EE566 Solid State Devices

Spring 2007
Dept of Electrical Engineering
University of Notre Dame
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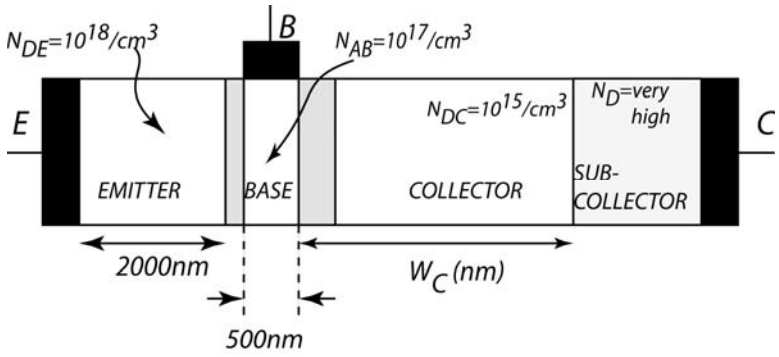
2nd Mid-Term Exam

04/13/2007

Problem (20 Points):



Consider the Si BJT shown above. Note the doping densities carefully, and the fact that the emitter doping is such that we can neglect bandgap narrowing. Assume T=300K, and excess minority carrier density at an ohmic contact to be zero. Use the following for your calculations:

$\varepsilon_S=11.7\varepsilon_0$ | $\mu_n=1500 cm^2/V.s$ | $\mu_p=450 cm^2/V.s$ | $\tau_n=\tau_p=0.5\mu s$ | $n_i^2=10^{20}/cm^6$ | $F_{BR}=3\times10^5$ V/cm

a) Sketch the *minority carrier distribution* in the entire BJT with the E-B junction forward biased at 0.5V, and the B-C ALSO forward biased at 0.5V.
b) Sketch the *minority carrier distribution* in the entire BJT with the E-B junction forward biased at 0.5V, and the B-C now reverse biased at 5V.
c) Find the emitter injection efficiency γ_E, base transport factor α_T, and the corresponding current gain β_F.
d) What is the collector width W_C such that it is *totally* depleted at $V_{CB}=0$ Volt? Make reasonable assumptions. Assume this to be the collector width for the rest of the problem.
e) Find the Early voltage for this transistor. Express it in terms of given quantities first before calculating the numerical value.
f) With this W_C, find the reverse-bias collector-base voltage V_{CB} at which the BJT breaks down. Assume the sub-collector is doped very heavily. Breakdown field for Si is given above.
g) How can you improve the CB breakdown voltage? What is the price you pay?