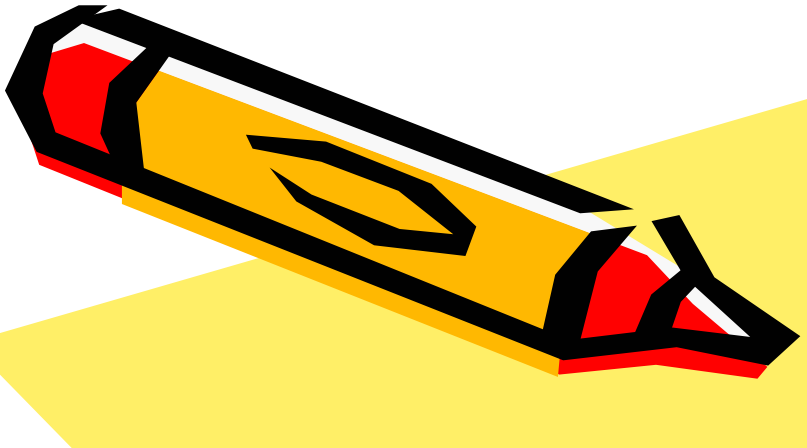
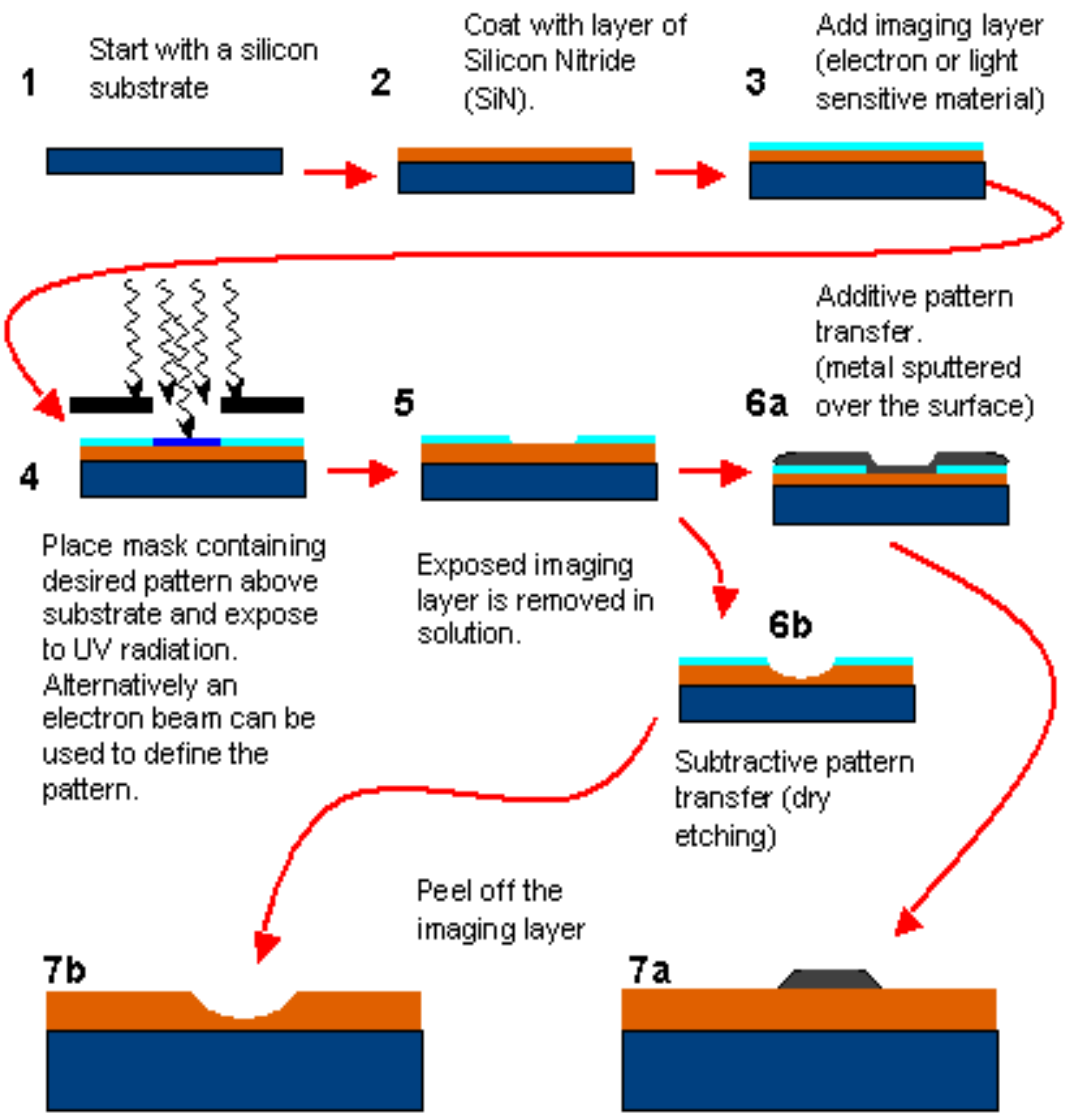


# Electron-Beam and X-Ray Lithography

Matt Shofnos
An-Jou Hsiung

# Overview

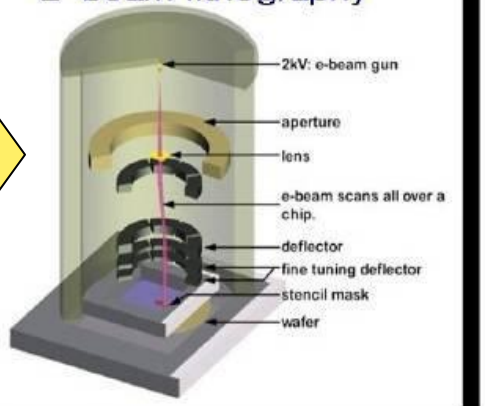
- What is Lithography?
  - Process used to transfer a geometric pattern onto a substrate
- Lithography Processes
- Lithographic Techniques



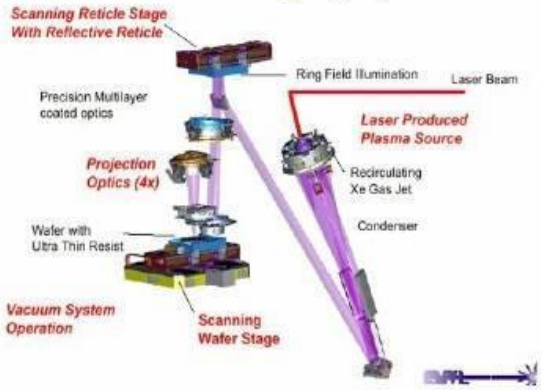

## Final Product

<http://www.macdiarmid.ac.nz/news/success/alkaisi.php>

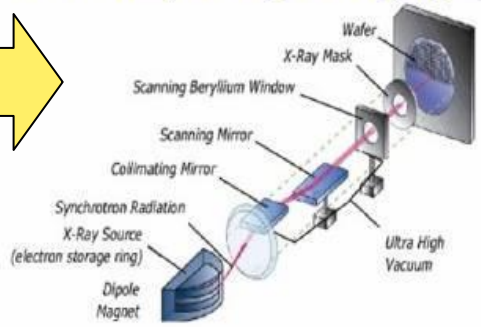
## E-beam lithography



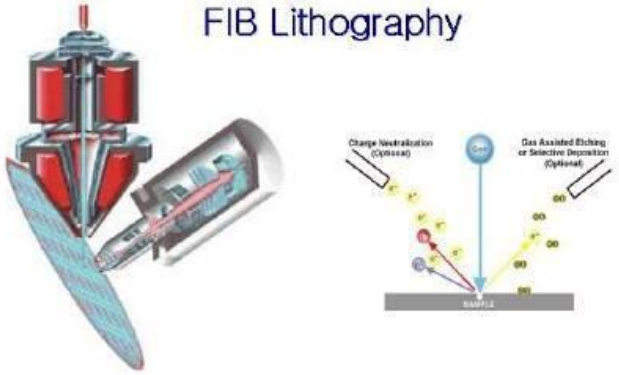

## EUV lithography



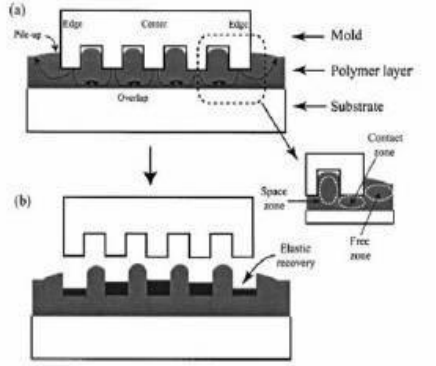

## Proximity X-ray Lithography



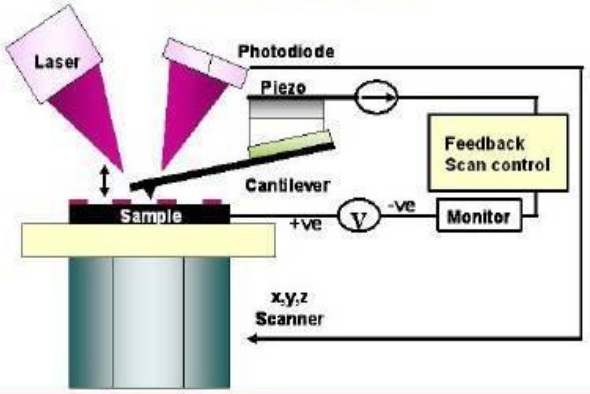

## FIB Lithography



## Nanoimprint lithography



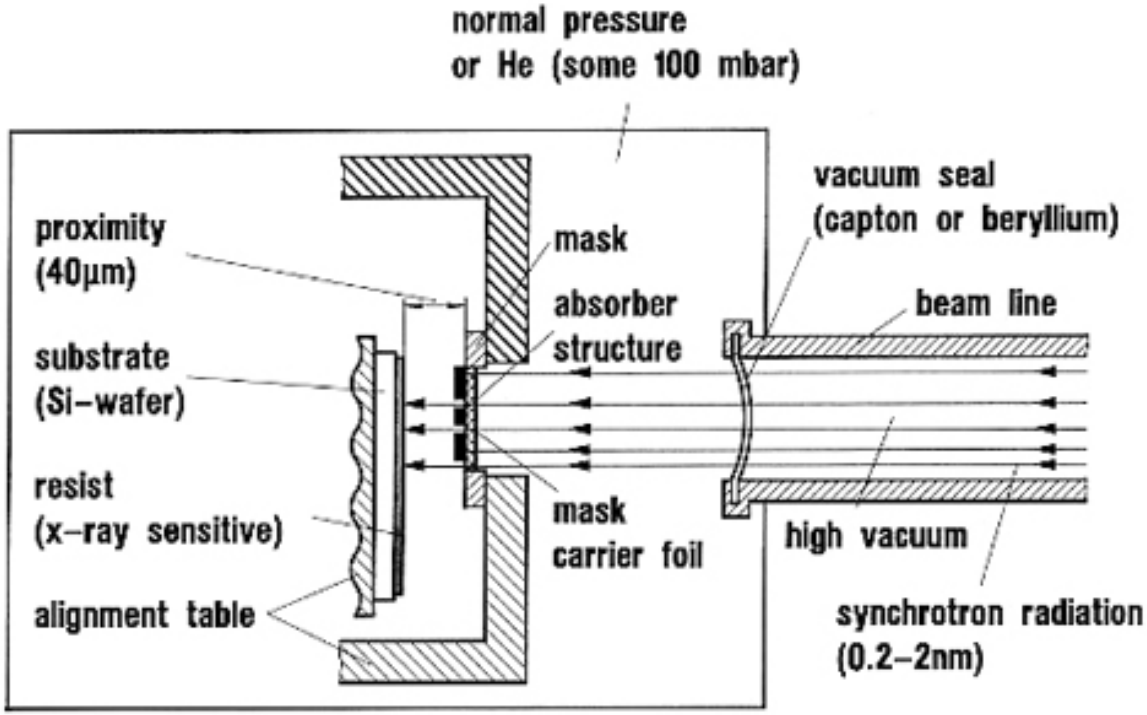

## SPM lithography




<http://otfl.hanyang.ac.kr/research/AFM%20lithography.htm>

# X-Ray Lithography

- Similar to traditional photolithography (or ultraviolet lithography)



# X-Ray Lithography - Pros

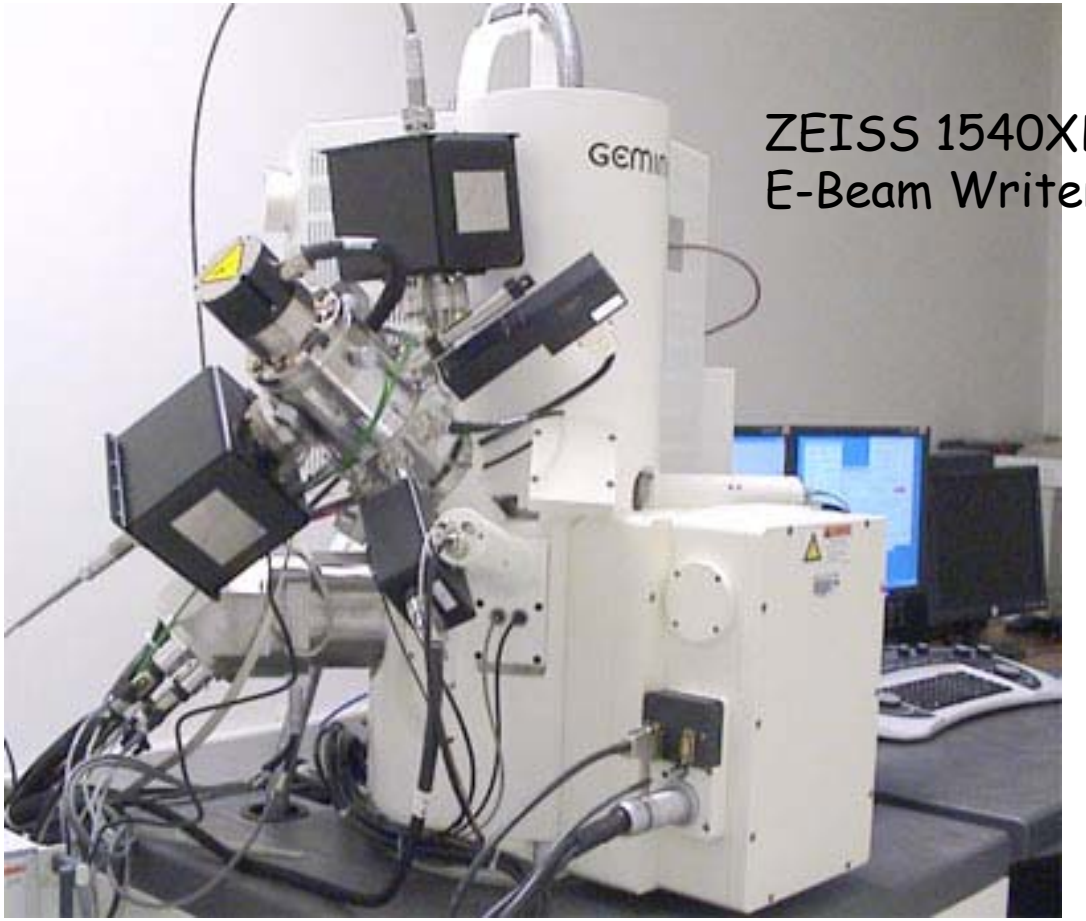
- Shorter wavelength (0.4 – 4nm) than UV light
- High penetration, high resolution
- Minimum feature size around 10 – 20 nm
- Simple process – can use both positive and negative resists
- Essentially negligible diffraction
- Longer mask lifetime than with photolithography

# X-Ray Lithography - Cons

- Very costly (compared to photolithography)
- Requires special masks and resists
  - X-ray absorbers: gold and tungsten
  - X-ray membrane: silicon carbide or diamond
- X-rays cannot be focused -> prevents the use of lenses

# E-Beam Lithography

- A technique that employs a focused beam of electrons for extremely precise patterning



ZEISS 1540XB CrossBeam
E-Beam Writer

<http://www.uta.edu/engineering/nano/facility.php?id=54&cat2=E-Beam>

# E-Beam Lithography - Pros

- The pattern is written directly onto the electron-sensitive resist (no mask is used)
- More precise than photolithography or X-Ray lithography
- Used to make high-resolution masks for photolithography and X-Ray lithography
- Beats the diffraction limit of light, minimum feature size around 5 nm

# E-Beam Lithography - Cons

- Very slow. Takes over 10 hours to scan across the entire surface of a wafer
- Very costly. One e-beam system costs upwards of 5 to 10  MILLION dollars
- Potential problems with electron scattering:
  - Electron energy: 100eV -> very slow, inefficient, damage the substrate
  - Electron energy: 10eV -> lower penetration depth and lower resolution

# Conclusion

- X-Ray and e-beam lithography can be used as complementary techniques
  - E-beam lithography is generally reserved for the manufacture of masks
- Nest generation in IC fabrication:
  - Cheaper, faster, and more precise

QUESTIONS??!!