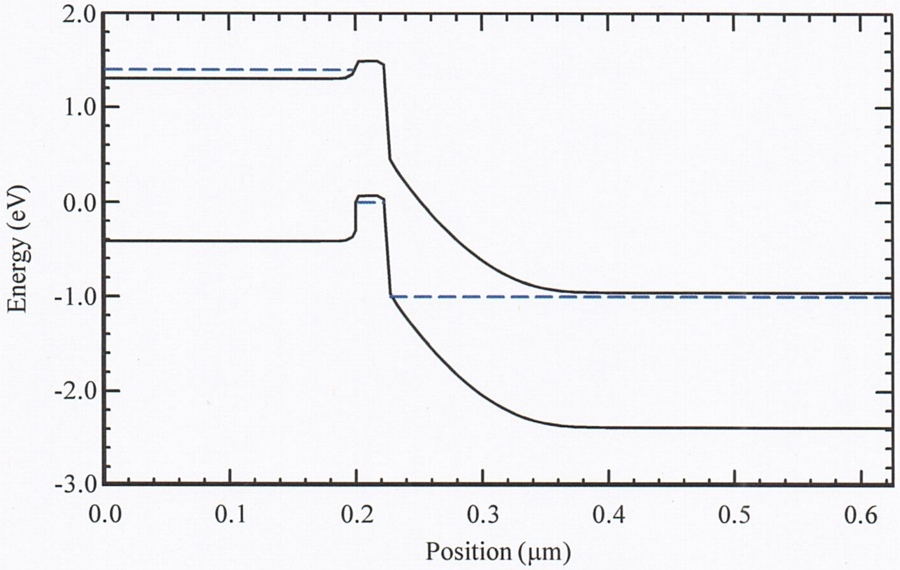
EECE 480 Assignment 4

1.



2

3

In$_{0.61}$ is a good mole fraction to use because its electron affinity is the same as for GaAs, i.e., $\Delta E_c = 0$ and, ∴, the barrier for electron injection into the base is minimized

Q1 = ⑤

```matlab
% EECE 480, Assignment 4, 2011
% HBT gain, fTi, fmax
%InGaP/GaAs HBT
%
clear all;

q=1.6e-19;
kT=8.62e-5*q*300;
Vth=0.0259;
h=4.14e-15*q;
m0=9.1e-31;
eps0=8.85e-12;   %F/m
%----------------------
%Material 1, n-emitter, In_61Ga_39P
%Material 2, p-base, GaAs
%Material 3, n-collector, GaAs
%Only the properties for GaAs are needed in this assignment

mestar=0.066*m0;
mhstar=0.524*m0;
Eg=1.42*q;
eps=12.9;
NC=2*(2*pi*mestar*kT/h^2)^(3/2);
NV=2*(2*pi*mhstar*kT/h^2)^(3/2);
ni=sqrt(NC*NV*exp(-Eg/kT));
vR=sqrt(kT/(2*pi*mestar)); %m/s, use low-doping value
```

%vR=~~2.18e5~~; 1.25e5;

%vR=~~1.25e5~~; 2.18e5;

} Any of these is OK

```matlab
%----------------------

NE=5e18*1e6;          %m-3
NB=5e19*1e6;
NCC=1e17*1e6;
L=2e-6;
Z=2e-6;
WB=25e-9;                      %m
VBE=1.4;
VBC=-1;
%--------------------------
mue=(8300.*(1+NB*1e-6./(3.98e15+NB*1e-6./641)).^(-1/3)).*1e-4;     %m2/Vs
De=0.0259.*mue;      %m2/s
taue=(NB*1e-6/1e10+(NB*1e-6)^2/(1.6e29))^(-1);
muh=(380./(1+NB*1e-6.*3.17e-17).^(0.266))*1e-4;      %m^2/Vs
VbiC=(kT/q)*log(NCC*NB/ni^2);
WBC=sqrt(2*eps0*eps*(VbiC-VBC)/q*(1/NCC+1/NB));
%---------------IC---------
n0B=ni^2/NB;
IC=Z*L*q.*n0B.*(exp(VBE./Vth)-exp(VBC./Vth))./(WB./De+1/vR);     %A
```

		v_R
1.1 mA	}	1.05e5 m/s
1.2 "		1.25e5
1.5 "		2.18e5

1

```matlab
%------------IB---------------------
IBrec=Z*L*q.*n0B.*WB./(2.*taue).*((exp(VBE./Vth)-1)+(exp(VBC./Vth)-1))./(1+WB./(4.*vR.↙
*taue));    %A
```

1

```matlab
IB=IBrec;
```

5.64 μA	}	$f(v_R)$
5.64 "		
5.64 "		

```
1 %------------gain--------------
  beta0=IC/IB
  %-------------small-sig params----------
2 gm=(L*Z*q*n0B/Vth)*exp(VBE/Vth)/(WB/De+1/vR);
1 CBb=gm*WB/2*(WB/De+1/vR);
  Cpi=CBb;
2 Cmu=Z*L*eps*eps0/WBC;
  CT=Cpi+Cmu;
2 fTi=gm/(2*pi*CT);
  %----RBsp--------------
  Bres=1/(q*NB*muh);
  RBqnb=Bres*L/(Z*WB);
  Rb=RBqnb/12;
  fmax=sqrt(fTi/(8*pi*Rb*Cmu));
```

200
217
268 } $f(v_R)$

43.6 mS
47.3 "
58.5 " } g_m $f(v_R)$

C_π $f(v_R)$ { 10.6 fF
10.6 "
10.6 "

2.4 fF
2.4 "
2.4 " } C_B $f(v_R)$

532 GHz
578 "
715 " } $f(v_R)$

77.8 Ω

333 GHz
347 "
386 " } $f(v_R)$.

Q2. $I_c = 1$ $I_B = 1$ $\beta = 1$ TOTAL ③

Q3. $g_m = 2$, $C_\pi = 1$, $C_\mu = 2$, $f_T = 2$ TOTAL ⑦

Q4. $R_b = 3$, $f_{max} = 2$ TOTAL ⑤