Nano structured materials-synthesis, properties, self assembly and applications

by Prof. A.K. Ganguli, Chemistry Department,
IIT Delhi, New Delhi.

Module 2, lecture 11 and 12: Lithography 1

Problem:

1. What is Lithography? What is the importance of lithography?
2. What are different types of lithography?
3. What is photolithography? What is photoresist? Give an example.
4. What are the factors important for photolithography?
5. How does positive photoresist work in photolithography?
6. What is the resolution in photolithography? How does it depend on the wavelength of the light?
7. What are the essential conditions for better resolution in photolithography?
8. What are the advantages and disadvantages of X-ray lithography?
9. Explain the mechanism of X-ray interference lithography.

Lithography 2:

1. What is electron beam? What is focused ion beam (FIB) technique?
2. What are the advantages of E-Beam Lithography over photolithography?
3. Explain the mechanism of dip-pen lithography.
4. What is atomic force microscopy (AFM)? How does it work?
5. What is the basic principle of Scanning tunnelling microscopy?

Module 2, lecture 11 and 12:

Solution:

Lithography 1 :

1. Lithography is a method of producing three-dimensional relief patterns on a substrate. It is like an image drawn (etched) into a coating of wax or an oily substance.
   Importance: Low cost IC and devices, miniaturized device fabrication.

2. Photolithography (optical, UV, EUV)
   E-beam/ion-beam lithography
   X-ray lithography
   Interference lithography
   Scanning Probe
   Step Growth
   Nanoimprint
   Shadow Mask
   Self-Assembly
   Nanotemplates

3. Light is used to transfer a geometric pattern from a photomask to a light-sensitive chemical "photoresist", or simply "resist," on the substrate. Example **SU8**

4. Type of resists
   Thickness of Resists
   Mask alignment
   Wafer surface
   Resist adhesion
   Exposure energy
   Temperature
   Development time

5. Shadow on photoresist is the pattern.

$$l_m = k_1 \frac{\lambda}{NA}$$

6. λ: wavelength of exposure
   k_1: parameter characterizing system and process dependence
   (typically between 0.25 and 1)
   Smaller features need smaller wavelengths of light

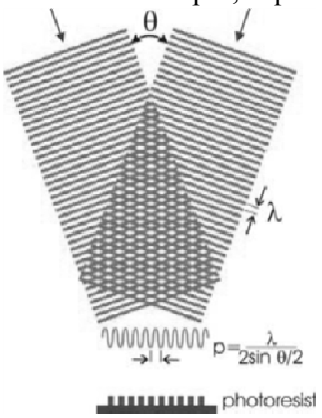
   UV : 365nm - 436nm
   Deep UV (DUV) : 157nm - 250nm
   Extreme UV (EUV) : 11nm - 14nm
   X-ray : < 10nm

7. Thinner photoresist & larger NA (numerical aperture)
   Shorter wavelength (DUV, and even X-rays)

8. **Advantages**
   resolves diffraction
   shorter wavelengths (.1-10 nm)
   smaller features

   Disadvantages:
   Thin X-ray Masks
   Deformations
   Vibrations
   Time Consuming

9. UV Laser is split, expanded and superimposed to form an interference pattern.



Lithography 2:

1. Electron beam is a concentrated, highly charged stream of electrons, which is generated by the acceleration and conversion of electricity. FIB is the technique where positive ions hit the sample surface producing secondary electrons and ions. A focused Ion beam of Ga ions are used for the gas assisted etching and making patterns or micromachining.
2. The resolution is not limited by diffraction, minimum feature is written on the nanoscale
   Can write smaller features than:
      X-ray Lithography
      Photolithography
   Pattern is written directly to the wafer
   Used to develop
      Specialized devices
      Prototype devices
3. The molecular biomaterial is first coated and dried onto a DPN tip.
   The subsequent transfer of molecules from tip to surface occurs through a water meniscus that forms spontaneously from the surrounding atmosphere.

4. when a cantilever tip comes close to the sample surface, due to the Atomic forces, Tip oscillates and results topography of the surface. This is a force probe topography measurement.
5. It is based on tunneling current between tip atom and sample atom which depends on Tip position.