

MSE 2069 – MATERIALS SCIENCE OF NANOSTRUCTURES

Problem Set 2 – Due Feb. 7, 2007

These problems are designed to be challenging and somewhat open-ended. It may be helpful to search for other textbooks to assist your derivations. Web searches and consultation with colleagues are permitted, but be sure that the work you turn in is your own.

1) NUCLEATION OF ISLANDS ON A SURFACE

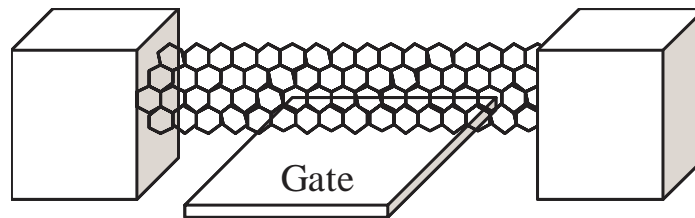
In their recent book, Michely and Krug discuss the theory for nucleation and growth of nanoscale islands on a surface. In chapter 2, they give a time-dependent equation number of stable islands on a surface subjected to a vapor flux:

$$\hat{N} \equiv \Omega N \approx \eta(\Theta, i^*) \left(\frac{\Omega^2 F}{D} \right)^{\frac{i^*}{i^*+2}} e^{E_{i^*}/(i^*+2)k_B T}, \quad (2.18)$$

- Show how this equation is derived. Explain each of the terms and what they mean physically.
- Consider the case of Au vapor incident on a clean SiO₂ substrate, with a pressure of 10⁻⁷ Torr. This system is known to form compact nanoscale islands on the surface. Using the above equation, plot the spatial density of islands [1/cm²] versus time for a substrate at two reasonable temperatures. Neglect re-evaporation, and assume dimers are immobile and stable (i*=1).
- Many nanostructure applications require monodisperse islands (all the same size), and arranged in an ordered 2D spatial array. Discuss how this might be accomplished in terms of the above model for nucleation.

2) CARBON NANOTUBES – DEVICE INTEGRATION

A new high-performance transistor device is developed using the unique electronic properties of carbon nanotubes. It consists of a SWNT suspended over a gate electrode and anchored by source and drain electrodes at each end. The overall length of the nanotube is about 100 nm, and it has been demonstrated to work reliably in a laboratory environment.



Propose a technique to build 10⁹ of these devices on a silicon wafer. Discuss what issues you might encounter in making an economical and reliable device. What physical aspects will play a role in determining the uniformity of performance characteristics over the entire population?