
EE566 Solid State Devices

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Dept of Electrical Engineering

University of Notre Dame

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Assignment 7

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Due: 03/24/2005

Reading

Chapter 6 of Muller/Kamins/Chan (**MKC**).

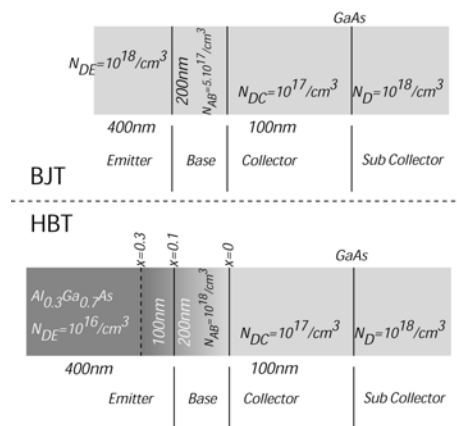
Problem 1¹ (Practice Problem on BJTs)

Problem 6.17, **MKC**.

Problem 2 (Follow up on Problem 1 - BJT in a radiation environment)

Problem 6.18, **MKC**.

Problem 3 (Homojunction vs Heterojunction Bipolar Transistors)



Consider the GaAs-based n-p-n BJT and HBT shown in the figure (not to scale!). The BJT is made of GaAs, whereas the base of the HBT is linearly graded from $\text{Al}_{0.10}\text{Ga}_{0.90}\text{As}$ at the emitter end to GaAs at the collector end. The emitter material of the HBT is $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$ linearly graded to $\text{Al}_{0.1}\text{Ga}_{0.9}\text{As}$ at the base end. All lengths in the diagram below are the TOTAL layer thicknesses. For most calculations, you will need to subtract the depletion thicknesses. Refer to Kroemer's paper (pg 76-78, handouts) for this problem. Use constants for GaAs at 300K.

- Sketch the detailed band diagram and the Electric field of the BJT and HBT in equilibrium. What is the purpose of the heavily doped sub-collector? What is the quasi-electric field E_B in the base of the HBT? Calculate, and then verify both with 1D Poisson.
- Solve the drift-diffusion equation in the base to obtain an expression for the minority carrier concentration in the base $n_B(x)$ in terms of E_B , collector current J_C , and effective base width W_B .
- Obtain an analytical expression, and calculate the numerical value for the base transit time τ_T in both the BJT and the HBT. What is the ratio? Make reasonable approximations.
- Find the emitter injection efficiency γ_E and the base transport factor α_T for the BJT and HBT. What is the ideal gain β_F at $V_{BE}=0.8$ volt? What is the improvement in the HBT?
- What are the pros and cons of each (BJT vs. HBT)? Compare in tabular form.
- With the help of the web, investigate the current interest in SiGe-based HBTs, and comment on how HBT ideas have resulted in a massive drive towards BiCMOS technology. Who are the major players in the field? What are the applications for Si-based HBTs? Write a paragraph summarizing your findings.

Problem 4 (BJT with recombination in the base)

Problem 6.19, **MKC**.

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.