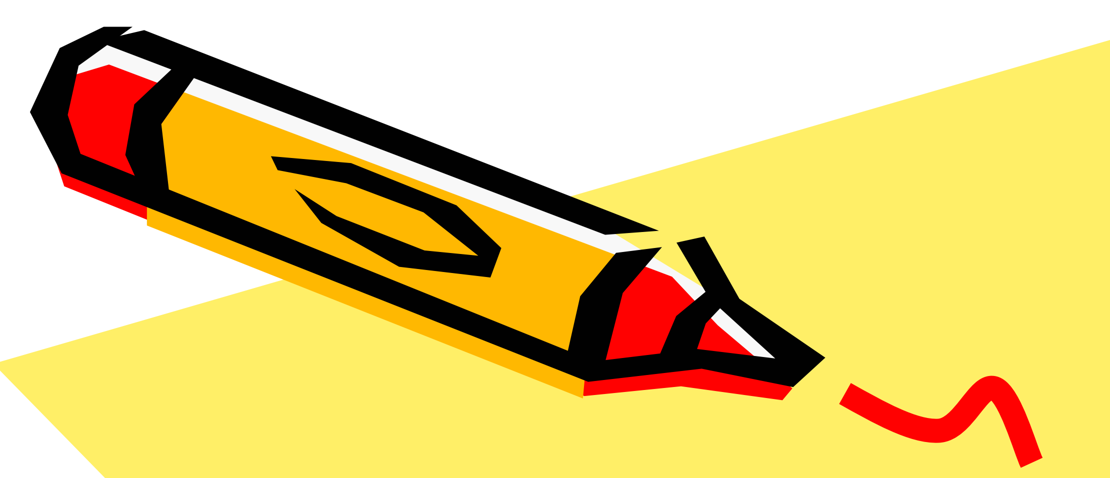
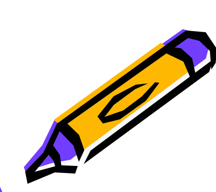


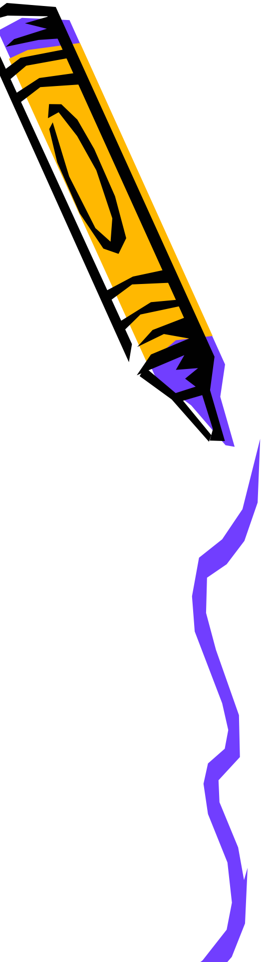
Electron-Beam and X-Ray Lithography

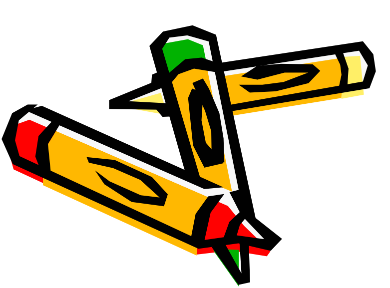
Matt Shofnos
An-Jou Hsiung



Overview

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





1 Start with a silicon substrate

2 Coat with layer of Silicon Nitride (SiN).

3 Add imaging layer (electron or light sensitive material)

4 Place mask containing desired pattern above substrate and expose to UV radiation. Alternatively an electron beam can be used to define the pattern.

5 Exposed imaging layer is removed in solution.

6a Additive pattern transfer. (metal sputtered over the surface)

6b Subtractive pattern transfer (dry etching)

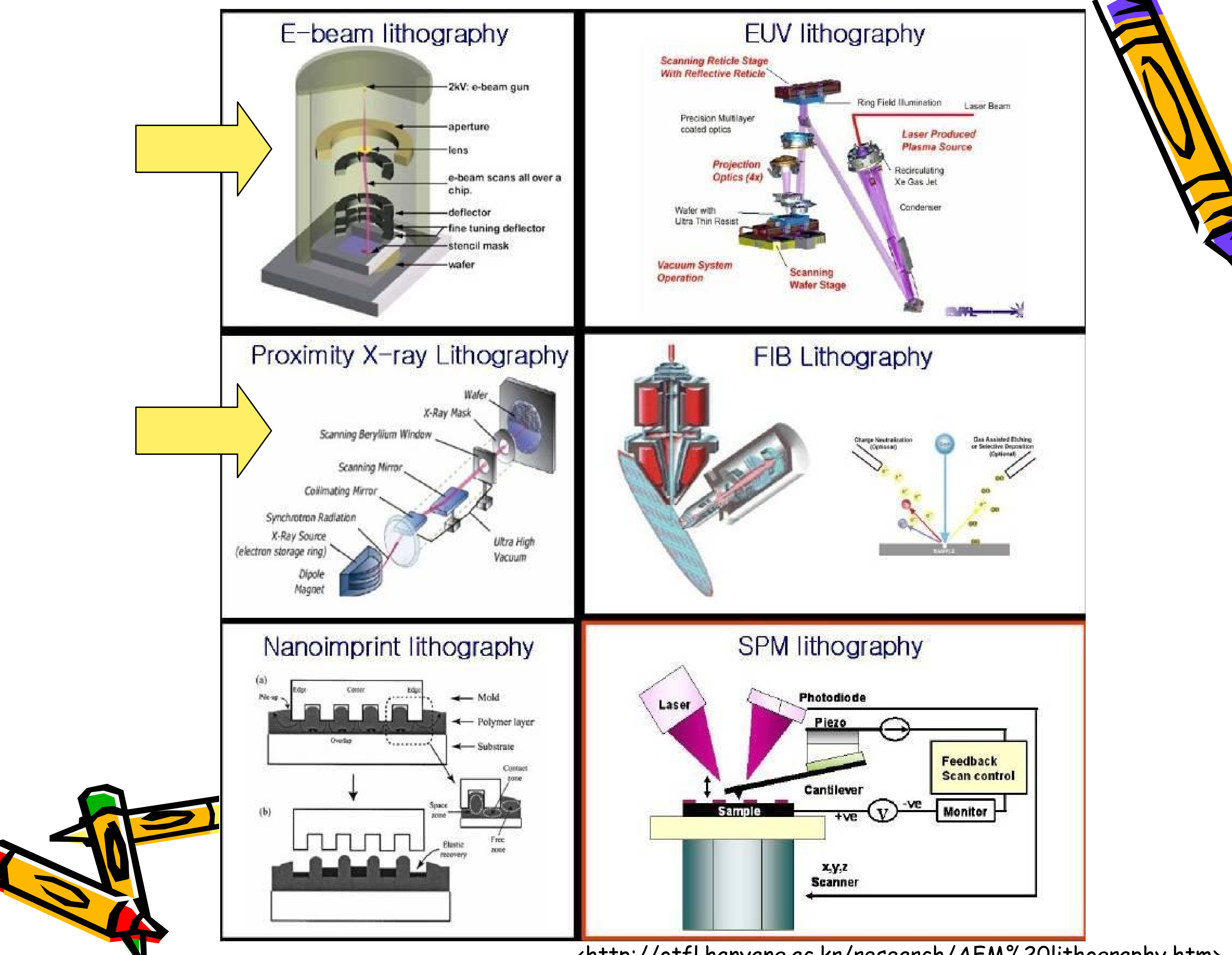
Peel off the imaging layer

7b

7a

Final Product

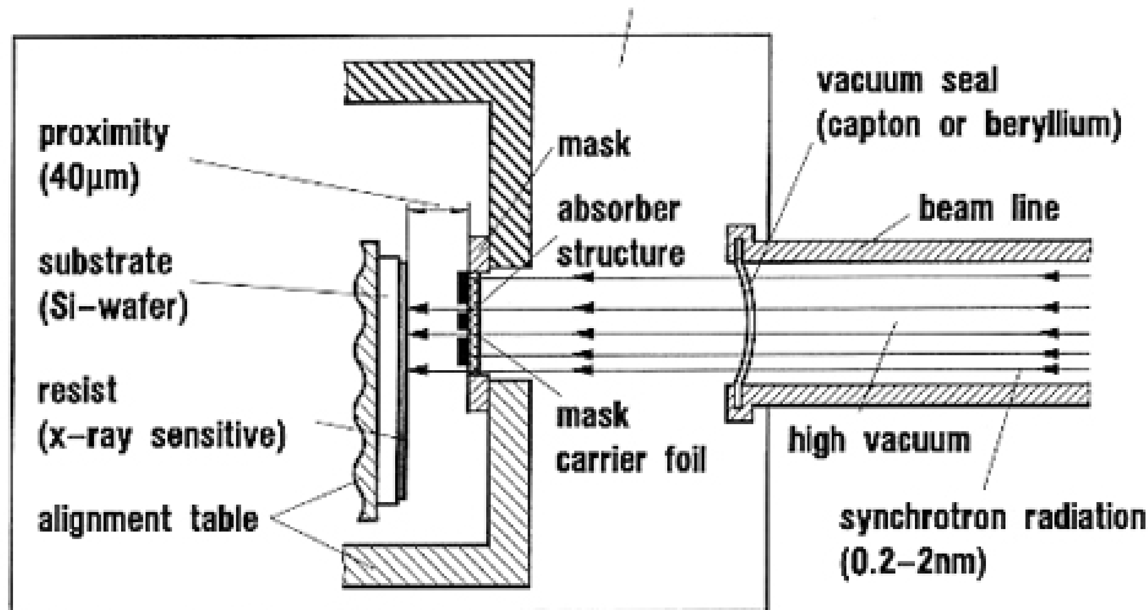
<http://www.macdiarmid.ac.nz/news/success/alkaisi.php>



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

X-Ray Lithography

- Similar to traditional photolithography (or ultraviolet lithography)

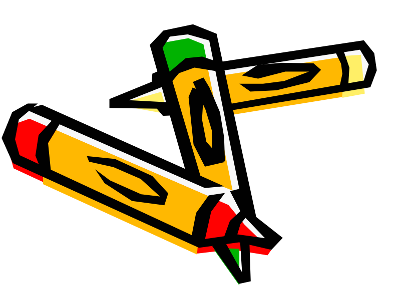


X-Ray Lithography - Pros

- 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

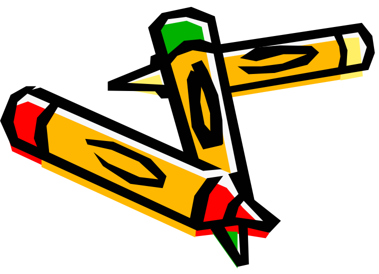
- Very costly (compared to photolithography)
- Requires special masks and resists
  - X-ray absorbers: gold and tungsten
  - X-ray membrane: silicon carbide or diamond
- X-rays cannot be focused -> prevents the use of lenses



E-Beam Lithography

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

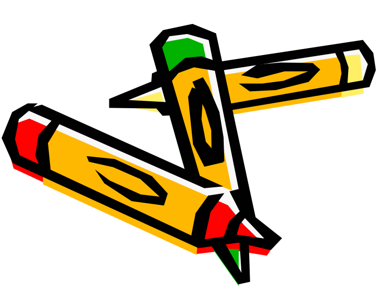
ZEISS 1540XB CrossBeam
E-Beam Writer



<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

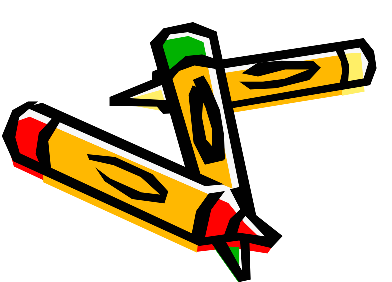


E-Beam Lithography - Cons

- 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??!!