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.

\[ l_m = k_1 \frac{\lambda}{N A} \]

6. \( \lambda \): 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.

   ![Interference Pattern](image)

**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.