CURRENT STATUS OF NANOIMPRINT LITHOGRAPHY DEVELOPMENT IN CNMM

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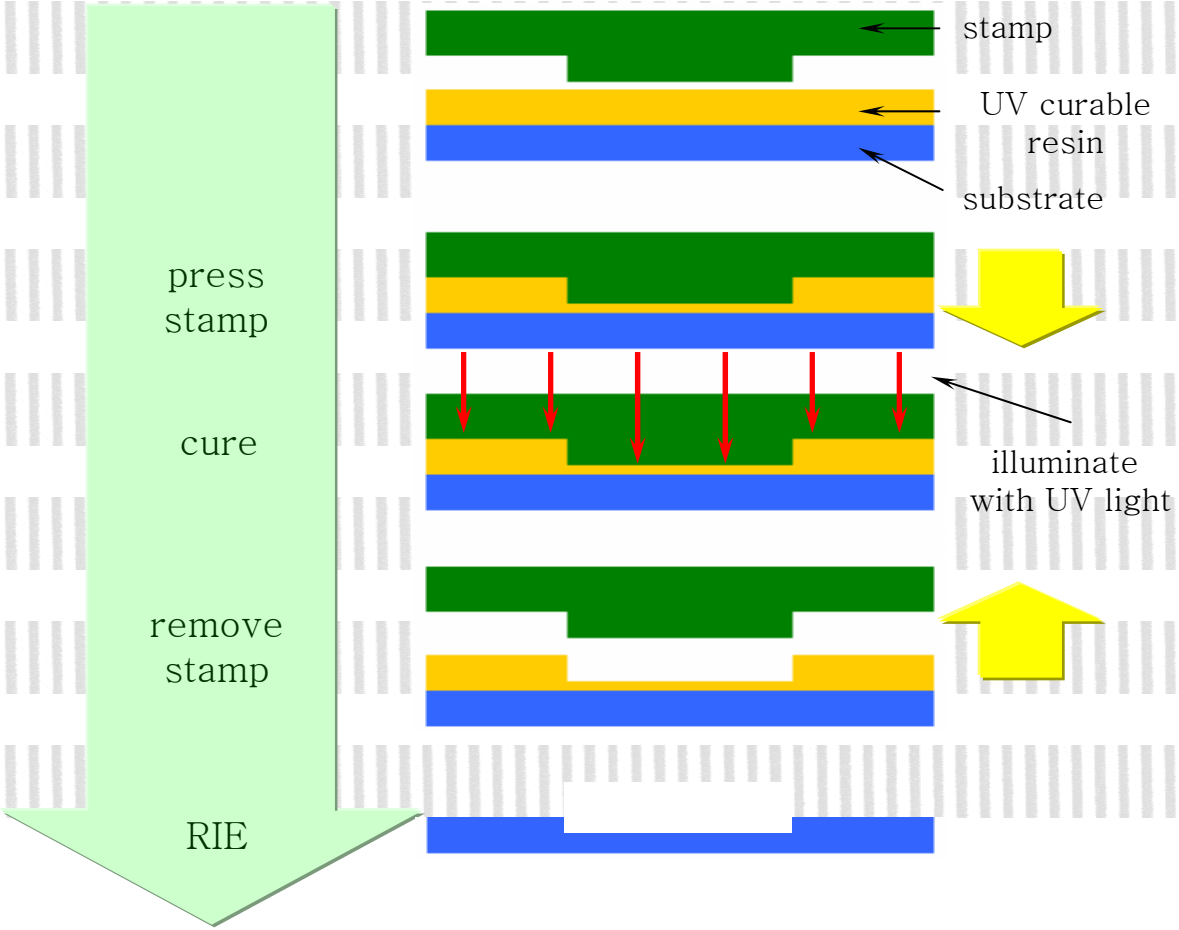
Outlines

Process technology

Single step UV-NIL

UV-NIL using a elementwise patterned stamp (EPS) in a low vacuum environment

Schematic of UV nanoimprint lithography (UV-NIL)



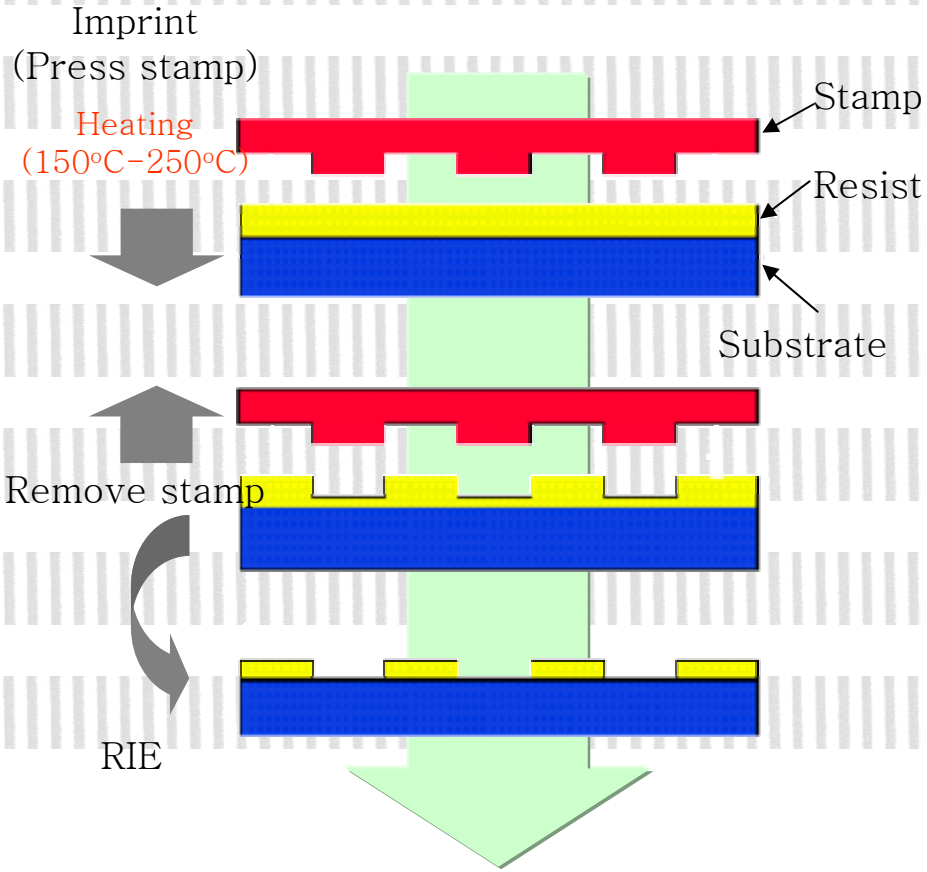
Characteristics of UV-nanoimprint lithography

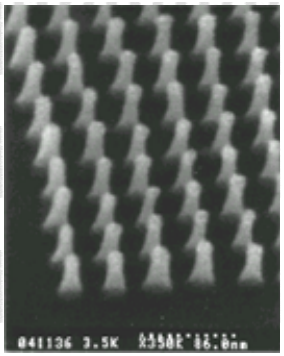
	Thermal type NIL	UV type NIL
Resin	Thermoplastic polymer	UV curable resin
Stamp material	Silicon, Nickel	Quartz, glass (transparent)
Processing temperature	> T_g (glass transition temperature)	Room temperature
Processing pressure	High (~ 30 bar)	Low (~ 1 bar)

- Advantages for mass production, multi-layer process, and step & repeat process

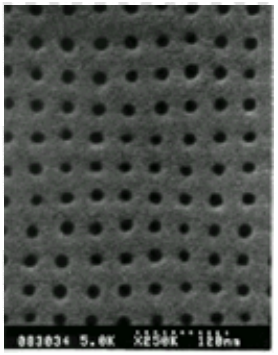
Recent studies on NIL

5 Nanoimprint lithography– Prof. Chou, Princeton University, 1995

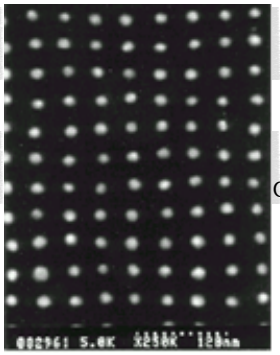




Imprint mold with 10nm diameter pillars

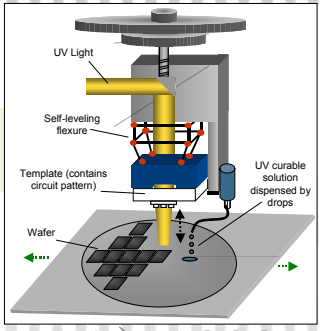


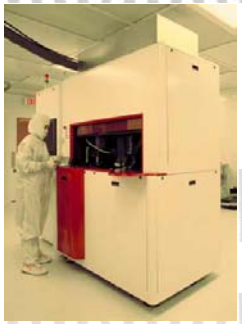
10nm diameter holes imprinted in PMMA



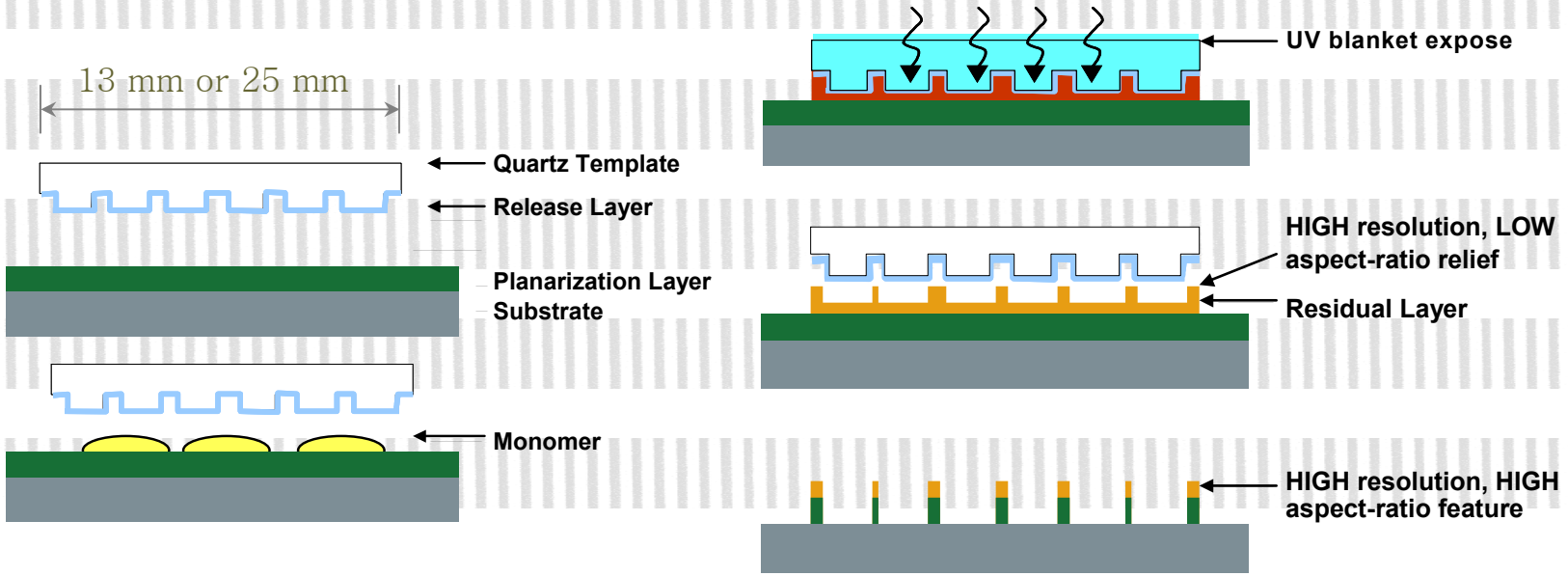
10nm diameter metal dots fabricated by NIL

Recent studies on NIL





- 5 UV-Imprint lithography
  - University of Texas at Austin (Sreenivasan et al.), 1999
  - Molecular Imprints Inc.
    - Step & Flash Imprint Lithography (SFIL)



Motivations

- Step & repeat type UV-NIL using a small area (≤ 1 in.) stamp

  ⇒ Low-throughput

  (The imprint time is 2-3 minutes for each field and 10-20 minutes for a 4 in. wafer)

- Single step UV-NIL using a large-area stamp in a medium/ high-vacuum environment

  ⇒ requires a vacuum-compatible system and UV curable resin

- For high-throughput manufacturing

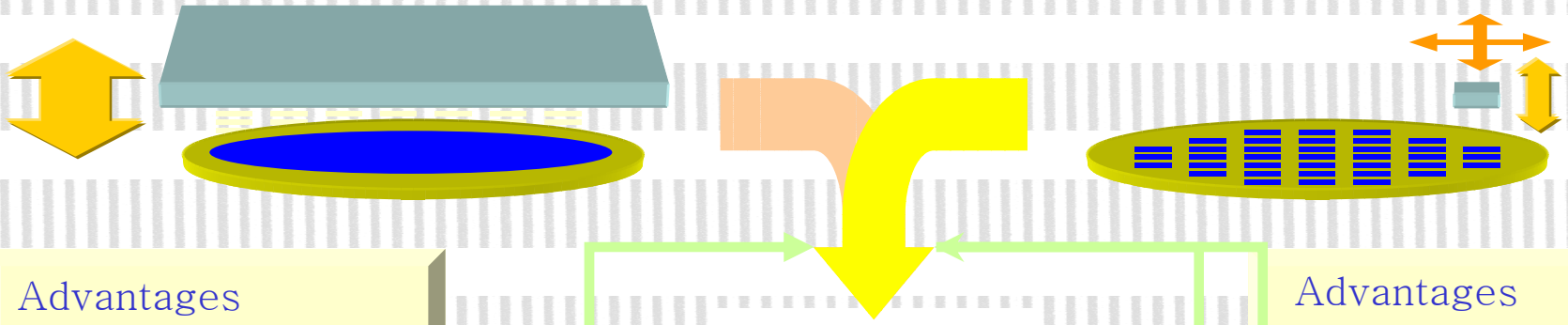
  ⇒ We have developed new UV-NIL processes using a large-area stamp in a low-vacuum or atmospheric environment

Elementwise patterned stamp

In a low vacuum-pressure or atmospheric environment

Single-step UV-NIL
using a large area flat stamp

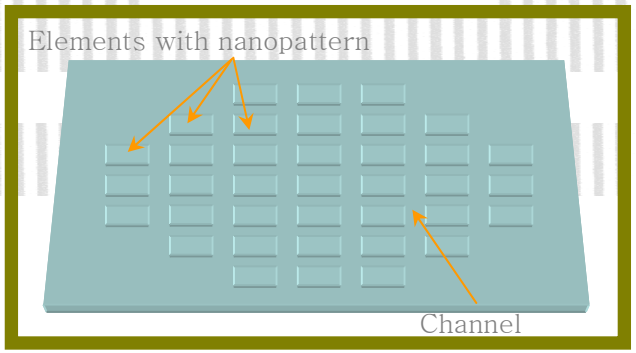
Step-and-repeat UV-NIL
using a small stamp



Advantages

- High-throughput

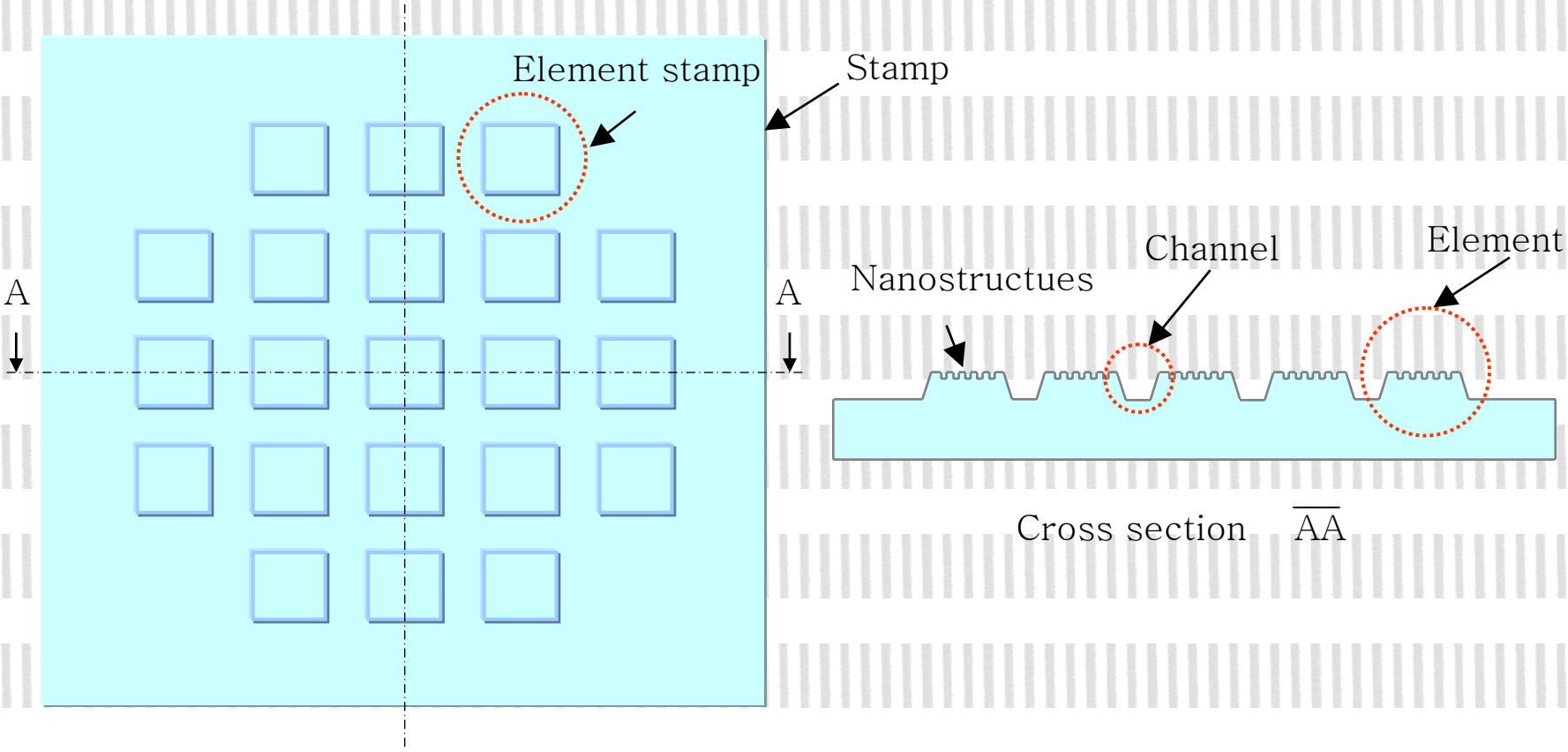
UV-NIL using EPS



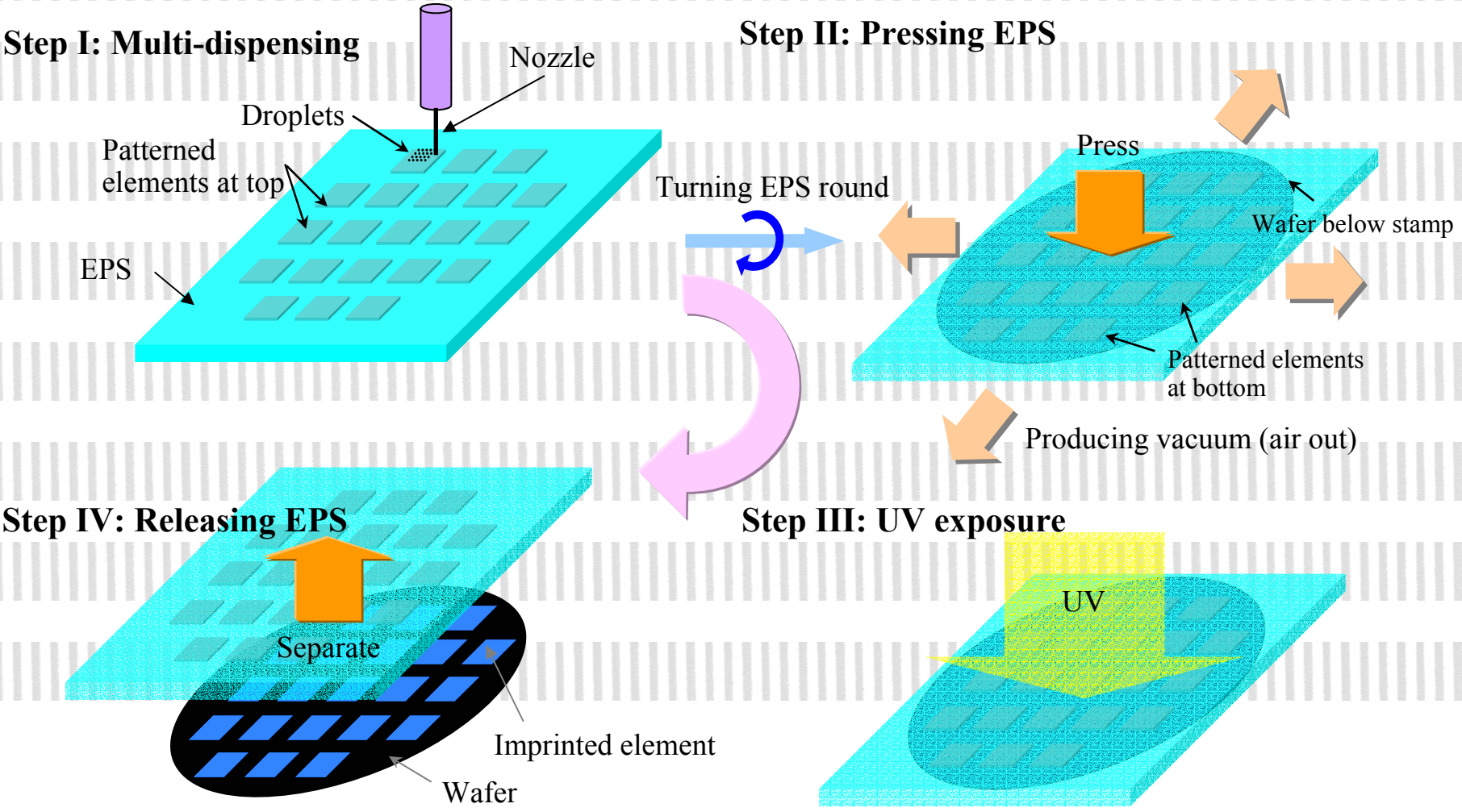
Advantages

- Low-cost stamp
- Prevention of air entrapment
- Easy release
- Precise alignment for each field

Elementwise patterned stamp



UV-NIL process using EPS

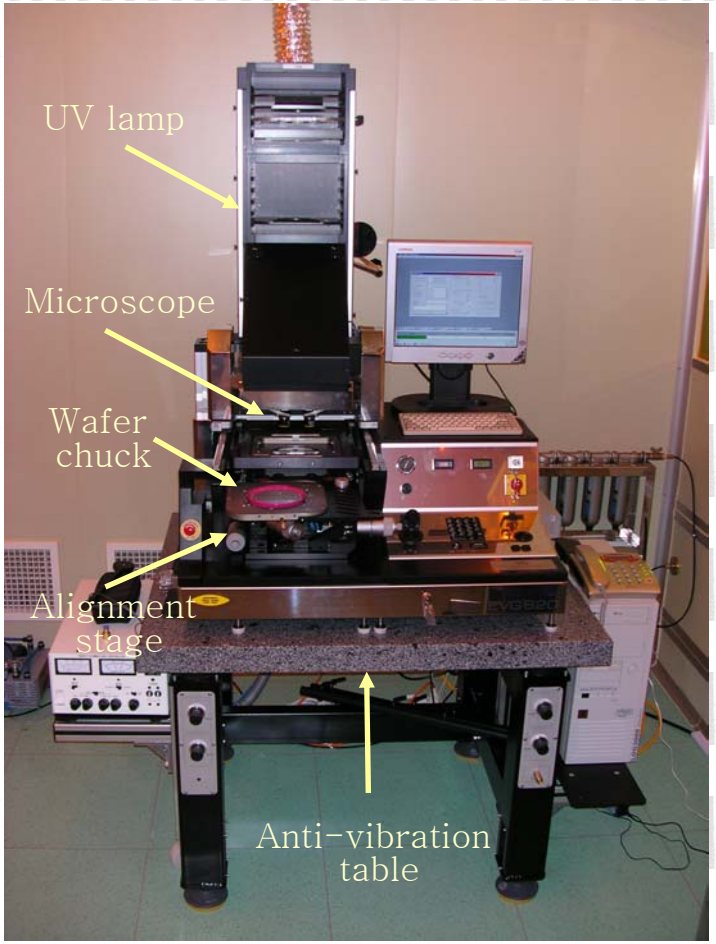


UV-NIL process using EPS

- Equipment- EVG620-NIL
  - Use 4 in. wafer
  - Vacuum hard contact mode

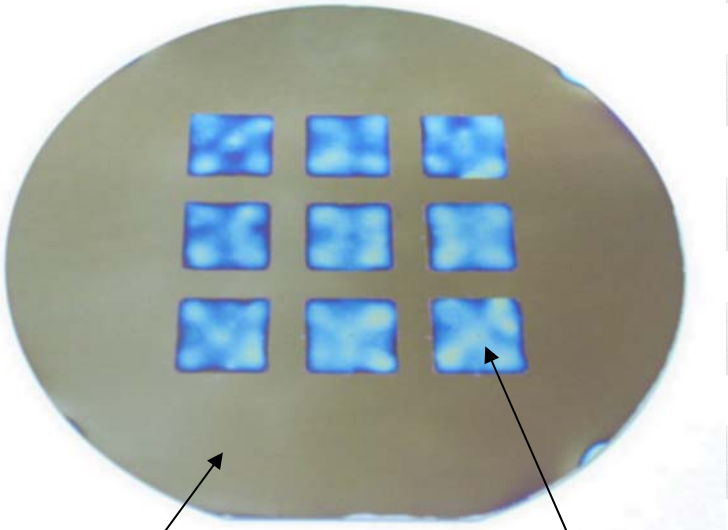
Parameters	
Pressure	800mbar
Exposure time	60 sec
Exposure intensity	36 mW/cm^2

- UV curable resist
  - PAK01(viscosity = 7 cps)

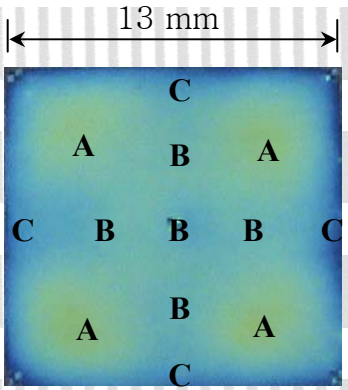


UV-NIL process using EPS

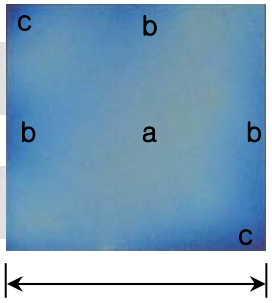
- 4 in. wafer with 9 successfully imprinted elements



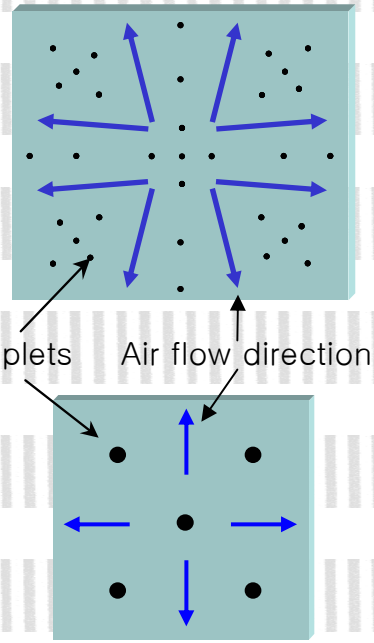
- Residual layer thickness (RLT) distribution



A: 90 - 100 nm
B: 60 - 70 nm
C: 50 - 60 nm

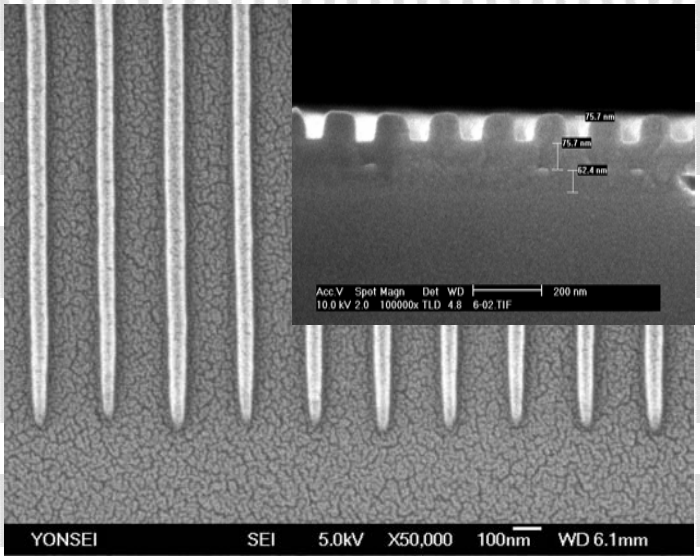


a: 70 - 80 nm
b: 50 - 60 nm
c: 40 - 50 nm

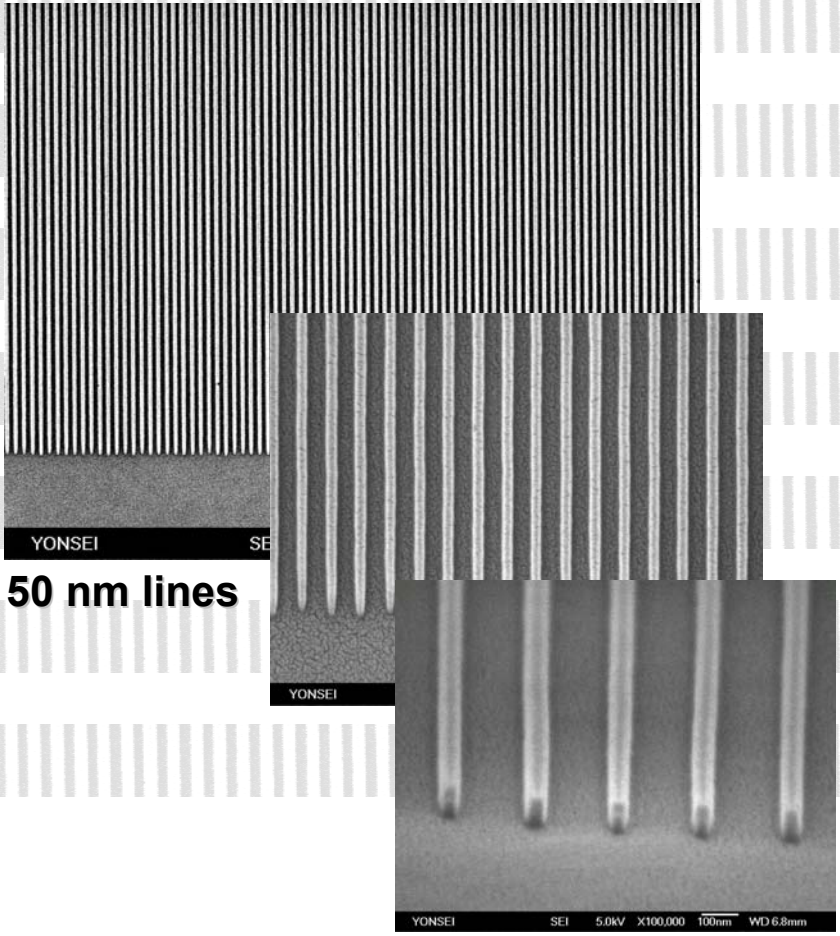


UV-NIL process using EPS

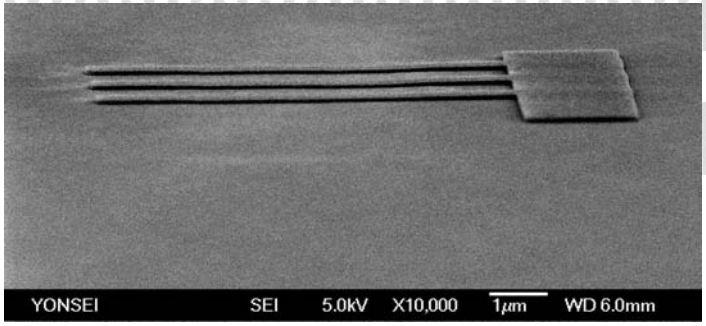
- Imprint results



70 nm lines



50 nm lines



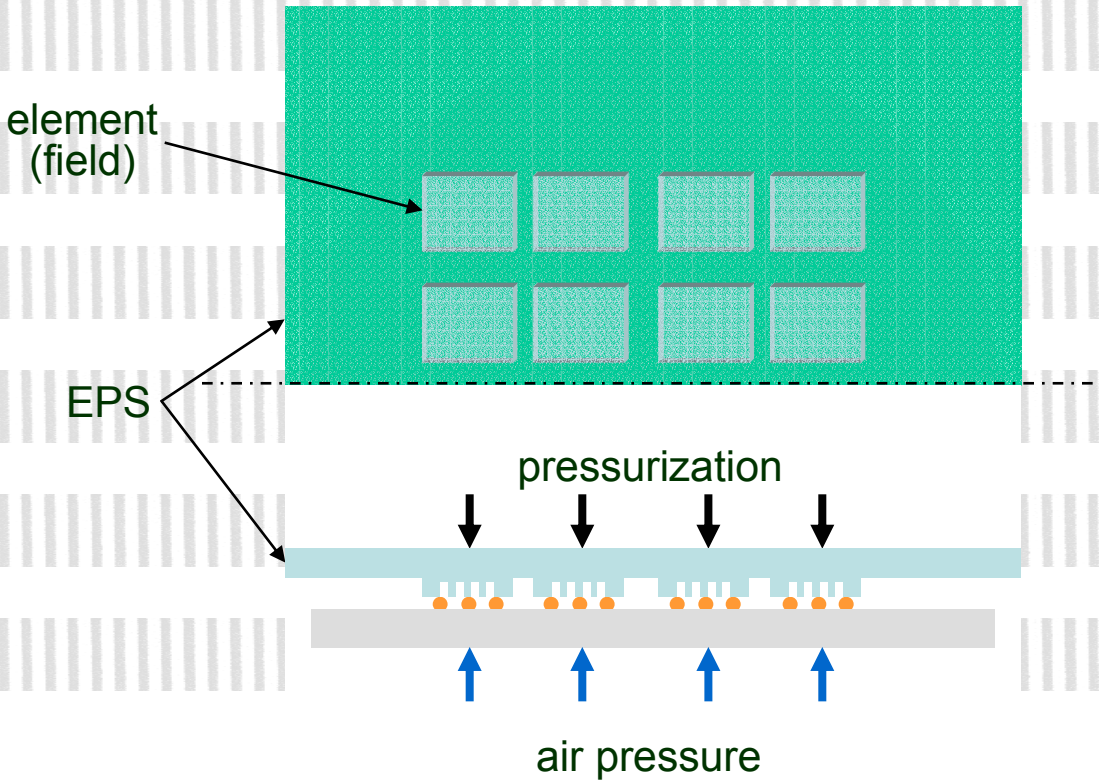
Process Technology

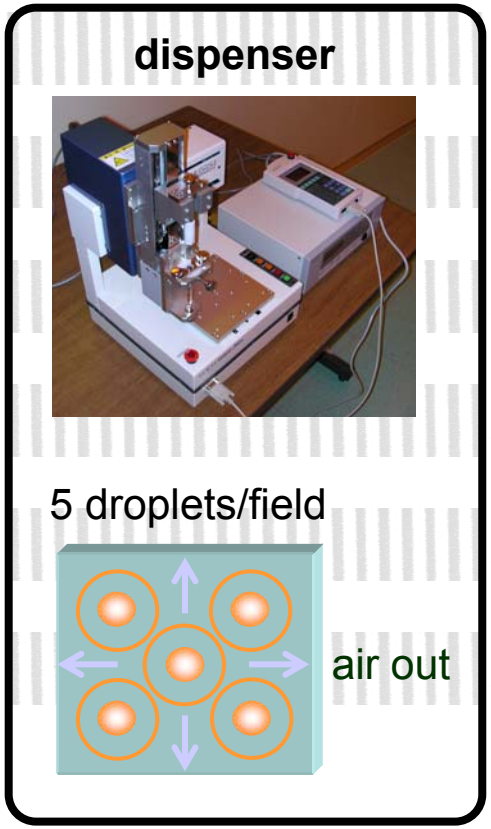
Single Step UV-NIL

UV-NIL using EPS and Additive Pressurization in an Atmospheric Environment

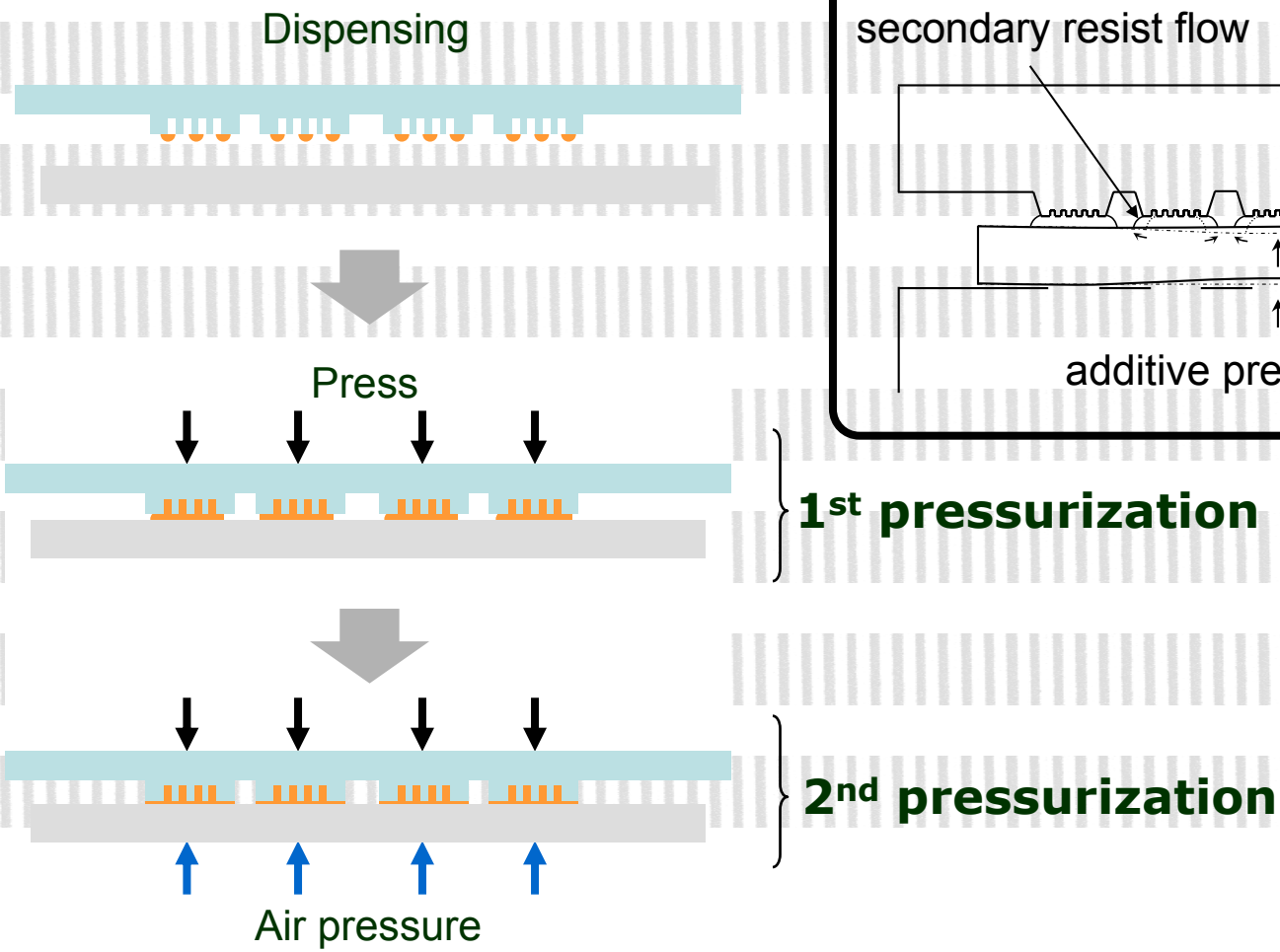
Single-step UV-NIL in an atmospheric environment

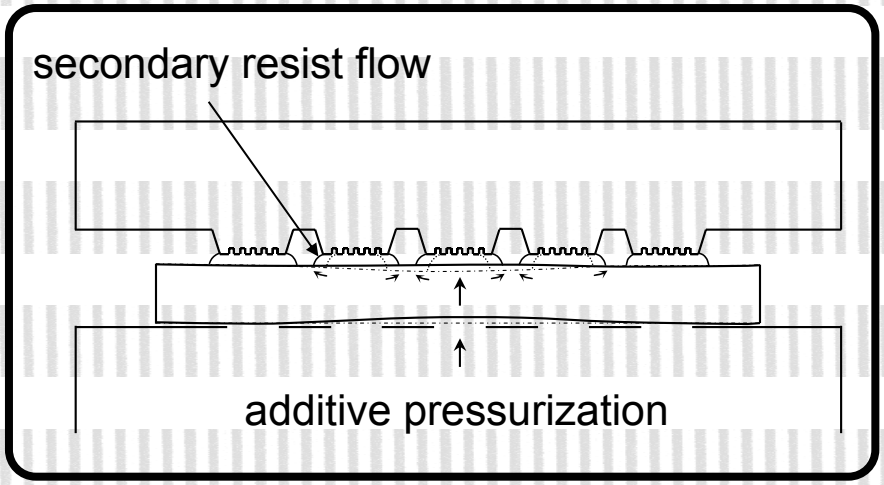
- **Elementwise Patterned Stamp (EPS): avoid air entrapment**
- **Additive Pressurization: uniform residual layer thickness**



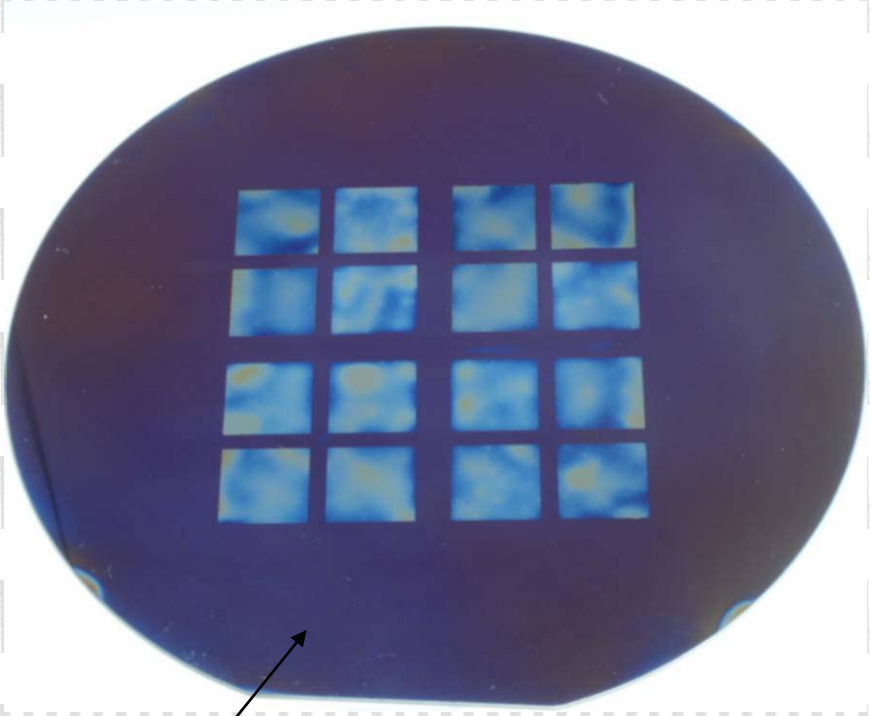


Single-step UV-NIL in an atmospheric environment

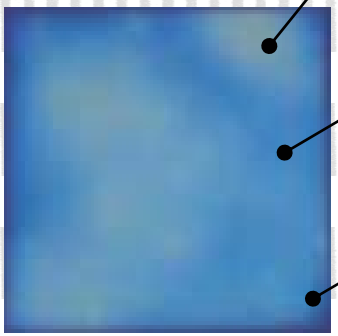




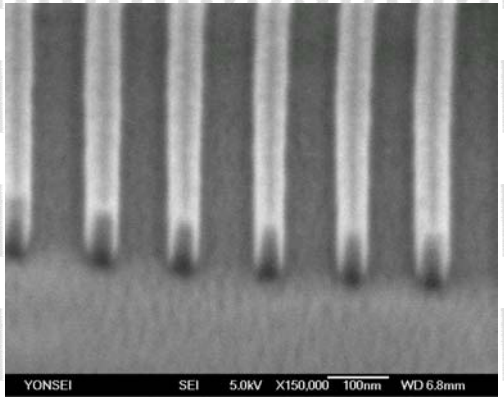
Imprint results



planarization layer (60 nm)



residual layer thickness



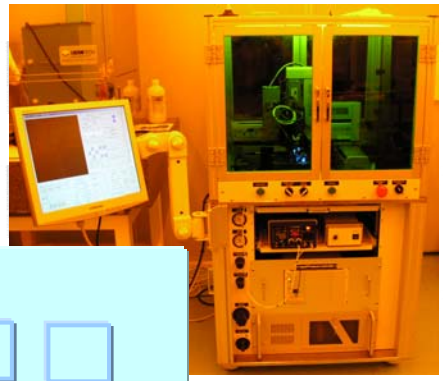
50 nm lines

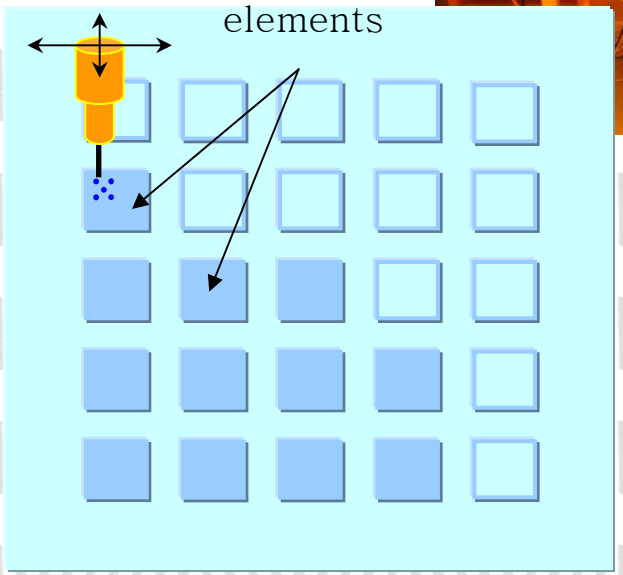
Process Technology

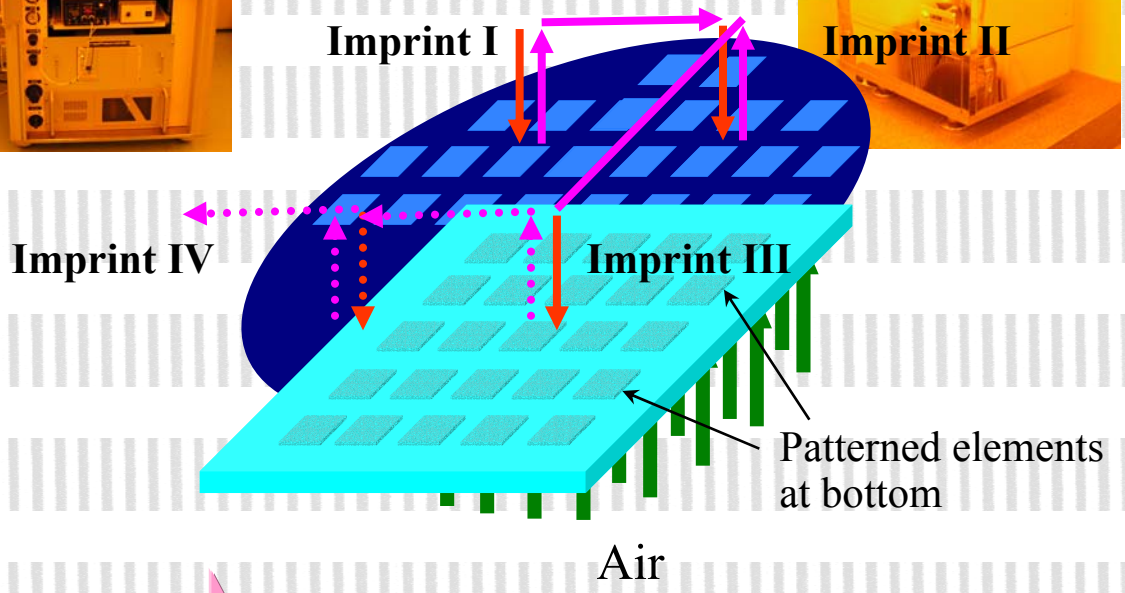
Step and Repeat UV-NIL

High Throughput Step-and-Repeat UV-NIL using a Large Area EPS

Step-and-repeat UV-NIL in an atmospheric environment



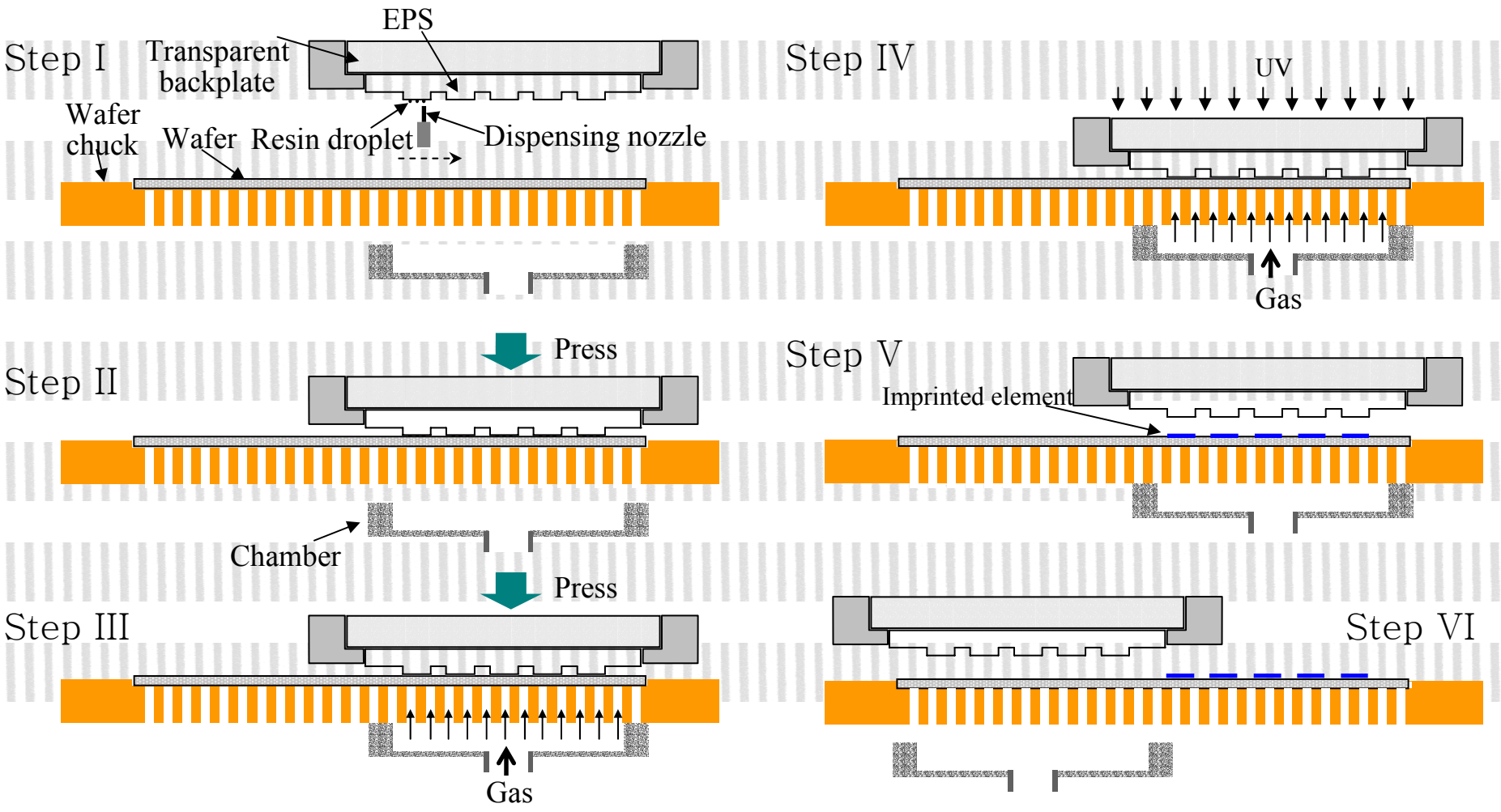




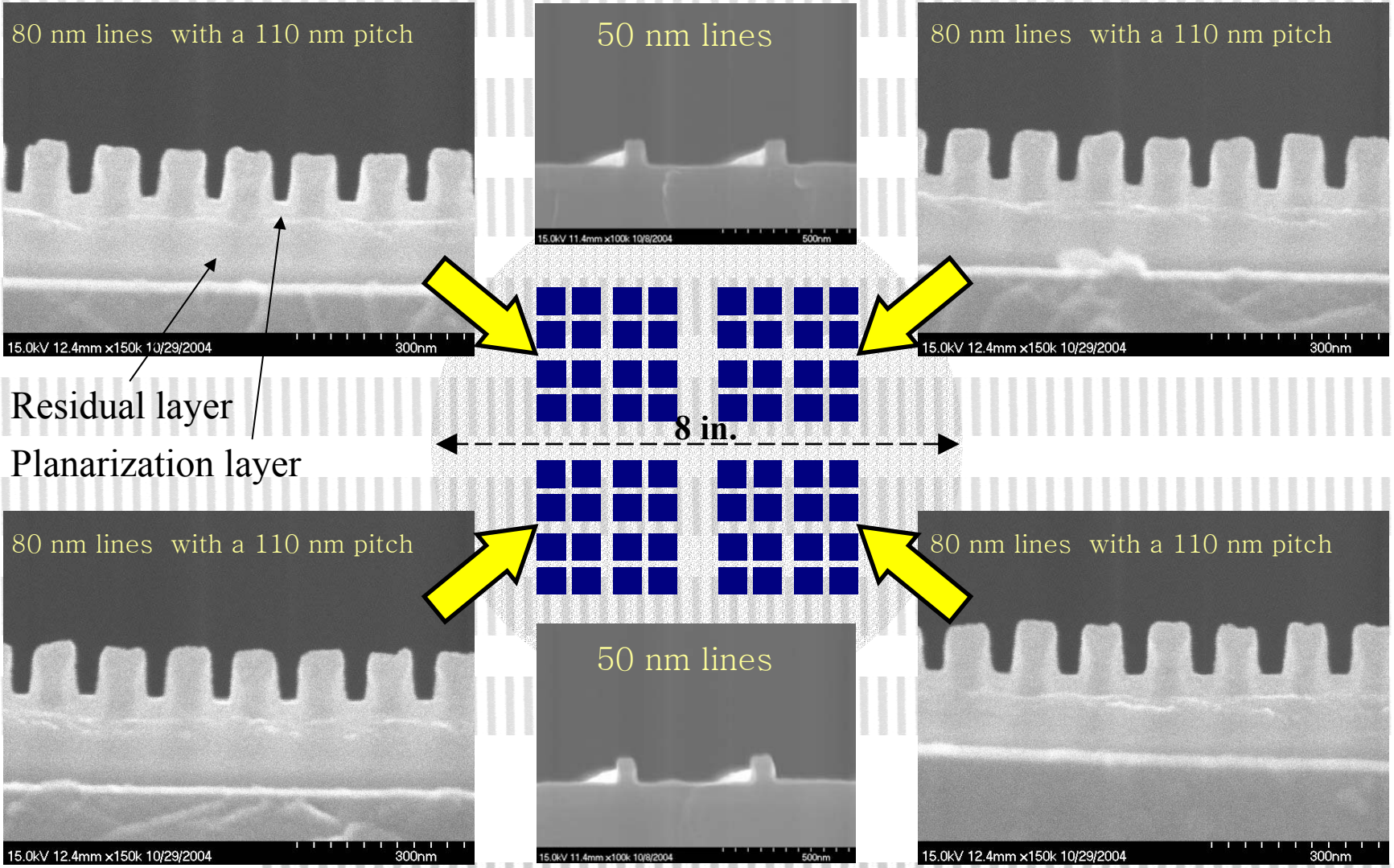
Selectively dispensing

Step-and-repeat imprint

Step-and-repeat UV-NIL in an atmospheric environment



Step-and-repeat UV-NIL in an atmospheric environment



Application Technology

Nano Wire Grid Polarizer

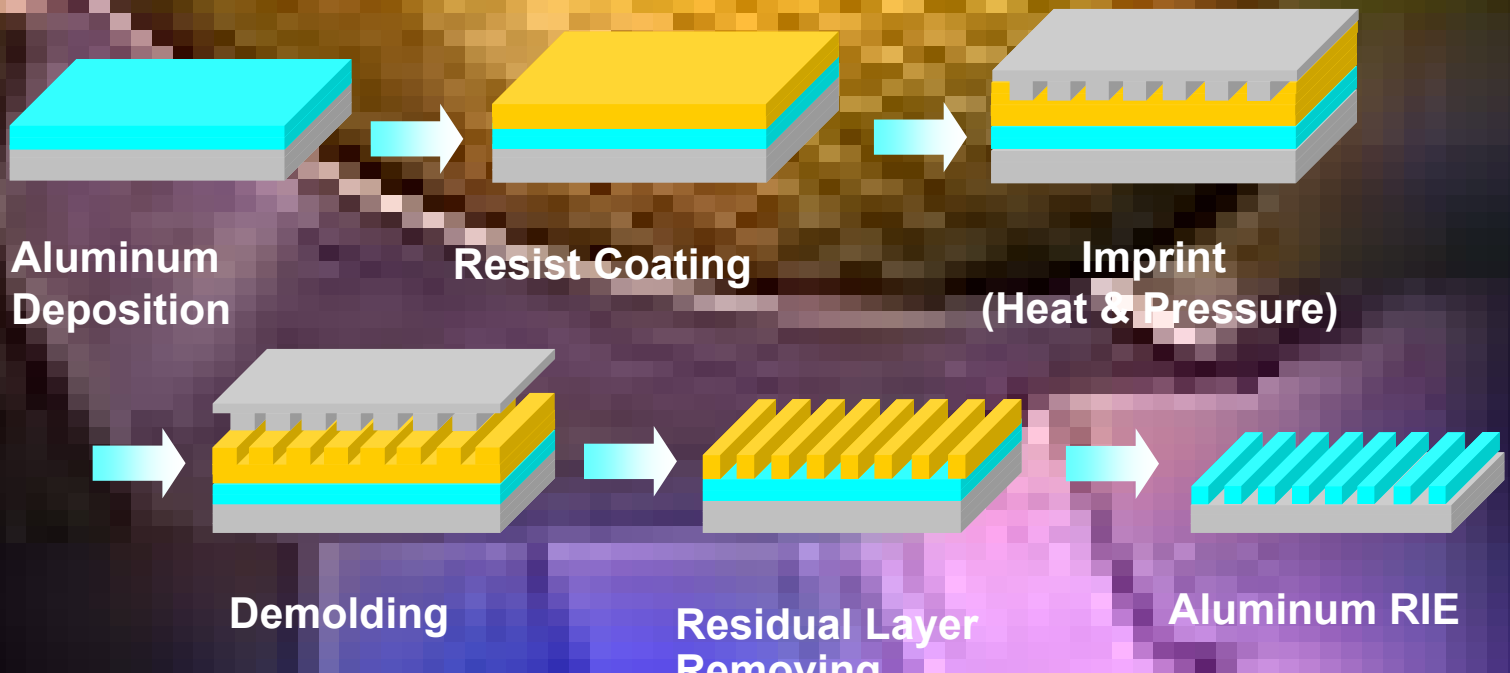
Nanoimprint Lithography

Advantages of Nanoimprint Lithography

High resolution
Low tool cost

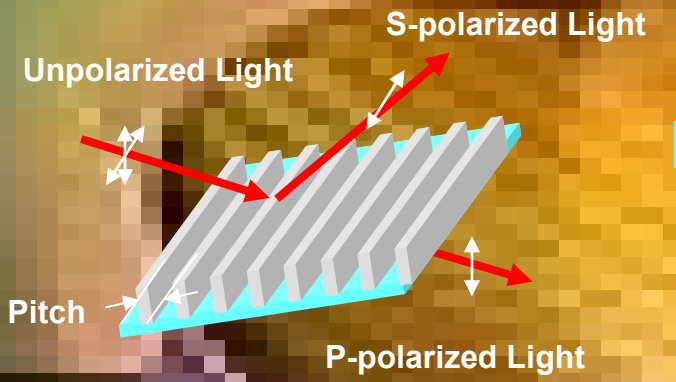
High throughput
Simple process

Process Flow (Nano Wire Grid Polarizer)

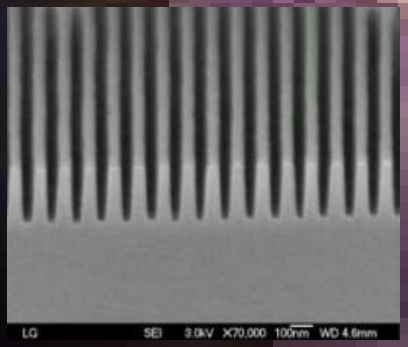


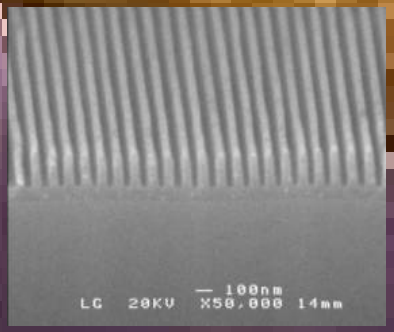
Nanoimprint Lithography

Development - Nano Wire Grid Polarizer



Projection TV





50 nm Half-Pitch Stamp

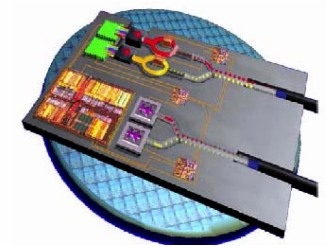
Imprinted Polymer Pattern

Contrast Ratio > 2,000,
Transmission > 83 % at λ= 470 nm

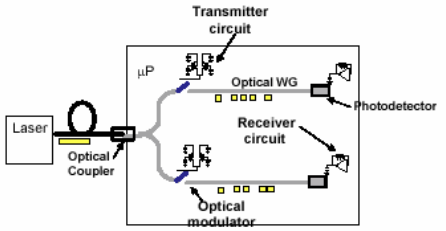
Application Technology

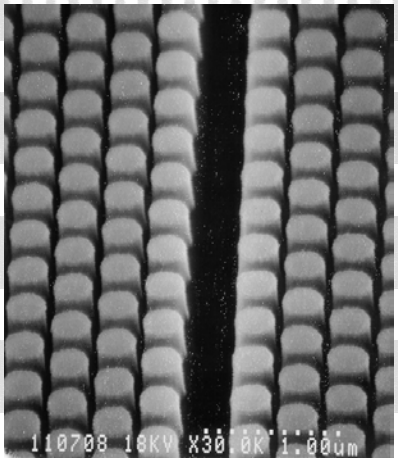
Photonic Band Gap Device

❑ Nanoimprinting of Photonic Crystal Waveguides



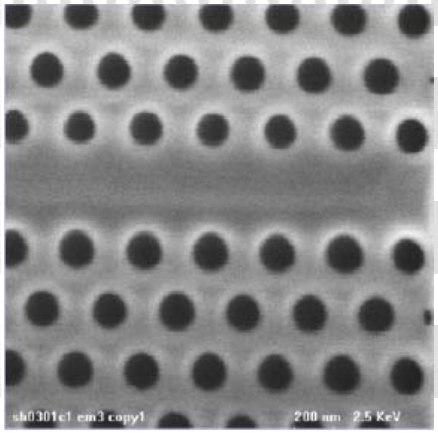
Future vision of hybrid optical integration of an optical transceiver with silicon photonic components and conventional CMOS drivers

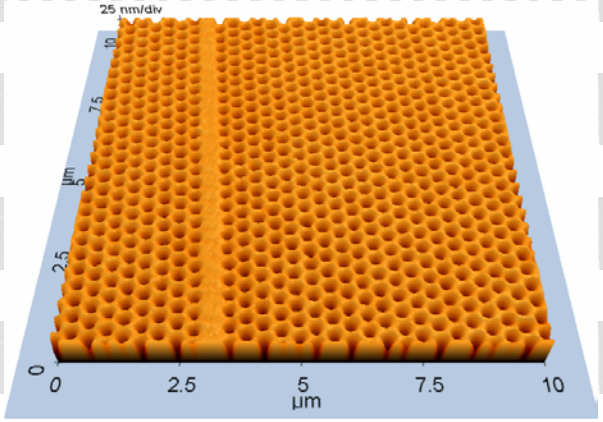




<SEM Image of Master>

Dimension
r = 150 nm
a = 400 nm

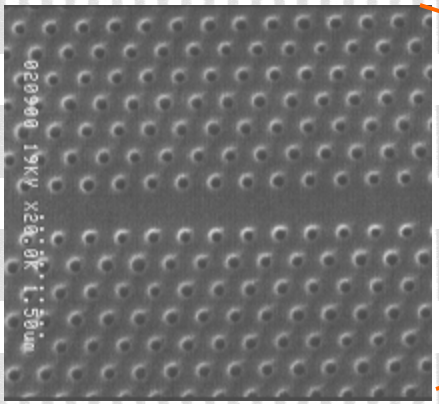


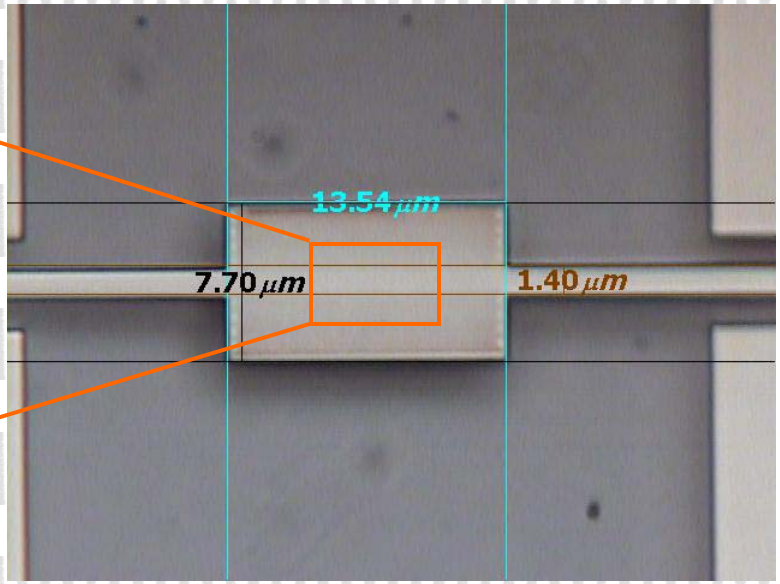


<SEM and AFM Images of Nanoimprinted Photonic Crystal Waveguide>

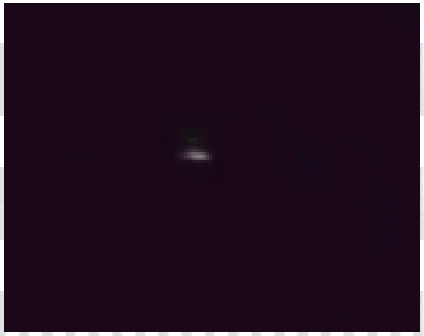
Dimension
r = 160 nm
a = 405 nm
Height = 335~340 nm

❑ Completed Photonic Crystal Waveguide





Dimension : 7.7 X 13.5 μm



<Near Field Pattern of
Photonic Crystal Waveguide>

Tool Technology

Single-step UV-NIL tool

UV-based Nanopatterning Equipment - CNMM

- **Area : 4 inch Wafer**
- **Min. Feature Size ≤ 100 nm**
- **Chip-size Multi-Head Imprinting**

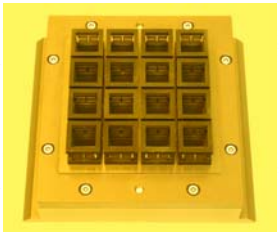
Nano-Precision Stage: 3nm

3-Axis Nano Leveling

Overlay & Alignment

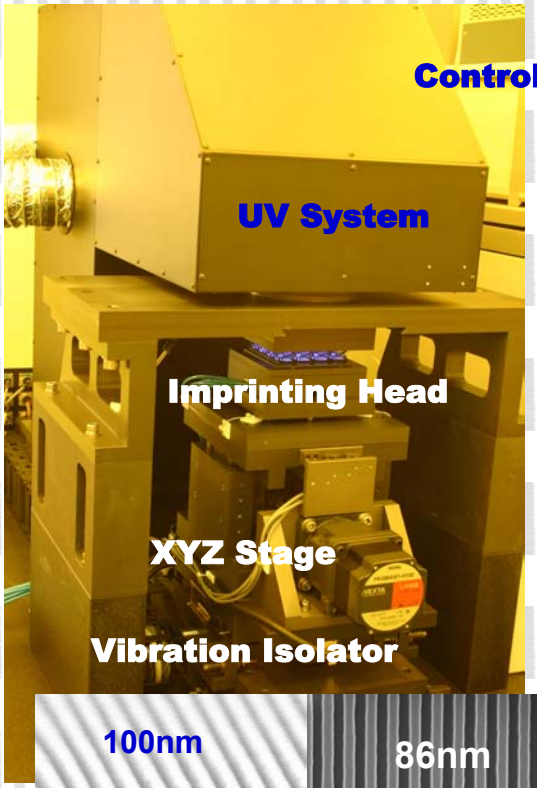
UV Light Source

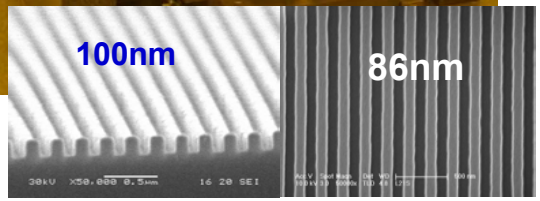
Vibration Control



Flexure stage for parallelization

NanoImprint Equipment





Summary

- NIL has several advantages over optical lithography
  - High resolution (feature size ~ 10 nm)
  - low cost
- Challenging issues
  - Minimizing defects
  - Residual layer thickness control
  - 1×stamp inspection and cleaning
  - 10 nm scale overlay alignment

Thank You!