Summer-2019 UM-SJTU JI Ve311 Homework #1

Instructor: Dr. Chang-Ching Tu

Due: 10:00 am, June 6, 2019 (Thursday) in class

Note:

(1) Please use A4 size papers.

(2) Please use the SPICE model below for simulation.

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.model Dbreak D Is=1e-14 Rs=0 N=1 TT=0 Cjo=0pF
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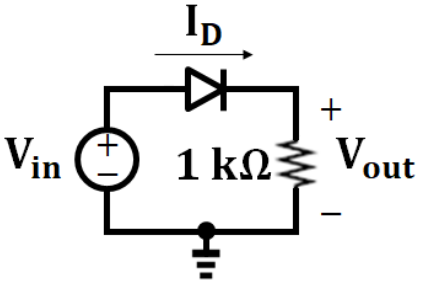
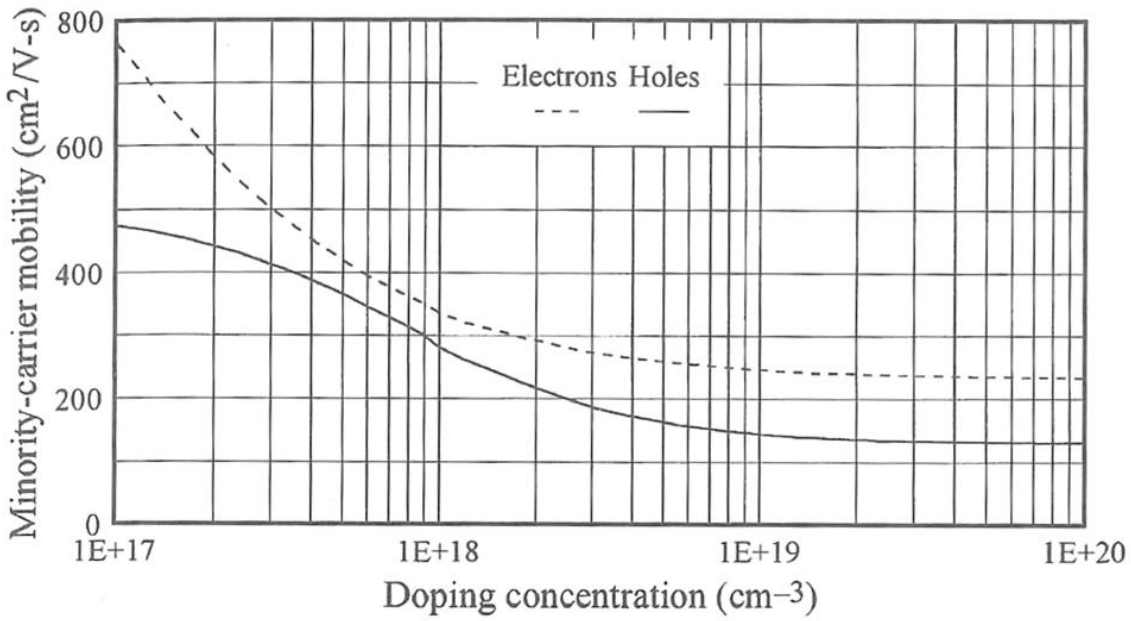
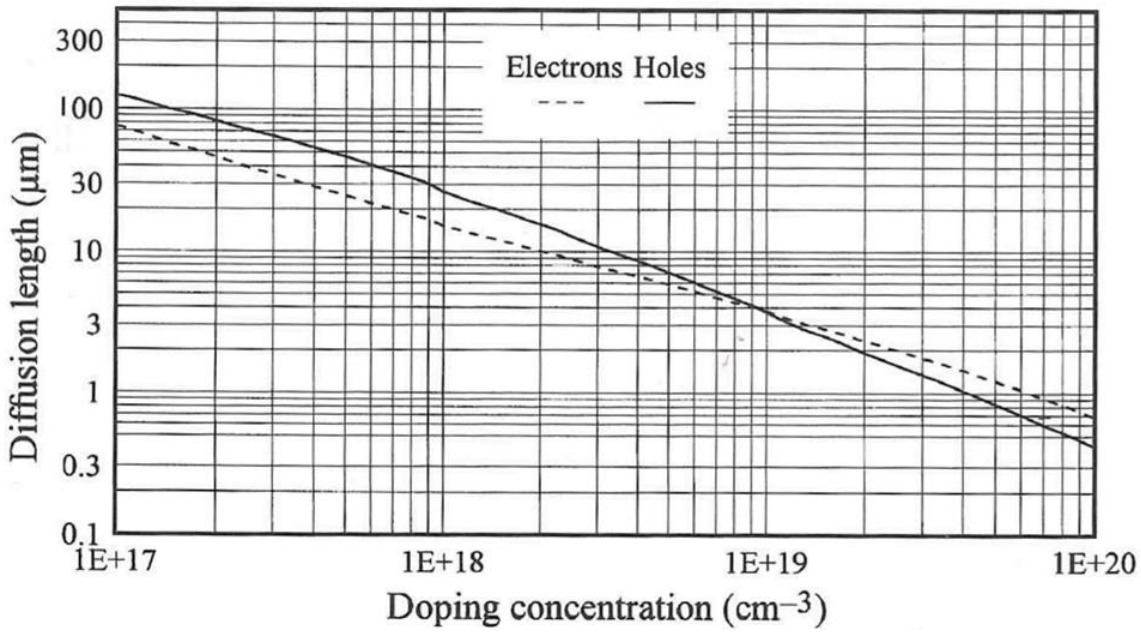
1. [Operation Principles of Si Diode] At 300 K, a Si diode with p-side heavily doped ($N_a = 5 \times 10^{19}\ 1/cm^3$) and n-side also heavily doped ($N_d = 1 \times 10^{20}\ 1/cm^3$). The Si diode junction area $= 100\ \mu m \times 100\ \mu m$. Note: $k = 1.38 \times 10^{-23}\ J/K$, $n_i = 10^{10}\ 1/cm^3$, $q = 1.6 \times 10^{-19}\ C$, $\epsilon_{Si} = 11.7 \times 8.85 \times 10^{-14}\ F/cm$.
   (a) [30%] Calculate the built-in potential ($\emptyset_i$), the depletion widths at the p-side (x_p) and n-side (x_n) respectively, and the largest built-in electric field (E_{max}), when the Si diode is in thermal equilibrium.
   (b) [30%] Calculate the diode current (I_D), when the Si diode is under 0.3 V forward bias. Use the appended figures for obtaining the values of diffusion coefficient (through Einstein Relations) and diffusion length.

2. [Pspice Simulation of Si Diode] For the circuit below:
   (a) [20%] Plot I_D vs V_{in} as V_{in} increases from -2 V to 2V. Explain why the result is a linear increase rather than an exponential increase.
   (b) [20%] Plot V_{out} vs time and V_{in} vs time on the same graph, when $V_{in} = 2\ V \times \sin(2\pi \times 60 \times time)$. Explain the working principle of this circuit.




Minority-carrier mobility (cm²/V-s)
800
600
400
200
0
Electrons Holes
1E+17
1E+18
1E+19
1E+20
Doping concentration (cm⁻³)


Diffusion length (μm)
300
100
30
10
3
1
0.3
0.1
Electrons Holes
1E+17
1E+18
1E+19
1E+20
Doping concentration (cm⁻³)