جامعة بنها المستوي 3

كلية العلوم انماء بلوري

Phy 354 1/1/2019

الزمن:2 ساعه..... اجب عن الاسئله الاتيه

Every question =20 Marks

1.

- **Discuss Scanning Electron Microscope in details**
- **The supersaturation can be kept constant by ……..**

2.

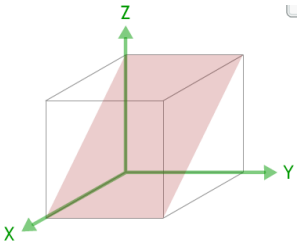
- **Derive an expression for the critical supersaturation**
- **Give short description for X-ray technique and define bremasterhalng?**

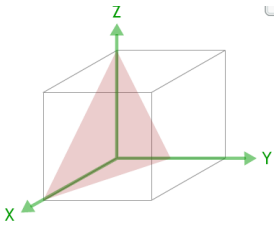
3.

- **Give short note about hydrothermal growth.**
- **Draw the (100) and (110) planes of a body centered cubic (bcc) lattice to *THE CORRECT scale (Give dimensions)*. You can assume that the length of the cell is 1. The bcc structure consists of atoms at each corner of a cubic lattice and an atom sitting at the cube center. Draw in where the atom positions are in the planes.**

4.

- **Determine the Miller indices (hkl) of the shaded planes below. Show your work on each step to determine the plane.**



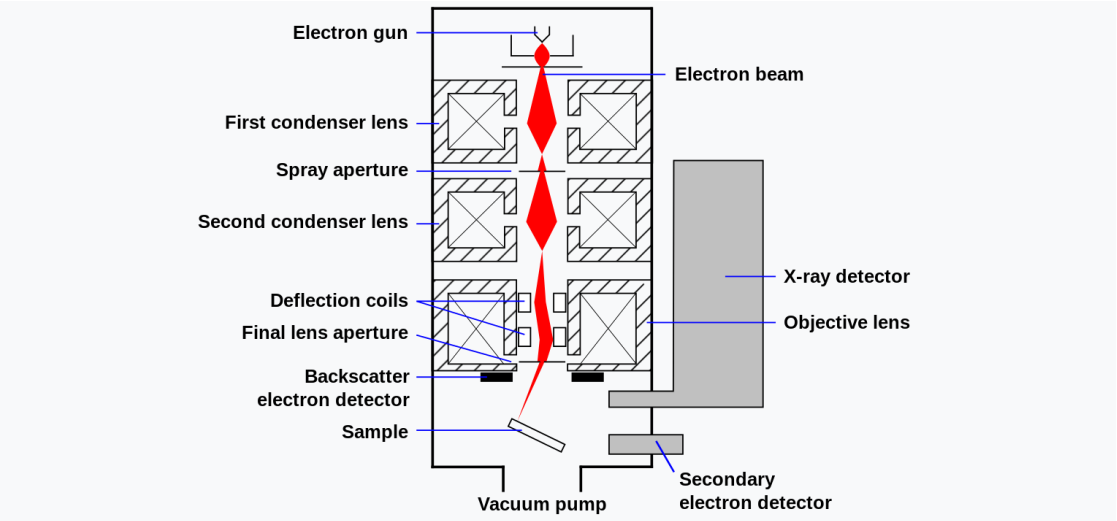


5. **Interplanar spacing for crystal systems with cubic symmetry can be expressed by the relation:**

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

where hkl is the Miller indicies and a is the lattice parameter. Using a Bragg Diffractometer, we would like to determine if our Aluminum film for interconnection to our MOSFET has (111) crystal orientation for good electromigration reliability. Our diffractometer uses Cu Kα radiation of wavelength 1.54 Å. Check to see if we actually have (111) Aluminum films if we measure θ ~22.4° for a first order diffraction peak. We also know that the lattice parameter of aluminum is 3.5Å.

1.



Analog type SEM

A **scanning electron microscope** (**SEM**) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. The electron beam is scanned in a raster scan pattern, and the position of the beam is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens are observed in high vacuum in conventional SEM, or in low vacuum or wet conditions in variable pressure or environmental SEM, and at a wide range of cryogenic or elevated temperatures with specialized instruments.[1]

The most common SEM mode is the detection of secondary electrons emitted by atoms excited by the electron beam. The number of secondary electrons that can be detected depends, among other things, on specimen topography. By scanning the sample and collecting the secondary electrons that are emitted using a special detector, an image displaying the topography of the surface is created.

In a typical SEM, an electron beam is thermionically emitted from an electron gun fitted with a tungsten filament cathode. Tungsten is normally used in thermionic electron guns because it has the highest melting point and lowest vapor pressure of all metals, thereby allowing it to be electrically heated for electron emission, and because of its low cost. Other types of electron emitters include lanthanum hexaboride (LaB

(6cathodes, which can be used in a standard tungsten filament SEM if the vacuum system is upgraded or field emission guns (FEG), which may be of the cold-cathode type using tungsten single crystal emitters or the thermally assisted Schottky type, that use emitters of zirconium oxide.

The electron beam, which typically has an energy ranging from 0.2 keV to 40 keV, is focused by one or two condenser lenses to a spot about 0.4 nm to 5 nm in diameter. The beam passes through pairs of scanning coils or pairs of deflector plates in the electron column, typically in the final lens, which deflect the beam in the x and y axes so that it scans in a raster fashion over a rectangular area of the sample surface.

Mechanisms of emission of secondary electrons, backscattered electrons, and characteristic X-rays from atoms of the sample

When the primary electron beam interacts with the sample, the electrons lose energy by repeated random scattering and absorption within a teardrop-shaped volume of the specimen known as the interaction volume, which extends from less than 100 nm to approximately 5 µm into the surface. The size of the interaction volume depends on the electron's landing energy, the atomic number of the specimen and the specimen's density. The energy exchange between the electron beam and the sample results in the reflection of high-energy electrons by elastic scattering, emission of secondary electrons by inelastic scattering and the emission of electromagnetic radiation, each of which can be detected by specialized detectors. The beam current absorbed by the specimen can also be detected and used to create images of the distribution of specimen current. Electronic amplifiers of various types are used to amplify the signals, which are displayed as variations in brightness on a computer monitor (or, for vintage models, on a cathode ray tube). Each pixel of computer video memory is synchronized with the position of the beam on the specimen in the microscope, and the resulting image is, therefore, a distribution map of the intensity of the signal being emitted from the scanned area of the specimen. Older microscopes captured images on film, but most modern instrument collect digital images.

1-

- The supersaturation can be kept constant by :

1. Isothermal evaporation of the solvent
2. lowering the temperature
3. adding solute
4. adding another solvent

-

2.

$$G = H - TS \tag{1.2}$$

where H is the enthalpy, S is the entropy and T is the temperature.

The formation of a crystal can be considered as a controlled change of phase to the solid state. The driving force for crystallization comes from the lowering of the free energy of the system during this phase transformation. The free energy change associated with such a transition is

$$\Delta G = \Delta H - T\Delta S \tag{1.3}$$

where $\Delta H = H_L - H_S$

$\Delta S = S_L - S_S$

$\Delta G = G_L - G_S$

At equilibrium $\Delta G = 0$

$\therefore \quad \Delta H = T_e \Delta S$

where T_e is the equilibrium temperature.

$$\therefore \quad \Delta G = \Delta H . \Delta T / T_e \tag{1.4}$$

where $\Delta T = T_e - T$

ΔG is positive when $T_e > T$ and it depends on the latent heat of transition. The free energy change can also be represented as the product of the entropy change and super cooling ΔT.

$$\Delta G = \Delta S . \Delta T$$

Though this representation is convenient for melt growth, one may depend on concentrations rather than supercooling for solution growth and vapour growth. Thus the equation modifies to

$$\Delta G \sim RT \ln (C/C_o)$$
$$\Delta G \sim RT \ln (P/P_o) \qquad (1.5)$$

In general

$$\Delta G \sim RT \ln S \qquad (1.6)$$

where S is the supersaturation ratio. Equation (1.4) and (1.6) explain how the free energy changes depend on the parameters like supercooling and supersaturation which are decisive in the process of crystallization. The rate of growth of a crystal can be regarded as a monotonically increasing function of ΔG, if the other parameters remain the same.

- .

The basic components of an X-ray tube are shown in Figure 7-4. The tube is operated in a vacuum, thus allowing independent control of the number and speed of acceleration of the electrons striking the anode. The anode is made of either tungsten or molybdenum. The cathode is composed of two parts: the filament made of tungsten, and a focusing cup. The filament is a helical coil about 0.2 mm in diameter. When current flows through the coil and the wire heats up; this energizes the electrons. If the heat is high enough, then the electrons escape from the metal. These electrons are then accelerated towards the anode by applying a high-voltage potential across the anode and cathode.

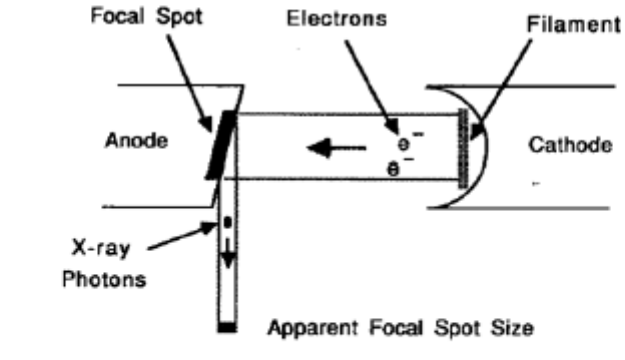
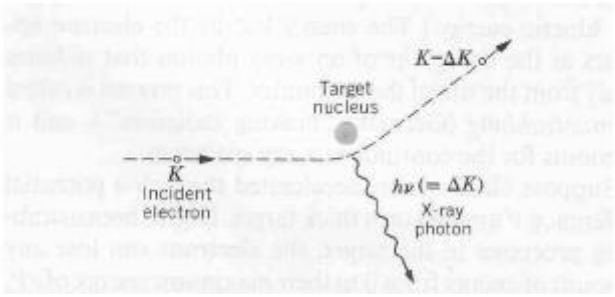


Figure 7-4 Basic components of an X-ray source

Potential energy eV have been converted to electromagnetic wave as follow :

$$\frac{h}{c\lambda_{\min}} = eV$$

The mechanism for bremsstrahlung is as follows:-



Bremsstrahlung ("Braking radiation"): An energetic electron which undergoes a sudden acceleration caused by interaction with a high-Z nucleus has a high probability of emitting a "bremsstrahlung" photon with an energy in the range from 0 to the full kinetic energy of the electron. This is the process that occurred in Röntgen's discovery experiment when electrons accelerated in the discharge struck the glass wall of the tube.

3.

- Hydrothermal growth

  Hydrothermal growth is growth technique we can use if the solubility of the solute in water is not high. Since the solubility increases with increasing temperature. This calls for employment of high pressure containers. For example, sapphire, quartz

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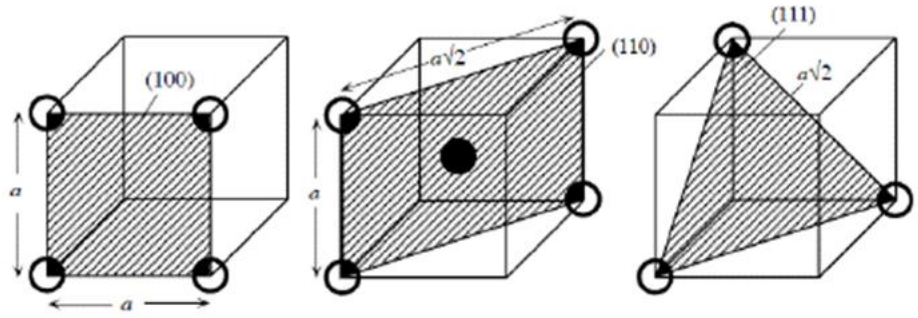
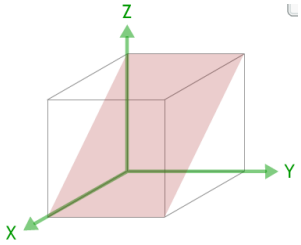


(100), (110), (111) planes in the BCC crystal

4.



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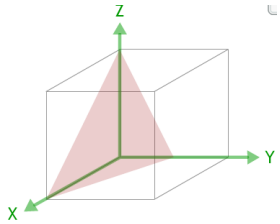

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5.

d1=3.5/(3^.5)

=2.02 Å

2dsin(θ)=nλ ⇒d2=-1.93

⇒d1≠d2

⇒we actually have not 111 aluminum film