EE 236 Devices Lab
Pre - Lab: Lab - 03

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Temperature and material dependence of PN diode, IV characteristics

1 Material Dependence

1.1 Aim of the experiment

Simulate the I/V characteristics of silicon ($V_{applied}$ varies from -5 V to 5 V) & germanium diodes, using default parameters at 300 K, and plot them.

1.2 Silicon and Germanium I/V Characteristic

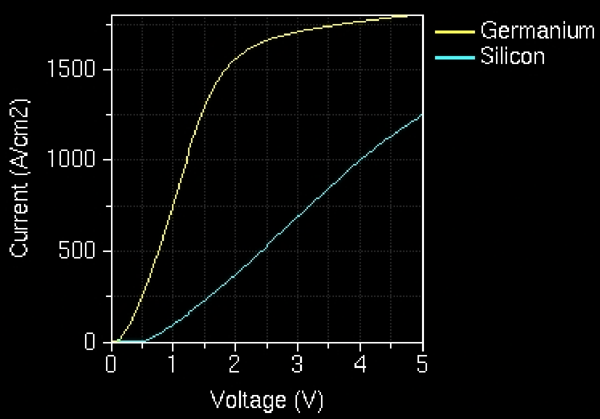


Figure 1: I/V Characteristic Linear Scale

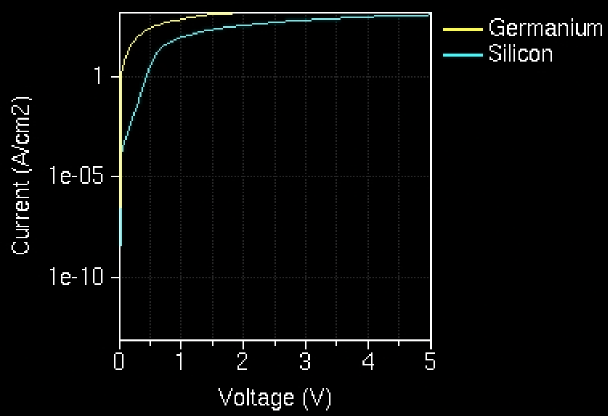


Figure 2: I/V Characteristic Log Scale

1.3 Cut in voltage at 10A/cm^2

	Silicon	Germanium
V_{Cutin}	0.568 V	0.125 V

Table 1: Cut-in Voltages for Silicon and Germanium at 10 A/cm^2

1.4 Explain the differences in the current densities and the cut-in voltages

The main difference arises due to difference in the band gap of the two materials. The bandgap of Germanium is 0.66eV while that of Silicon is 1.12 eV. The higher band gap of Silicon causes a higher cut in voltage in Silicon, while the lower band gap of Germanium leads to lower current density of the material's diode.

2 Non Idealities of PN Diode

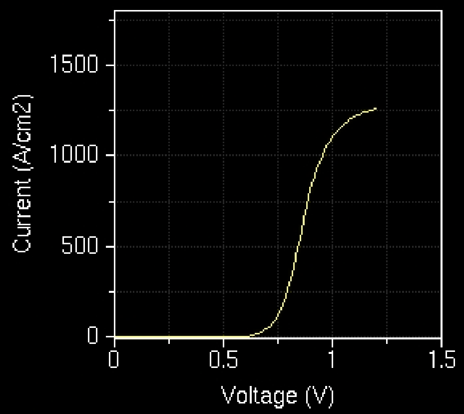
2.1 Aim of the Experiment

Analyze the non-idealities in the IV characteristics of a silicon PN diode at 300K over a voltage range of 0 to 1.2V. By varying the applied voltage and extracting the ideality factor across different operating regions: recombination (0 - 0.2V), ideal (0.3V - 0.5V), and high injection (0.6V - 0.8V).

2.2 I/V Characteristics

Parameter	**Value**
N_a (Acceptor Concentration)	$1 \times 10^{18} cm^{-3}$
N_d (Donor Concentration)	$1 \times 10^{14} cm^{-3}$
$\tau_{electrons}$ (Electron Lifetime)	$1 \times 10^{-7} s$
τ_{holes} (Hole Lifetime)	$1 \times 10^{-7} s$

Table 2: Material Parameters and Carrier Lifetimes



2.3 Ideality Factor Values

Regime	Ideality Factor ()
Recombination (0 - 0.2V)	1.363
Ideal (0.3V - 0.5V)	1.14
High Injection (0.6V - 0.8V)	2.018

Table 3: Ideality Factors in Different Regimes of a Silicon PN Diode

2.4 Reason of Saturation

The diffusion of minority carriers from neutral regions lead to saturation.

3 Temperature Dependence

3.1 Aim of the experiment

Simulate the IV characteristics of the silicon diode from 250 K to 400 K, in steps of 25 K

3.2 Cut in Voltage at !A/cm^2

Temperature (K)	**Cut-in Voltage (V)**
250	0.67
275	0.62
300	0.56
325	0.50
350	0.44
375	0.38
400	0.32

Table 4: Cut-in Voltage as a Function of Temperature for a PN Diode

As the temperature increases, the cut in voltage decreases.

3.3 Band Gap Calculation

Temperature (K)	**ln(** I^3_{Tsat} **)**	**ln(**I_{sat}**)**	$\frac{1}{kT}$ ($\times 10^{20}$)
250	-39.36438275	-22.8	2.90
275	-36.28031329	-19.43	2.63
300	-33.47134742	-16.36	2.41
325	-30.85147555	-13.5	2.23
350	-28.37379946	-10.8	2.07
375	-26.06077808	-8.28	1.93
400	-23.95439364	-5.98	1.81

Table 5: Temperature Dependence of $\ln(I^3_{Tsat})$, $\ln(I_{sat})$, and $\frac{1}{kT}$ for a PN Diode

Band Gap E_g is 0.8865eV