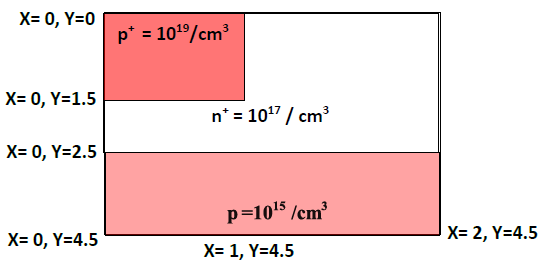
**Instructions**

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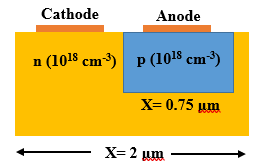
* **For all the assignments, consider device dimensions and other simulation parameters same as the one given in the lab manual unless otherwise specified.**
* **Students will be given 1 hour for completing this assignment.**

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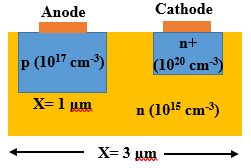
1. For a Silicon PN Junction Diode, value of built-in potential and doping concentration of the n-type region are specified as 0.85 V and 1017 cm-3 respectively.
   1. Calculate the doping concentration of the p-type region if the total depletion region width across the junction is expected to be 0.45 μm.
   2. Plot the band diagram of the given diode using Silvaco Atlas. Indicate, built-in potential and depletion region width in the p-type region in the energy band diagram. Verify whether those are matching with the analytically obtained values.
   3. Use Silvaco Atlas and plot the electric field across the depletion region. Calculate the maximum value of electric field. Cross-check whether the electric field is matching with the analytical result.
   4. Plot the CV characteristics of the diode if cathode voltage is varied from 0 to 5 volt at an AC frequency of 1 kHz while the anode is connected to ground.
2. Consider a Germanium PN Junction Diode with n-type doping concentration of 1016 cm-3. If the value of contact potential is specified as 0.4 V,
   1. What can be the possible value of doping concentration in the p-type region if the total depletion region width of 0.3 μm is to be obtained across the junction.
   2. Use Silvaco Atlas to plot the energy band diagram of the given diode and show that the analytically obtained depletion region width and contact potentials are matching with the simulation results.
   3. Plot the electric field across the depletion region using Silvaco Atlas. What will be the position of maximum electric field? Explain your answer. Verify your simulation result against the analytically calculated value.
   4. Plot the CV characteristics of the diode if anode voltage is varied from -6 to 0 volt at an AC frequency of 2 kHz while the cathode is connected to ground.
3. For a Silicon PN Junction Diode, the value of built-in potential in the n-type region is 0.3 V and doping concentration of the p-type region is given as 1015 cm-3. (Consider Knee Voltage of Si pn junction diode as 0.7 V).
   1. Find out the value of doping concentration of the n-type region if the total depletion region width across the junction is to be 0.55 μm.
   2. Simulate the PN junction diode using Silvaco Atlas to obtain its band diagram and specify built-in potential and depletion region width in the n-type region in the same diagram. Match the simulation results with the analytically obtained values.
   3. Obtain the electric field across the depletion region using Silvaco Atlas and indicate its maximum value. Cross-check it with the value obtained using analytical formula.
   4. Plot the CV characteristics of the diode if cathode voltage is varied from -2 to 4 volt at an AC frequency of 1 kHz while the anode is kept at 2 volt.
4. Assume that for a Germanium PN Junction Diode, value of contact potential in the p-region is given as 0.1 V. Doping concentration of the p-type region is given as 1018 cm-3. (Knee voltage of Ge diode = 0.3 V).
   1. Calculate the doping concentration of the n-type region if the total depletion region width across the junction has to be 0.35 μm.
   2. Obtain the band diagram of the given diode using Silvaco Atlas. Show the built-in potential and depletion region width in the n-type region in the same band diagram. Verify the simulation results against analytically obtained values.
   3. Plot the electric field across the depletion region using Silvaco Atlas. Indicate the position of maximum electric field and justify your answer. Cross-check the simulation result with the analytical value.
   4. Plot the CV characteristics of the diode if cathode voltage is varied from 4 to -2 volt at an AC frequency of 1 kHz while the anode is kept at 2 volt.
5. Design a Schottky Diode having the metal contact work function of 4.33 eV. Consider n type silicon with doping concentration of 1017 cm-3. Simulate the structure using Silvaco Atlas. Find out the Schottky barrier height and total depletion width across the junction. Verify whether the analytically obtained result is matching with the simulated one. (Hint: A Schottky Diode is formed between metal and moderately doped n-type semiconductor. In Silvaco, a Schottky contact can be formed between Metal and Semiconductor by specifying workfunction of the metal contact. The step has already been given in the lab manual).
6. Design a Schottky Diode having the metal contact work function of 4 eV. Consider p type silicon with doping concentration of 1016 cm-3. Find out the Schottky barrier height and total depletion region width across the junction analytically as well as through simulation using Silvaco Atlas. (Hint: A Schottky Diode is formed between metal and moderately doped n-type semiconductor. In Silvaco, a Schottky contact can be formed between Metal and Semiconductor by specifying workfunction of the metal contact. The step has already been given in the lab manual).
7. Design and Simulate a Planar NPN Bipolar Junction Transistor using Silvaco Atlas with β of about 20 to 25 considering Collector and Emitter doping concentrations of 1015 and 1019 cm-3 respectively. Obtain the band diagram of the same transistor through simulation (Hint: A planar structure has all of its contacts on same plane).
8. Design and Simulate a Planar PNP Bipolar Junction Transistor using Silvaco Atlas with β of about 15 to 20 considering Collector and Emitter doping concentrations of 1016 and 1020 cm-3 respectively. Obtain the band diagram of the same transistor through simulation (Hint: A planar structure has all of its contacts on same plane).
9. Design the following PNP BJT considering the dimensions as shown in the figure. Define Base, Collector and Emitter Electrodes with zero thickness. Find the value of Beta of the designed BJT.



1. Design a NPN Bipolar Junction Transistor having early voltage in the range of -250 to -300 Volt considering Collector and Emitter doping concentrations of 1016 and 1018 cm-3 respectively.
2. Simulate a NPN Bipolar Junction Transistor with Emitter, base and collector doping concentrations of 1020, 1016 and 1015 cm-3 respectively using Silvaco Atlas. Plot variation of base and collector currents in log scale with base emitter voltage. Obtain the Gummel plot for the same BJT. From the output characteristics, calculate early voltage of the device.
3. Design and simulate an Enhancement Mode N-channel MOSFET using Silvaco Atlas considering p type substrate with doping concentration of 1016 cm-3 and gate workfunction of 4 eV. Find out threshold voltage of the device. Define different regions of operation of the MOSFET in terms of surface potential. Plot the band diagram along M-O-S structure as the device moves from Accumulation to Inversion depending upon applied gate bias. Also show the variation of electron concentration in the channel for different regions of operation.
4. Design and simulate a Depletion Mode N-channel MOSFET using Silvaco Atlas considering n type substrate with doping concentration of 1016 cm-3 and gate workfunction of 4 eV. Find out threshold voltage of the device. Define different regions of operation of the MOSFET in terms of surface potential. Plot the band diagram along the Metal-Oxide-Semiconductor region as the device moves from Accumulation to Inversion depending upon applied gate bias. Also show the variation of electron concentration in the channel for different regions of operation.
5. Simulate a Depletion Mode N-channel MOSFET using Silvaco Atlas such that the channel disappears at a gate voltage about -0.8 V. Consider source and drain doping concentrations of 1019 cm-3. Show the gradual movement of the device from Accumulation to strong inversion in terms of energy band diagram. Specify voltage ranges for each region of operation.
6. Simulate an Enhancement mode N-channel MOSFET considering p-type substrate of doping concentration of 1015 cm-3. Show the variation of electrostatic potential across the MOS structure. Calculated the electric field at the Oxide-Semiconductor interface. Verify the answers through simulation. Also, plot the transfer and output characteristics of the device as the gate voltage is varied from 0 to 2 volt and drain voltage is varied from 0 to 5 volt.
7. Design the following PN junction diode structure using Silvaco Atlas. Consider thickness of n and p regions as 1 and 0.5 μm respectively. Obtain I-V characteristics of the diode and calculate its knee voltage. Plot band diagram of the diode and indicate the depletion region on n and p regions in the same band diagram.



1. Design and Simulate the given PN junction diode using Silvaco Atlas. Consider thickness of the n-type silicon substrate as 1.5 μm and that of p type region as 0.6 μm. Obtain the band diagram of the diode and indicate the depletion region and maximum electric field across the junction. Verify the simulation results against the analytically obtained values.



1. Simulate the following MOS Capacitor using Silvaco Atlas. Consider a negative interface charge of 3e10 cm-2 at the Oxide-Semiconductor interface. Plot the energy band diagram of the MOS structure and show the device operation in Accumulation, depletion and inversion regions depending on applied gate bias (using the band diagram). Calculate Flat band voltage of the given structure and verify it through simulation. Also obtain the Capacitance-Voltage characteristics of the MOS capacitor at 1 kHz. (Syntax used to obtain CV characteristics of PN junction diode can be used to obtain CV characteristics of the MOS capacitor.)

