ELEG 667–016; MSEG-667-016 - Solid State Nanoelectronics – Fall 2005

Homework #6 - due Thursday, 3 November 2005, in class

1. **Molecular Beam Epitaxy:** The evaporation of a material from a Knudsen cell is given by the Langmuir equation on p. 206 of the text (Waser). Assuming that the evaporated atoms travel ballistic trajectories, following a cosine distribution versus angle as shown in Figure, 13, calculate the flux of atoms striking a unit area of substrate per second at a distance L from the source. Using this equation, calculate the arrival rate of gallium (as in the growth of GaAs). For Ga, use the atomic mass of 70; length L = 15 cm; the area of the Knudsen orifice of 5 cm^2; and the equilibrium vapor pressure of Ga = $4x10^{-3}$ Torr at T= 1000C. Estimate the corresponding growth rate in µm per hour.

2. **Chemical Vapor Deposition:** Analyze the two fundamental types of limitations to chemical deposition, using the nomenclature of the text (Waser). The rate j_k due to chemical reaction kinetics follows a thermal activation energy (E_{act}) such as:

$j_k \sim \exp[- E_{act} / k_B T]$

where k_B is Boltzmann's constant and T is the absolute temperature.

The growth rate limitation due to the mass transport of chemicals to the growing film follows a diffusion equation such as:

$j_t \sim \sqrt{D} / T$
where D is a diffusivity

Using these equations, analyze the data of Figure 37 on page 214, for the growth of polysilicon. Estimate the activation energy E_{act} , and the effective diffusivity D.
Discuss in your own words the sensitivity of the growth rate to temperature in the two regimes of: (a) reaction kinetics -limited growth, and (b) mass transport -limited growth. Give the temperature ranges for the two growth rate limitations.

Homework assignments will appear on the web at:
http://www.ece.udel.edu/~kolodzey/courses/eleg667_016f05.html
Note: On each homework and report submission, you must please give your name, the due date, assignment number and the course number.