

UNIVERSITY OF CALIFORNIA, BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE 105: Microelectronic Devices and Circuits

Spring 2013

MIDTERM EXAMINATION #1

Time allotted: 45 minutes

NAME: _____

STUDENT ID#: _____

INSTRUCTIONS:

1. Unless otherwise stated, assume
 - a. temperature is 300 K
 - b. material is Si
2. **SHOW YOUR WORK.** (Make your methods clear to the grader!)
Specially, while using chart, make sure that you indicate how you have got your numbers. For example, if reading off mobility, clearly write down what doping density that corresponds to.
3. Clearly mark (underline or box) your answers.
4. Specify the units on answers whenever appropriate.

SCORE: 1 _____ / 15

2 _____ / 15

Total _____ / 30

PHYSICAL CONSTANTS

Description	Symbol	Value
Electronic charge	q	1.6×10^{-19} C
Boltzmann's constant	k	8.62×10^{-5} eV/K
Thermal voltage at 300K	$V_T = kT/q$	0.026 V
$V_T \ln(10) = 0.060$ V at $T=300$ K		

PROPERTIES OF SILICON AT 300K

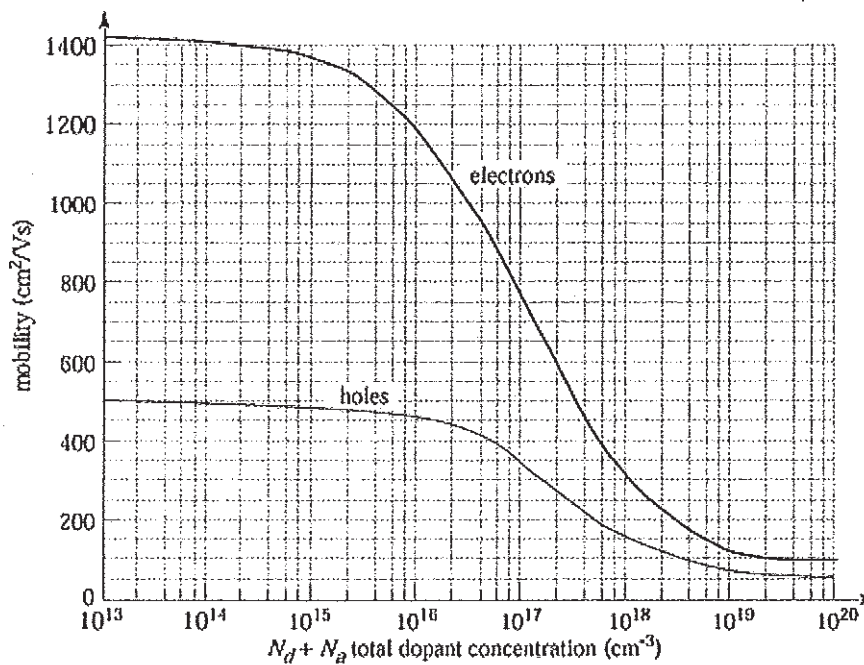
Description	Symbol	Value
Band gap energy	E_G	1.12 eV
Intrinsic carrier concentration	n_i	10^{10} cm ⁻³
Dielectric permittivity	ϵ_{Si}	1.0×10^{-12} F/cm

Electrostatics: $\frac{dE}{dx} = \frac{\rho}{\epsilon}$ $E = -\frac{dV}{dx}$

Depletion region Width: $W = \sqrt{\frac{2\epsilon}{q} \left(\frac{1}{N_a} + \frac{1}{N_d} \right) (V_{bi} - V_{Applied})}$

Reverse saturation current of a diode, $J_s = qn_i^2 \left(\frac{D_n}{N_A L_n} + \frac{D_p}{N_D L_p} \right)$

Electron and Hole Mobilities in Silicon at 300K



Prob 1. [15]

(a) [12 pts] A Si sample is doped first with B to $10^{17} / \text{cm}^3$.

(i) [2 pts] Find out the number of electrons and holes.

(b) [10 pts] Now the Si sample is further doped with As to $2 \times 10^{17} / \text{cm}^3$ and a voltage of 1 Volt is applied across the sample. Find out the amplitude of the current that will flow due to this voltage. Assume that the sample has the following dimensions: Length=10 μm , Width=1 μm and thickness=1 μm .

(c) [3 pts] What is the mechanism of current flow in a p-n junction diode under (i) forward and (ii) reverse bias. Simply mention the mechanisms.

Prob 2: [15 pts]

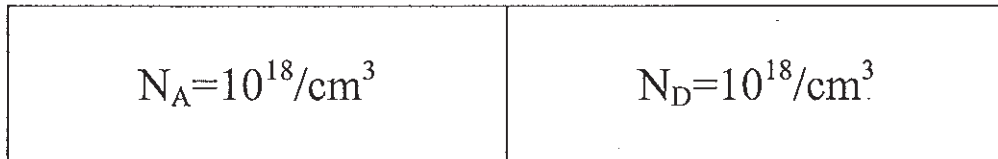
(a) [3 pts] For the following p-n junction diode, roughly sketch the

(i) charge density profile

(ii) electric field profile

(iii) energy band diagram

across the junction.



(b)[8 pts] A p-n junction has to be designed such that the width of the depletion region on the N side is $0.212 \mu\text{m}$, the built in potential is 0.72 V and the maximum electric field at the junction is $3.4 \times 10^4 \text{ V/cm}$. What doping density on the p and n side will have to be used to design such a diode? What is the capacitance of this diode?

(c) [4 pts] What are the different mechanisms of reverse bias breakdown in a p-n junction diode? What are the main physical mechanisms responsible for each of these breakdown mechanisms?