Willkommen
Welcome
Bienvenue

Outcoupling schemes by large area microstructured surfaces

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Advanced Materials Processing
Empa
Thun, Switzerland

Outline

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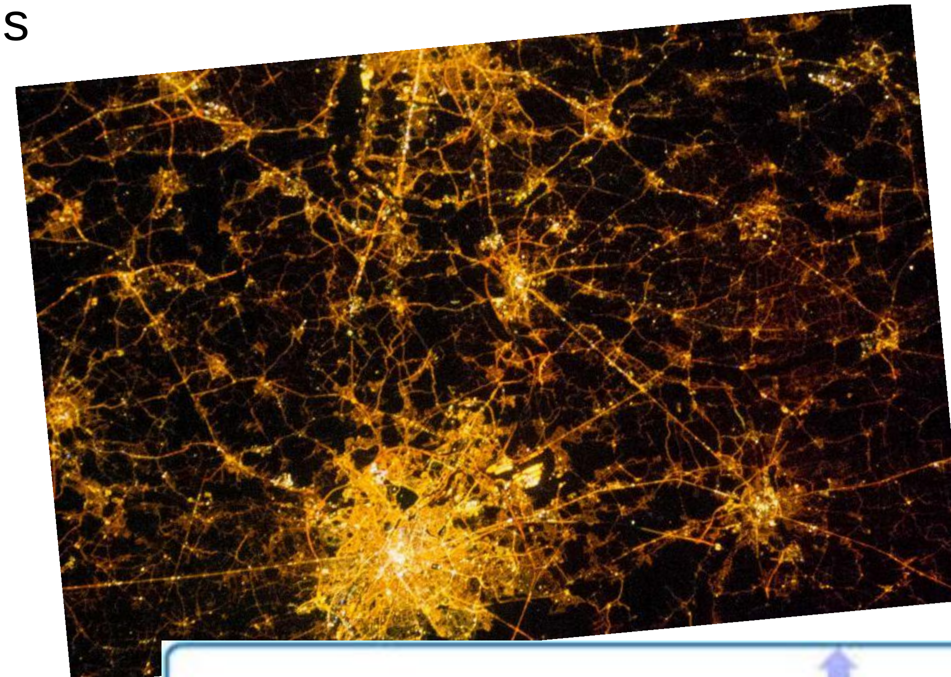
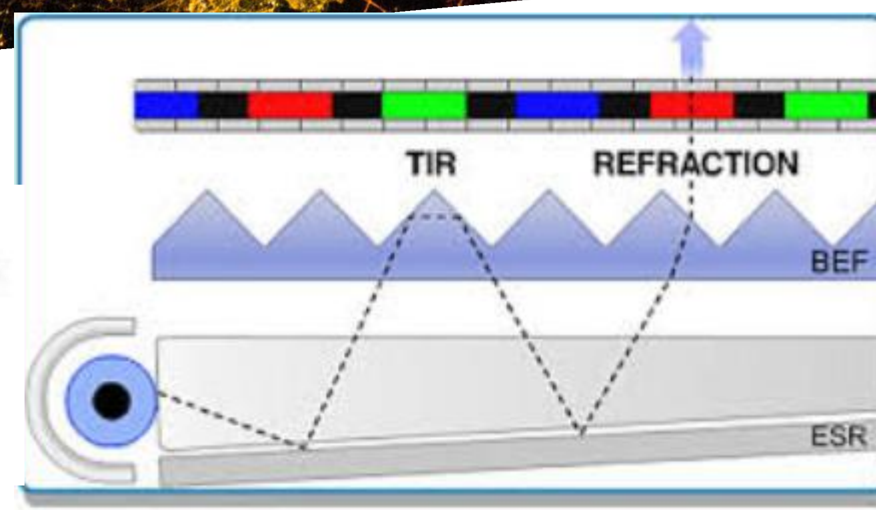
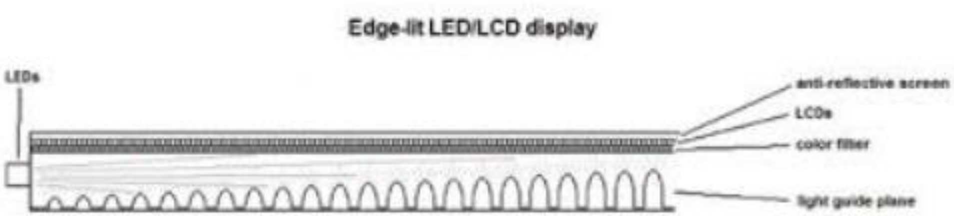
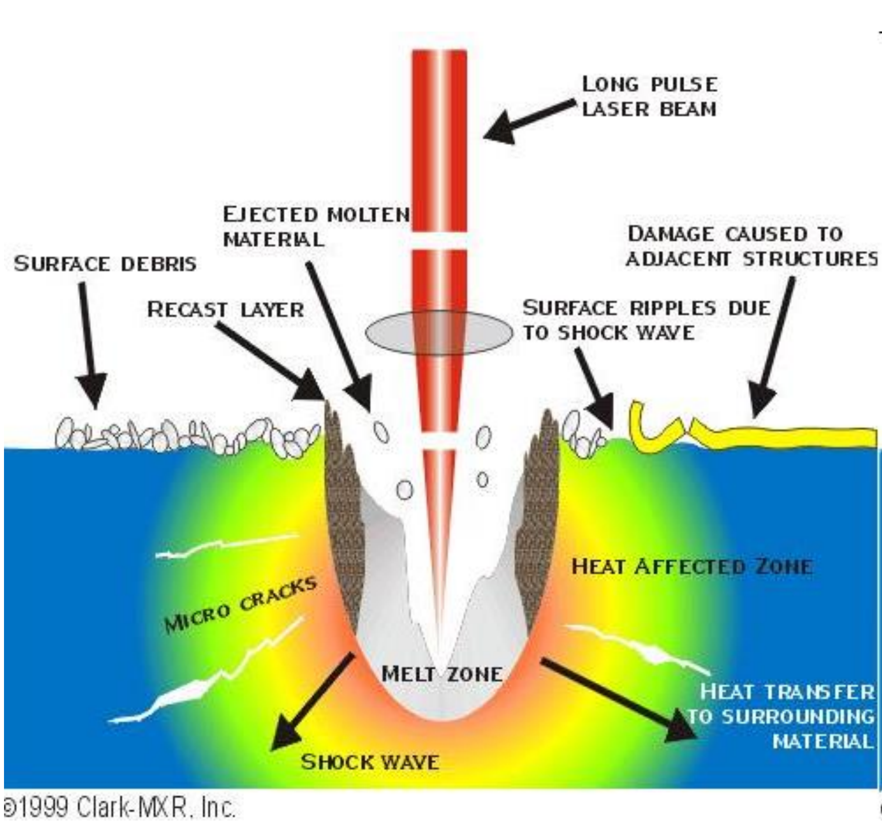
- Ablation process - limitations
- Excimer lasers
- Installation in Thun
- Examples

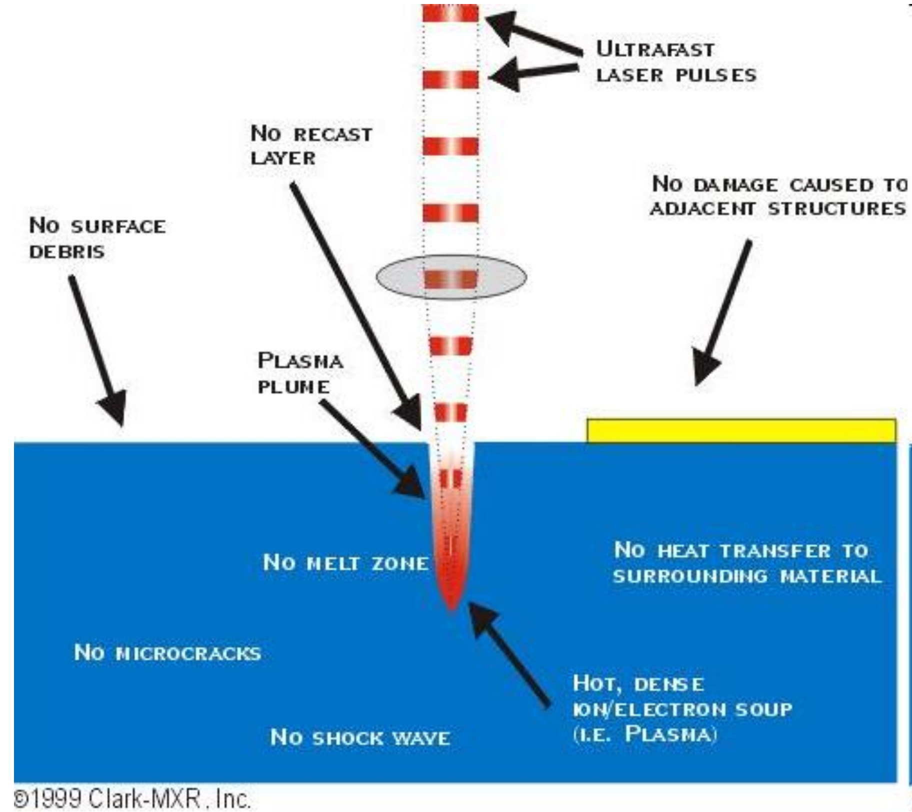






ns-Machining vs. fs-Machining

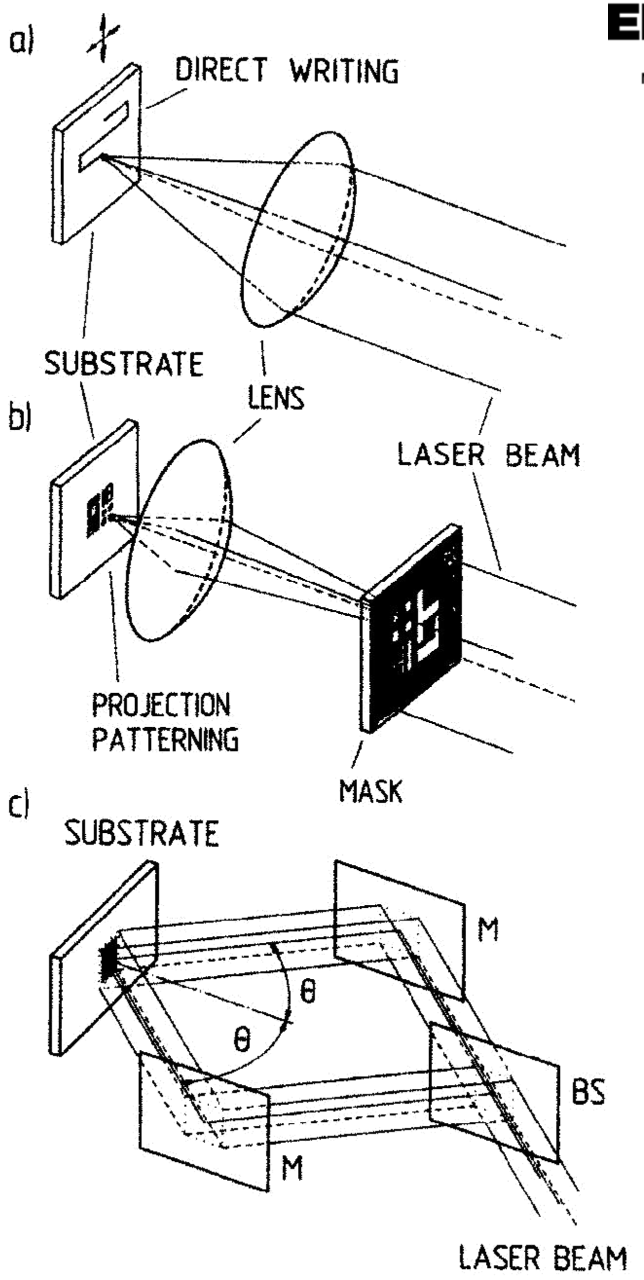




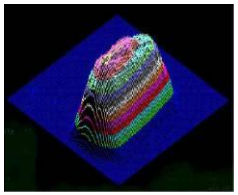
ns

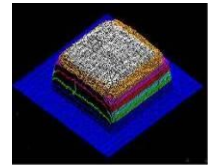
fs

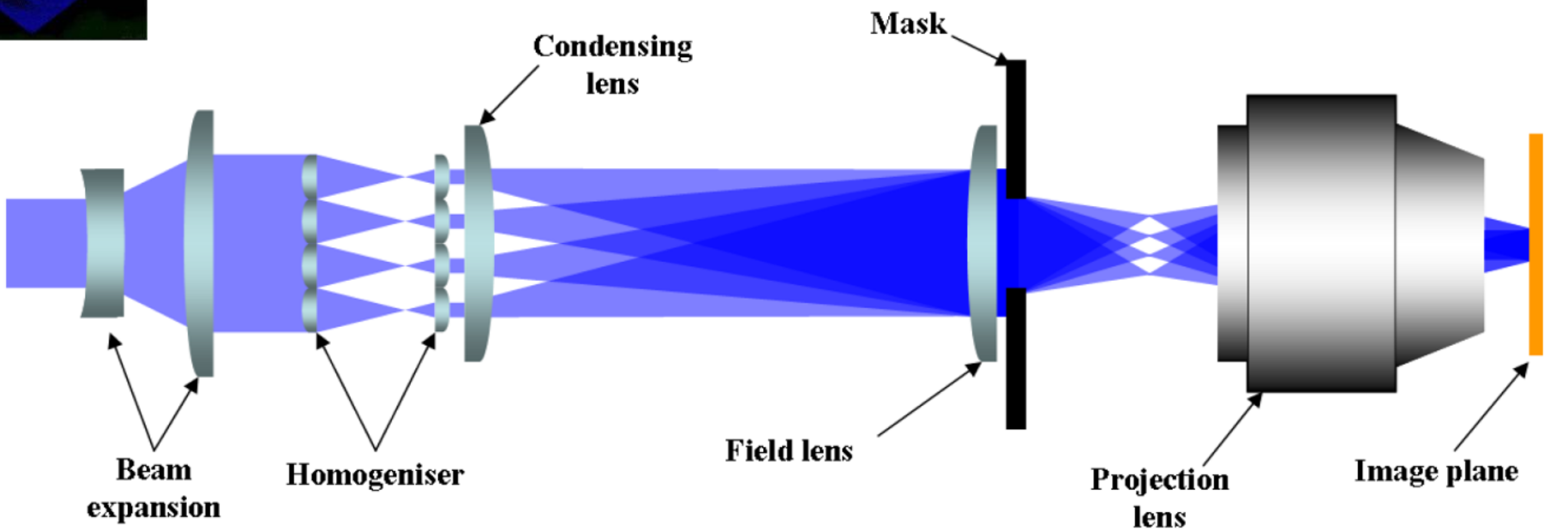
Different exposure of light



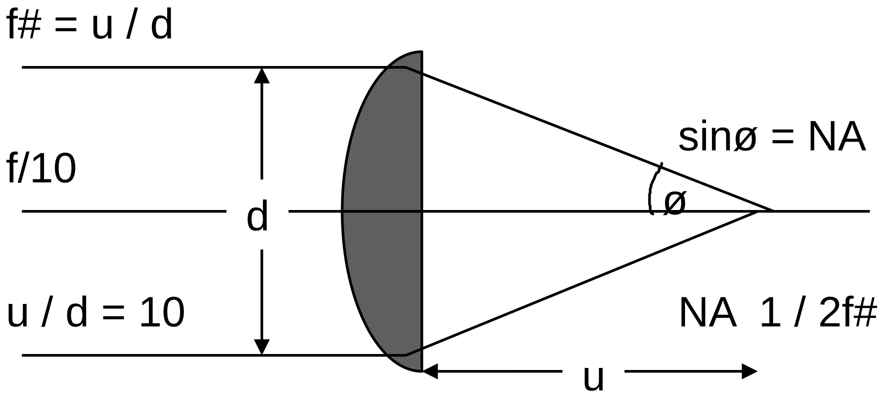
Mask projection system







Focus control - resolution and N.A.



Diffraction Resolution Limit

$$= \frac{k\lambda}{NA}$$

k=0.8

NA=0.1   λ=248 nm

Res. limit = 2 µm

k=0.6

NA=0.85   λ=193 nm

Res. limit = 136 nm

Depth of field

$$D\ of\ F = \frac{\lambda}{NA^2}$$

NA=0.1   λ=248 nm

dof = 25 µm (±12 µm)

NA=0.85   λ=193 nm

dof = 270 nm (±135 nm)

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What happens at Empa Thun ?

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Full process

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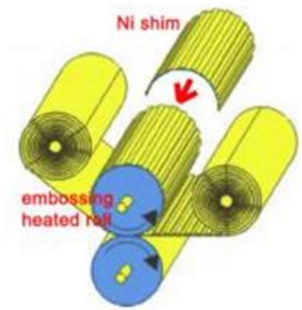
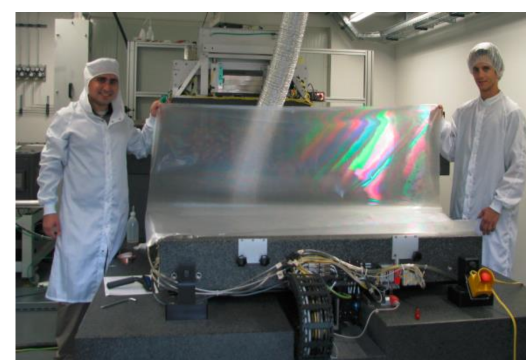
From Idea to CAD → Master substrate → Metal copy Ni shim → Production tools → Roll to roll embossing



From requirements to origination to mass production

Crealas and its partners can offer you all the steps from design up to roll to roll production.



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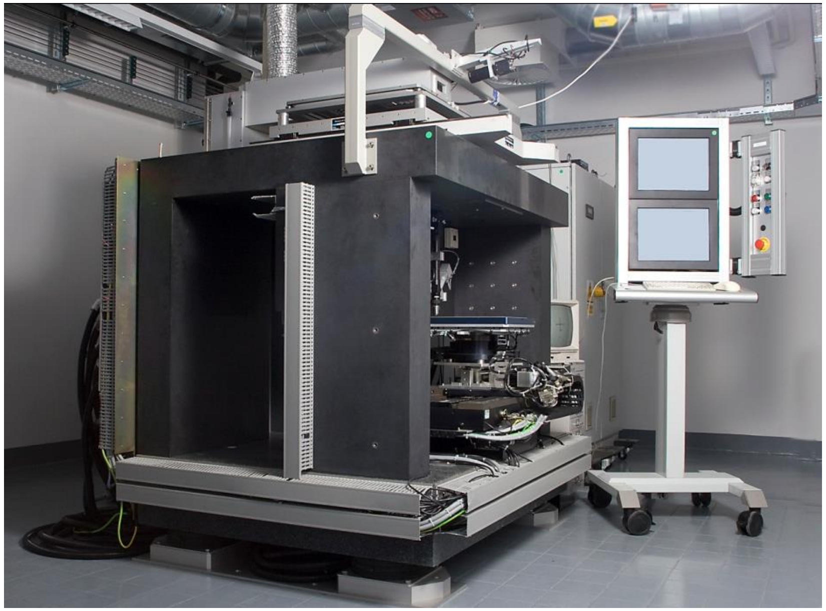
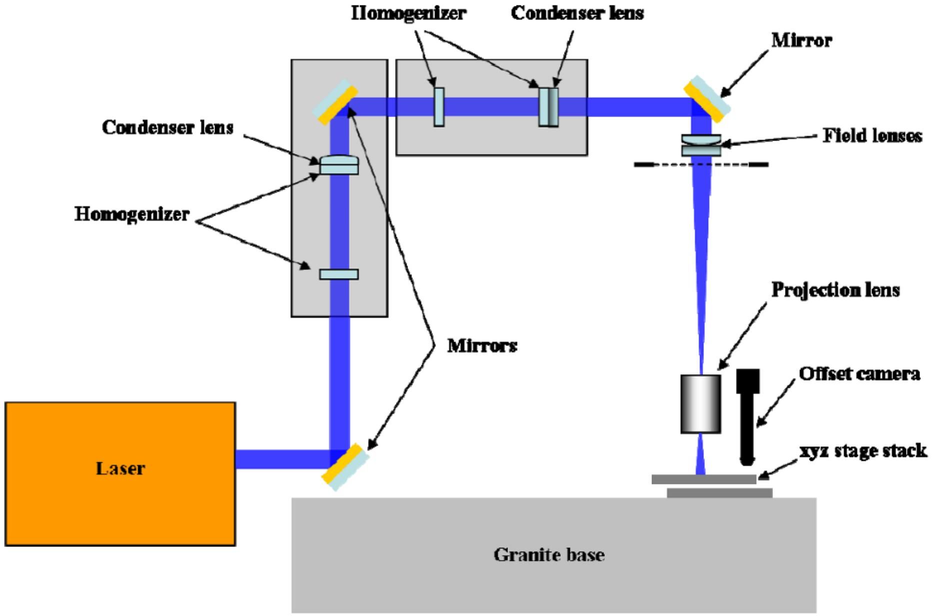
XL Micromachining System





Travel	400 mm
Accuracy	±0.50 µm
Repeatability	±0.20 µm
Straightness	±0.40µm
Flatness	±0.40µm

XXL microprocessing machine

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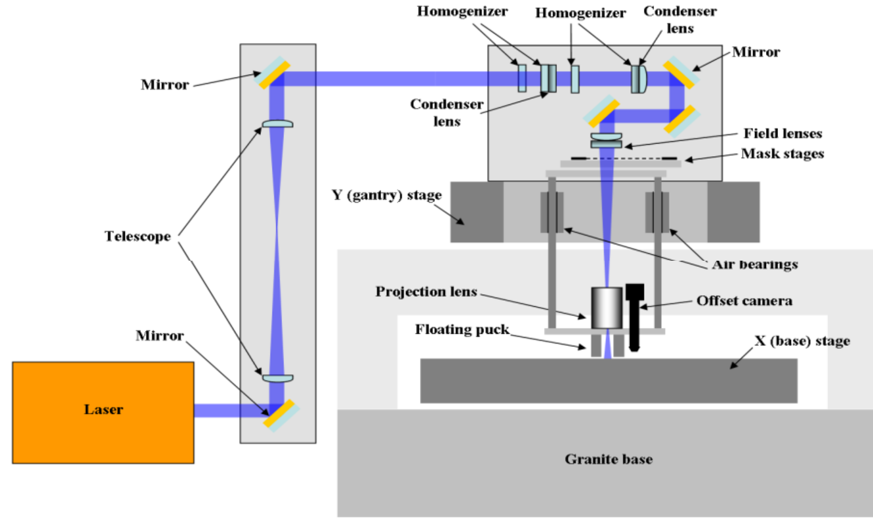

Specification	*Unit*	*X-axis Spec*	*Y-axis Spec*
Travel	Mm	> 2200	> 1450
Payload	Kg	~ 115	~ 280
Speed	mm/s	200	360
Acceleration [1]	m/s^2	0,75	1
Resolution	µm	0,04	0,04
Bi-directional repeatability	µm	±2	±2
Accuracy (before calibration) [2]	µm	±4,5	±3
Straightness, bi-directional	µm	±2	±1,5
Flatness, bi-directional	µm	±5	±5
Roll, bi-directional	Arcs	2	1
Pitch, bi-directional	Arcs	2	1
Yaw, bi-directional	Arcs	2	2
Orthogonality (after calibration)	Arcs	2	

Some highlights

- 3 m^2 exposure area
- Ultra high precision: x/y axis < 40 nm resolution (laser interferometer based encoders)
- Repeatability 3 um over full travel (+/- 1.5 ppm)

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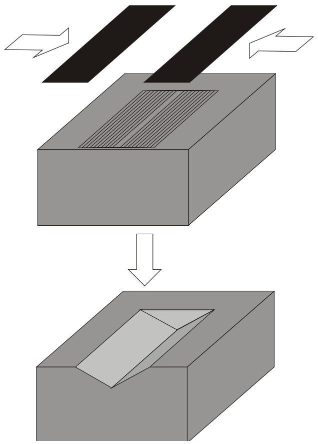
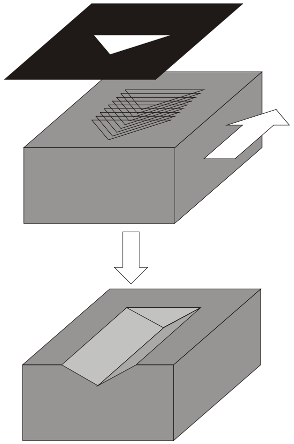
Advanced mask imaging

Projection ablation options for complex surface shapes

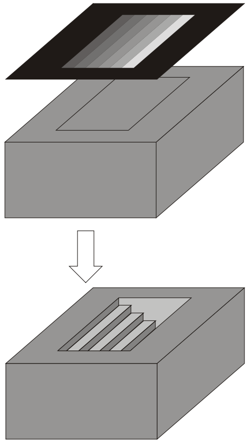
Variable aperture mask



Scanned mask &/or workpiece



Gray scale mask



Synchronized Image Scanning (SIS)

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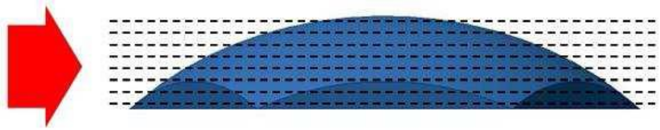
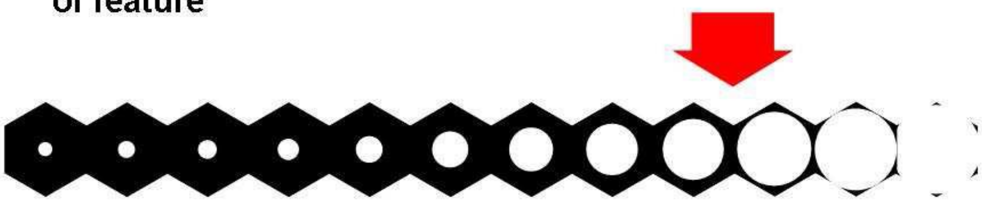
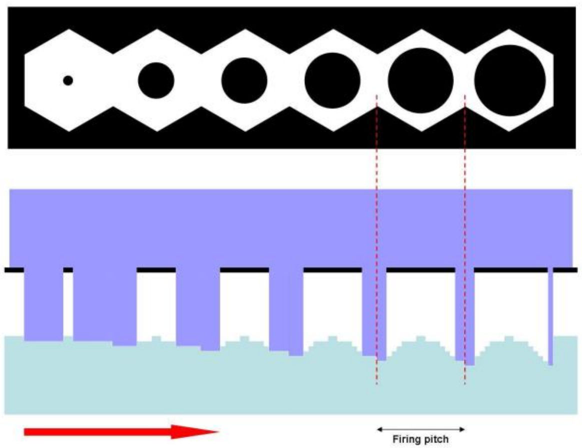
1. Take 3D model of feature

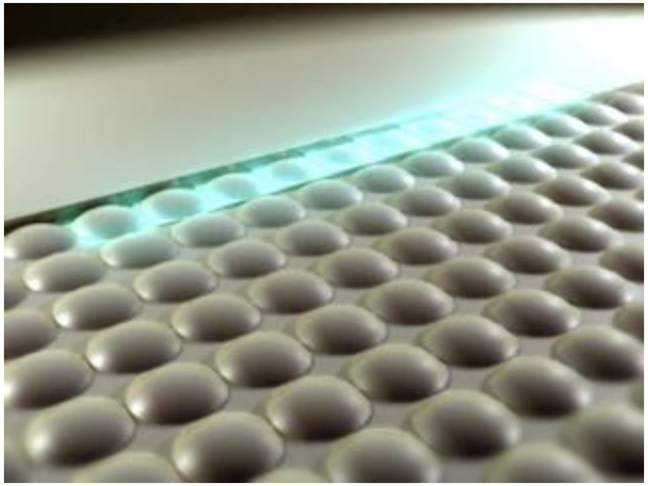


2. Slice at required thickness



2. Array of contours to be placed on mask





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Intensity modulation of the imaged pattern

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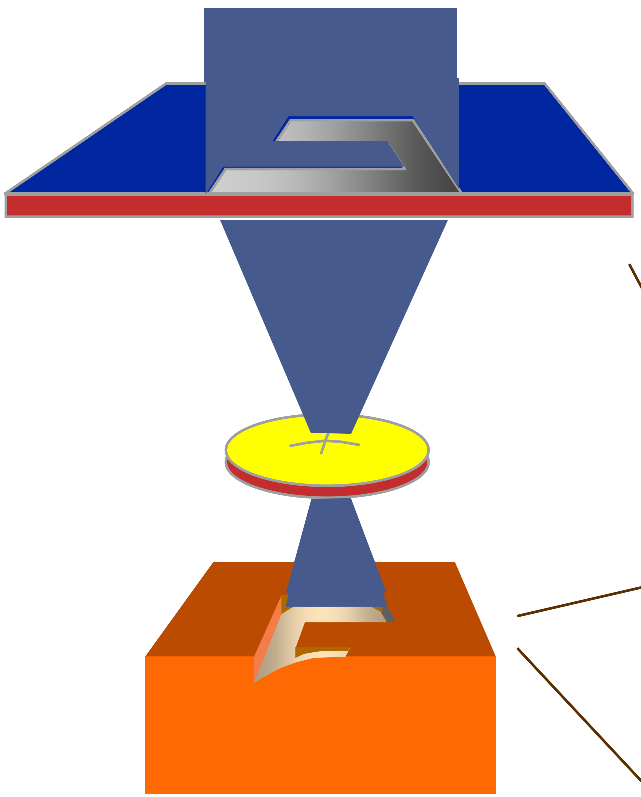

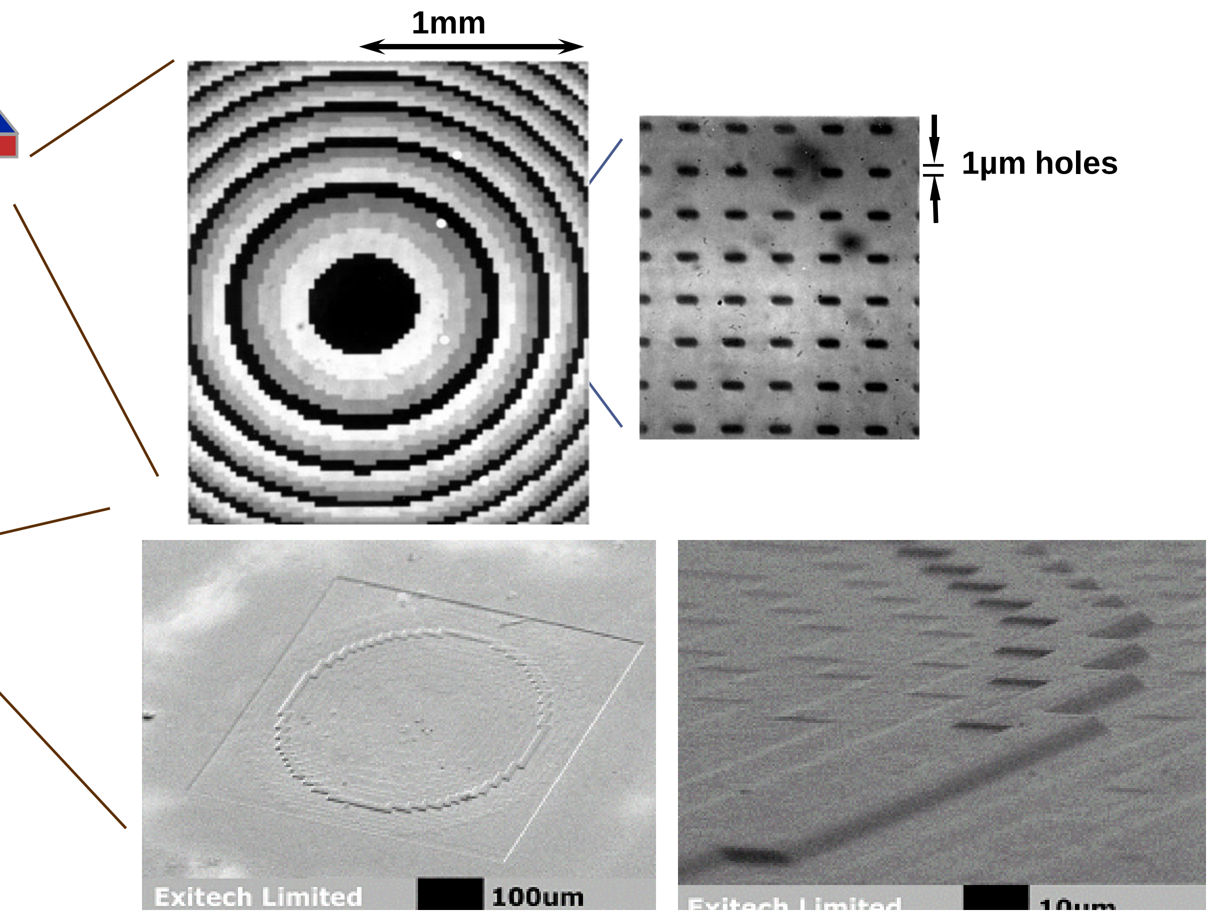

- Depth information incorporated in half-tone mask
- Transmission varied by changing hole size or density

8-level Diffractive Optical Element

Material: Polycarbonate; Laser: KrF excimer 248nm; Optics: x5, 0.13NA;

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What can be & has been done with our systems?

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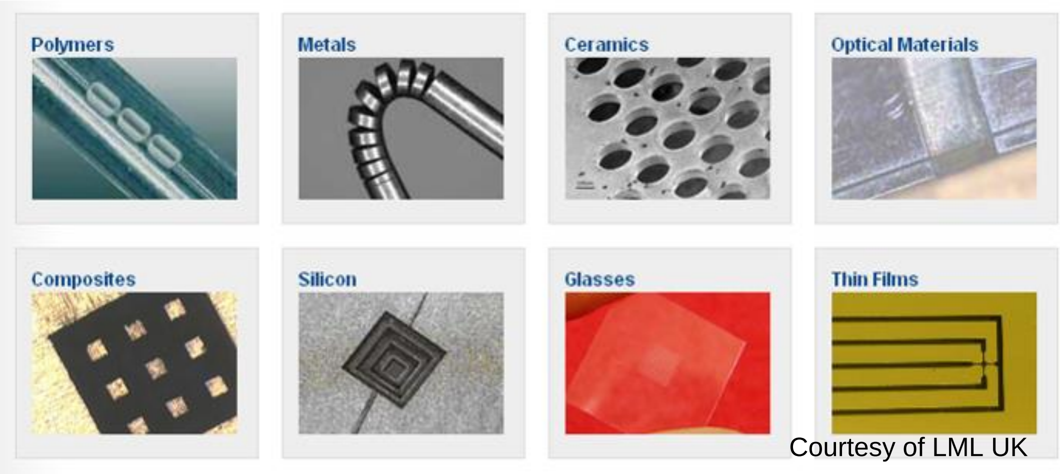
Wide range of materials can be ablated

- Polymers
- Metals
- Glasses
- Silicon
- Optical materials
- Composites
- Ceramics
- Thin films



Courtesy of LML UK

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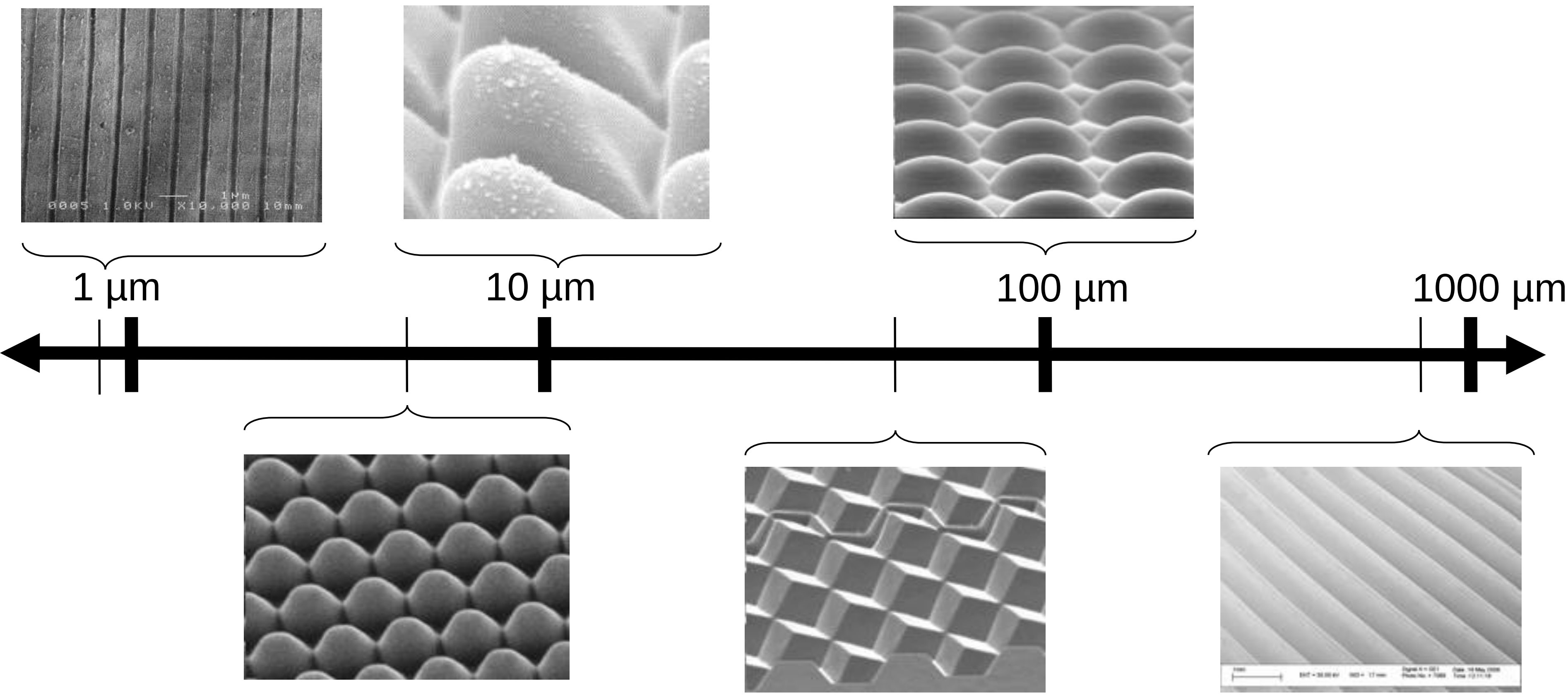
Mask imaging from submicron to millimetre feature



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Feature quality: fit of target shape

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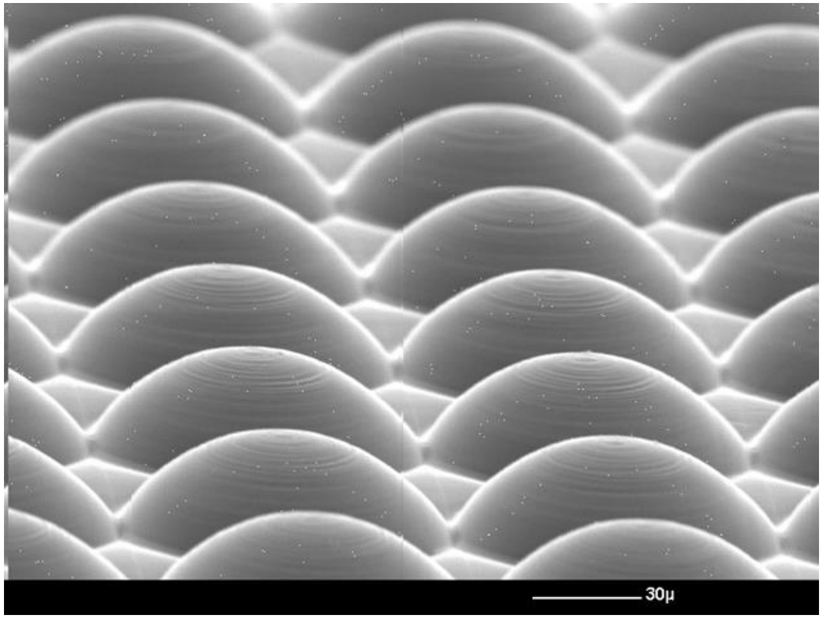

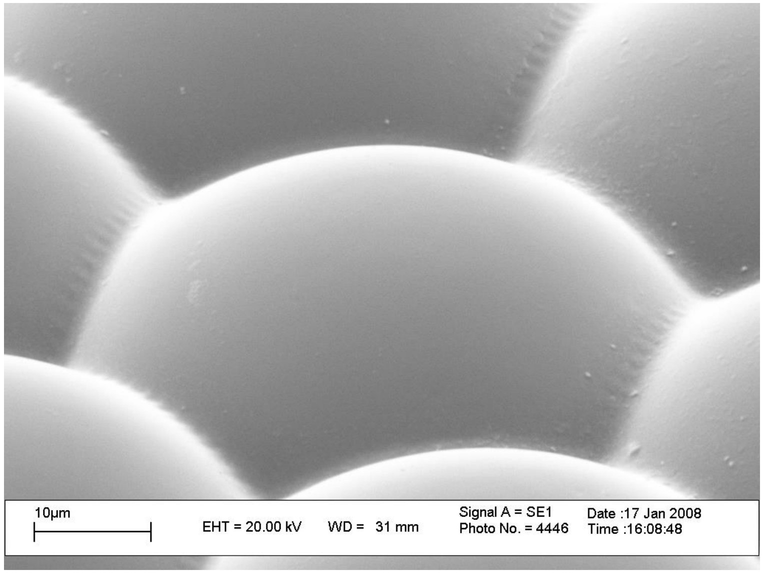

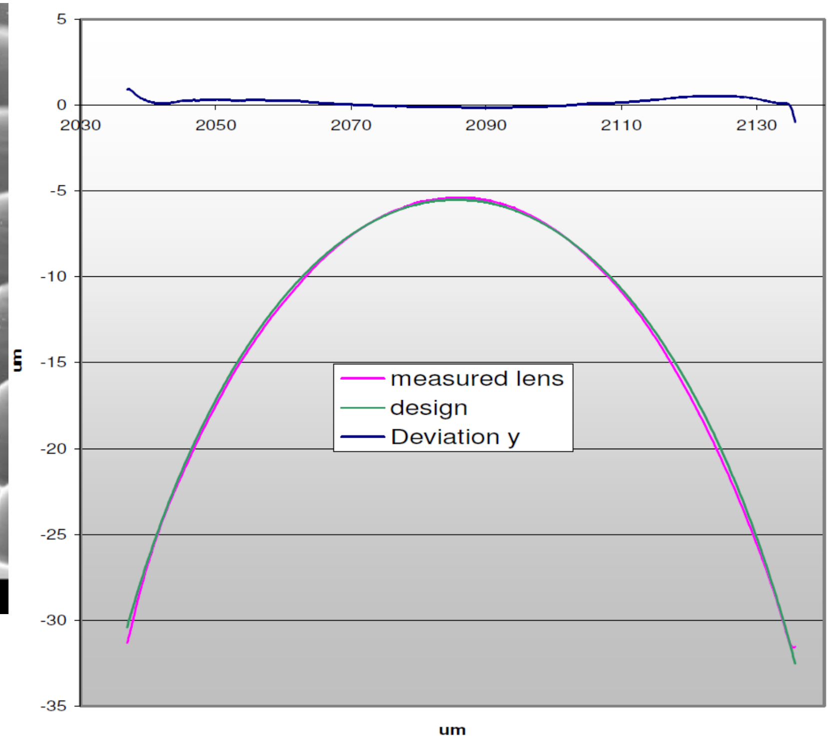

The average deviation from the best fit ROC is 147 nm with a ROC of 59.2 μm while the target is 60 μm.

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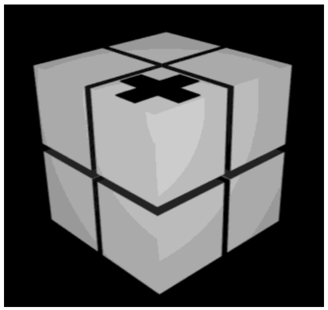
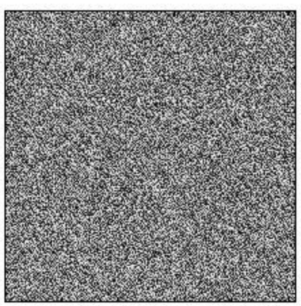
DOE

- Diffractive Optical Elements

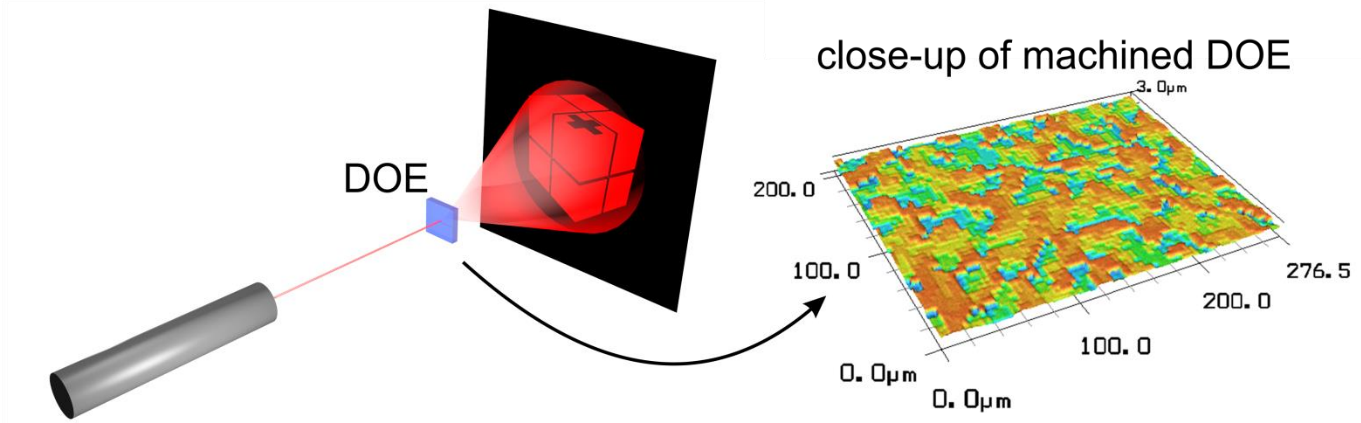


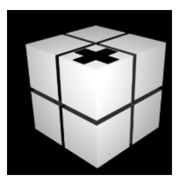
Optical function



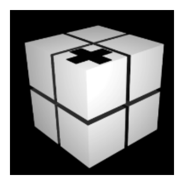
Computed DOE

Iterative algorithm

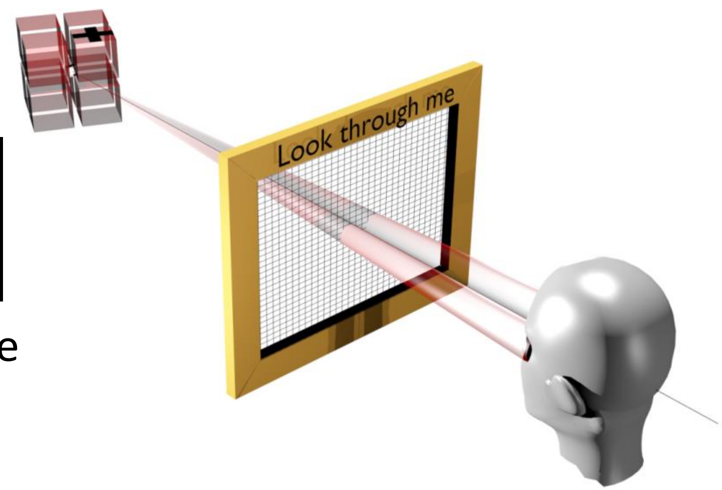




Left eye
-2°



Right eye
+2°



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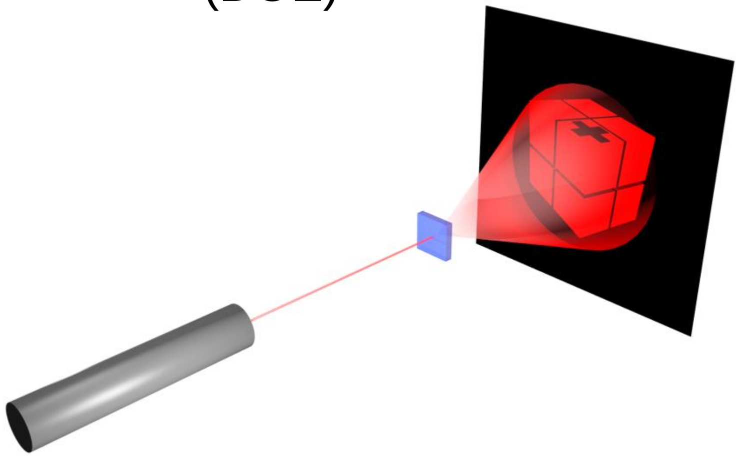
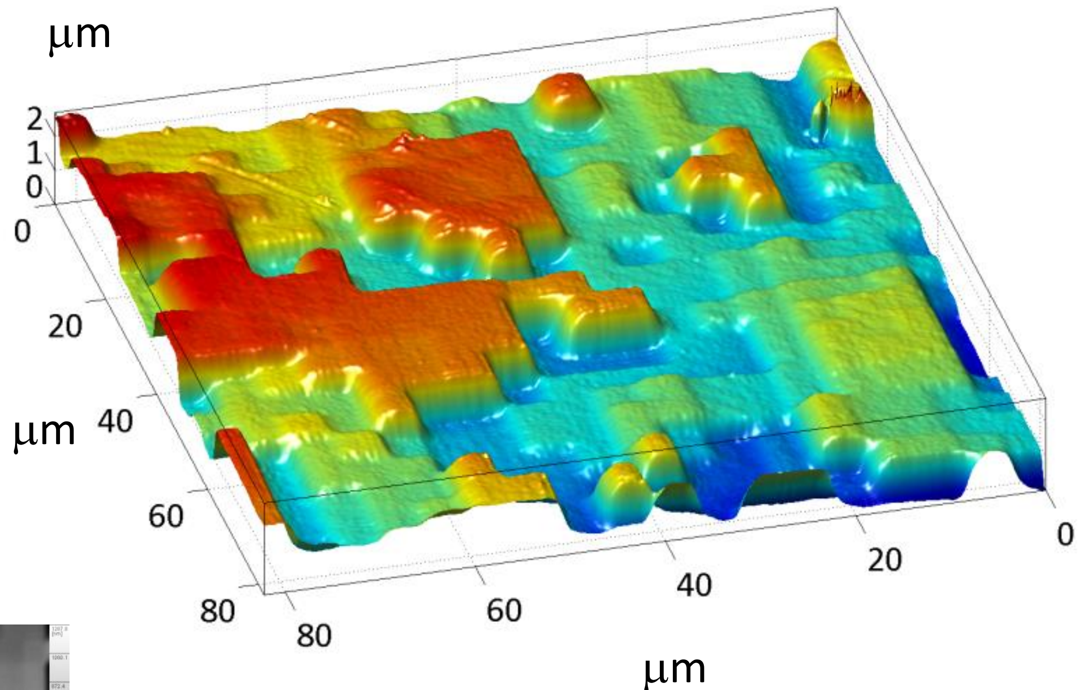
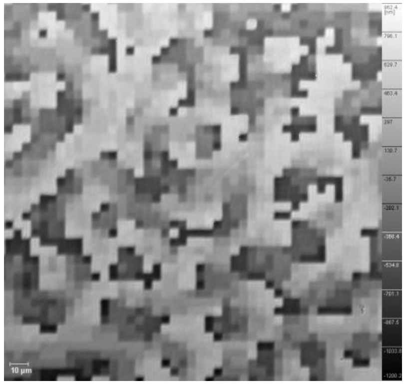
Characterization of phase elements

Diffractive optical element (DOE)

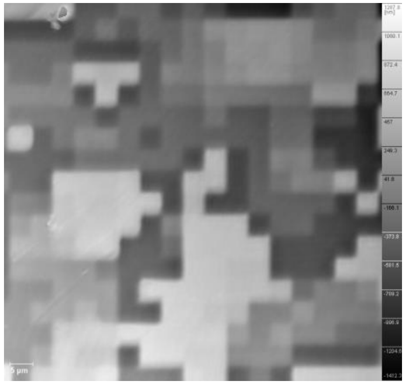




Phase maps



20x



50x

DHM of 8-levels DOE : unit element 5x5μm^2

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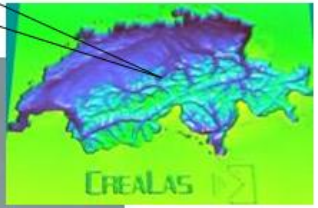
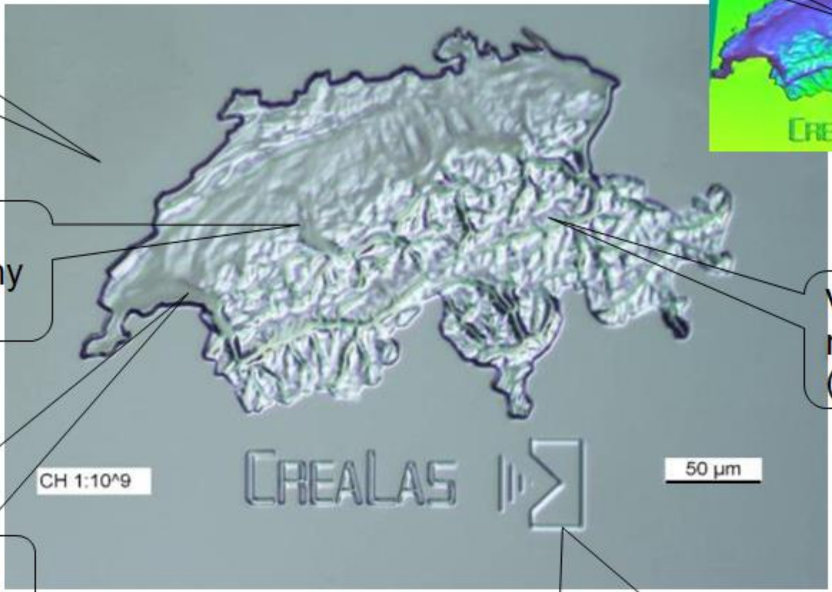
Technology:

Ultra high depth definition (<100nm)



Fast writing (5 ms)



Highly defined surface topography (1 km = 1 um)

Very low surface roughness (20 nm rms)

Thick film etching (5 um)

High resolution (2 um lines)

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3 D TV: Large area precision masters

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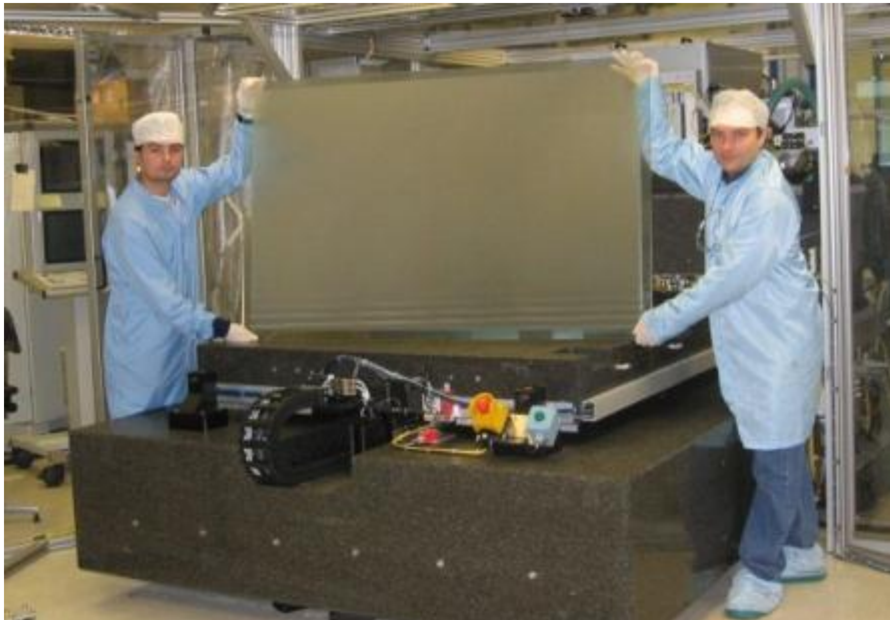
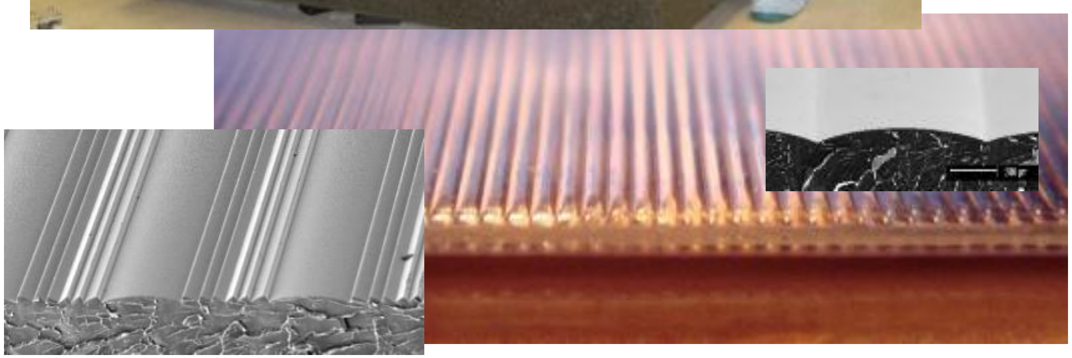
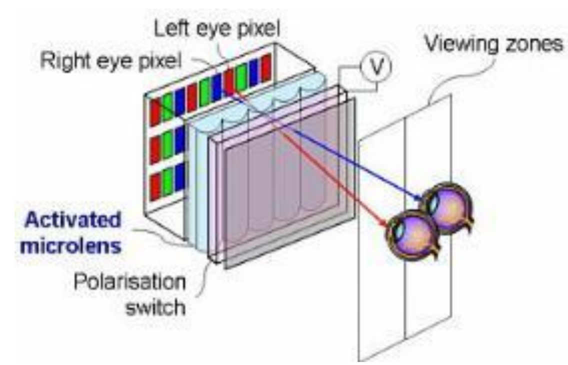
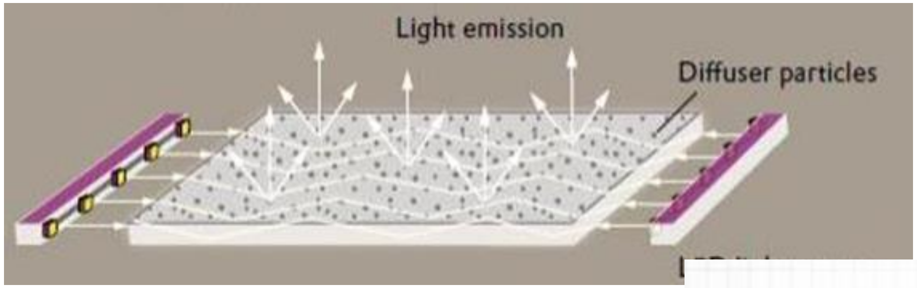
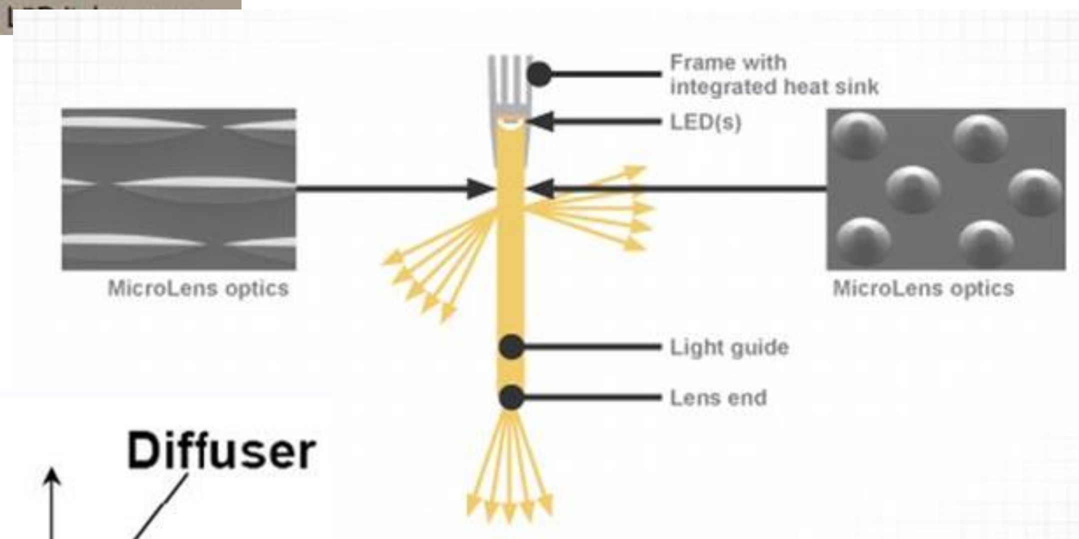


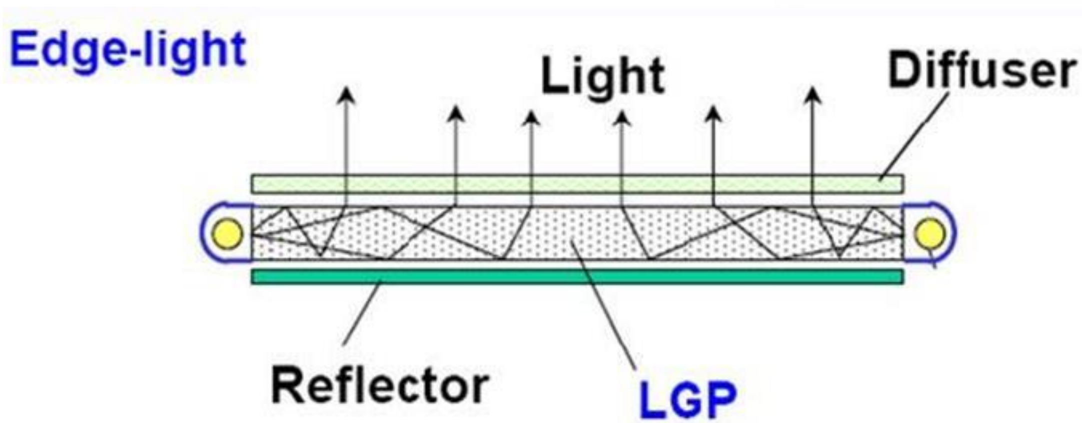




Edge light illumination







Further applications

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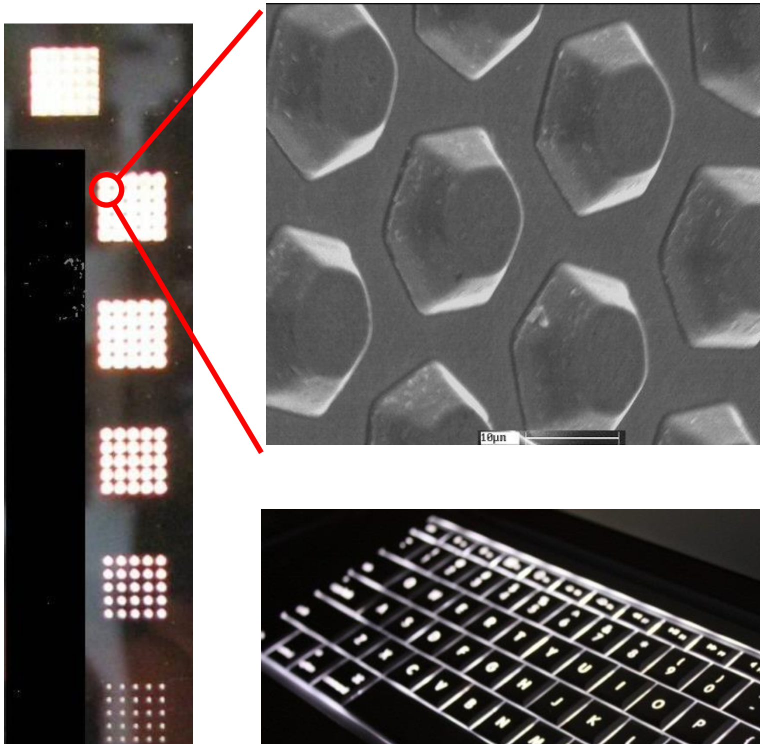
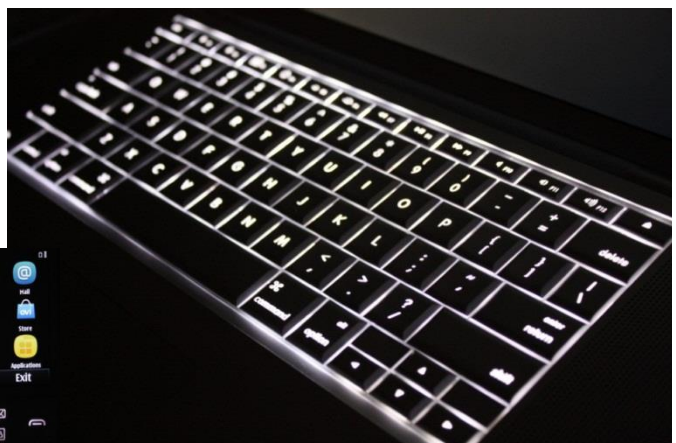
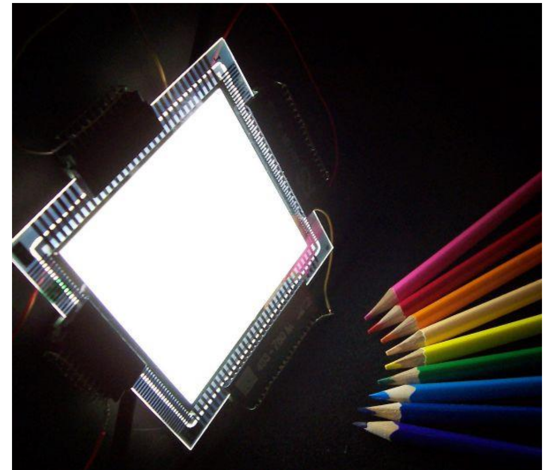
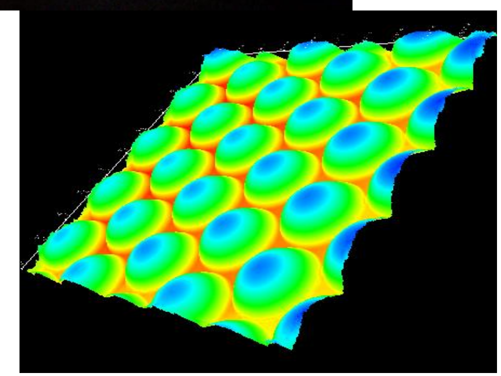
Keyboard illumination:





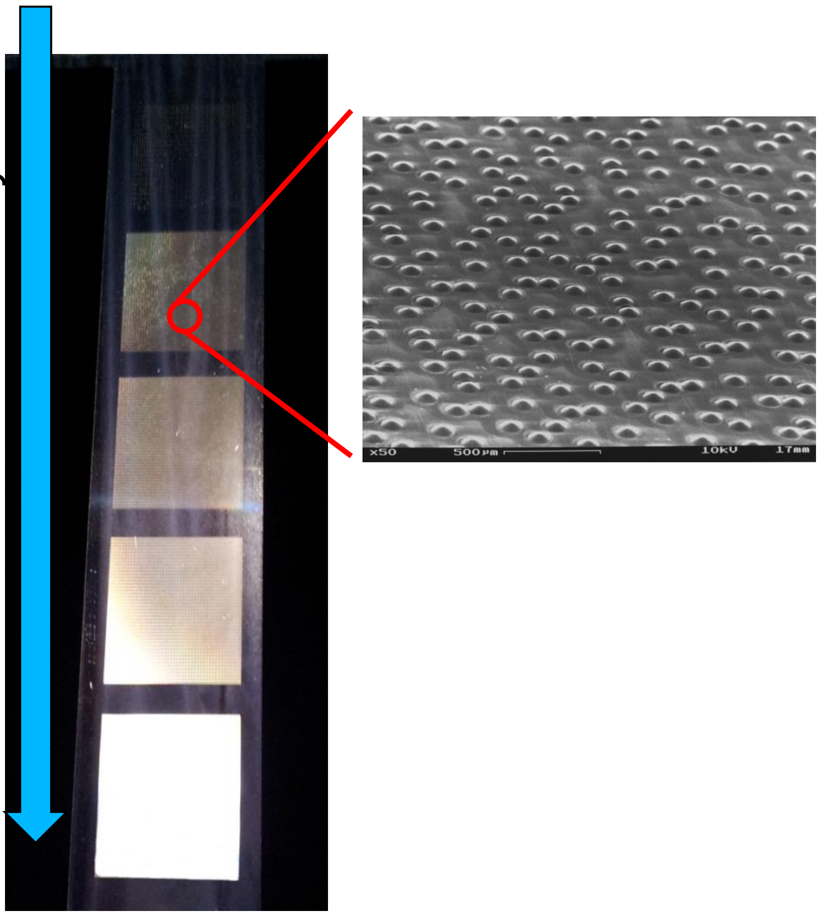
OLED out-coupling:

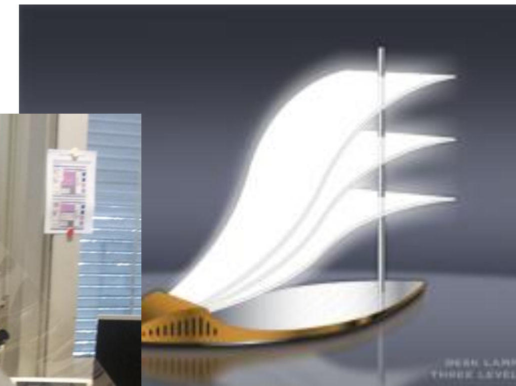




Masters for Panel LED-Edge Illumination

Increase in feature density





Full scale structures

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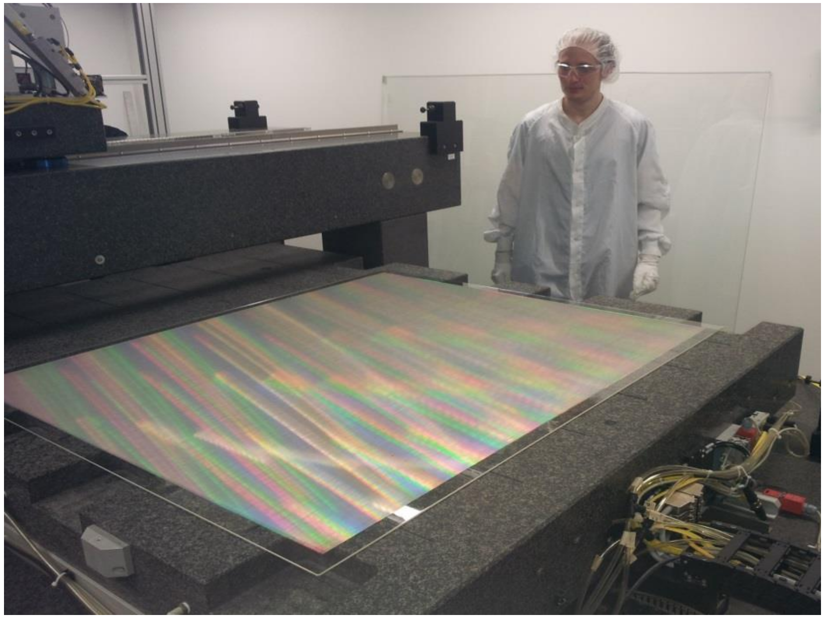

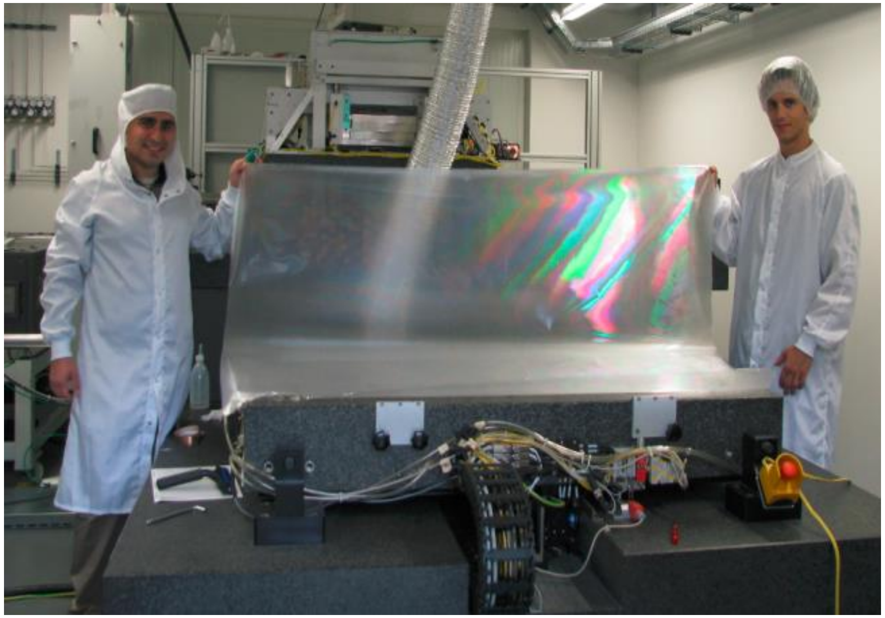

Conclusions

- Large surface laser processing possible
- Master pieces - replication