# ¨Advanced production technologies for multi-functional nano-structured plastic components¨

Dr. Nikos Kehagias

Institució CERCA Centres de Recerca de Catalunya

Generalitat de Catalunya

CSIC Consejo Superior de Investigaciones Científicas

UAB Universitat Autònoma de Barcelona

**www.icn2.cat**

Institut Català de Nanociència i Nanotecnologia

EXCELENCIA SEVERO OCHOA

- From NaPa to NaPANIL to Plast4Future

- Market trends
  - Towards 2020 – Technology and market shares

- EU level Collaboration- Plast4Future technology
  - NIL for free form patterning
  - Nano-injection moulding

- In Line R2R Nanometrology

# EU project NaPa (2004-2008)

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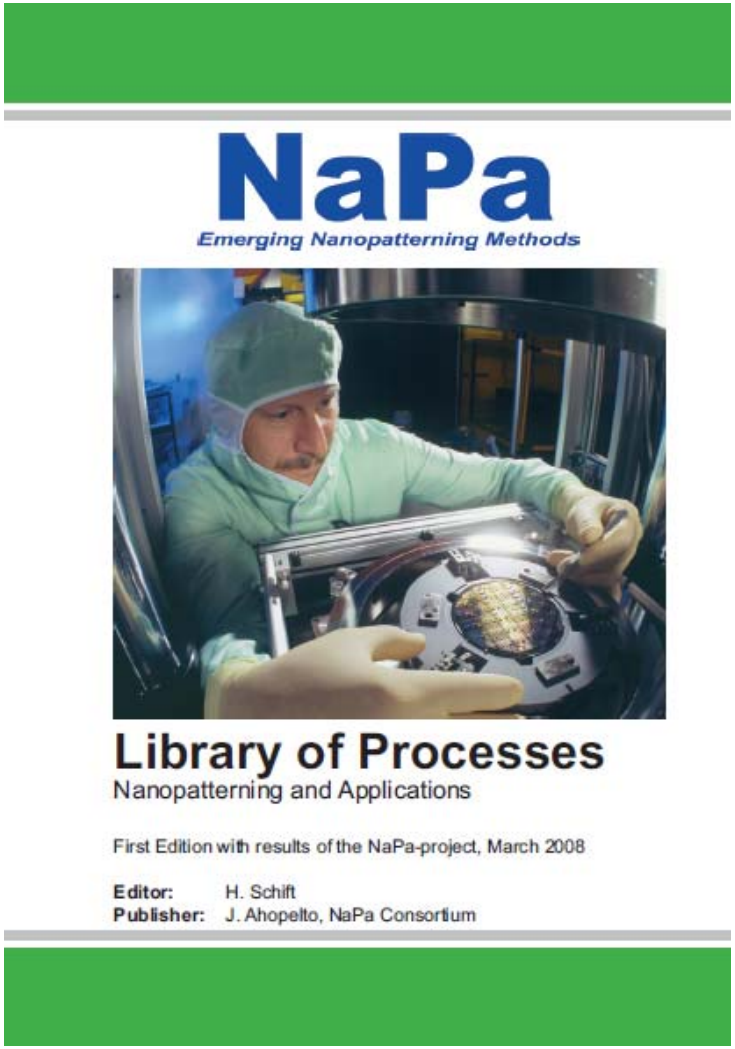


## NaPa Core Partners

VTT
Tyndall National Institute
EPFL École Polytechnique Fédérale de Lausanne
IBM
LAAS
micro resist technology
Tyndall National Institute
SUSS MicroTec

## Participating Groups

csem
AMO
CEMES
GDRTEC
CNM
EVG
CNR Centro Ricerche FMT
inasmet
TASC
Tekniker
University of Glasgow
Universiteit Twente

Leti CEA
LTM
Lund University
Universiteit Twente
NanoComms
nanoplus
NPL National Physical Laboratory
PSI

# EU project NaPaNIL (2008-2012)

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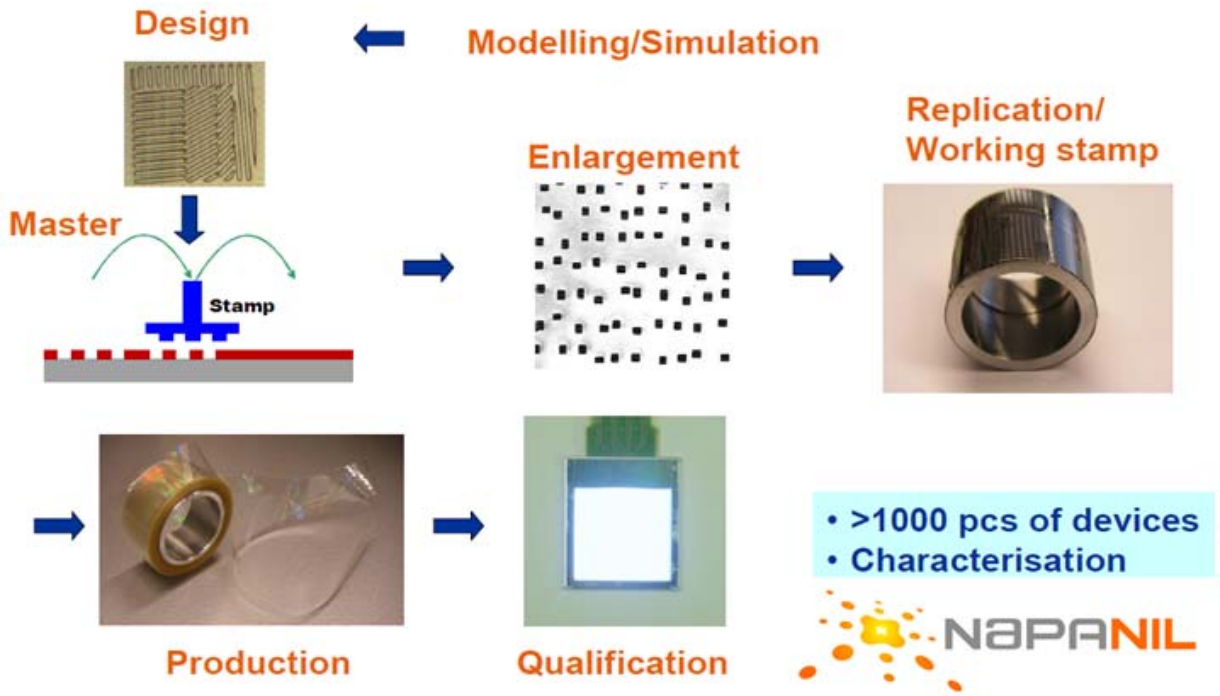
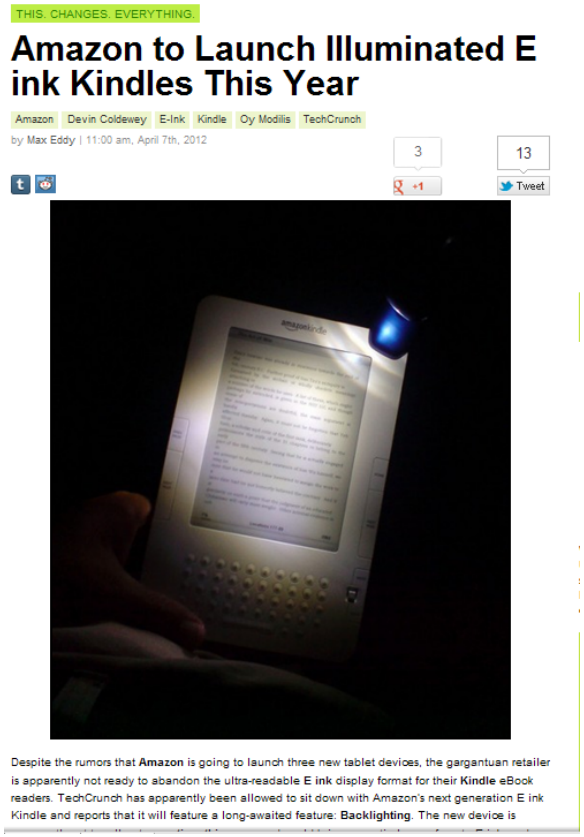
NaPaNIL



THIS. CHANGES. EVERYTHING.

**Amazon to Launch Illuminated E ink Kindles This Year**

Amazon Devin Coldewey E-Ink Kindle Oy Modilis TechCrunch

by Max Eddy | 11:00 am, April 7th, 2012

3 +1 13 Tweet

Despite the rumors that **Amazon** is going to launch three new tablet devices, the gargantuan retailer is apparently not ready to abandon the ultra-readable **E ink** display format for their **Kindle** eBook readers. TechCrunch has apparently been allowed to sit down with Amazon's next generation E ink Kindle and reports that it will feature a long-awaited feature: **Backlighting**. The new device is

# Manufacturing value chain

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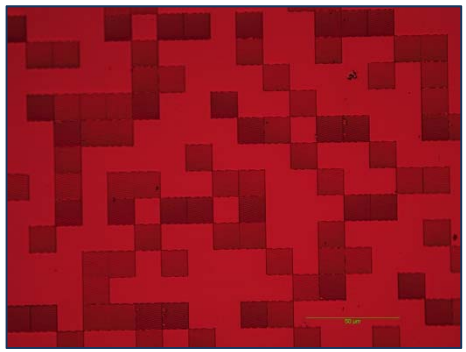
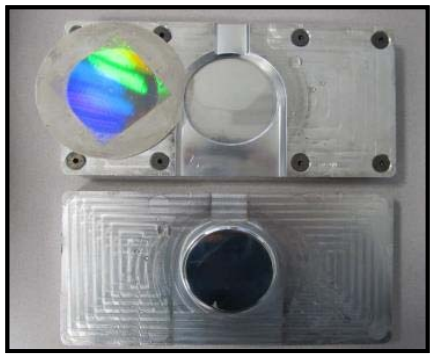
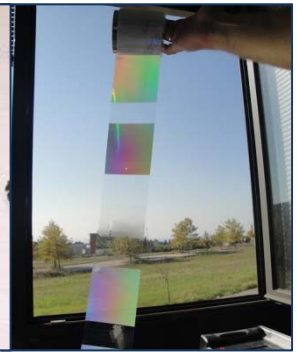
DESIGN → MASTER GENERATION → MASS REPLICATION → APPLICATION




## Manufacturing necessities:

- High Resolution <100 nm
- Low cost
- High Throughput
- Feasible

# NIL Related Equipment

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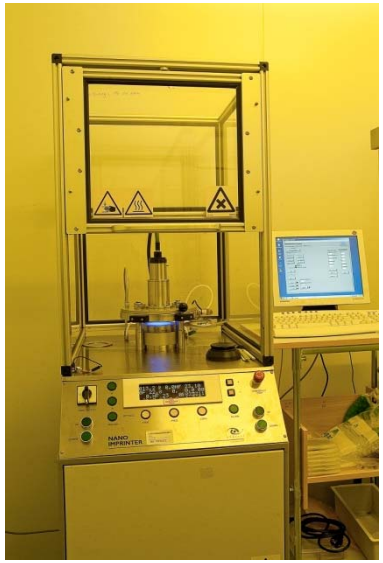
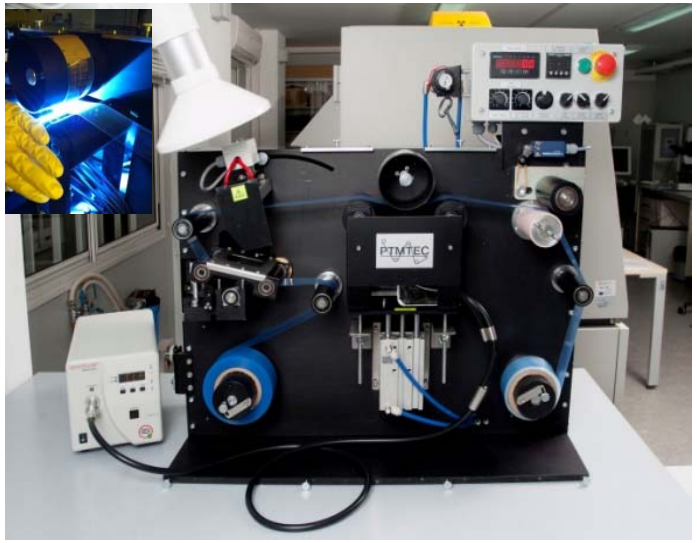


Obducat NIL

NPS300 S&R NIL- SET



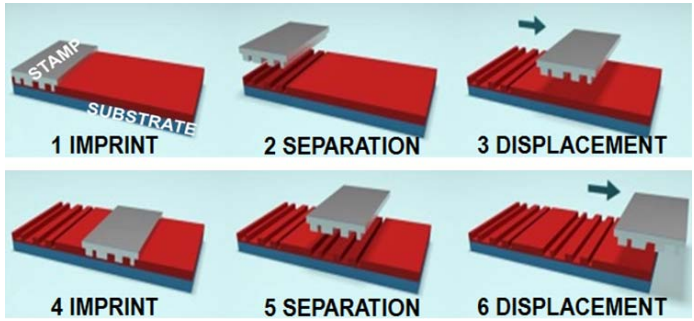
Desk top R2R NIL

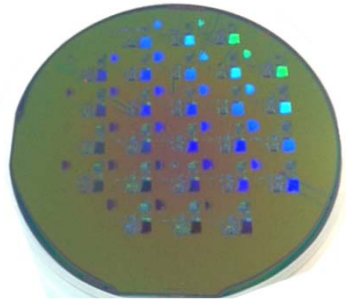
CNI Tool- NIL Technology ApS

Solvent NIL chamber

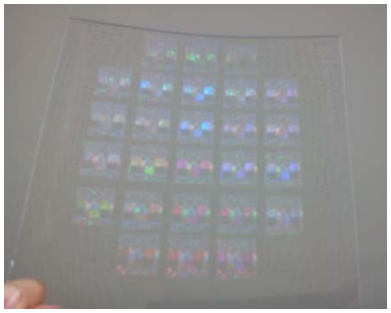
Nickel electroplating

# Step & Repeat Nanoimprint lithography (S&R NIL)



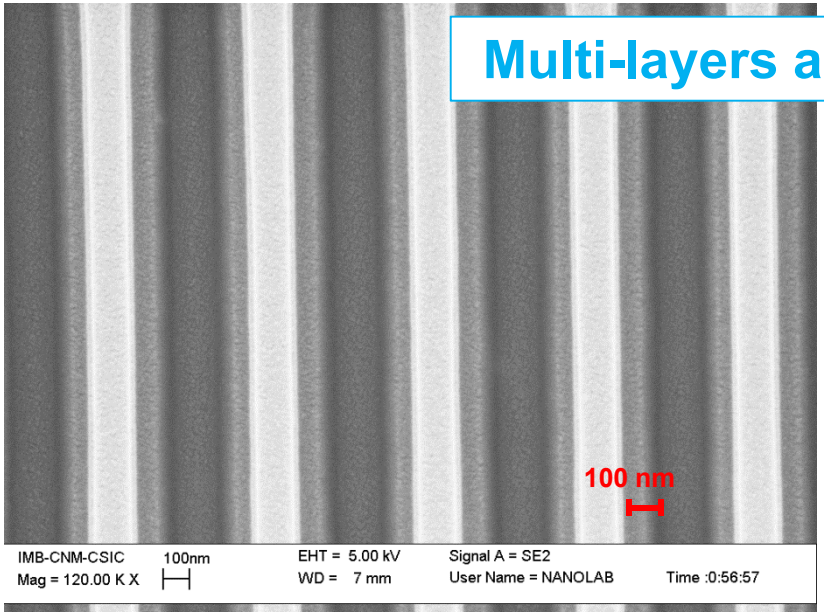
Si substrate

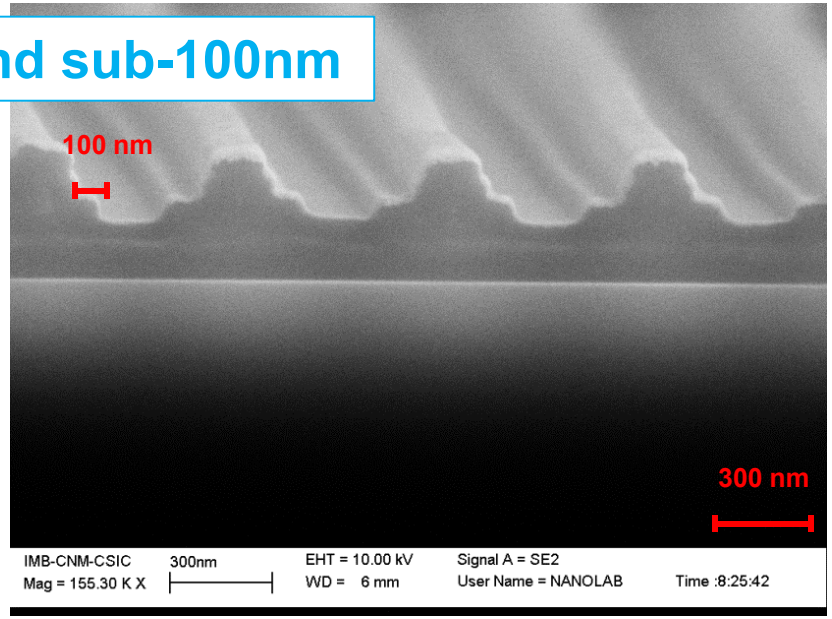


PC substrate

FLEXIBLE polymer film

## Multi-layers and sub-100nm



# Roll to Roll NIL (R2R NIL)

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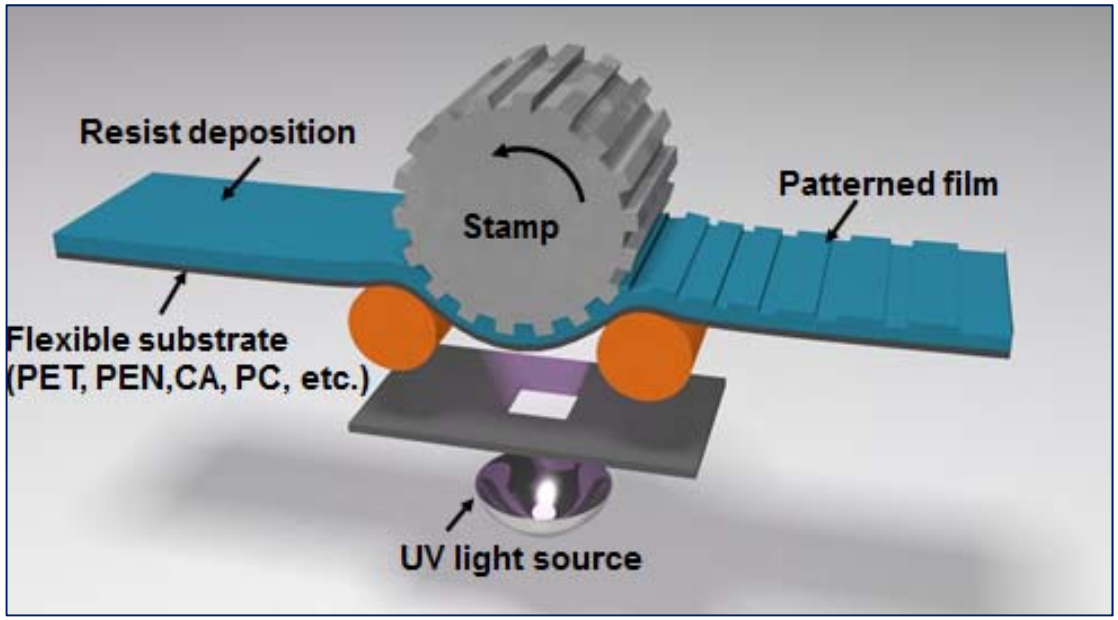
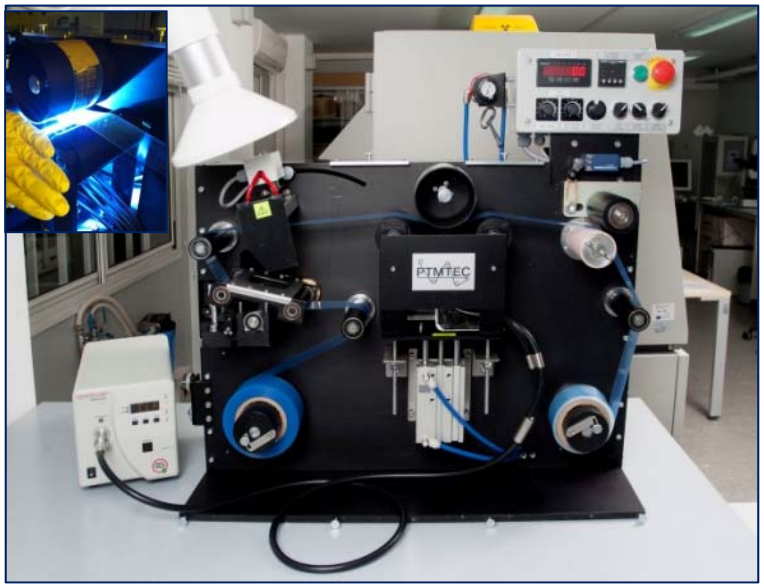
## Continuous




*R2R NIL process*




*R2R NIL equipment at ICN2*

# Roll to Roll NIL

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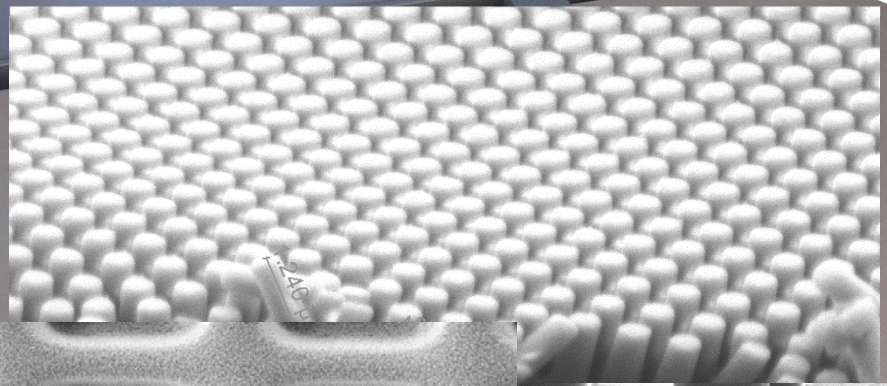
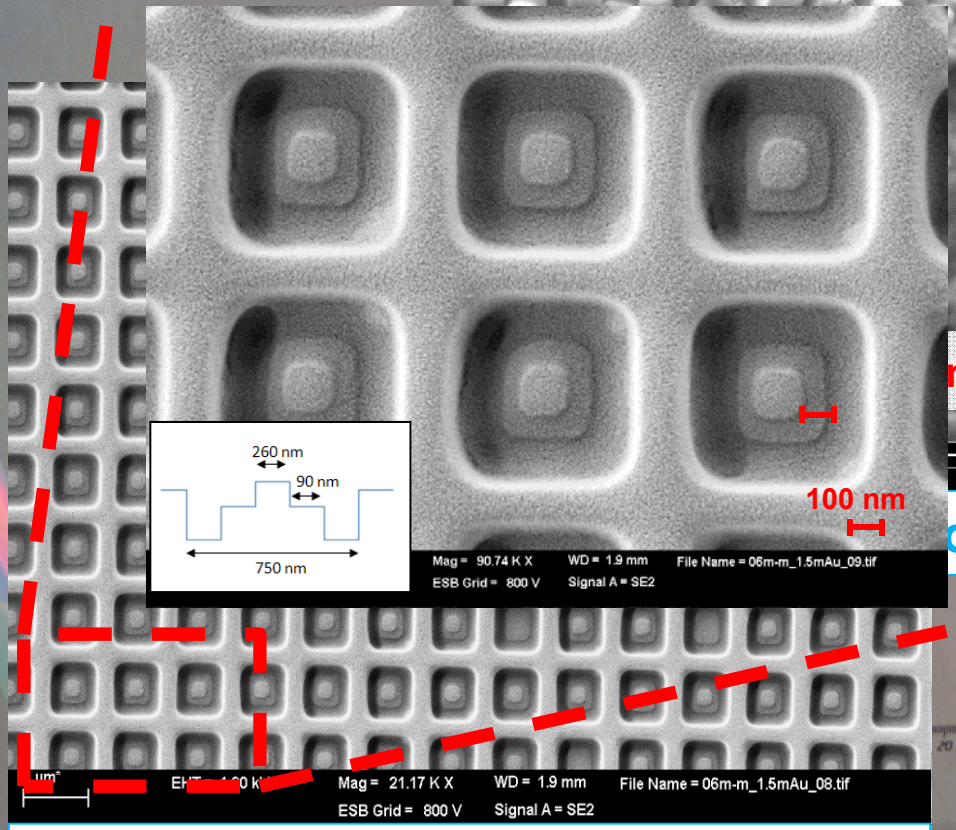
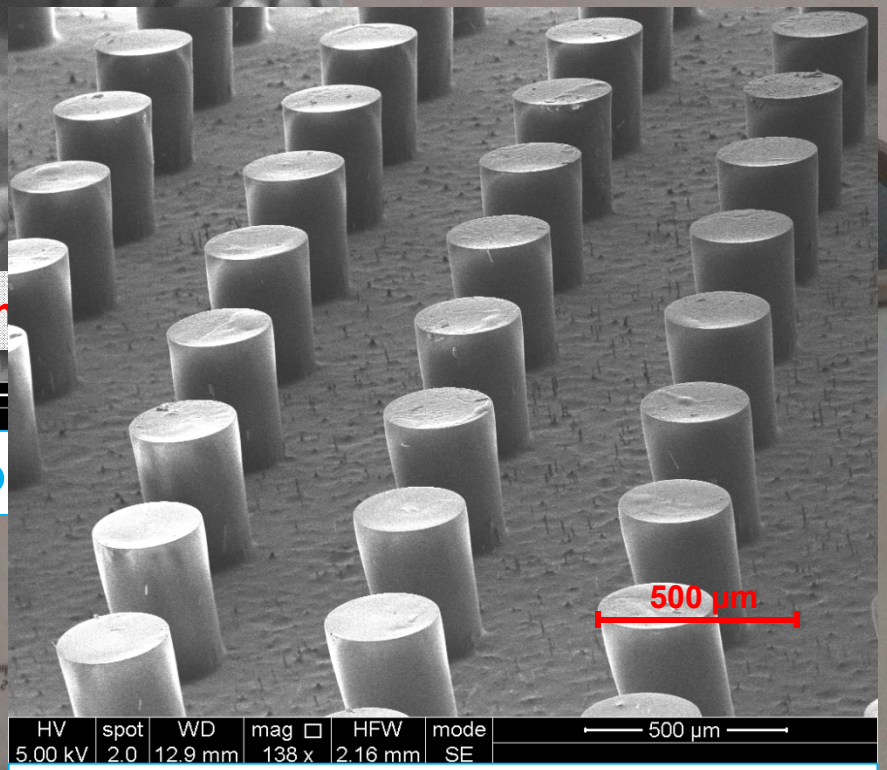
EXCELENCIA SEVERO OCHOA






**Multilevel nm scale**




**Macro- Micro scale**

# Towards 2020 – Technology and market shares

# Nano-patterning Market Outlook

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**Emerging domain for high growth industries such as:**

- Semiconductors for LEDs
- CPUs & memory devices
- Life sciences for medical diagnostics and cell sorting
- Data storage for DVDs and Magnetic storage devices
- Surface structuring for cell control and anti reflective structures
- Optics for filters , Polarizers, etc.
- Security for tags and holography
- Micro fluidic devices
- Optical communication systems (Diff. gratings).

# Nanopatterning Global Market Outlook

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- Global nano-patterning market is estimated as US$ xx billion in 2015 - projected to reach US$ xx billion by 2020
- NIL represents xx% of the total nano-patterning market
- NIL is estimated as US$ xx billion in 2015 - projected to reach US$ xx billion by 2020
- UVNIL fastest growing NIL technology representing xx% share of the market in 2015
- UV-NIL market is estimated at US$ xx billion in 2015 - projected to reach US$ xx billion in 2020
- Hot embossing market is estimated at US$ xx million in 2015 - projected to reach US$ xx billion in 2020

# Plast4Future EU project

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DTU **Plasmon Color Technology**

NIL ICN2 Fraunhofer KIT **Tool Lithography**

UDDEHOLM **Tool steel**

TOOLpartners **Tool Surface machining**

CRF CENTRO RICERCHE FIAT MAIER

micro resist technology **Tool Resist**

LEGO CRP

GEMECON **Tool ion-milling**

**Nanoscale polymer replication**

# Plast-4-Future Objective

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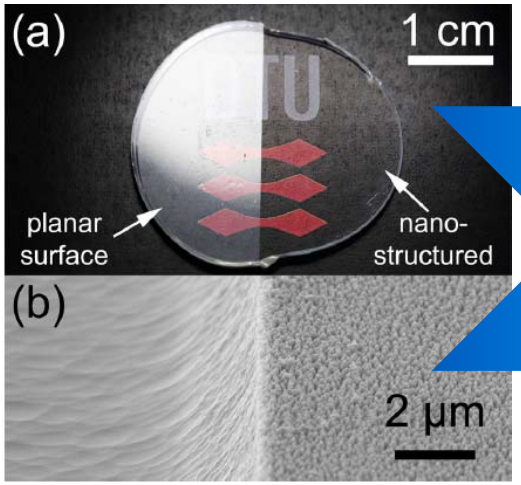
## Lab-scale demonstration




Christiansen, Appl. Phys. Lett. (2012)

**PLAST4FUTURE**

## Production



PLAST4FUTURE

http://www.plast4future.eu/

# Industrial Applications

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## Automotive Interior Surfaces

Easy-to-clean interior trims
Interiors optical surfaces (anti-reflective, colours changing, iridescent)
Soft-touching and sticking surfaces

## Automotive Lighting Systems

Automotive - 3D thin, lightweight and low power consumption courtesy lighting systems
Optics for dashboard and headlamps (Anti-fog and anti-reflective)
Backlighting light-guide/ light-curtain.

## Plastic Toys

Low cost and low environmental impact plastic toys parts with functional properties (easy-to-clean, colour changing)
High added value plastic toys integrating functional surfaces and active devices (LEDs)

PLAST4FUTURE

# Free form NIL on injection moulding inserts

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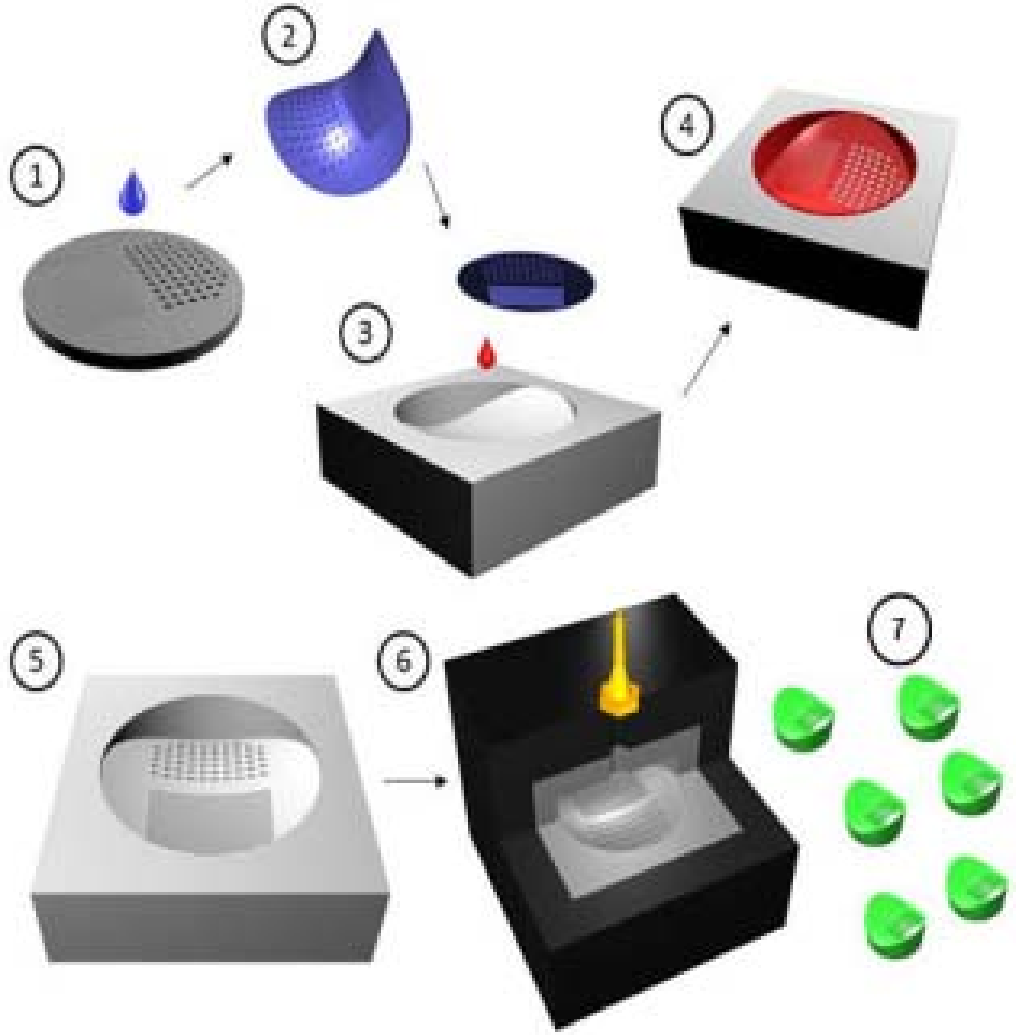

# New Tool Steel

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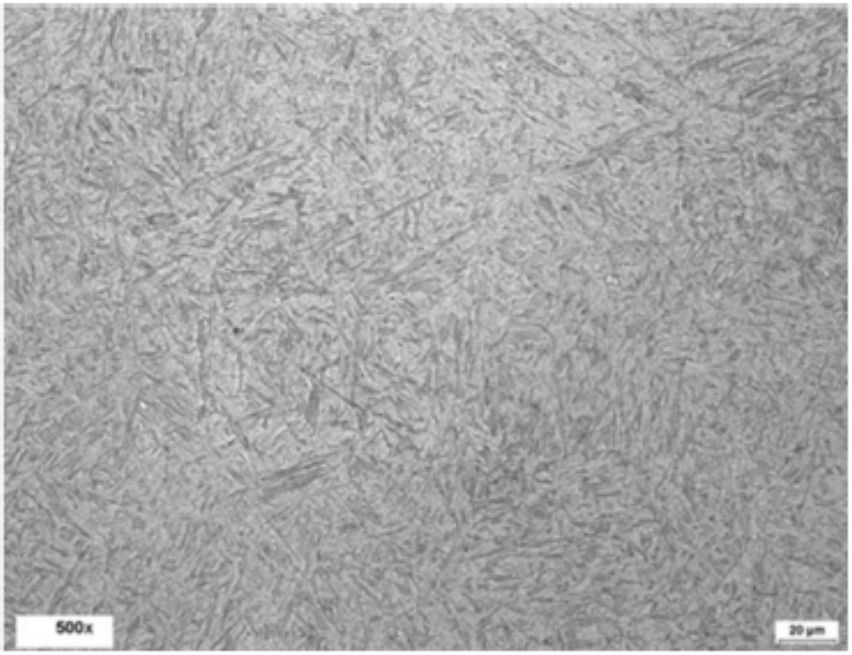
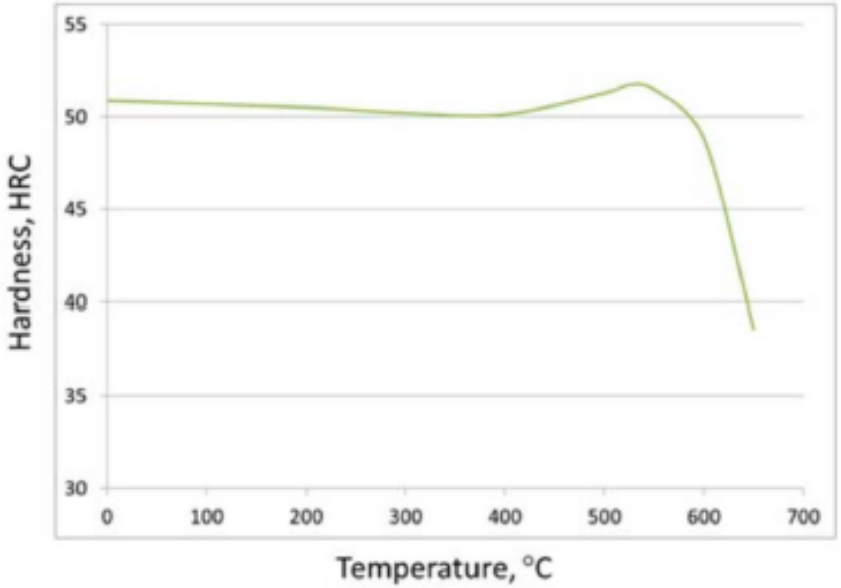
The new P4F steel is a molybdenum-, chromium-, vanadium- and nickel-alloyed tool steel of hot work type.




UDDEHOLM

# High quality polishing

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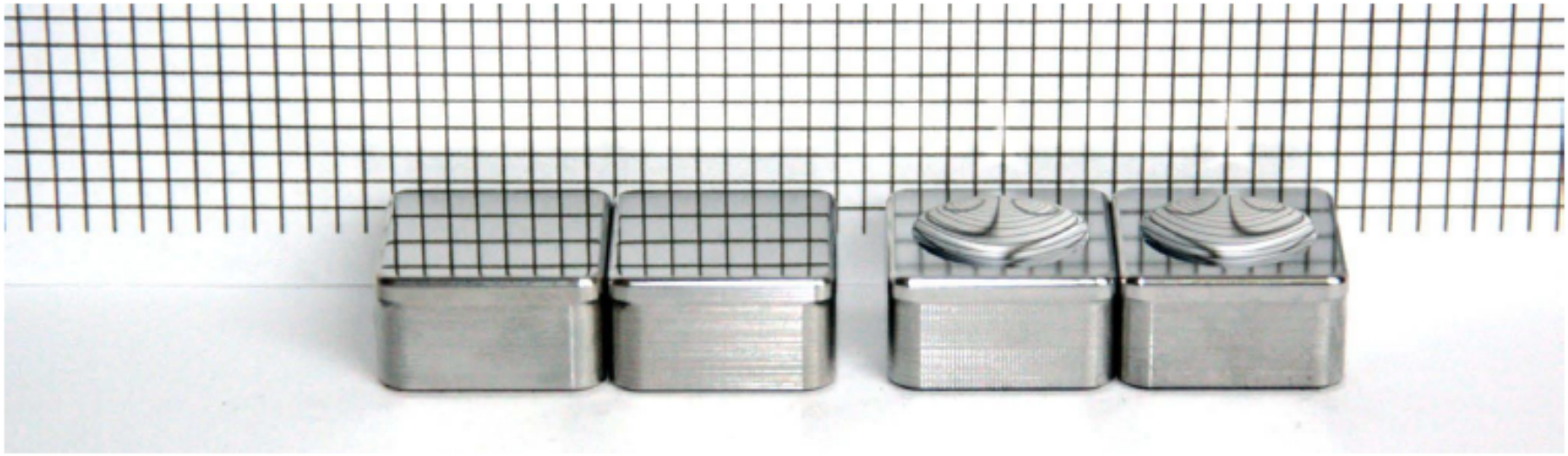
## High quality steel tool surfaces



Inserts for moulds

Planar and double-curved surfaces for nano-texturation

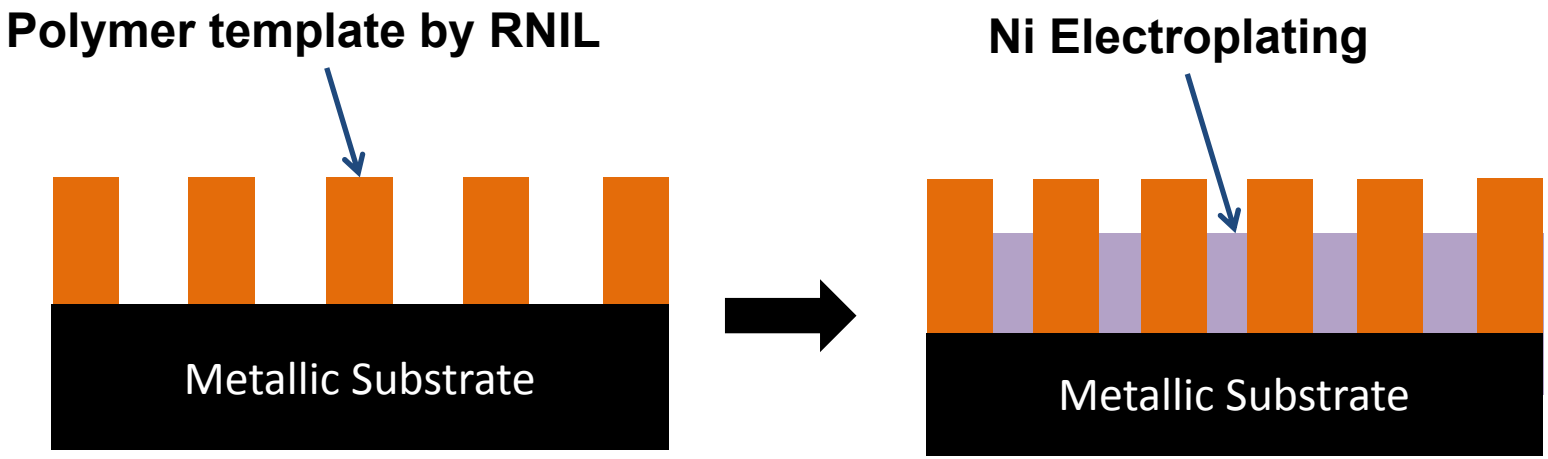
Surface area: 20x20 $mm^2$, currently extended to 100x100 $mm^2$

$R_a$ average 9 nm

TOOLpartners

Danish solutions · Worldwide possibilities

# Towards Nano-injection moulding




- Nanoimprint Lithography to create nanostructures with no residual layer on metallic substrates
- Use a polymer as a mask for bottom-up electroplating process

# Flexible Reverse Nanoimprint lithography (RNIL)

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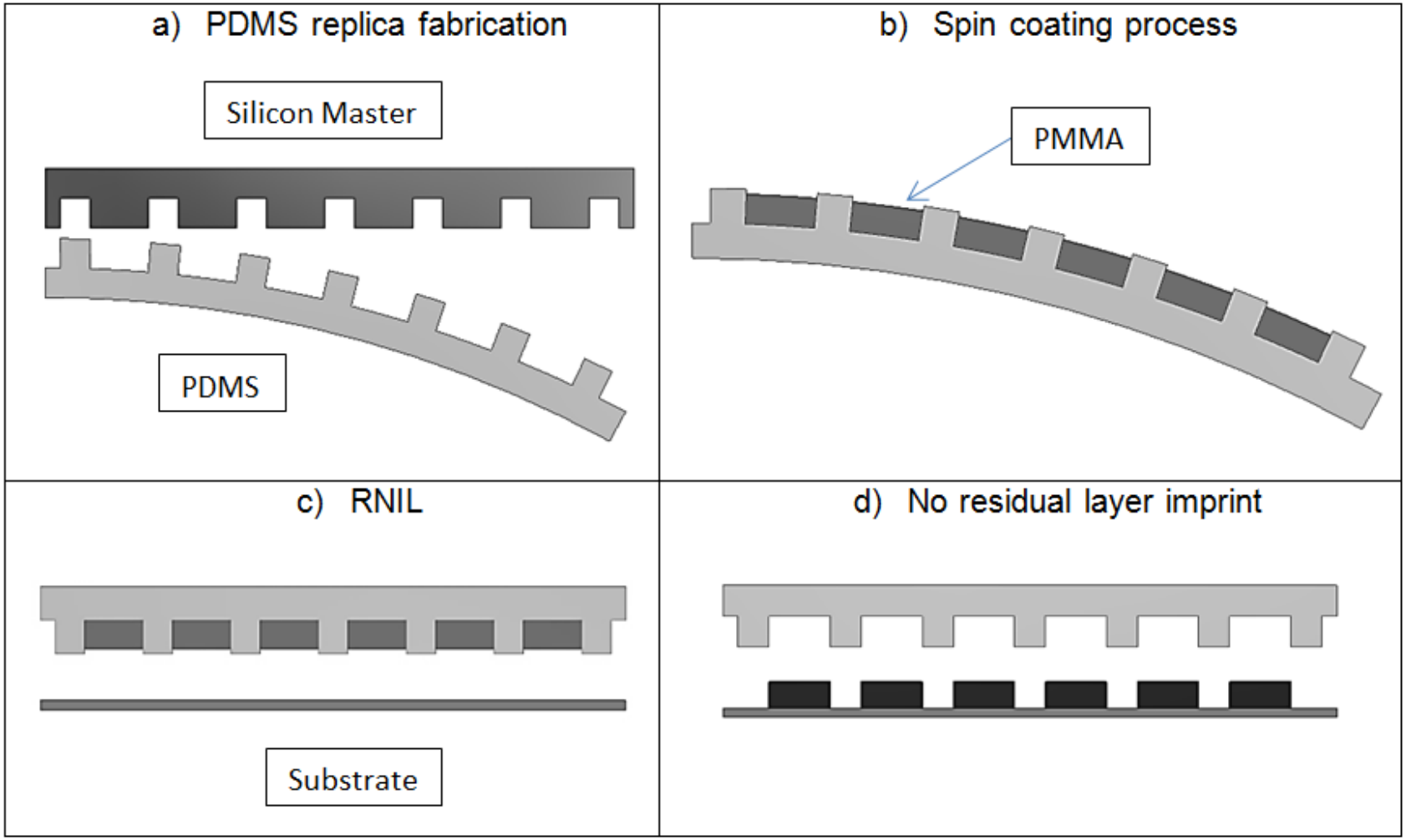
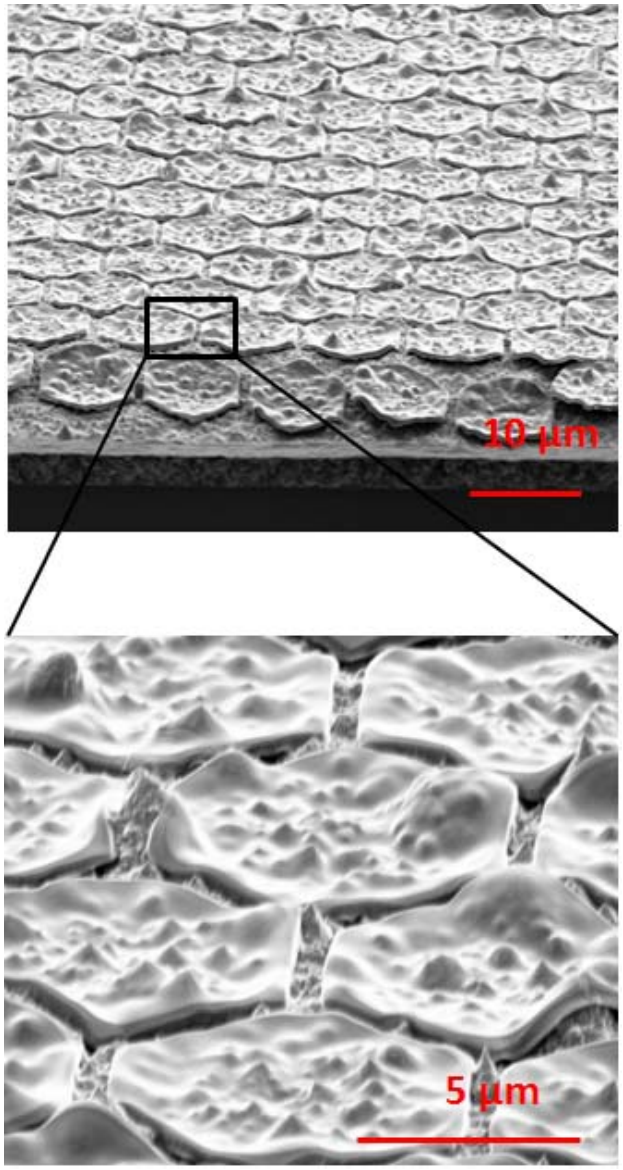
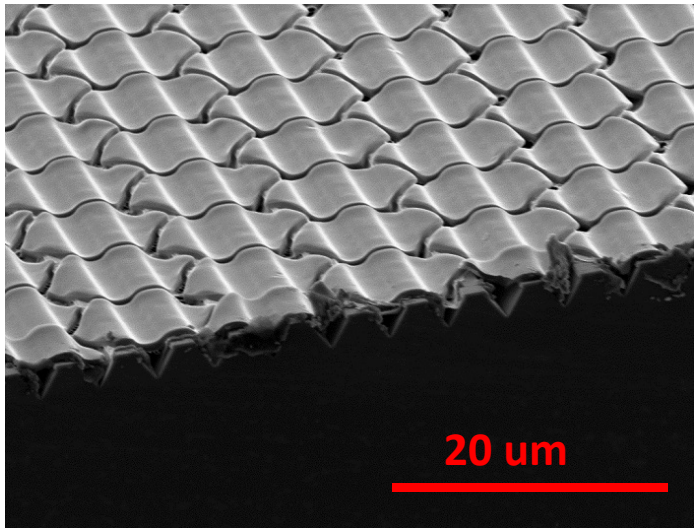
EXCELENCIA SEVERO OCHOA

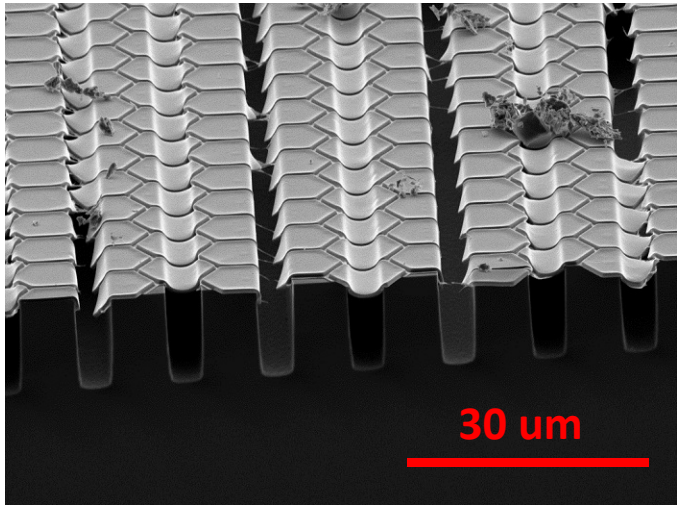


# Flexible RNIL over topographies

ICN2
Institut Català de Nanociència i Nanotecnologia
EXCELENCIA SEVERO OCHOA



# Manufacturing Process Chain

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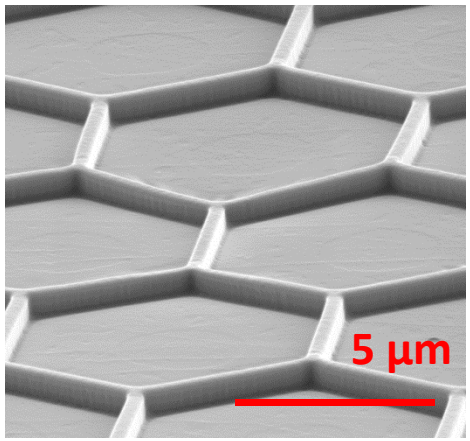
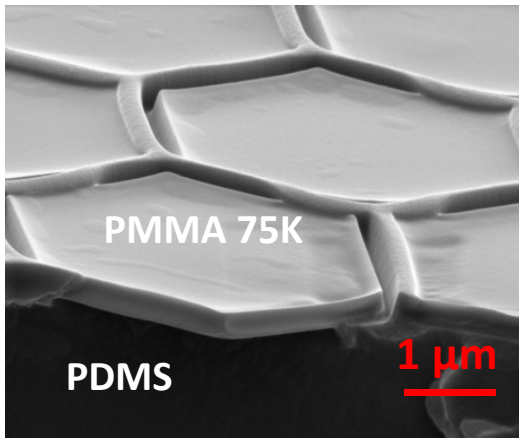
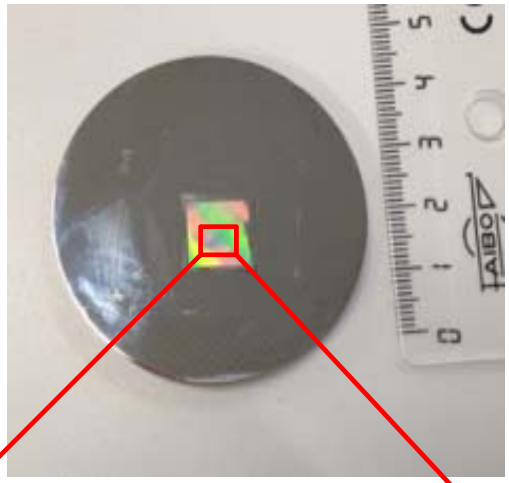
## PDMS Stamp

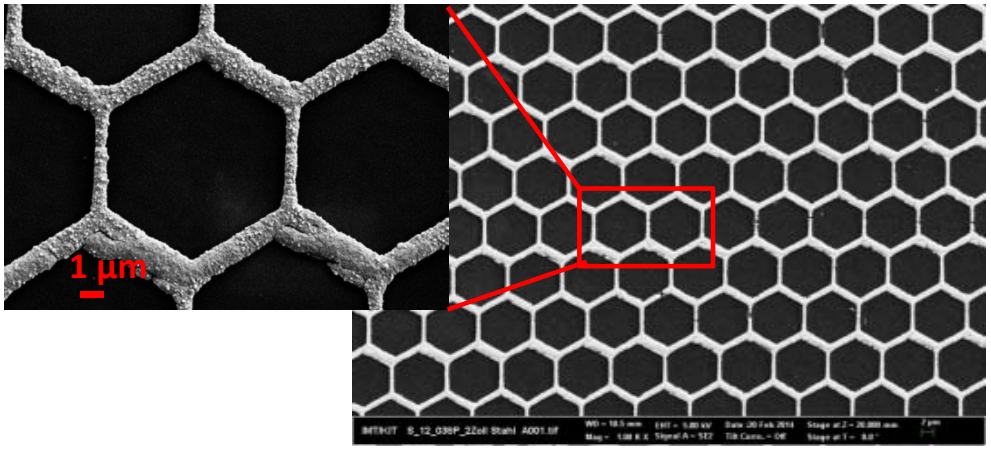



## PMMA Coated Stamp




## Imprinted features

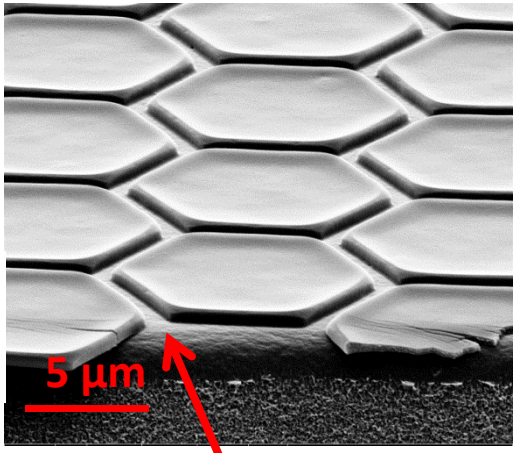





Bottom up Ni Electroplated cavities

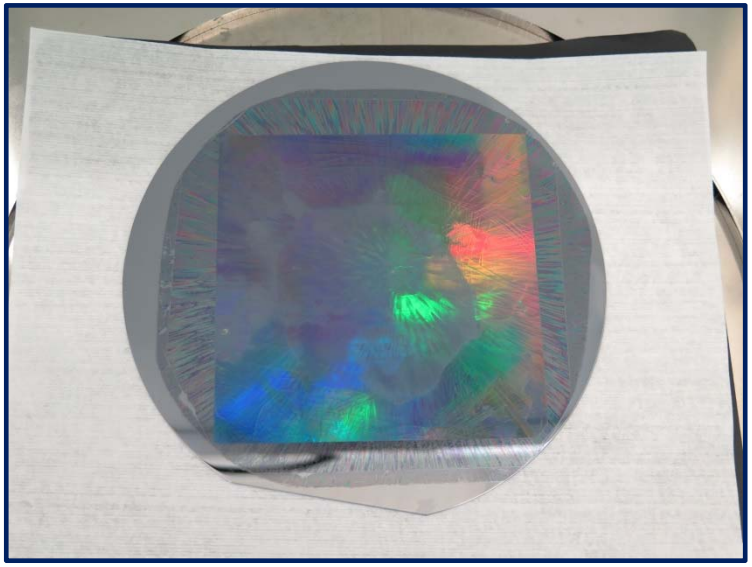
Ni electroplating

KIT Karlsruhe Institute of Technology

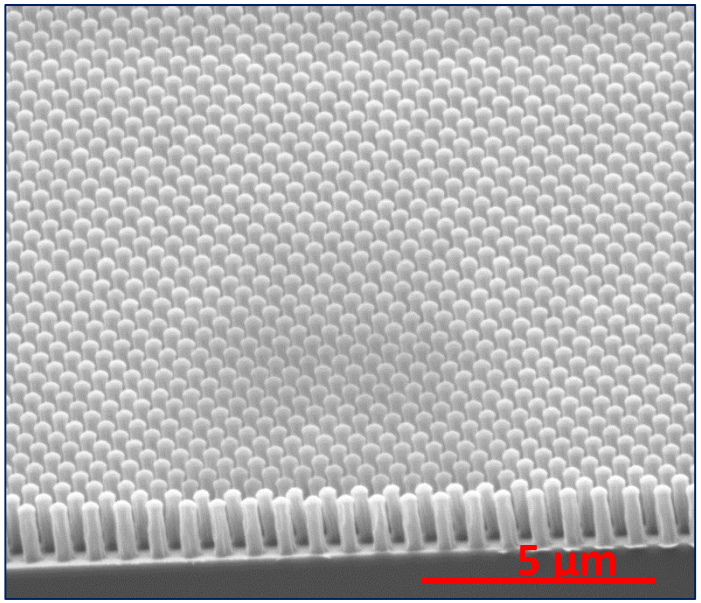



No residual layer

# Upscaling: Flexible RNIL



6 inch wafer: 100 mm x 100 mm patterned area




Easy to paint structures

# Industrial Applications

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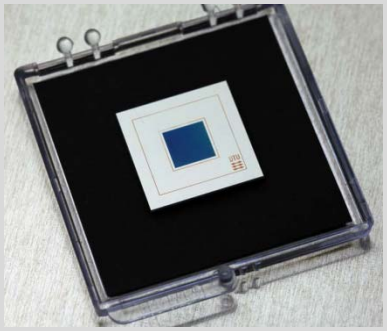
## Colour effects

DTU

NIL TECHNOLOGY



## Easy to paint

MAIER

CRF CENTRO RICERCHE FIAT

## Superhydrophobic

KIT

NIL TECHNOLOGY

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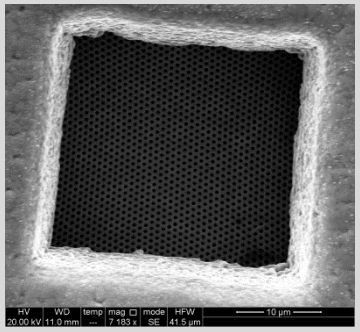

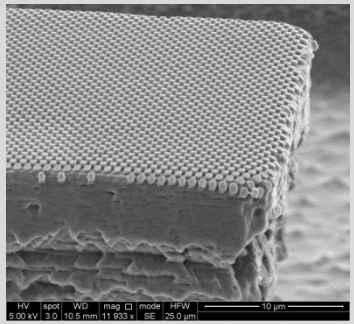

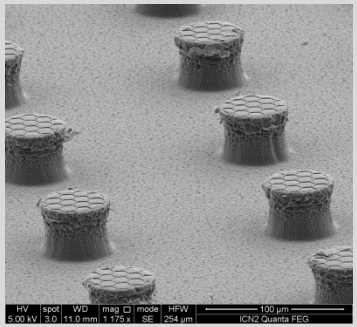

# Towards Super-hydrophobicity

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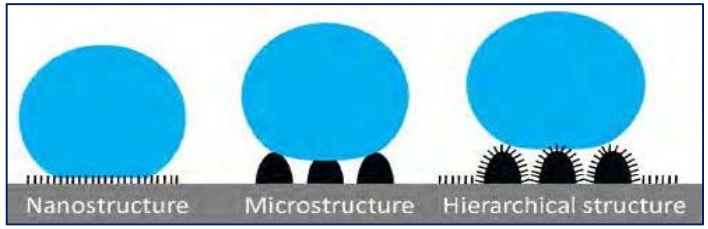
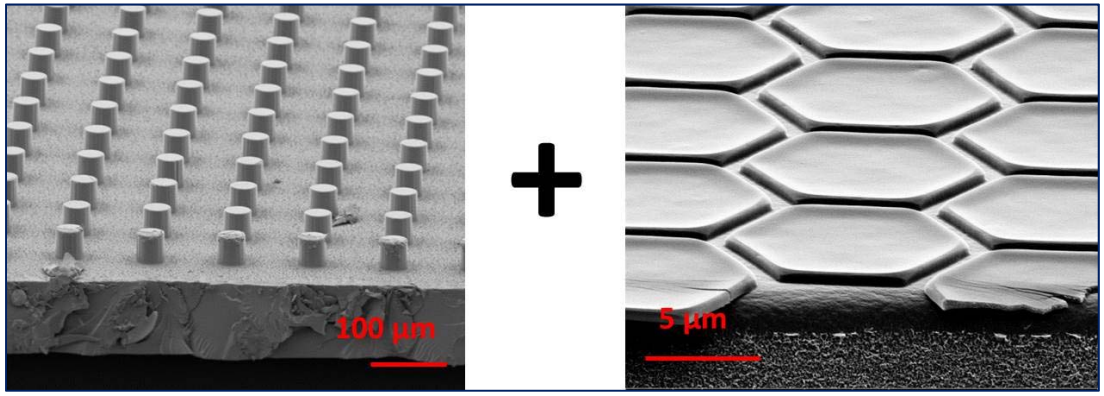
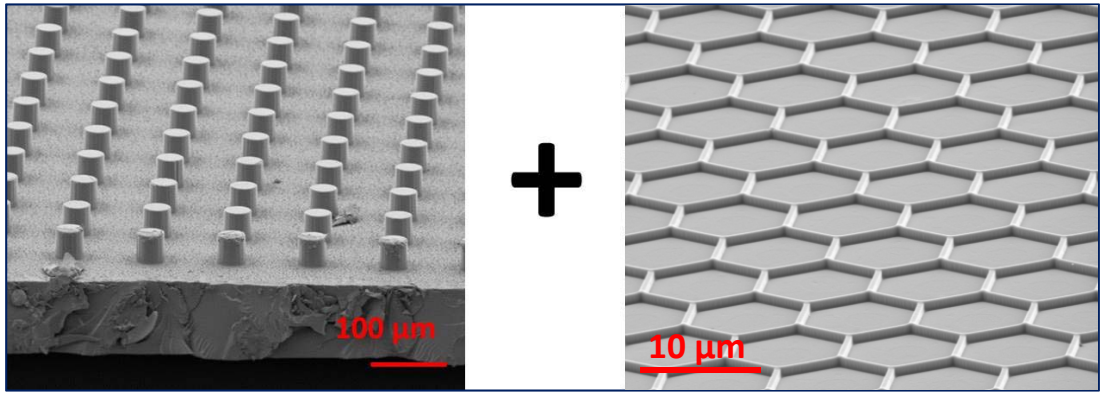
EXCELENCIA SEVERO OCHOA

## Hierarchical structures




Pillar configuration




Line configuration

# Hydrophobic structures

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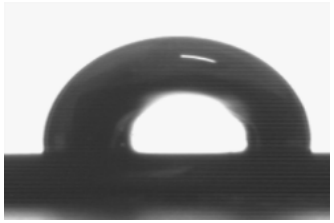
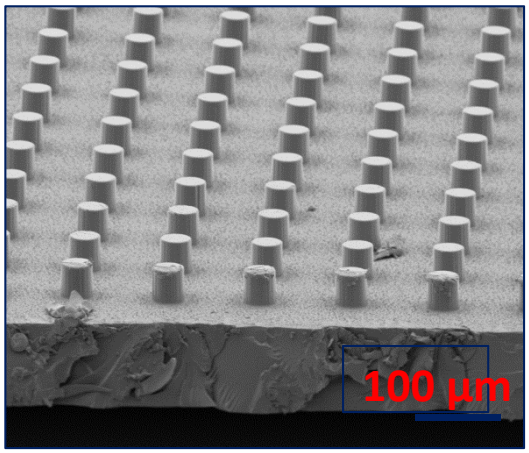
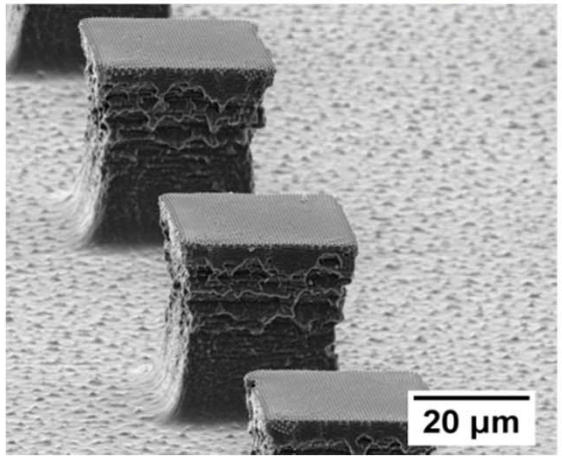


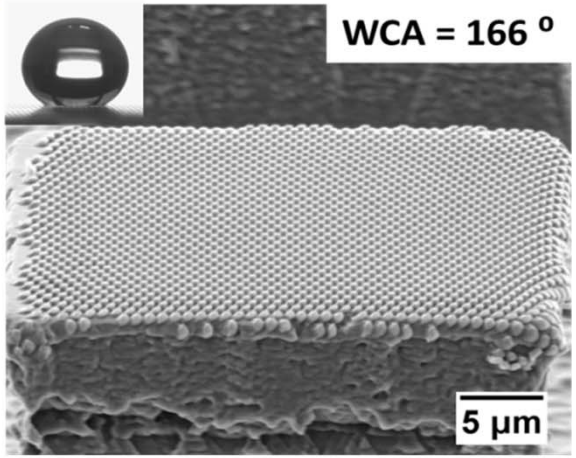
WCA on Flat Surface: 90 º



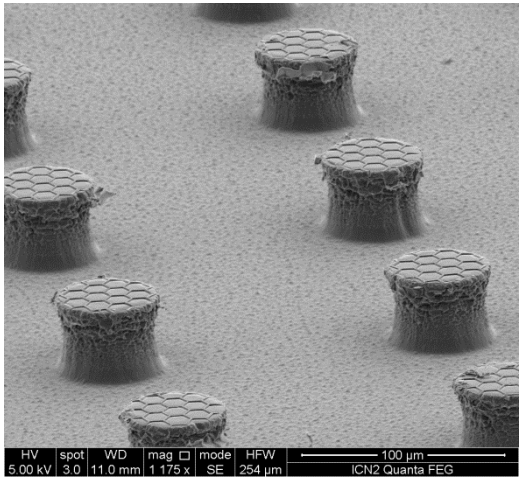

WCA: Θ*=134$^0$

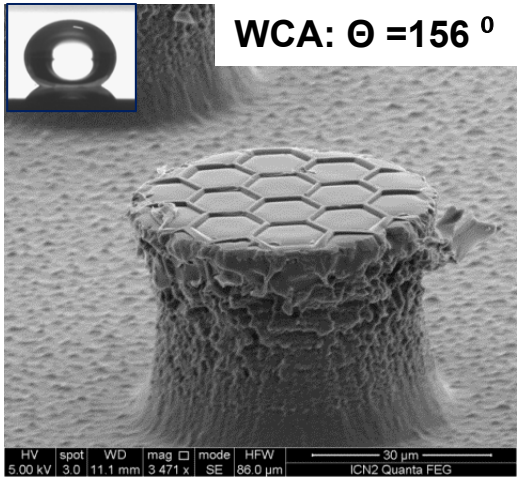
## High Aspect Ratio Pillar




## Hexagonal Lines Structure



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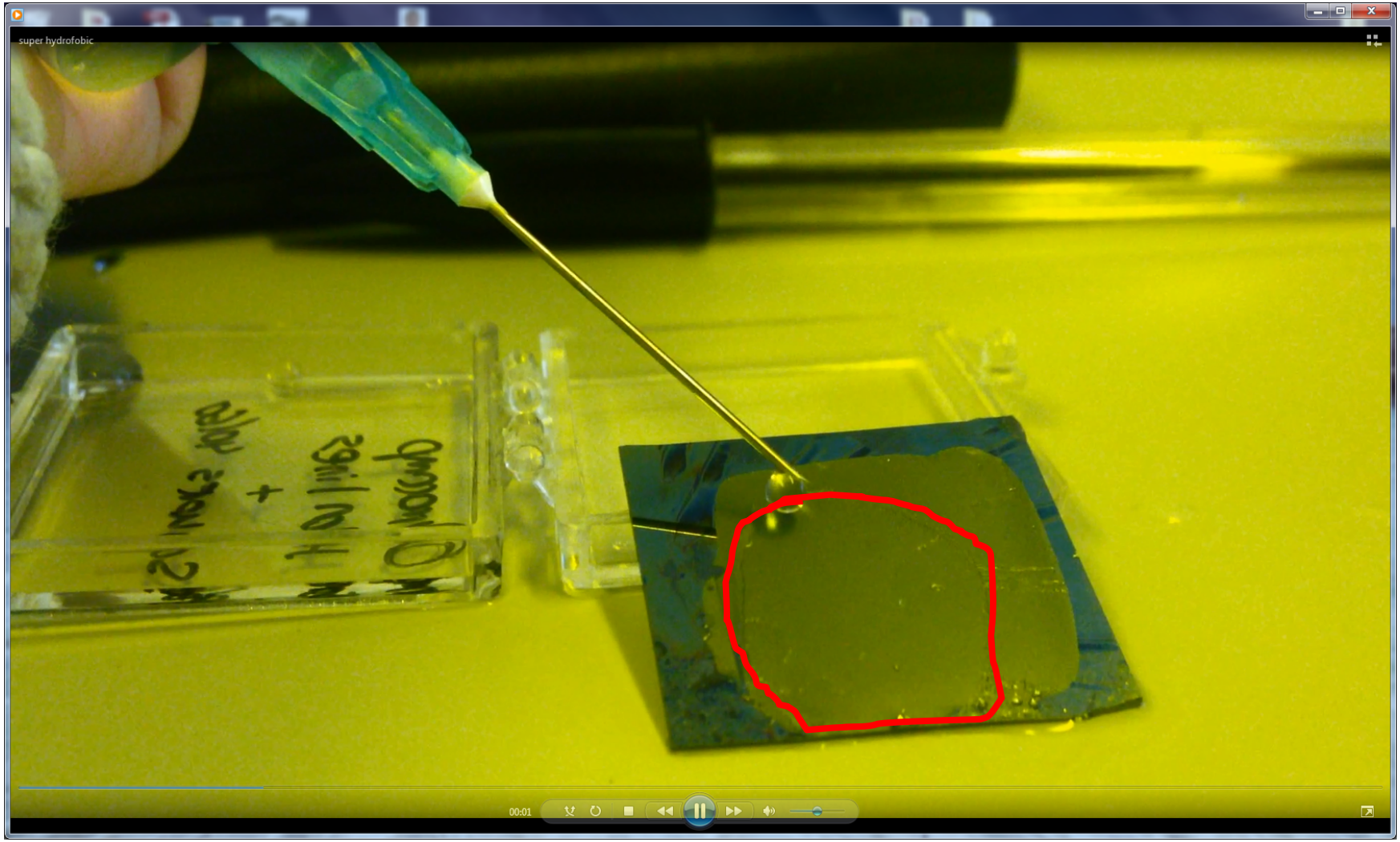
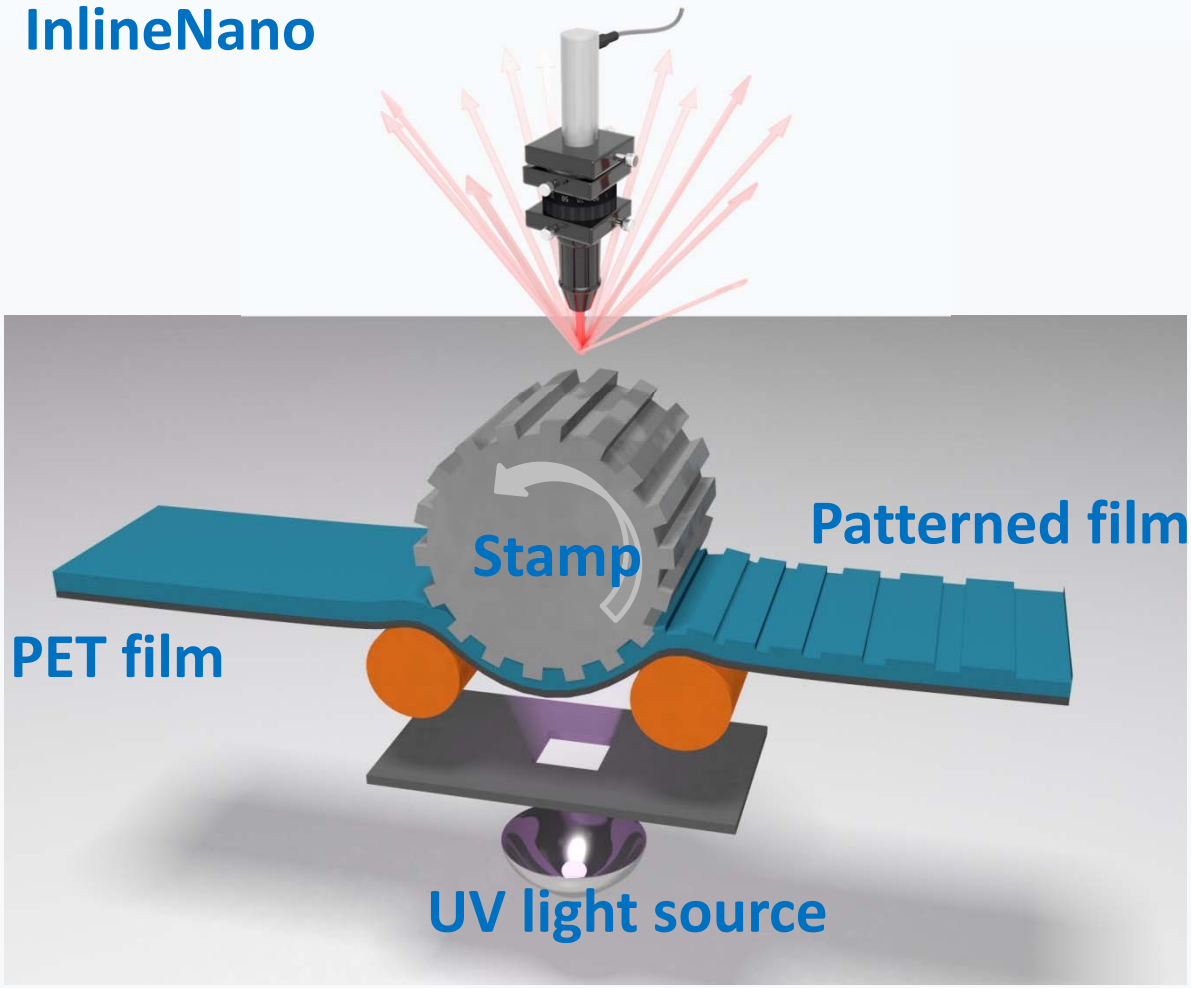



**Super-hydrophobic behaviour**

# Roll-to-Roll Nanometrology




*Patent Application “Inspecting nanostructures”;

Application Nr: European Patent Application no. EP14156430.2; Date: 24 February 2014

# Roll-to-Roll at ICN2
with InlineNano setup

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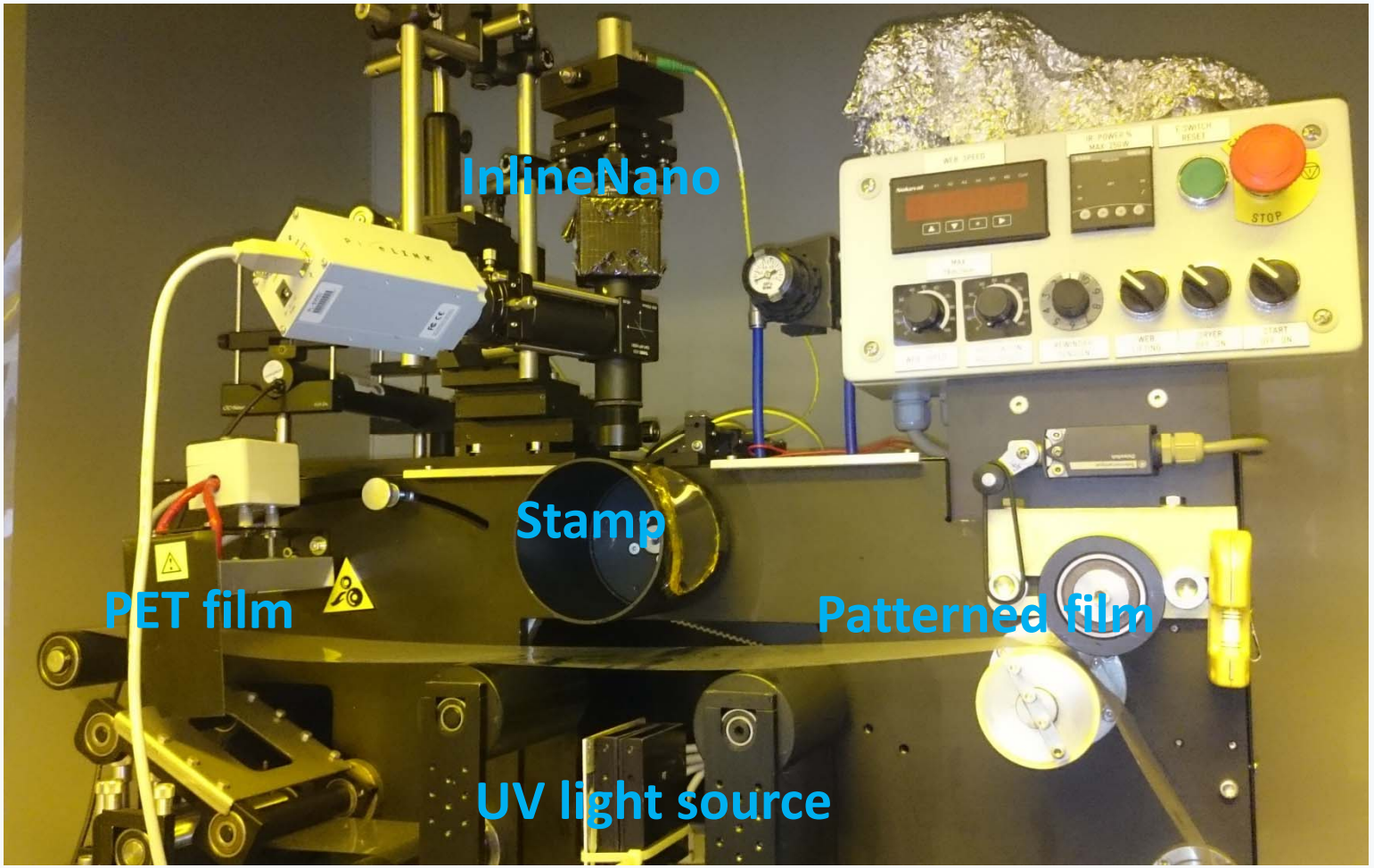


*Patent Application “Inspecting nanostructures”;

Application Nr: European Patent Application no. EP14156430.2; Date: 24 February 2014

# Schematics of Silicon Master
# - A Line Grating -

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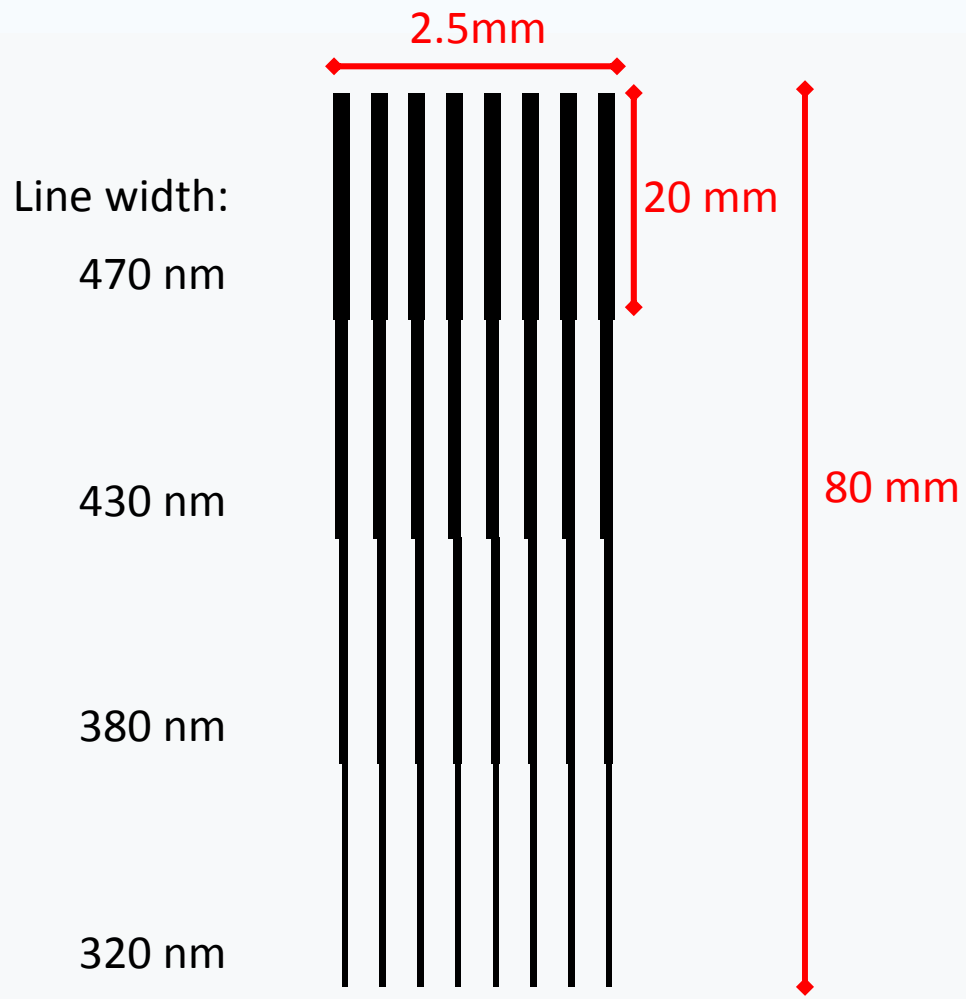
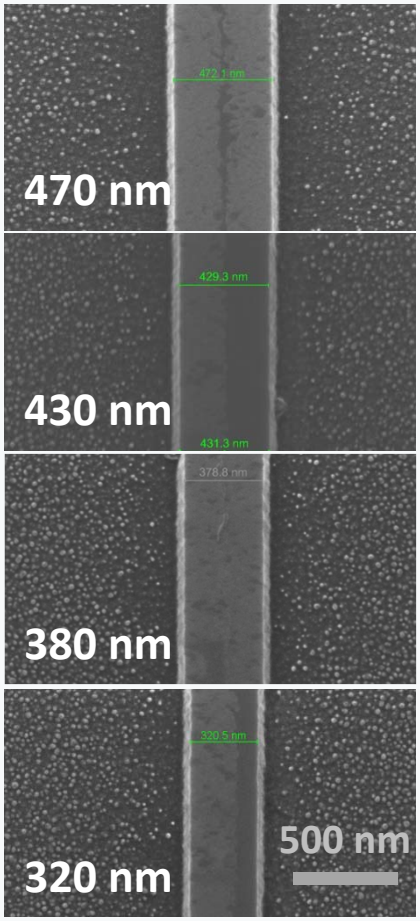
Spacing: 6 µm; Height: 100 nm




SEM of a line




*Patent Application "Inspecting nanostructures";

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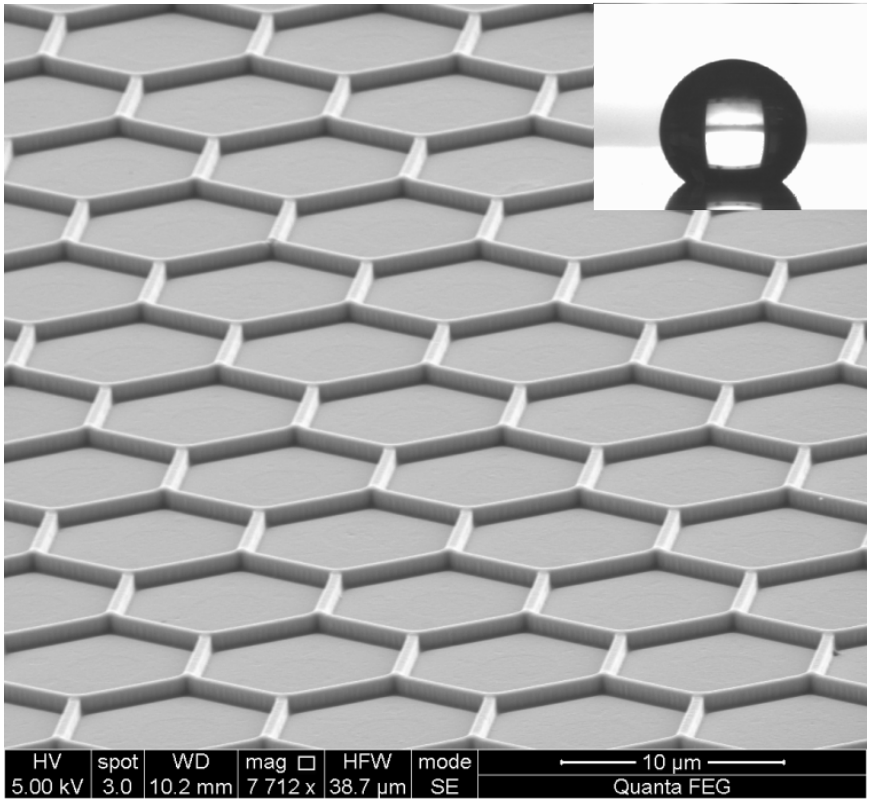
# THANK YOU FOR YOUR ATTENTION




nikos.kehagias@icn.cat