VLSI Technology

Assignment 2

Part 1: Multiple choice questions – tick the correct answer(s)

1. After ion-implantation, the region of maximum damage is
   (a) At the surface (x = 0)
   (b) At the point of peak doping concentration ($x = R_p$)
   (c) Between surface and the point of peak doping concentration ($0<x<R_p$)
   (d) Beyond the point of peak doping concentration ($x > R_p$)

2. The common p-type dopant in silicon is/are
   (a) Boron
   (b) Boron and Gallium
   (c) Gallium
   (d) Boron, Gallium and Aluminium

3. Assuming constant diffusivity, the doping profile for an infinite source diffusion process can be approximated as
   (a) Gaussian
   (b) Exponential
   (c) Erfc
   (d) Pearson IV

4. The damage in the ion-implanted sample is primarily due to
   (a) Electronic stopping
   (b) Nuclear stopping
   (c) A combination of electronic and nuclear stopping
   (d) None of the above

5. State which of the following statements is/are true
   (a) Positive photoresist softens on exposure to UV light
   (b) Positive photoresist hardens on exposure to UV light
   (c) Negative photoresist softens on exposure to UV light
   (d) Negative photoresist hardens on exposure to UV light

Part 2 : Fill in the blanks

1. The two main advantages of e-beam lithography over optical lithography are ……..
2. Arsenic is preferred over phosphorus as a dopant for emitter because it does not exhibit ……..
3. The different roles played by the three different constituent components during the etching of silicon in HNA (nitric acid, hydrofluoric acid and acetic acid) solution are:
   HNO_3 ……
   HF……..
   CH_3COOH……..

4. As ClF_3 is added to Cl_2 during dry etching of undoped silicon, the etch profile becomes progressively …….

Part 3: Numerical Problems

1. Phosphorus is diffused at 1150°C into a uniformly doped p-silicon substrate with acceptor concentration of $N_A = 10^{16}/cm^3$. Given that the solid solubility and the diffusion co-efficient of phosphorus in silicon at 1150°C is $10^{20}/cm^3$ and $10^{-12}cm^2/s$ respectively,
   (a) Calculate the total number of phosphorus atoms/area in silicon after a predeposition time of 1 hour.
   (b) If after this step, drive-in is carried out for 2 hours at the same temperature, what will be the final junction depth and
   (c) the surface concentration?

2. Phosphorus is implanted into a uniformly doped p-silicon substrate with acceptor concentration of $N_A = 10^{16}/cm^3$. If the beam current density is 2 $\mu A/cm^2$ and the implantation is carried out for 10 minutes,
   (a) Calculate the implantation dose
   (b) Find the peak doping concentration assuming $R_p = 1.1\mu m$ and $\Delta R_p = 0.3\mu m$
   (c) Find the surface doping concentration

Self study: Compare the results in problems 1 and 2. What do you think is a major advantage of ion-implantation?