Westsächsische Hochschule Zwickau
University of Applied Sciences

nanolab

Applications of thermal nanoimprint lithography

Chemnitzer Seminar
Systems Integration Technologies

M. Eng. Steffi Proschwitz

Outline

- Research Group
- Motivation
- Basics of thermal Nanoimprint Lithography
- Laser Interference Lithography for Master Structures
- Replication of moth-eye-inspired AR-Structures
- Thermal Imprint of fluorescent Nanoparticles
- Outlook

Research Group

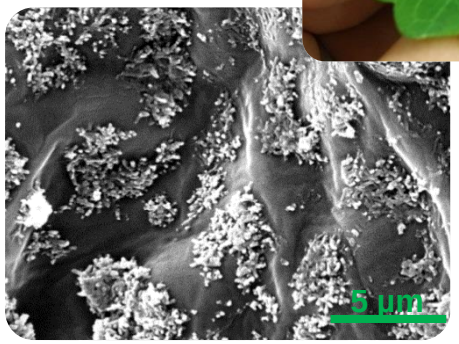
main focus: nanotechnology and functional surfaces

- head of group (since October 2011): Prof. Dr. Daniel Schondelmaier
- merge education and research

cleanroom facility

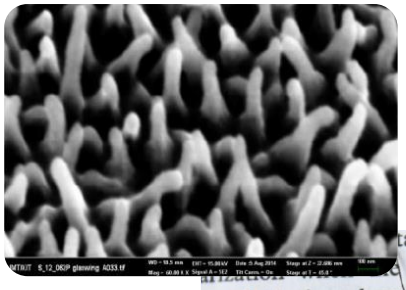
- 100 m² (ISO 5)
- established in 2014

Motivation

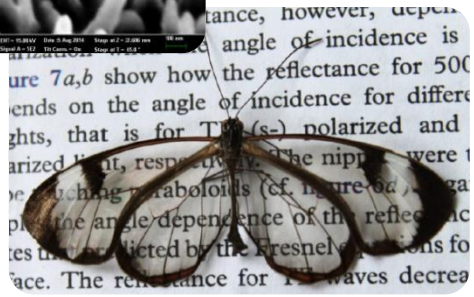


self-cleaning surfaces

nano structures

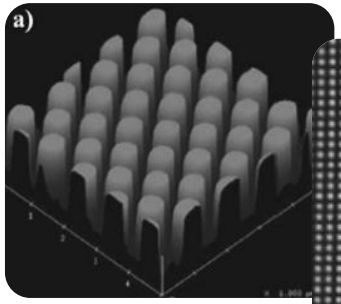


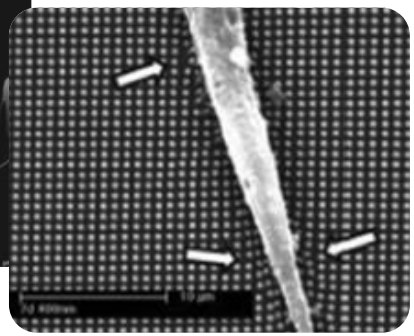
antireflective properties



[1]http://www.kit.edu/kit/english/pi_2015_037_nature--low-reflection-wings-make-butterflies-nearly-invisible.php

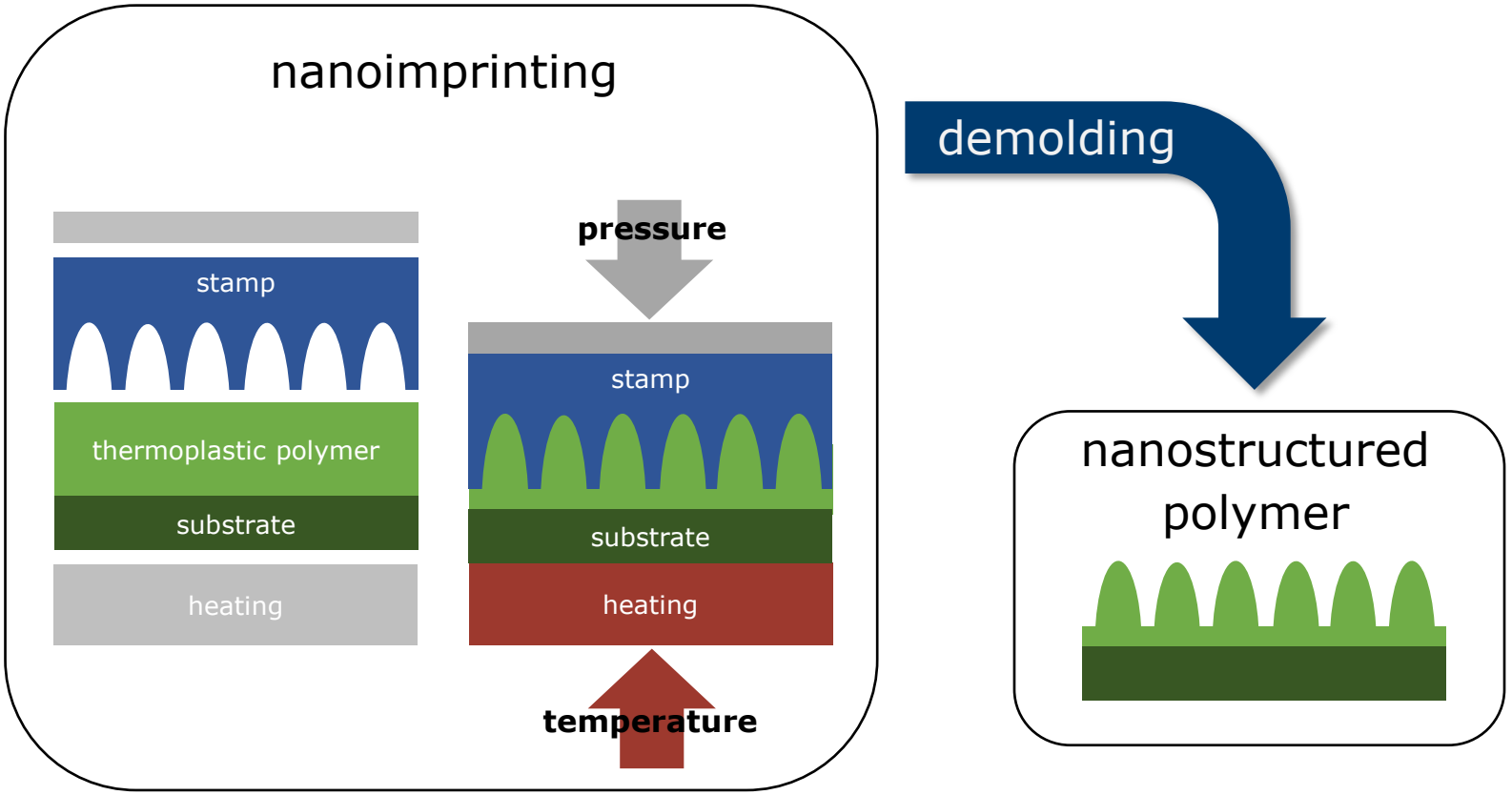
biomedical applications



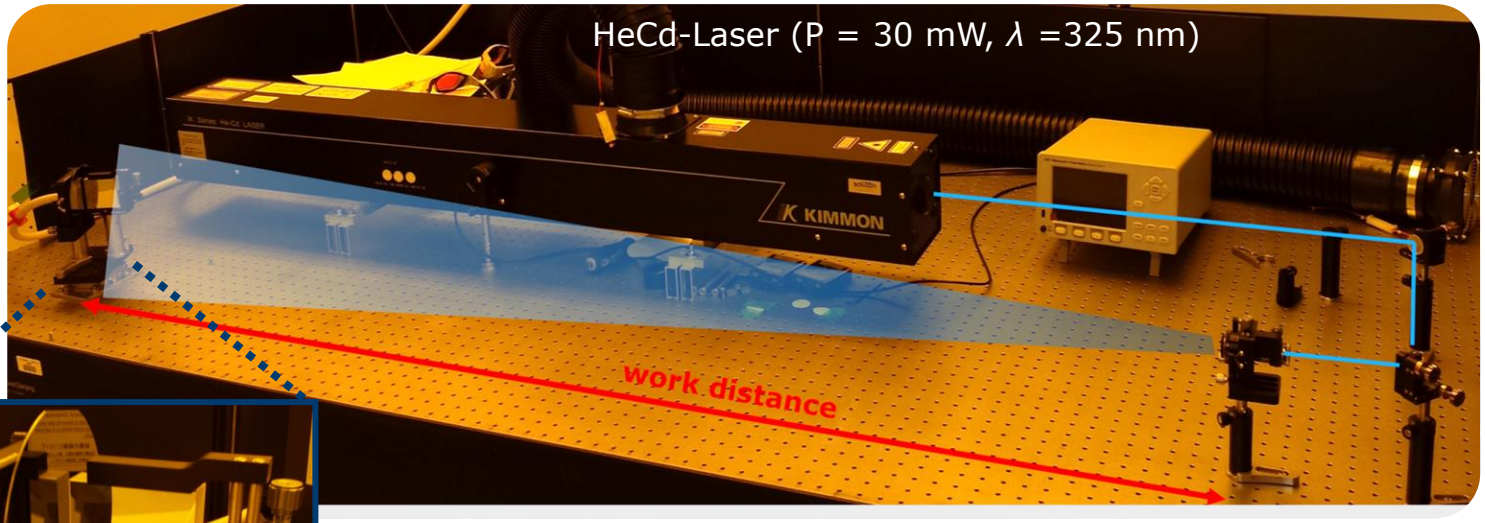


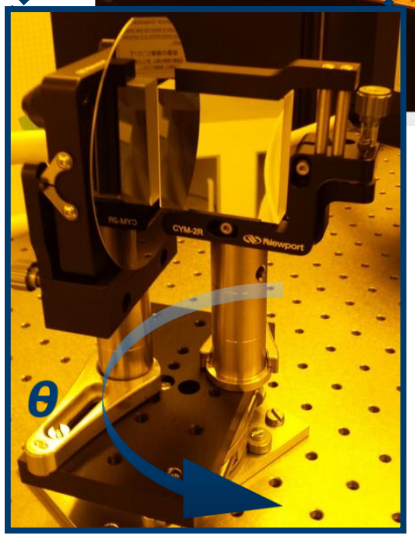
[2] Milner KR, Siedlecki CA. Submicron poly(l-lactic acid) pillars affect fibroblast adhesion and proliferation. Journal of Biomedical Materials Research Part A 2007;82:80–91.

Basics of thermal Nanoimprint Lithography



Laser Interference Lithography for Master Structures



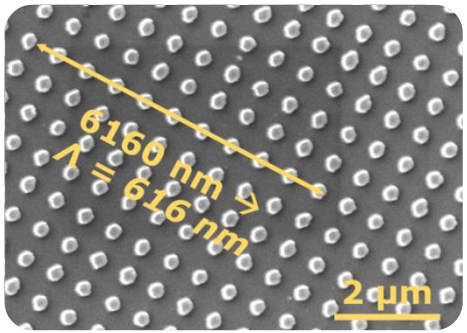


Lloyd-mirror-interferometer

double exposure

θ = 15° → $\Lambda_{theoretic}$ = 628 nm

two exposures with t = 275 s



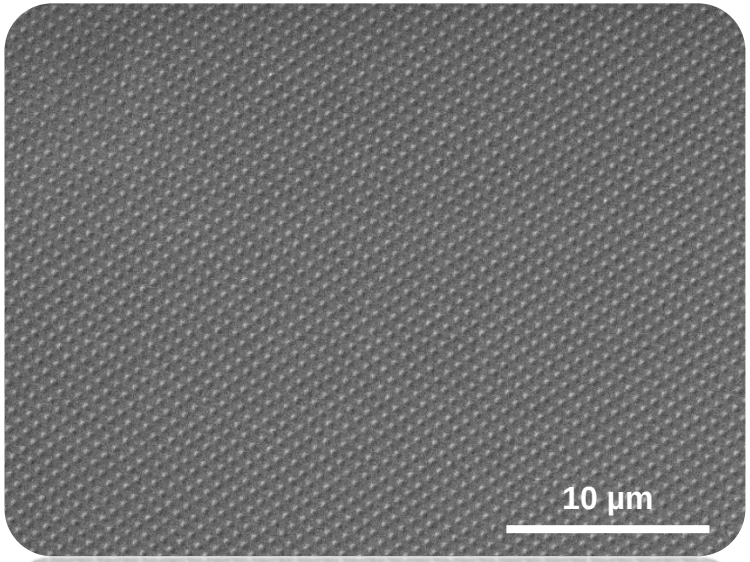
Laser Interference Lithography for Master Structures

- resist structure casted in PDMS → soft stamp

Imprint

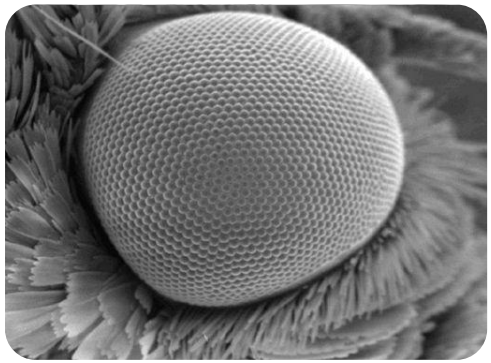
T_{imp} = 160°C
p = 4 bar
t = 10 min

PMMA on Si wafer



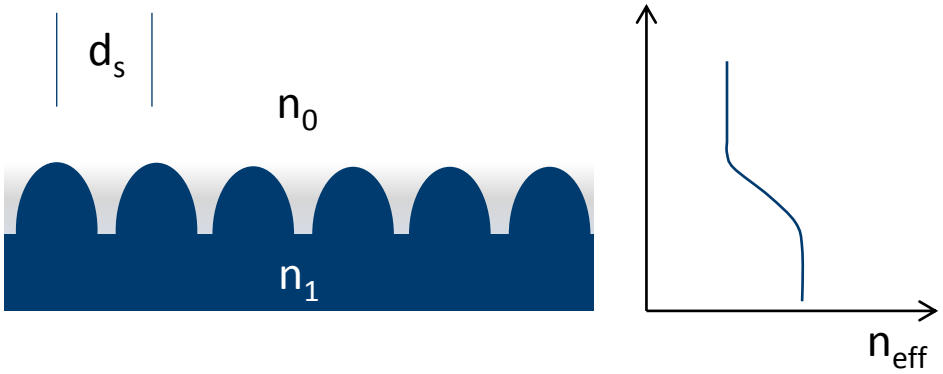
Replication of moth-eye-inspired AR-Structures

- Moth-eye effect



[3] http://www.biokon.de/news-uebersicht/kuenstliches-mottenauge-als-lichtfaenger-wasserstoffproduktion-mit-sonnenlicht/

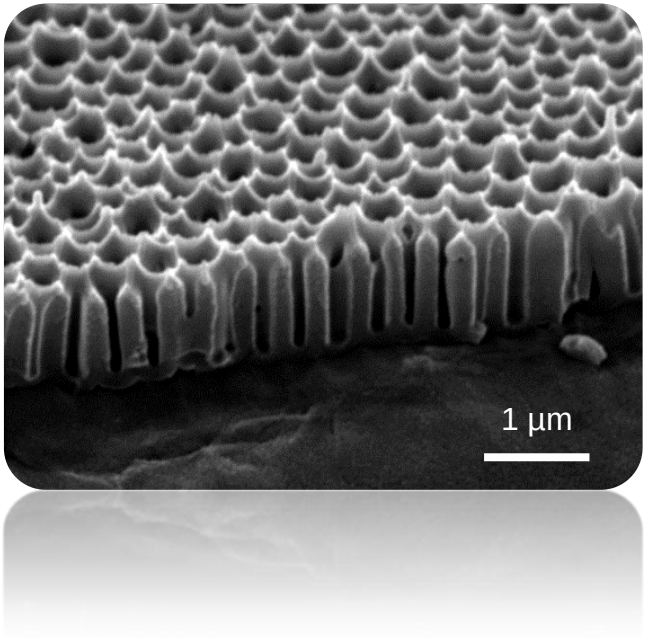
- application as antireflection layers for optics, photovoltaics
- conventional approach: destructive interference within (multi-)layer structures, dependent of wavelength!
- moth-eye cornea has antireflection properties due to continuous change in the effective refractive index of air to material



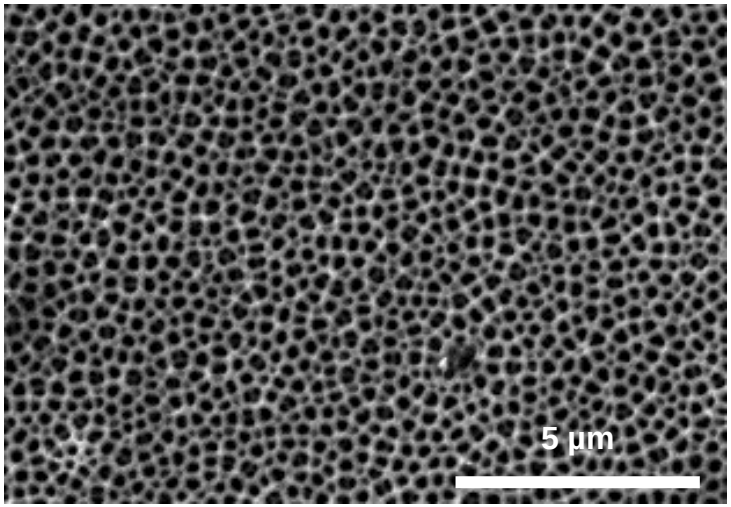
Replication of moth-eye-inspired AR-Structures

- substrate: electropolished aluminum (99,99 %)
- anodic oxidation
  - Anodizing voltage: 150 V
  - Electrolyte concentration: 0,5 %phosphoric acid
  - Time: 3 h
- etching process for opening pore structures
  - chromic acid for 2 min

➢ pore diameter ≈ 200 nm



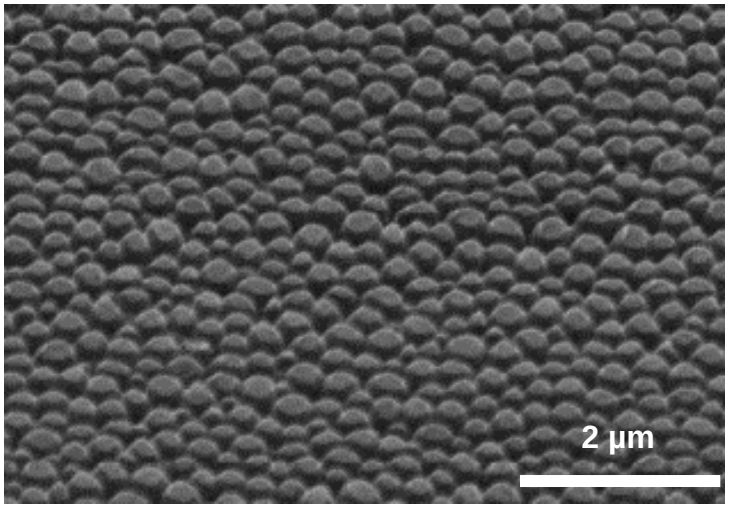
Replication of moth-eye-inspired AR-Structures



anodized aluminum wafer

- Pretreatment: 30 min dip coating with Dynasylan® solution

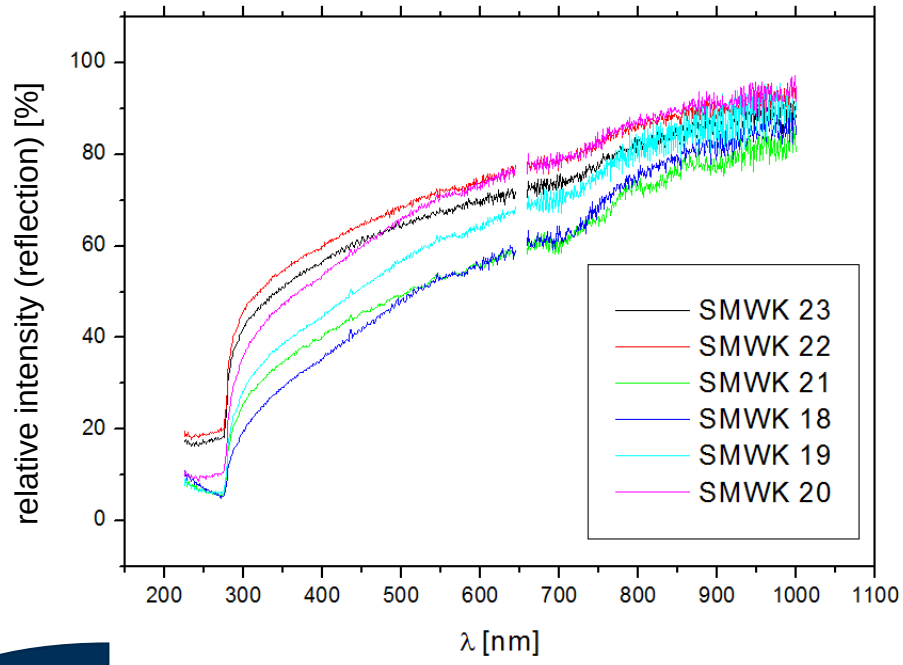
Imprint at 120°C & 4 bar for 10 min



polystyrene sheet

Replication of moth-eye-inspired AR-Structures

spectral reflectivity

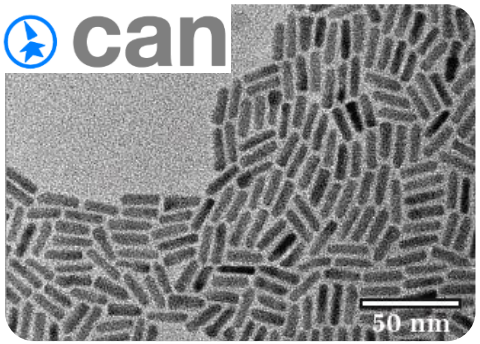


reduction of reflectivity

Thermal Imprint of fluorescent Nanoparticles (FNP)

Resist: PMMA + PGMEA + CANdots® A plus

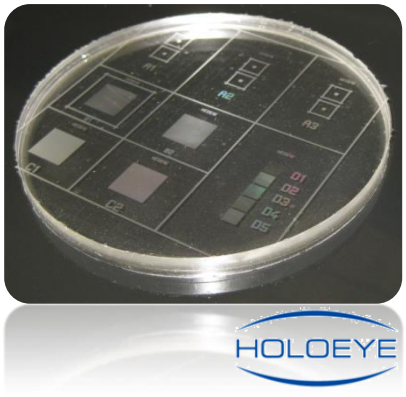
- elongated coreshell particles (CdSe/CdS in hexane)
- emission maximum λ = 562 nm
- diameter < 5 nm, length < 24 nm



[4] http://www.can-hamburg.de/files/candots_r__series_a_plus.pdf

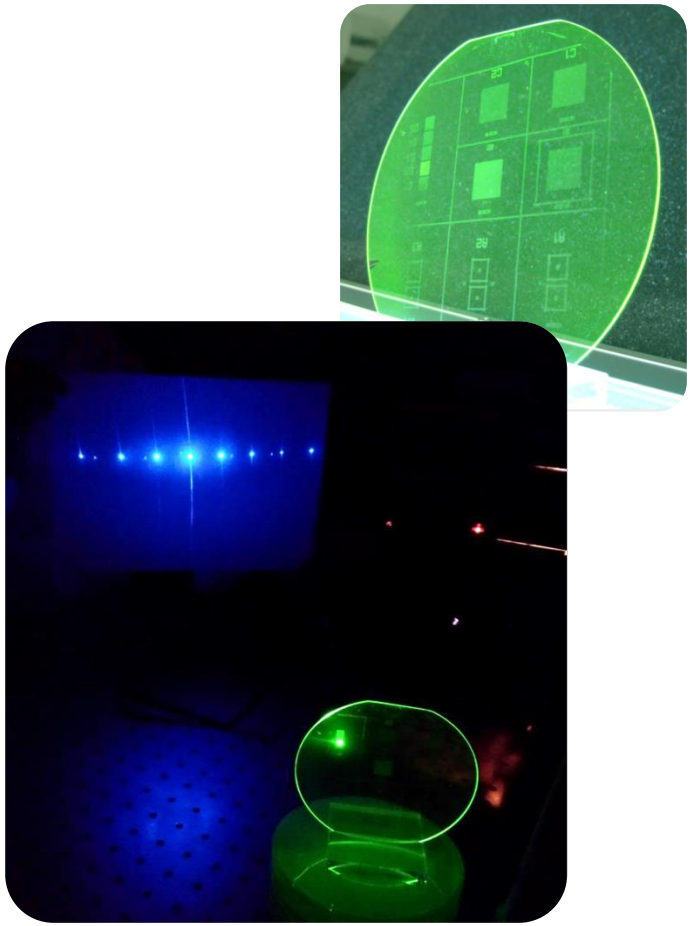
Thermal Imprint of fluorescent Nanoparticles (FNP)

PDMS soft stamp



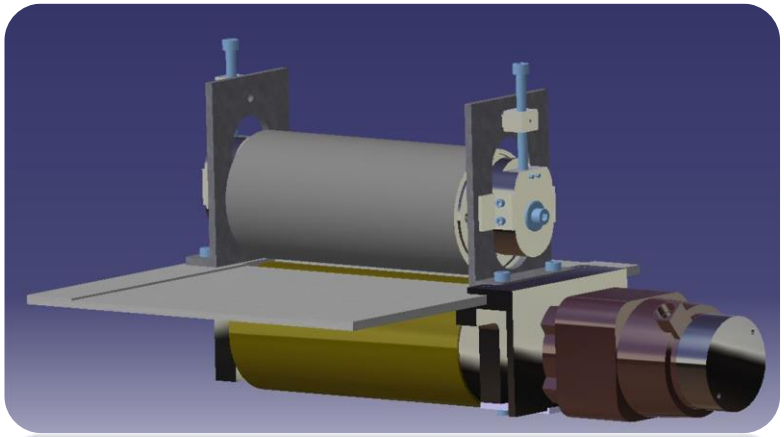
Imprint

T_{imp} = 130°C
p = 2 bar
t = 10 min



- remaining fluorescent behavior for temperatures up to 130°C
- no effect of FNP on structure quality

Outlook



Lab-scale roll-to-roll nanoimprint device

- heating the surface of a thermoplastic polymer sheet by flash lamp

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Thank you for your attention!

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