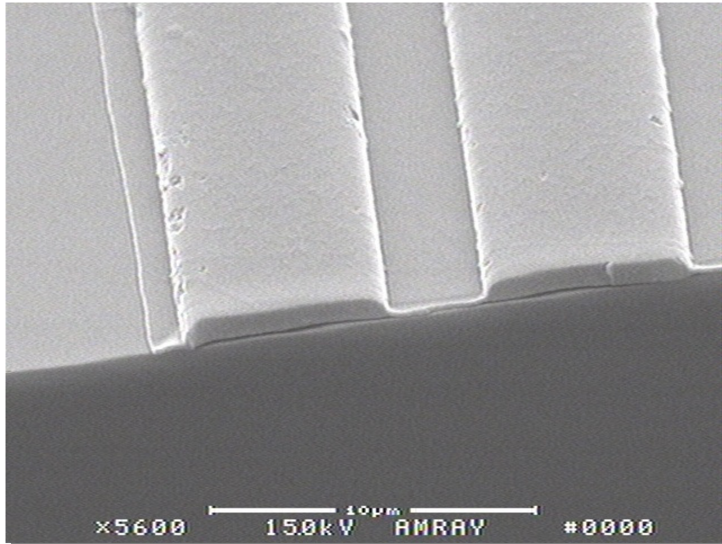
NANOIMPRINT LITHOGRAPHY



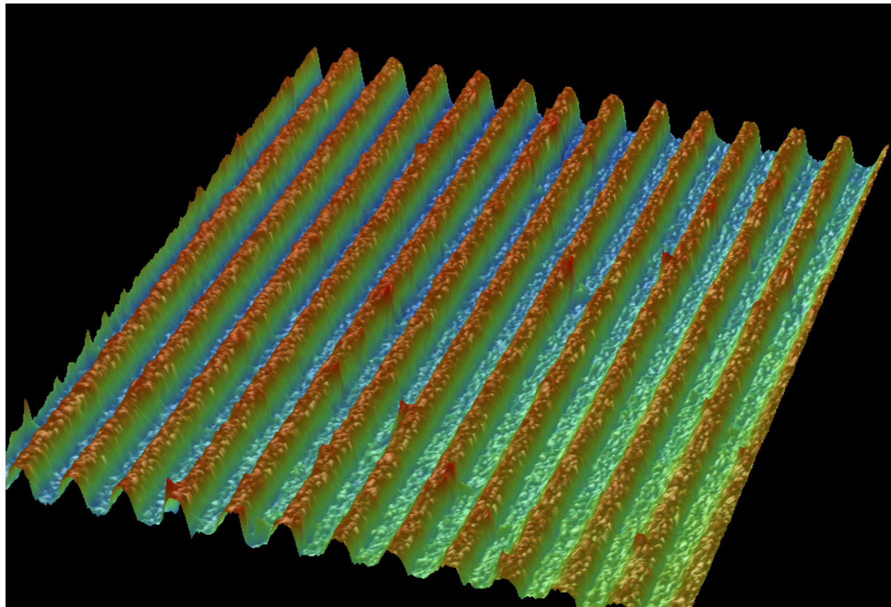
Steven Glenn
Ward Johnson
Advisor: Prof. Dale Ewbank
Department of Microelectronic Engineering, RIT
NSF REU grant # ECCS-0731485

Outline

- Introduction
- Factors affecting Nanoimprinting
- Process Steps
- Results and Analysis
- Conclusion and Future Work
- Acknowledgements

Nanoimprint Lithography

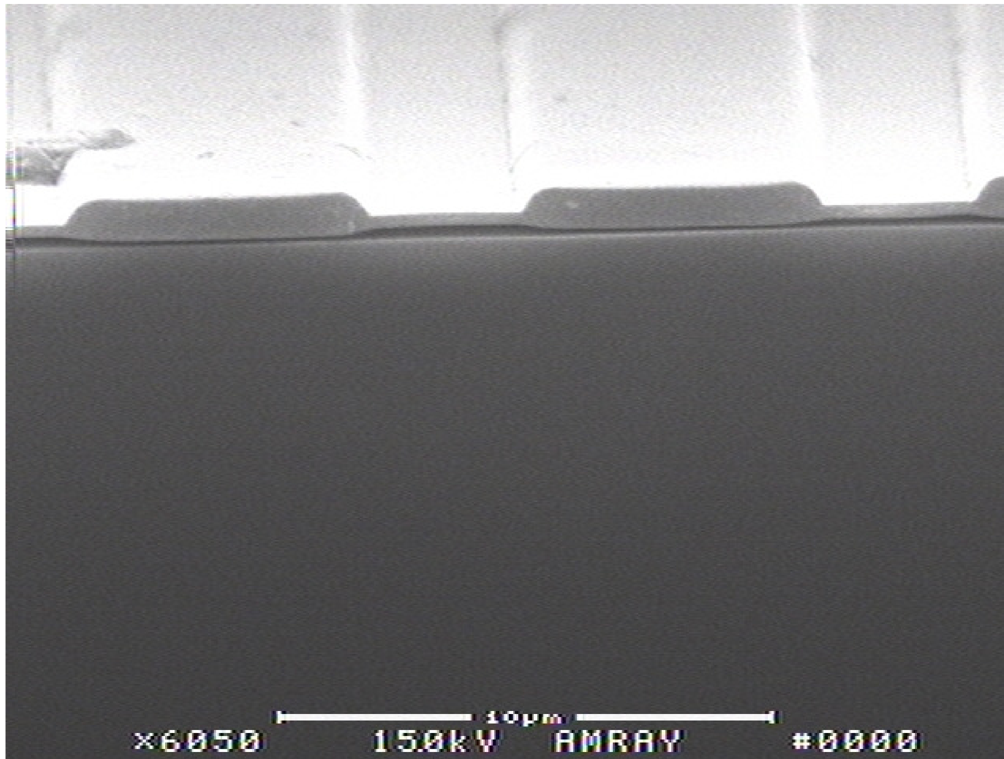
- Low cost, high resolution, large area patterning process
- Does not require an expensive optical system
- Allows for patterning down to the sub-100nm regime



Captured using Wyco NT1100

Goal

- To achieve lines and spaces from a 10 µm pitch relief mask in a cross-linked imprint resist.



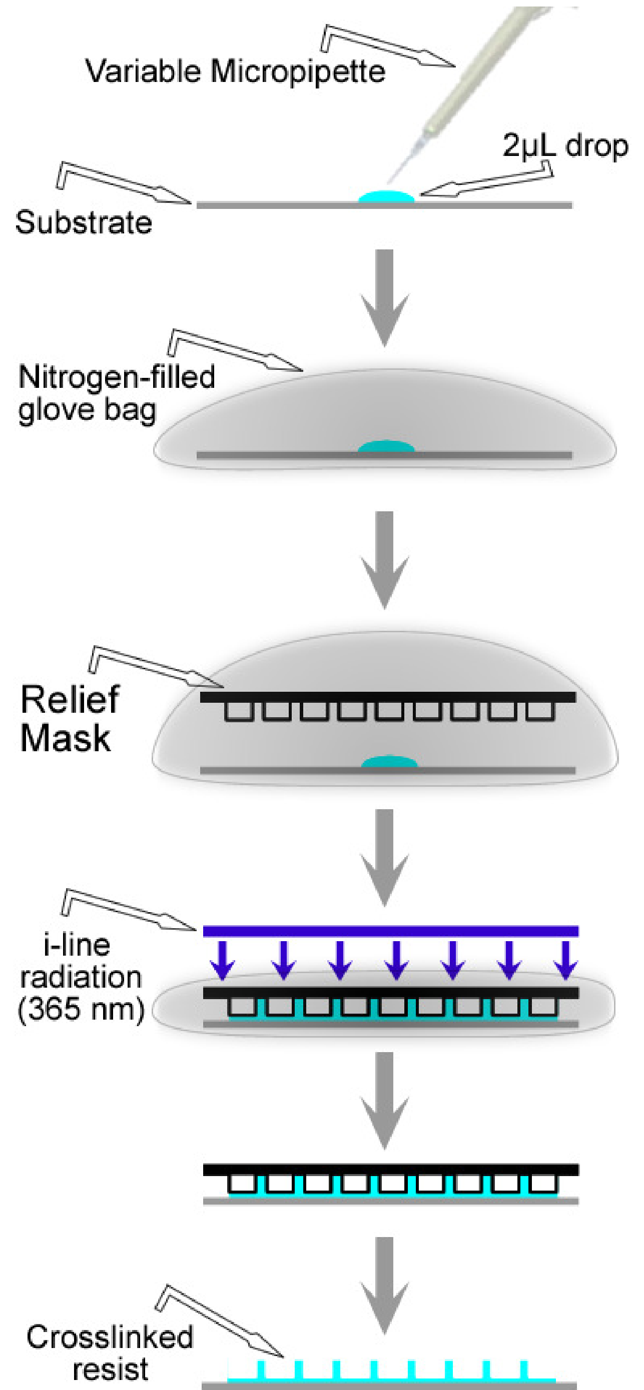
Imprint Resist

- .274 grams ethylene glycol diacrylate (30%)
- .343 grams isobornyl acrylate (37.5%)
- .274 grams butyl acrylate (30%)
- .035 grams Irgacure 651 (2.5%)

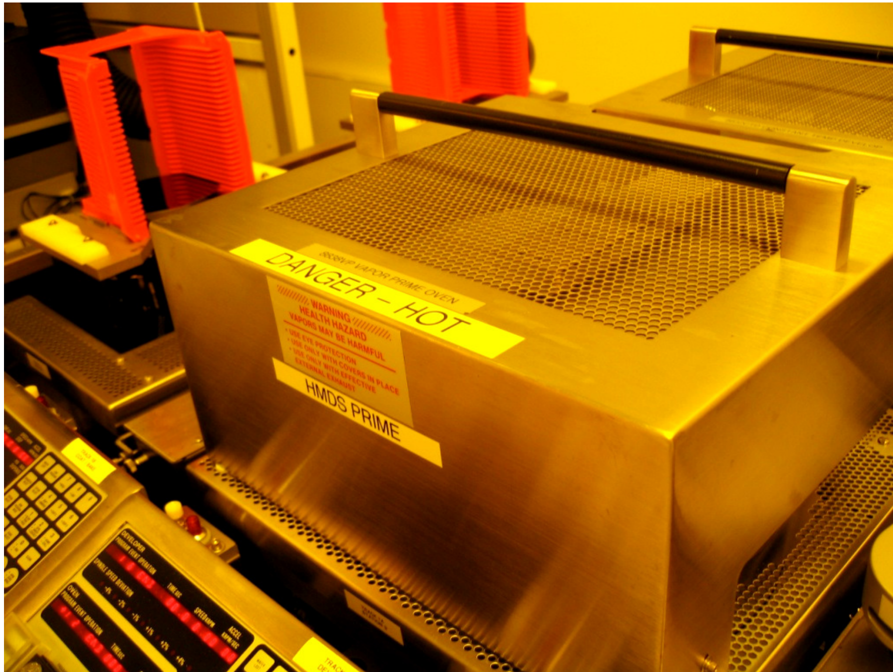
Factors

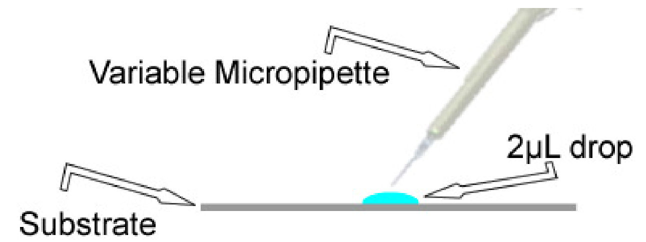
- Oxygen Inhibition
  - Prevents cross-linking process from occurring fully and completely causing exposed resist to remain fluid.
- Controlled Pressure
  - Due to the need for an non-oxygen environment and controlled pressure, a trade-off would have to be decided upon.
- Release Agent
  - If not reliable, can cause either most of the resist to stick to mask or your resist to be damaged.
- Glove Bag Light Transmission
  - Glove Bag needs to be flat against mask. The further the glove bag is from the mask, the less irradiance the mask sees.

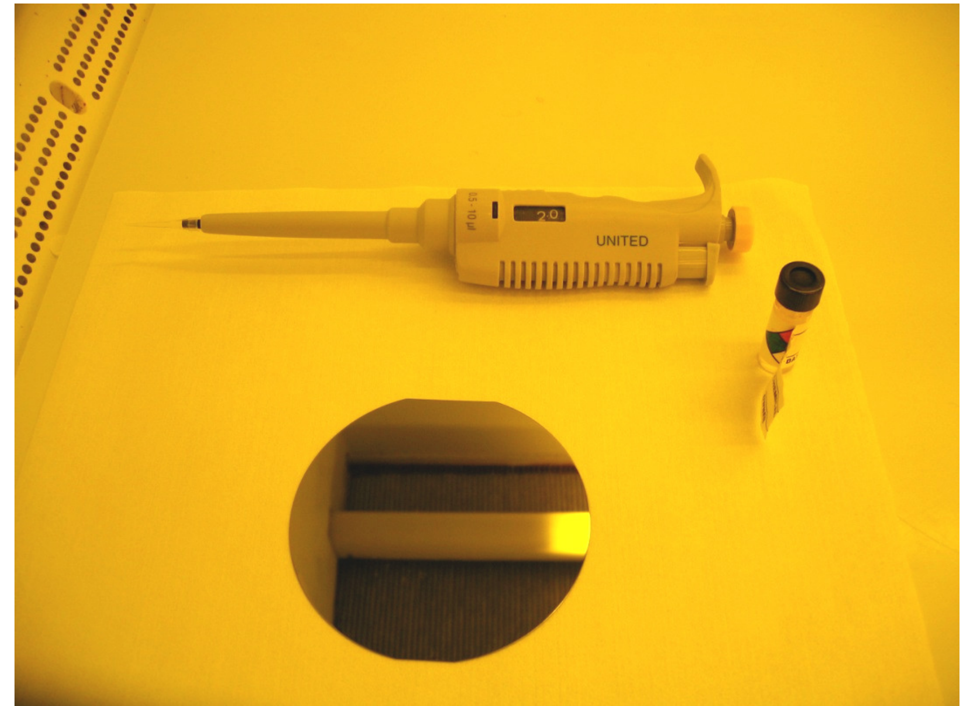
Process Steps



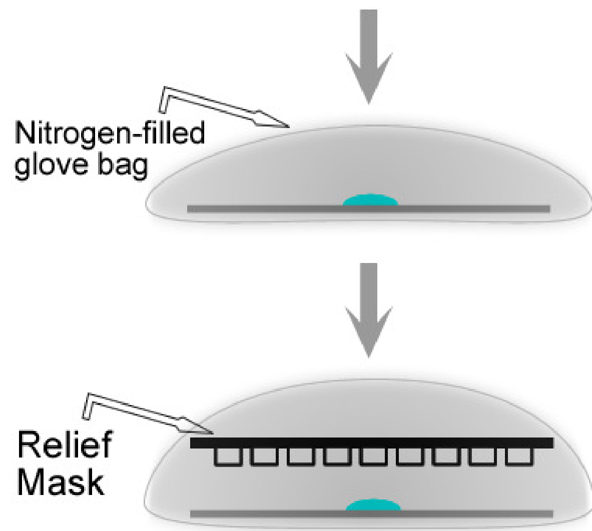
Preparation



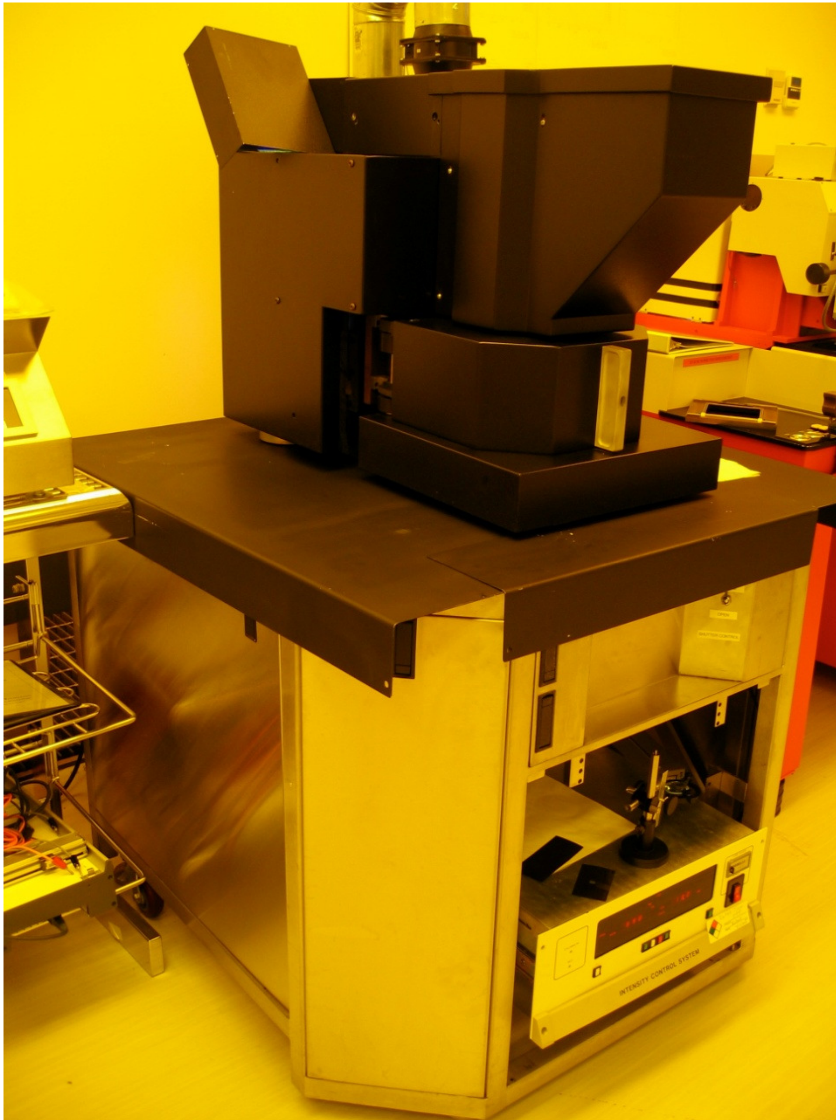


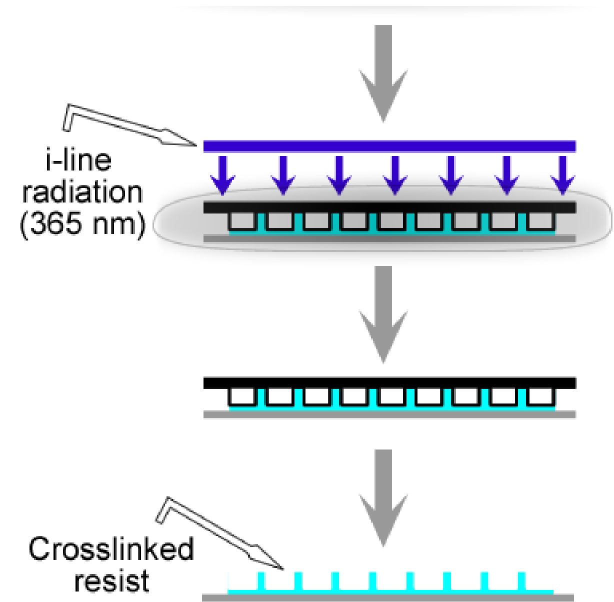


Nitrogen Environment



Exposure & Separation





Resist Removal

- Branson Asher
  - One to two hard ashes necessary to completely remove resist
- Acetone and Isopropyl Alcohol
  - Targeting the edges of the resist causes it to peal up making it easier to remove with compressed air or a chemical wipe

Examination & Results

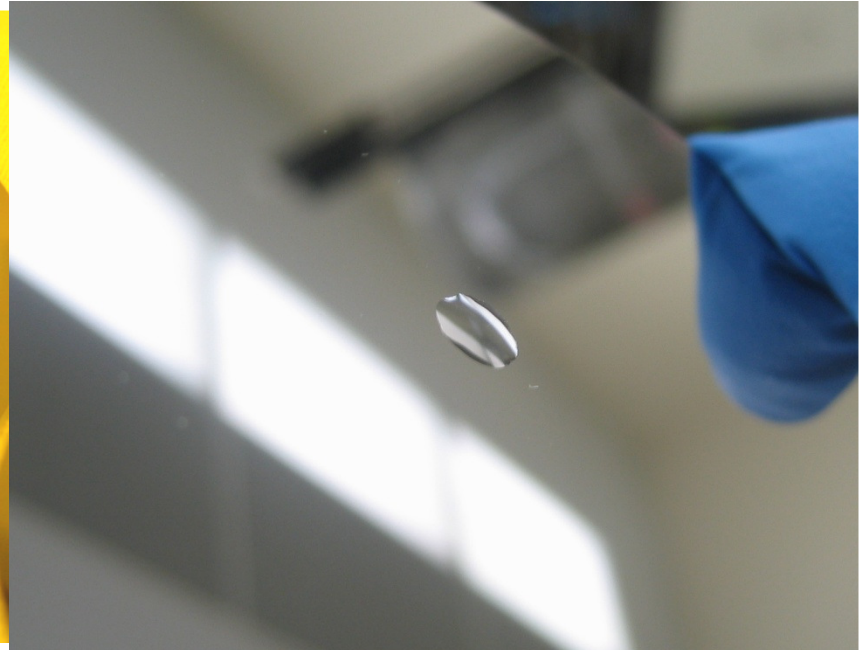
- The wafer is checked for resist or lack thereof from the separation.
- The resist is examined using:
  - Leica Microscope
  - Wyko NT1100 Optical Profiler
  - Amray Surface Electron Microscope (SEM)

Amray SEM

Source: http://smfl.microe.rit.edu/

(SMFL, Rochester Institute of Technology)

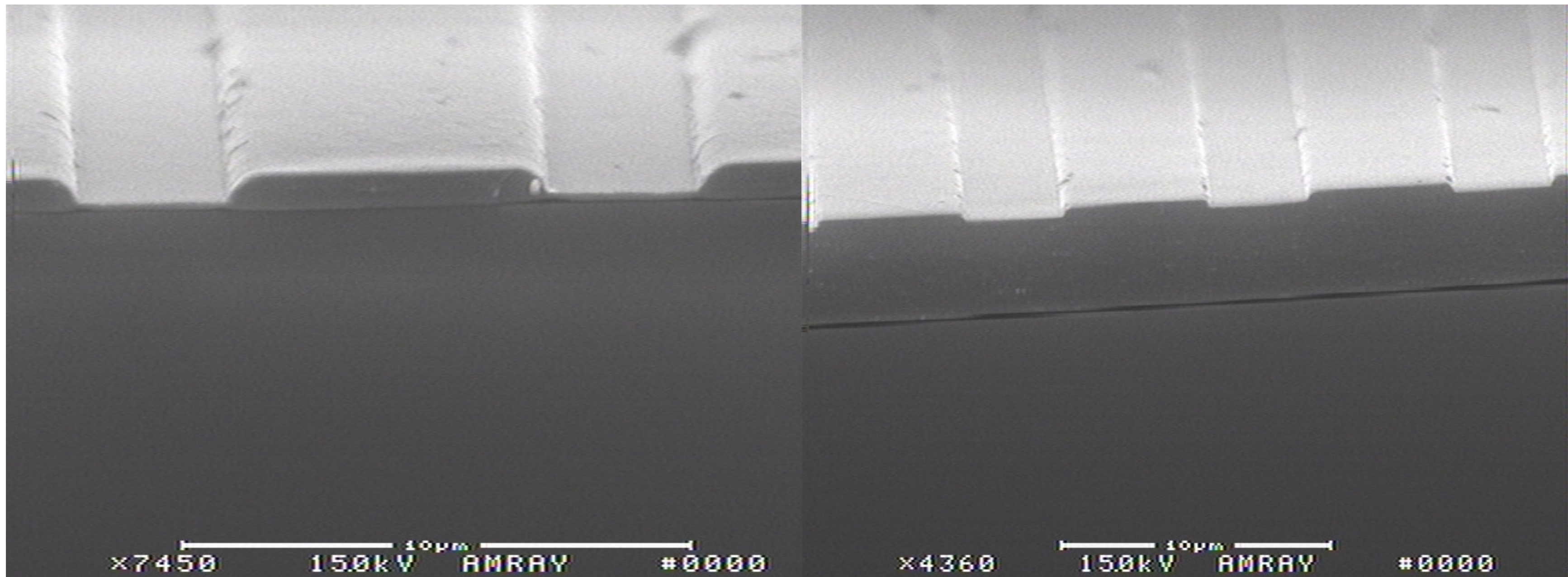
Oxygen Inhibition



2µL resist drop exposed in Nitrogen-Oxygen Environment

2µL resist exposed in Nitrogen Environment

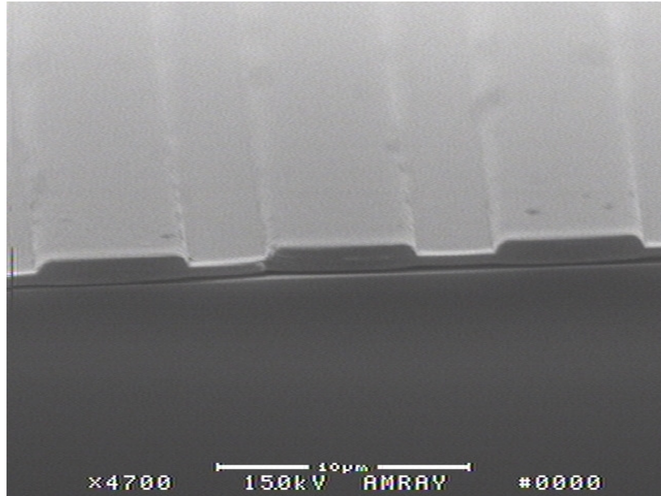
Varying Resist Thickness

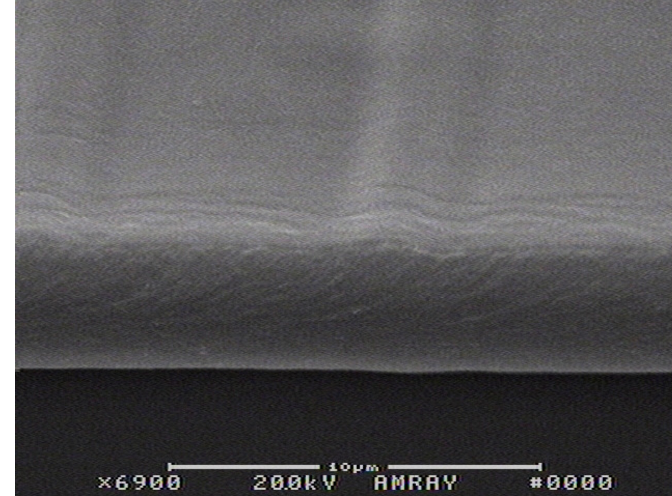


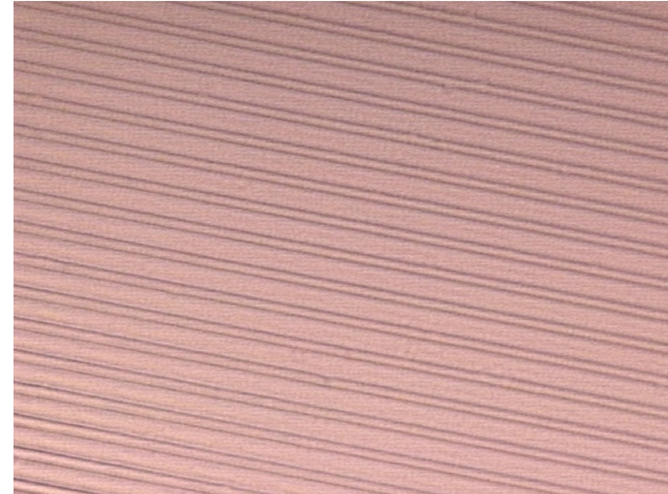
Closer to edge of resist

Closer to center of resist

Varying Pressure

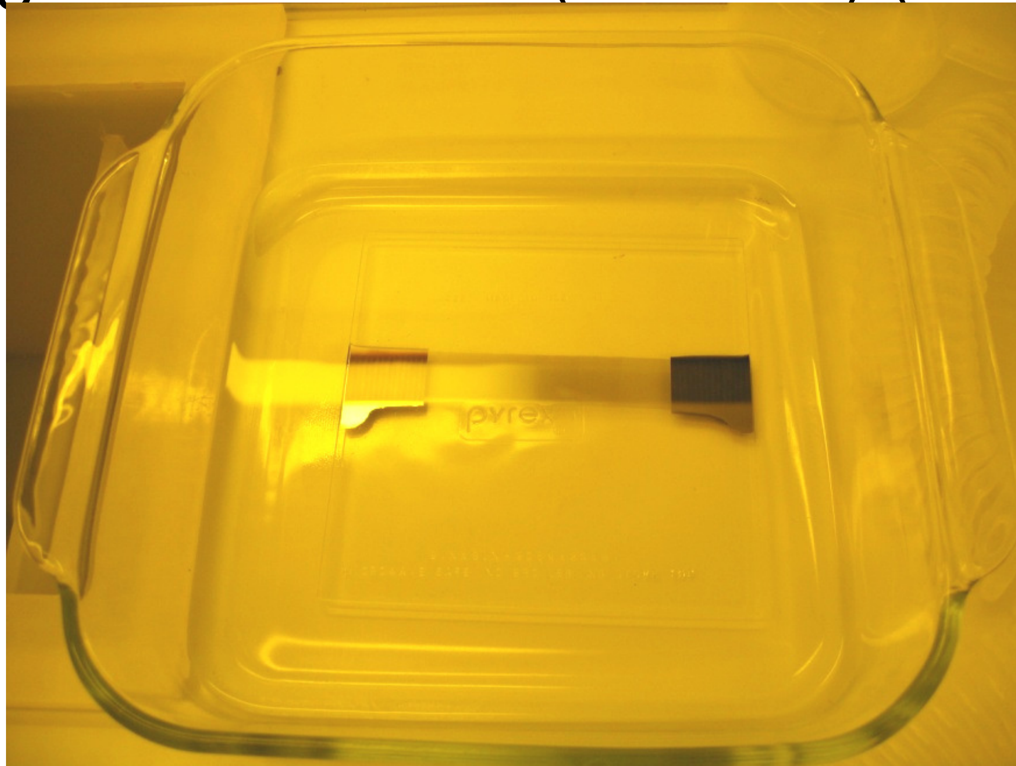






Release Agent

- .28 grams of (heptadecafluoro-1,1,2,2-tetrahydrodecyl)dimethylchlorosilane (0.2%)
- 139.72 grams RER 600 (PGMEA) (99.8%)



Conclusion

- Nanoimprint Lithography has shown itself to be a low-cost alternative to optical lithography. The total cost for materials was under $1000.
- With the lack of the proper equipment, getting a uniform resist coating with controlled pressure and nitrogen was unattainable.
- This exploration is successful nevertheless because we have achieved what we sought from the beginning—to imprint lines and spaces in a cross-linked resist.

Future Work

- Smaller Lines and Spaces
- Larger Line Aspect Ratio in Mask
- Better Release Agent
- Pattern Transfer
- Controlled Pressure
- Spin-on Resist Application

Acknowledgements

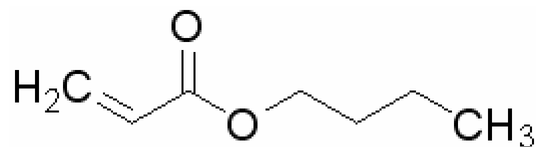
- Prof. Dale Ewbank (Department of Microelectronics, RIT)
- Ward Johnson (Department of Microelectronics, RIT)
- SMFL Staff
  - Thomas Grimsley
  - Sean O’Brien
  - Dr. Alan Raisanen
- Dr. Thomas Smith (Department of Chemistry, RIT)
- Nitin Nampalli (Department of Microelectronics, RIT)
- University of Texas at Austin
  - Dr. Grant C. Willson (Department of Chemical Engineering)
  - Frank Palmieri (Department of Chemical Engineering)
- National Science Foundation (NSF REU grant # ECCS-0731485)
- CIBA Specialty Chemicals
  - Dr. Eugene Sitzmann

References

- "Imprio 250 Nano-Imprint Lithography Systems." Molecular Imprints. 2007. 6 Aug. 2007 <http://www.molecularimprints.com/Products/I250page.html>.

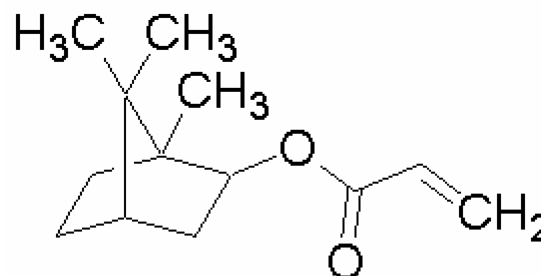
Chemical Structures

Butyl acrylate



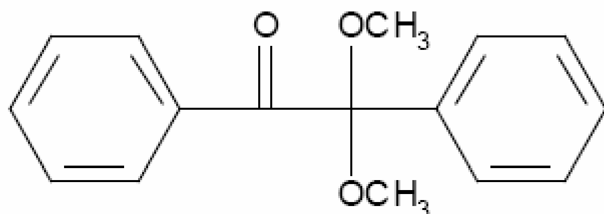
Source: http://www.sigmaaldrich.com/ (Sigma-Aldrich)

Isobornyl acrylate



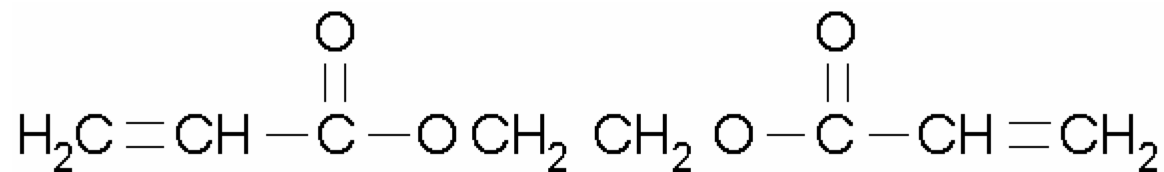
Source: http://www.sigmaaldrich.com/ (Sigma-Aldrich)

Irgacure 651



Source: http://www.cibasc.com/ (CIBA Specialty Chemicals)

Ethylene glycol diacrylate



Source: http://www.sigmaaldrich.com/ (Sigma-Aldrich)