The exam consists of nine questions/problems with the following point distributions: 30+15+25+15+15. The first five questions are qualitative and examine your basic knowledge of various fabrication processes used in making semiconducting devices. The other 4 are quantitative and require some calculations and sketching.

1) Write the balanced chemical reaction occurring during dry and wet silicon dioxide growth? What is the range of temperatures in these processes? Name one advantage of each oxide as compared to the other one ***(6 points)***

2) Name three advantages of ion implantation as compared to diffusion for doping semiconductors? Plot the doping profile (doping concentration vs. depth) following ion implantation before and after annealing. ***(6 points)***

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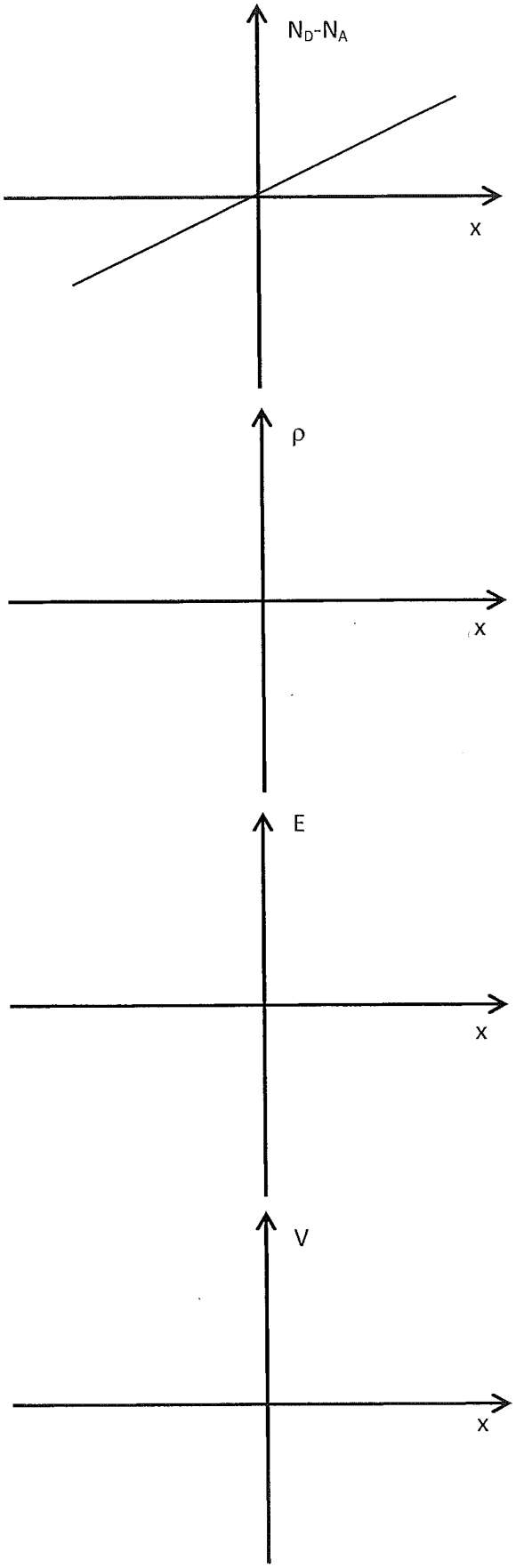
3) Name three advantages of sputtering as compared to evaporation for depositing metals. ***(6 points)***

4) What is epitaxy? How is it different from CVD? Name one important application of epitaxial growth. ***(6 points)***

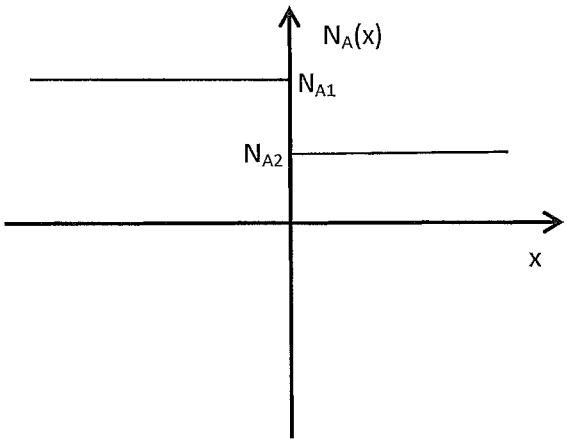
5) Name two advantages of the silicon-on-insulator (SOI) technology on performance of devices and circuits. What are typical thicknesses of the top silicon and buried oxide layers in commercial state of the art SOI technology? ***(6 points)***

6) Plot the charge density, electric field and voltage for a linearly graded pn junction with doping profile shown below. Assume a total depletion width of W. You do not need to derive any expression just plot/sketch the profiles/curves. ***(15 points)***



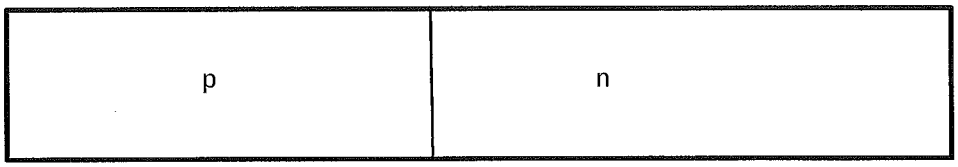
7) Consider the p_1-p_2 isotype (i.e., both sides are doped with the same type of dopant, p in this case) homo-junction (i.e., both sides are made of similar material having the same bandgap, you can assume silicon in this case) shown below,
   - Draw the energy band diagram for the junction assuming non-degeneracy and $N_{A1}>N_{A2}$. ***(5 Points)***
   - Derive an expression for the built-in voltage (V_{bi}) that exists across the junction at equilibrium. ***(10 Points)***
   - Make a rough sketch of the potential, electric field, and charge density inside the junction ***(10 Points)***

Hints: Assume non-degenerate statistics. Do not automatically assume depletion approximation



8) The silicon pn junction shown below operates at 300K with doping concentrations of $N_a=10^{15}$ cm^{-3} and $N_d=10^{17}$ cm^{-3},
   - Calculate the steady-state carrier concentrations (for both the majority and minority carriers) in each region at +0.5V forward and -1V reverse bias.
   - Plot minority carrier concentrations profiles in both cases; clearly mark the concentrations at the edge of the depletion region on the plots.

   Assume $V_T=26$ mV and $n_i=10^{10}$ cm^{-3} ***(15 points)***



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9) A metal-semiconductor contact is formed between gold and n-type silicon doped to a level of $N_d=5x10^{16}$ cm^{-3} at 300K. Plot the band diagram at zero applied external voltage. Is the junction ohmic or rectifying? Calculate the barrier height (Φ_B) and built-in potential across the junction ***(15 points)***

Gold work function (Φ_M) is 5.1 eV, silicon electron affinity (χ_s) is 4.01 eV, and effective density of state function in the silicon conduction band is $N_C=2.8x10^{19}$ cm^{-3}. Assume $V_T=26$ mV and $n_i=10^{10}$ cm^{-3}