# EECS 523 Homework #2_

1- From a process control point of view, to have a better control of the predeposition time, times > 10 min are required. From an economic point of view, times < 10 hours are required. Equipment limitations restrict 700˚C < T < 1200˚C. You need only consider simple Gaussian and erfc type profiles in this problem.
a) Is it possible to dope an MOS channel region by predeposition to shift threshold voltages? The required dose is $5 \times 10^{11}$ $cm^{-2}$, boron.
b) What would be a reasonable schedule (T, t) for an MOS source drain predep? The required dose is $5 \times 10^{15}$ $cm^{-2}$, arsenic. The junction depth cannot be deeper than 0.2 µm for device reasons. Assume the substrate doping is $10^{18}$ $cm^{-3}$.
c) What sheet resistance would your profile in b) have if the substrate doping is $10^{18}$ $cm^{-3}$ P-type?

2- A boron diffusion is performed in silicon such that the maximum boron concentration is $10^{18}$ $cm^{-3}$. For what range of diffusion temperatures will electric field effects and concentration dependent diffusion coefficients be important?

3- A $10^{14}$ $cm^{-2}$ phosphorus implant through a 200 nm SiO2 mask layer is performed so that the peak concentration is at the silicon/SiO2 interface. An annealing is then performed for 30 min at 1000˚C. Calculate the location of the junction with the substrate doped at $10^{15}$ $cm^{-3}$. Assume no diffusion in the masking layer and ignore any segregation effects. Assume the same range statistics for SiO2 and Si.

4- How thick does a mask have to be to reduce the peak doping concentration of an implant by a factor of 10,000 at the mask/substrate boundary. Provide an equation in terms of the Range and the Standard Deviation of the implanted profile.

5- In the ion implantation process, positively charged ions impact on the semiconductor surface. Normally these ions are neutralized by capturing electron from the conducting substrate. However, when the mask is an insulator like SiO2 , the charge on the ions may not be neutralized as easily. Consider the case where a dose Q is implanted into the surface of a SiO2 layer (assume all the charge resides at the oxide surface). Further assume that the oxide can withstand an electric field of $10^7$ V/cm before it breaks down. What implant dose Q is required to cause electrical failure of the mask?

6- An implanted profile is formed by two boron implantations. The first uses an energy of 100 keV and the second an energy of 200 keV. The peak concentration of each distribution is $5 \times 10^{18}$ $/cm^3$. Draw a graph of the composite profile and find the junction depth(s) if the phosphorus background concentration is $10^{16}$ $/cm^3$. What are the doses of the two implant steps?