

# microrelleus

## Femtosecond laser microstructuring for moulds and prototypes on automotive lighting

Raúl García – Microrelleus SL  
EPIC Online Technology Meeting on Automotive Lighting



# LIGHTING APPLICATIONS

- 1) Who we are
- 2) Femtosecond laser technology
- 3) Lighting prototypes
- 4) Microstructuring for lighting
- 5) Mold texturing
- 6) Micro-optics

# Who we are

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



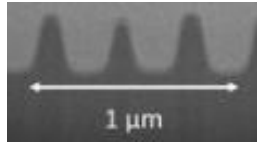
# Technology - Machining technology positioning

We can achieve smaller milling details than conventional technologies in an industrial way!!  
(not in a laboratory)

Lighting applications  
(microstructuring & texturing)

PMMA / PC Prototypes & Small series  
Moulds / Tools

nanometers



**Nanotechnology processes (litography, etc.)**

Down to some nm (nanometers)

**Femtosecond laser technology**

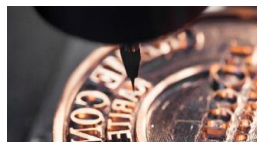
Down to  $10\mu\text{m}$  (0,01mm)

**Conventional technologies:**

**Milling-machine, die-sinking EDM, etc.**

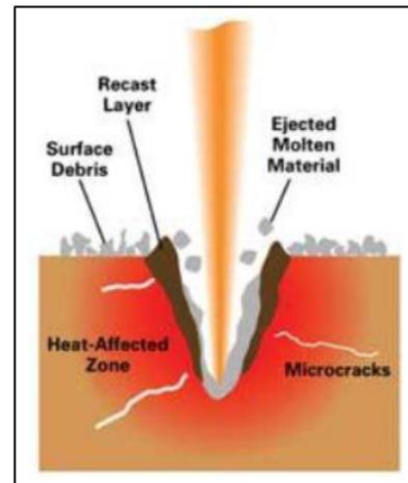
From several millimeters to aprox.  $100\mu\text{m}$  (0,1mm)

millimeters



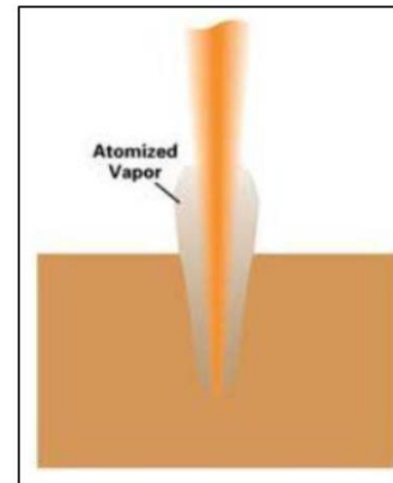
**Nanosecond laser ( $10^{-9}\text{sec}$ )**

- Heat affected zone
- Burr



**Femtosecond laser ( $10^{-15}\text{sec}$ )**

- "Cold" ablation
- Absolutely burr-free

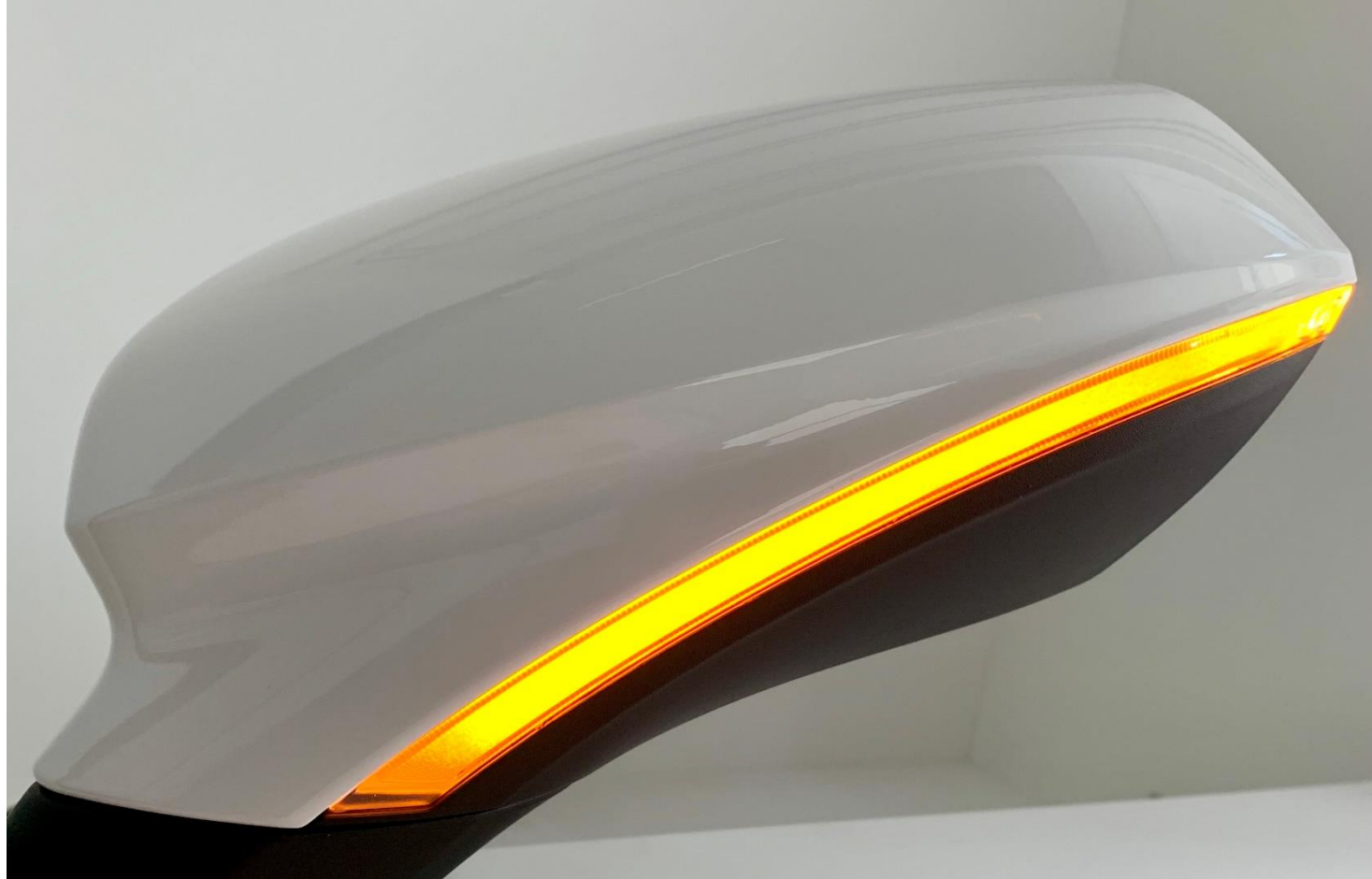


\*Femtosecond laser beam diameter:  
from  $50\mu\text{m}$  to  $10\mu\text{m}$



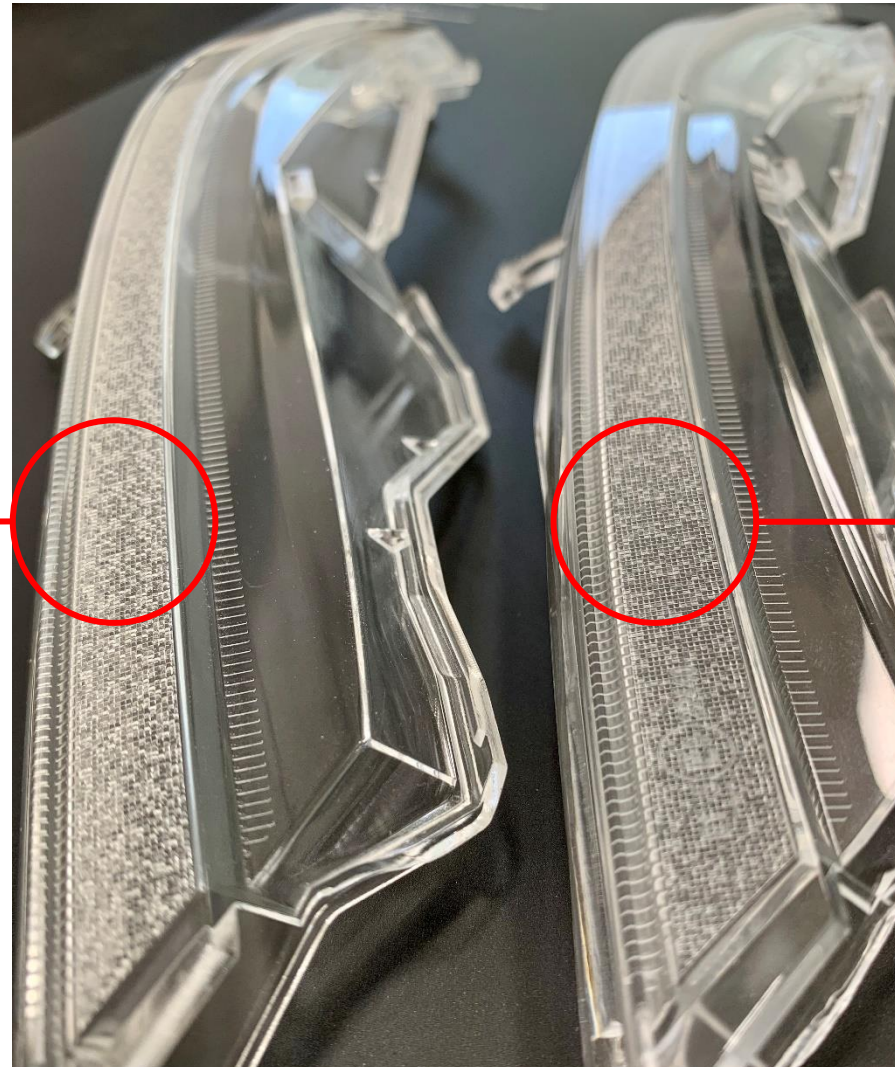
# Lighting prototypes – microstructure and texture

Because of the “cold ablation” of the laser we can achieve details, textures and millings that were not possible before on prototype (both for functional or design purposes with the light). We can work on PMMA, PC, or any material.



# Lighting prototypes – microstructure and texture

Texture engraved directly over PMMA part (prototype)

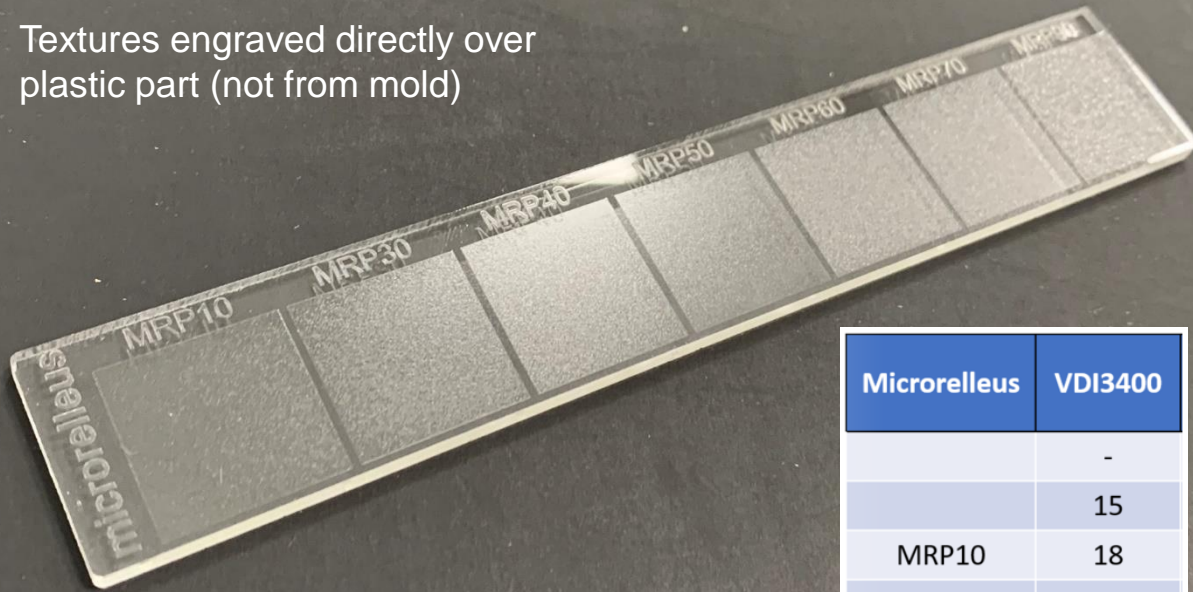


PMMA part injected in texturized mold (production)



# Lighting prototypes – microstructure and texture

Textures engraved directly over plastic part (not from mold)



Microrelleus	VDI3400
	-
	15
MRP10	18
MRP20	21
MRP30	24
MRP40	27
MRP50	30
MRP60	33
MRP70	36
MRP80	39
MRP90	45

VDI engraved on mold  
(injected parts)



VDI30 and VDI 36 engraved  
directly over PMMA



# Lighting prototypes – microstructure and texture



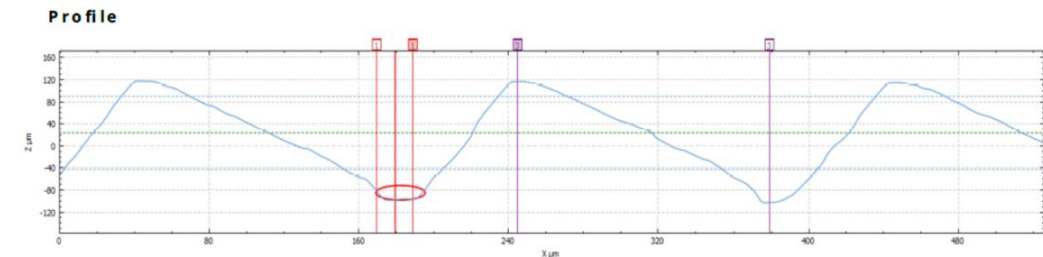
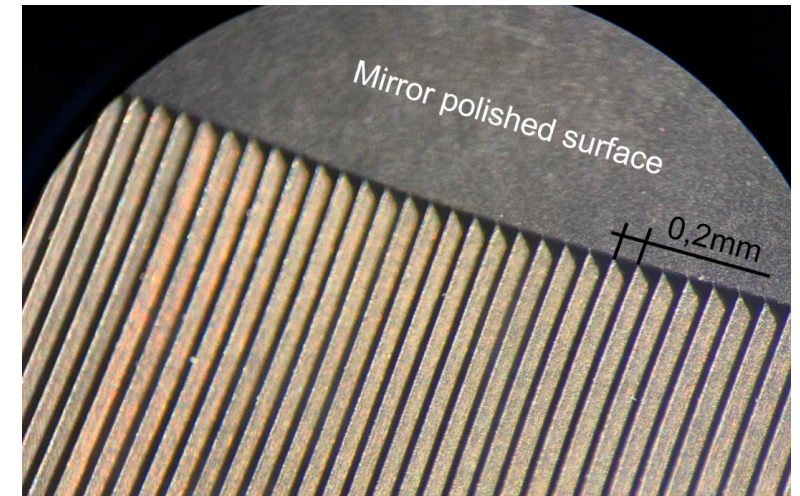
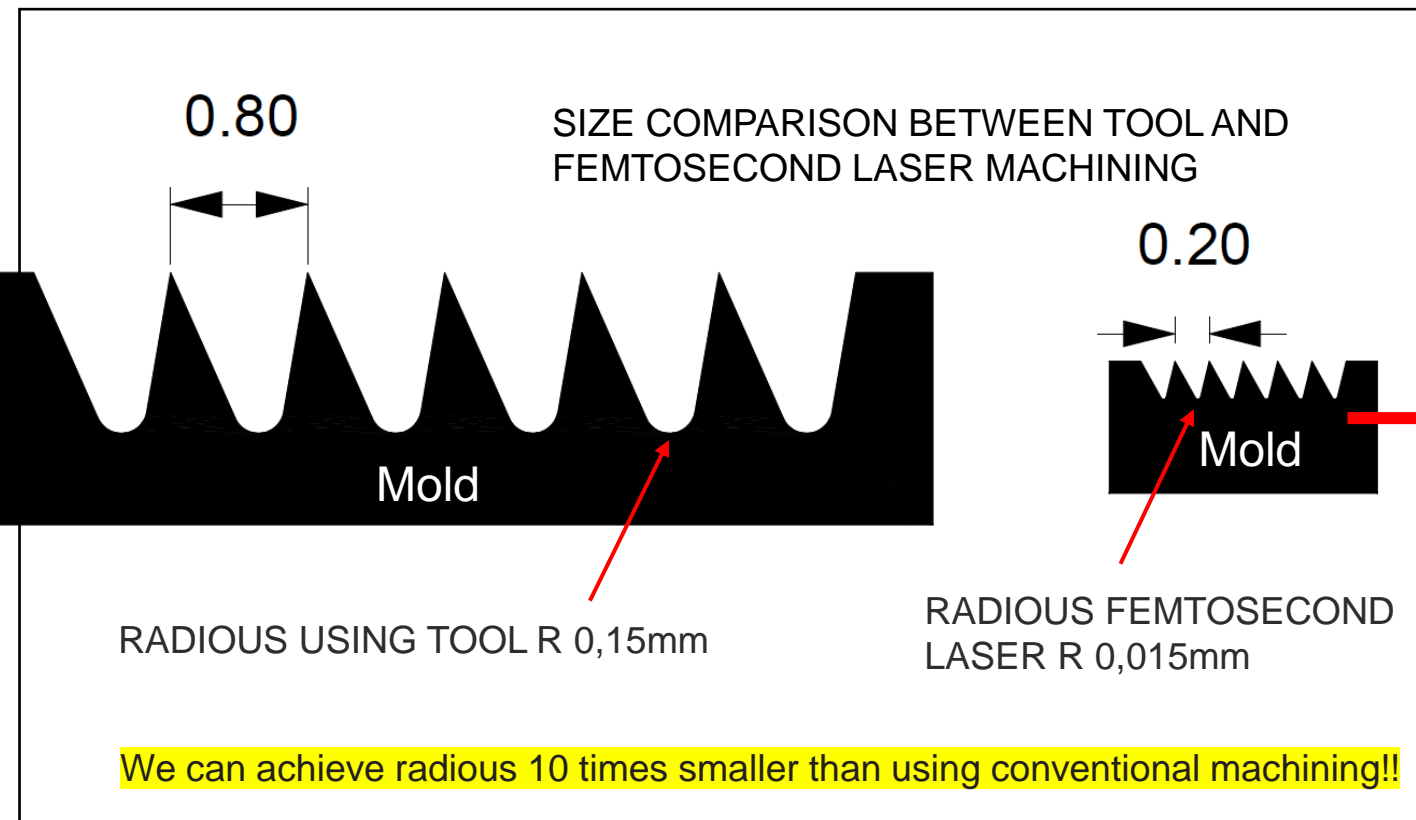


# Lighting prototypes – microstructure and texture



# Microstructuring for lighting

Because of the “cold ablation” of the laser, we can create micro-structures absolutely burr-free, with very good tolerances, perfectly defined and with very sharp edges. This capacity let us create micro-structures to get benefit on the light behaviour.

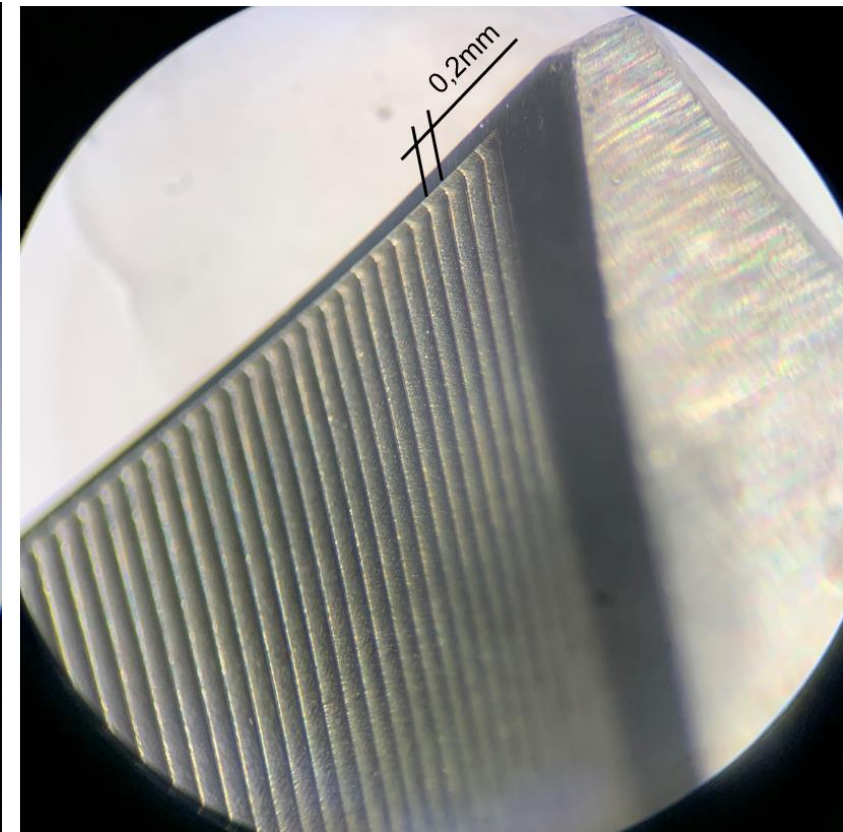
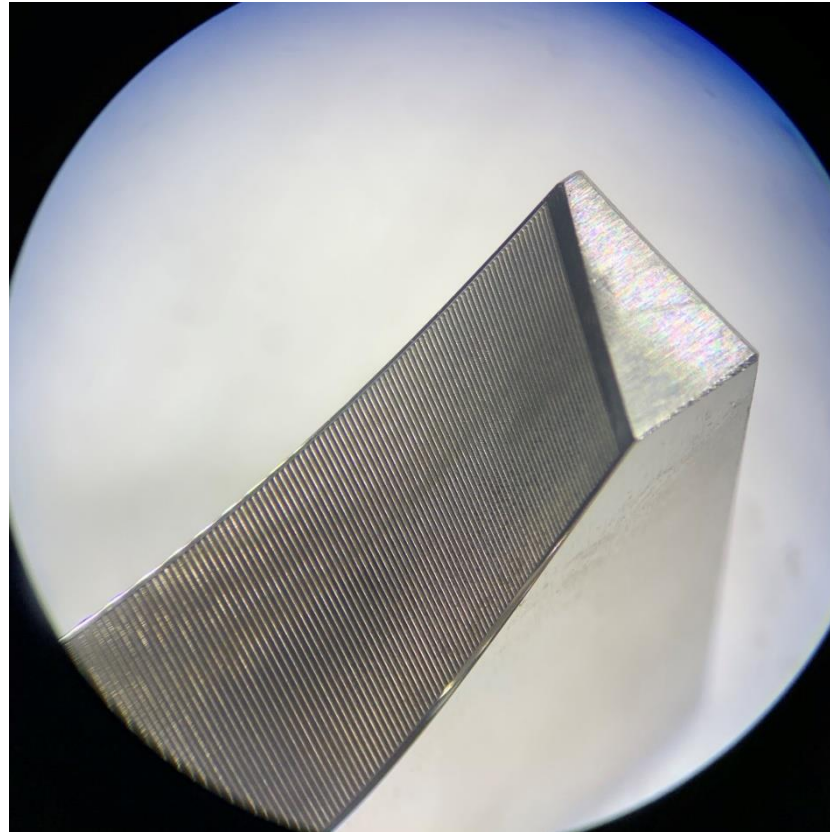
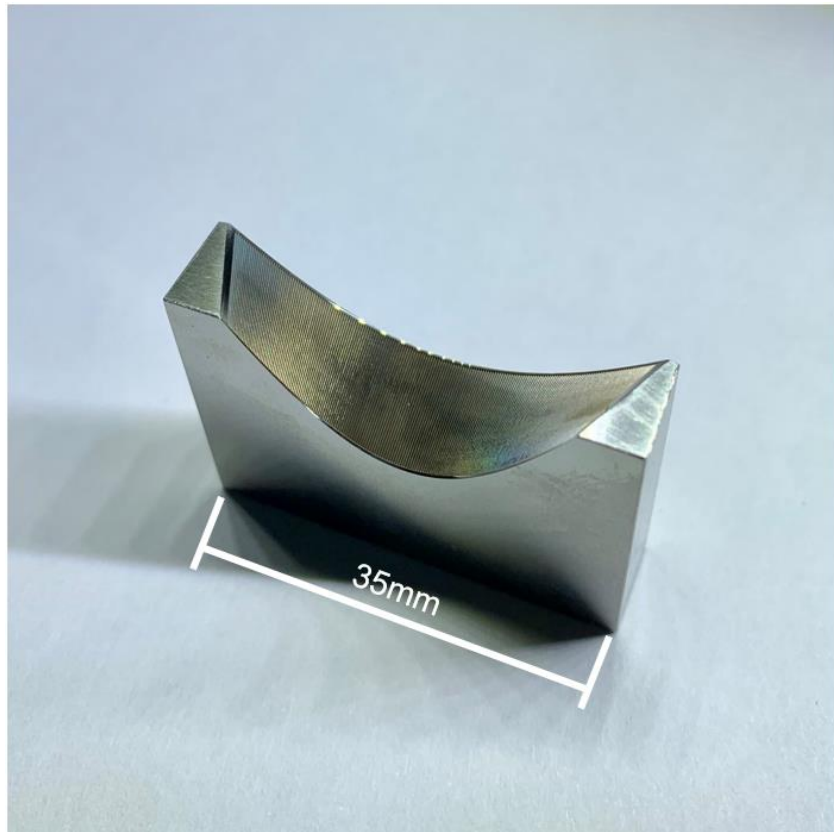


## Notes

- 1 Circle  $D_{xy} = 26.415 \mu m$   $A_{xy} = 548.00 \mu m^2$
- 2 Distance  $\Delta L = 200.23 \mu m$   $\Delta Z = 132.22 nm$   $\angle = 0.04^\circ$

# Microstructuring for lighting

We work using 5 axis, so we can create the structures over any 3D shape.  
Result is a clean micromilling with very good superficial finishing

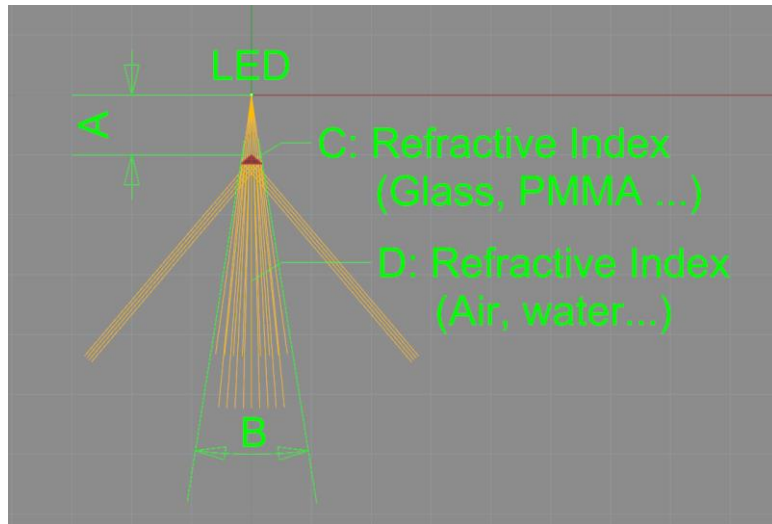


# Microstructuring for lighting

We developed our own simulator in cases where customer doesn't know which texture to apply:

Entrance data of the simulator:

- A) Distance between LED and the surface
- B) Output LED angle
- C) Material that the light will go through
- D) Medium that the light goes through
- E) Microstructure or texture



## EXAMPLE OF REAL PROJECTS DONE USING OUR OWN SIMULATOR

### OPENING LIGHT

Customer goal: opening light 30 degree per side after crossing our microstructure

Result on final injected part: light was opened 29 degree per side

### INCREASING LIGHT INTENSITY IN A LIGHT GUIDE

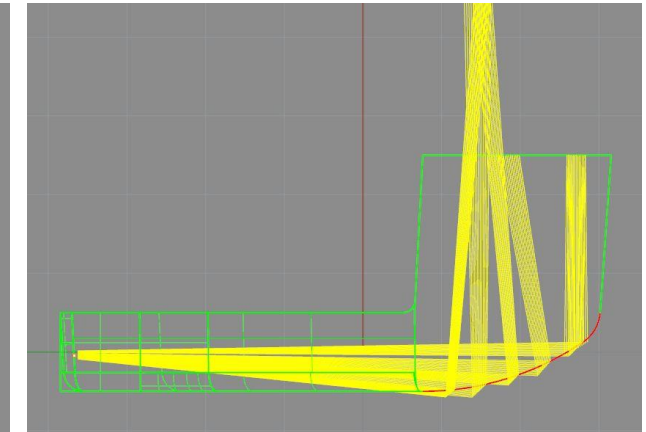
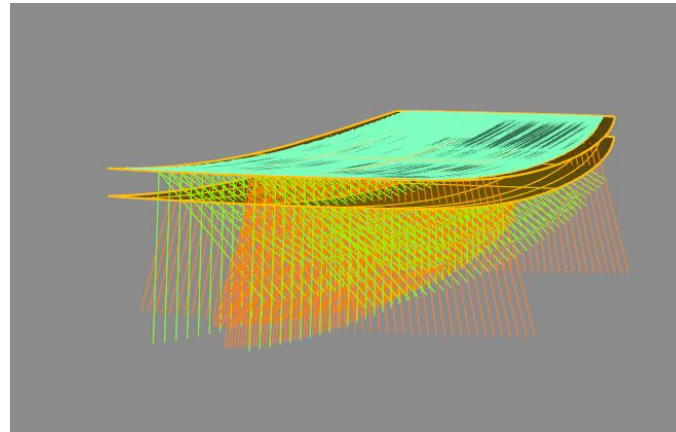
Customer goal: increase light intensity because of the big light loss they had in the changing direction area of the light guide

Result on final injected part: light intensity in target zone was 2 times higher in photometry test

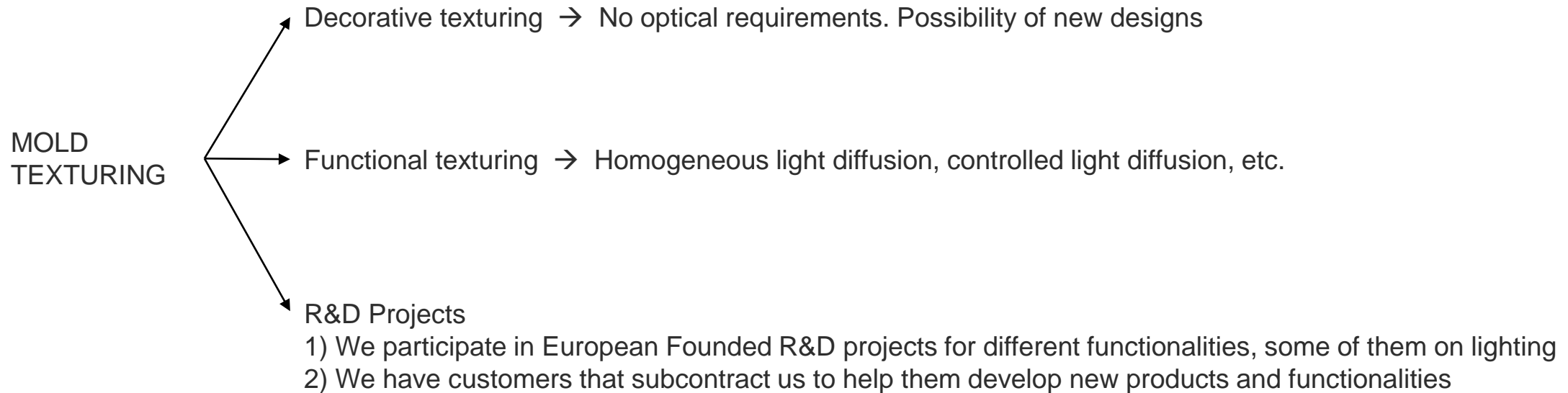
### CHANGING LIGHT DIRECTION TO INCREASE LIGHT INTENSITY IN TARGET ZONE

Customer goal: change light direction 20degree after crossing our micro-structure to increase light intensity in the target zone

Result on final injected part: light intensity in target zone was 2 times higher in photometry test



# Mold texturing



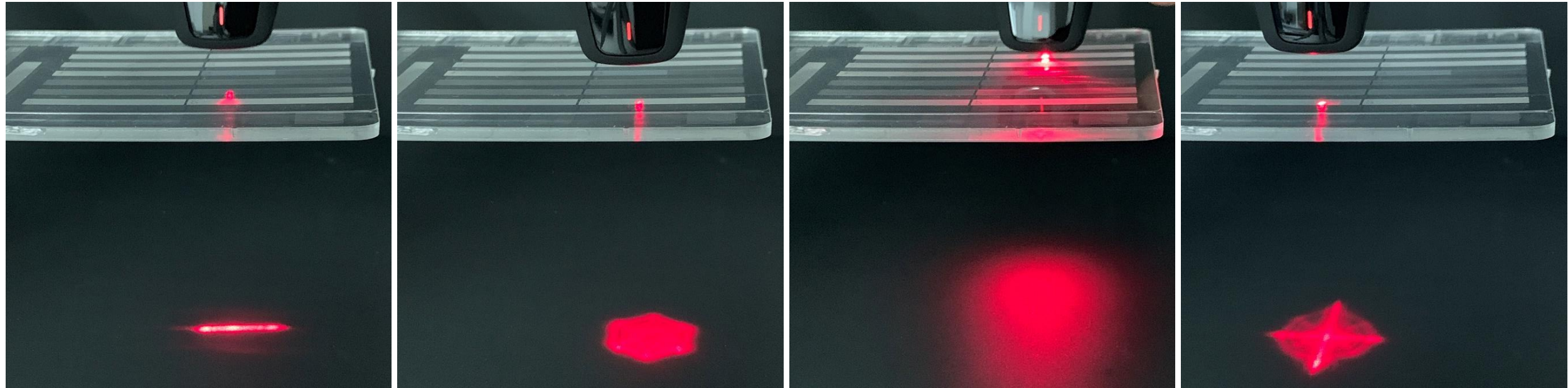
# Mold texturing

DECORATIVE TEXTURING



# Mold texturing

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

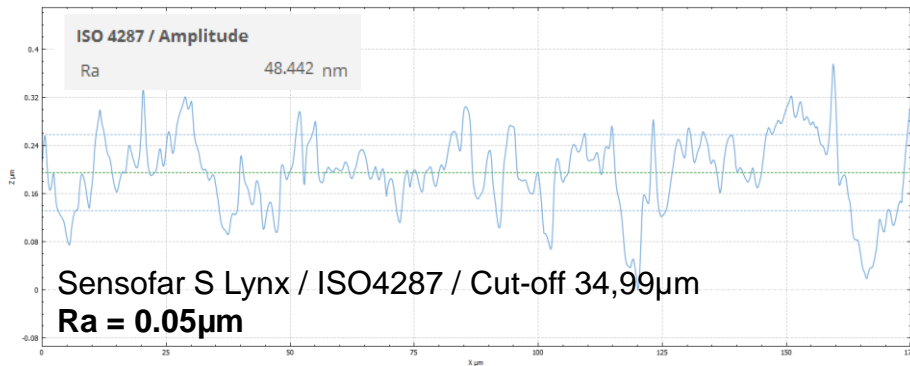
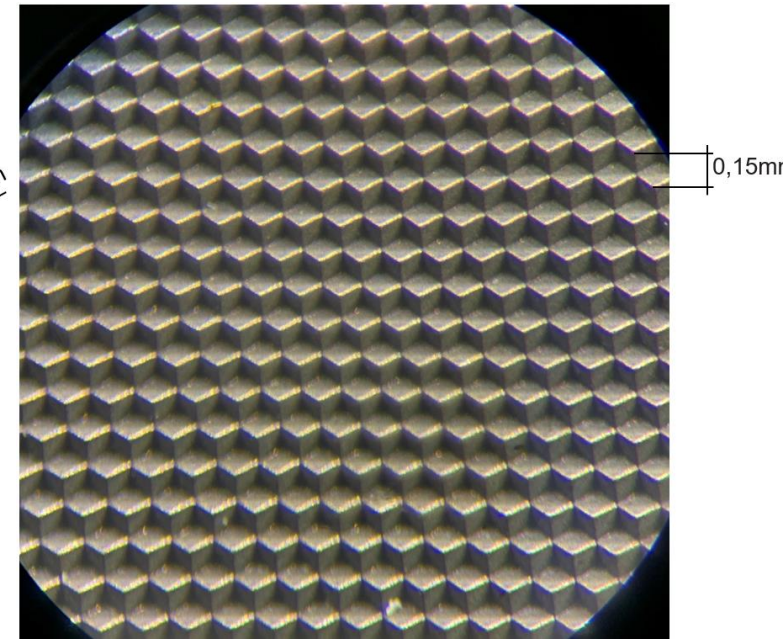
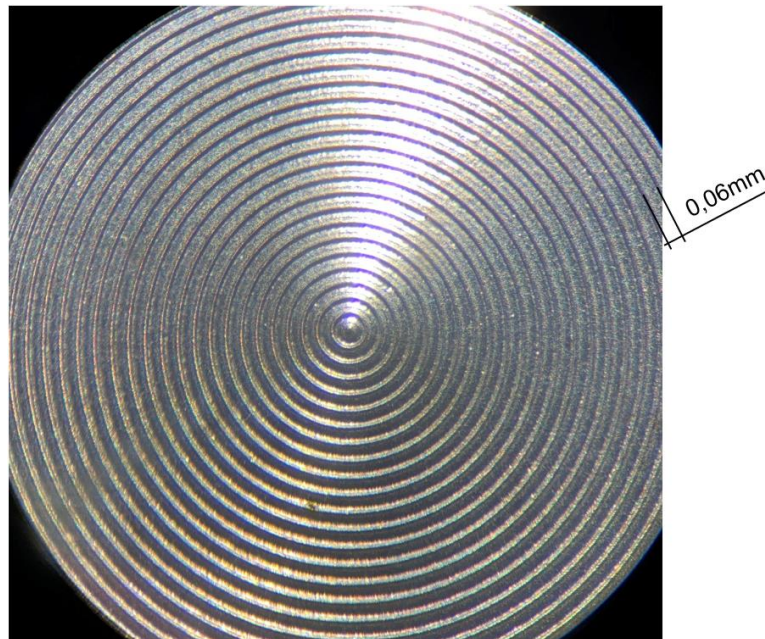
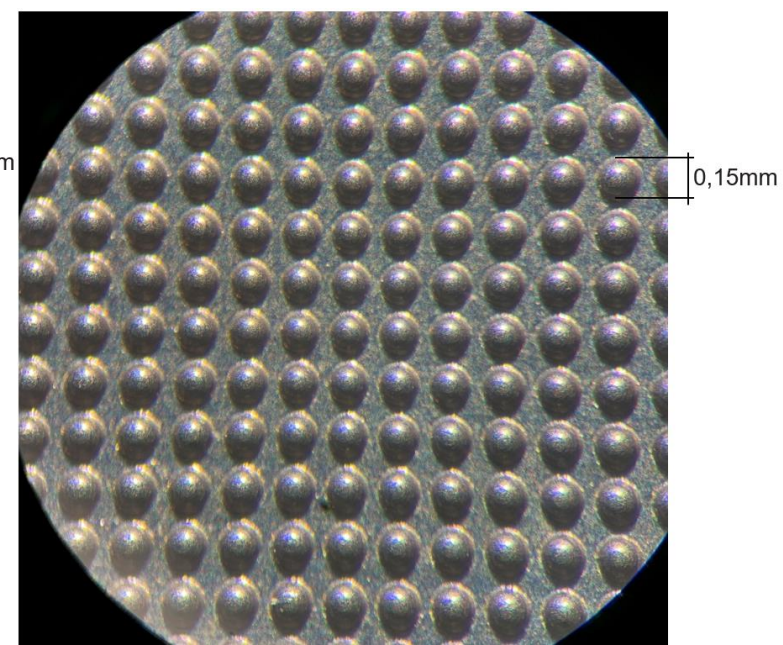
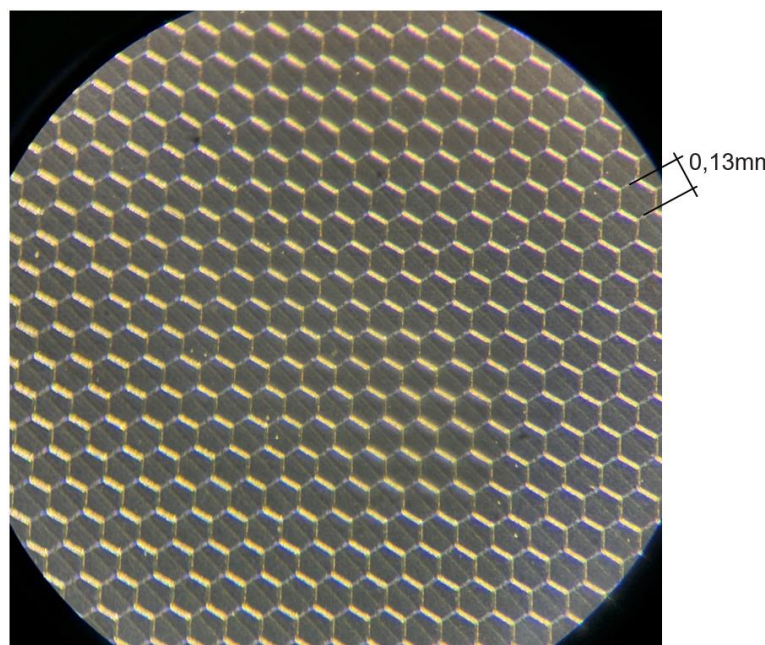
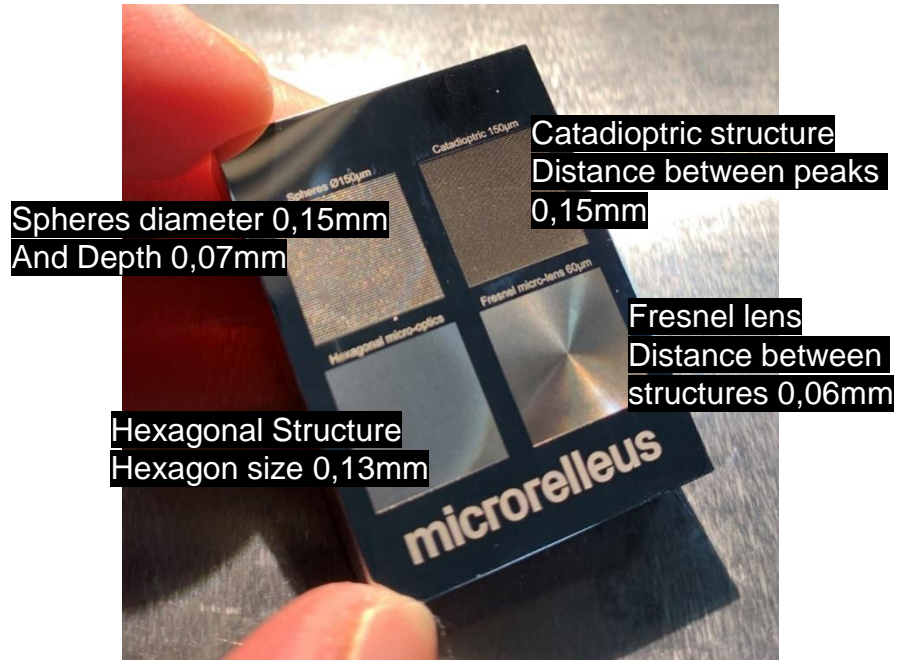


Pina-Estany, J., García-Granada, A. A., & Corull-Massana, E. (2018). Injection moulding of plastic parts with laser textured surfaces with optical applications. *Optical Materials*, 79, 372-380.  
Textures: Microrelleus

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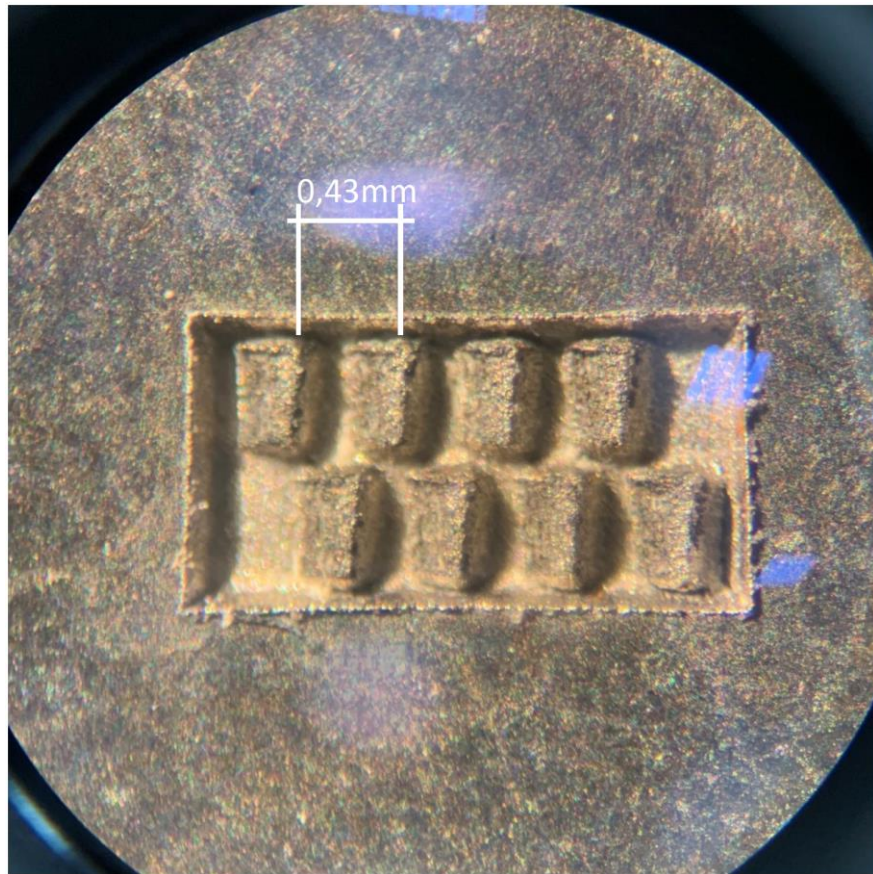
# Micro-optics



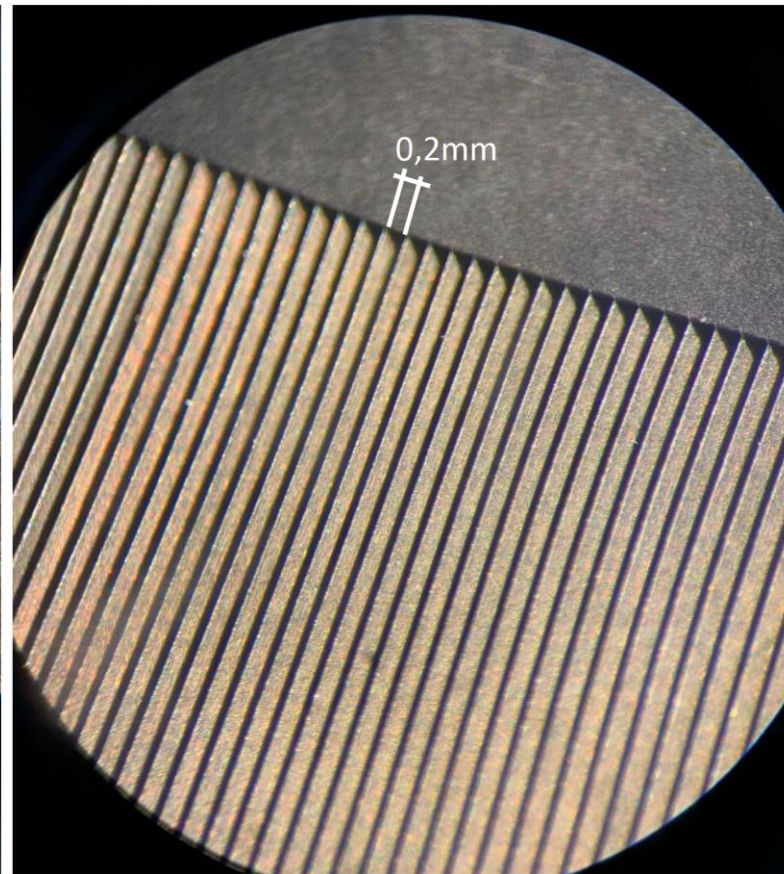


# Femtosecond laser quality – some examples

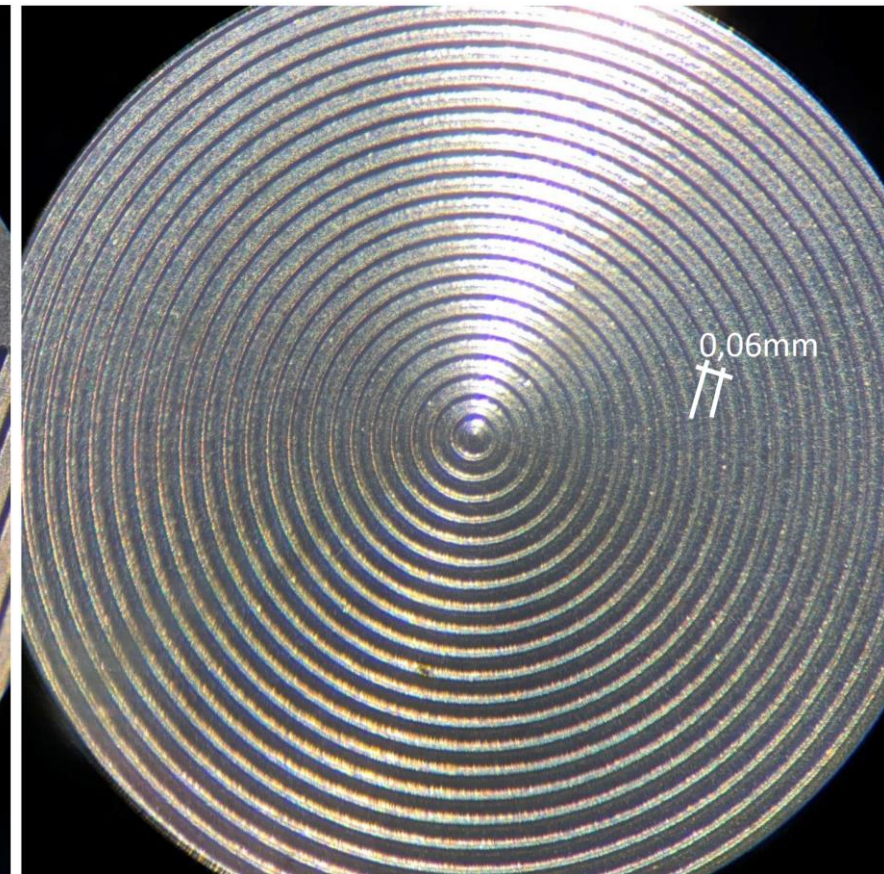
Nanosecond laser



Femtosecond laser

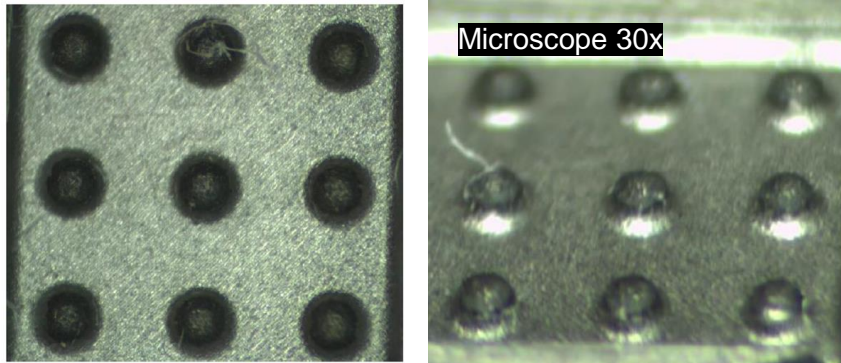


Femtosecond laser

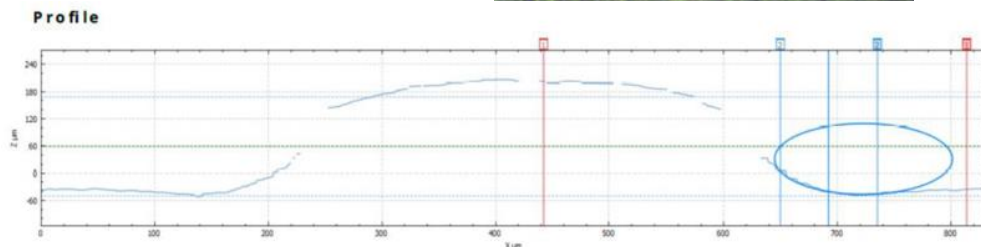
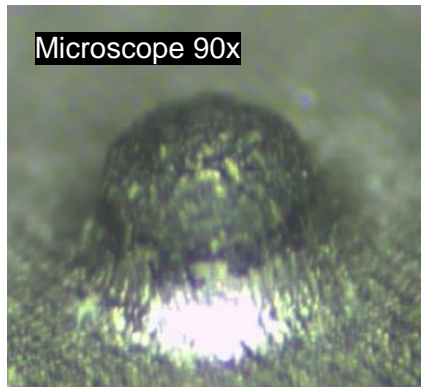
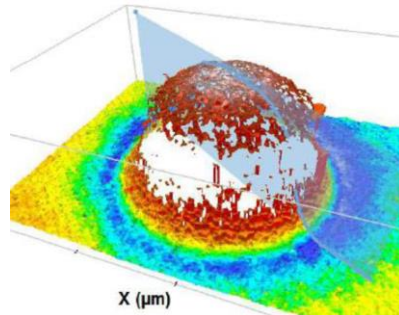


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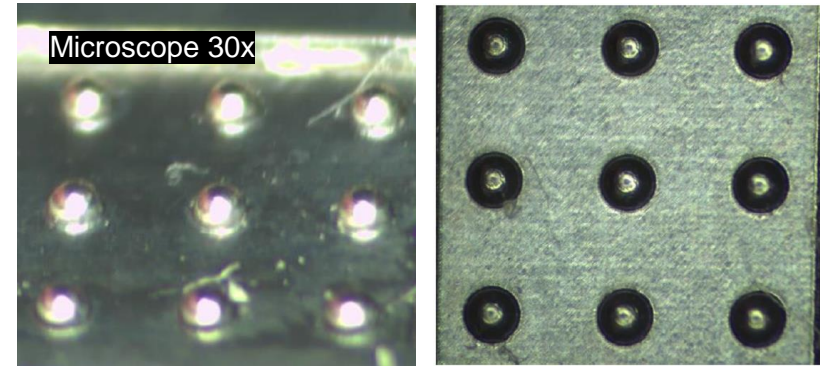
Nanosecond laser (spheres diameter 0.4mm)



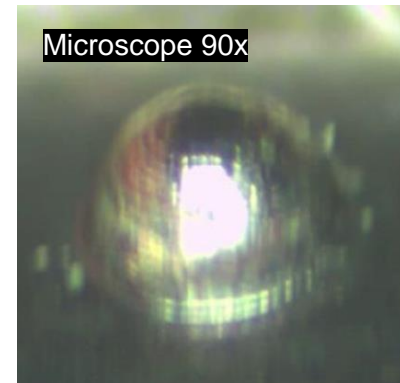
Confocal microscope.



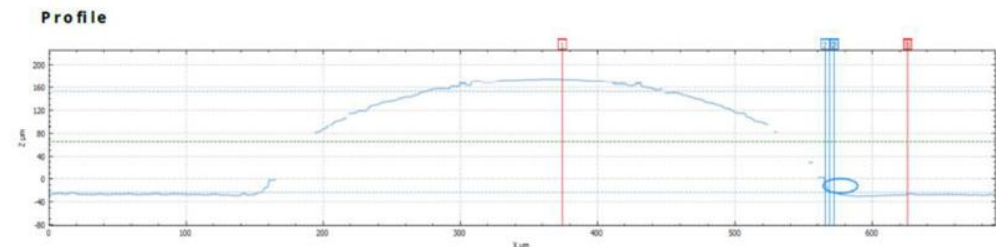
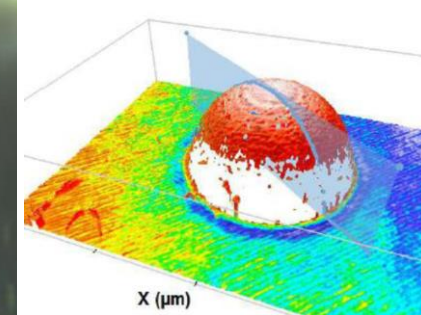
Femtosecond laser (spheres diameter 0.4mm)



Microscope 90x



Confocal microscope.



# MICRORELLEUS SERVICES



## WHAT CAN WE OFFER WITH THE FEMTOSECOND LASER TECHNOLOGY:

- Laser microstructuring, laser texturing and industrial engraving service focused on maximizing the added value of our customers.
- Femtosecond laser applied over final part: single part or serial production
- Femtosecond laser applied over mold or tool
- R&D for customer: as this is a very new and disruptive technology there are a lot of new manufacturing possibilities, so we develop and test our new customers needs.
- We collaborate with Tecnology Centers and Universities to offer complete solutions to our customers: texture or microstructuring design for functionality, test on laboratory, prototypes, etc.
- Our customers: final product manufacturers, mold-makers, plastic injectors, OEM's, Tier 1, Tier 2, etc.

# microrelleus

Laser microstructuring  
Laser texturing  
Industrial engraving

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