Mid term examination, 100min., closed book, individual efforts

May 8, 2008

1. BJT

The NPN structure with W_E =0.2 μm, W_B=0.1 μm and W_C = 100 μm (or infinity). $N_{D,E}$ = 1.E20/cm^3, $N_{A,B}$=5E18/cm^3 and $N_{D,C}$ = 6E16/cm^3 is biased with VBE=0.7V and VCE=3V. A_E= 1 μm^2, Vt(thermal voltage)=24mV v,sat(saturation velocity of electron) =1E7cm/sec in the CB depletion region.

With this, it was found that the flux component at each point of emitter(E), base(B), and collector(C) are

Fn,B(0)= 1.e23 /cm^2-sec: Fn,B(Wb)= 0.99 Fn,B(0)
Fp,E(0)= 0.01Fn,B(0); Fp,E(We)= 0.99Fp,E(0)
Fp,C(0)=1.E17/cm^2-sec

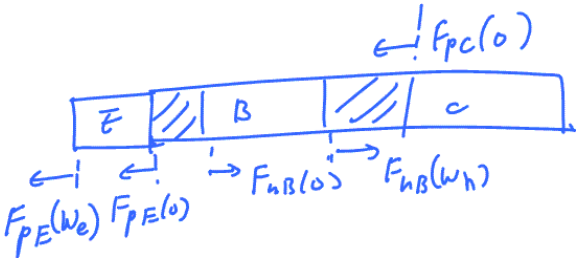


Fig. The flux density in each region of NPN BJT

b)Total recombination rates:
in the EB junction : 1e20/cm^2-sec.
in the BC depletion layer is -5E18/cm^2-sec.(net generation)
c) After base push out occurs, Ic is proportional to exp(VBE/2Vt).

A. General DC BJT characteristics

When Ic = # # * IE + ICBO

Find # # , I#$_{CBO,}$ for the bias condition above.

B. Onset of the base push out

Find the critical collector current for the start of base widening. Also,
Find VBE voltage for the critical collector current.(Hint. Jc0 = qNdc v,sat.

C. Plot transistor # , vs. Ic (roughly, Ic from VBE=0.3V to Ic =10*Ic0(start of base push out))

D.BVceo

The BVcbo is measured to be 7V. Also, M in the BC junction can be written as

M = 1/(1-(Vcb/BVcbo)**4).

Assume that in the case for base open, Vcb=~ Vce.

1) Find ICEO when VCE=6V.(Assume ICBO is same as the value a) above)

Here assume that transistor # , is same as the value in a) above.

Check the validity of this assumption using the data in D.

You measure the ICEO vs. VCEO as shown in fig. 1.

2) What is the estimated value for BV#CEO.(Here assume that transistor # , is same as the value in a) above.)

3) Explain the reason for the negative resistance.

4) Estimate the ICEO value from which BVCEO increases again.

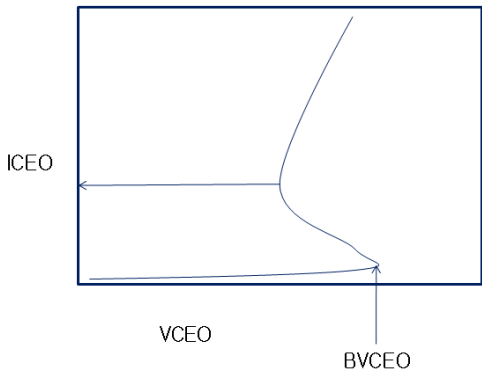


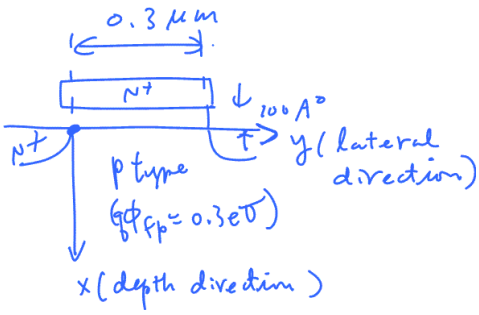
fig. 1. Measured ICEO vs. VCEO(assume that VCEO=VCBO)

2. MOSFET

Consider the gated PN junction structure as shown in fig. 2.

(N+ polysilicon with Ef=Ec, P substrate with Na=1.E17/cm#3 so that q±/#p =0.3eV)

A. Draw the band diagram along x direction (including gate, oxide and P substrate) when VS=0, VB= -1V and VG=VT.(Denote the surface potential ³s ,Efn, Efp, Ei in the figure)



B. Obtain the ψ_s (surface potential) value when VG=VT. (Hint. Notice that VT is when ψ_s is $2\phi_{fp}$ with respect to Efn, not Efp).

C. In the case for B, what is Qdmax[C/cm^2].. Express the answer in terms of ϕ_{fp}, Na and other parameters.