
EE566 Solid State Devices

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Dept of Electrical Engineering

University of Notre Dame

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Assignment 4

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Due: 02/17/2006

Reading

Chapter 4 of Textbook.

Problem 1¹ (Breakdown voltage of Si p⁺-n junction)

Problem 4.27, Textbook.

Problem 2 (Punchthrough Diodes)

Problem 4.31, Textbook.

Problem 3 (p-n Junction current flow: Practice problem)

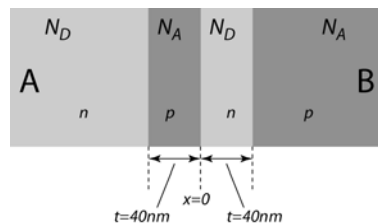
Consider a GaAs p-n junction. The relevant parameters are $N_d=N_a=10^{18}/\text{cm}^3$, $\tau_n=\tau_p=10\text{ns}$, $D_n=100\text{cm}^2/\text{s}$, $D_p=20\text{cm}^2/\text{s}$, and breakdown field $F_{BD}=400\text{kV}/\text{cm}$. Do the following –

- Plot the charge-field-band diagram at zero bias. Compare with a 1D Poisson simulation.
- Sketch the mobile charge (both majority and minority) density vs distance at a forward bias of 0.4 Volt.
- Sketch the electric field and the band diagram (with quasi Fermi levels) at this forward bias.
- Sketch the corresponding current densities (diffusion and drift components for both n- and p-type carriers) as a function of distance at 0.4 Volt forward bias. Find the total current density flowing across the junction.
- Repeat the above sketches for a reverse bias of -5 Volts.
- Find the reverse bias at which the p-n junction will break down.

Problem 4: (The Funny Junction)

Consider the silicon p-n junction shown below with a rather messed-up junction region.

- Sketch the charge, electric field and band diagram for this device at zero applied bias. What is the built-in voltage between the quasi-neutral regions in A and B? Use $n_i=6.68\times 10^9/\text{cm}^3$, and $N_D=N_A=10^{17}/\text{cm}^3$. Assume regions A and B to be very long.
- Find a *general algebraic relation* between the depletion widths W in regions A and B in terms of the thickness t and the built-in voltage V_{bi} . Do NOT neglect Gummel correction. Assume $N_D=N_A=N_o$ for simplicity. Then, calculate W for $t=40\text{nm}$, $N_o=10^{17}/\text{cm}^3$.
- At what bias voltage will the electric field at $x=0$ fall to zero? Find algebraically first, then calculate the numerical value. Is it forward-bias or reverse-bias?
- At this bias, sketch the band diagram, showing the quasi-Fermi levels.
- Find the total current density (in A/cm^2) flowing through our funny junction at this bias. Use $\tau_n=\tau_p=10\mu\text{s}$.



¹ Remember to use proper units and label every figure/plot. Use natural scales such as nm for length, KV/cm for electric fields, and eV for energies. Turn in your answers worked out neatly. Please attach this question sheet to your solution when you turn it in.