Name: ______________________________

CHE323/384 Chemical Engineering for Micro- and Nanofabrication
Fall, 2014, Chris A. Mack

Final Exam - Practice

closed book, closed notes, three formula sheets, calculators allowed

Definitions: Please provide short (one to two sentence) definitions of the following terms. DO NOT use any equations. Make all definitions in words. (1 pt each)

1) Shot noise

2) Cpk

3) Pellicle

4) Bottom-up patterning

Questions: Please provide short (one to two sentence) answers to the following questions. (3 pts each)

1) How can the natural period of directed self-assembly be reduced?

2) Explain the main advantages and disadvantages of electron-beam lithography.

Problems: Show all work. State all assumptions clearly.
1. (10 pts) Given a (100) silicon wafer with an existing 200-nm thick oxide film, you wish to grown an additional 150 nm of SiO_2 (for a total oxide thickness of 350 nm). Design a wet, atmospheric pressure oxidation process at 950˚C to do this job.

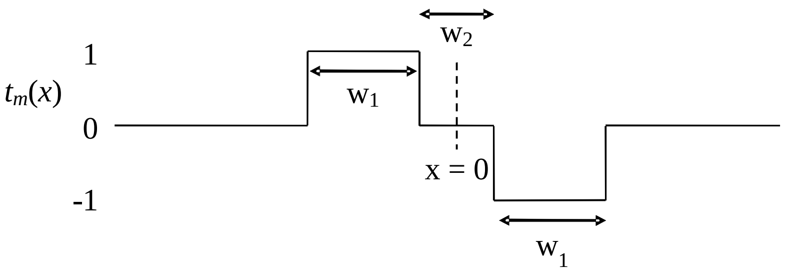
2. (10 points) Consider a resistor made of p-type silicon with a cross-sectional area of 0.3 μm^2, and a length of 15 μm. The doping level in the resistor is 3×10^{17} cm^{-3}. What is the resistance at room temperature?

3. (10 points) Determine the film deposition rate for an LPCVD system in which the mass transport coefficient h_G = 700 cm/s, the surface reaction rate constant k_s = 65 cm/s, the partial pressure of the reacting species is 0.2 torr, the total pressure in the chamber is 4 torr, the total concentration of all atoms/molecules in the gas is 4×10^{16} cm^{-3}, and the final atom density in the deposited film is 5×10^{22} cm^{-3}. Is this system reaction-controlled or diffusion-controlled?

4. (10 pts) A silicon diode is doped such that the *n*-side has $N_D = 2 \times 10^{18}$ cm^{-3} and on the *p*-side $N_A = 5 \times 10^{16}$ cm^{-3}. What is the room temperature built-in voltage for the resulting p-n junction? At zero bias, what is the depletion region width?

5. (20 pts) We wish to design a dual-well CMOS such that the two wells have the same depth at the substrate concentration of $3\times10^{15}\ cm^{-3}$, with arsenic used for the n-well and boron used for the p-well. Very shallow implants are used with a dose of $2\times10^{14}\ cm^{-2}$ for both. Since arsenic diffuses more slowly, it is introduced first and then driven-in partially. Then the boron is introduced and the rest of the anneal (drive-in diffusion) is performed until both junctions reach 1.2 microns. For a 1100 ºC process, what drive-in times will be needed? Assume that the diffusivities are constant at their intrinsic silicon values.

6. (20 pts) Derive the diffraction pattern of a phase-shifted double space pattern that does not repeat:



7. (10 pts) Assume a typical chemically amplified positive resist with an exposure rate constant C = 0.030 cm^2/mJ, and a PEB time of 60 s at 115 ºC. If the resist shows no deblocking until a dose of 8.0 mJ/cm^2, what is the relative quencher loading for the resist?