Molecular Imprints

The Impact of Step and Flash Imprint Lithography for Nano-Manufacturing in Emerging Market Applications

Pascal Gubbini , Niyaz Khusnatdinov, Gerard Schmid, Nick Stacey , Ian McMackin,
Jin Choi, Ecron Thompson, Rob Hershey, Dwayne Labrake

Litho 2006 Marseille

Molecular Imprints Solution

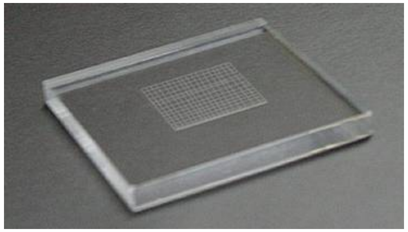
Tool

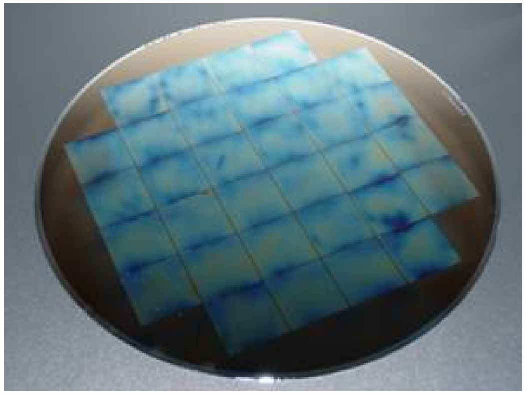
Material

complete Solution

Template Support

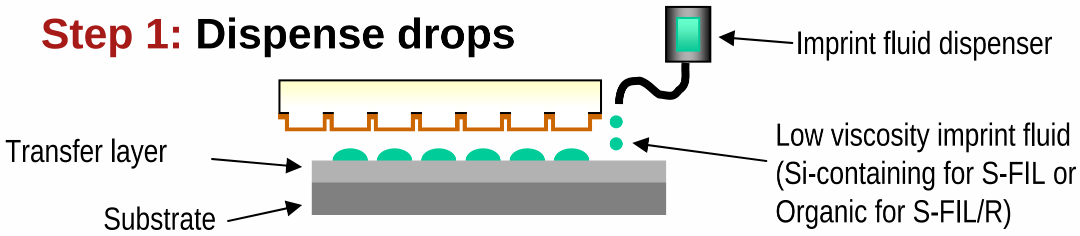
Process



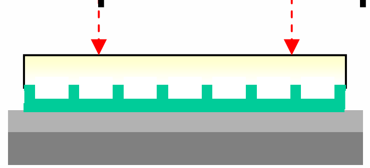


Step & Flash Imprint Lithography (S-FIL & S-FIL/R™)

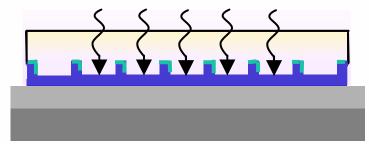
Step 1: Dispense drops



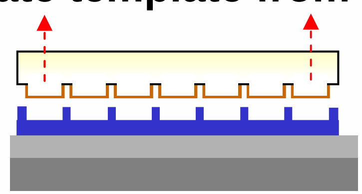
Step 2: Lower template and fill pattern



Step 3: Polymerize imprint fluid with UV exposure

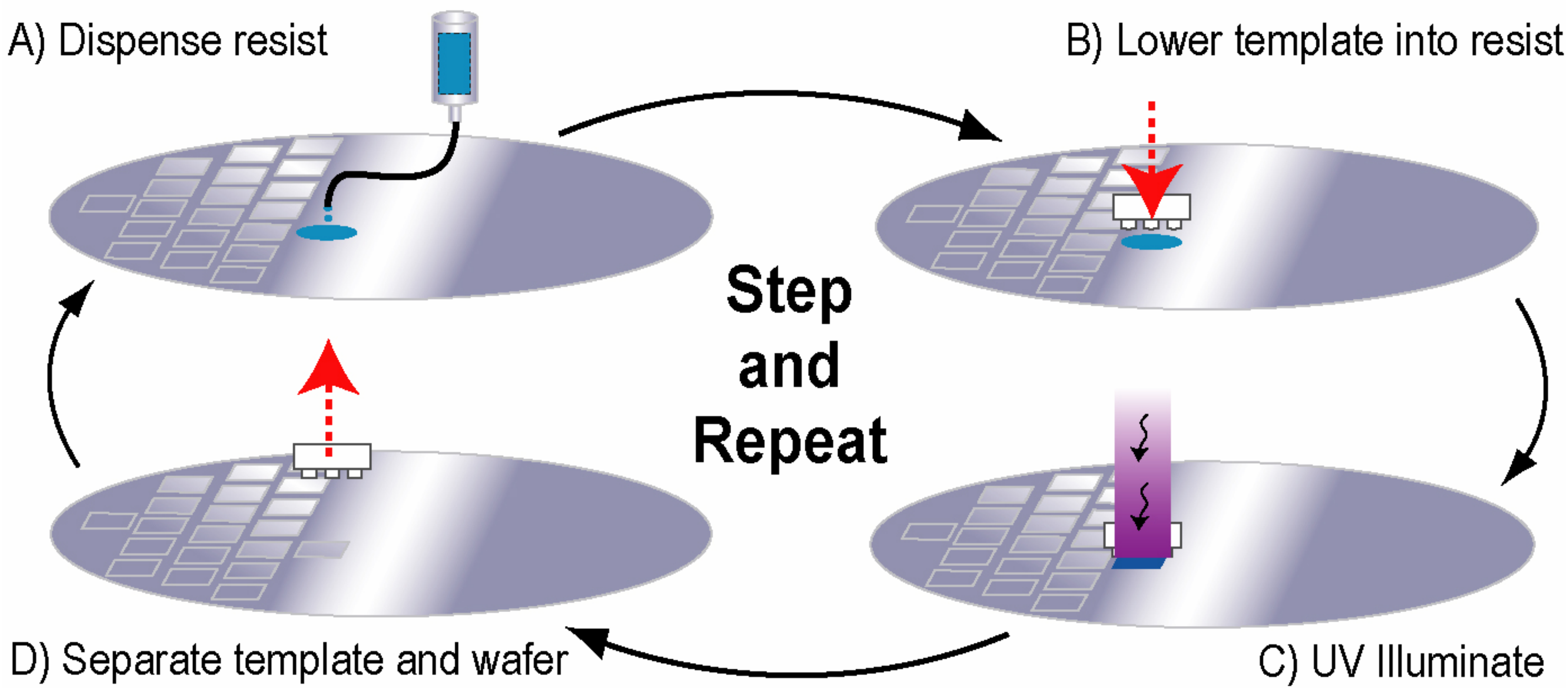


Step 4: Separate template from substrate



Process on wafer scale

Step and Flash Imprint Lithography (S-FIL™)

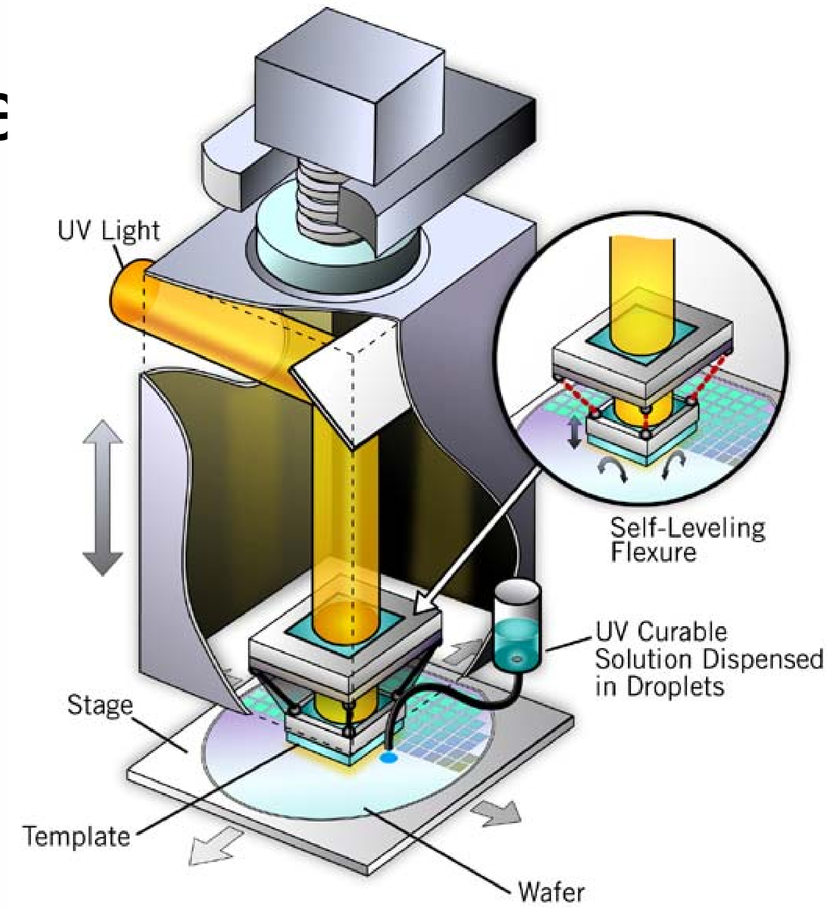


Room temperature
Low pressure

Step & Flash Imprint Lithography (S-FIL & S-FIL/R™)

- Field-to-field fluid dispense
- Low viscosity fluid (1 to 5 cps)
- Liquid volume match template pattern

- Room temperature
- Low pressure (< 0.5 psi)
- No contact between template and substrate



Imprio Products

IMPRIO 55

- Overlay: 1 um, 1s
- Up to 200 mm
- 25x25mm field

IMPRIO 100

- Overlay: 500 nm, 3s
- Up to 200 mm
- 25x25mm field
- Automatic Field Alignment

IMPRIO 250

- Overlay: 50 nm, 3s including magnification correction
- Up to 300 mm
- 26x33mm field
- Fully Automatic cassette to cassette wafer handling.

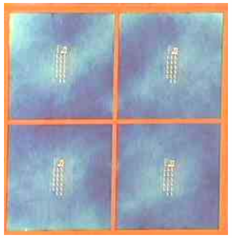
Sub 100nm Lithography techniques

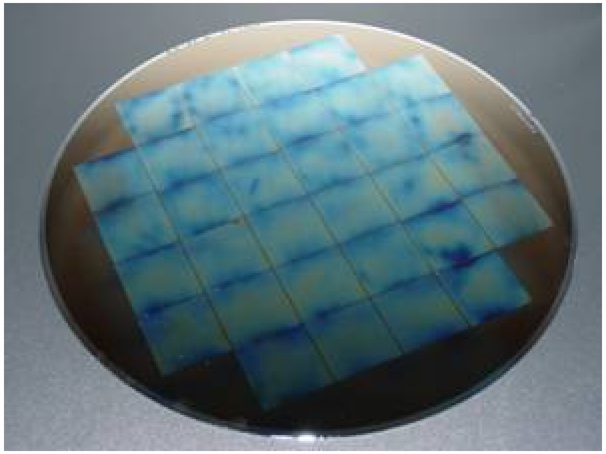
	Optical Litho	EBL	Nano-imprint
Low Defect Process	√	√	√
Pattern Independence	√	--	√
Precision Overlay Alignment	√	√	√
Handles Fragile Substrates	√	√	√
High resolution	--	√	√
Reliable processes	√	√	√
Wafer scale uniformity	√	√	√
Copies Critical Dimensions Exactly Excellent LER and CD control	--	--	√
3-D Patterning of Functional Materials	--	--	√
Low Cost of ownership for sub-500 nm resolution patterning	--	--	√

Complementary Techniques

E-Beam: can write patterns down to 8nm resolution but at slow speed

Nanoimprint pattern a full wafer in minutes.

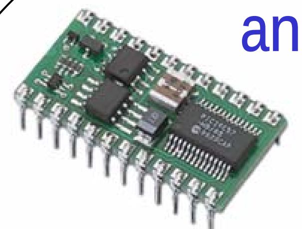




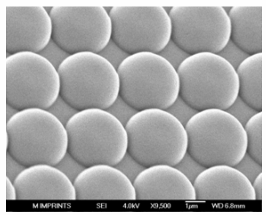
Nanoimprint Lithography : The E-Beam Amplifier

S-FIL Nanoscale Market Opportunities

Integrated Circuits and Devices

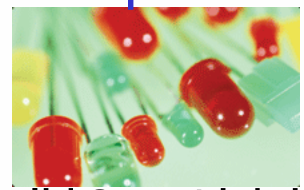


Semiconductors

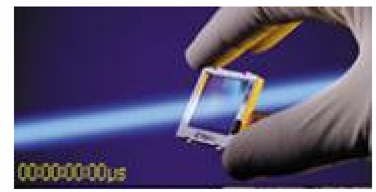


Optic Above IC's

Optical Components



Solid State Lighting

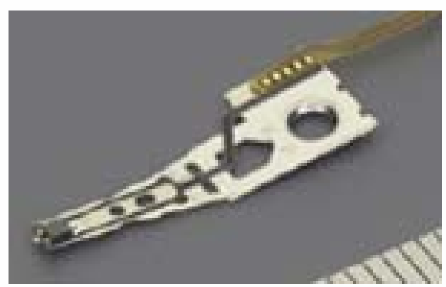


Projection TV's

Potential $6+ Billion/Yr Lithography Equipment Market

Other Applications

Patterned Data Storage

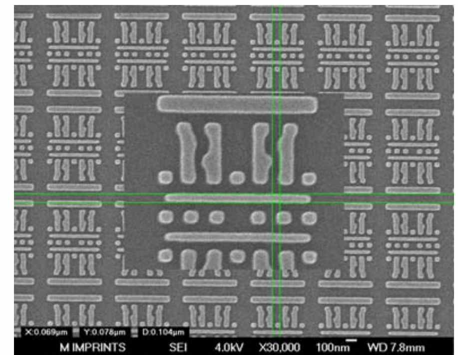


Thin Film Heads

Bio-Medical

Industrial Applications Company Focus

- Advanced Lithography



- LED Light Extraction

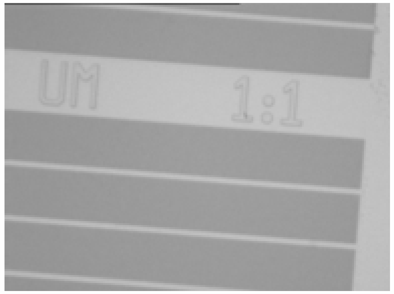
- Optical Elements
- Patterned Media

Molecular Imprints

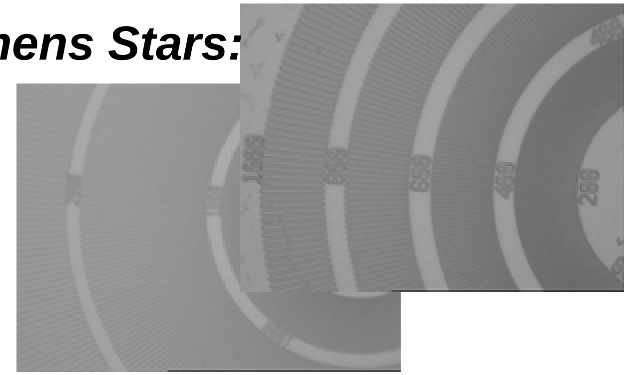
Emerging Market Applications

2D Imprint Capabilities: >100um to <100nm

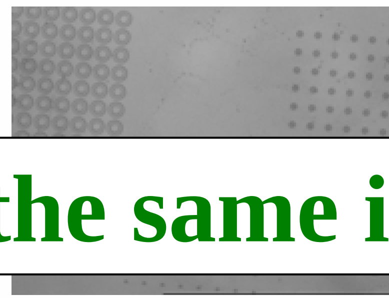
Gratings:

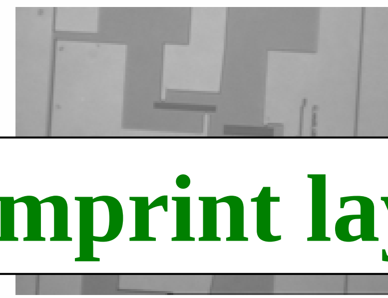


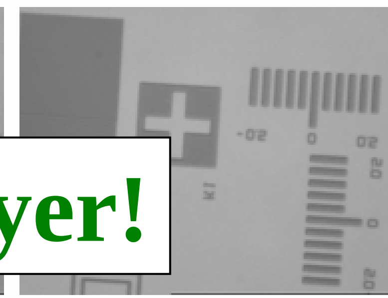
Siemens Stars:



Misc. large features:

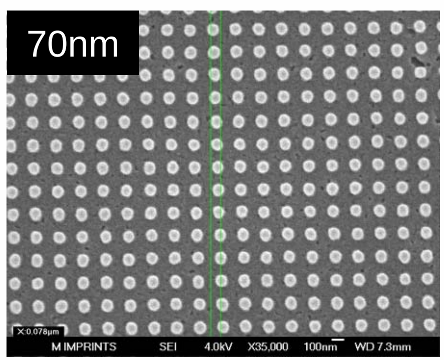


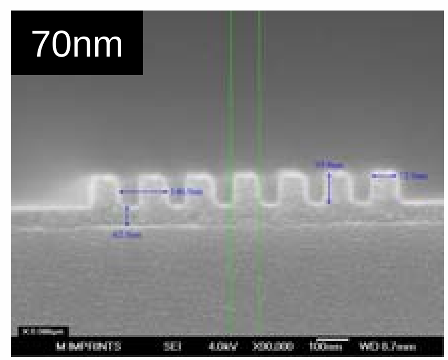


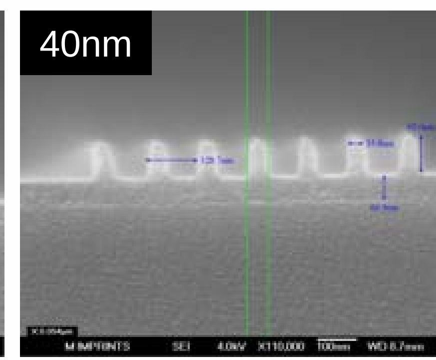


All on the same imprint layer!

Misc. small features:



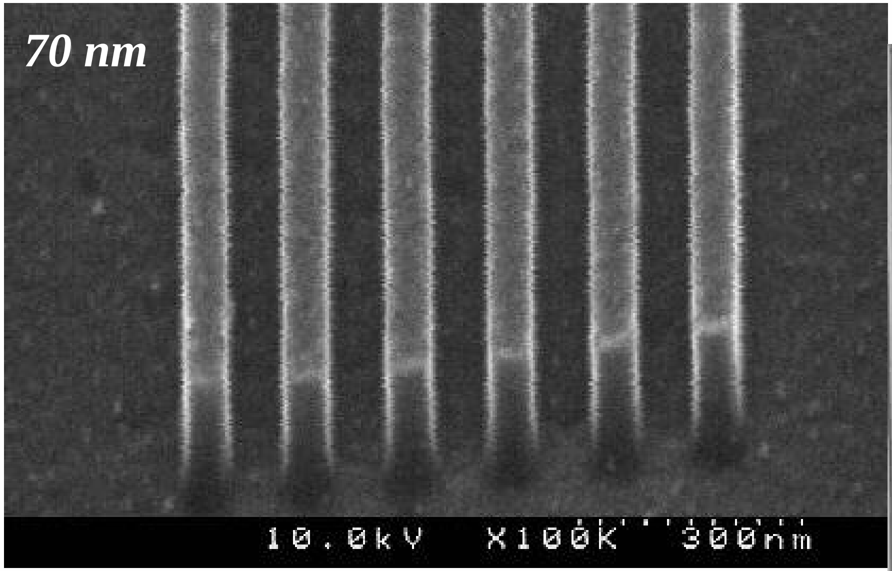


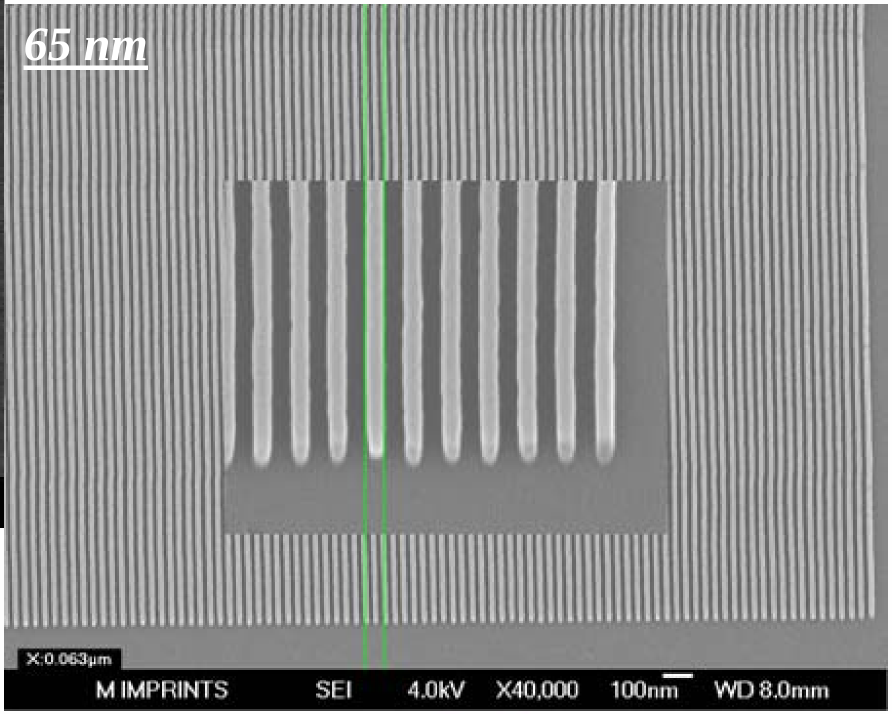


Molecular Imprints

Application: Wire Grid Polarizers

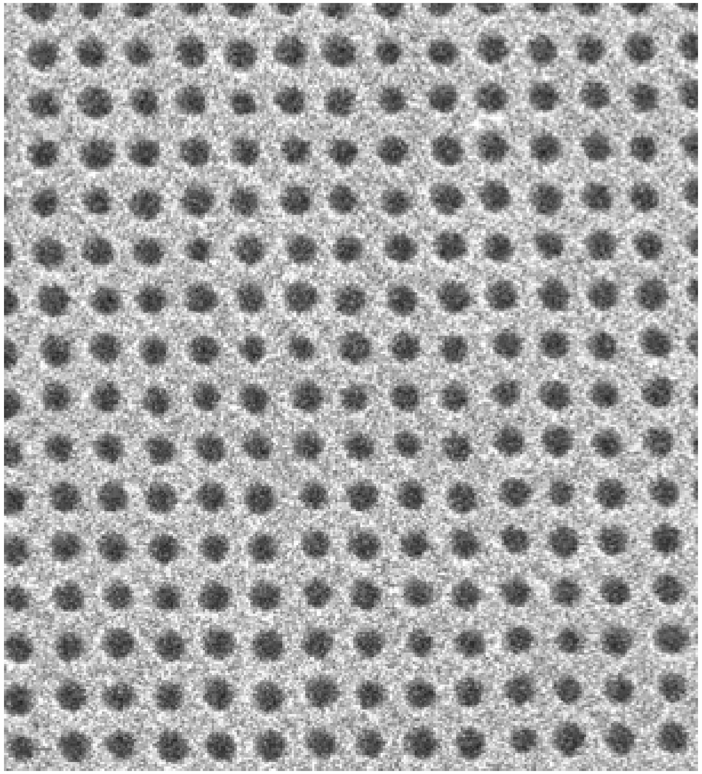
- Goal: Fabricate an aluminum wire grid polarizer on a glass substrate to increase the polarizer's extinction ratio for TV projectors
- Approach: Imprint sub-70nm lines/spaces nano-grating structure
- Experimental Results: >99.5% extinction ratio

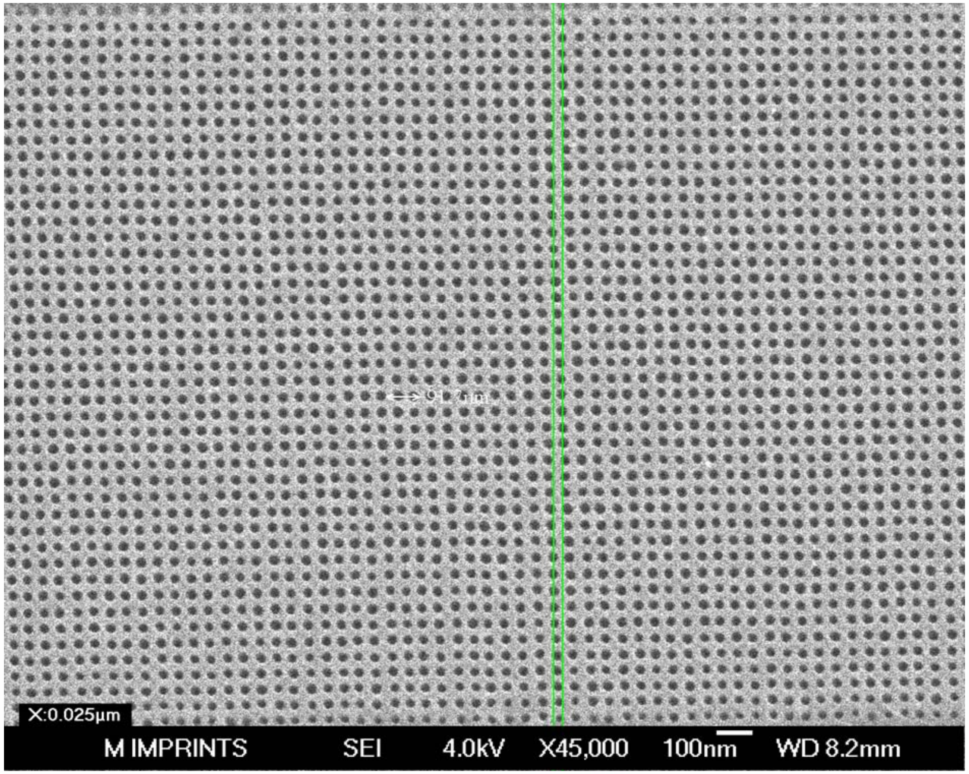




Application: High Density Storage

- Goal: Implement bit patterning on memory disk substrates to increase the memory density of Hard Disk Drives (HDD).
- Approach: Imprint 25nm hyper-dense contacts (45nm pitch)
- Experimental Results: >300 Gb/in^2 capable patterned media

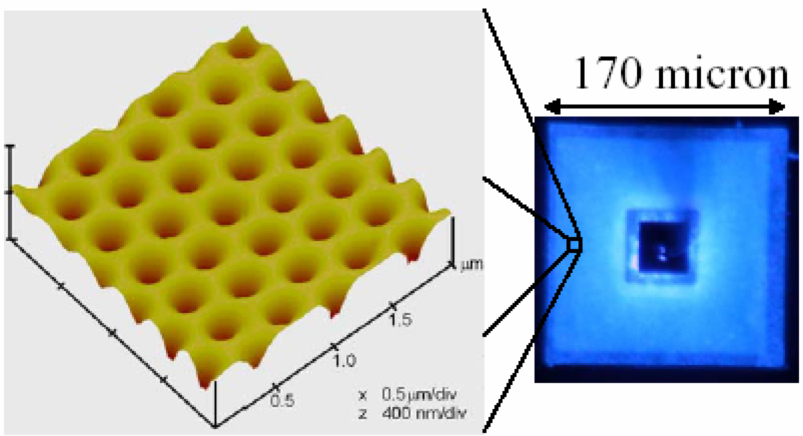




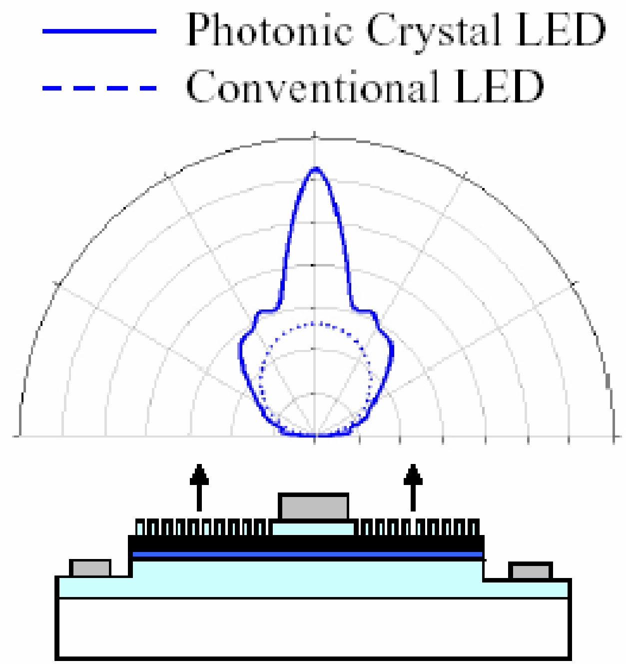
Higher Brightness LEDs using Photonic Crystals

- Goal: High brightness photonic crystal LED (PXLED)
- Approach: Photonic crystal patterned on top of GaN layer
- Experimental Results: Total light extraction gain of ~1.5 times relative to planar LED's , optimize light directionality

Top-view of Photonic Crystal LED



250nm holes etched into GaN



Light intensity vs. angle.
The Photonic Crystal LED's light emission is narrow.

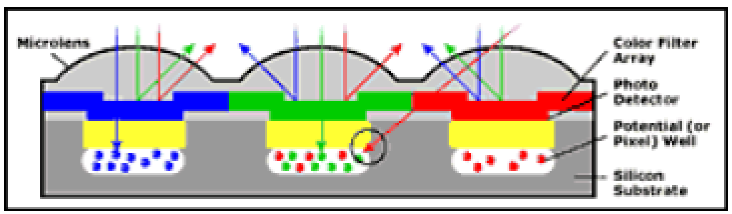
Source: Lumileds, *Applied Physics Letters*, May 10, 2004

Molecular Imprints

Micro-lenses for Image Sensors

Image Sensor Challenges

- Light gathering
  - Shrinking light collection zone
  - Getting correct focal length and alignment
  - Fill factor of Lens relative to pixel
- Reduce Optical Crosstalk



Anatomy of the Active Pixel Sensor Photodiode

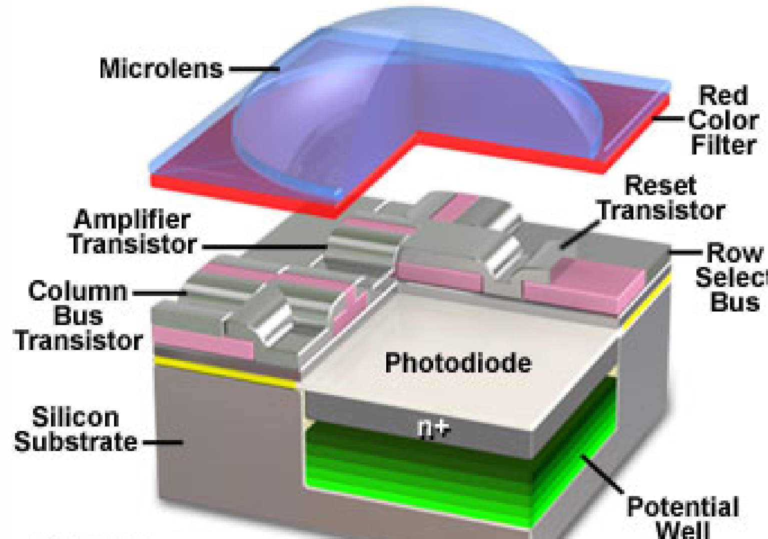
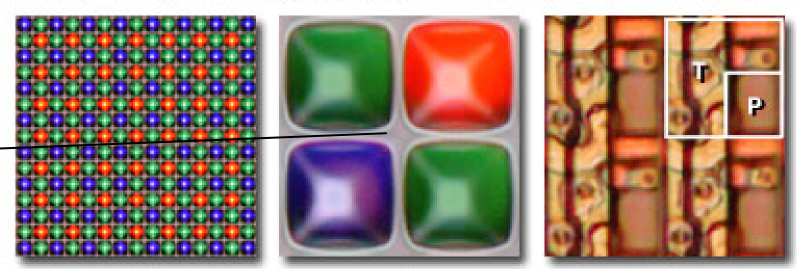


Figure 3

Bayer Color Filter Mosaic Array and Underlying Photodiodes



(a) (b) (c)

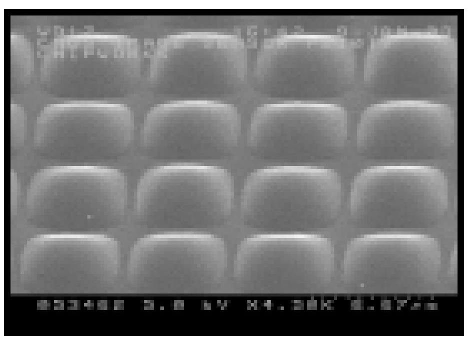
Figure 2

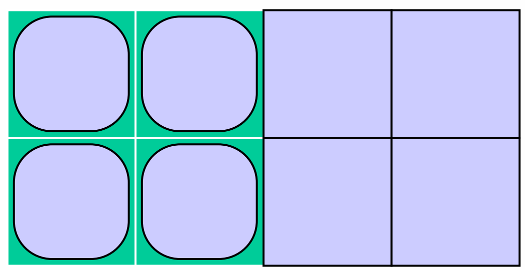
Goal: eliminate dead space between lenses.

Value Proposition

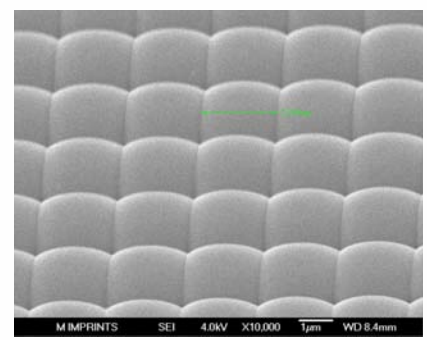
- Driven by pixel size shrinkage
  - 2 – 3 um Pixel – 130nm CMOS
  - 1.2-1.8 um Pixel – 90nm CMOS
- Value driven by reduction in space between lenses

Reflow Lens





Imprinted Lens

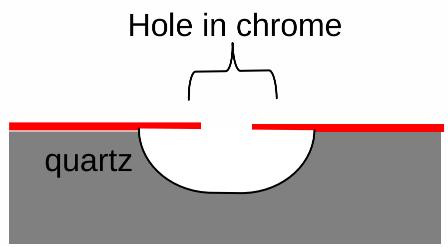


Grayscale Templates: Micro Lenses at MII

- Template fabrication
- Imprint Material
- Imprint Process

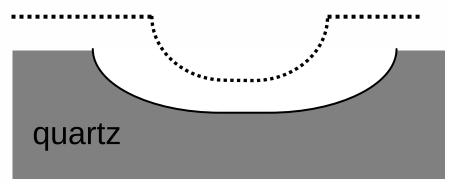
Grayscale Template Fabrication

1. Use E-beam or laser PG to define holes in chrome-on-quartz photomask



First etch – defines lens depth

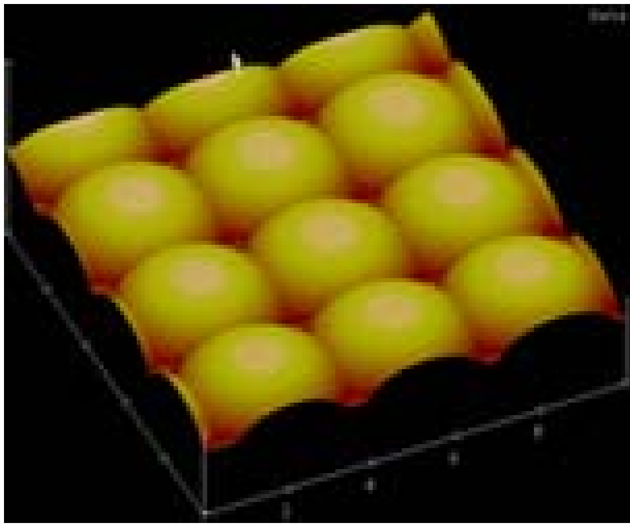
2. Use wet etching through holes to create isotropic features in quartz

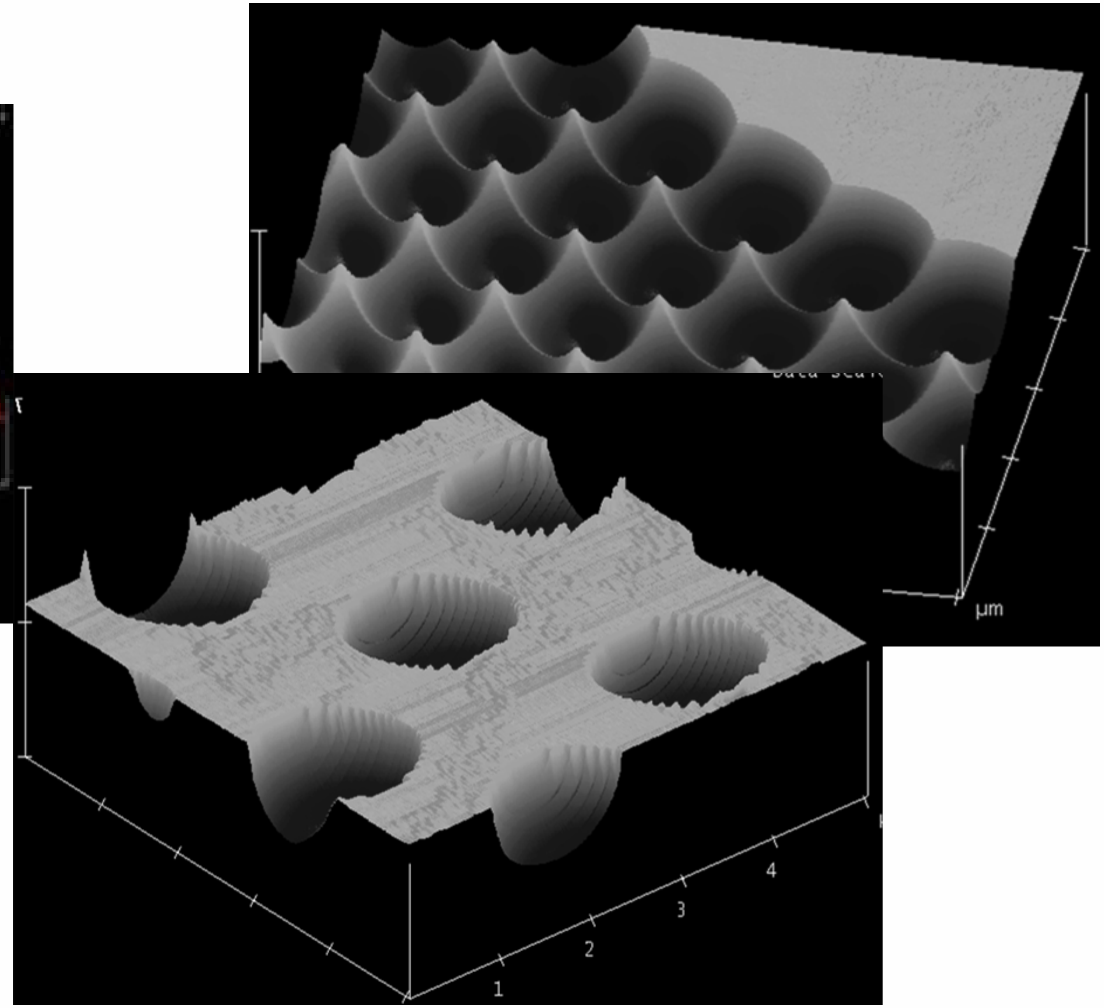


Second etch – defines lens width

3. Use wet etching of stripped quartz to modify lens shape

Grayscale Templates:

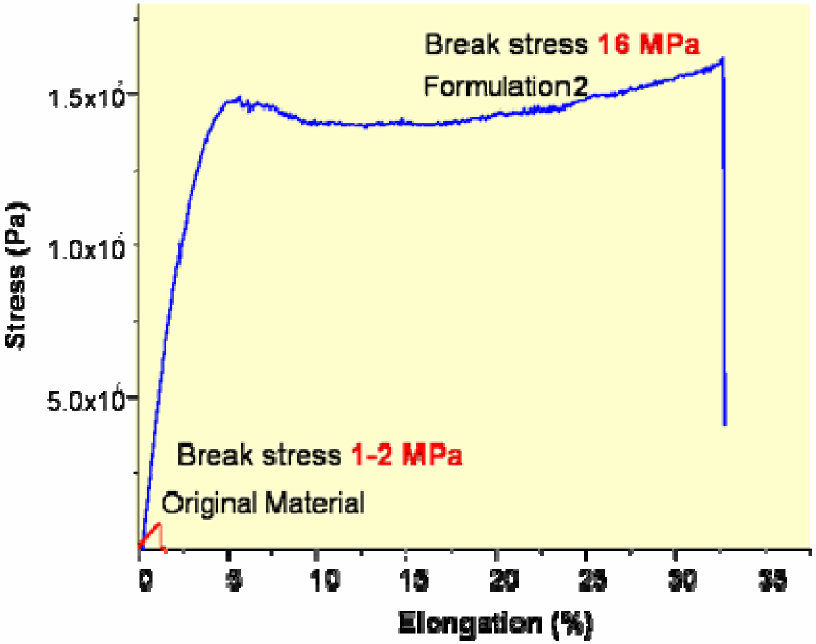




Demonstrated good control of lens dimensions

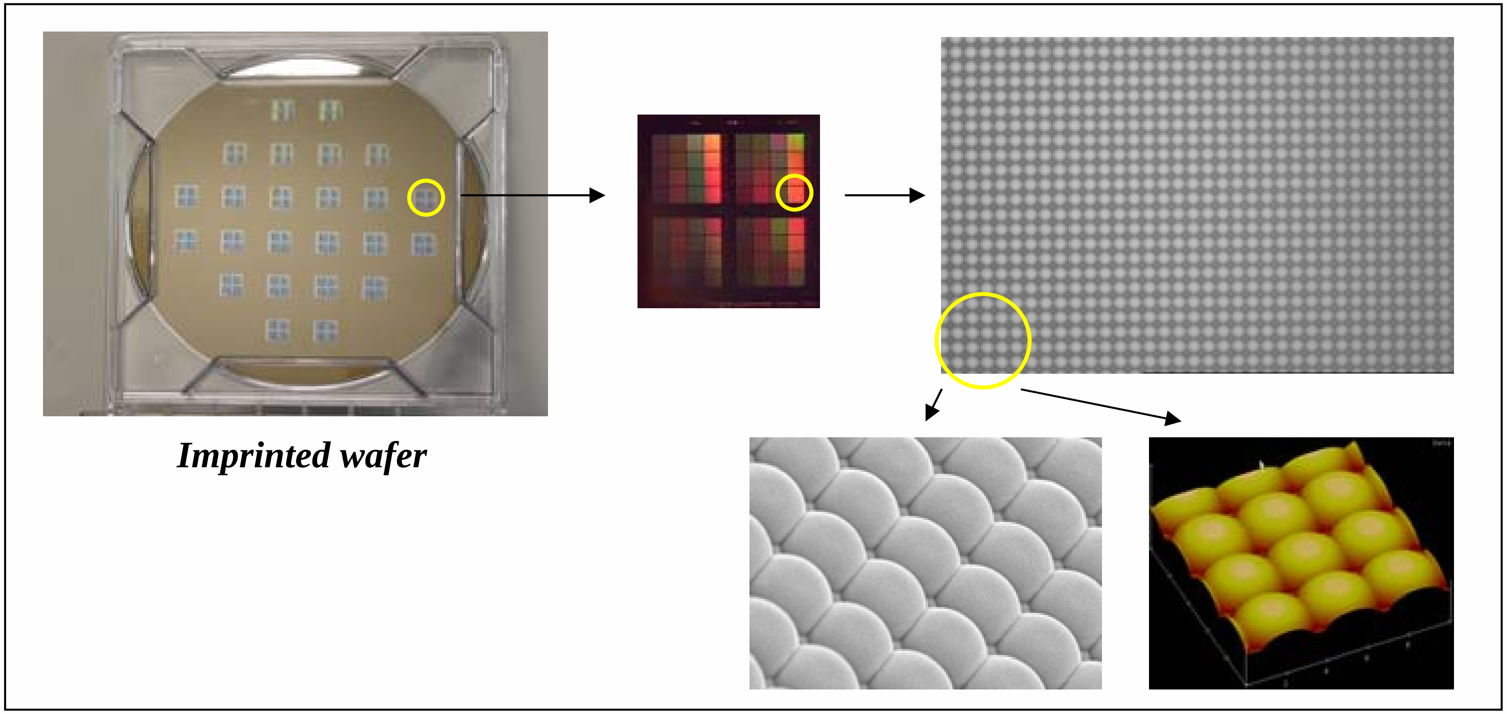
Imprint Material = Optical Object

- MII developed acrylate based functional materials for microlens
  - Index of refraction 1.4 – 1.5
  - pass photo darkening tests
  - thermal stability > 200 C
- Optimized mechanical and release properties
- Zero waste
  - 10 ml of material processes 1000's 200 mm wafers



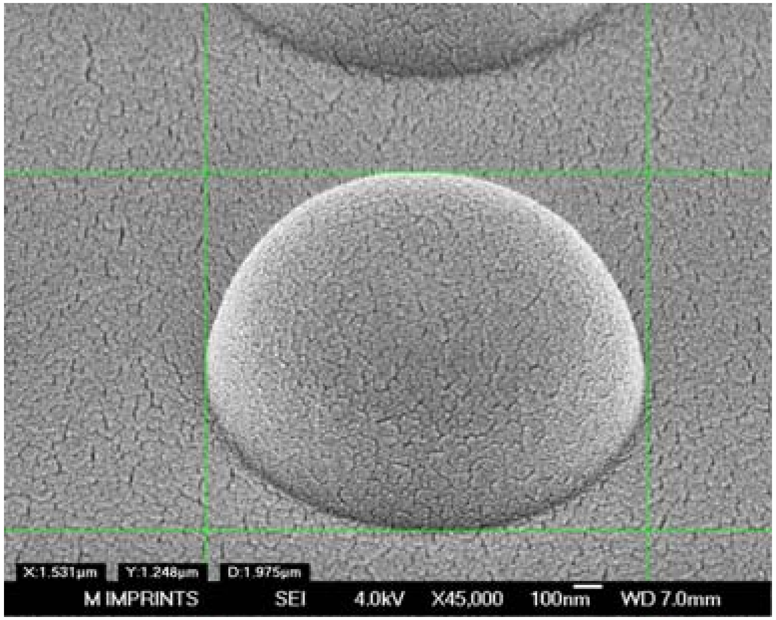
Micro-Lens Imprint Results

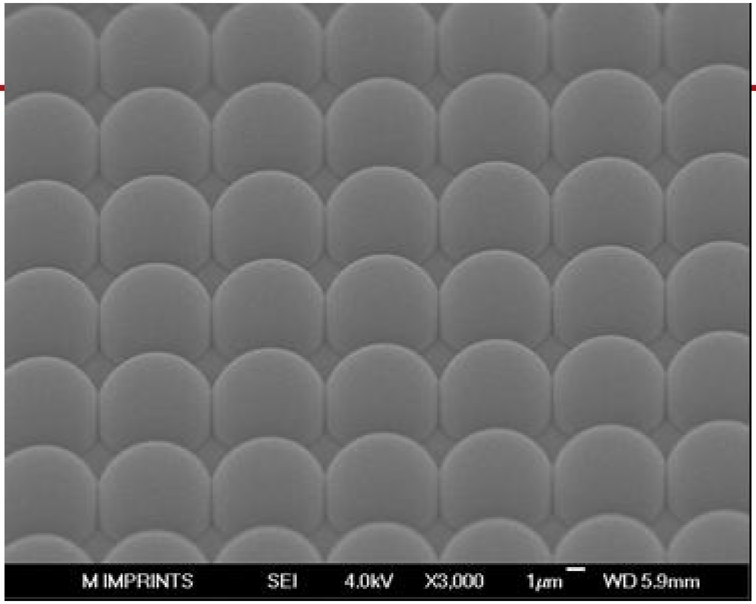
- Grayscale Template and Imprint

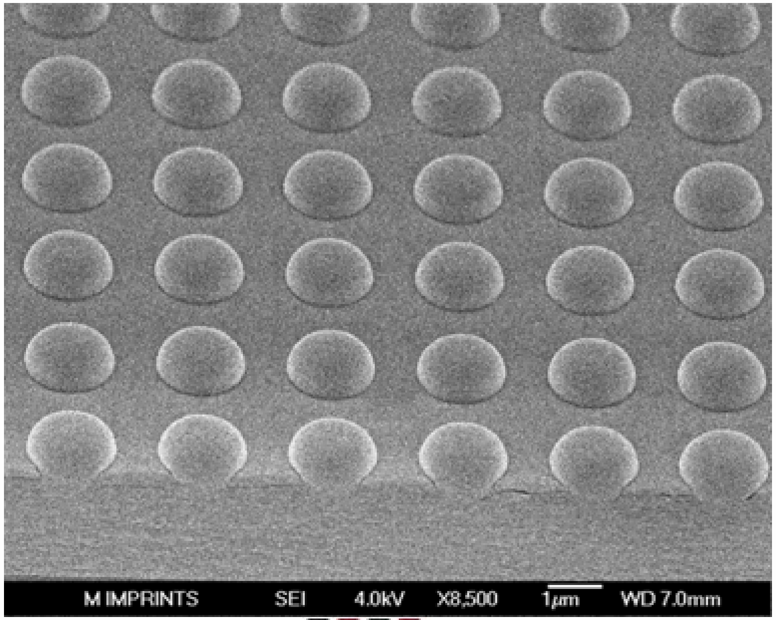


Imprinted wafer

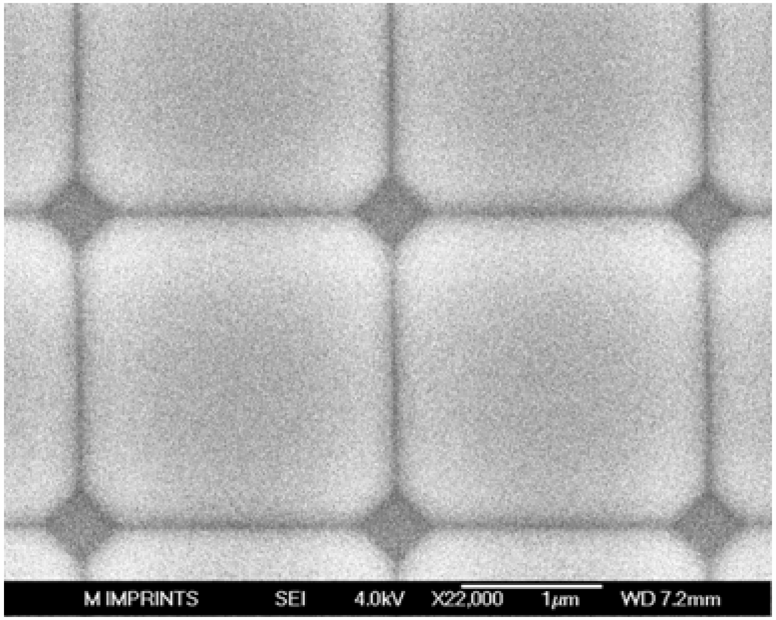
Isolated 1.5 micron lenses

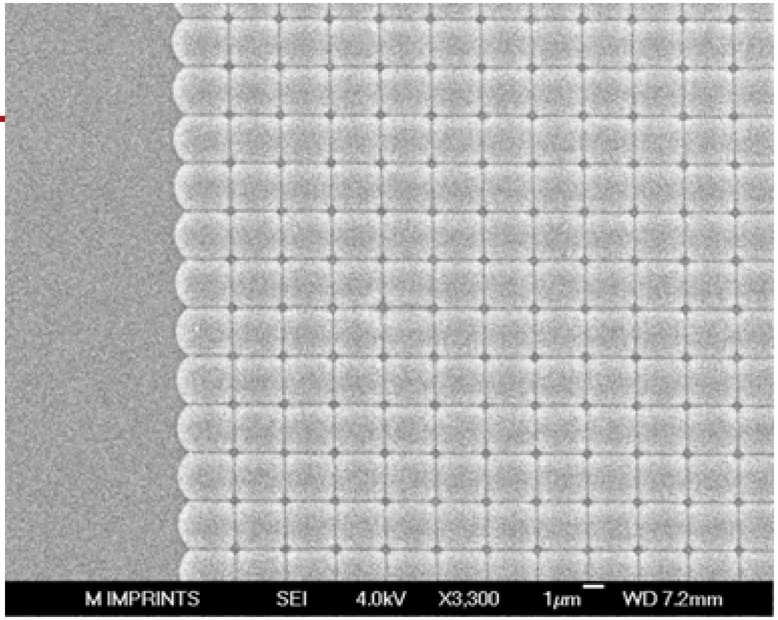


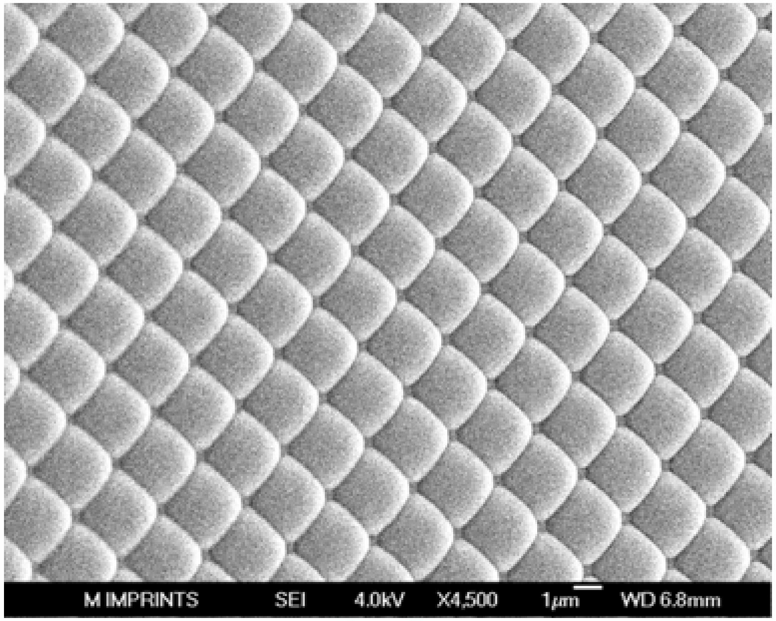




Dense 2 micron lenses

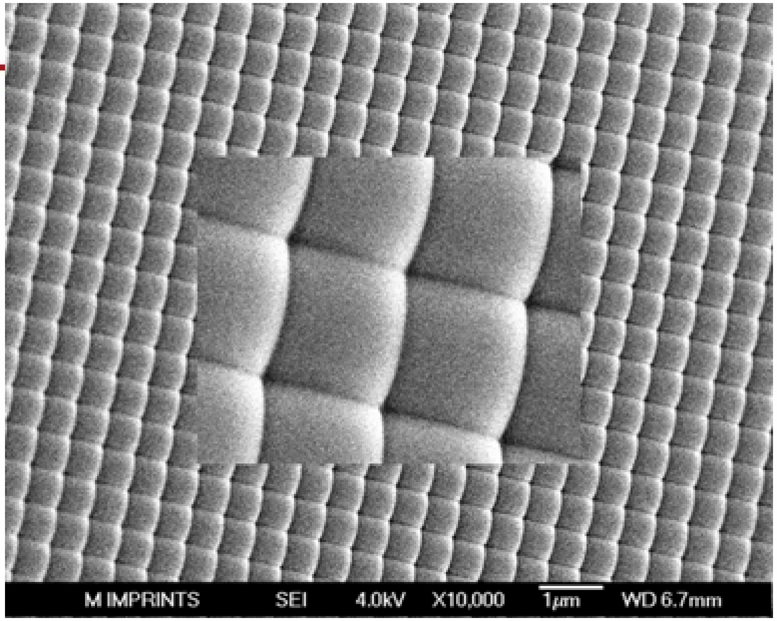


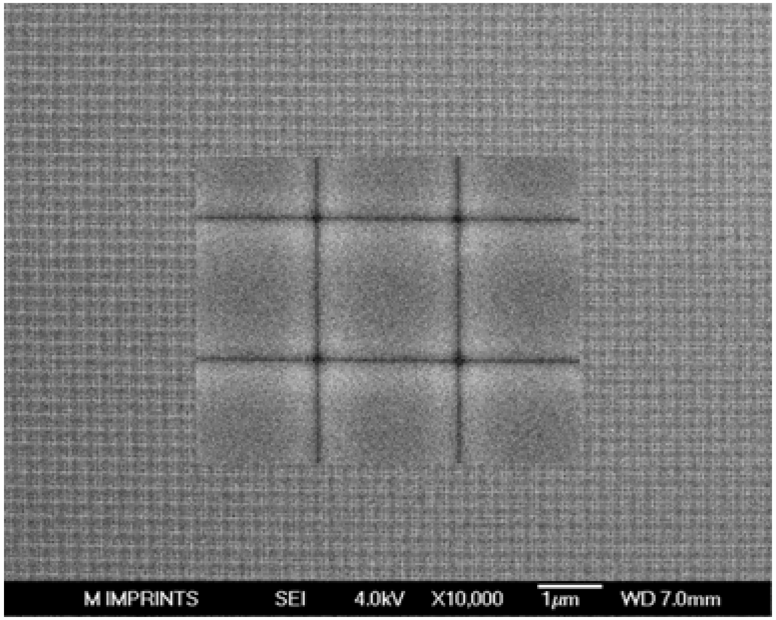


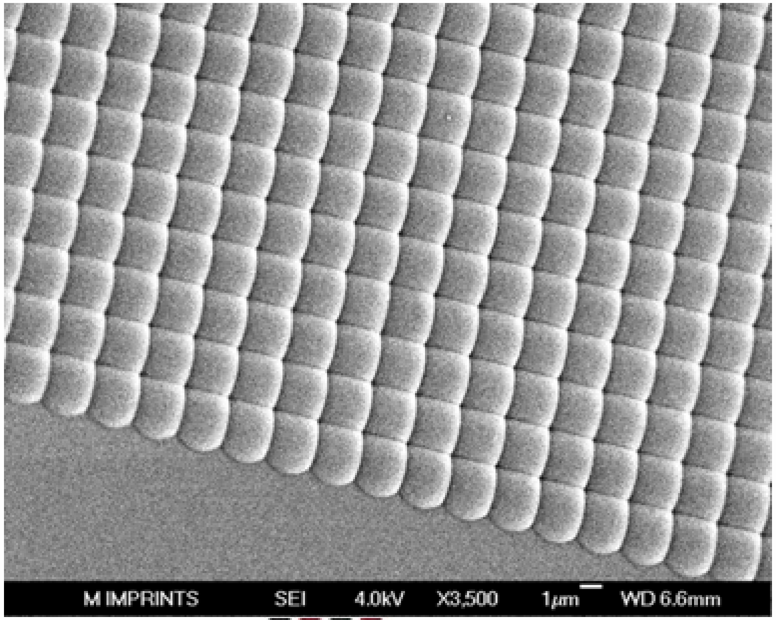


Super dense 2 micron lenses

The radius effectively overlaps.







Micro-Optical Lens Arrays

Background: Added to a digital camera's CMOS/CCD image chip to improve optical collection efficiency

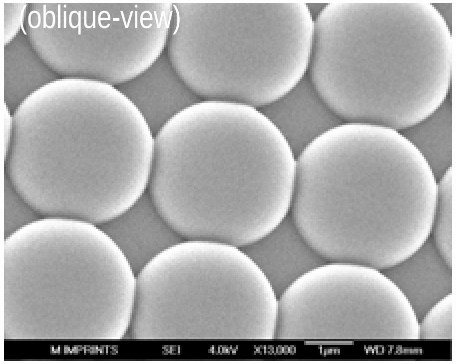
Challenge: Patterning of high packing density lens arrays

Experimental Results: will be presented by device manufacturer in the near future

Benefits of S-FIL

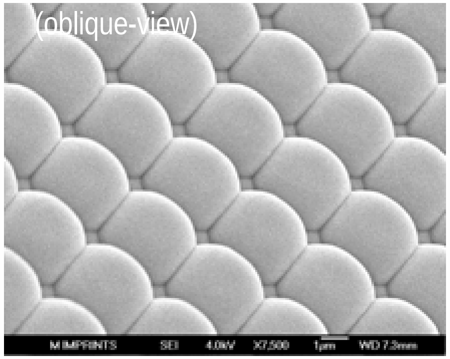
- S-FIL's 3-dimensional imprinting capability enables
  - Micro-lens array replication in a single step
  - No etching required
  - Higher micro-lens array packing density
  - Customized lens shapes
  - Imprinting using 'functional' materials (ie: optimized for a specific optical index of refraction)
- Enables improvement in optical collection efficiency

Imprinted array of micro-lenses



Imprinted array of micro-lenses

(high density packing)



Conclusion

Nano Imprint lithography is demonstrating

to be a cost effective production lithography technology for sub 100nm and microns size patterns for different Industrial applications and

with unique capabilities of multilayer and 3D

Imprint of functional materials