EUMINAfab – a European Research Infrastructure on multimaterial micro- and nanotechnologies

Mastermaking and Strukturing Facilities @ Cardiff

Manufacturing Engineering Centre - Cardiff University
Steffen G. Scholz
14.09.2010

36 Installations

EUMINAfab

MEC 4

CrossBeamXB1540

Mastermaking

Laserprocessing

Micro&Nanoimprimting

1

NPL-MeasLab

NanoMetrology

Noble metal

e-beam

MiPlaza

LTPS line

Etching

4

CHARPAN Tool

IMS-CHARPAN 1

Surface nanotexturation

LTF

PVD

CVD

XPEEM

HRTEM TITAN

PVD/CVD

6

KNM F

Auger Nanoprobe

Abberation corrected TEM

Laser processing

DPN

VB6

HSPC Micromech

µIM

P&n imprint

PVD-Cluster

dLIGA

In situ NANO BL

11

ULTRA LAB

METRO LAB

TMM

REPLICATION LAB

NIL LAB

4

PHOTOPOL

SelfAss

CRF-MN

ScreenP

PVD-Org

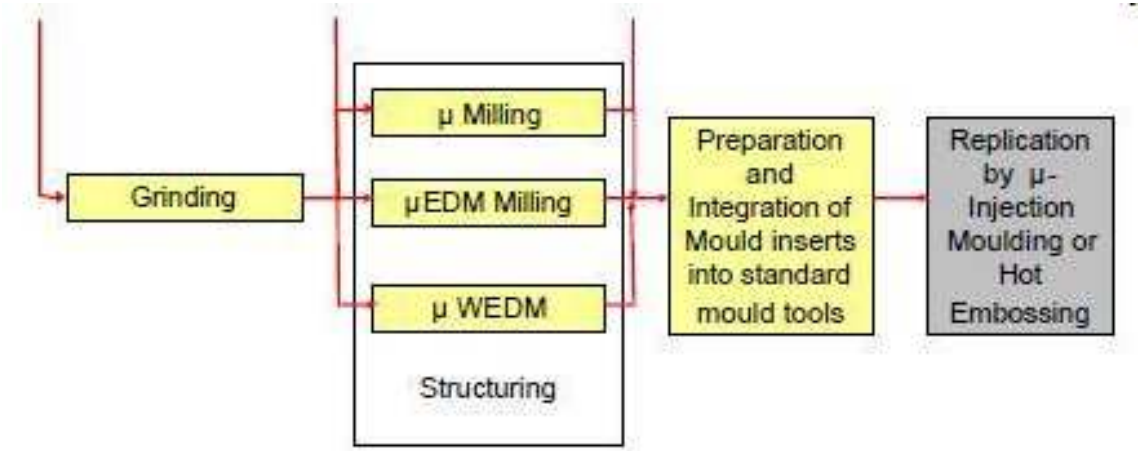
EO

5

Installation

Short name of infrastructure

Mastermaking and Structuring of Mould inserts



- Micro Milling, Kern HSPC 2216
- Micro-EDM, AGIE Comp.
- Micro & Vertex machines
- Micro EDM Milling system SARIX SX-100-HPM 3D
- Grinding
- Micro SLA

Oppotunity: Functional micro and nano structured surfaces

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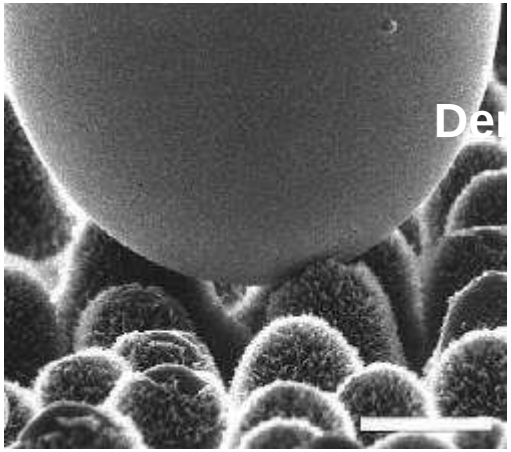
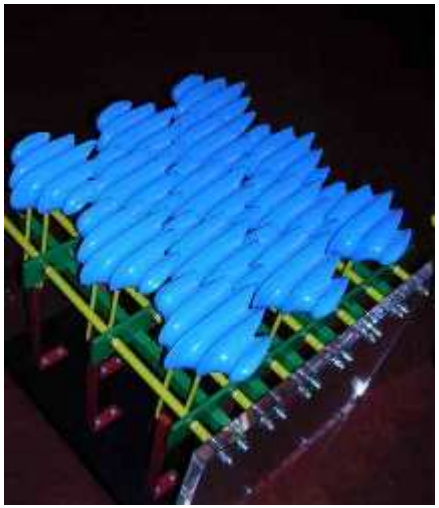
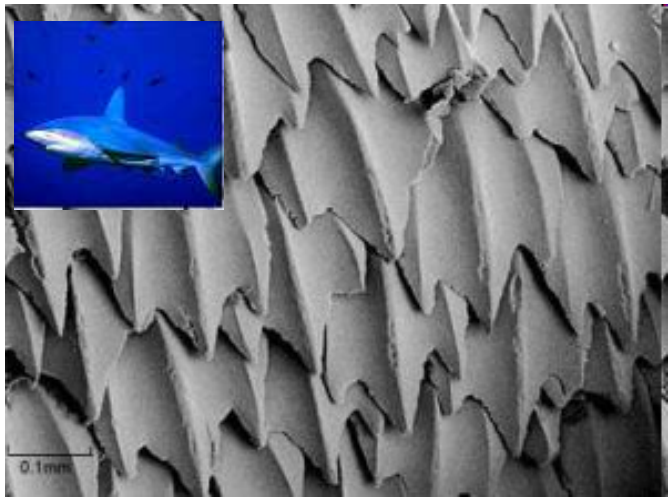






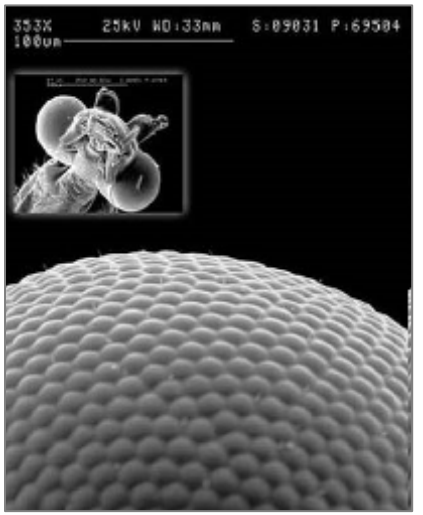
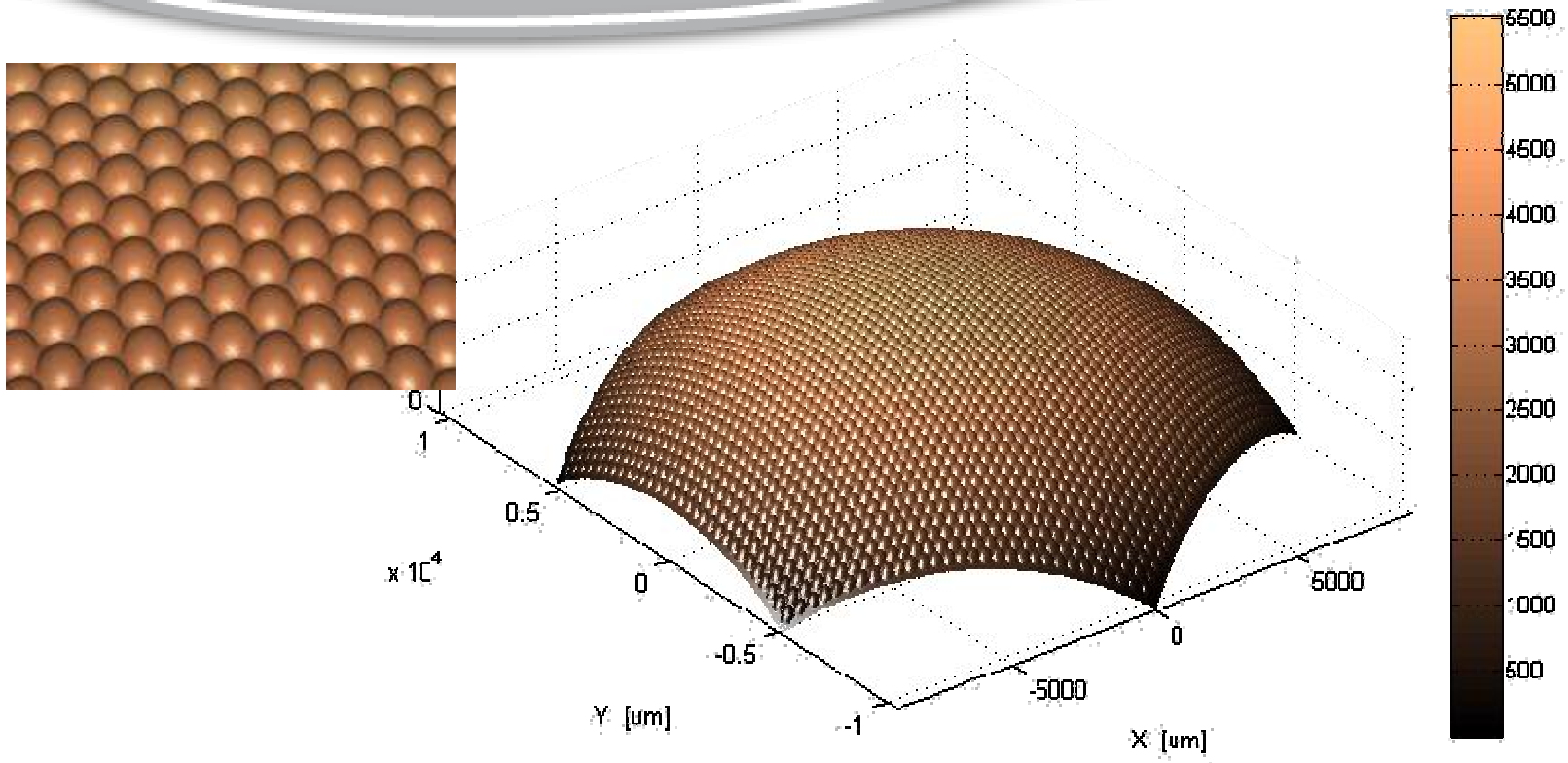


Photo: DLR

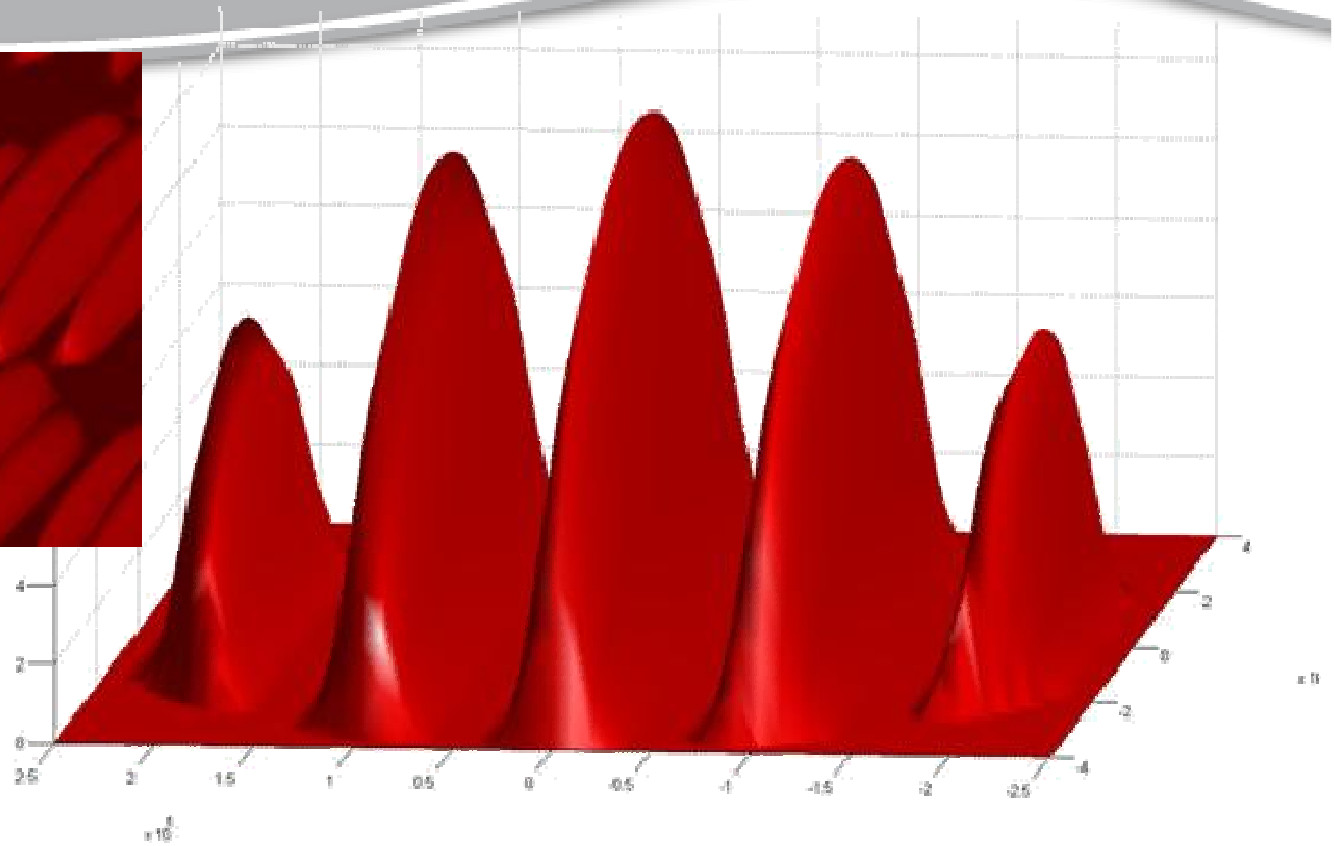
Bio-mimetic modelling: household fly eye like surface



- Hexagonal design for Ommatidia and protuberances: 3D on 3D
- Ommatidium: 9 µm in height and 21 µm in diameter
- Protuberances on top of the ommatidia: Ø 350 nm and 120 nm in height
- Dimensions of protuberances in range of wave length of optical light

Scholz, S., Griffiths, C. A., Dimov, S. S., Brousseau, E. B., Lalev, G. and Petkov, P. *New process chains for replicating micro and nano structured surface with bio-mimetic applications*. ANTEC 2009 - Proceedings of the 67th Annual Technical Conference & Exhibition. Chicago, IL, June 22 - 24.

Bio-mimetic modelling: shark skin like surface

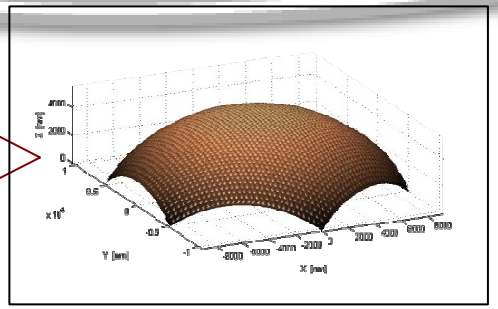


- Ellipsoid design with gaps: height up to 130 µm, distance between peaks 100 µm, length up to 500 µm
- Hexagonal design of functional elements (denticles) to achieve optimal spacing
- Functional elements on both planar and 3D freeform surfaces

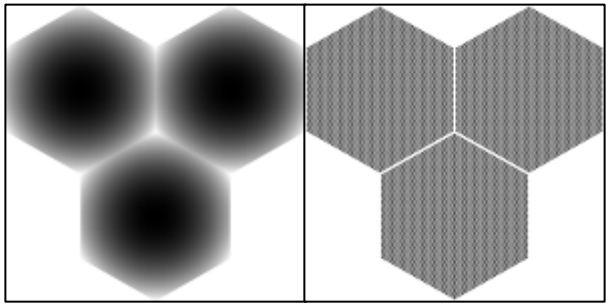
Scholz, S., Petkov, P., Brousseau, E., Griffiths, C., Hirshy, H. and Dimov, S. *Process chain for replicating bio inspired micro structured surfaces*. 4M/ICOMM 2009 - The Global Conference on Micro Manufacture. Karlsruhe, Germany, September 2009.

Process chain: replication of moth's eye like surfa

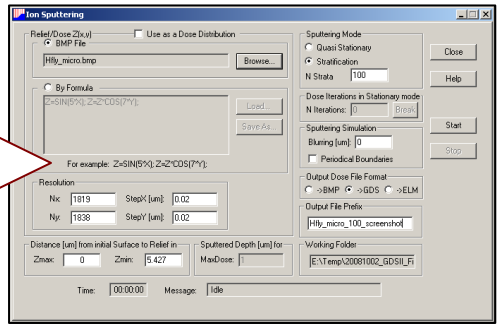
1) Bio-mimetic modelling



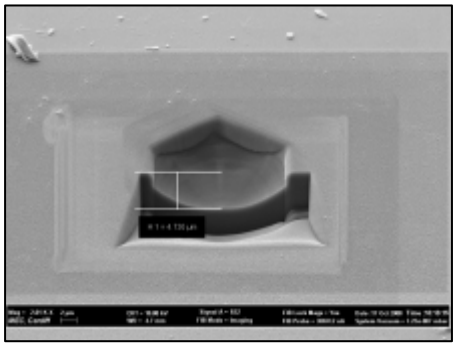
2) CAM solutions

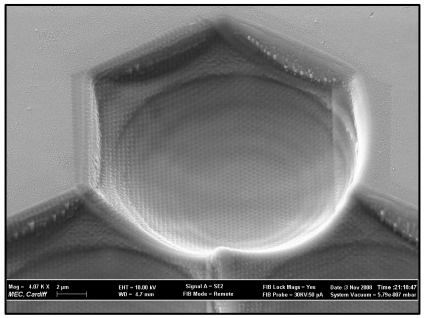


3) Generation of GDSII files

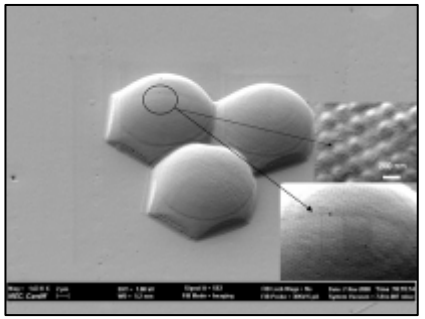


4) FIB machining





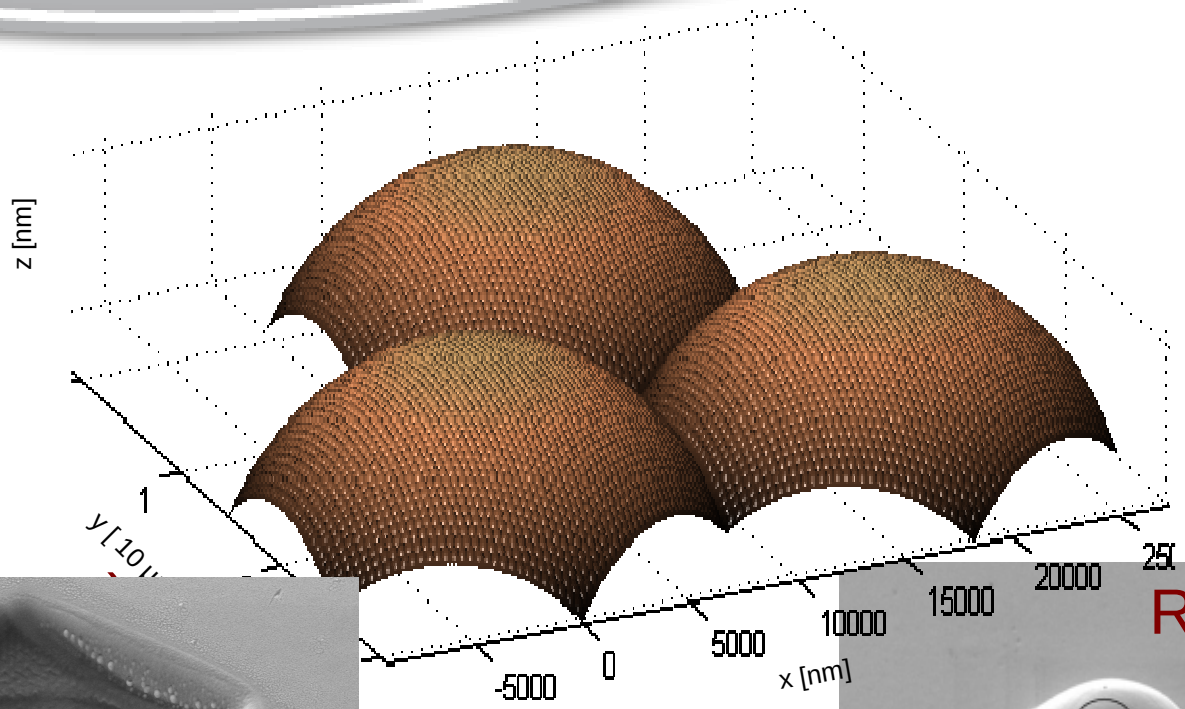
5) IM replication

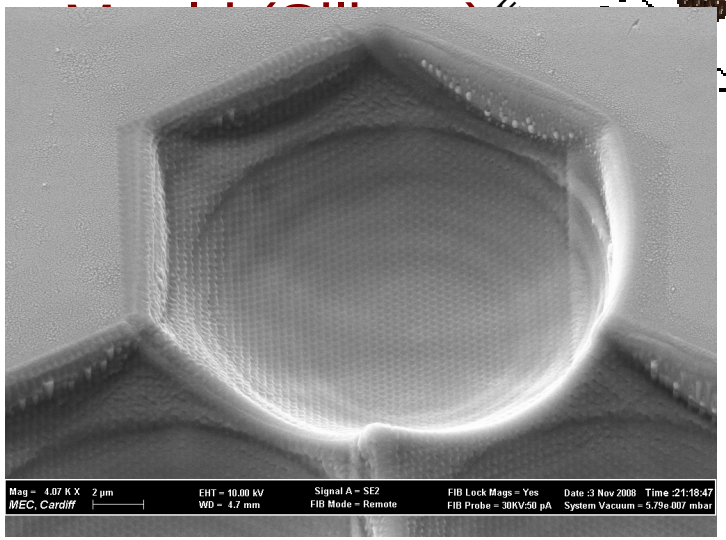


Scholz, S., Griffiths, C. A., Dimov, S. S., Brousseau, E. B., Lalev, G. and Petkov, P. *New process chains for replicating micro and nano structured surface with bio-mimetic applications*. ANTEC 2009 - Proceedings of the 67th Annual Technical Conference & Exhibition. Chicago, IL, June 22 - 24.

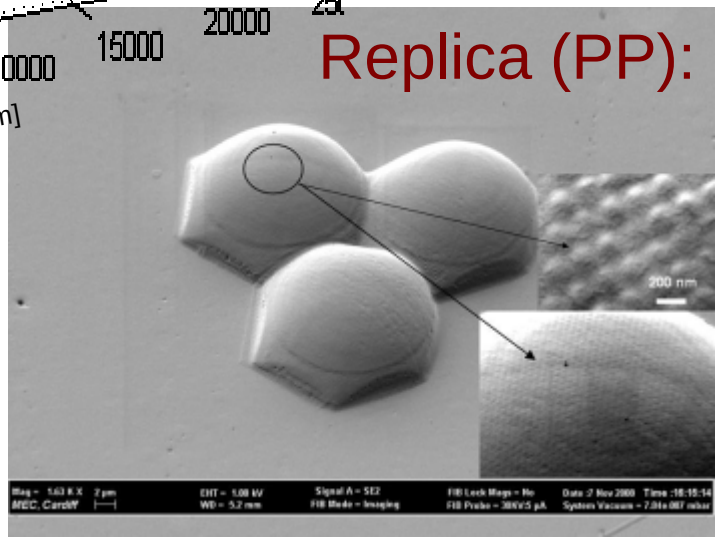
Results: replication of moth's eye like surfaces

Model:





Replica (PP):



Scholz, S., Griffiths, C. A., Dimov, S. S., Brousseau, E. B., Lalev, G. and Petkov, P. *New process chains for replicating micro and nano structured surface with bio-mimetic applications*. ANTEC 2009 - Proceedings of the 67th Annual Technical Conference & Exhibition. Chicago, IL, June 22 - 24.

Process chain: replication of shark skin like structures on 3D freeform surfaces

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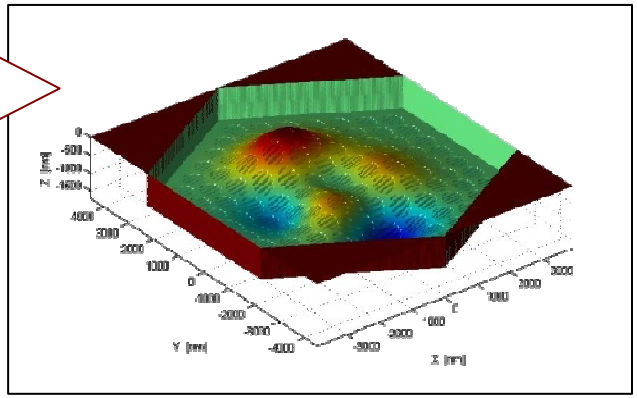
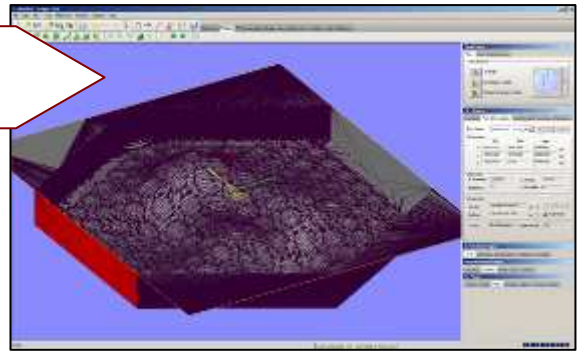
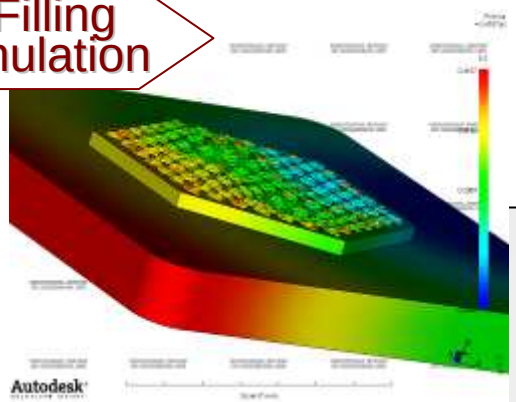
1) Bio-mimetic modelling



2) CAM solutions

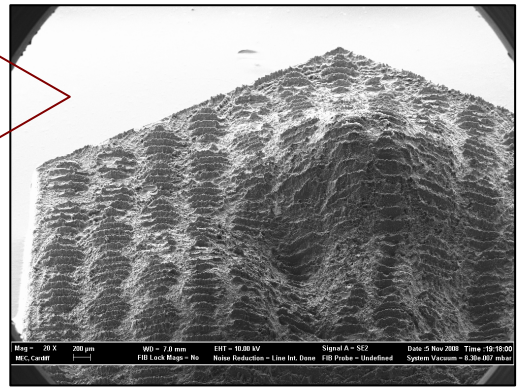


3) Filling simulation



4) Laser milling

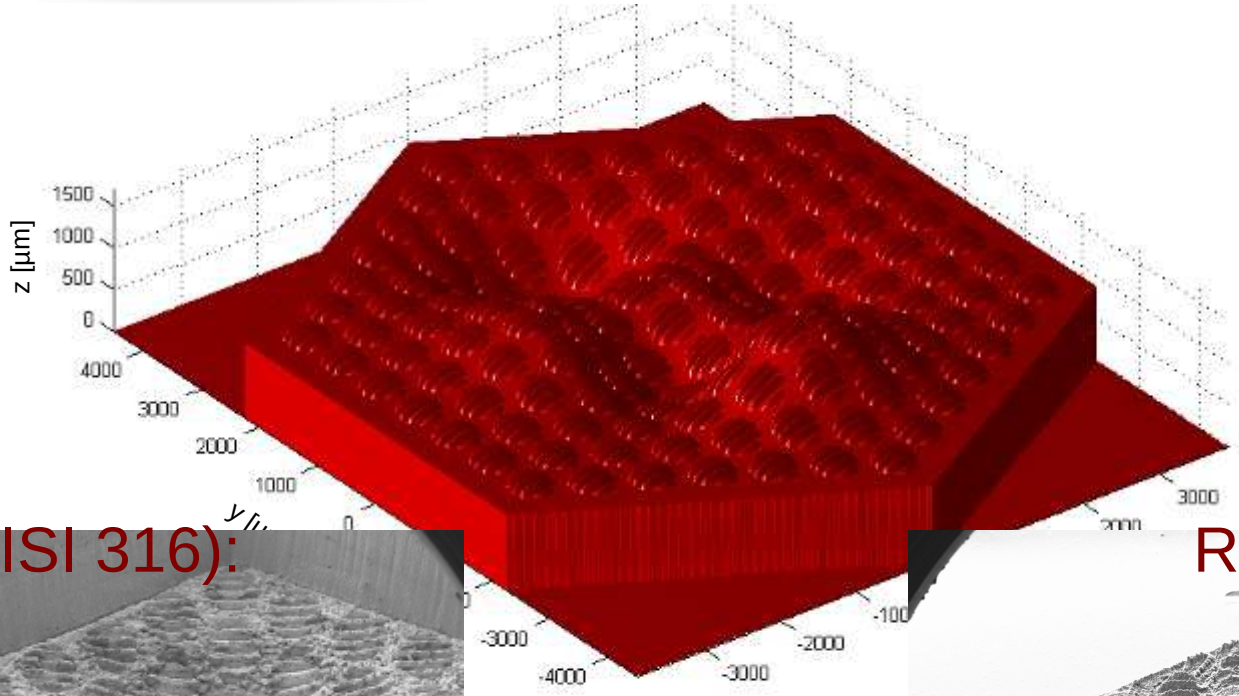
5) IM replication



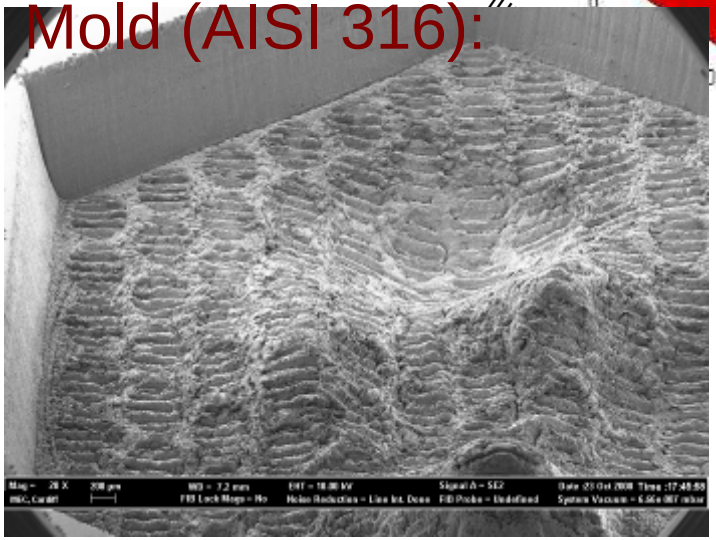
Scholz, S., Petkov, P., Brousseau, E., Griffiths, C., Hirshy, H. and Dimov, S. *Process chain for replicating bio inspired micro structured surfaces*. 4M/ICOMM 2009 - The Global Conference on Micro Manufacture. Karlsruhe, Germany, September 2009.

Shark skin like texturing on 3D freeform surface

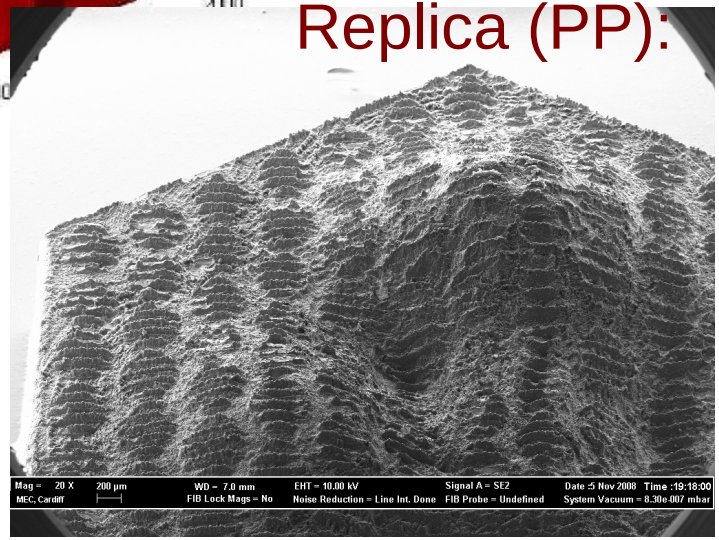
Model:



Mold (AISI 316):



Replica (PP):



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Shark skin like texturing on 3D freeform surface

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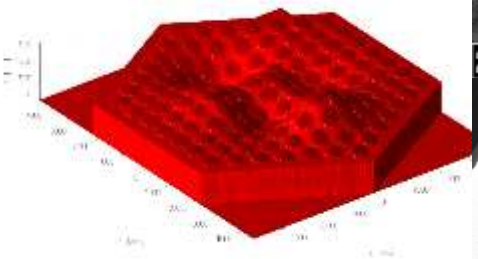
ms Laser

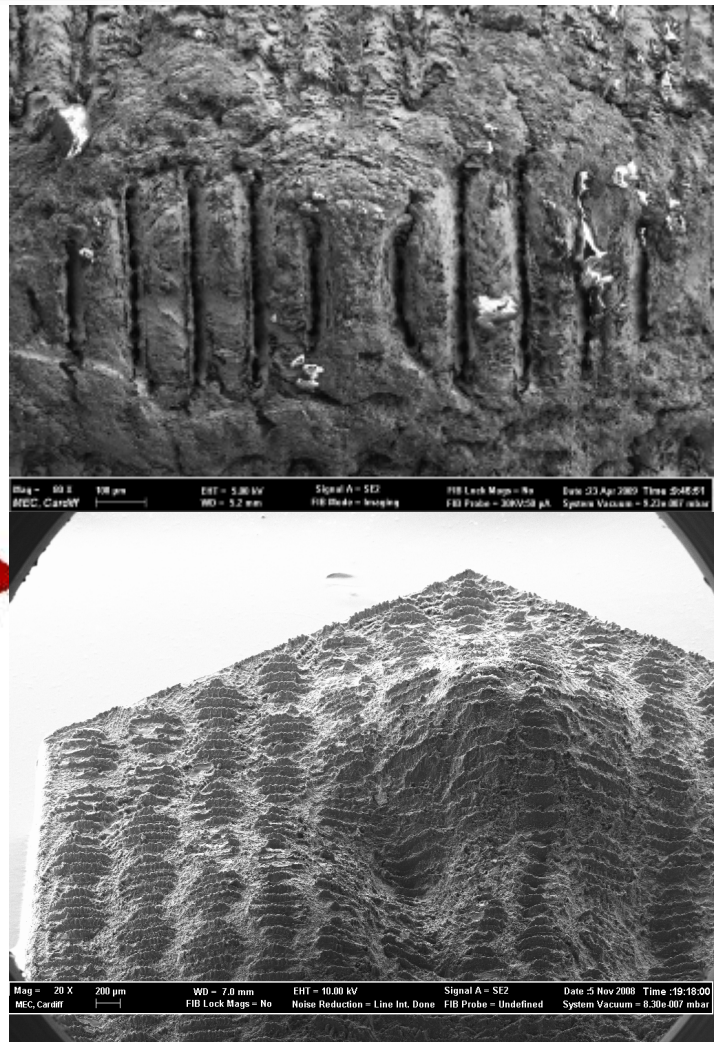
ps Laser

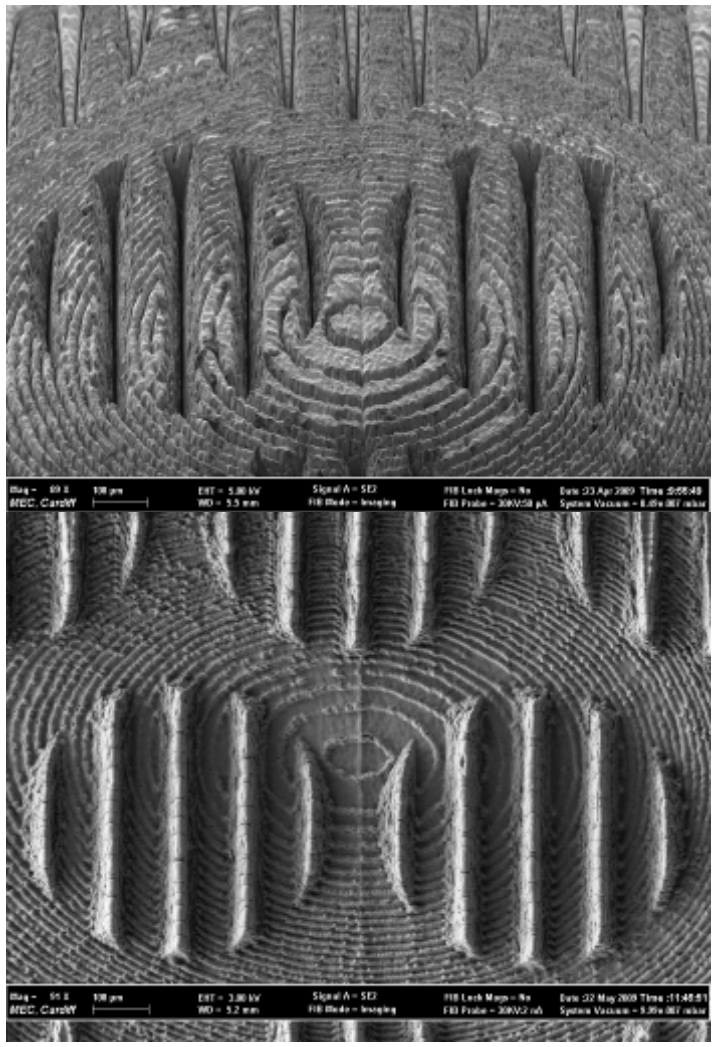
Mold(AISI316):

Model:



Replica (PP):





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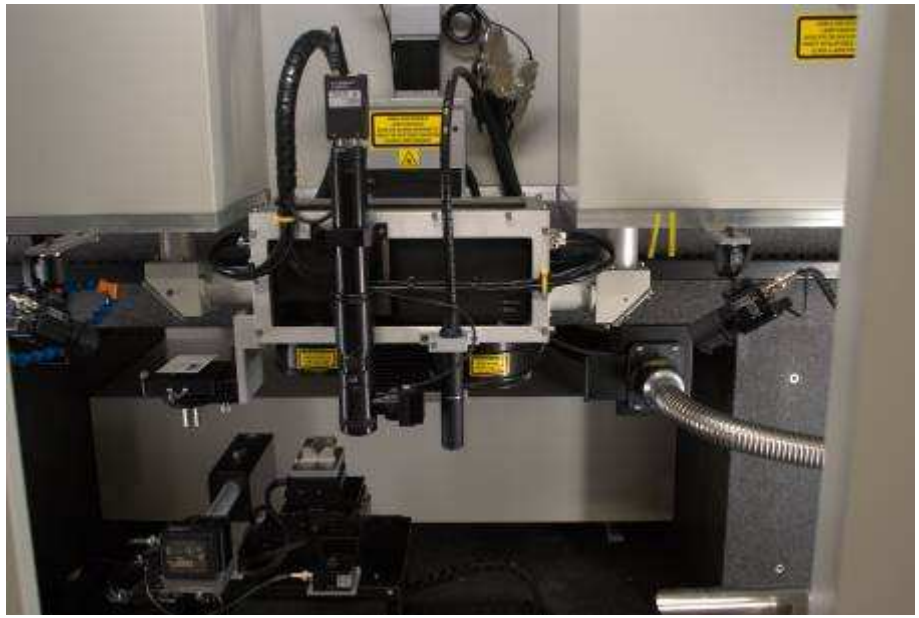
Micro second laser ablation

- Laser ablation system, DML 40 SI
  - pulse duration 10 µs
  - repetition rate 30 kHz
  - scanning speed 280 mm/s
  - power 70 % (5.2W)
  - fluence of 1.8 J/cm2
- Processing time
  - Planar: 20 min
  - 3D: 1,5h

Scholz, S., Petkov, P., Brousseau, E., Griffiths, C., Hirshy, H. and Dimov, S. *Process chain for replicating bio inspired micro structured surfaces*. 4M/ICOMM 2009 - The Global Conference on Micro Manufacture. Karlsruhe, Germany, September 2009.

Pico second laser ablation

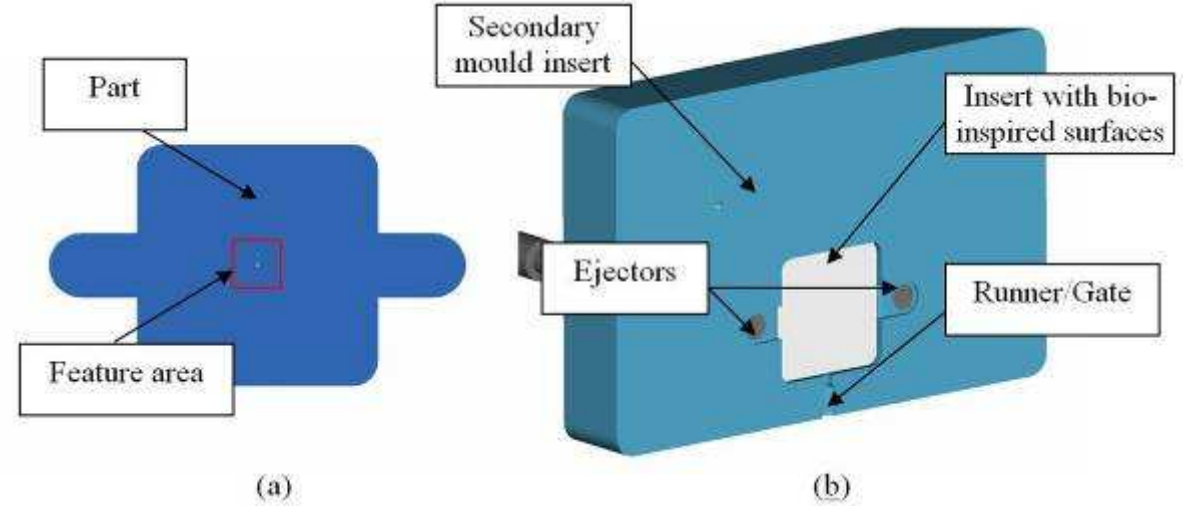
- Laser ablation system, Oxford laser, 2 beam lines
  - Wavelength 355 nm
  - Pulse duration 8 ps
  - Repetition rate 50 kHz
  - Scanning speed 10 mm/s
  - Power 40 mW
  - Fluence of 0.31 J/cm^2



- Processing time
  - Planar: 630 min
  - 3D: 15000 min

Scholz, S., Petkov, P., Brousseau, E., Griffiths, C., Hirshy, H. and Dimov, S. *Process chain for replicating bio inspired micro structured surfaces*. 4M/ICOMM 2009 - The Global Conference on Micro Manufacture. Karlsruhe, Germany, September 2009.

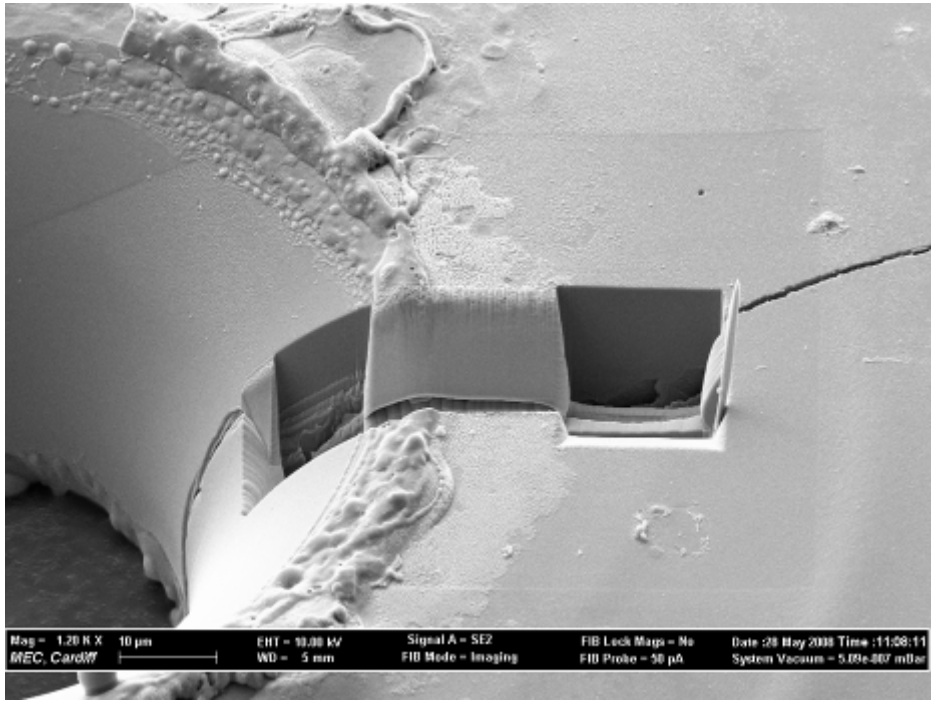
Replication by injection molding



- Battenfeld Microsystem 50
- Material: SABIC 56M10 (PP)
- Process parameter:
  - Barrel temperature 220 °C
  - Mold temperature 40 °C
  - Injection speed 200 mm/s
  - Cooling time 4 s
  - Holding pressure time 6s

Scholz, S., Petkov, P., Brousseau, E., Griffiths, C., Hirshy, H. and Dimov, S. *Process chain for replicating bio inspired micro structured surfaces*. 4M/ICOMM 2009 - The Global Conference on Micro Manufacture. Karlsruhe, Germany, September 2009.

Micromachining response of amorphous and cr
Ni-based alloys



SEM image of the FIB milled trench in an amorphous Ni78B14Si8 that starts at the hole side wall and continues through its surrounding area

Conclusions:

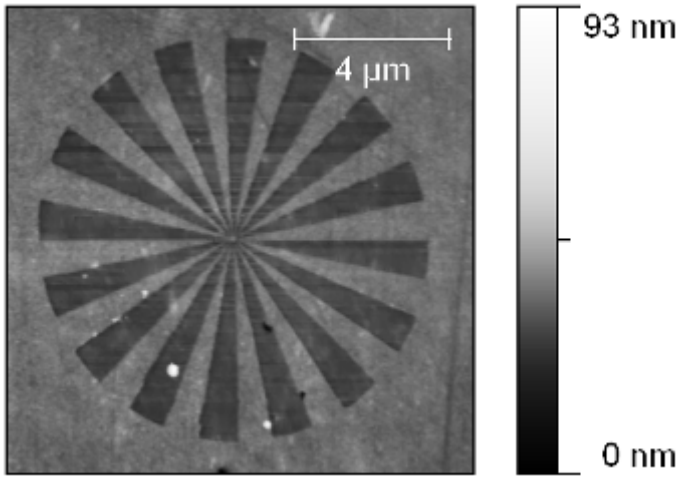
- Laser processing both with short and long pulses is a promising technique for micromachining amorphous Ni-based alloys because does not lead to material crystallisation.
- There was no signs of crack formation in amorphous Ni-based alloys and thus a higher surface integrity can be achieved after after µs laser machining.
- The µs and ps laser machining of micro-scale features and micro-structures in metallic glasses is possible while preserving the attractive mechanical properties of metallic glasses.

Quintana I., Dobrev T., Aranzabe A., Lalev G., Dimov S. (2008) Investigation of amorphous and crystalline Ni alloys response to machining with micro-second and pico-second lasers, *Applied Surface Science*, 255(13-14), 2009, 6641-6646

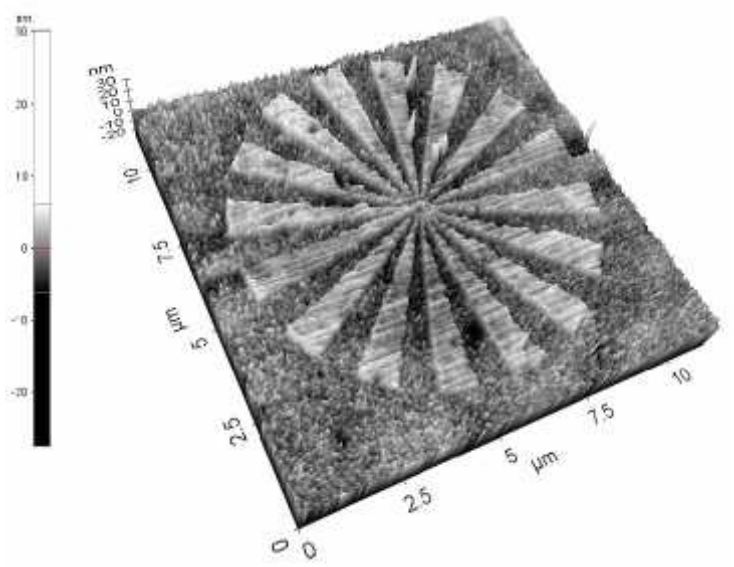
AFM-scratching for master making

- Feasibility study for rapid master making

AFM scratching of Au/Pd layer on Si substrate



Micro injection moulding (PP replica)



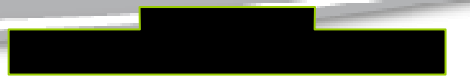
- Main result
  - Validation of AFM scratching as a master making route for small batch manufacture of nano structured polymer components.

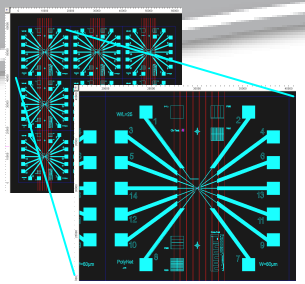
Brousseau et al. (2009) Investigation of a new process chain based on atomic force microscopy scratching. Proc. 4M2009, pp. 267-270

Hybrid Processing Chain for Organic Electronics

EUMINAfab

Preparation of quartz blanks with 25mmx 25mm x 30 µm mesa





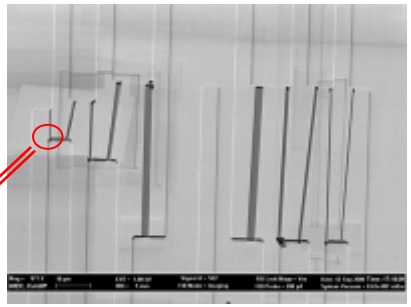
Test design & layout

Several single OTFTs with macroscopic contact pads

Micro structuring of quartz templates

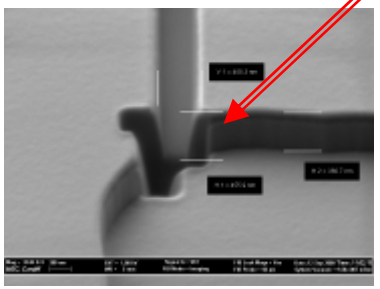
Photolithography

Pre-structured quarts template



Nano structuring of quartz templates

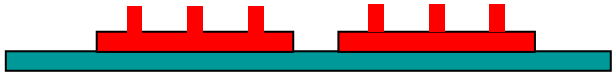
FIB



Adding 300-400nm functional features

Micro/nano imprinting of resist

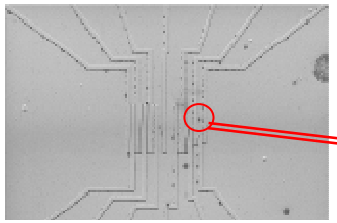
UV NIL

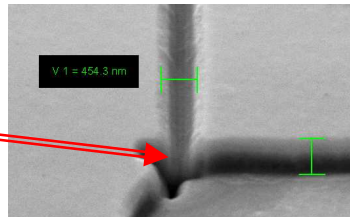


Producing an array of 25x25 mm functional fields

Transfer the polymer topography on Ni shim

Ni eletroforming





Integration of Ni shims on rollers for NIL R2R

V. Velkova, G. Lalev, H. Hirshy, S. Scholz, J. Hiitola-Keinänen, H. Gold, A. Haase, J. Hast, B. Stadlober, S. Dimov (2010)
Design and validation of a novel master-making process chain for organic and large area electronics on flexible substrates,
Microelectronic Engineering

Maturity assessment of processes and process pairs

The proposed work comprises the following tasks:

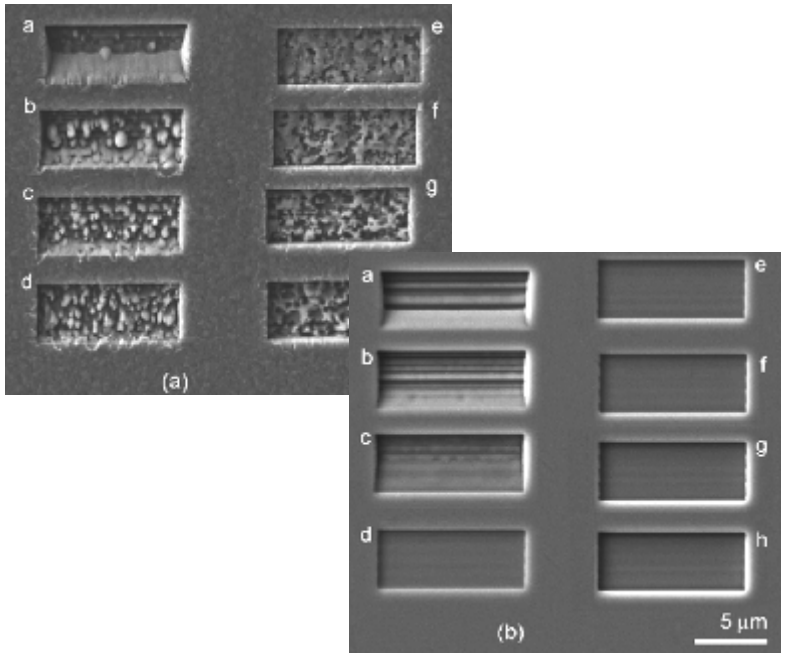
(i)Characterisation of the morphology of the coatings FIB/SEM(STEM) installation

(ii)Micro/nano structuring of the Ti(TiC-N) coatings with FIB

(iii)Micro/nano-structuring of the Ti(TiC-N) coatings with Laser

(iv)Characterisation of the surface integrity of the resulting patterns using AFM or/and SEM.

Polycrystalline (a) and amorphous (b) Ni78B14Si8 - 90 s exposure time & scan loops of 1, 2, 3, 4, 10; 20, 40 and 56, respectively.



W Li, R Minev, S Dimov and G Lalev (2007) Patterning of amorphous and polycrystalline Ni78B14Si8 with a focused-ion-beam, *Applied Surface Science*, *Vol. 253 (12)*, *5404-5410*

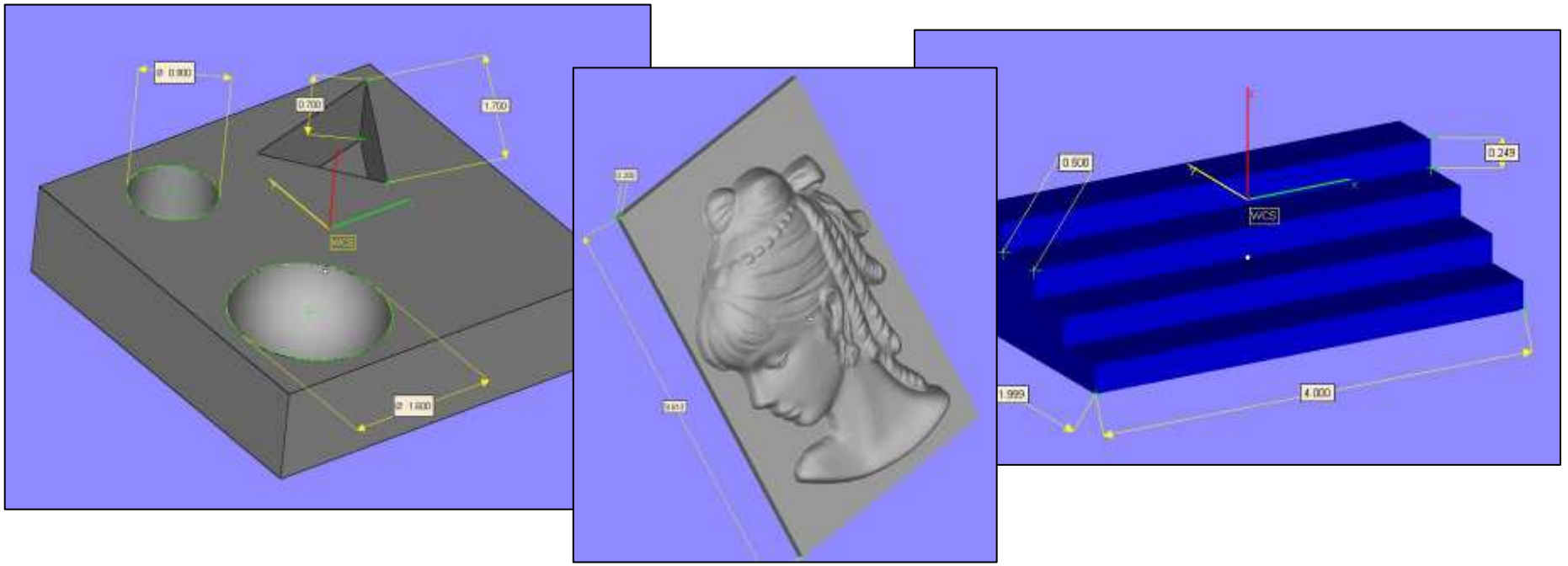
Maturity assessment of processes and process pairs

Comparative study on laser material processing utilizing DPSS and fibre lasers (second and third generation) for tool making and prototyping

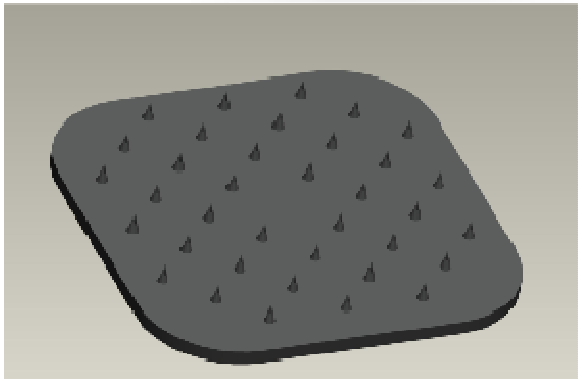
-agreeing the design of test part & selecting a material
-test structures:

(i) DMG machine utilizing IPG fibre laser source
(ii) MEC 3G fiber laser source
(iii) MEC DPSS laser source

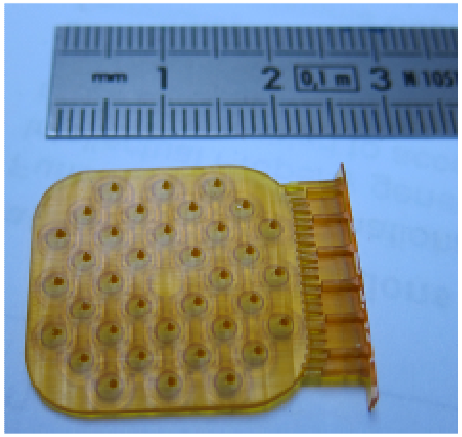
- characterization: surface roughness, heat affected zones, planarity and uniformity, dimensional accuracy and true form representation



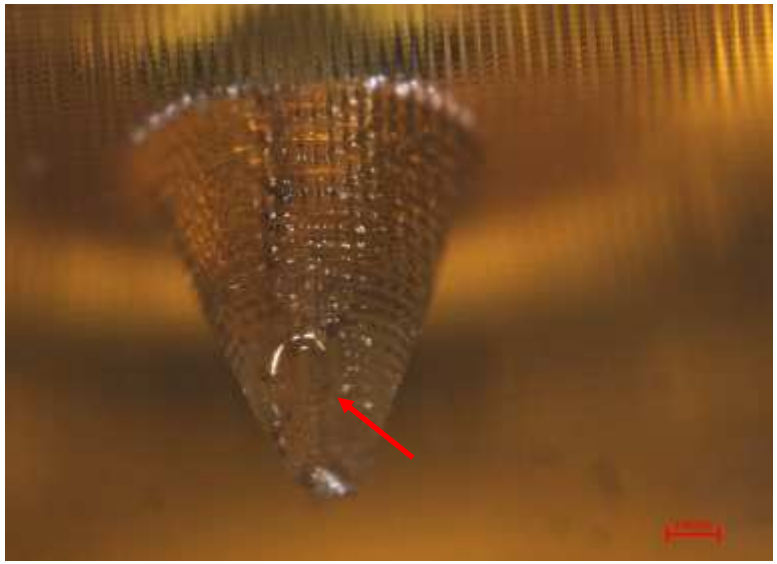
Feasibility Study: Array of hollow Micro needles



Model



Micro SLA



Pico Second Laser Hole: 50 μm

Technology Datasheets

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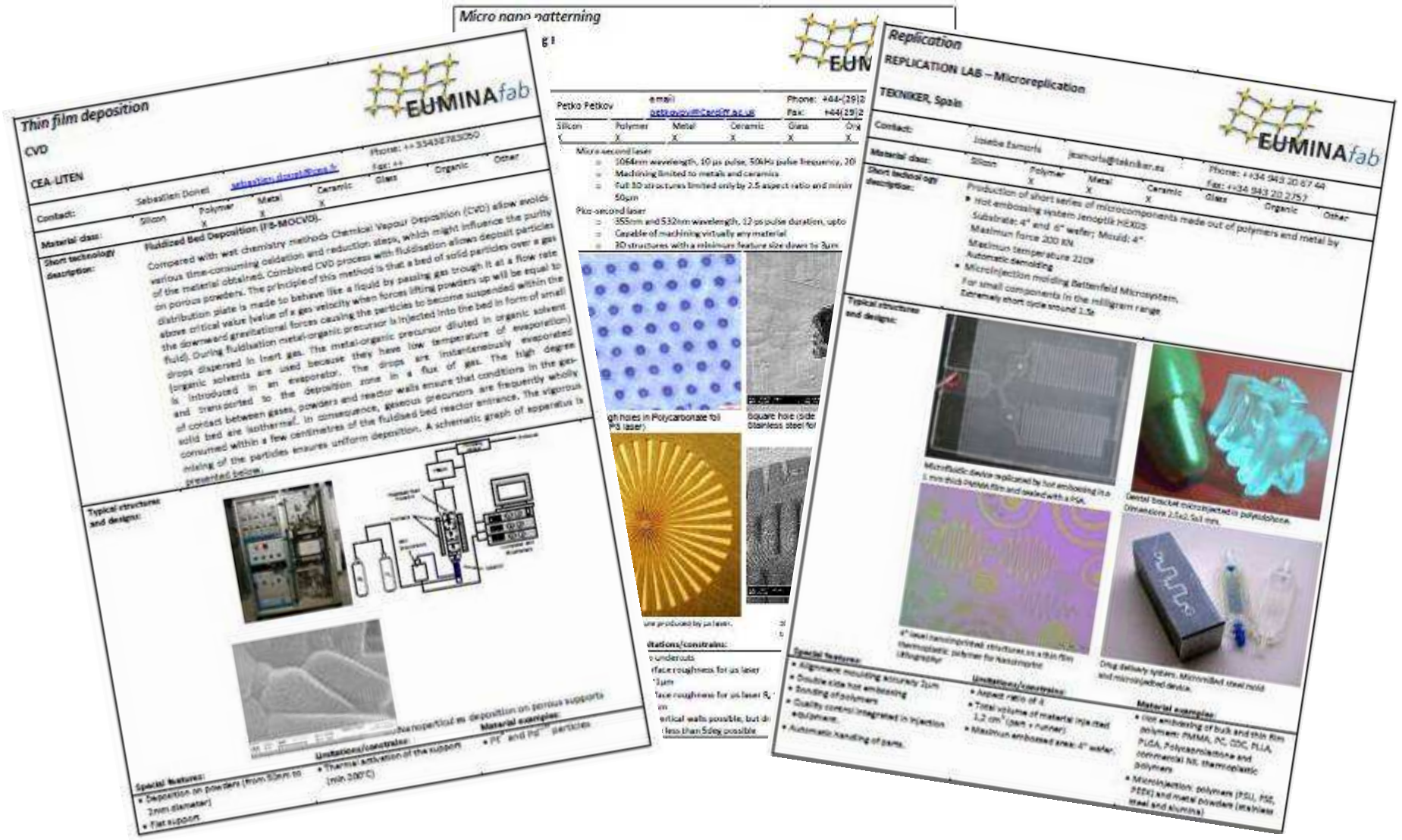

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Thank you for your kind attention!

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Integrating European research infrastructures for micro-nano fabrication of functional structures and devices out of a knowledge-based multimaterials' repertoire