EUMINAfab: Towards an European Approach for Characterisation of Multimaterial Micromanufacturing Process Capabilities

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Total budget: 10.6/7.8 M€

8 partners provide access to 36 installations and > 75 processes

Capital investment > 200 M€

> 60 technological experts

> 1350 machine days

Access is free of cost for „public research“ !!

Challenge: Keep overview over existing technological capabilities
EUMINAfab –
A transnational Research Infrastructure

„One Stop Shop“ – Access to 36 installations and > 75 processes
### 36 installations → a MNT toolbox

<table>
<thead>
<tr>
<th><strong>μ and nanostructuring</strong></th>
<th><strong>Thin film deposition</strong></th>
<th><strong>Replication</strong></th>
<th><strong>Characterisation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron beam</td>
<td>PVD technologies (e.g. noble metals, DLC, nanocomposites, metals, nitrides)</td>
<td>μ injection moulding (e.g. polymers, metals, ceramics; small series)</td>
<td>HRTEM</td>
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<tr>
<td>E-beam &amp; SCIL</td>
<td>Sole Gel: spin and dip coating</td>
<td>μ hot embossing (small series)</td>
<td>XPEEM</td>
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<td>Ion beam (Focused cross beam)</td>
<td>Org. PVD (e.g. organic liquids &amp; powders, oxides)</td>
<td>Thermal imprinting &amp; UV-NIL</td>
<td>X-ray tomography</td>
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<tr>
<td>DPN</td>
<td>CVD (metals, polymers, ceramics)</td>
<td>NIL process chain (UV photolitho, dry &amp; wet etching)</td>
<td>Auger Nanoprobe</td>
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<tr>
<td>Direct X-ray litho</td>
<td>Self Assembly (e.g. semiconductors, organic)</td>
<td></td>
<td>In situ synchrotron X-ray diffractometry (&gt; 2010)</td>
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<tr>
<td>Laser technologies (e.g. ps, fs, surface texturation)</td>
<td>Screen printing (e.g. metals, dielectrics)</td>
<td></td>
<td>AFM, conductive AFM</td>
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<tr>
<td>Mechanical μmachining (freeform)</td>
<td>Optical Coating</td>
<td></td>
<td>Spectrophotometry / radiometry</td>
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<td>Photopolymerisation</td>
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<td>Profilometry (e.g. low force contact mode &amp; white light mode)</td>
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<td>Mastermaking process chain</td>
<td></td>
<td></td>
<td>µCMM</td>
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<td>DRIE (Si, glass, SiO2)</td>
<td></td>
<td></td>
<td>Low force balance, ellipsometry</td>
</tr>
</tbody>
</table>
Case Study: Neuro-medical-electrode

E. Minev, K. Popov, R. Minev, S. Dimov, V. Gagov, M. Packianather, Accuracy study of micro SLA parts by utilizing a grid method, 4M2010
Hybrid Processing Chain for Organic Electronics

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

Micro structuring of quartz templates

Nano structuring of quartz templates

Micro/nano imprinting of resist

Transfer the polymer topography on Ni shim

Integration of Ni shims on rollers for NIL R2R

Test design & layout
Several single OTFTs with macroscopic contact pads

Photolithography

Pre-structured quartz template

Adding 300-400nm functional features

FIB

UV NIL

Producing an array of 25x25 mm functional fields

Ni electroforming

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
Rapid prototyping: Hollow Micro Needle Arrays

Process chain:
- Modelling
- Master making (μSLA)
- Laser

Application:
- Drug delivery system
Micromachining response of amorphous and crystalline Ni-based alloys

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.

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

AFM-scraping for master making

Feasibility study for rapid master making

AFM scraping 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.

Opportunity: Functional micro and nano structured surfaces
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
Process chain: replication of moth’s eye like surfaces

1) Bio-mimetic modelling
2) CAM solutions
3) Generation of GDSII files
4) FIB machining
5) IM replication

FIB machining

- FIB system, Carl Zeiss XB1540
  - micro scale lenses:
  - 1000 layers
  - probe current of 2nA

- nano scale protuberances:
  - 24 layers
  - probe current of 50 pA

- Machining time for three ommatidia: 3h
Results: replication of moth’s eye like surfaces

Model:

Replica (PP):
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

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

1) Bio-mimetic modelling

2) CAM solutions

3) Filling simulation

4) Laser milling

5) IM replication

Process chain for micro structured bio inspired shark skin functional surface

Bio mimetic modelling

Ns Laser
Ps Laser
Micro injection Moulding

Drag reduction properties - aquanautic applications

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
Shark skin like texturing on 3D freeform surface

Mold(AISI316):

Model:

Replica (PP):
Shark skin like texturing on planar surface

Mold (AISI316):

Model:

Replica (PP):

ms Laser

ps Laser
Your gateway to multimaterial micro nano fabrication

Thank you for your attention

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