Nanoimprint Lithography
status and trends

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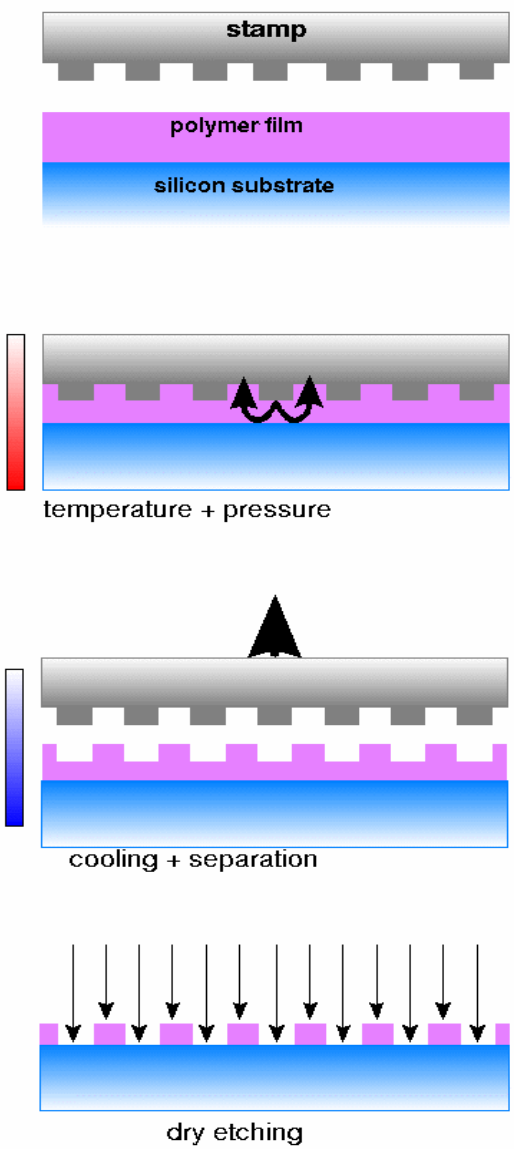
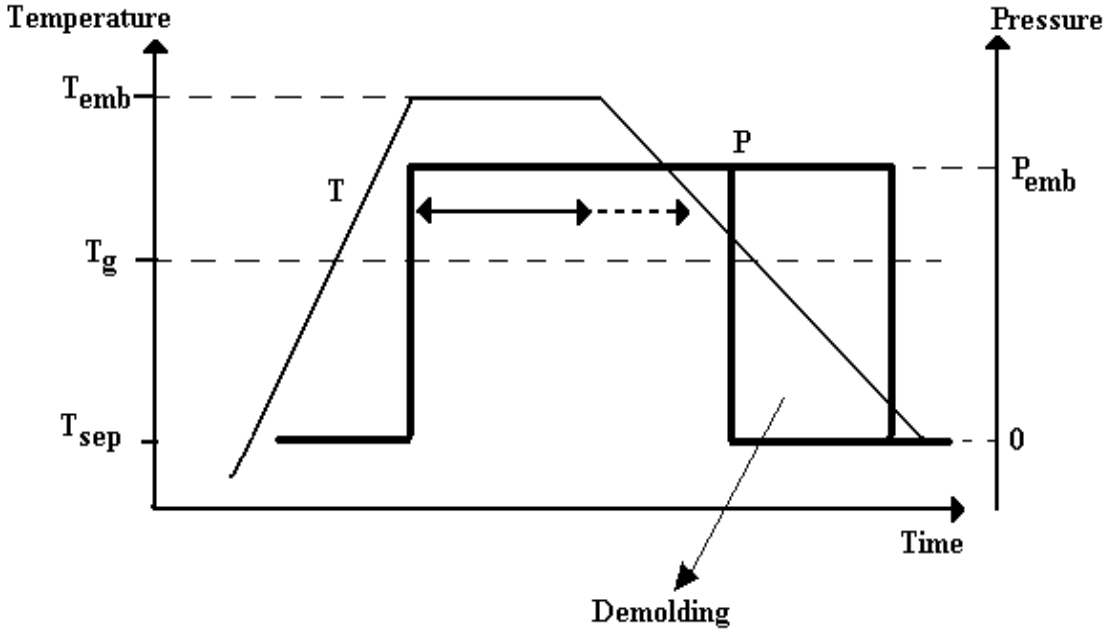
Nanoimprint lithography



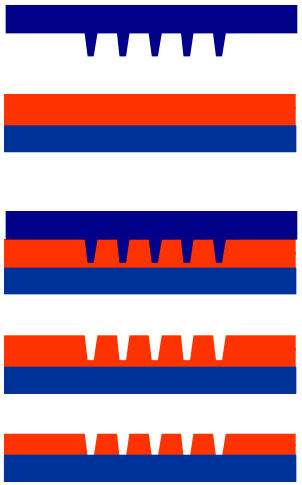


Features sizes	Half pitch	Overlay accuracy	Imprint surface
2 nm (S Chou)	6 nm (S Chou)	Sub 20 nm (MII)	>200 mm ϕ (CNRS-LTM)

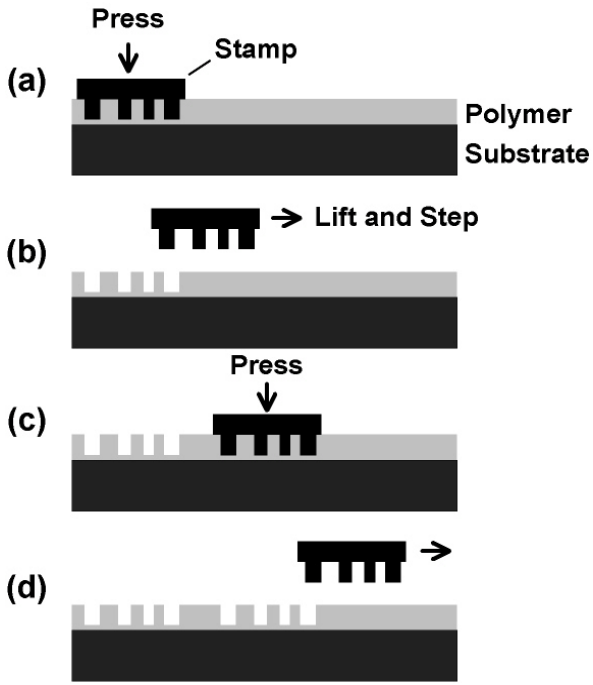
NIL techniques

Parallel and sequential methods.
Thermal NIL, UV NIL and combined approaches
Also Step-and-Flash imprint lithography

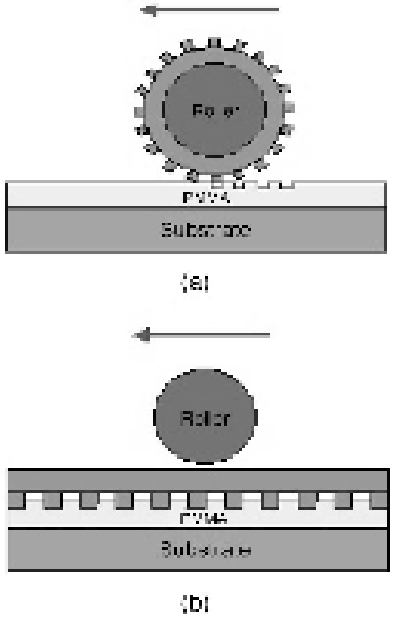
Parallel



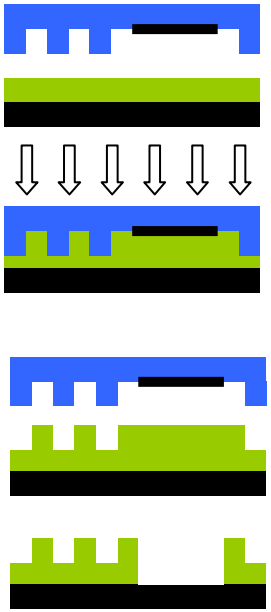
Sequential



Roll-to-roll



UV-NIL



"Alternative Lithography: unleashing the potentials of nanotechnology", Ed C M Sotomayor Torres, Kluwer 2003

Application areas of NIL

Electronics

High density data storage
Back-end Si processes
Organic electronics
3D and 2D nano-contacts
Localized growth of nanotubes

Biology

Lab-on-a-chip modules
Opto-microfluidics
Templates for cells growth
Chemical and biological assembly
Surface wetting

Photonics

Diffractive and refractive optics
1D and2D photonic crystals
Templates for self-assembly
Non-linear optics
Organic LEDs

Mechanics

2D – 3D NEMS
Suspended patterned structures
Nano-motors
…

Others: Security, Environmental control, …

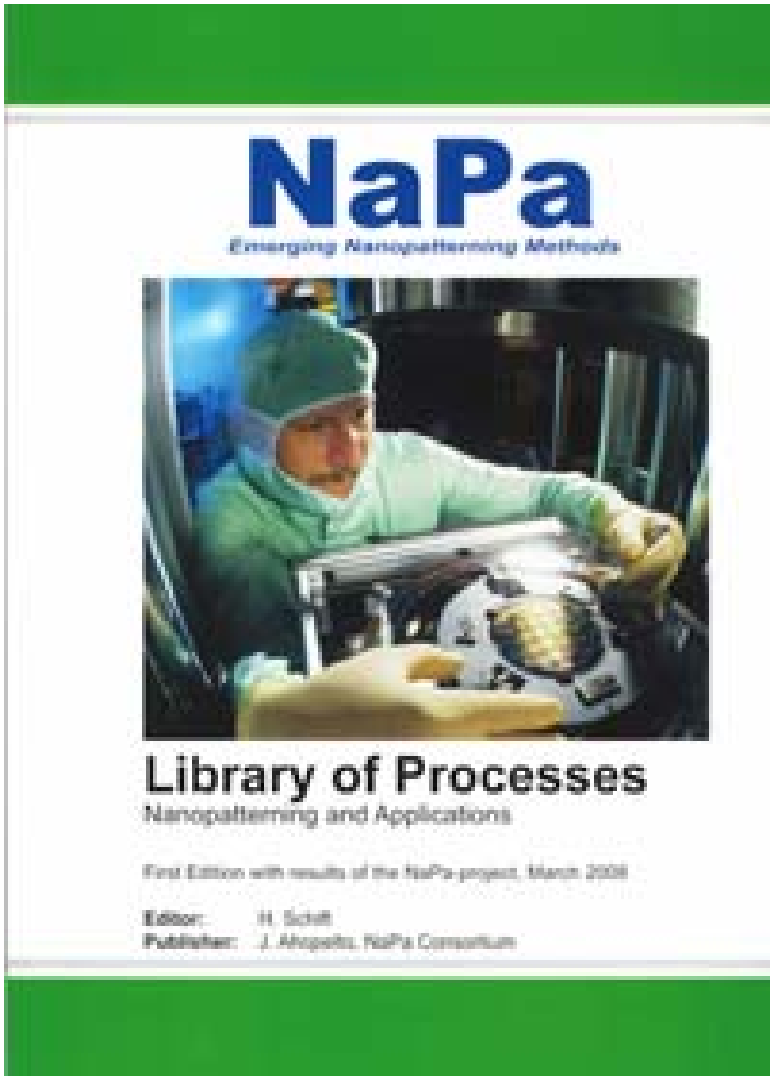
NaPa Library of Processes

Processes for printed devices:

- DFB's
- Optical encoder
- OLEDs
- Opto-microfluidic lab-on-a-chip
- NEMS
- Photonic crystals

EU FP 7 project NAPANIL:

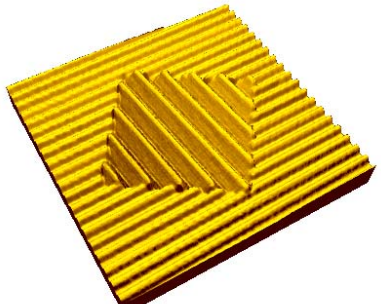
Manufacturing of 3D diffractive optical surfaces with sub 100 nm and 100's micrometer features.



Free download from www.NAPANIL.org

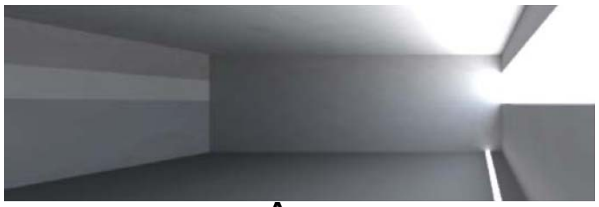
NaPANIL industrial applications

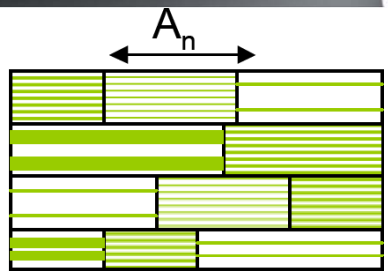
Planar Diffractive Optical Elemetns



modines

Light Directional Elements





SAINT-GOBAIN
RECHERCHE

Emissive Head-up Display

CRF CENTRO RICERCHE FIAT

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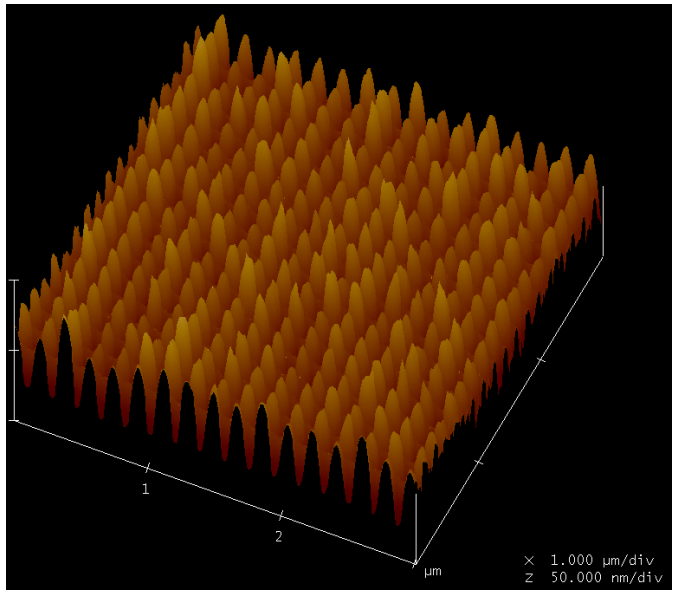
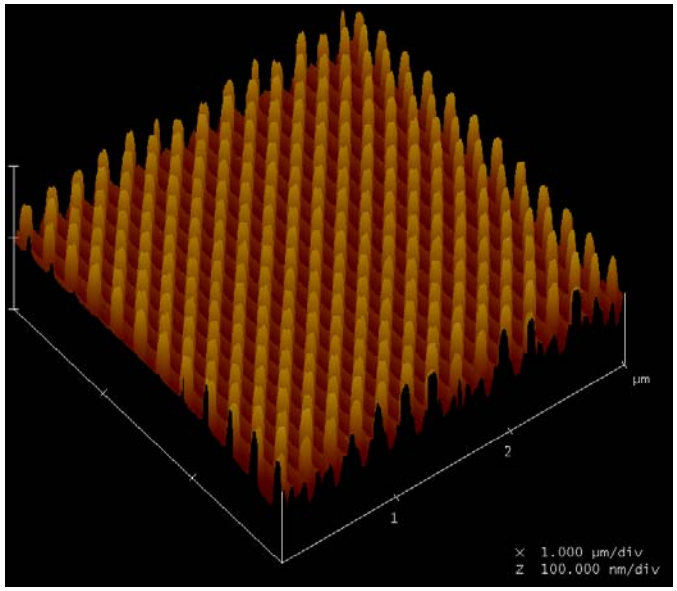
Manufacturing Technologies:
Status and Main Achievements

Imprint of 180nm Period 2D Gratings into PDMS (AMO, SVI)





Imprint tool:
EVG620
Resist:
AMONIL@200nm
Imprint pressure:
900mbar

U. Plachetka, AMO (2009).

Stamp: S-PDMS (PAM)
Structure: 2D-grating, pillars (ca. 35-55nm deep)

Stamp: H-PDMS
Structure: 2D-grating, pillars (80nm deep)

OUTLOOK:
These stamps will be instrumental for future LDIR applications with high resolution gratings

Sylgard 184
Surface hardness: 0,7% (at 60°C)
Compression modulus: 2N/mm²

Material-A
Surface hardness: 3,3% (at 60°C)
Compression modulus: 9,7N/mm²

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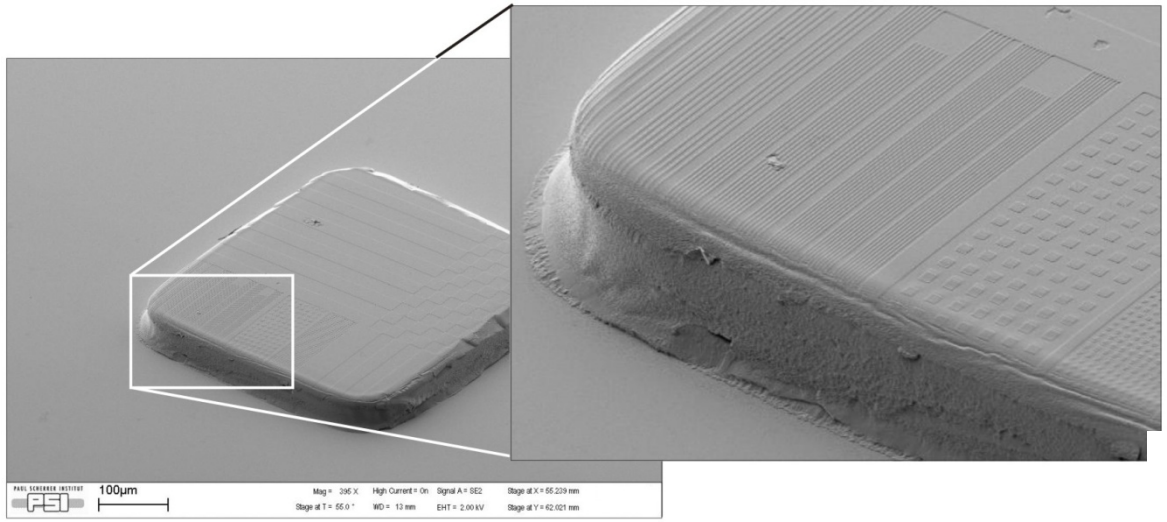
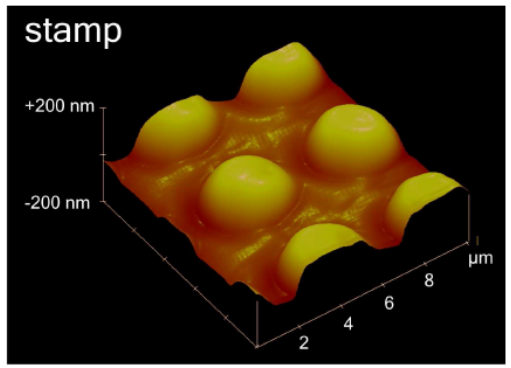
Manufacturing Technologies:
Status and Main Achievements

Roll to Roll and Step and Repeat with Ormostamp Copies (PSI, MRT, VTT)

Single Ormostamp mesas after two copying steps

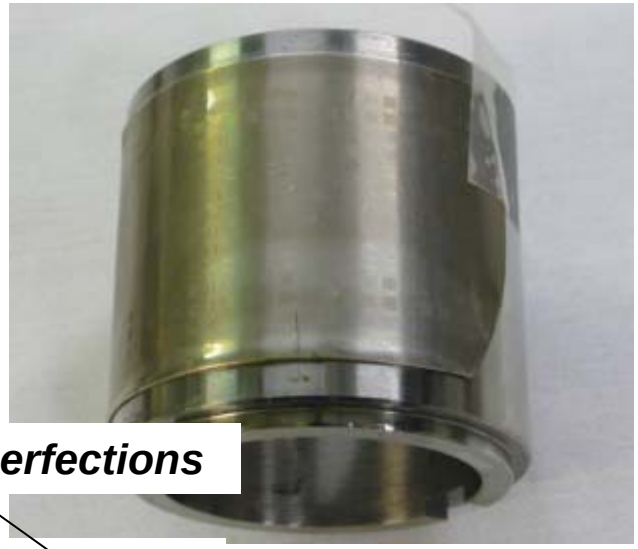




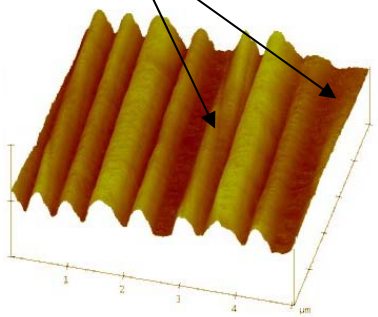
AFM micrographs of both the surface relief of the Ormostamp® mesa and the imprinted polymer structure.

H. Schift et al., EIPBN 2009, in J. Vac. Sci. Technol. (2009).

Ormostamp bendable mold



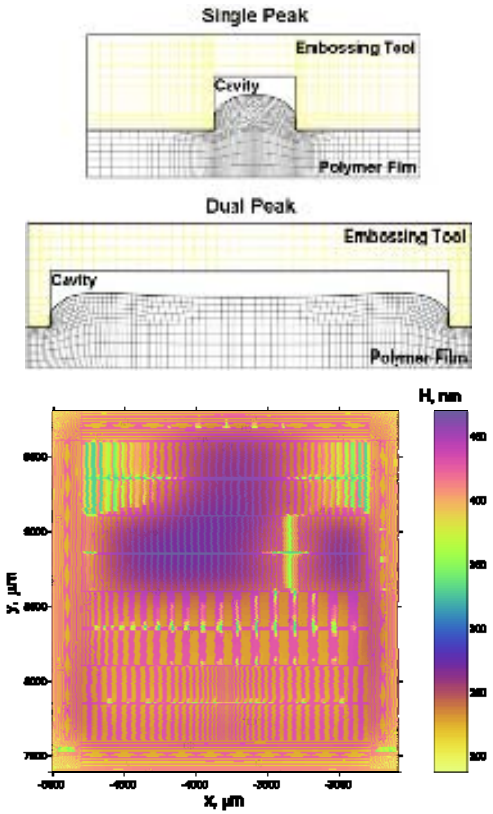
imperfections

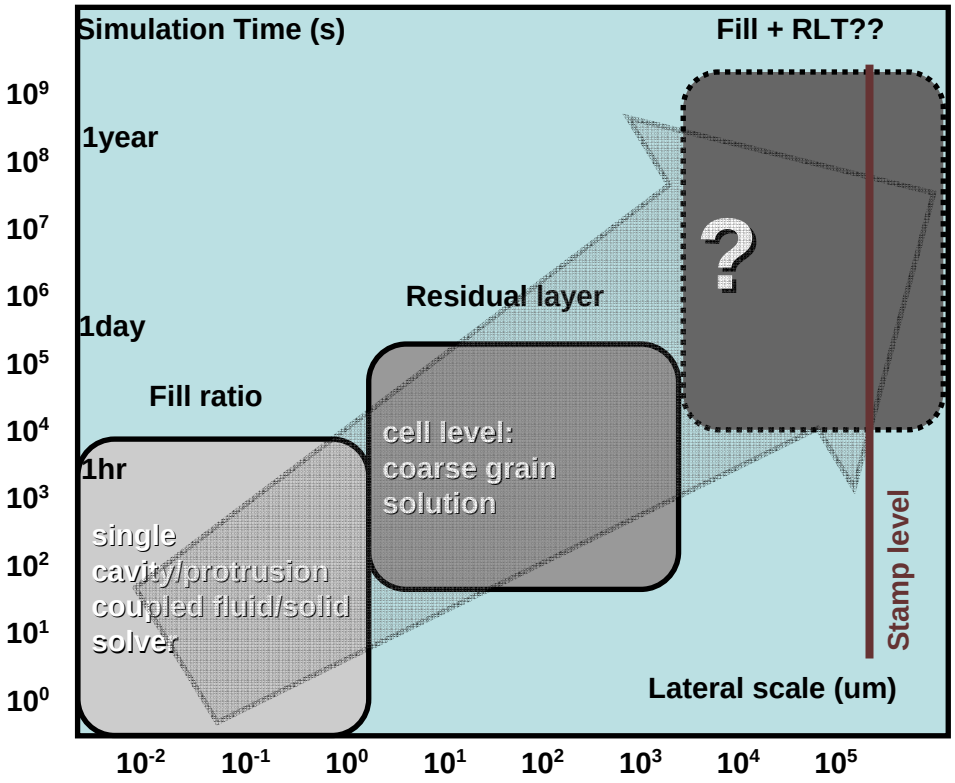


after 12 m

Ormostamp will be used as alternative to Nickel but also for new types of stamps

NIL Modeling requirements





- Fill ratio, residual layer thickness
- Rendering of any protrusion/cavity shape
- Optimize protrusion placement at local and stamp levels

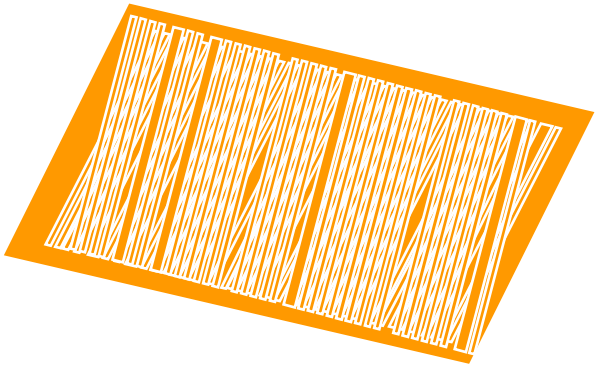
- Fast simulations
- Large areas
- 3 steps
- Embossing
- Stamp release
- Long-term evolution

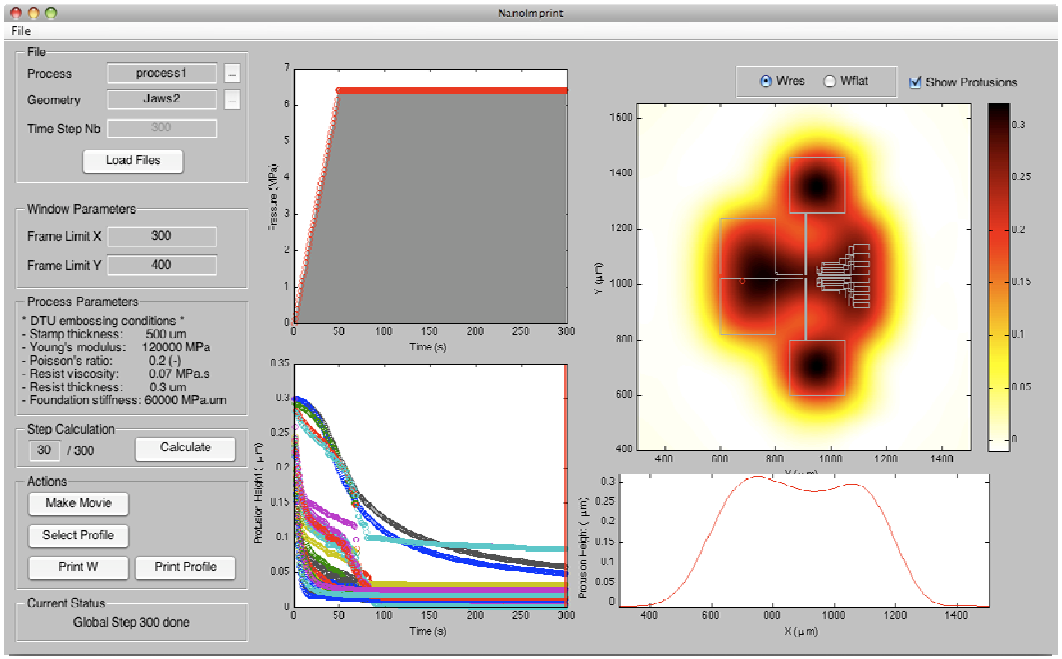
NaPANIL

Novel modeling solutions

NIL parametric design language

- compact, human readable
- designed for storage of NIL 2D+3D structures
- open source: www.napanil.org





Goals

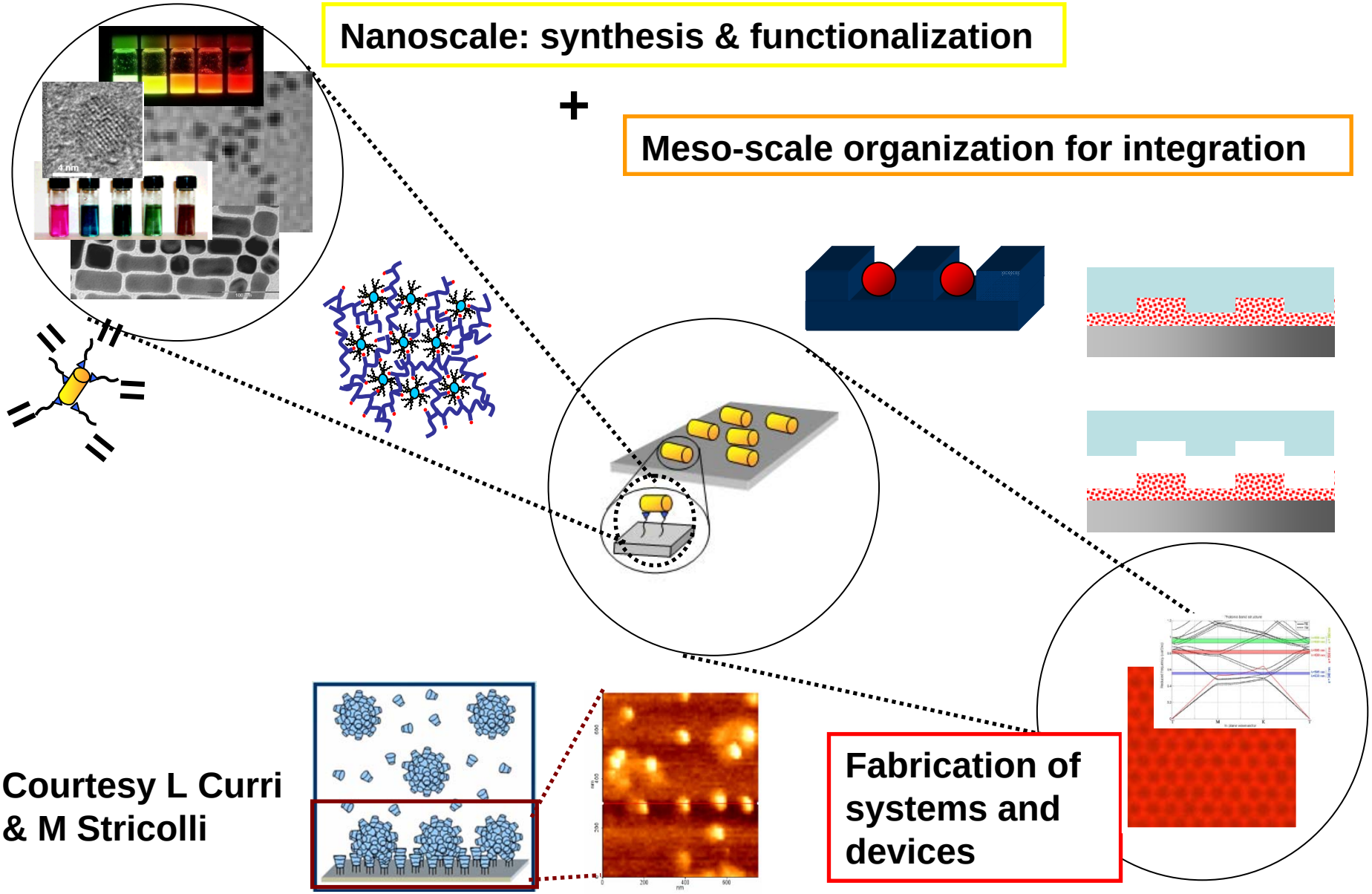
- Full stamp, full process
- < 3 hours simulation time

NIL Simulation Suite

- cell level simulation time < 5min
- pressure driven, use standard process definition
- commercial: www.cognoscens.com

NAPANIL

Nanoparticles in nanofabrication



Courtesy L Curri & M Stricolli

Outlook

- Nanoimprint lithography is maturing and making transition to large volume manufacturing processes in, for example, optical components and data storage media.
- Combination of emerging nanopatterning methods, such as thermal NIL and uV-NIL, NIL and self assembly, … will open new avenues for innovation in manufacturing.
- Stamp cost is addressed by stamp replication in polymers
- Understanding of nanorheology and metrology for NIL methods useful in manufacturing environments still needed.
- Novel printable nanocomposite materials and nanoscale interactions of electrons, photons, plasmons and phonons promise a huge range of science and engineering applications of NIL in its various expressions.

Acknowledgements

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M Tamborra, L Curri
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Nanolab

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CNRS LTM, Grenoble

LTM
LABORATOIRE DES TECHNOLOGIES DE LA MICROÉLECTRONIQUE

SEVENTH FRAMEWORK PROGRAMME

NaPa
Emerging Nanopatterning Methods
2004-2008

M Voegel, F Reuther and G Gruetzner
mrt GmbH, Berlin

micro resist technology