Willkommen
Welcome
Bienvenue

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Materials Science & Technology

Mask projection surface structuring

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Advanced Materials Processing
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EPHJ - Geneva, 18.6.2014

Outline

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

ns-Machining vs. fs-Machining

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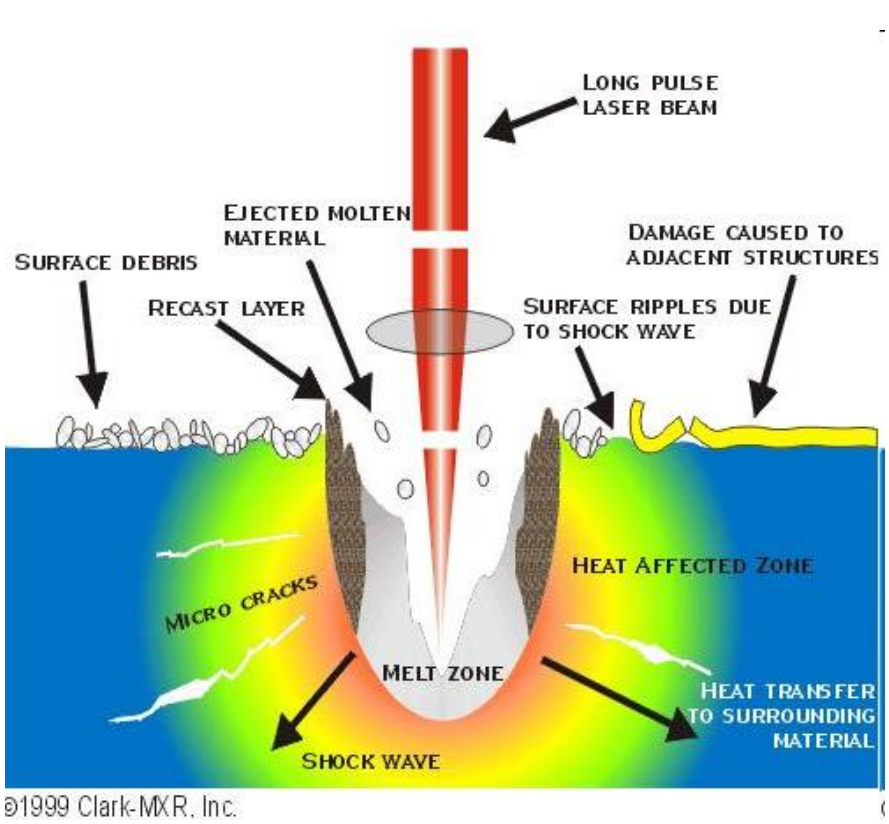
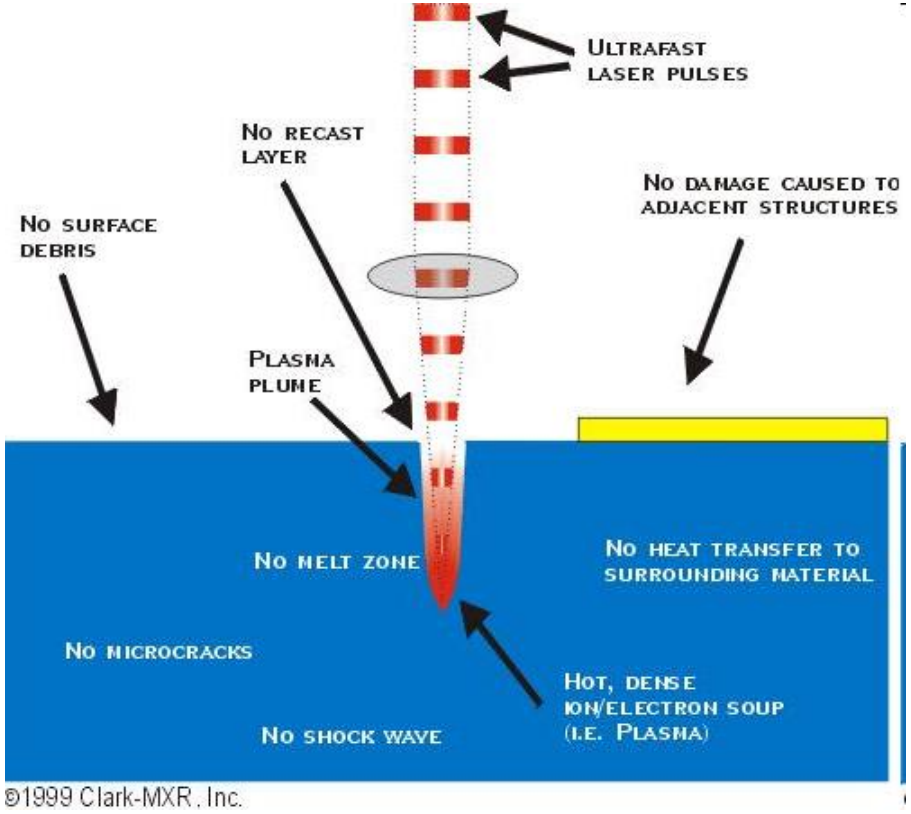
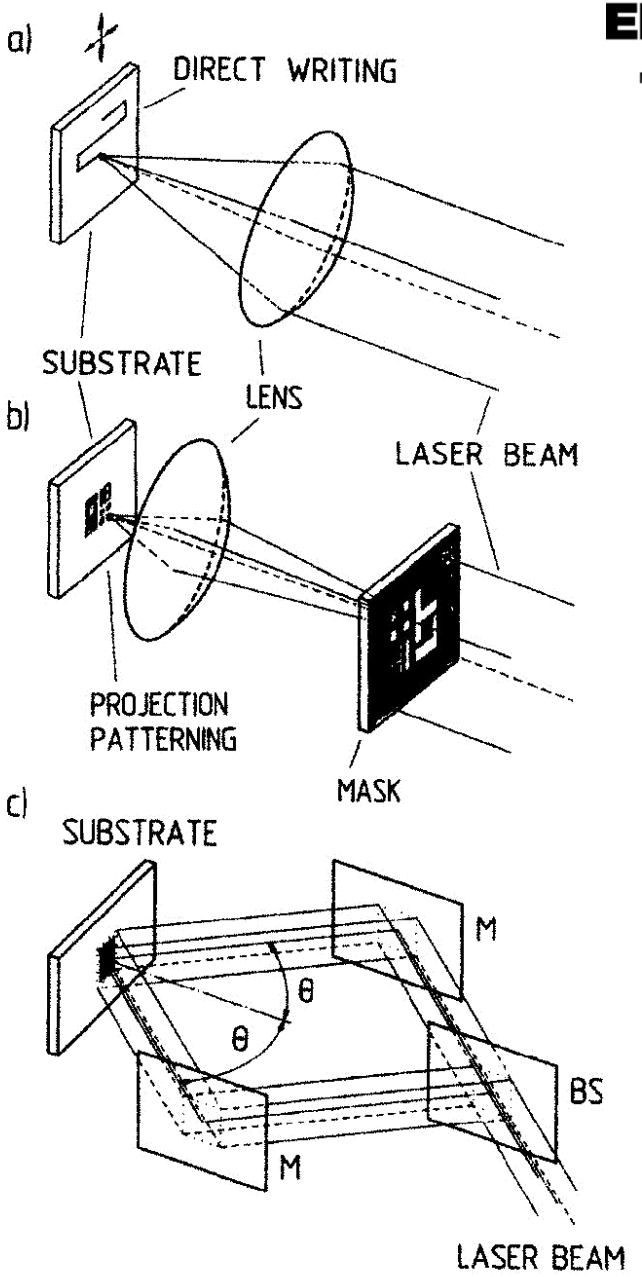




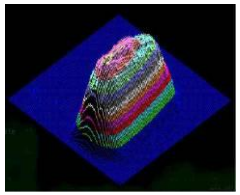
ns

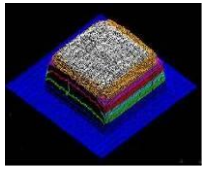
fs

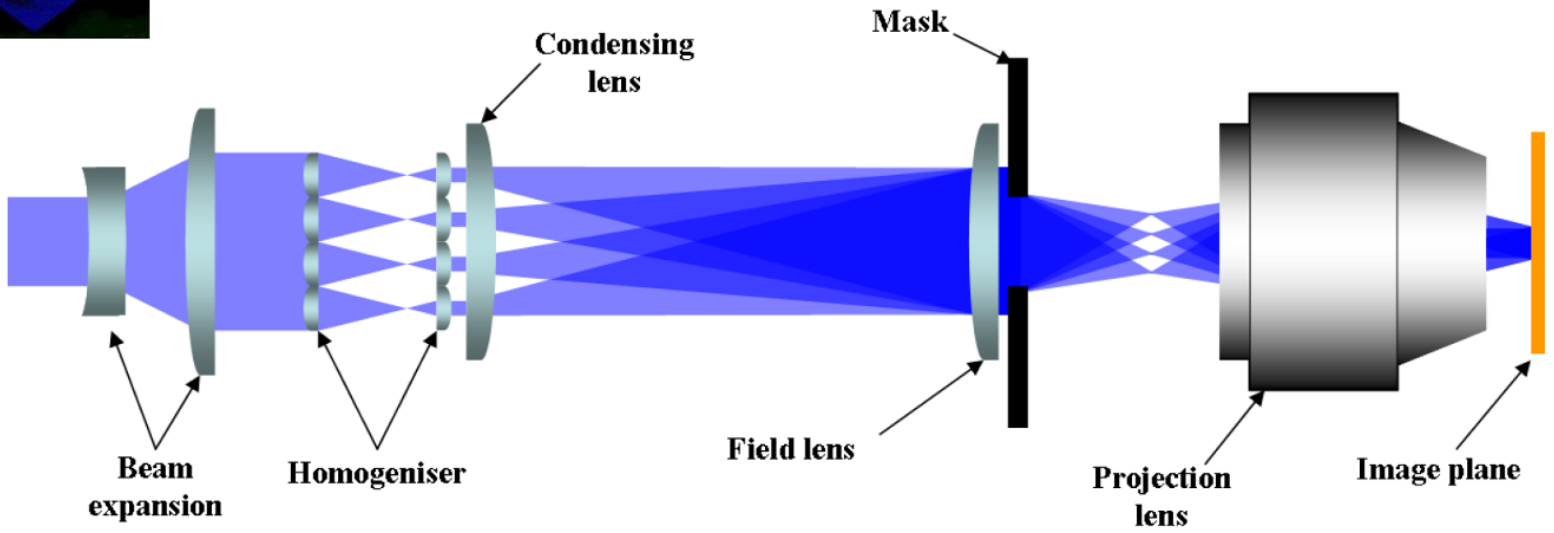
Different exposure of light



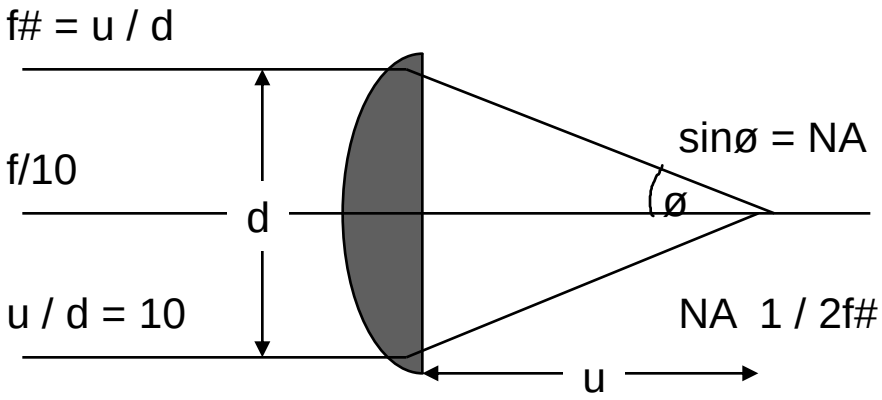
Mask projection system







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

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

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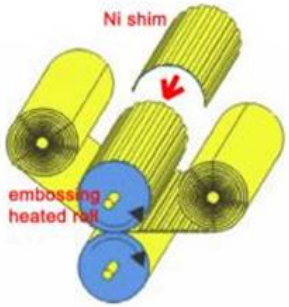
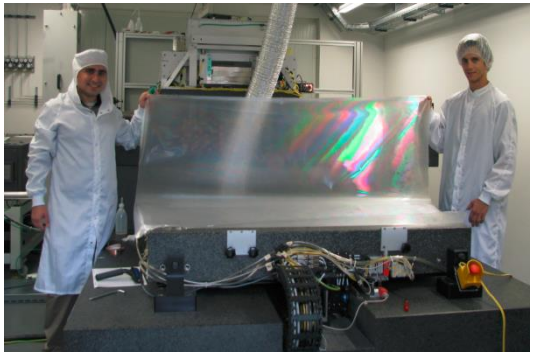
From Idea to CAD → Master substrate → Metal copy Ni shim → Production tools → Roll to roll embossing



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

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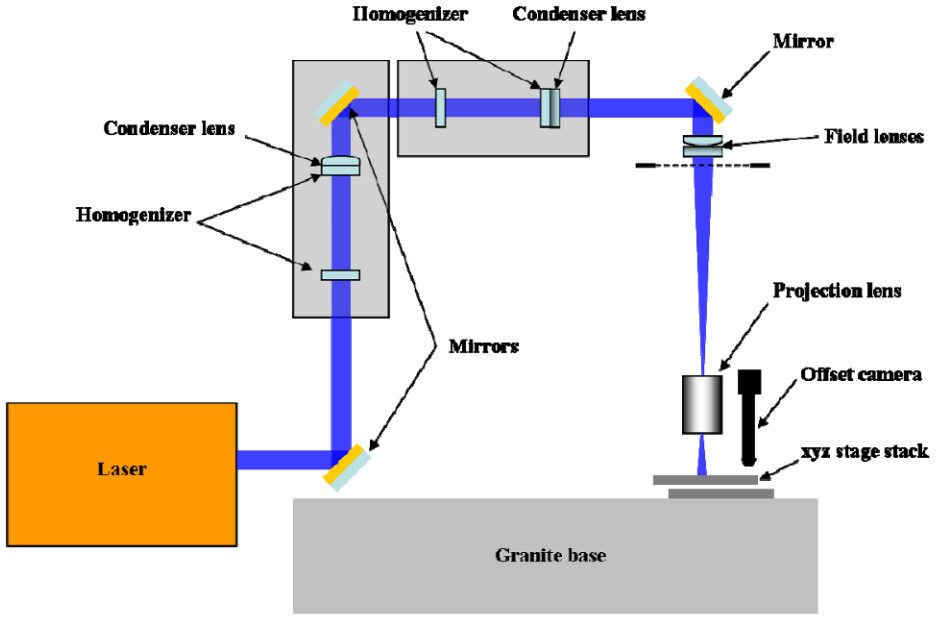

Travel	400 mm
Accuracy	±0.50 µm
Repeatability	±0.20 µm
Straightness	±0.40µm
Flatness	±0.40µm

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XXL microprocessing machine

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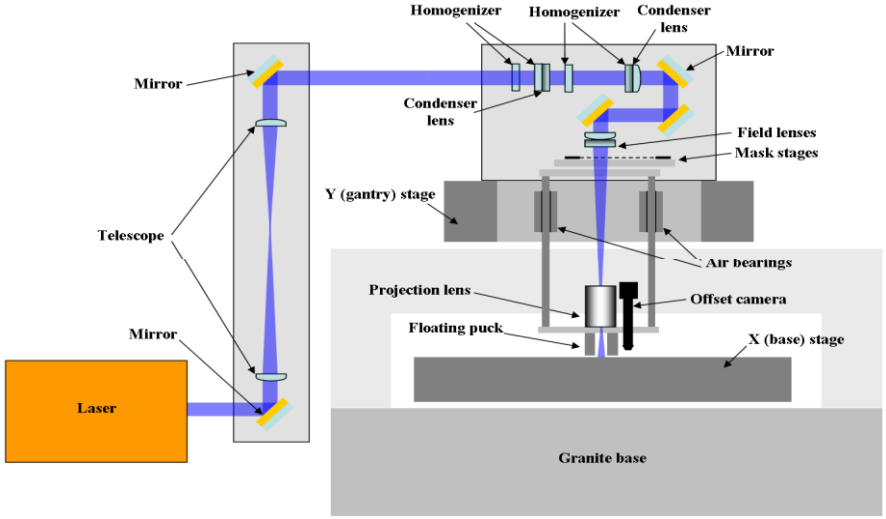

Specification	Unit	X-axis	Y-axis
		Spec	Spec
Travel	Mm	> 2200	> 1450
Payload	Kg	~ 115	~ 280
Speed	mm/s	200	360
Acceleration [1]	m/s^2	0,75	1
Resolution	µm	0,04	0,04
Bi-directional repeatability	µm	±2	±2
Accuracy (before calibration) [2]	µm	±4,5	±3
Straightness, bi-directional	µm	±2	±1,5
Flatness, bi-directional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

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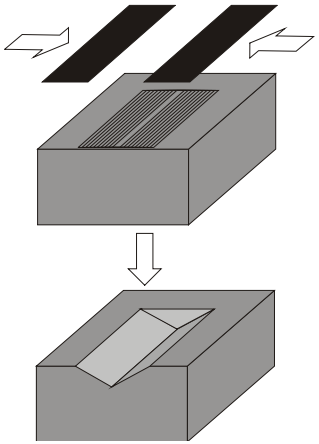
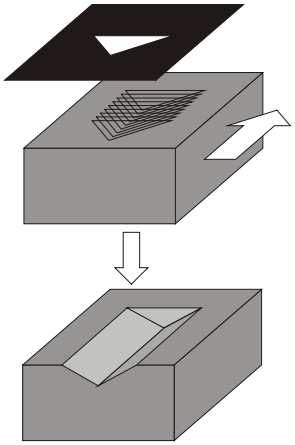
Projection ablation options for complex surface shapes

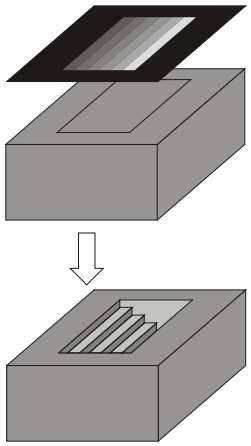
Variable aperture mask



Scanned mask &/or workpiece



Gray scale mask



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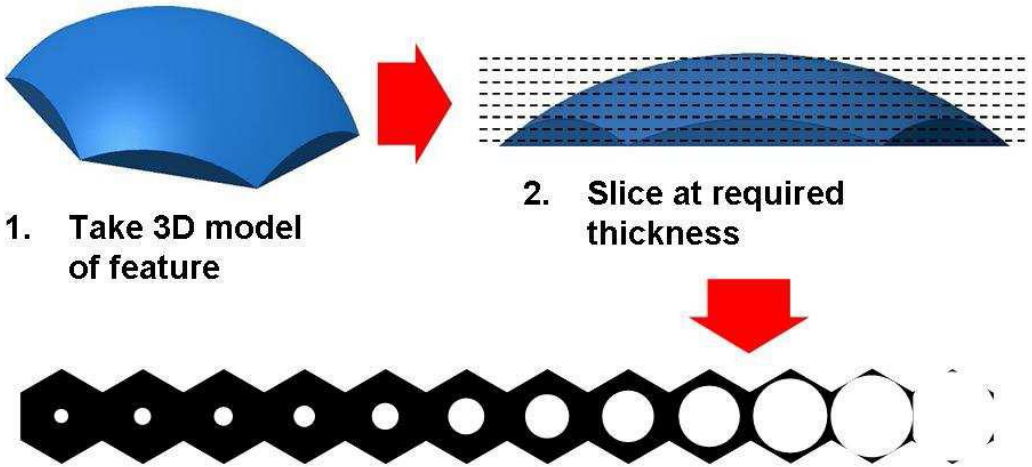
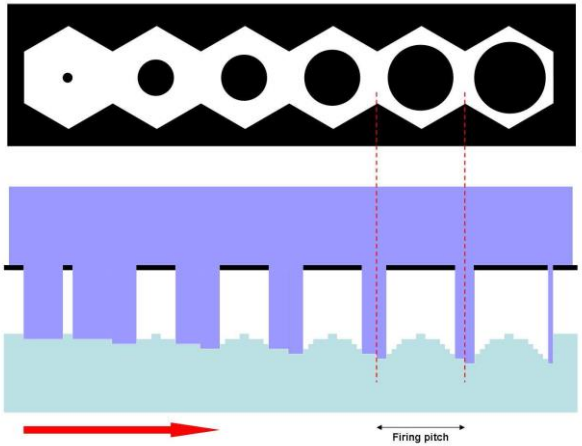
Synchronized Image Scanning (SIS)

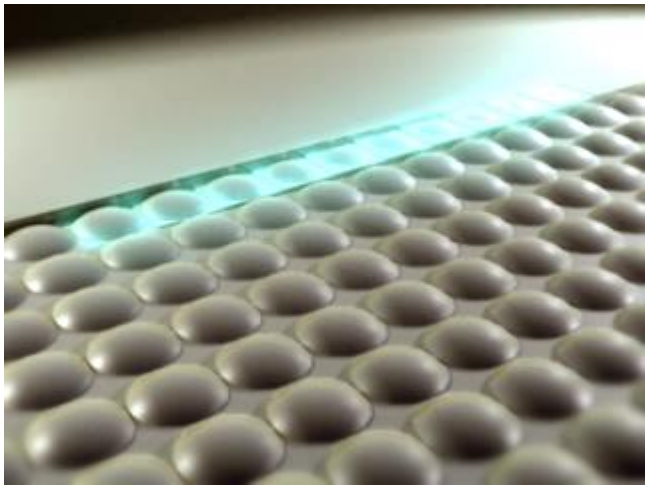


1. Take 3D model of feature

2. Slice at required thickness

2. Array of contours to be placed on mask





Intensity modulation of the imaged pattern

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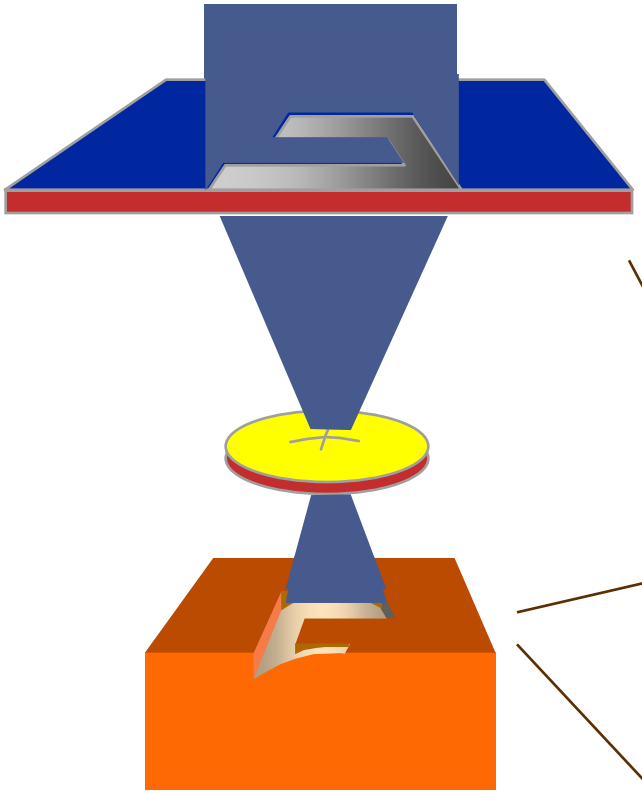

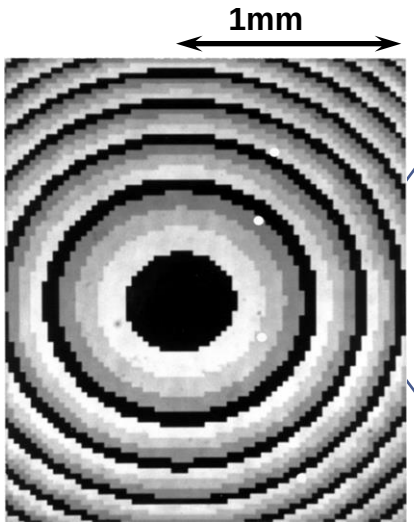

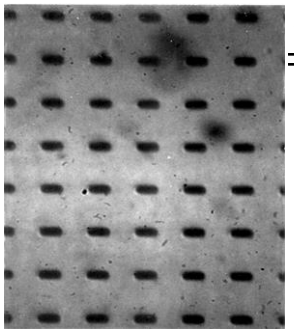

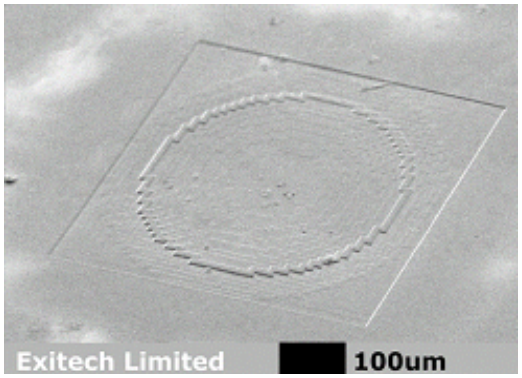

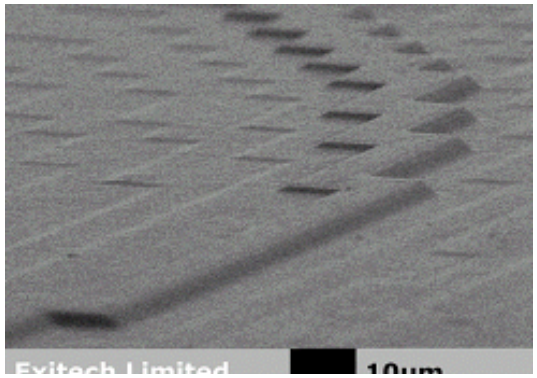

- Depth information incorporated in half-tone mask
- Transmission varied by changing hole size or density

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

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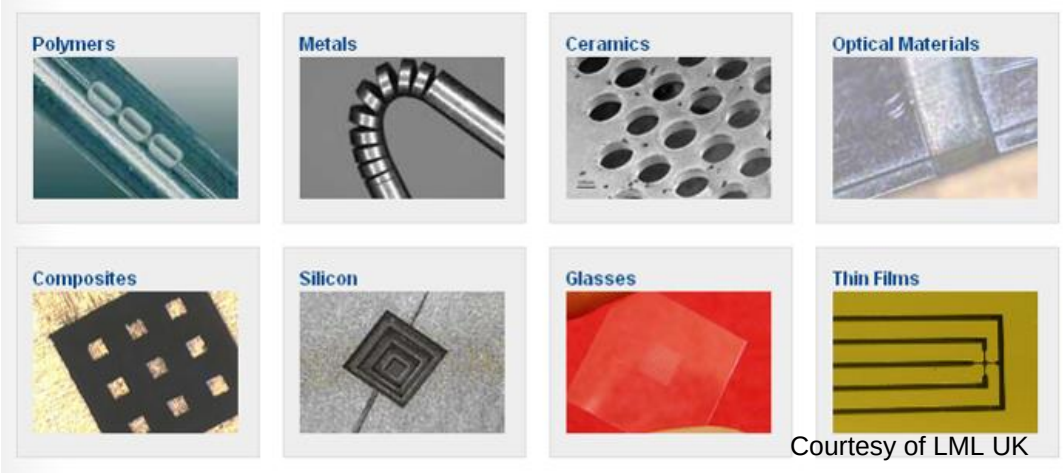
- Polymers
- Metals
- Glasses
- Silicon
- Optical materials
- Composites
- Ceramics
- Thin films



Courtesy of LML UK

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Laser machining of ceramics

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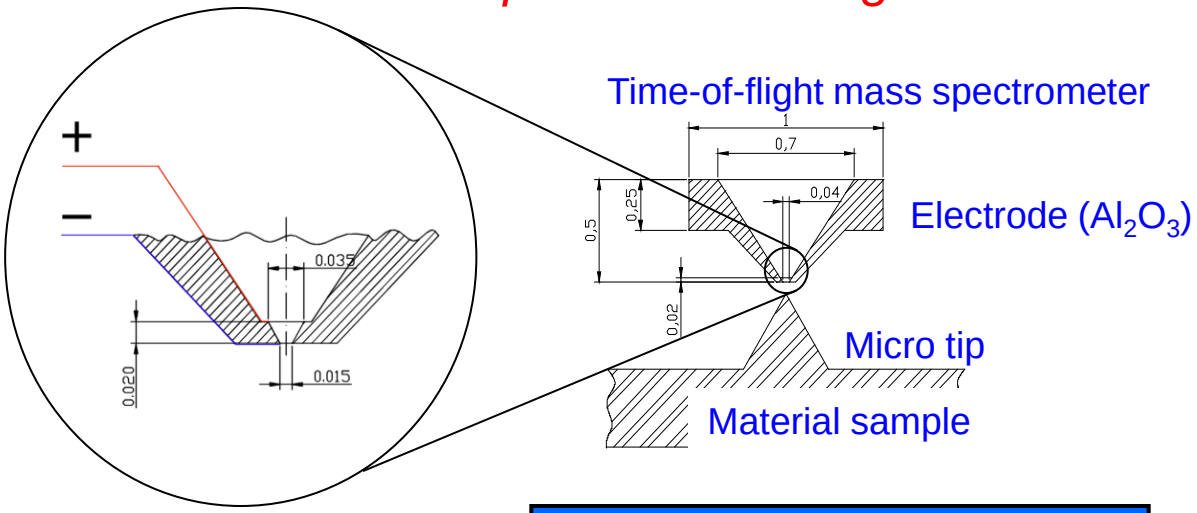
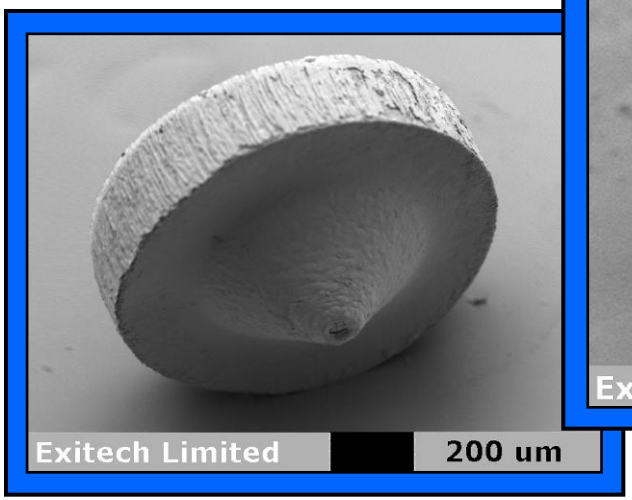
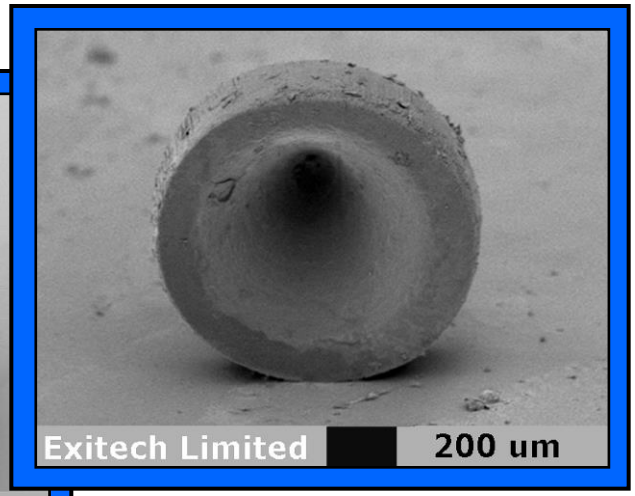
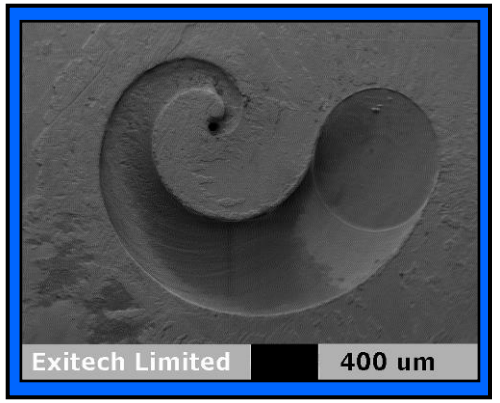
- *Schematic of one part of Scanning Atom Probe Instrument (SAP)*



248nm (KrF)
10J/cm2







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Microstructures in „green“ ceramics

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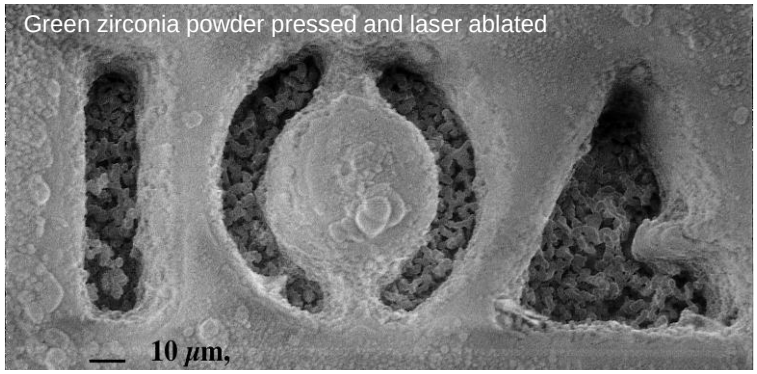
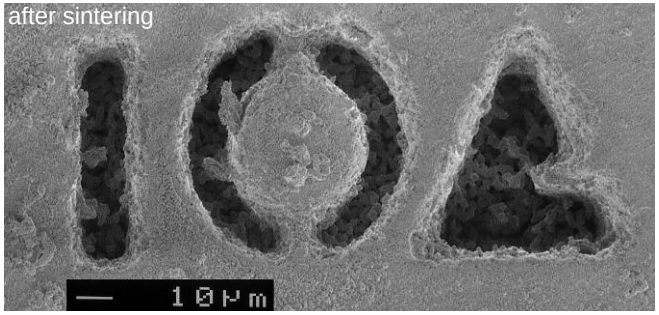
- 1/50 of energy density needed to machine
- Potential for highly efficient micro structuring of ceramics





Courtesy of EPFL

Laser machining of polymers

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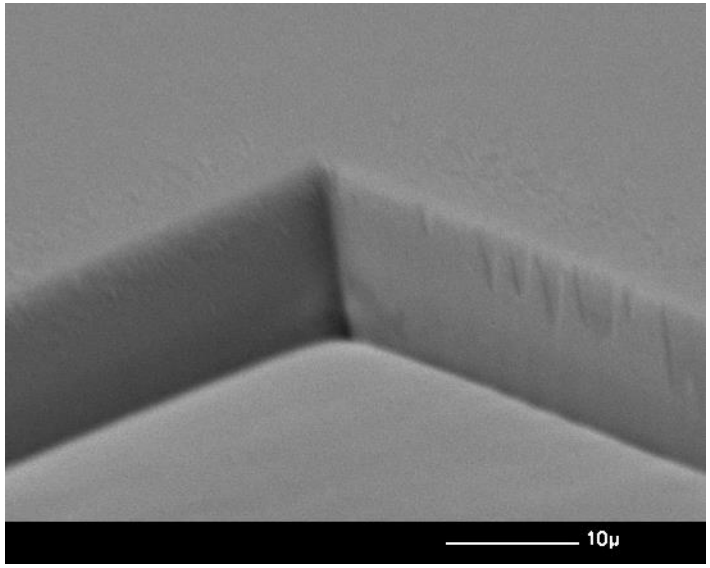
- Low ablation threshold (< 100 mJ/cm^2)
- Low surface roughness
- High edge definition
- …



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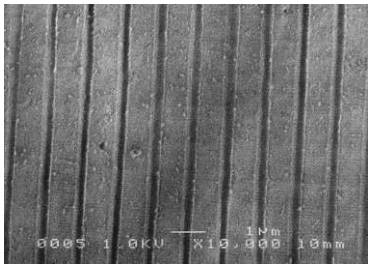
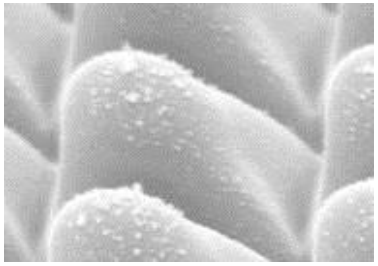
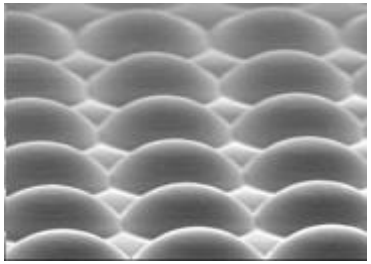
Mask imaging from submicron to millimetre feature





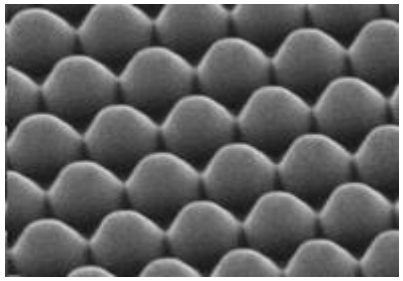


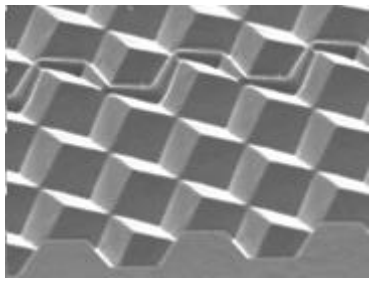
1 µm

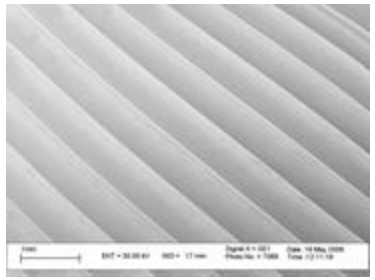
10 µm

100 µm

1000 µm







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Feature quality: fit of target shape

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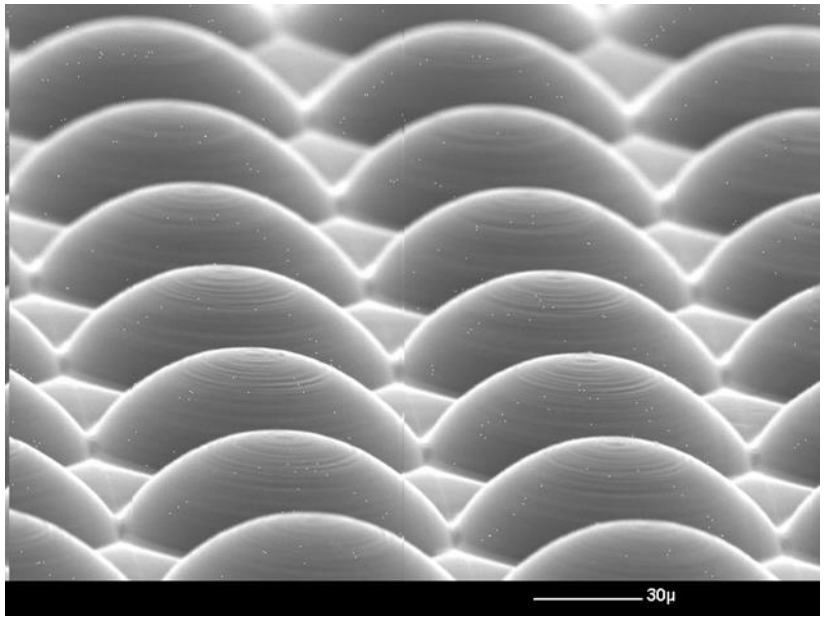

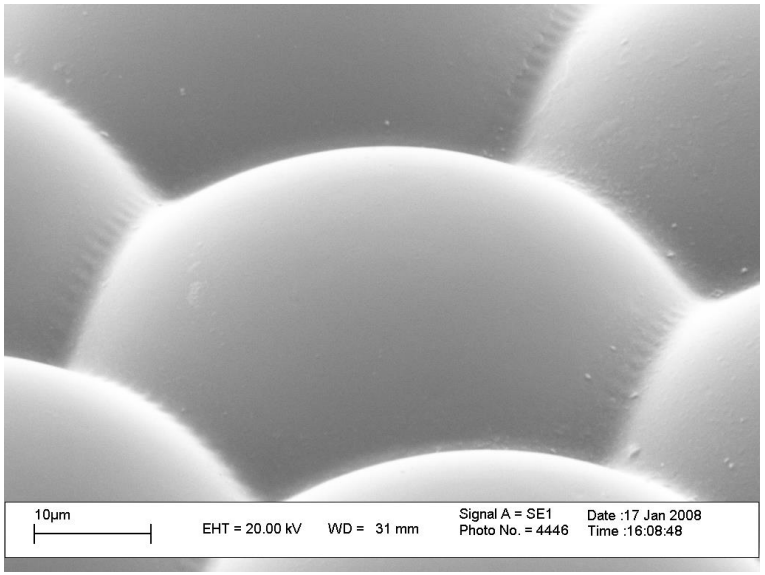

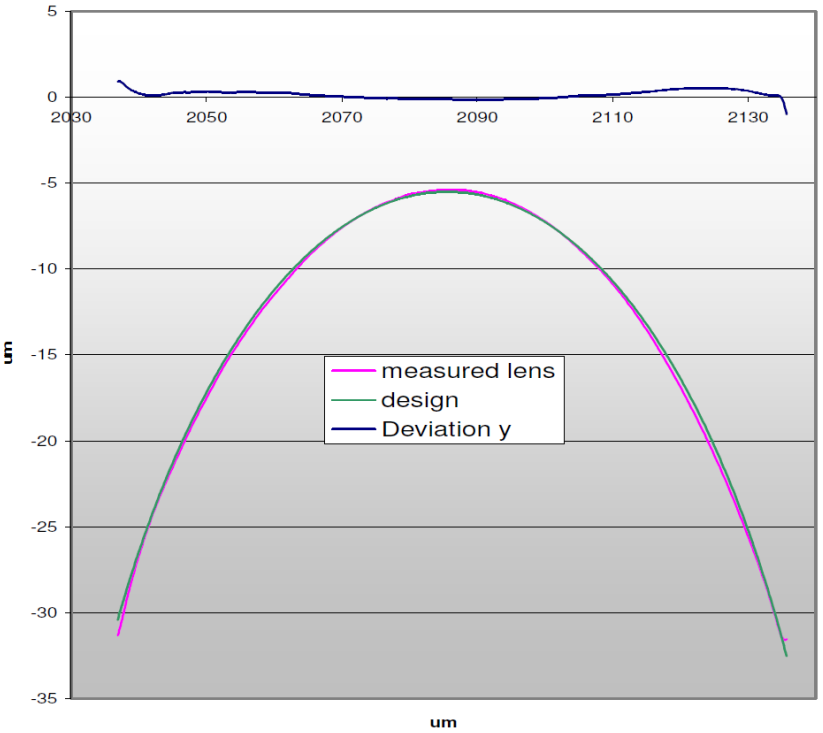

The average deviation from the best fit ROC is 147 nm with a ROC of 59.2 µm while the target is 60 µm.

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Examples

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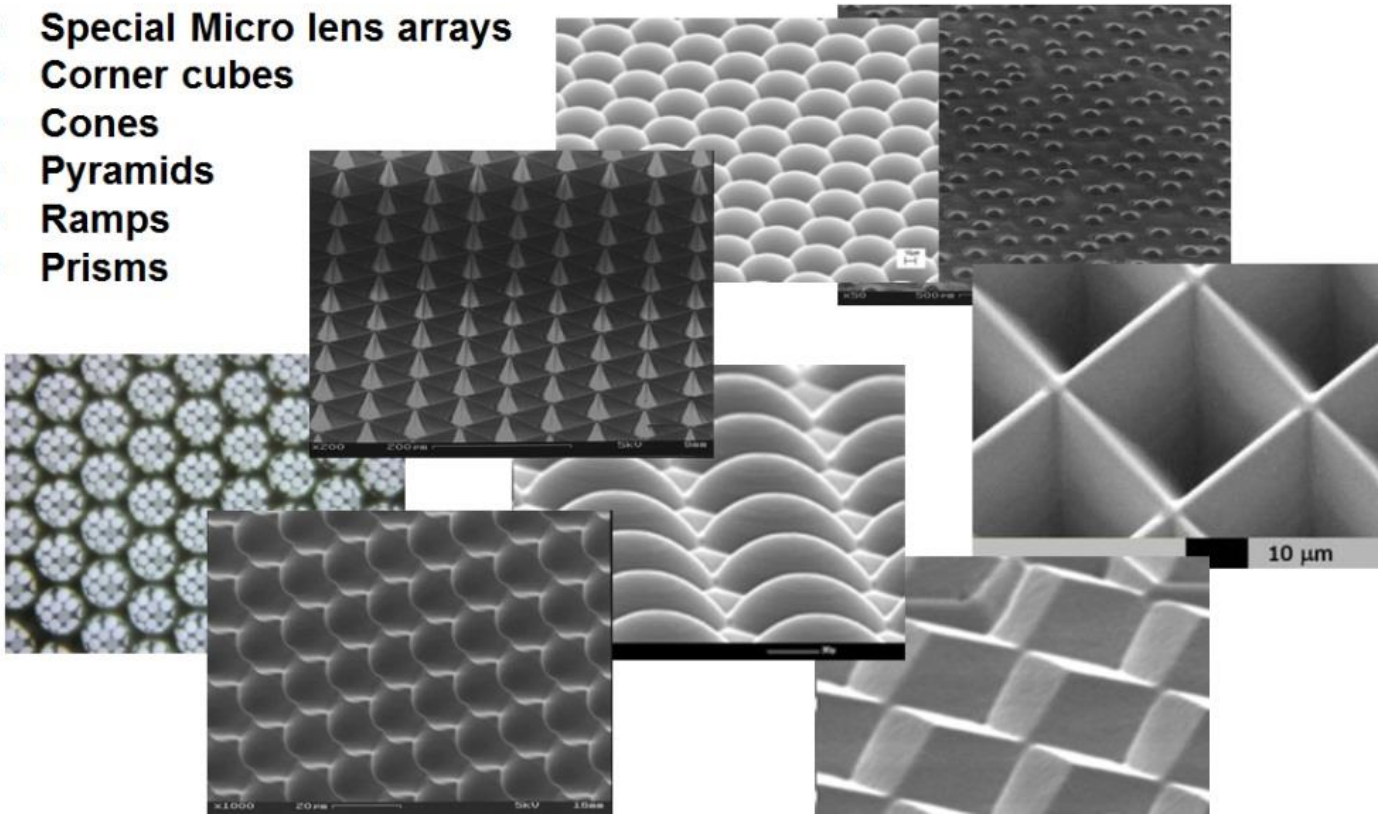
Highly engineered Micro-Structures

- Special Micro lens arrays
- Corner cubes
- Cones
- Pyramids
- Ramps
- Prisms



- **Individual feature size *x/y*: 2 µm – 1000 µm**
- **Feature height or depth *z*: 0 – 250 µm**
- **Wall angles and slopes α: 0° – 85°**

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Large surface replication

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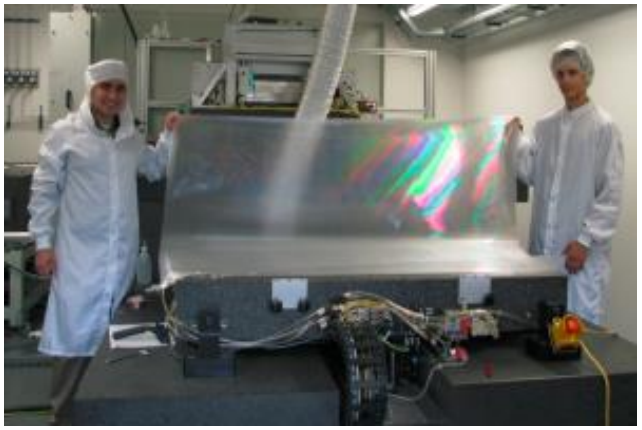
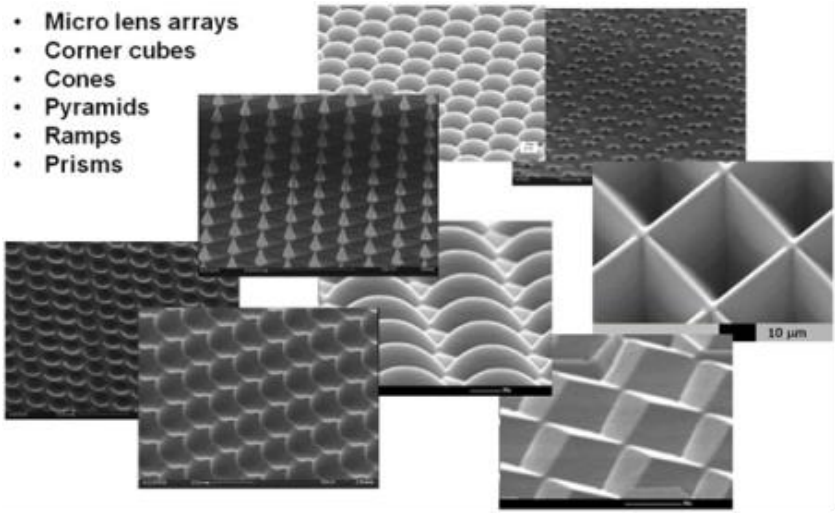
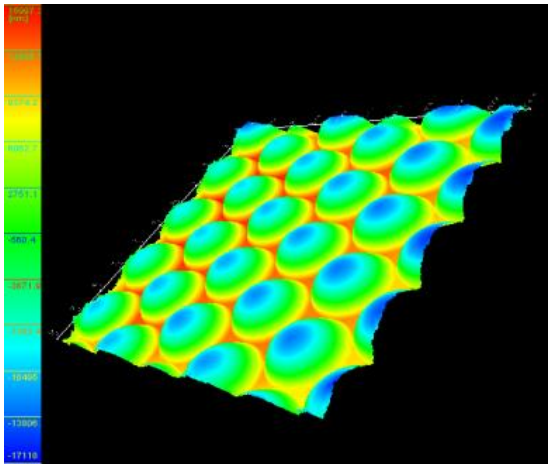
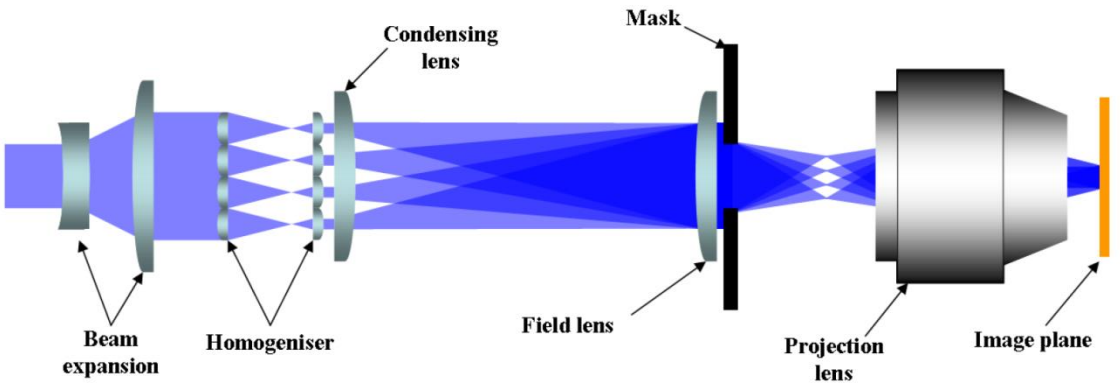






Laser cut Microlens array
DHM measured ⦰ = 70 µm, *h* = 25 µm



LAMP - Team: Dr Karl Böhlen, Mr Erdem Siringil, Dr Kilian Wasmer

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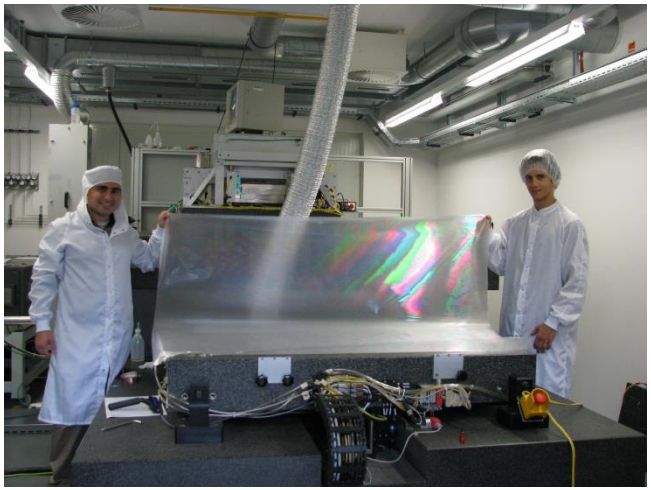
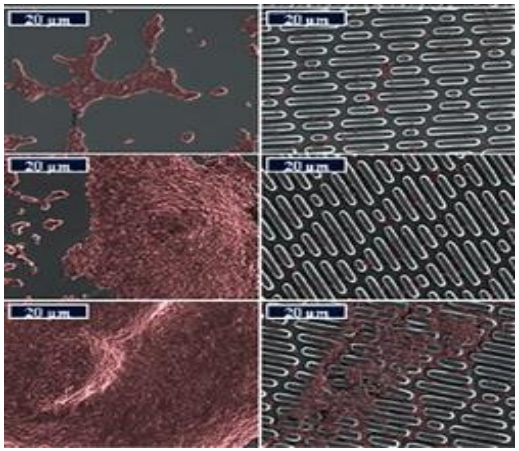
Gradients of structures

- Bio-platform of advanced micro-topographical surface

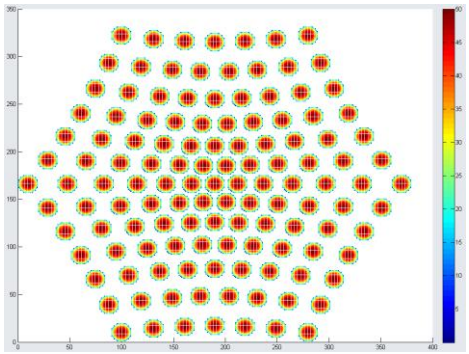


Laser Center Thun
Exitech PPM601E capability of micro-structuring very large areas up to 1900 x 1450mm^2.



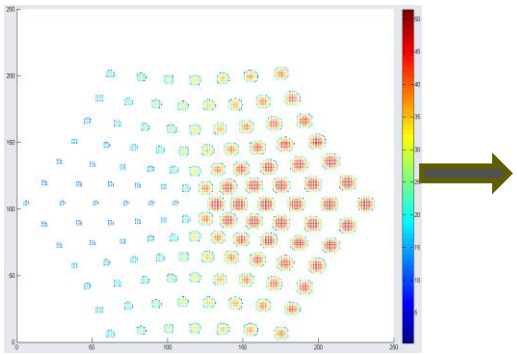
Existing Structures taken from Materiomics => 2.5D, *http://www.utwente.nl/tnw/tr/people/principleinvestigators/jandeboer/research*

Full 3D-structure with grandient
The colour indicates the circles diameter.
The pitch increases with the angle.
The scales unity is [µm]

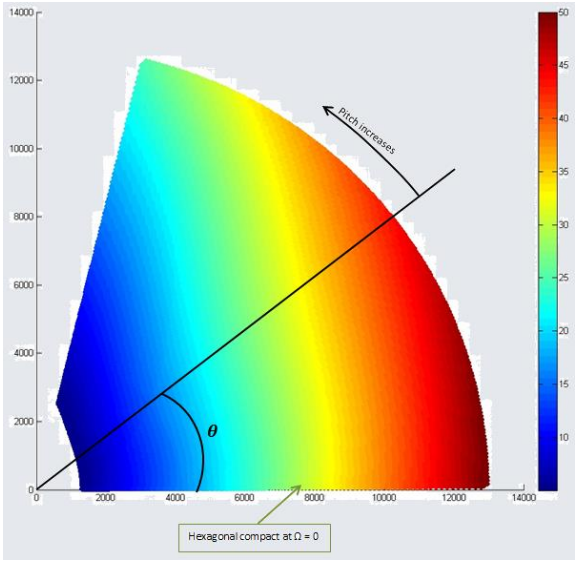


$R = f(r)$

Or



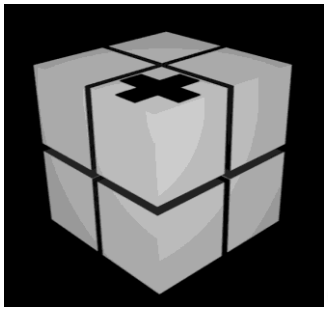
$R = f(r) \cdot g(\theta)$



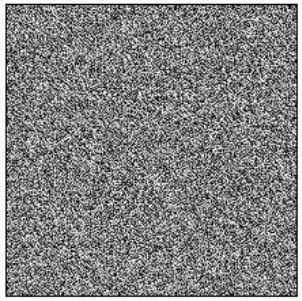
LAMP - Team: Dr Karl Böhlen, Mr Erdem Siringil, Dr Valentina Dinca, Dr Kilian Wasmer

DOE

- Diffractive Optical Elements

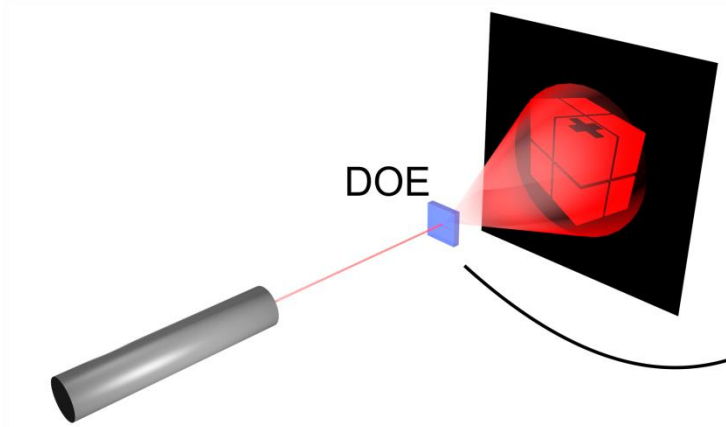


Optical function

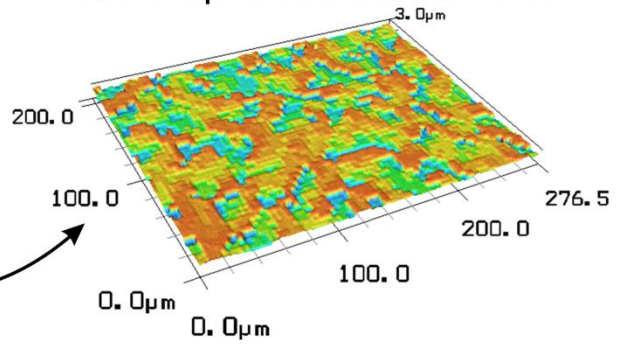


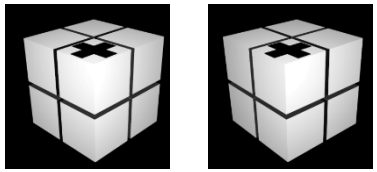
Computed DOE

Iterative algorithm



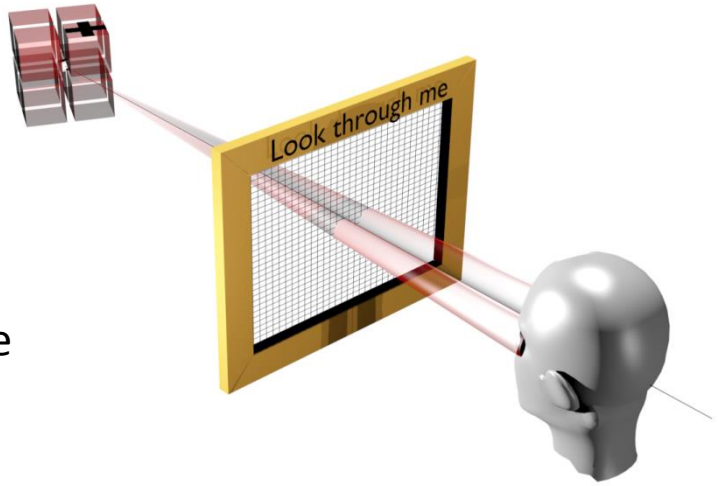
close-up of machined DOE





Left eye
-2°

Right eye
+2°



Characterization of phase elements

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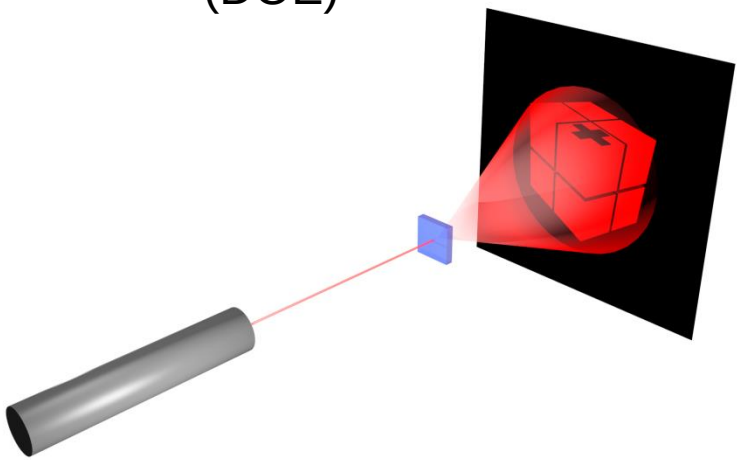
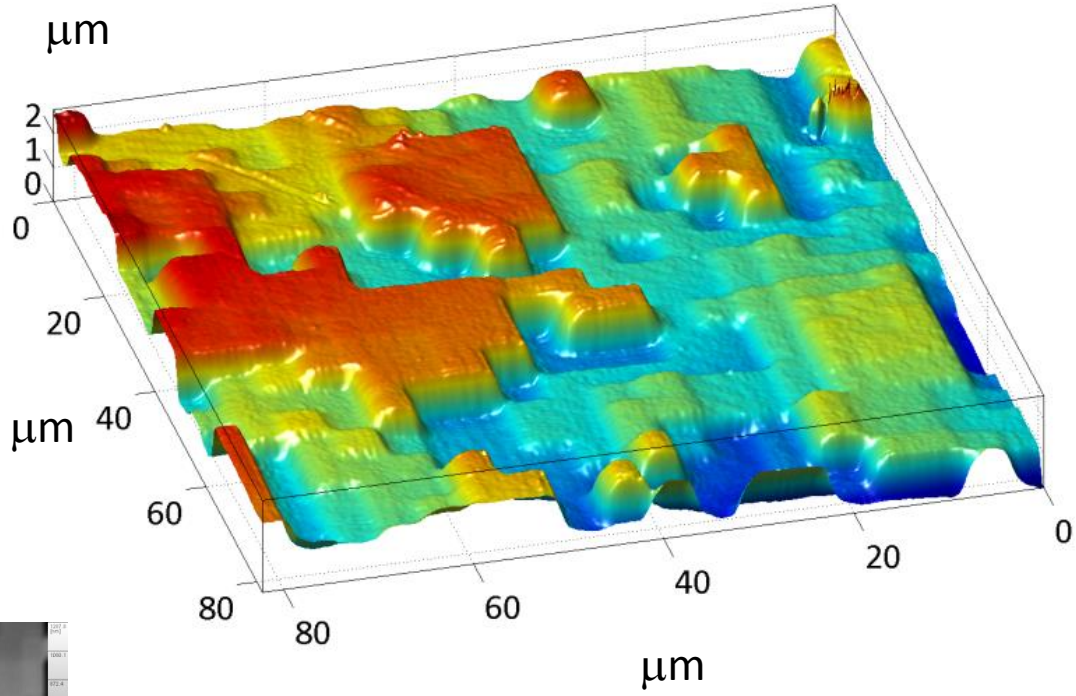
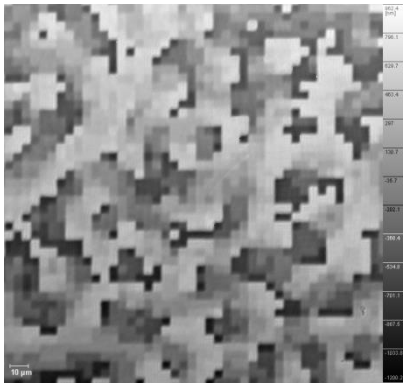
Diffractive optical element (DOE)



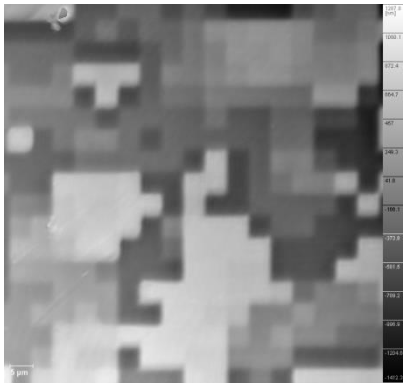


DHM of 8-levels DOE : unit element 5x5µm²

Phase maps



20x



50x

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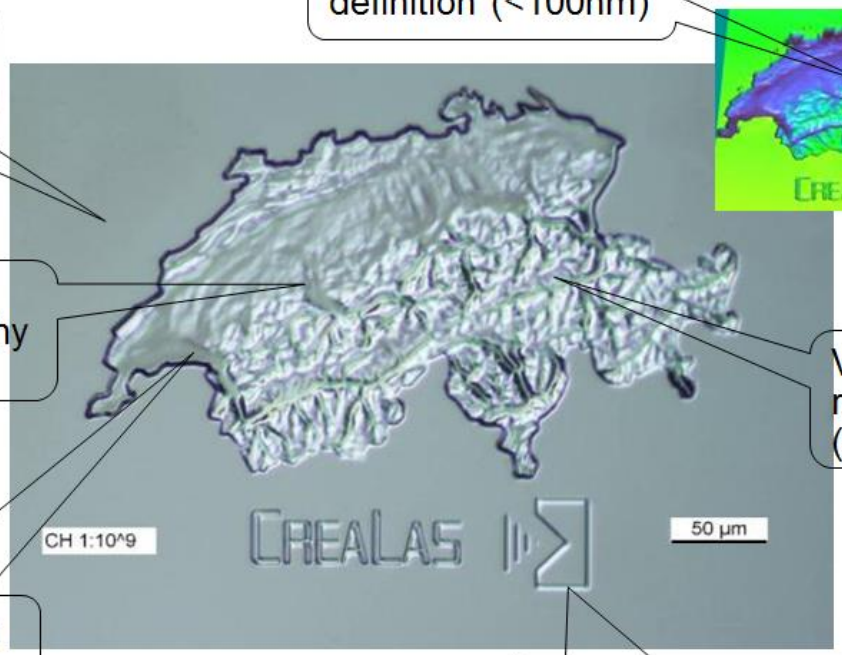
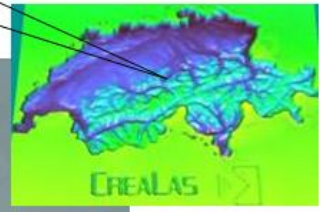
Technology:

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)

crealas
smart microstructures

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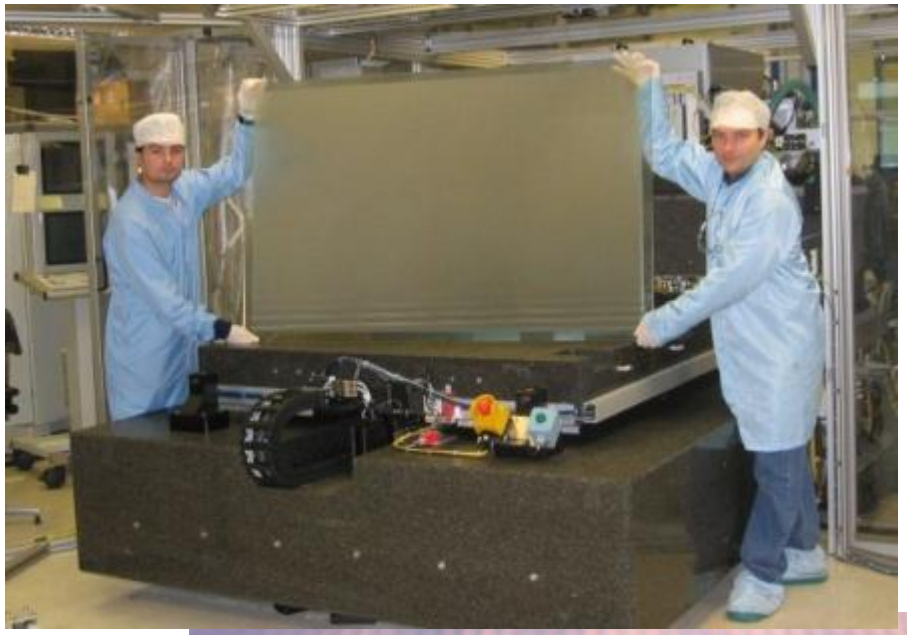
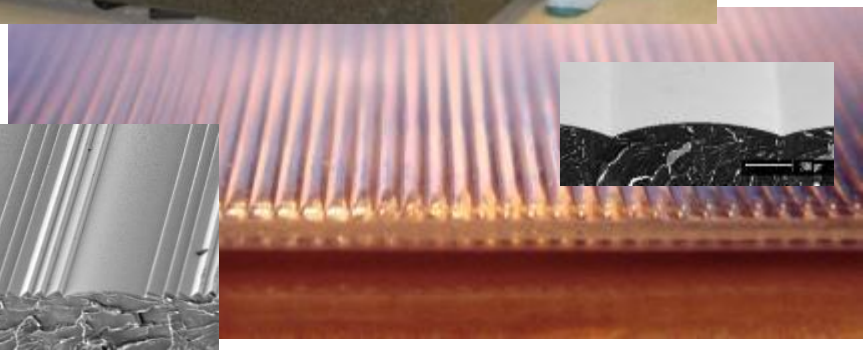
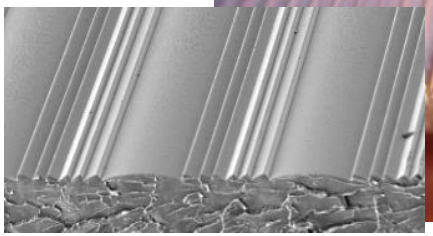
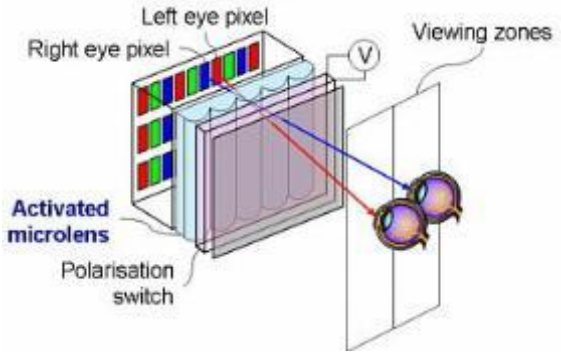
3 D TV: Large area precision masters









Applications

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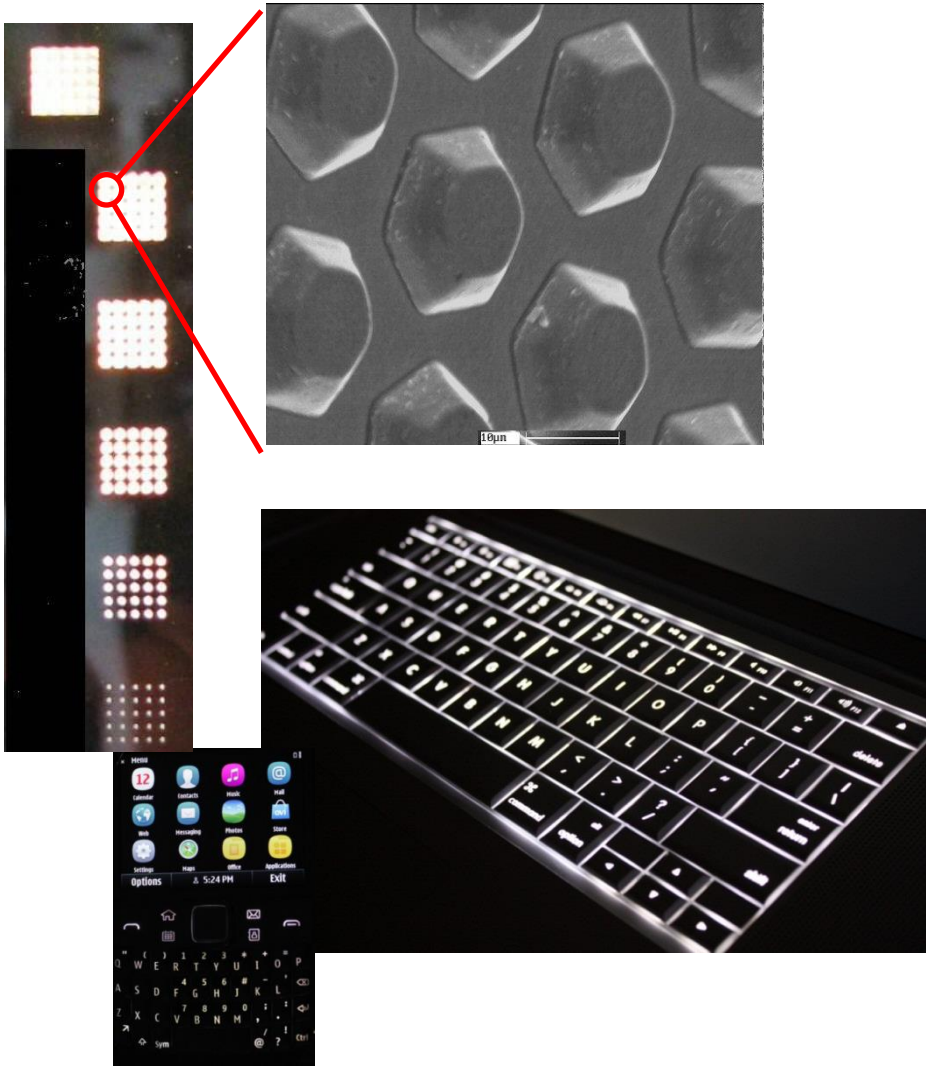
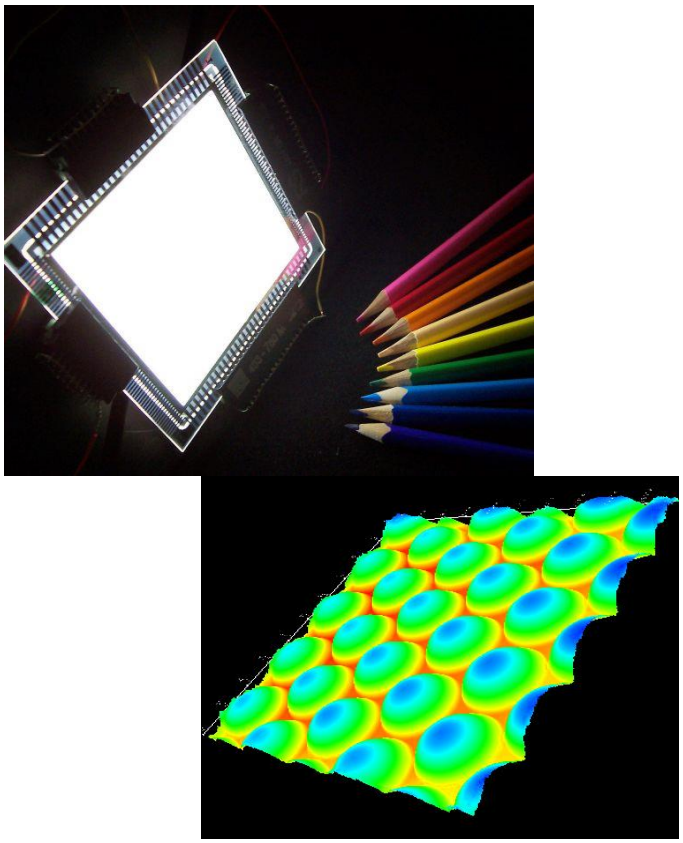
Keyboard illumination:



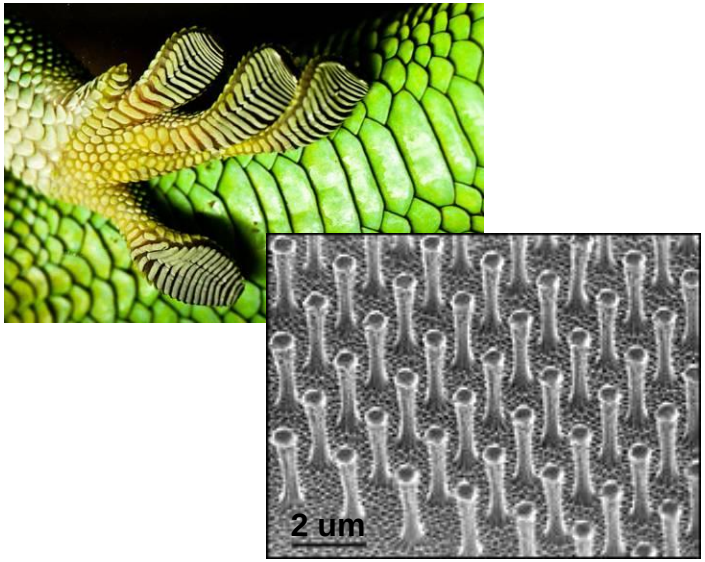
OLED out-coupling:

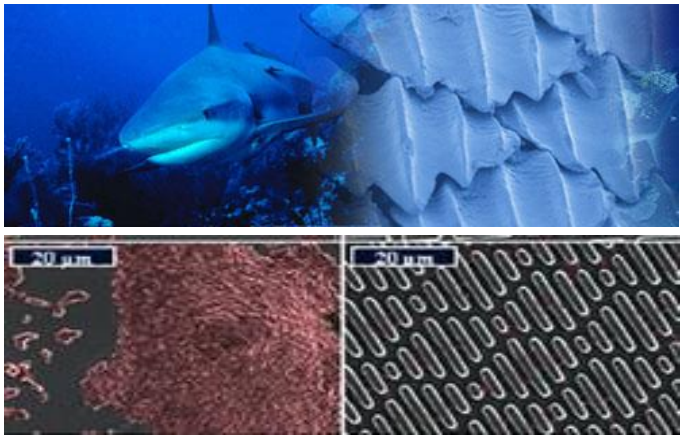


Applications

Advanced surfaces

- Biomimic surfaces (Lotus, Gecko, etc)
- Friction and drag reduced surfaces
- Selectively activated (e.g. hydrophilic & hydrophobic)





Applications

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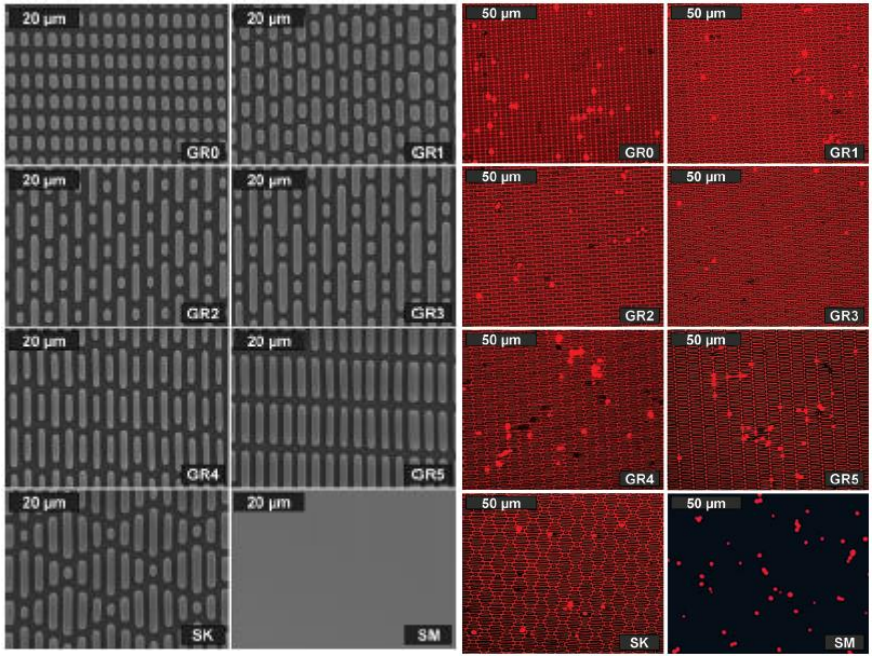
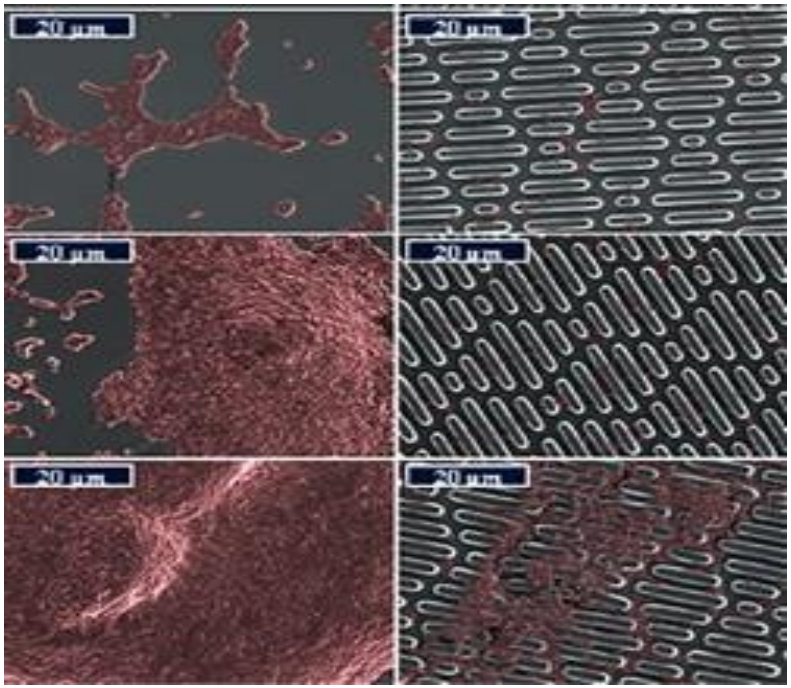
Advanced surfaces

- Biomimic surfaces (Lotus, Gecko, etc)
- Friction and drag reduced surfaces
- Selectively activated (hydrophilic & hydrophobic)



James F. Schumacher et. al, *Langmuir* 2008, *24,* 4931-4937



Kenneth K. Chung et. al, Biointer*phases*, 2007, 2, 89-94

Conclusions

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- Large surface laser processing possible
- Master pieces - replication

Thank you