Printing Nanostructures with a Dissolvable Stamp

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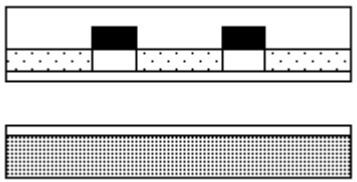
Stanford University

September, 2004

MxL Development

Two Advancements

Initial Idea (2000)



A Expose Mask/Resist

B Then Transfer

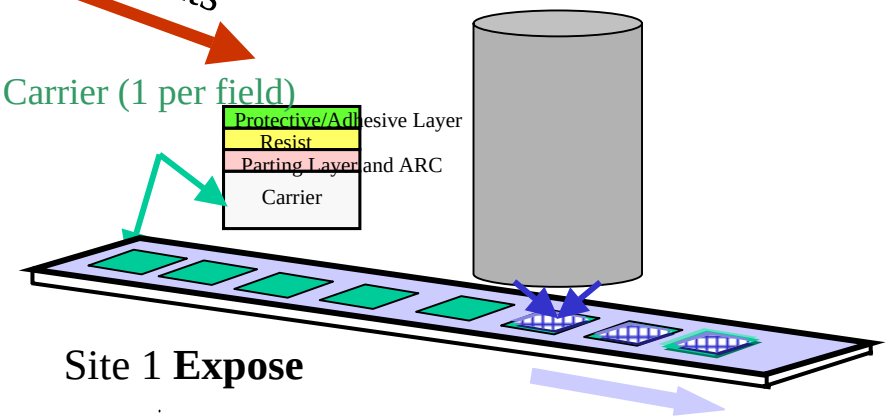
Experiments

Advancement 1

Manufacturing Sequence

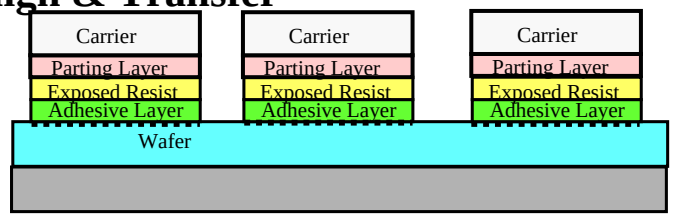
Intermediary Concept (2001)

Carrier (1 per field)



Site 1 **Expose**

Site 2 **Align & Transfer**



Advancement 2

Chemical Process

Water-Soluble Template (2002)

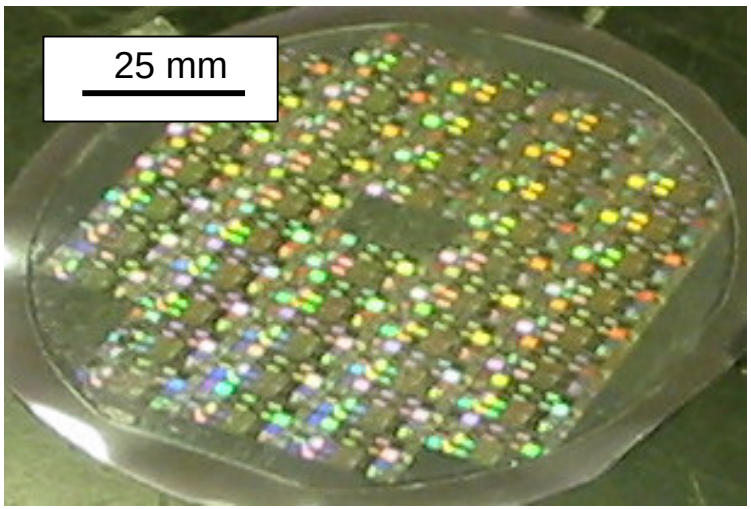
Site 1 **Replicate**

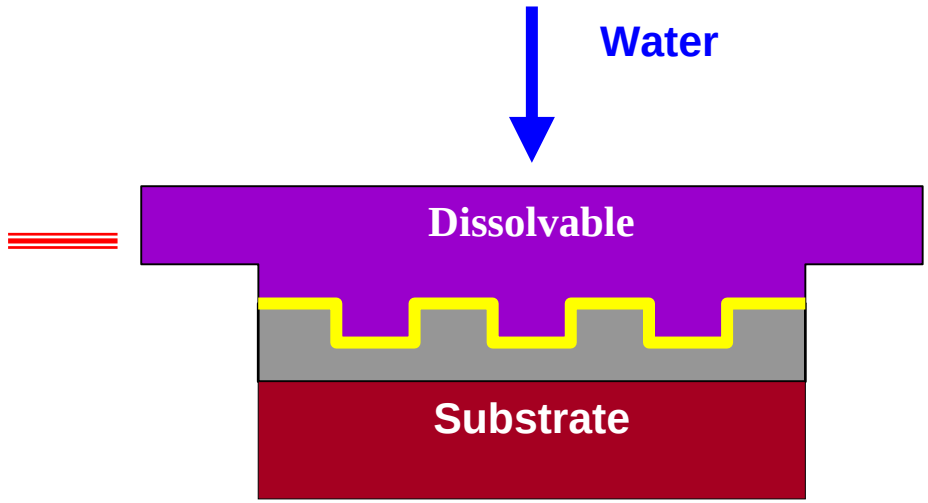
Experiments

Site 2 **Align, Transfer, Dissolve**

New Mask Material

- Film forming solution that replicates surface patterns at ambient conditions in less than 1 min, and dissolves in water





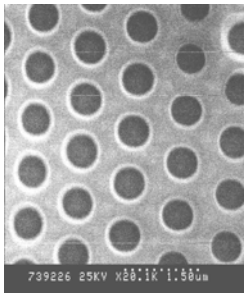
eliminates demolding

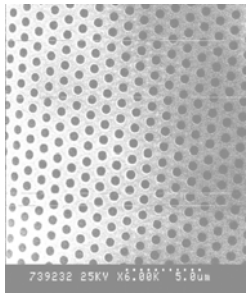
- Three alternatives: Quartz, Silicon, PDMS

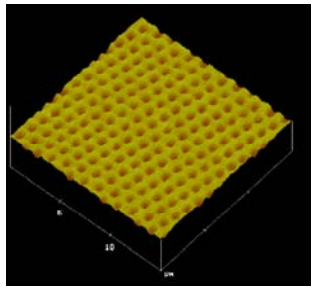
Initial Uses of Stanford MxL Process

Photonic Crystals

Prof. Solgaard, Dr. Y.A. Peter, Mr. Onur Kilic

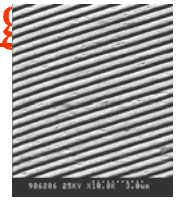


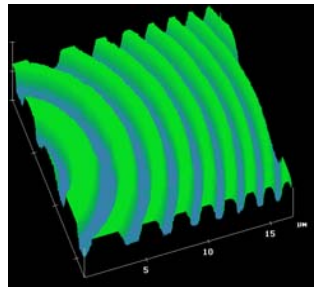


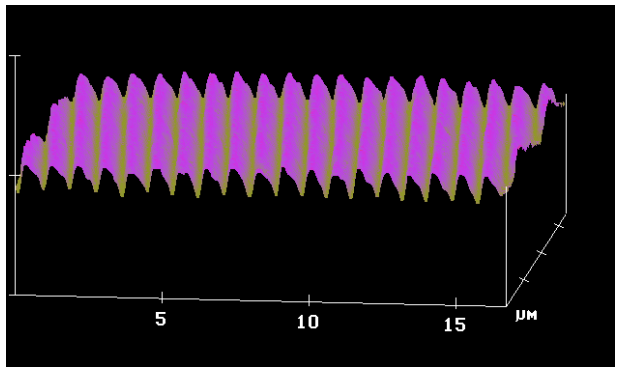


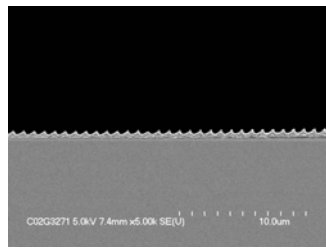
Diffraction Grating

Dr. Sergei Orlov





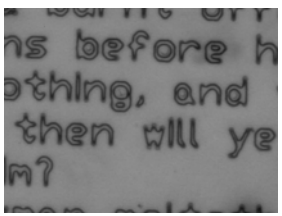




Micro-printing

Undergrad student project to microprint alphanumerics

Mr. Tze Wee Chen

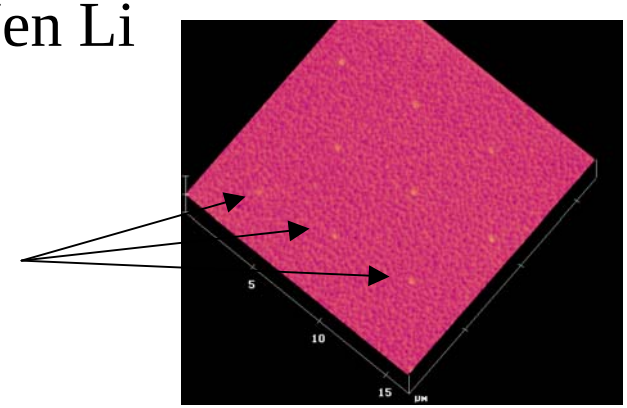


Au

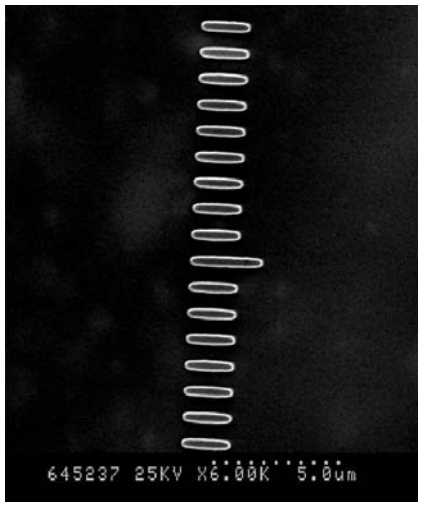
DNA Sensors

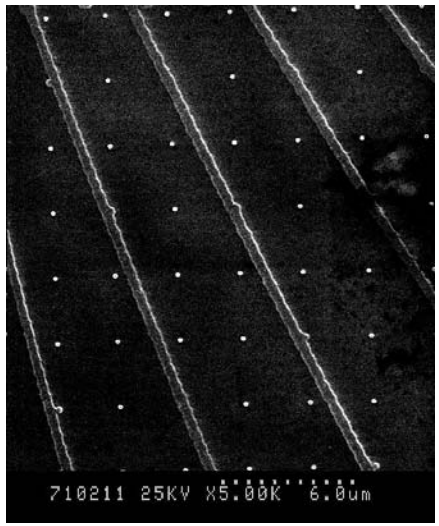
Integrated Nanosystems, Inc.

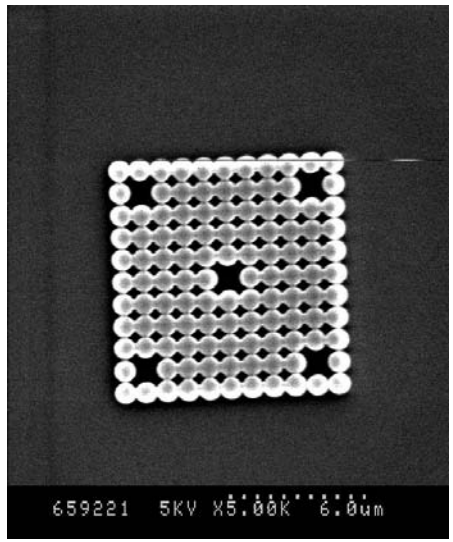
Dr. Jen Li

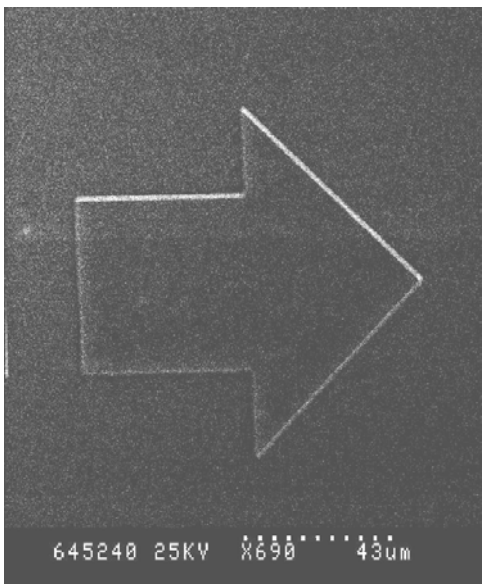


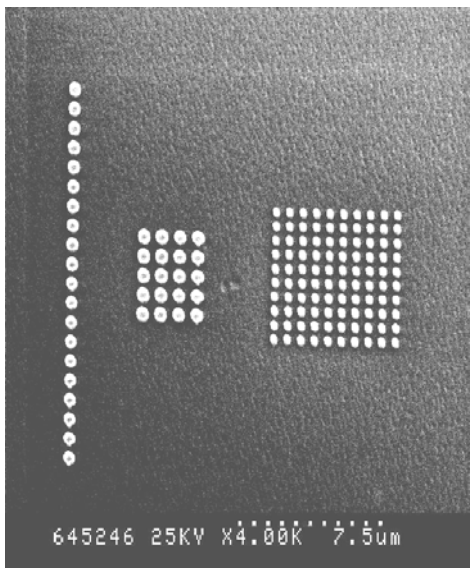
Large Feature Size > 1μm

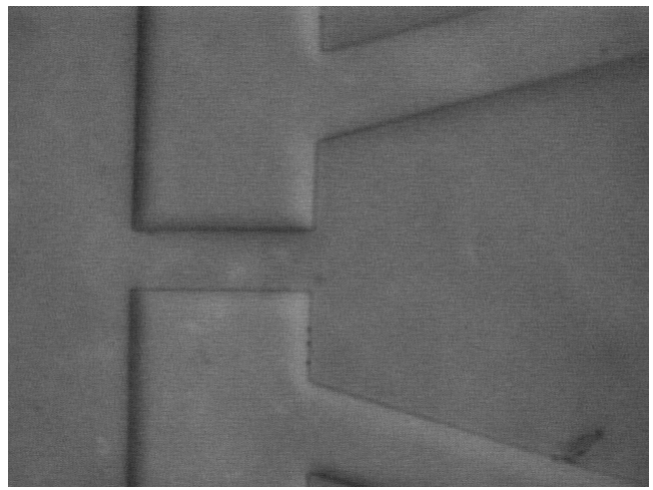




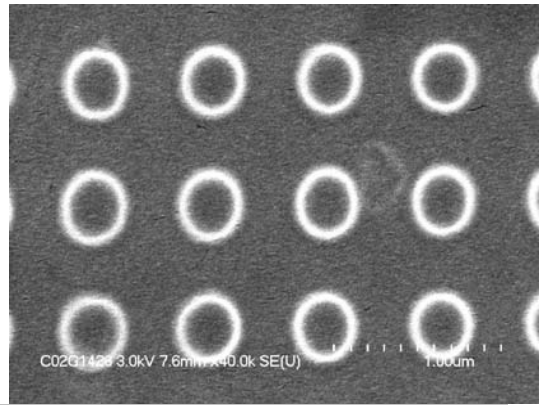


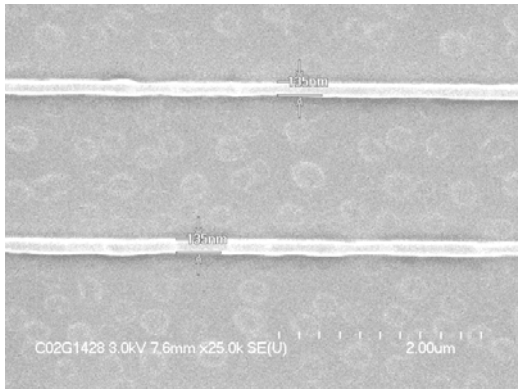


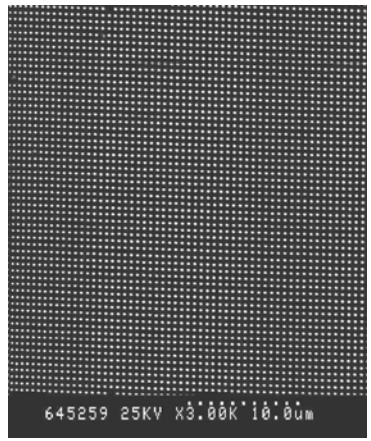




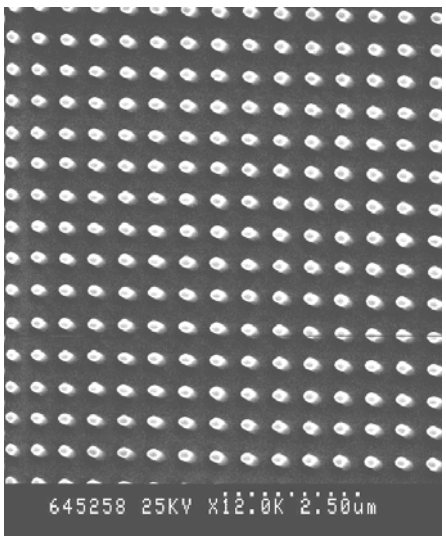
Feature Sizes less than 1 μm and above 100 nm

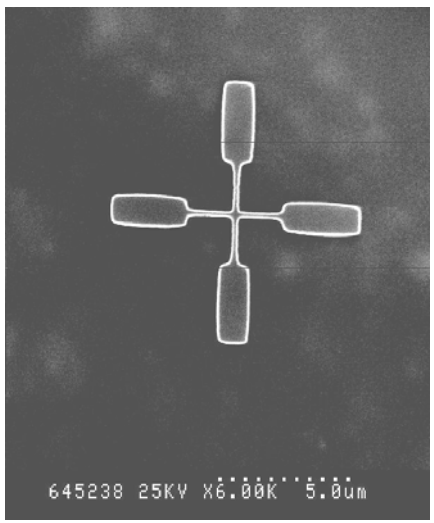


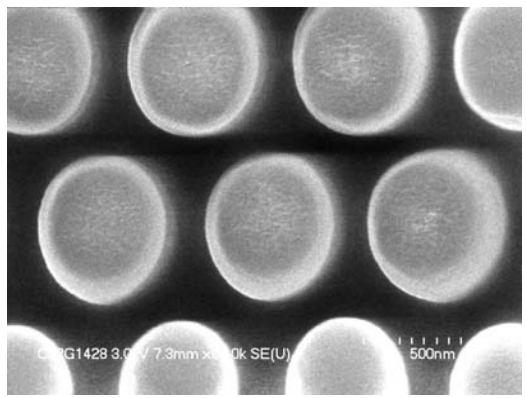




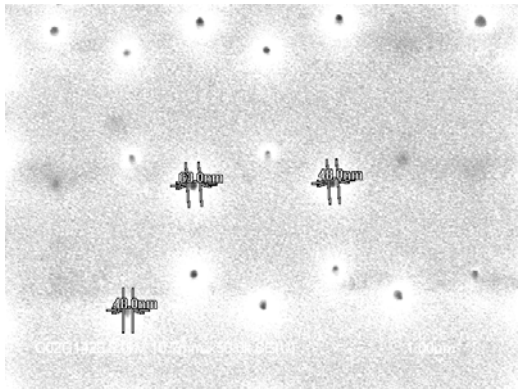
135 nm lines



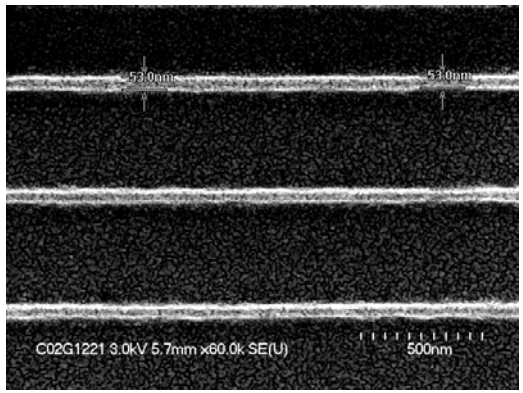




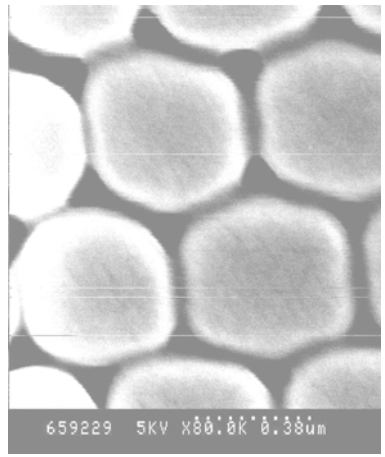
Feature Dimensions Below 100 nm

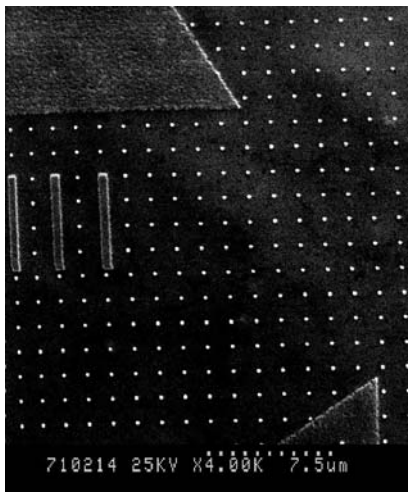


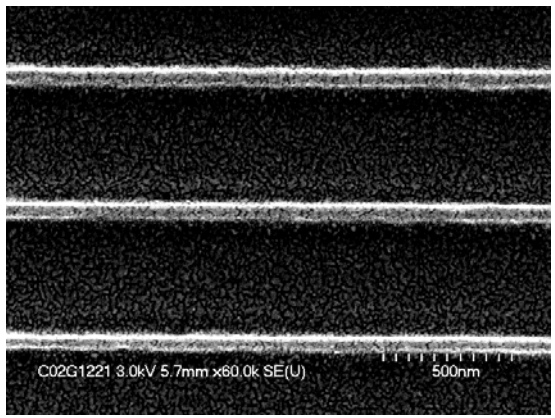
48 nm and 63 nm holes



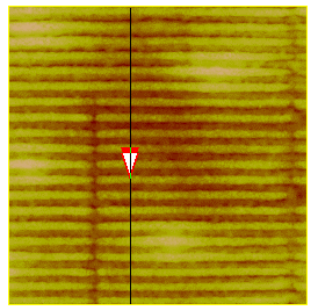
53 nm lines

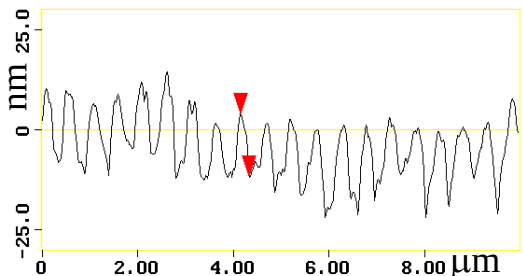






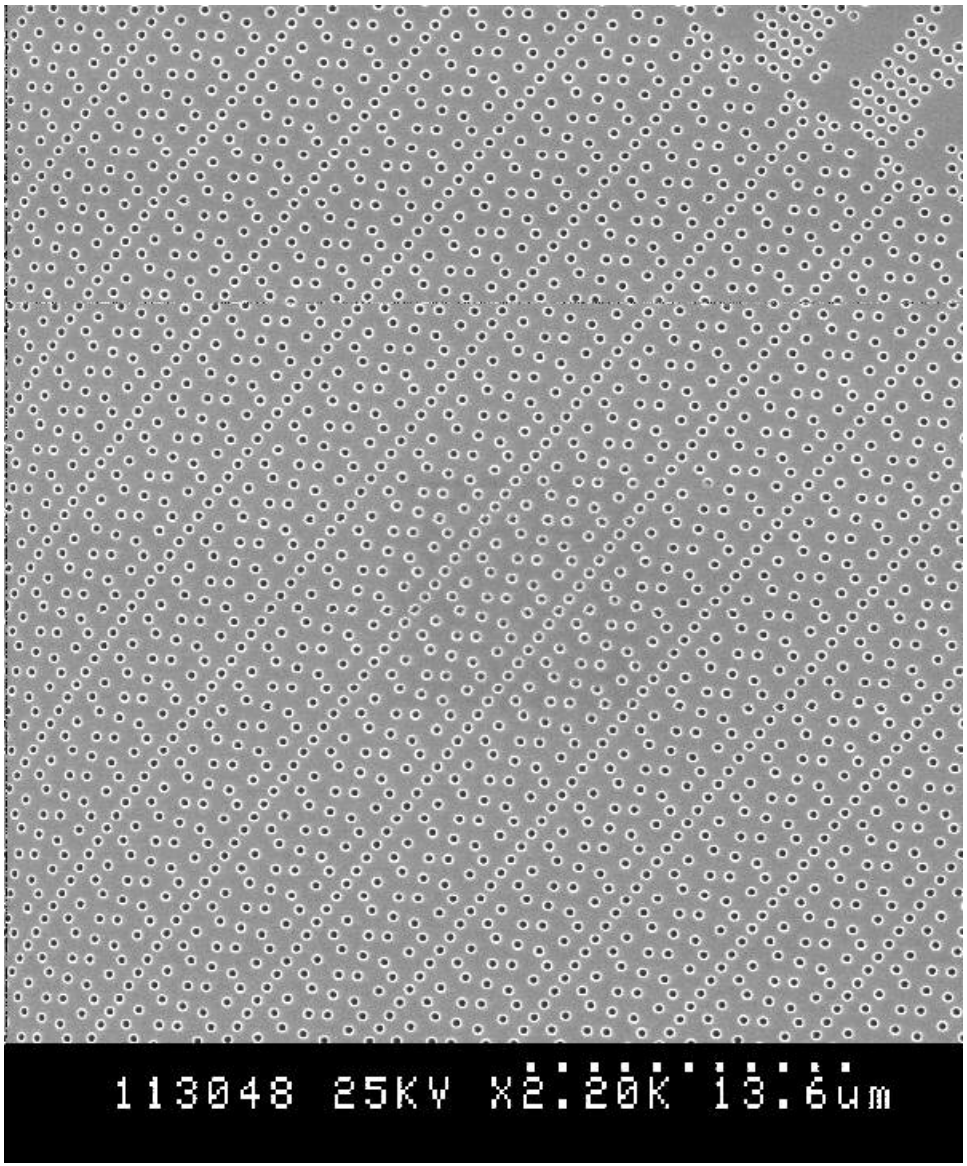
~50 nm lines





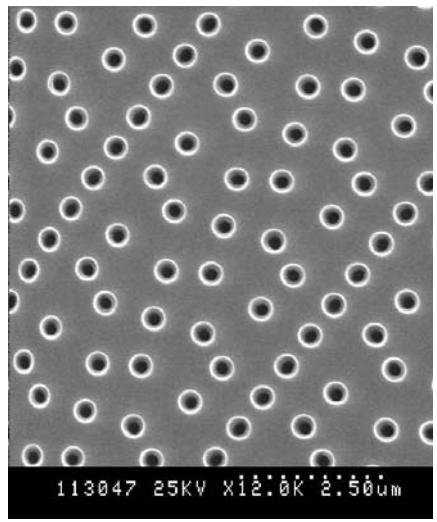
16 nm vertical distance

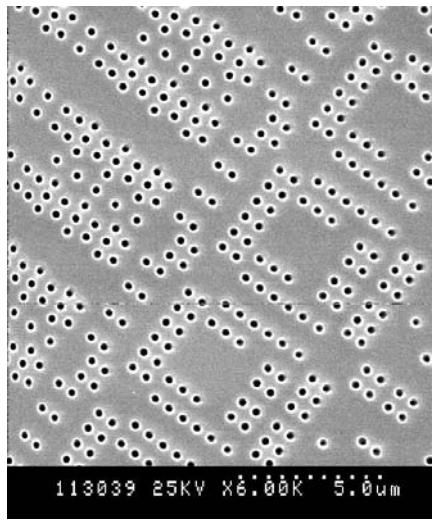
Fabrication of Lithography Level of Industrial Microprocessor



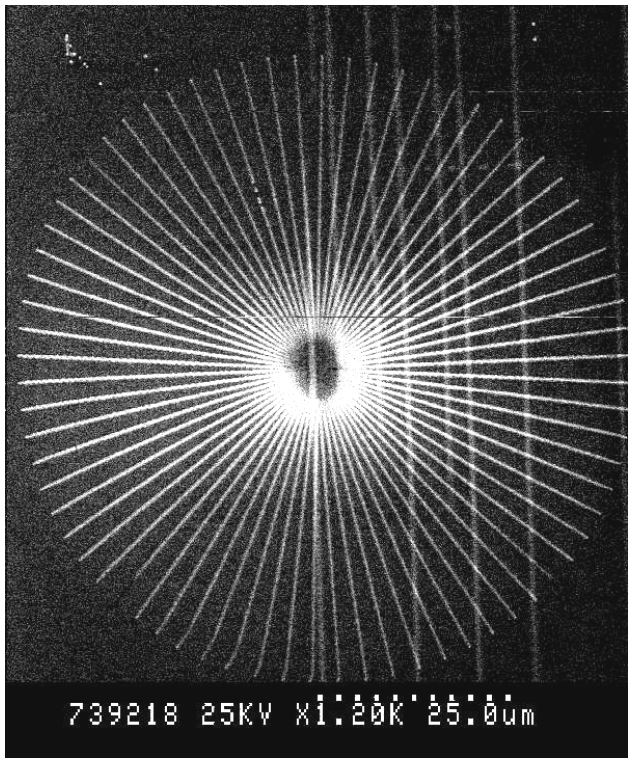
- Print a wafer as master for each level of lithography

- Results shown here are of a contact hole layer for an industrial microprocesser of 0.25 μm design rules; layer fabricated via MxL process



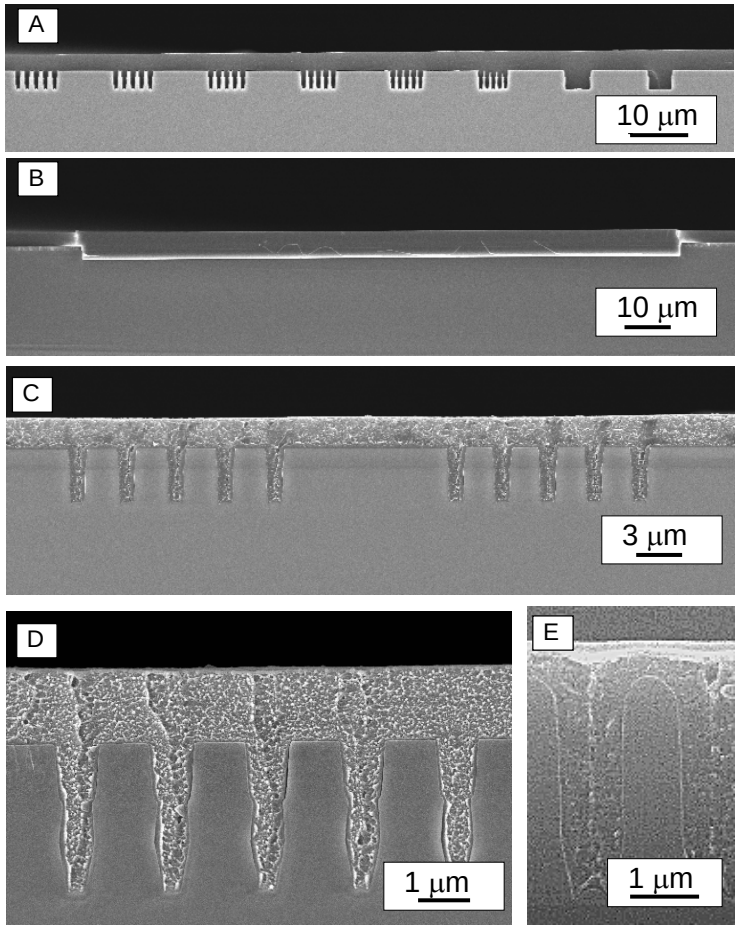


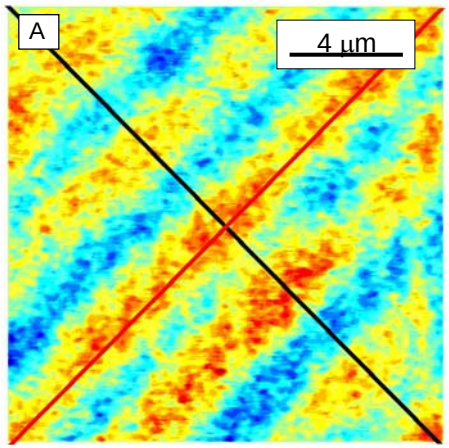
Printing over Topography

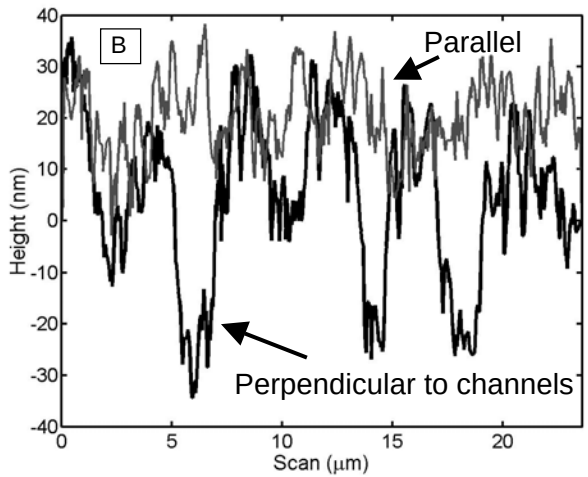


converging to 60nm lines
over 1000 Å SiO_2/Si topography

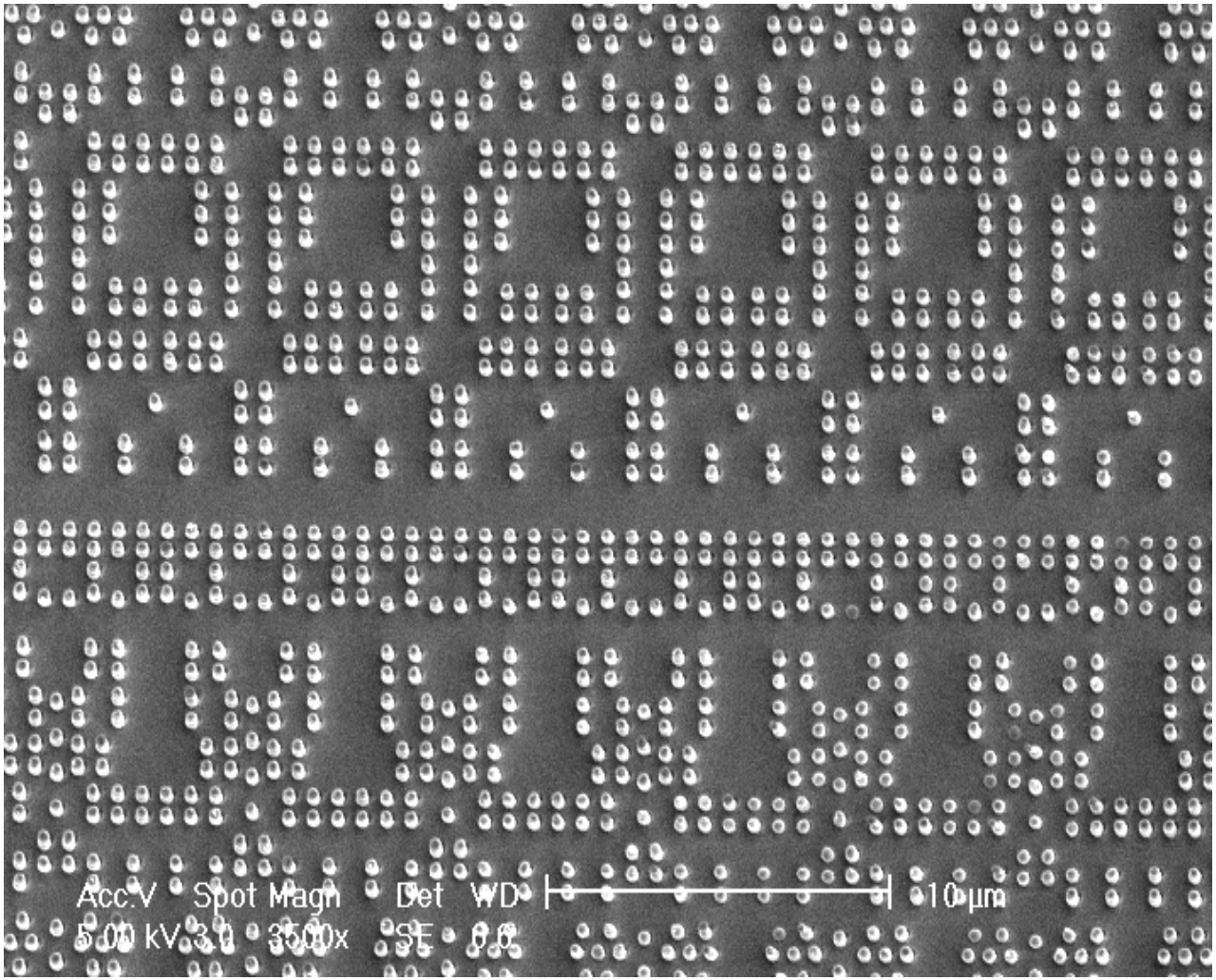
Planarizing Surface Topography by Replicating Null Pattern

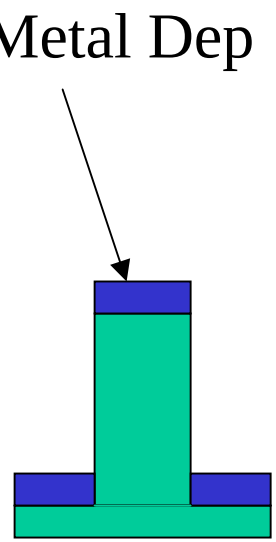




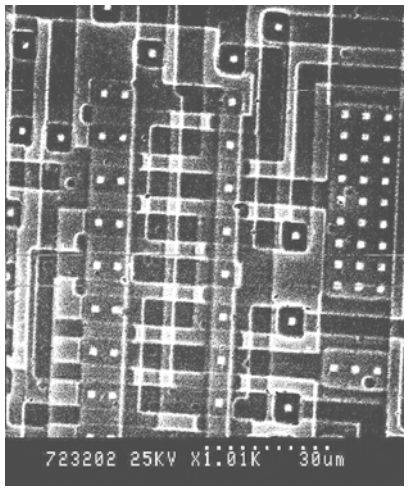


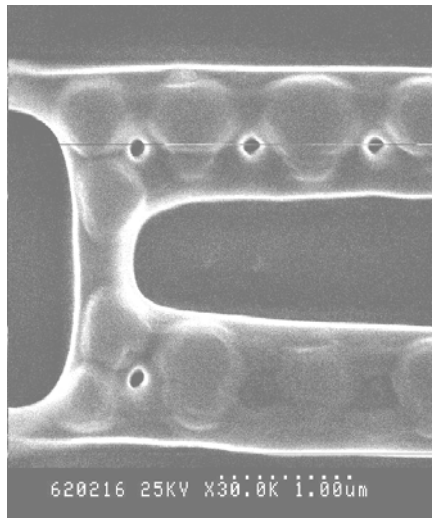
Collimated Materials Deposition

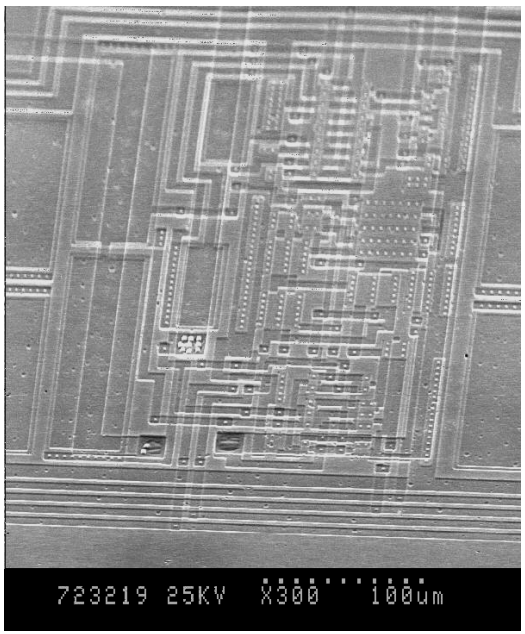


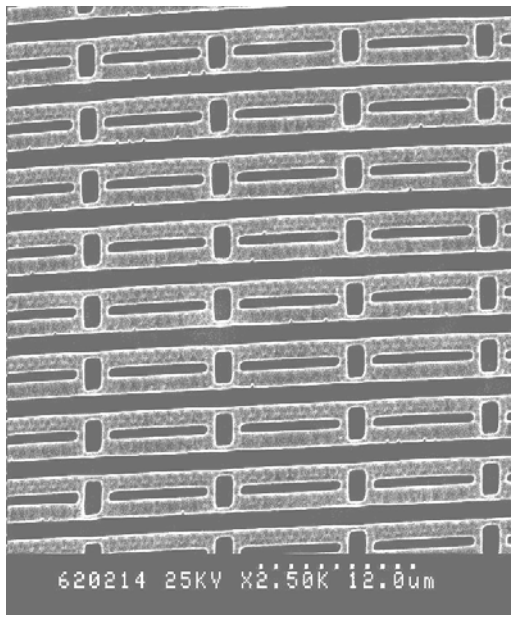


Printing 3-D Patterns

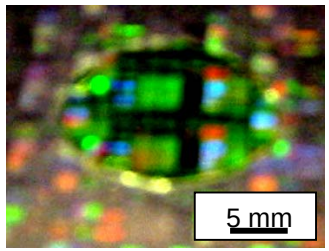


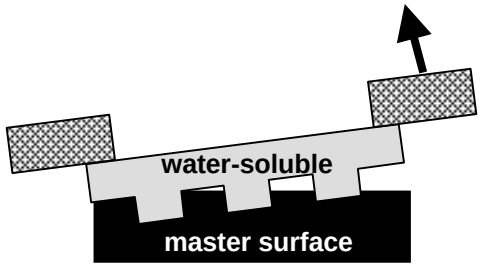




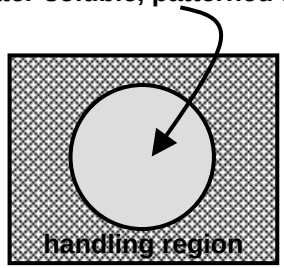


Thin Film Templates

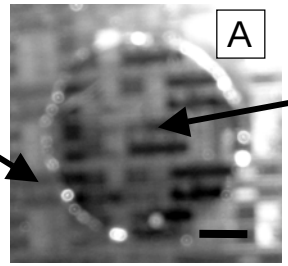




(A)

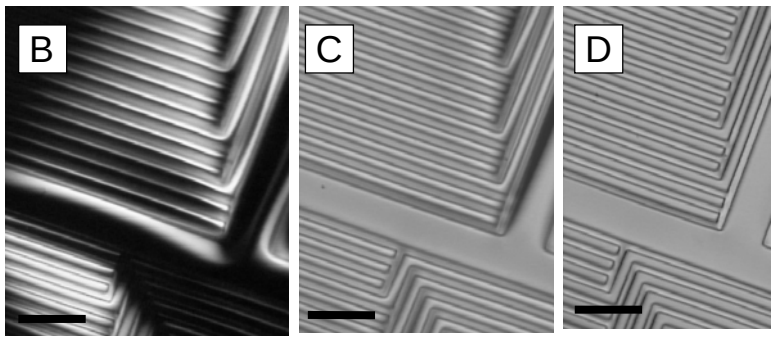


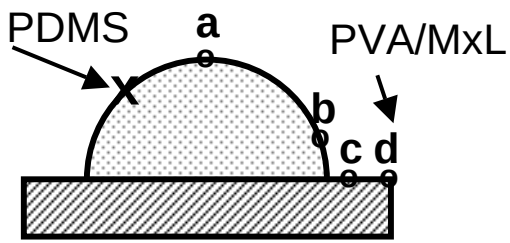
(B)



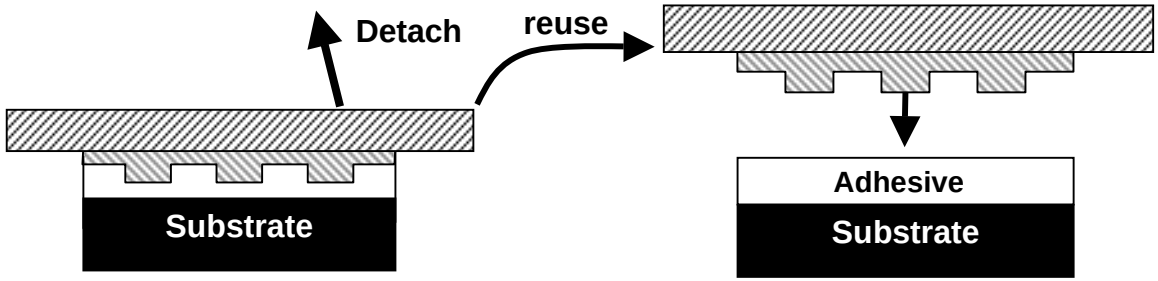
support region
(~100 μm thick)

water-soluble,
patterned, suspended
thin film of PVA



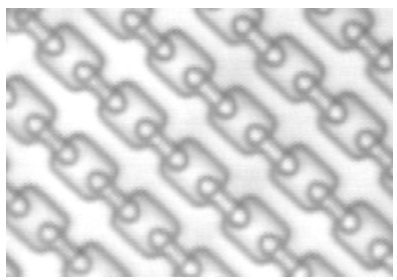


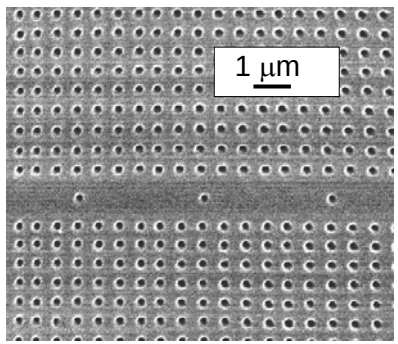
Using PVA as Imprinting Template

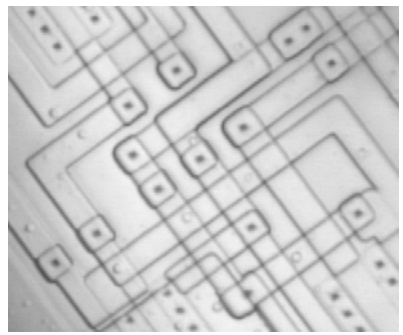


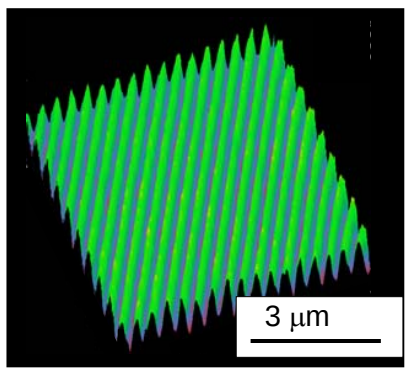
Patterns after 3 imprints

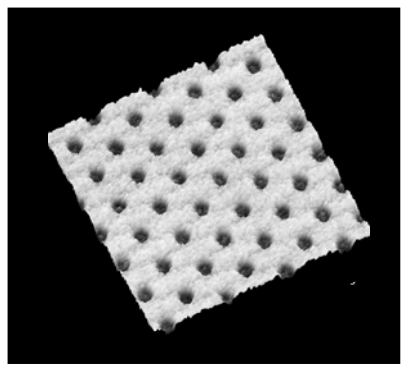
Template used with adhesives that don't seem to form strong bond with PVA template (low viscosity materials)





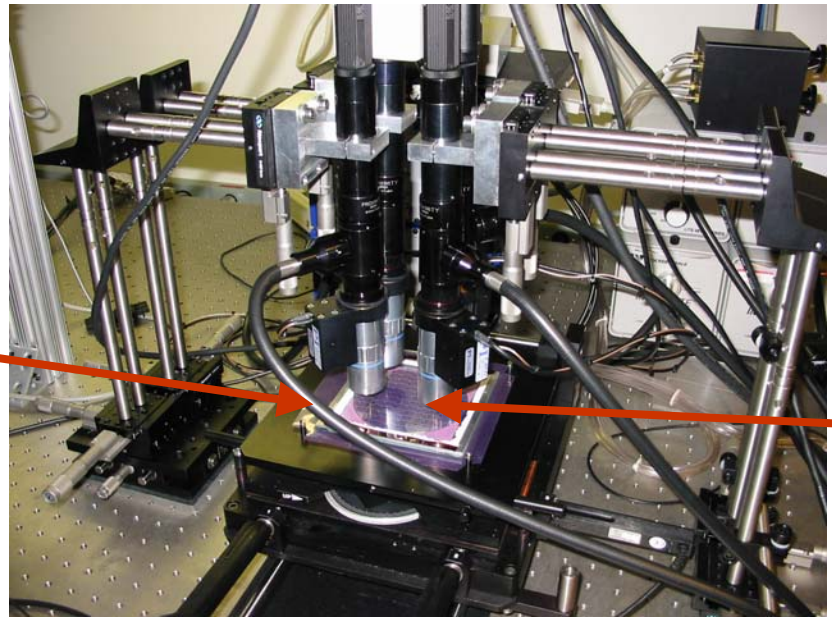






Alignment Apparatus

Intermediary with 100mm Pattern



100mm Wafer

Standard Aligner with MxL mask

- MxL used in place of quartz mask

- MxL is a **chemical answer** for resolution extension

Technology Transfer

- Start-up company: Transfer Devices, Inc.
  - Polymer mask and chemical process company for nanoimprint and molecular transfer lithography

- Nanoimprint lithography products
  - **MxL**: single-use stamp
  - **xPT**: multi-use stamp

Summary

- Dissolvable stamp for high resolution printing
- Lots of Applications
  - Performance/Effort & Performance/Cost Very High
- MxL enhances resolution
- Forms patterns and transfers materials