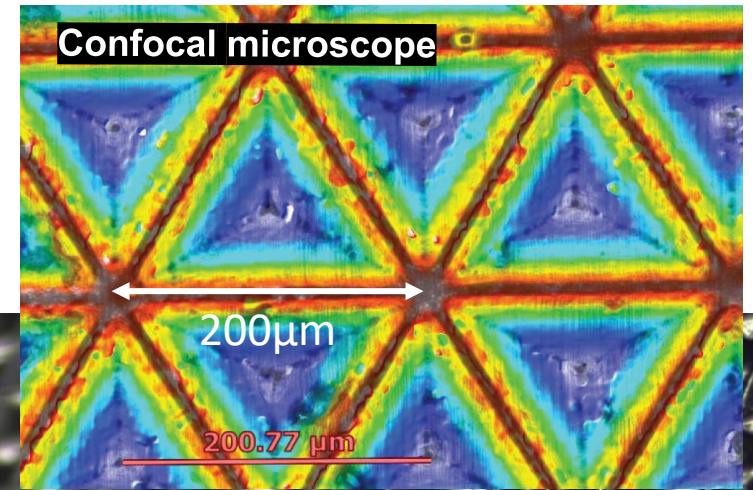
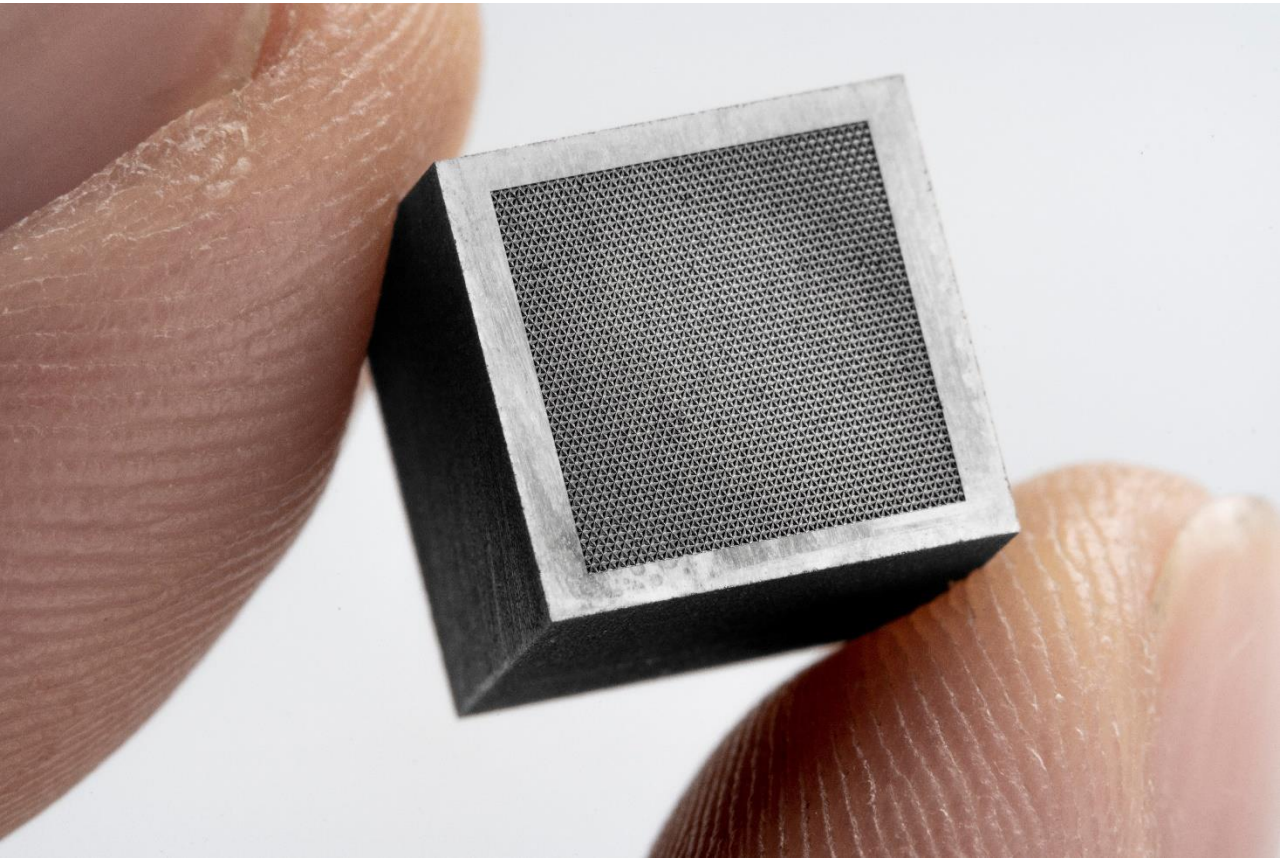
*Which is the minimum
size we can achieve?
Ask us for our design guide!!*

We can achieve radii 10 times smaller than using conventional machining!!

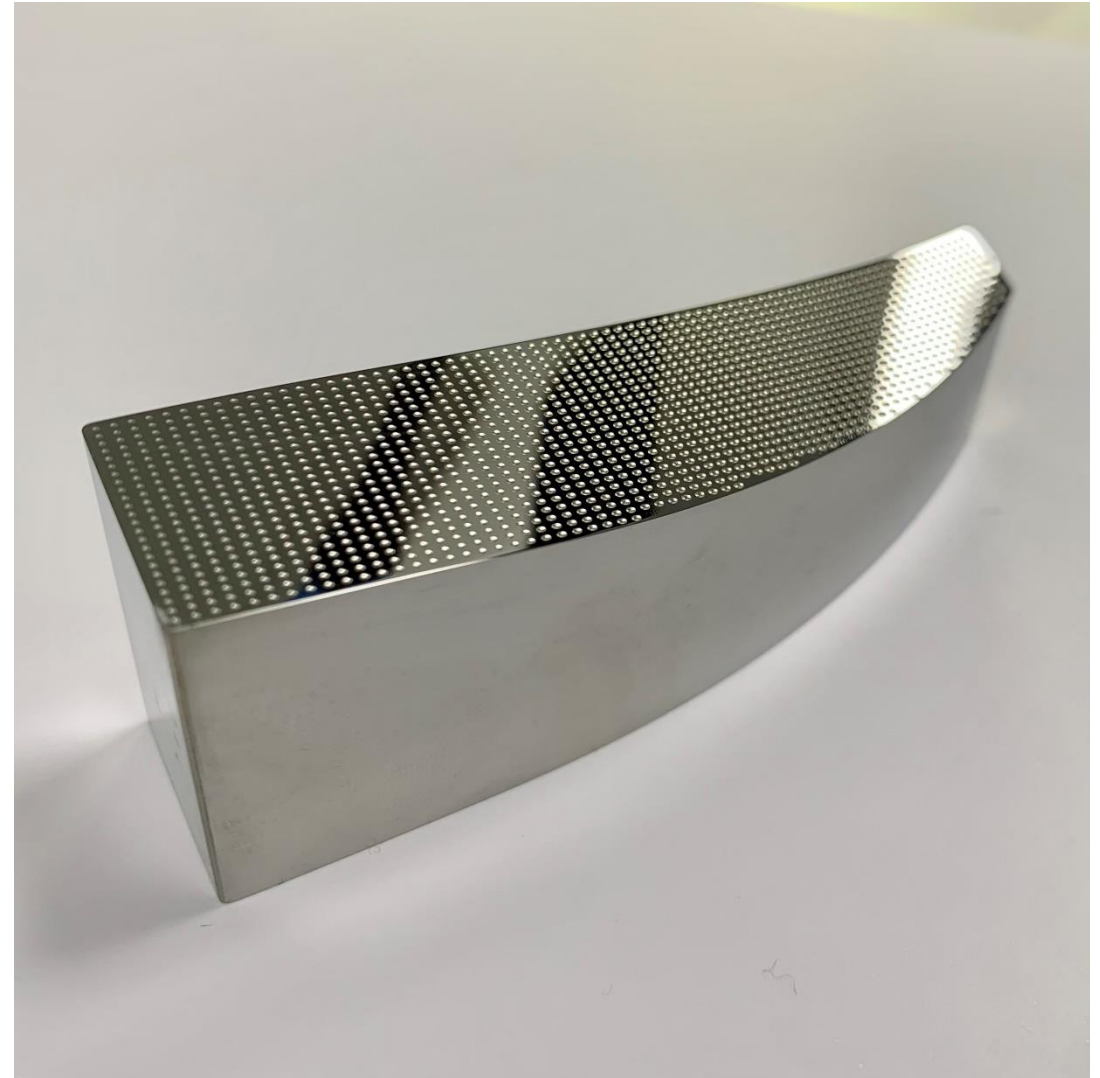
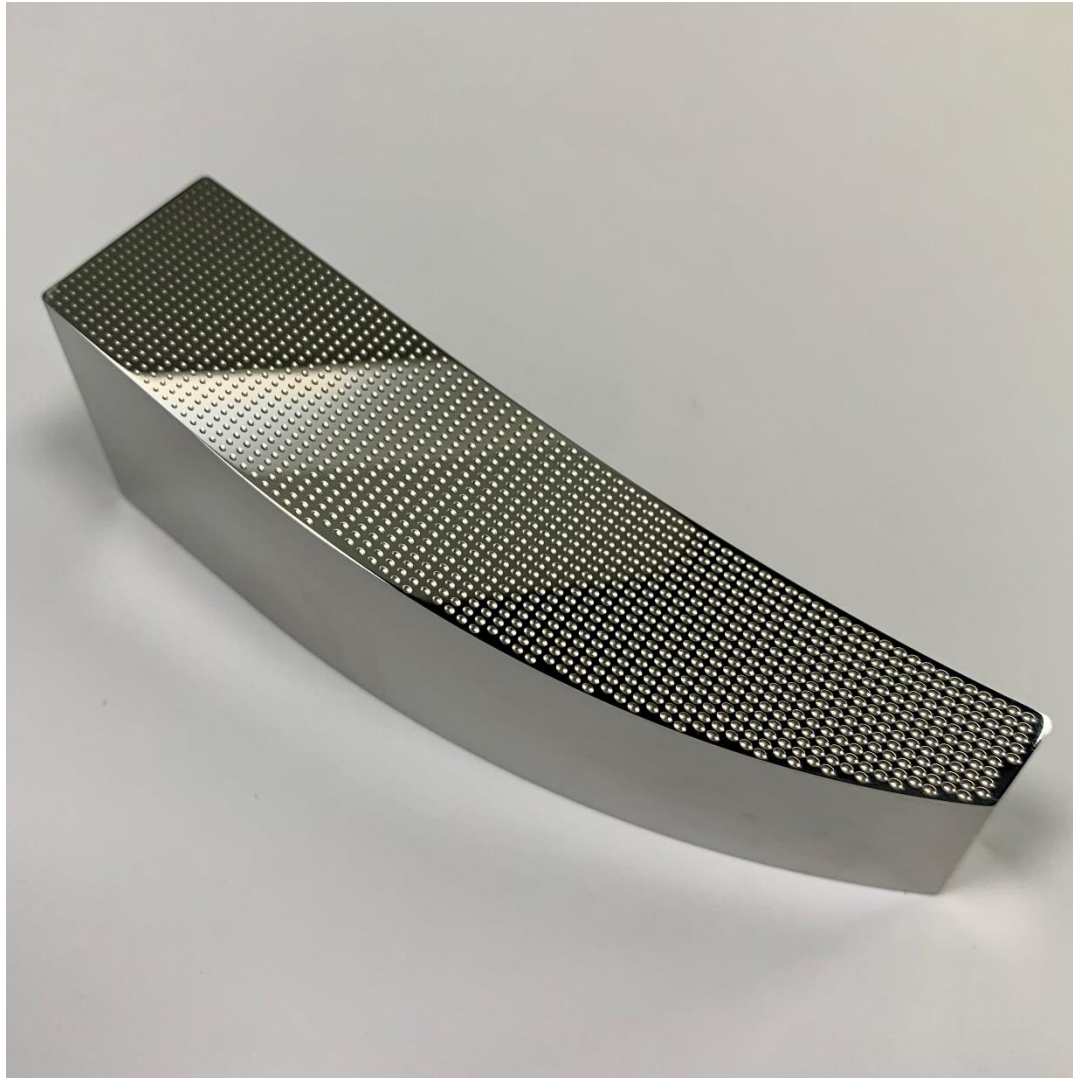
Mould microstructuring for lighting



Mould microstructuring for lighting

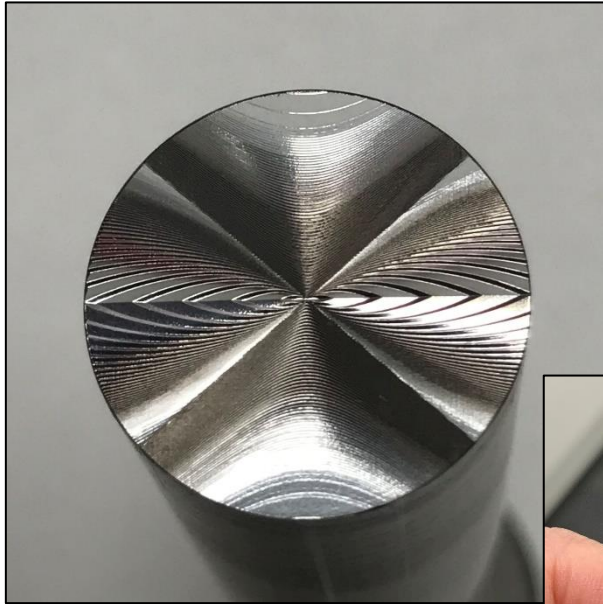


Micro-optics on mould

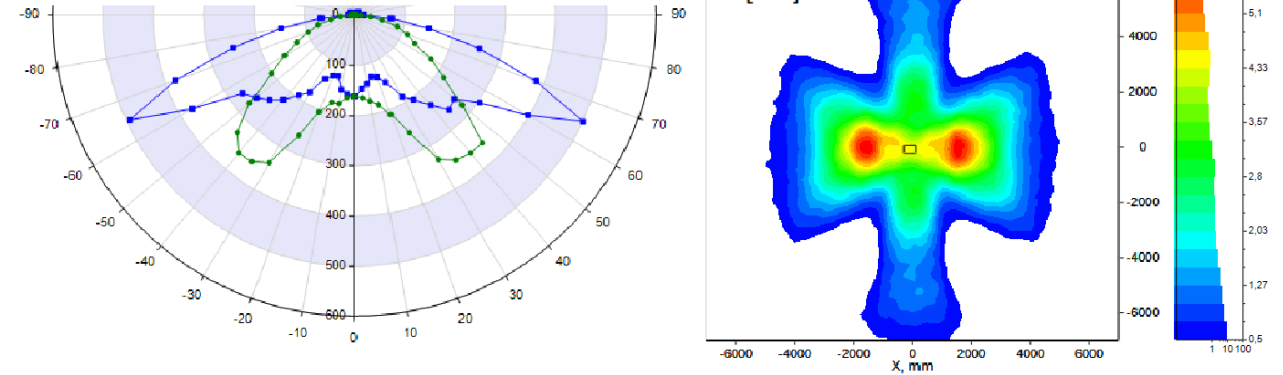


Micro-optics on mould

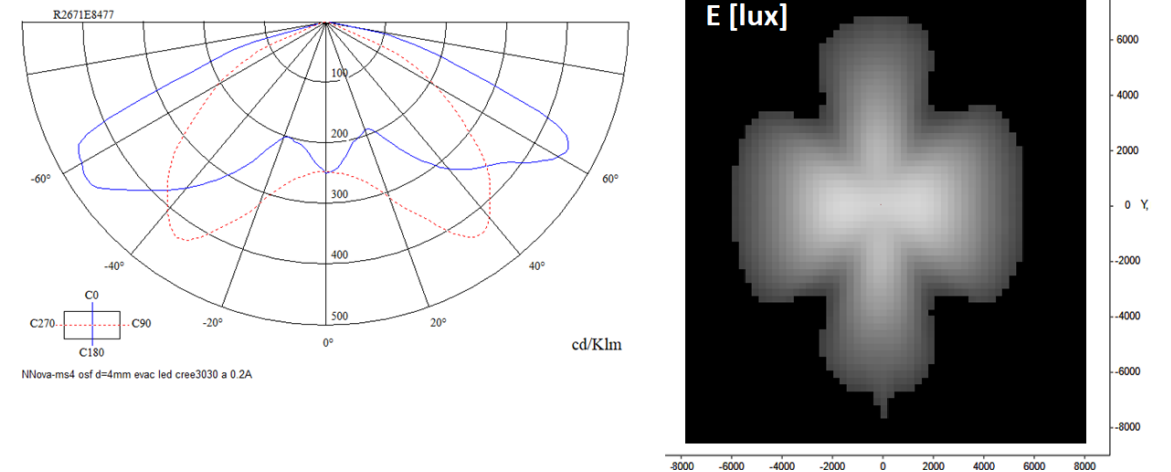
Freeform micro-optics (Customer: Daisalux)



Simulated value

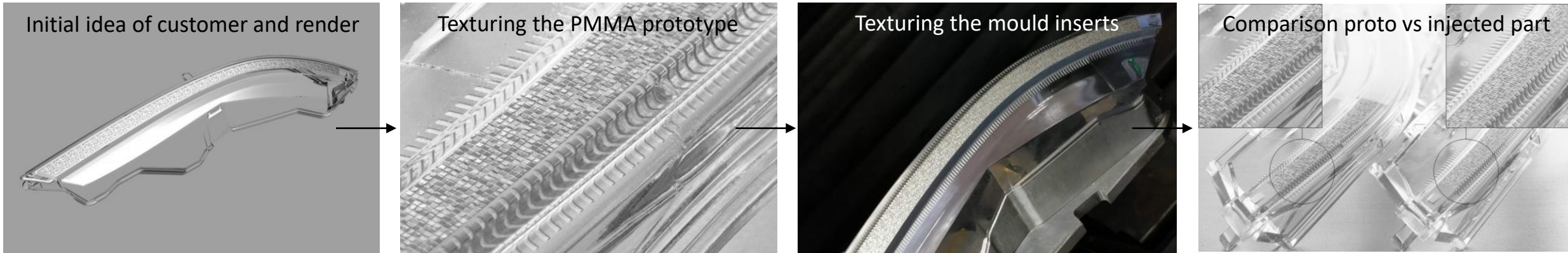


Measured value



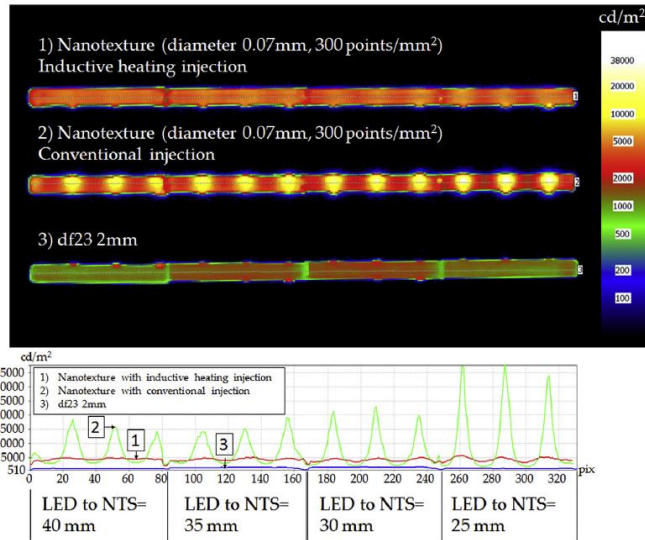
Mould texturing – decorative texturing

Seat León 2020 → texture in the signal mirror indicator



Mould texturing – functional texturing

2018 → Functional texturing →
Light Diffusion to try to avoid hot spot of the LED



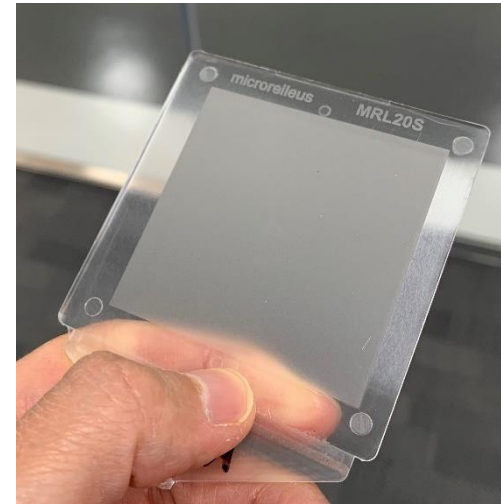
Luminance images and luminance plots of nanotexture with optical diameter 0.07 mm and 300 points/mm² connected at 8 V. The four areas match with the four distances between LED and NTS/df23 defined in the mock-up, from left to right: 40 mm, 35 mm, 30 mm and 25 mm.

BUT...

- 1) Not possible to ensure homogeneity (we used nanosecond laser for the texturing)
- 2) Need of heat&cool injection for good result

Pina-Estany, J., García-Granada, A. A., & Corull-Massana, E. (2018). Injection moulding of plastic parts with laser textured surfaces with optical applications. *Optical Materials*, 79, 372-380.
Textures: Microrelleus

2020 → Development of textures on mould for **light diffusion purposes** (MRL10S, MRL20S, MRL30S)



Better homogeneity →

MRL10S → MRL20S → MRL30S

← Better luminance

MRL10S ← MRL20S ← MRL30S

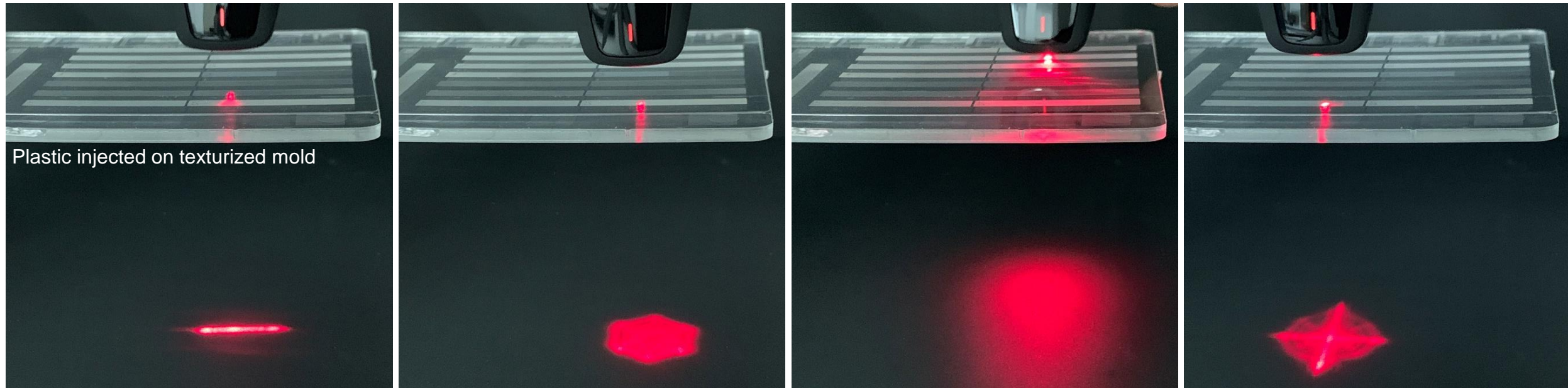
Important points we took into consideration for the design of the textures:

- 1) Diffusion quality and luminance
- 2) Repeatability and stability of the texture (femtosecond laser)

- Burr is not having any influence on the diffusion.
- Very controlled process and textures over any material or conditions.
- No need of heat&cool injection

Mould texturing – functional texturing

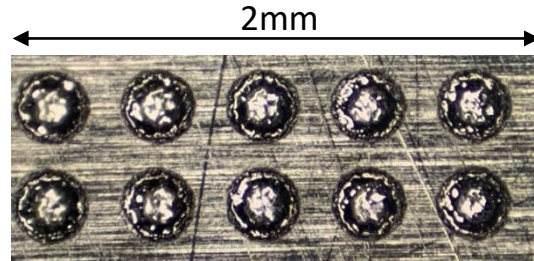
FUNCTIONAL TEXTURING → LIGHT DIRECTION 1D & LIGHT DIRECTION 2D



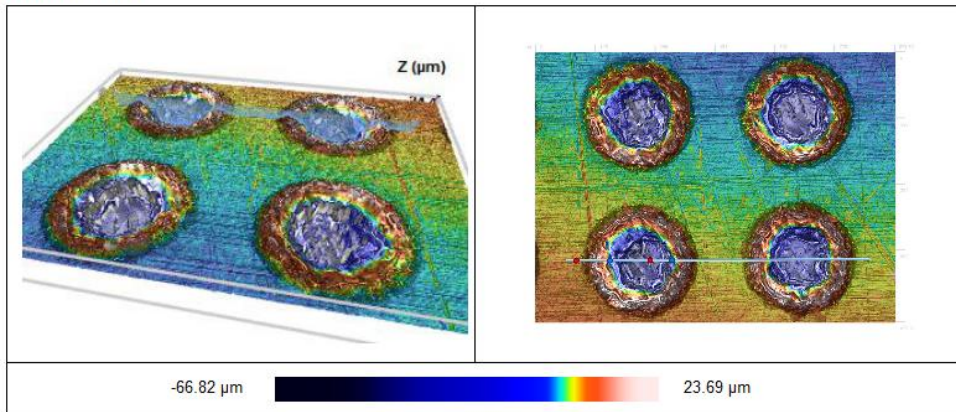
Pina-Estany, J., García-Granada, A. A., & Corull-Massana, E. (2018). Injection moulding of plastic parts with laser textured surfaces with optical applications. *Optical Materials*, 79, 372-380.
Textures: Microrelleus

Femtosecond laser quality – comparison vs nano

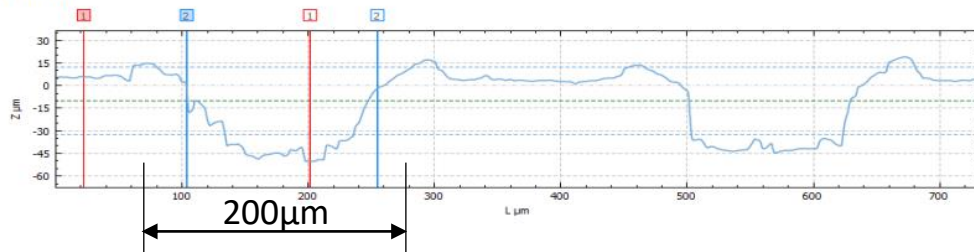
Nanosecond laser
Low relief in the mould



Visualization



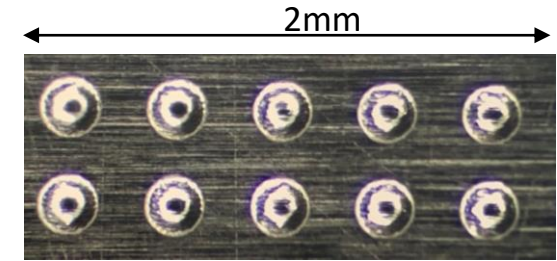
Profile



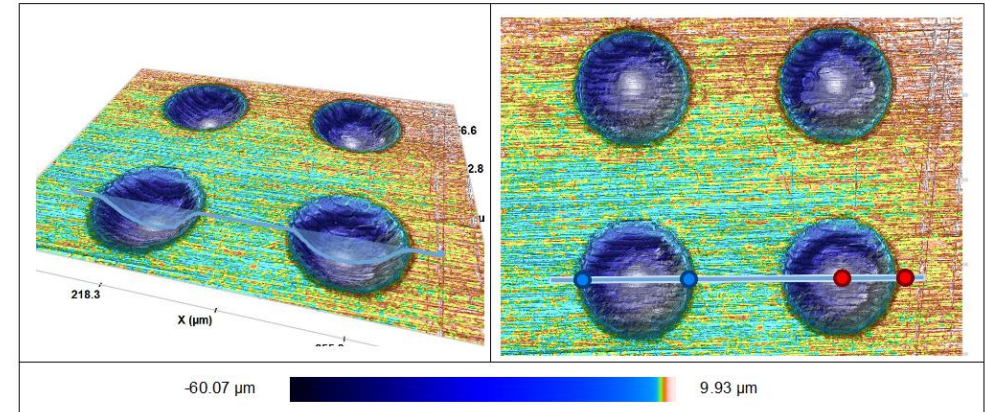
Notes Profile

- | | | | |
|---|-------------------------------------|----------|---|
| 1 | ■ | Distance | $\Delta L = -179.31 \mu\text{m}$; $\Delta Z = 56.192 \mu\text{m}$; $\angle = 17.40^\circ$ |
| 2 | ■ | Distance | $\Delta L = -150.93 \mu\text{m}$; $\Delta Z = 1.8138 \mu\text{m}$; $\angle = 0.69^\circ$ |

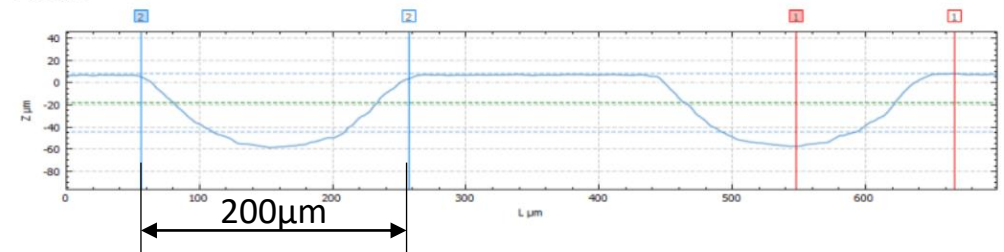
Femtosecond laser
Low relief in the mould



Visualization



Profile

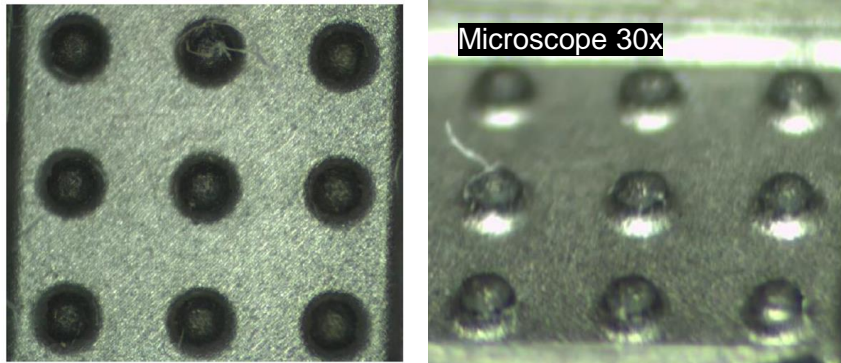


Notes Profile

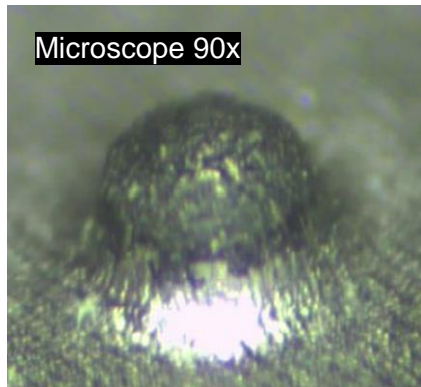
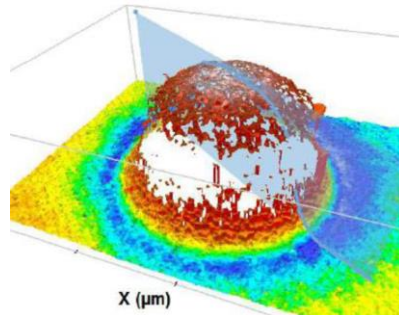
- | | | | |
|---|-------------------------------------|----------|---|
| 1 | ■ | Distance | $\Delta L = -119.33 \mu\text{m}$; $\Delta Z = 65.505 \mu\text{m}$; $\angle = 28.76^\circ$ |
| 2 | ■ | Distance | $\Delta L = -201.25 \mu\text{m}$; $\Delta Z = 1.8021 \mu\text{m}$; $\angle = 0.51^\circ$ |

Femtosecond laser quality – comparison vs nano

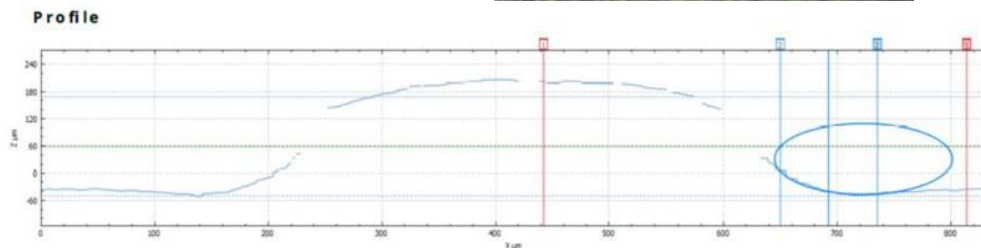
Nanosecond laser (spheres diameter 0.4mm)



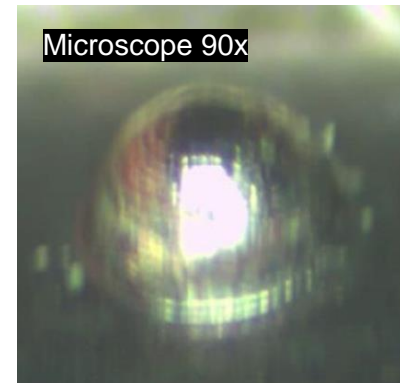
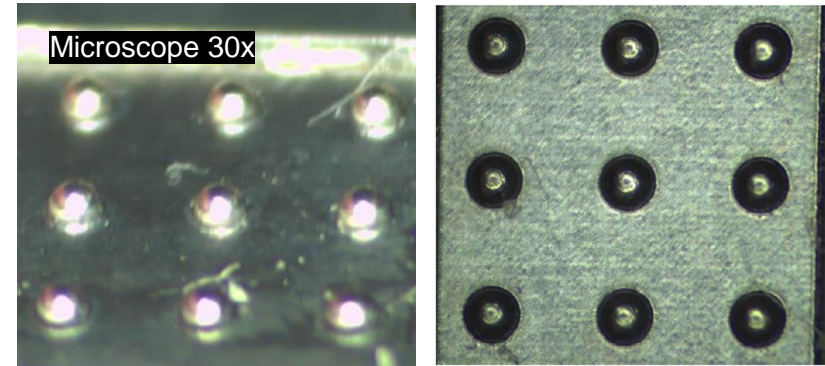
Confocal microscope.



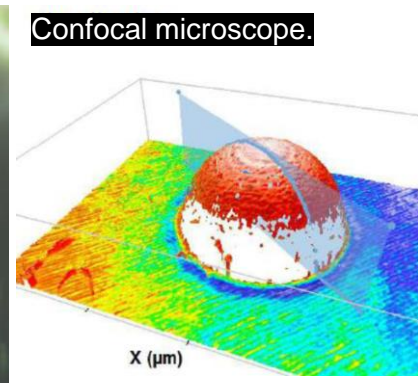
Microscope 90x



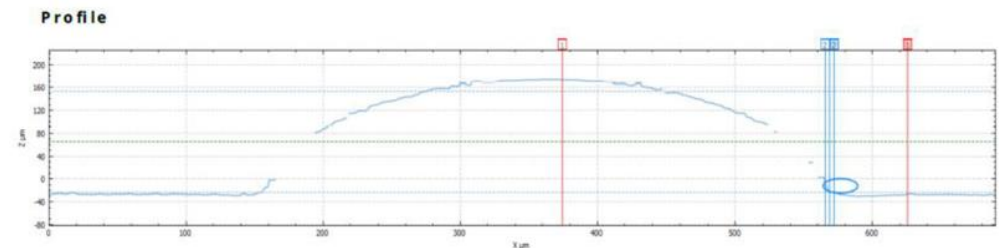
Femtosecond laser (spheres diameter 0.4mm)



Microscope 90x

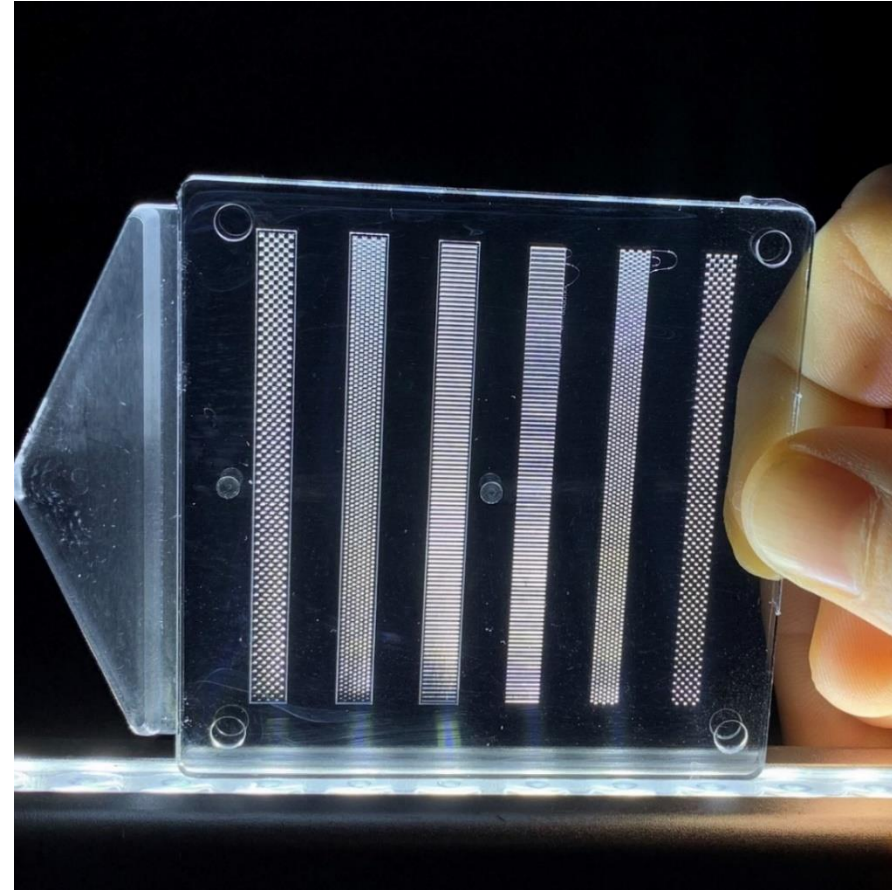
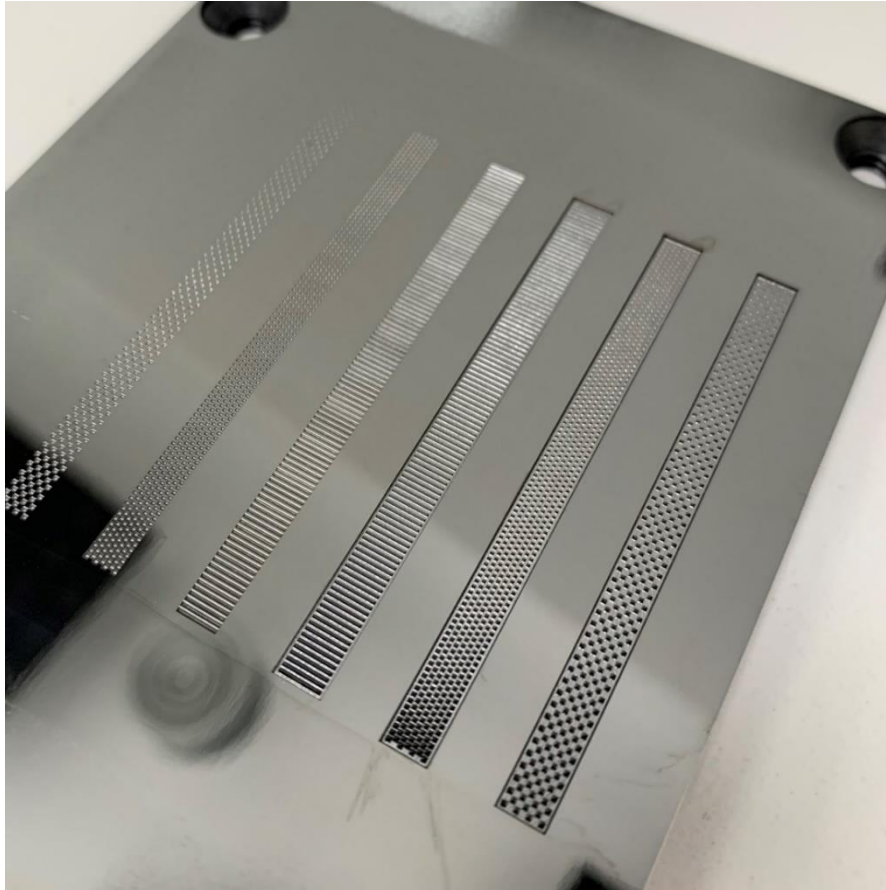


Confocal microscope.



Femtosecond laser quality – light guide application

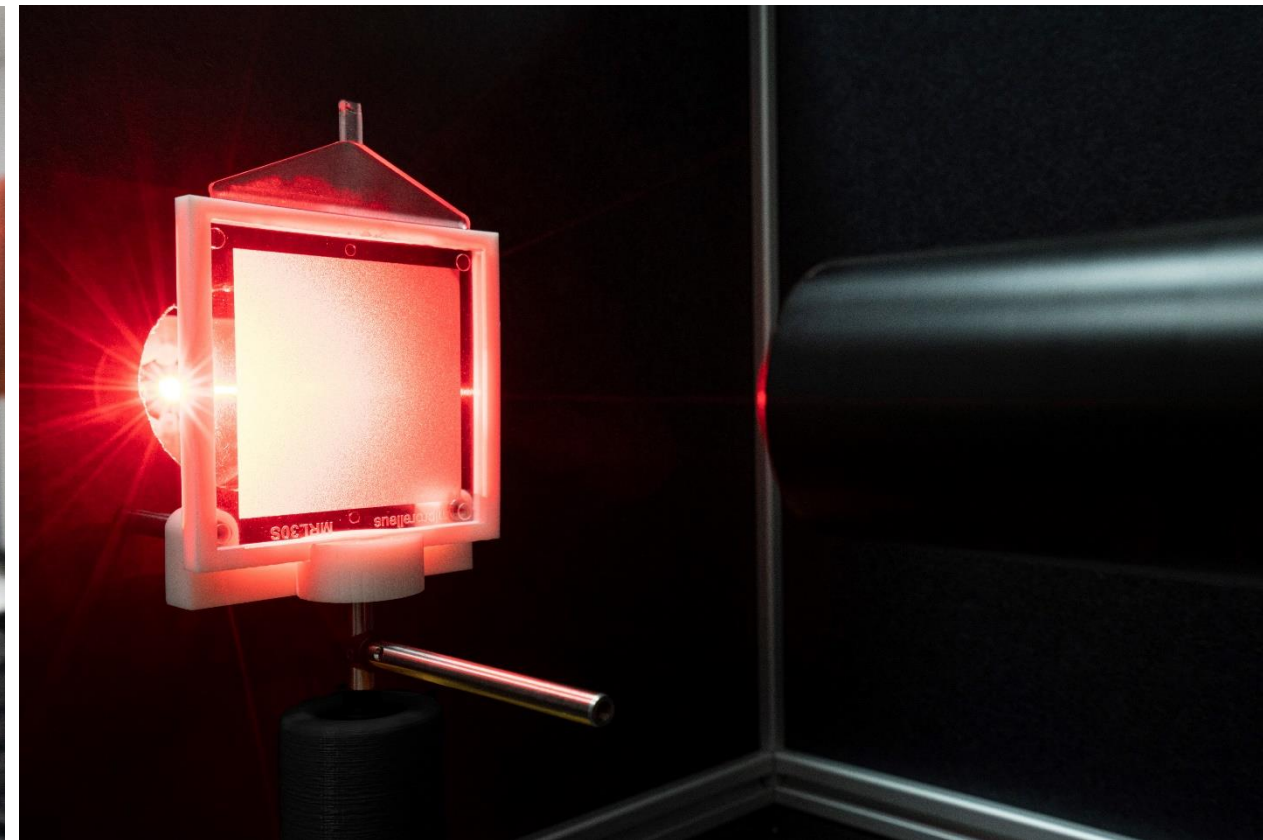
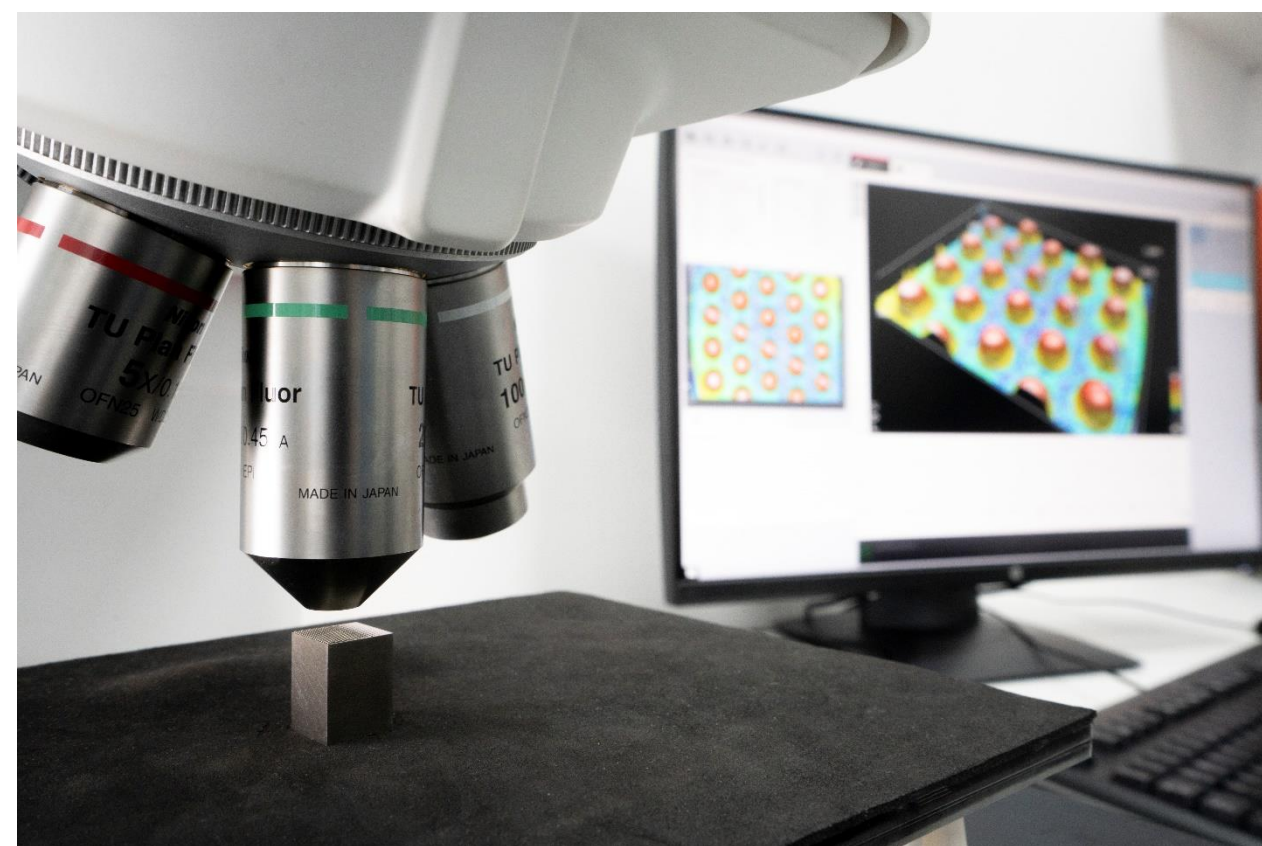
Different microstructure designs for achieving homogeneous light intensity in a light guide
Customer: Weidplas



Quality control & measurement

We use confocal and focus variation microscope to measure the microstructuring and texturing.

We have our own photometry laboratory to obtain basic measurements that help us to know the quality and the homogeneity of our textures and microstructures.



microrelleus

Laser microstructuring
Laser texturing
Industrial engraving

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