# Tunneling Model for Heterojunction

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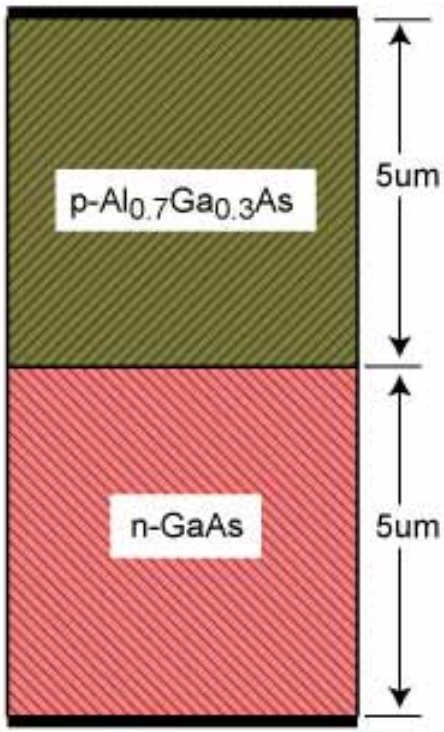
# Objective of the study

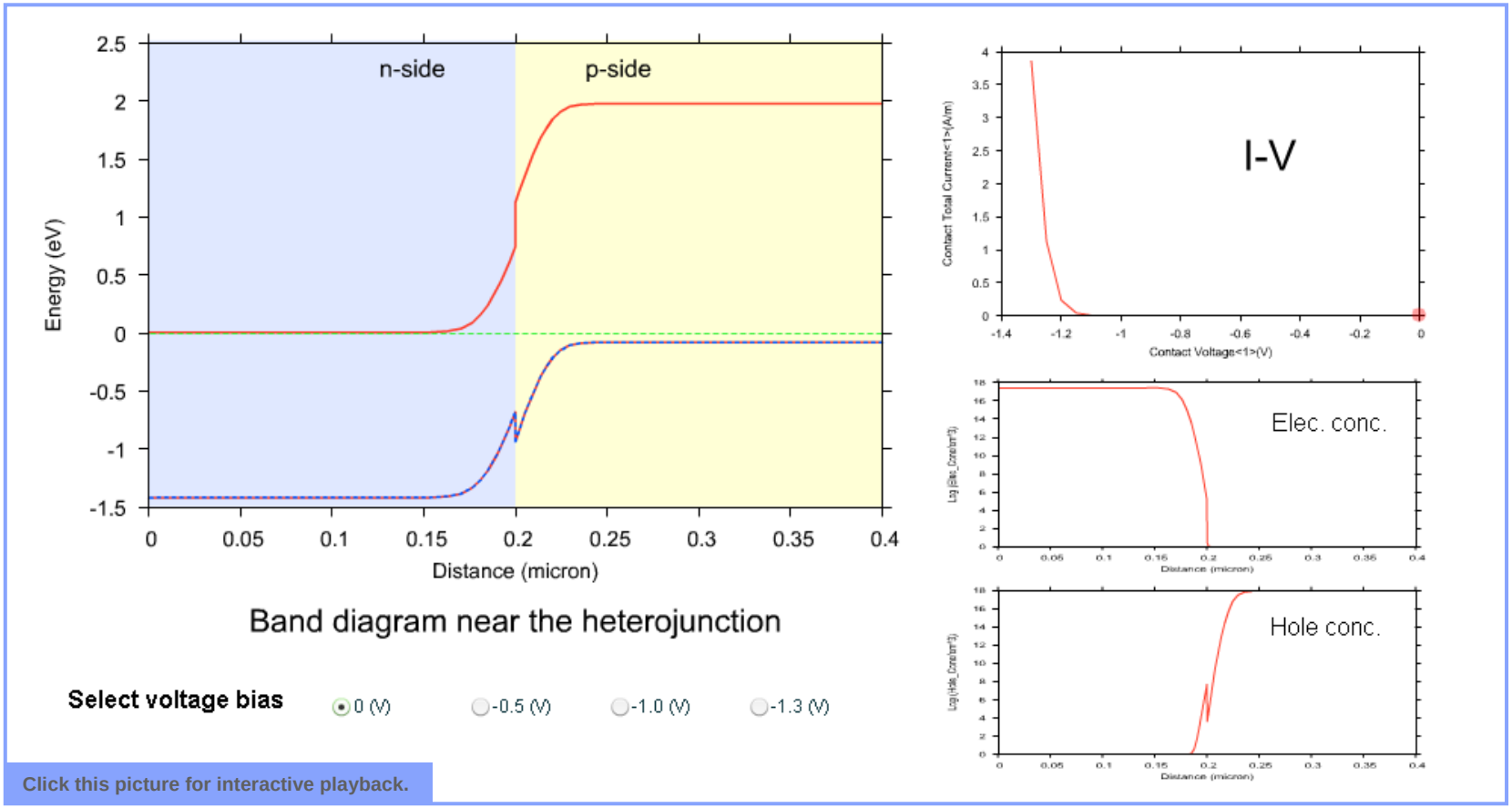
- To understand the significance of quantum tunneling model at heavily doped heterojunction.
- Investigate the effect of using composition grading and large internal extra point instead of using rigorous quantum tunneling model.

# Schematic of the basic model




- GaAs/AlGaAs Heterojunction.
- Each layer is uniformly doped.
- 1-dimensional Structure.

# DD-model only




- 1e24 (1/m^3) n- and p-doping concentration.
- Hole transport is hindered by sharp energy barrier at the heterojunction.

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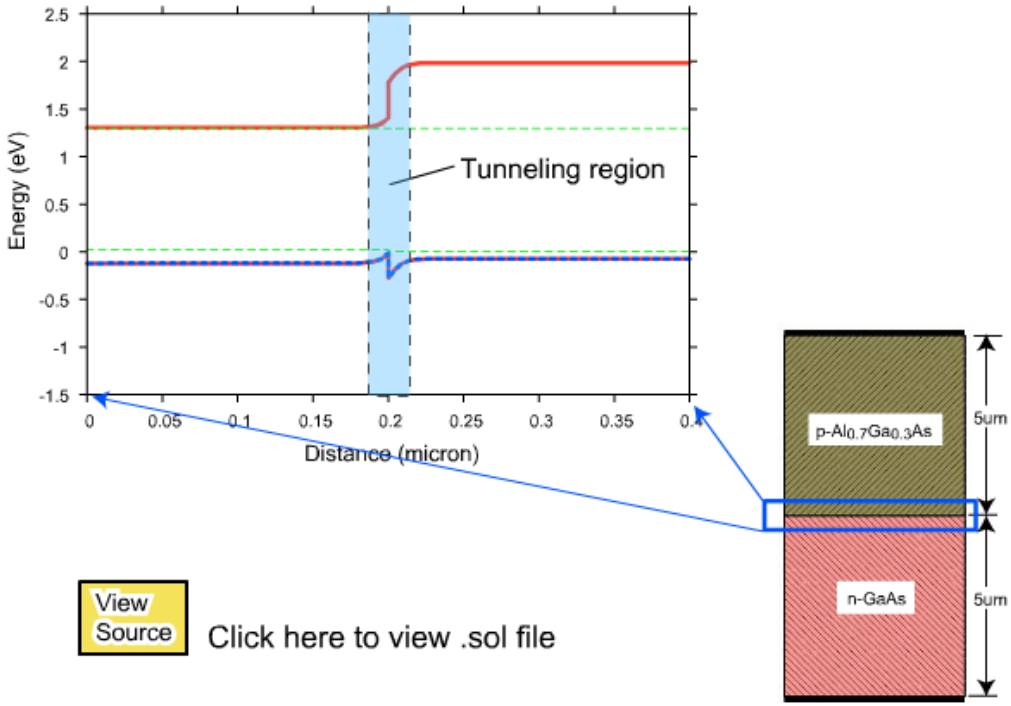
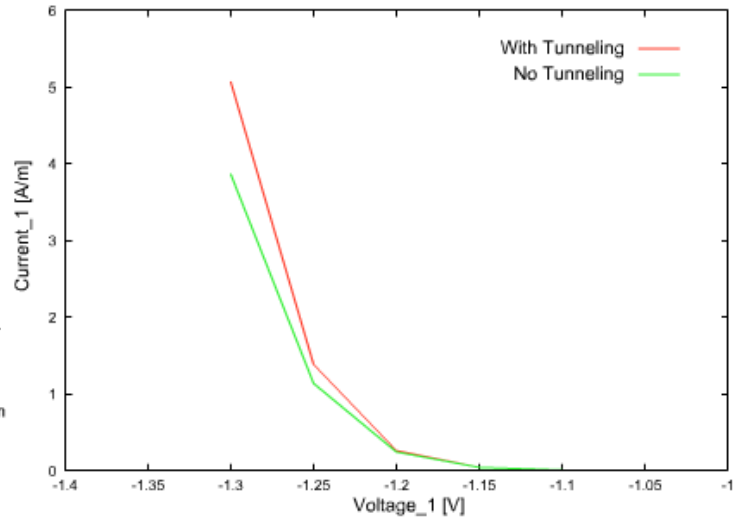
# DD plus tunneling model




View Source

Click here to view .sol file




Comparison of I-V curve

Click this picture for interactive playback.

- Tunneling effect for hole is set near the hetero-junction.
- Tunneling effect enhances carrier transport.

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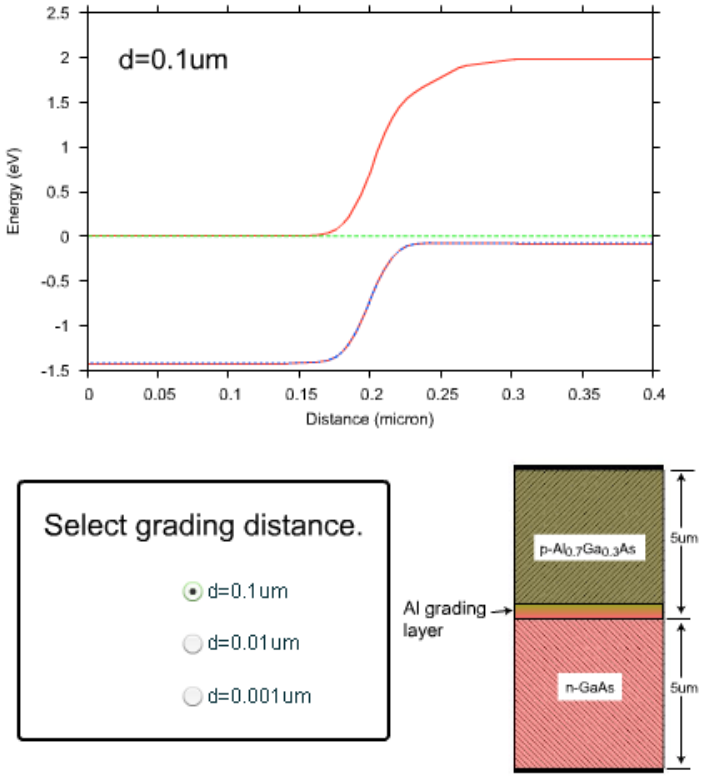
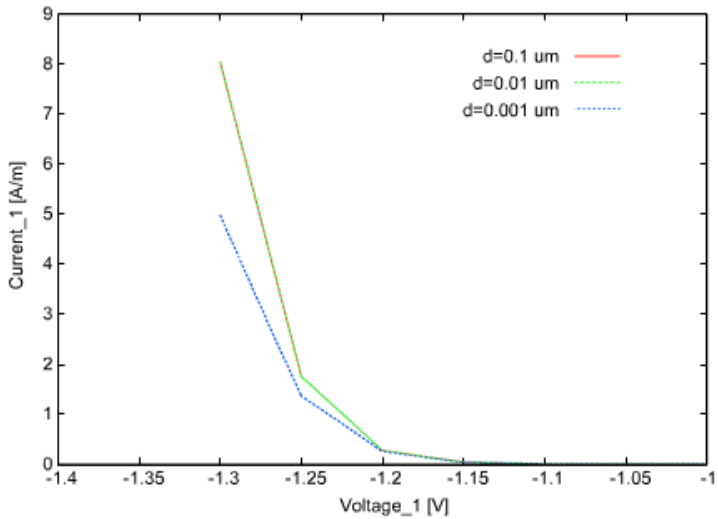
# Al composition grading




Dependence of I-V curve w.r.t. grading distance.

Click this picture for interactive playback.

- Grading distance is crucial for I-V characteristics.
- Large grading distance flattens out hole barrier.

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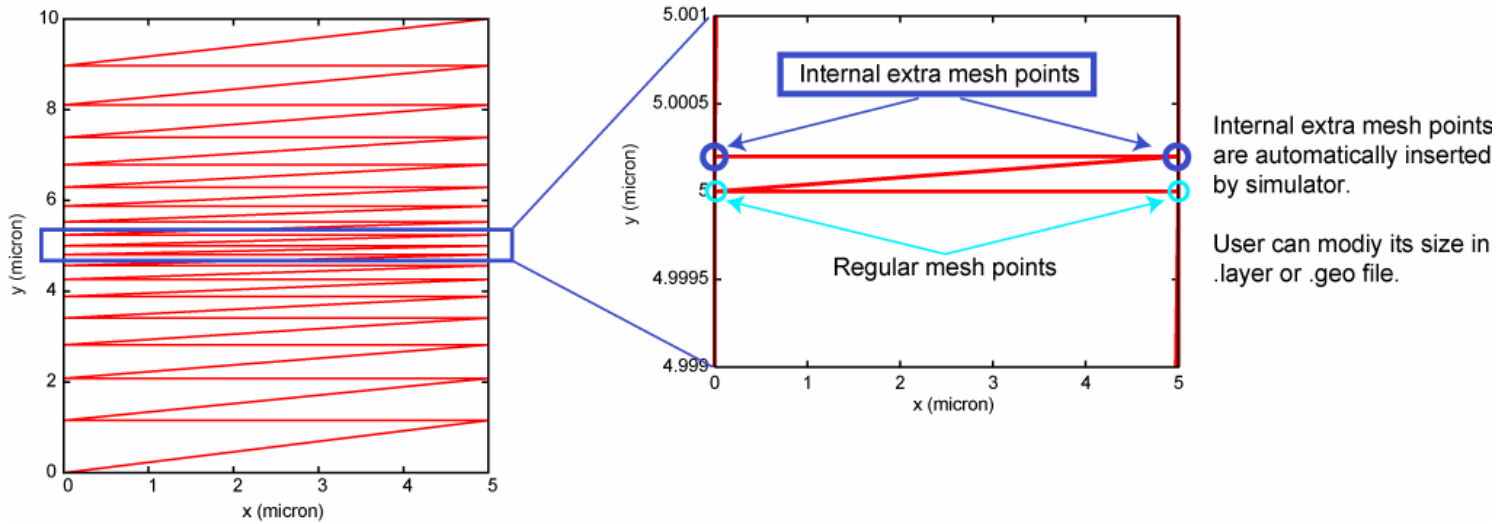
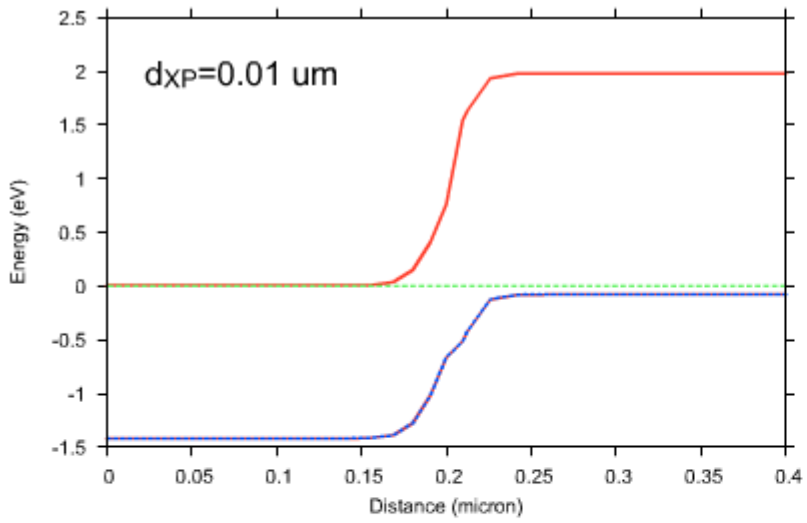
# What is the internal extra point?

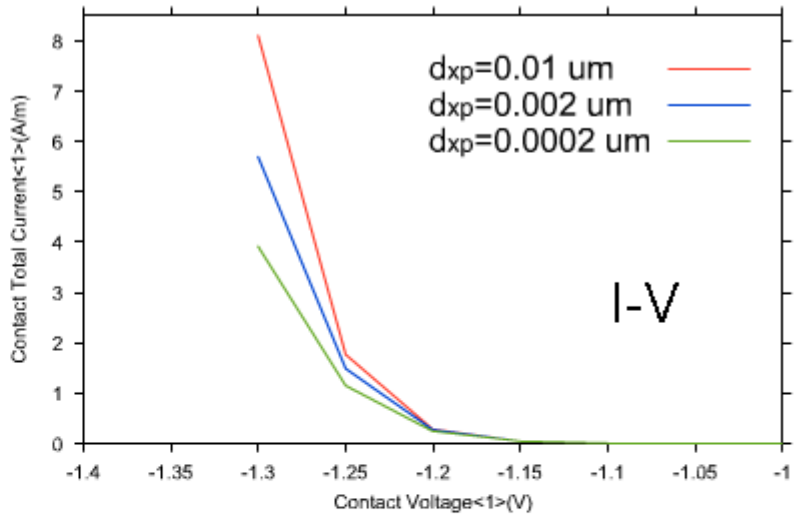


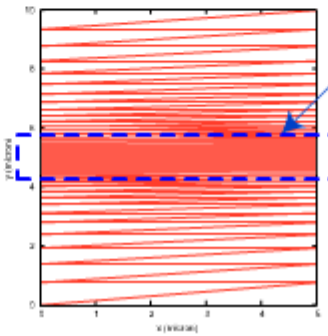

- Internal extra mesh point defines the sharpness of heterojunction. It corresponds to the width of interface between different materials.
- Use of internal extra mesh point relaxes the dependence of results on the distribution of regular mesh points.

# Using large internal extra point.




Band diagram at equilibrium.



Click here to enlarge.

Select size of internal extra point

XP=0.01 um  XP=0.002 um  XP=0.0002 um

View layer file

Click this picture for interactive playback.

- Large Internal extra point also flattens out hole barrier and enhances carrier transport.

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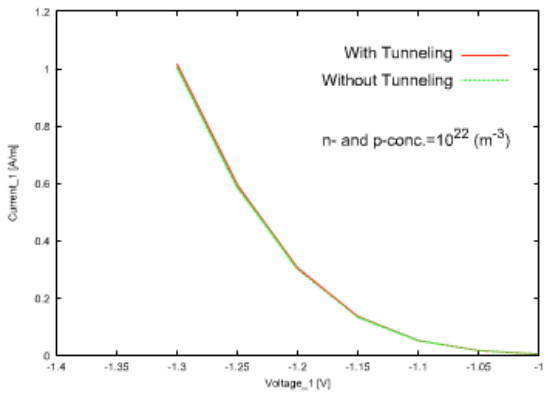
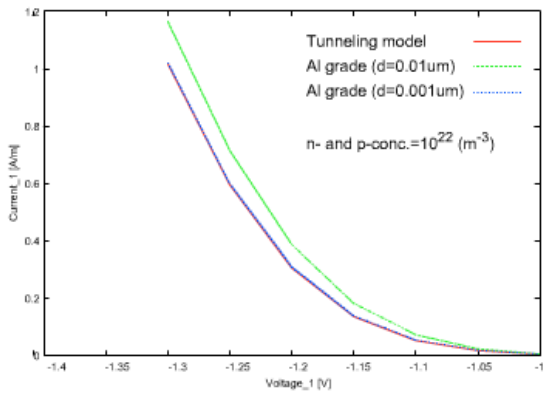
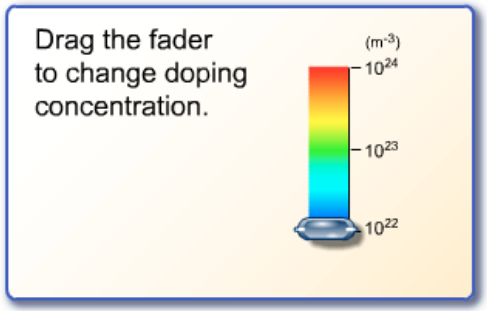
# Doping concentration dependence of I-V curve of each model

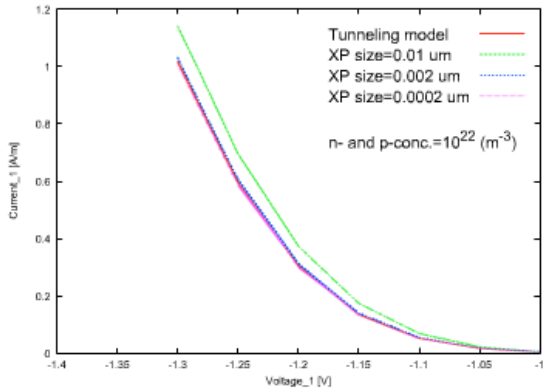



DD model vs. DD+Tunneling




Al grading vs. Tunneling model




XP size vs. Tunneling model

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- Tunneling effect becomes important at higher doping level.
- Proper choice of Al grading distance or internal extra point can bring I-V curve closer to rigorous tunneling model.

# Summary

- Quantum tunneling model causes distinguishable effect on carrier transport at high doping level.
- Al composition grading can mimic quantum tunneling effect by flattening potential barrier. However, choice of the grading distance is crucial.
- Using of sufficiently large internal extra point can bring same effects as in composition grading.
- Quantum tunneling model is a most reliable way to treat the quantum mechanical enhancement of carrier transport.