By completing the PN-Junction Lab in *ABACUS - Assembly of Basic Applications for Coordinated Understanding of Semiconductors*, users will be able to: a) conduct drift-diffusion modeling, b) describe the physical and mathematical operation of PN-Junctions, and c) build and validate a simple PN Junction simulation tool.

The specific objectives of the PN-Junction Lab are:

<table>
<thead>
<tr>
<th>Physical Model</th>
<th>Mathematical Model</th>
<th>Computational Model</th>
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<tbody>
<tr>
<td>a) Introduce <strong>drift-diffusion</strong> theoretical model</td>
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<tr>
<td>- Poisson equation</td>
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<td>- Continuity equation</td>
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<tr>
<td>b) Apply <strong>numerical solution techniques</strong> for sparse matrices for solving:</td>
<td></td>
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<tr>
<td>- Equilibrium Poisson equation</td>
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<td></td>
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<tr>
<td>- Drift-diffusion model</td>
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<tr>
<td>c) <strong>Build and validate</strong> your own PN junction simulation tool</td>
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</tbody>
</table>
**Recommended Reading**

Users who are new to the physics of pn-junctions and their modeling should consult the following resources:


**Demo**

PN Junction Lab: First-Time User Guide

PN Junction Lab Demonstration: Asymmetric PN Junctions

**Theoretical descriptions**

* [Tutorial_PADRE_Simulation_Tools.pdf](tutorial) (tutorial)

* [Physical and Analytical Description of the Operation of a PN Diode](physical, analytical model)

* [PN junction in forward bias](simulation)

* [Numerical solution of the Drift-Diffusion Equations for a diode](computational model)

* [Drift-Diffusion Modeling and Numerical Implementation Details](implementation details and source code dissemination)

**Tool Verification**

Verification of the PN-Junction tool is done by comparison of the simulation results for the electric field in equilibrium with the depletion charge approximation results. This verification process can be done only while running the tool, as it superimposes the depletion charge approximation results.

[Verification of the Validity of the PN Junction Tool](Verification of the Validity of the PN Junction Tool)
Examples

The following Worked Examples for a PN Diode are described in detail:

Example 1: Equilibrium PN-Junction
Example 2: PN-Junction Under Bias
Example 3: Non-Symmetric Junction
Example 4: Series Resistance

Exercises and Homework Assignments

1. Basic operation of a PN diode - Theoretical exercise
2. Homework for PN Junctions: Depletion Approximation (ECE 305)
3. PN Junction Lab Exercise: Non-Idealities in a PN Diode
4. PN Diode Exercise: Series Resistance
5. Exercise: PIN Diode
6. PN Diode Exercise: Graded Junction
7. PN diode - Advanced theoretical exercises
8. Schottky diode - Theoretical exercises

Solutions to Exercises

Solutions are provided only to instructors!

Evaluation

This test will assess the users conceptual understanding of the physical, mathematical and computational knowledge related to the operation and modeling of PN Junctions.

ABACUS: Test for PN Junction Lab

Challenge

Users are challenged to integrate what they have learned about PN Junctions.
Solve a Challenge for a PN Diode