Nanometer Scale Patterning and Processing

Spring 2016

Lecture 33

Nanoimprint Lithography (NIL) – Residual Layer After Nanoimprint

- Section 2

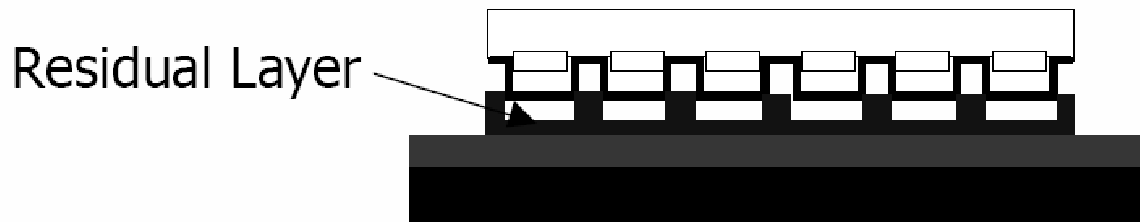
RESIDUAL LAYER AFTER NANOIMPRINT

Nanoimprint lithography (NIL)

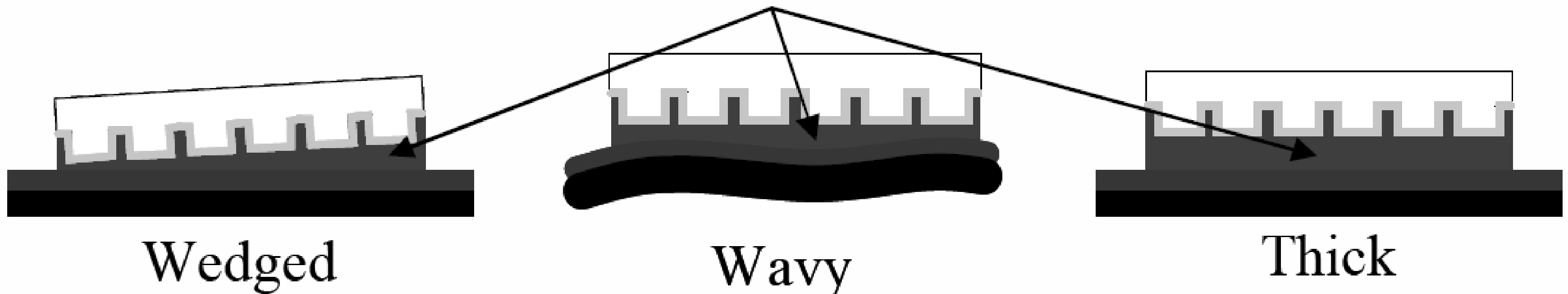
1. Overview.
2. Thermal NIL resists.
3. Residual layer after NIL.
4. NIL for large features (more difficult than small one).
5. Room temperature NIL, reverse NIL, inking.
6. NIL of bulk resist (polymer sheet, pellets).

Residue Layer

Residual Layer is due to the **undisplaced** liquid



Avoid: Non-uniformities



Residual layer needs to be thin and uniform

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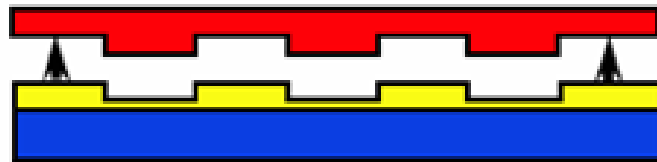
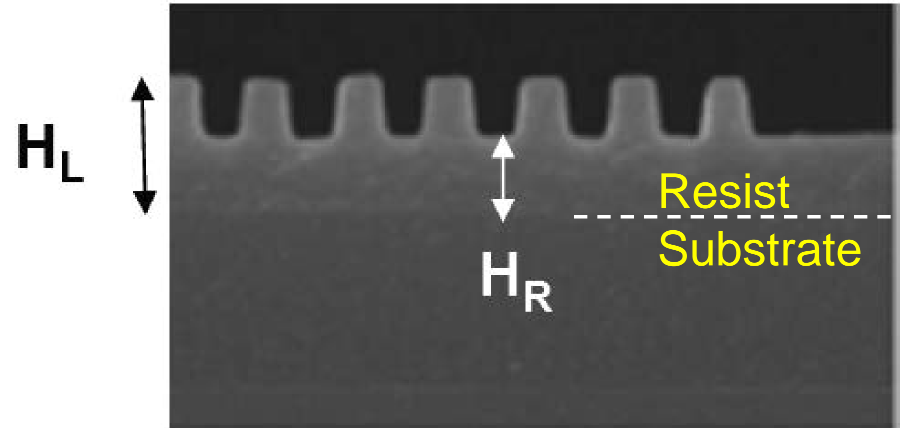
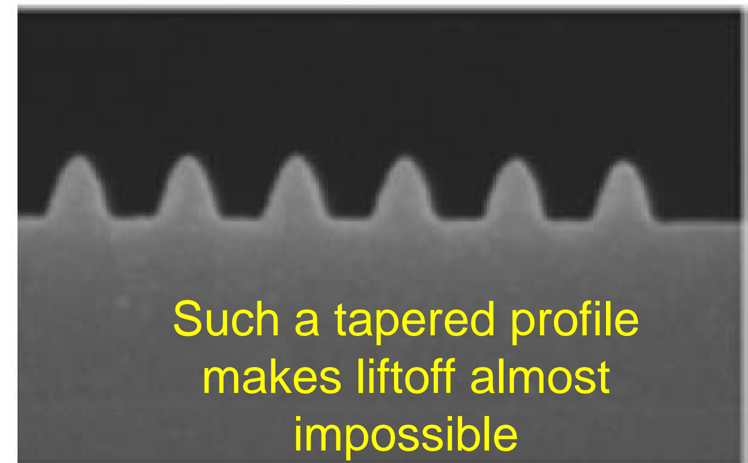
Residual layer: thinner is better for easier pattern transfer





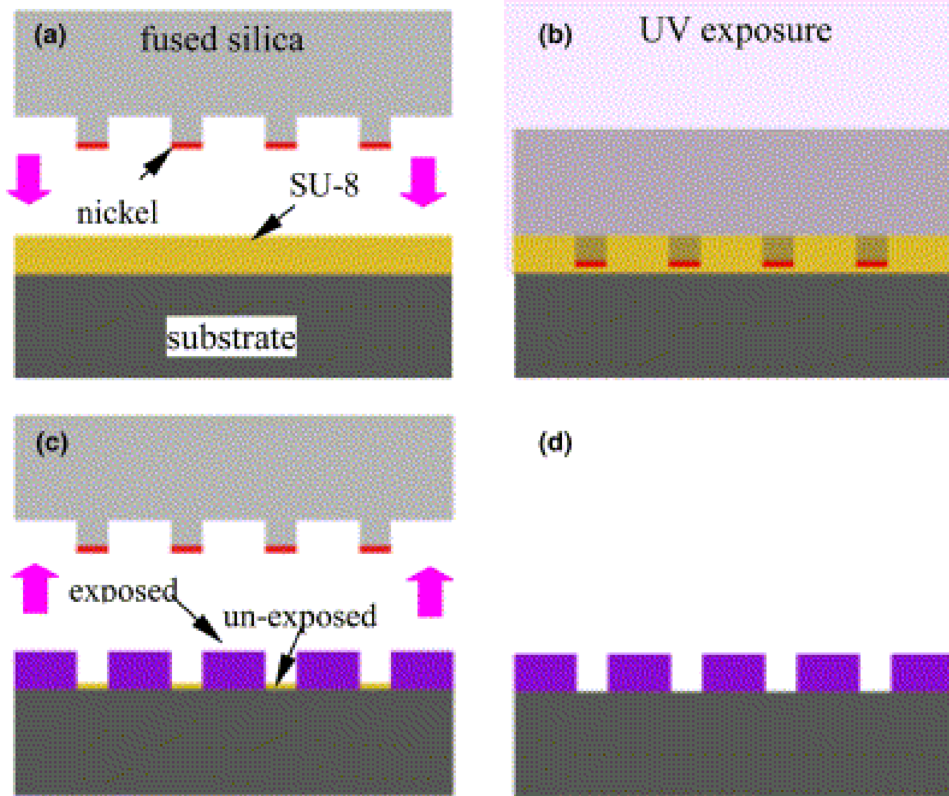
RIE descum



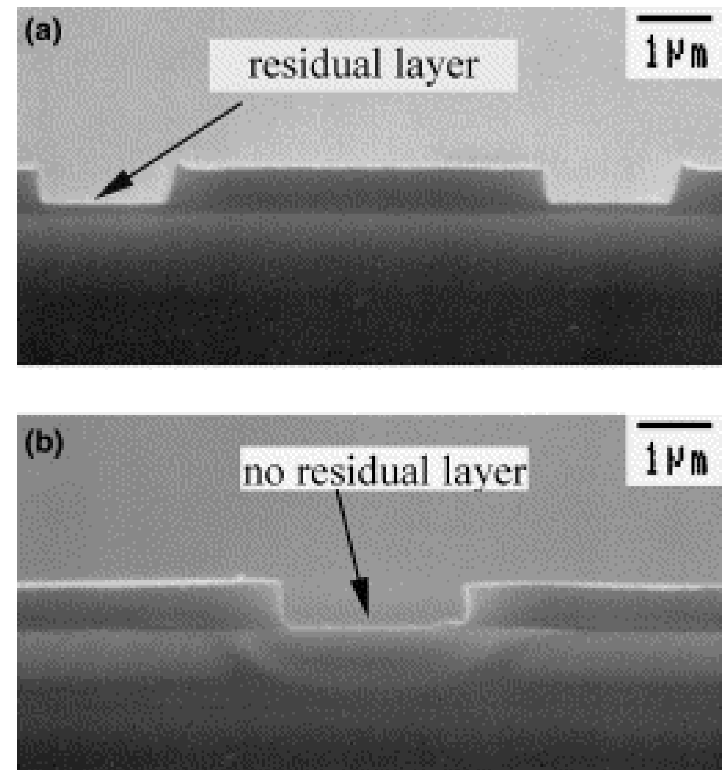
Too thick residual layer makes subsequent RIE more demanding: hard to control profile, pattern size shrinkage (CD loss).
So resist thickness should be ~ pattern height of mold.
CD: critical dimension.

How to get rid of residual layer

Light-blocking metal layer, use a developer solution instead of the separate O_2 RIE step.



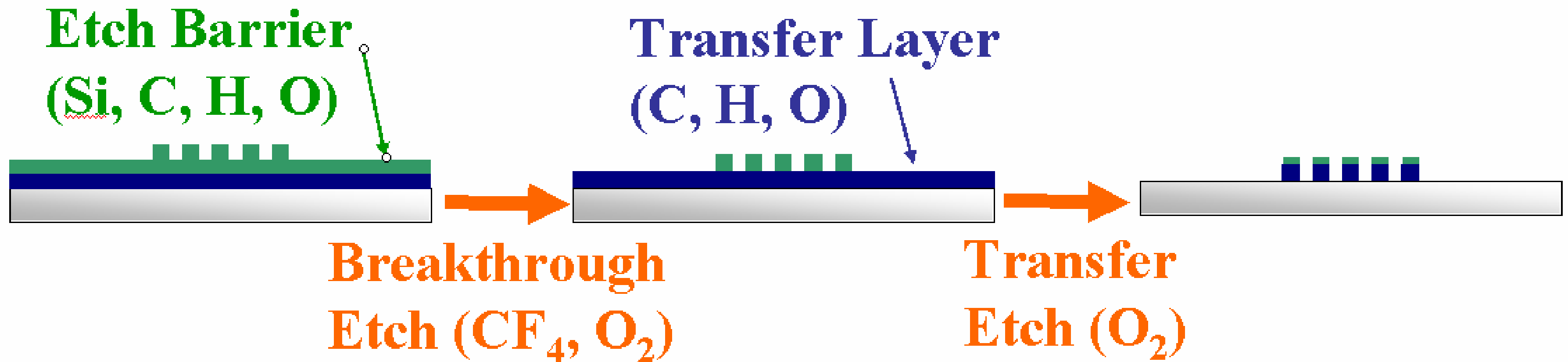
Un-exposed area developed (since SU-8 is negative resist)



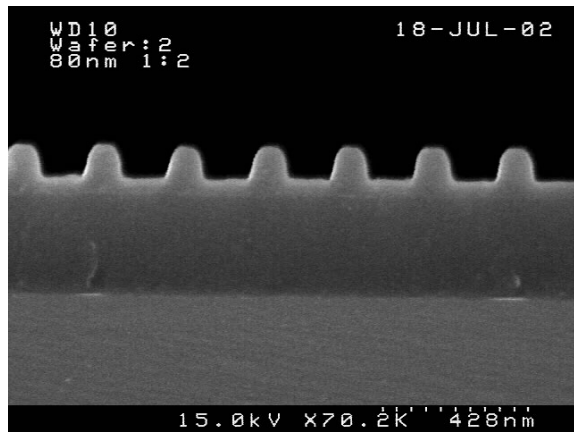
Comparison of residual layers in micro-scale resist pattern obtained by: (a) conventional NIL; (b) the current technique where no residual layer is left.

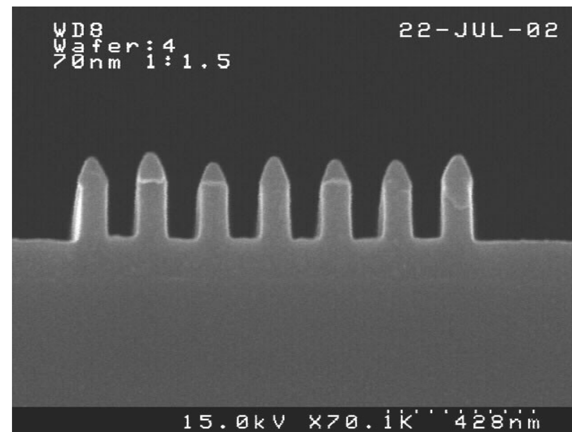
Cheng and Guo, "A combined-nanoimprint-and-photolithography patterning technique", MEE, 2004.

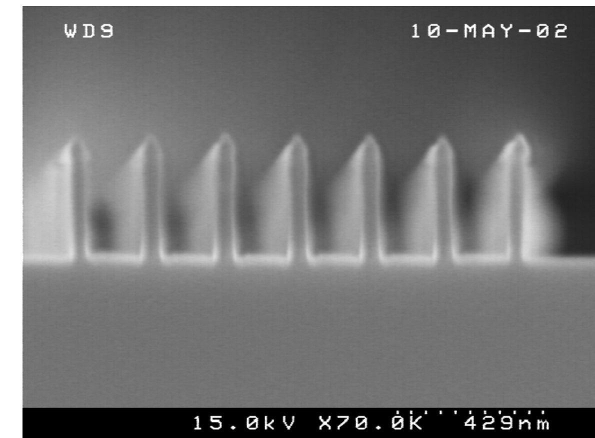
Etch Transfer after Imprint



http://willson.cm.utexas.edu/Research/Sub_Files/SFIL/Demonstrations/Etch/etch1.bmp







http://willson.cm.utexas.edu/Research/Sub_Files/SFIL/Demonstrations/Etch/etch.php

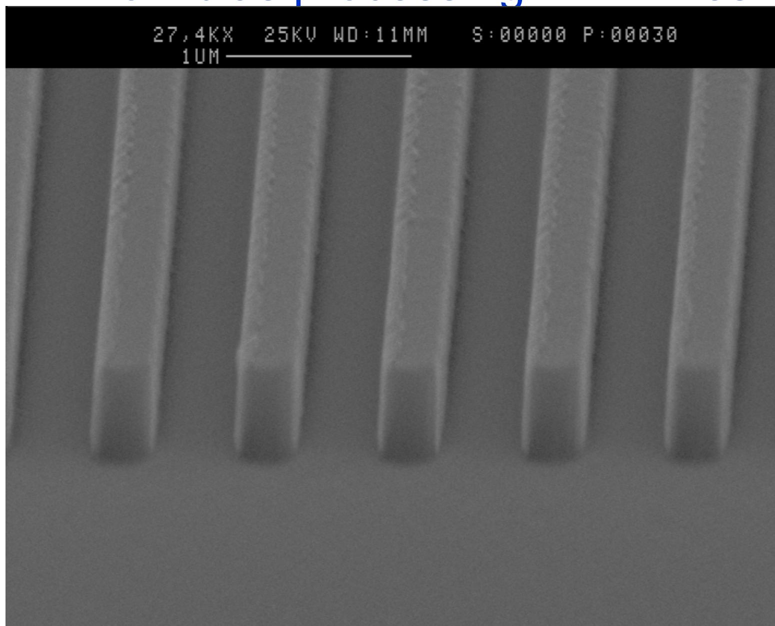
ICP etching of residue layer

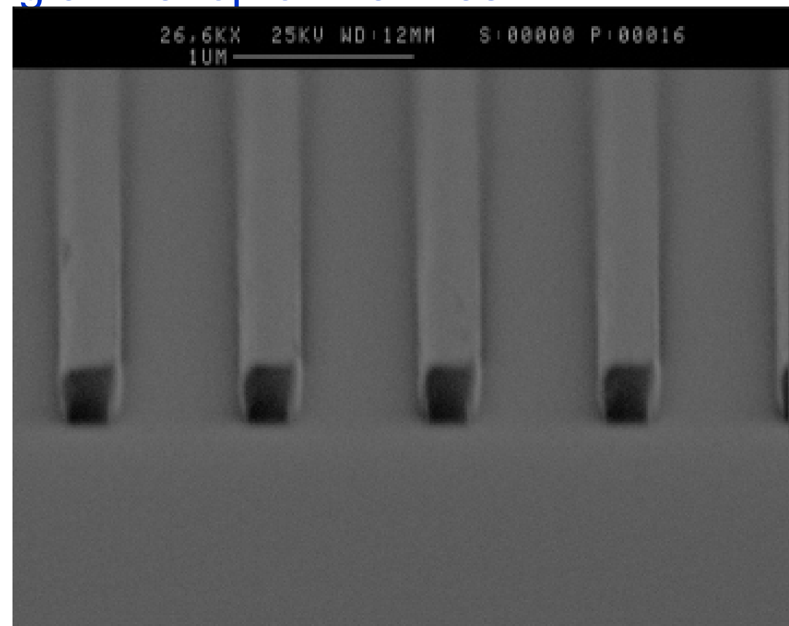
ICP: inductively coupled plasma, high plasma density and etching rate, better control

(According to an ICP tool seller)

ICP provides the best performance for etching residual layer:

- Low pressure processing minimizes isotropic (lateral) etching and loss of profile.
- Lower temperature processing also helps.
- Low bias processing minimizes faceting at the top of the lines.



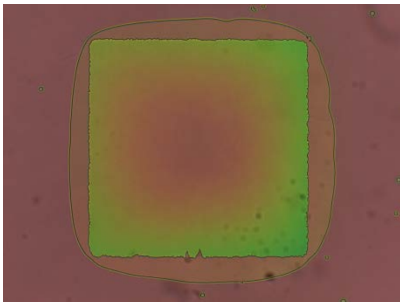


Polystyrene Nano-imprint descum (i.e. residue removal) on Al. 200nm residual removed in 2 minutes using a pure O_2 ICP plasma – linewidth remains constant at 0.35μm (??)

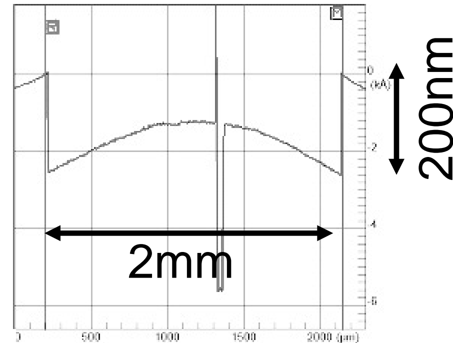
Another way to reduce residue layer effect: use tri-layer (or bi-layer) resist

Square (mm) imprinted into PMMA

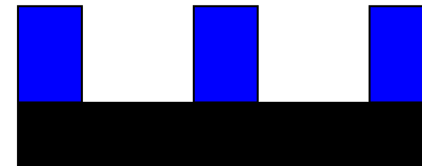
Optical image

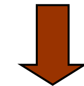


Profile

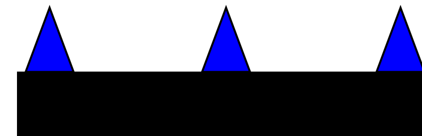


But for nanoscale features…



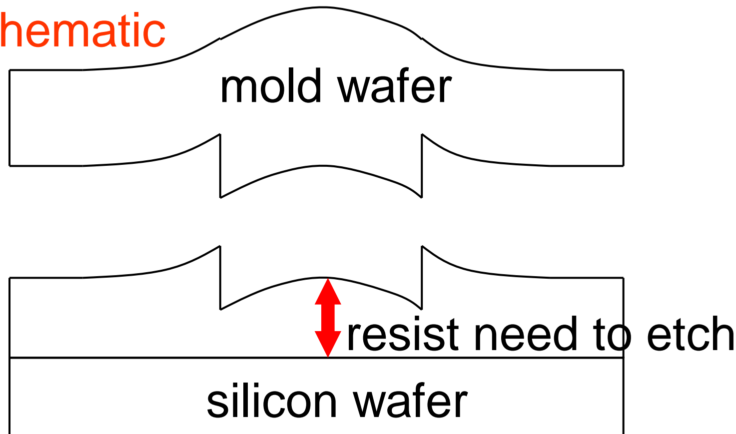


after excessive etch



Such a profile makes liftoff difficult.
Solution: use tri-layer resist system

Schematic



Need excessive etch to remove the thick resist at the square center