3.044 Recitation 11 (05/05/05-05/06/05)
Topics

- Mean Free Path
- Structure Zone Model
- Fabrication Processes

Mean Free Path

Mean free path is the average distance a molecule travels before colliding with other molecule. The derivation of mean free path is done by taking the ratio between volume of a cylinder swept by a moving molecule and the collision area. The volume per molecule is then estimated by ideal gas law.

$$\lambda = \frac{Volume/n}{Area} = \frac{kT}{\sqrt{2}\pi\sigma^2 P}$$

A $\sqrt{2}$ factor is from the relative velocity since the molecule being hit is also moving.

Structure Zone Model (Thornton 1977)

Thin film structures vary depending on the depositiion rate and temperature.
Inert Gas Pressure vs. Ts/Tm
Evaporation: Z3 , Z2, Z1
Sputtering: Z3, Z2, ZT, Z1

(Summarized from http://fy.chalmers.se/~krasnov/FKA195/lectures/film%20structure.pdf)

Zone	Structure	Properties	Mechanism
Z3	large equiaxed grain boundaries	low dislocation density, soft recrystalized grains	high temperature, suface and bulk diffusion
Z2	columnar, dense grain boundaries	hard, low ductility	surface diffusion (Z1->Z2 transition increases with deposition rate)
Z1	dome tops, voided boundaries	high dislocation density, hard	substrate induced, low temperature (negligible surface diffusion)

Table 1: Evaporated coating (Table 9.1 Ohring 1992)

Zone	Structure	Properties	Mechanism
Z3	large equiaxed grain boundaries, smoth surface	low dislocation density, soft recrystalized grains	high temperature, suface and bulk diffusion
Z2	columnar, tight grain boundaries, facet top	hard, low ductility	surface diffusion (Z1->Z2 transition increases with deposition rate)
ZT	similar to Z1, no void or domes, dense grain	high dislocation density, hard, high strength, low ductility	negligible surface diffusion
Z1	fibrous, low dense grains, voided boundaries,	hard	substrate induced, low temperature (negligible surface diffusion)

Table 2: Sputtered coating (Table 9.1 Ohring 1992)

Fabrication Technology

Photolithography is a standard method used to define pattern on the microelectronic devices. The whole process generally starts from deposition of photoresist material on a substrate, followed by exposure to far-UV light through a mask or direct exposure of Electron Beam. The resulting pattern can be processed further by etching or deposition on the specified area.

Photoresist Deposition

1. Spin Coating (Liquid Process)
2. Chemical Vapor Deposition (Vapor phase): Vapor of monomers
   - -Plasma Enhance CVD
   - -Hot Filament CVD
   - -Initiated CVD

Photoresist Materials

The way photoresist materials work can be viewed as film in photography.
Positive Tone: The exposed area breaks down and is dissolved in the developer.
Negative Tone: The exposed area crosslinks and unexposed area dissolved.

Post Processing

(1) Etching: Photoresist is deposited on the desired film. Unwanted part is etched away.
(2) Deposition: Photoresist is done on the substrate. Deposition is done on the top. Unwanted part is removed with the photoresist.

Applications: Optical Waveguide: Pattern with Index of Refraction contrast. Light is refracted in the high IR path; Circuit board: Pattern with circuit layout; Computer Chip