

Ae 244, Fall term 2007, HOMEWORK #1

Due on Friday October 12th at 12pm (noon) in Linda Miranda's office Firestone 106.

Problem 1 (25 points)

The evolution of Nanotechnology.

Read the transcript of the famous lecture by Richard Feynman, "There is Plenty Room at the Bottom" and the response to it "There is plenty of tyranny at the top" (posted on the class website). Where do you think we stand now with respect to the predicted advances in nanotechnology? Identify the name of three leaders in the field? (Write max a 1 page answer).

Problem 2 (25 points for part (a) + optional 30 bonus points for (b) and (c) if completed)

Structure and design of carbon nanotubes.

Read the following papers (posted on the class website) and answer the questions:

- (1) Hamada et al., "New one dimensional conductors: graphitic microtubules", Physical Review Letters, vol. 68, no. 10, pp. 1579-1581 (1992)
- (2) Saito et al. "Electronic structure of chiral graphene tubules" Applied Physics Letters, vol. 60, no. 10, pp.2204-2206, (1992)

- (a) What are the criteria to distinguish metallic and non-metallic nanotubes? Explain physically the rationale. (25 points)
- (b) Is an appropriate description for the Density of States (DOS) in a carbon nanotubes 1-dimensional or 2-dimensional? (See figure 3 in Saito's paper). Why? (optional extra 15 points)
- (c) How can one design a two-walled carbon nanotubes where the inner wall is metallic and the outer wall insulating? (optional extra 15 points)

Problem 3 (25 points)

(a) Plot the deposition rate (on a log scale) vs. $1/T$ (Kelvin) for 600-1200oC for a CVD system with the following parameters:

$$h_G = 0.5 \text{ cm s}^{-1}$$

$$k_s = 4 \times 10^6 \exp(-1.45\text{eV}/kT) \text{ cm s}^{-1}$$

Partial pressure of incorporating species = 1 torr

Total pressure = 1 atm

$$C_T/N = 1/10,000$$

Identify the reaction and mass transfer limited regimes.

(b) Redo the problem when the total pressure is decreased to 1 torr, so that h_G increases by 100 times. Assume that the partial pressure of the incorporating species remains the same, and C_T decreases by the same factor as the total pressure. (Since both the total pressure and the partial pressure of the incorporating species = 1 torr, this means that the gas is made up of only the incorporating species in this case).

Problem 4. (25 points)

(a) Describe the difference between positive tone and negative tone patterning in terms of chemical changes in the polymer photoresist and resulting solubility.

(b) Describe at least one advantage and one disadvantage of electron beam lithography relative to far-UV lithography.