UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION (TYPE C), APRIL 23, 2000

MMS 317 S

Examiner: Prof. Z.H. Lu

1. During sintering process, two spherical powders with same diameter d are merged to form a larger spherical powder with diameter D. Given that the mass is conserved in the process and surface energy is γ, calculate the energy reduction. (10%)

2. Sketch a diagram illustrating the basic elements of float-zone process. Discuss how float-zone process may be used to (a) grow single crystal and (b) purify materials. (10%)

3. Assume that k_{eff} for a dopant in silicon is 0.75, compare dopant concentration in portions of a crystal that form on solidification one-quarter, one-half, and three quarters of the melt. The volume of the melt is small, and the initial concentration of the dopant in the melt is $5x10^{16}$ cm^{-3}. (note: $C_s=k_{eff}C_m(1-x)^{keff-1}$) (10%)

4. In the case heteroepitaxy growth, there are three possible growth modes. Sketch a diagram illustrating each of these growth modes. Explain when and why material systems follow these modes. (10%)

5. Discuss how XPS or AES may be used to determined each of the heteroepitaxy growth modes you just described in the above question. (10%)

6. Describe all possible methods for generating physical vapors. Discuss pros and cons of each of these methods. (10%)

7. If you are to evaporate Cu-Al (10 at. % Cu) from a single thermal boat, estimate the composition (in at.%) of the deposited Cu-Al film. Assume the temperature of the Al-Cu melt is 1350 K. Other known parameters are: $P_{Al}=10^{-3}$ torr; $P_{Cu}=2x10^{-4}$ torr; $M_{Al}=27$; $M_{Cu}=63.7$. (10%)

8. If the residual water vapor pressure is $1.5x10^{-7}$ torr in an Al evaporator at 300K. A high purity (less than $2.4x10^{-5}$ at.% O) Al thin film is required for a particular engineering application. Estimate the minimum Al deposition rate. The water molecule has a reaction probability of 10^{-3}. Known parameters: $M_{H2O}=18$; $M_{Al}=27$; $\rho_{Al}=2.7$ g/cm^3. (10%)

9. Briefly describe different reaction types used for chemical vapor deposition. (10%)

10. Assume a particle follows a probability function (known as Fermi-Dirac function) $f(E)=e^{-E/kT}/(e^{-E/kT}+1)$, for occupying an energy state E at temperature T. Assume no external force field, i.e. the particle energy is determined by its kinetic energy, and the motion is restricted to 2 dimension. Calculate the average particle velocity at (a) very high temperature and (b) very low temperature. (10%)