Device Simulation of Tunnel Field Effect Transistor (TFET)

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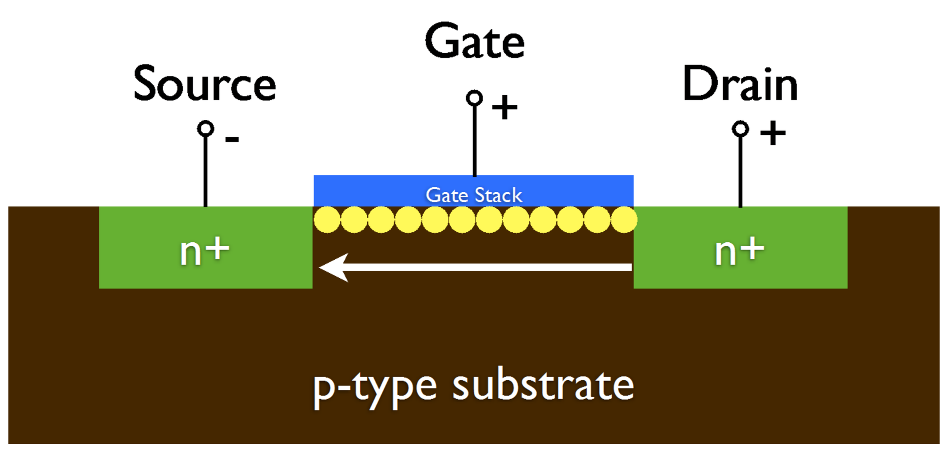
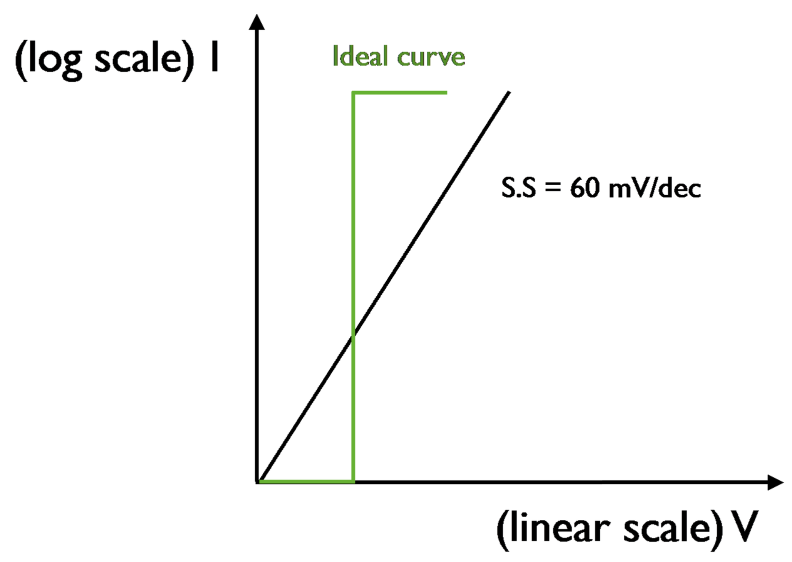
Abstract

In this project, NanoElectronics MOdeling Tools fifth generation (NEMO5) is used to simulate the TFETs with two different structures, InAs-GaSb and InAs-AlSb-GaSb. AlSb here is acting as an insulator due to its relatively large band gap so that we can easily manipulate the band alignment. The simulation result shows that the sub-threshold swing (S.S) of the first structure (InAs-GaSb) can be reduced to 33 mV/dec, which indicates the performance of TFET can be better than traditional MOSTFETs and demonstrates the potential of TFETs. Furthermore, we investigate how different material properties will affect the performance of TFET. Eventually, we provide an accessible 3D simulation template of TFETs for future study.

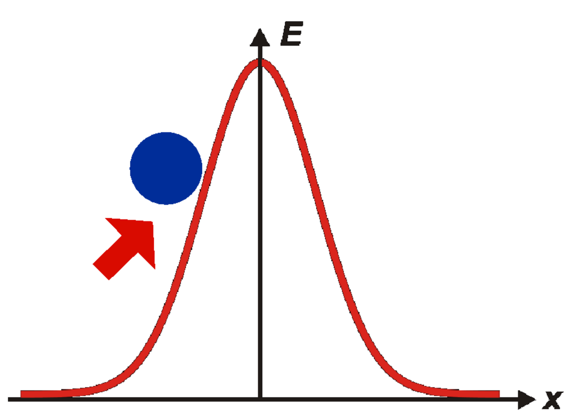
Introduction

As people scale down the size of Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs) into the nanoscale, we have an electronic unit containing more components. It consumes more energy so that power consumption becomes a huge issue. However, it is very difficult to lower supply voltage due to the transport mechanism of traditional MOSFETs, which is governed by the carrier diffusion over a thermal barrier. Even in the ideal case, the sub-threshold swing of MOSFETs is limited by 60 mV/dec.

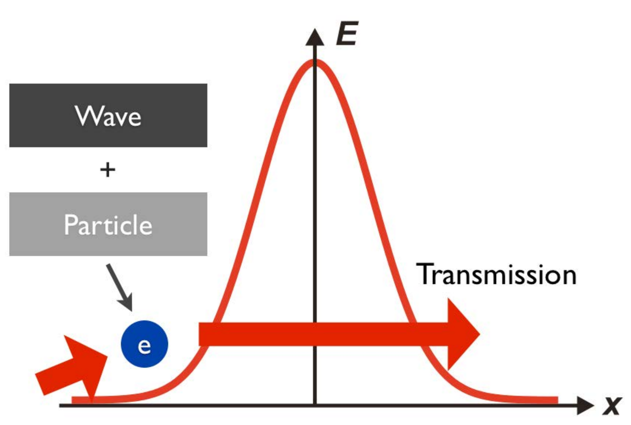




Therefore, Tunnel Field-Effect Transistor is considered as a promising solution because its transport mechanism is under quantum mechanics.



Classical Mechanics

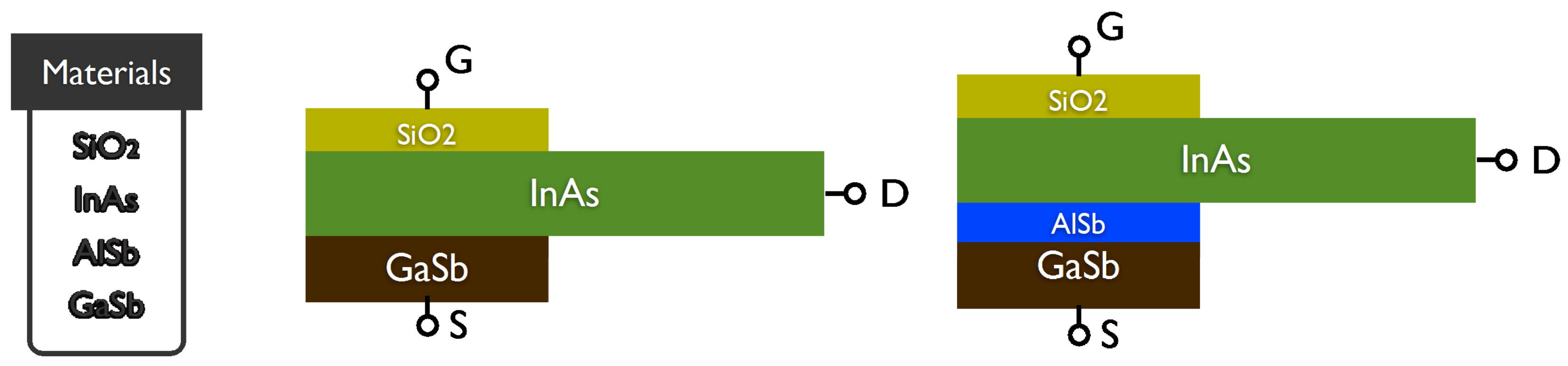


Quantum Mechanics

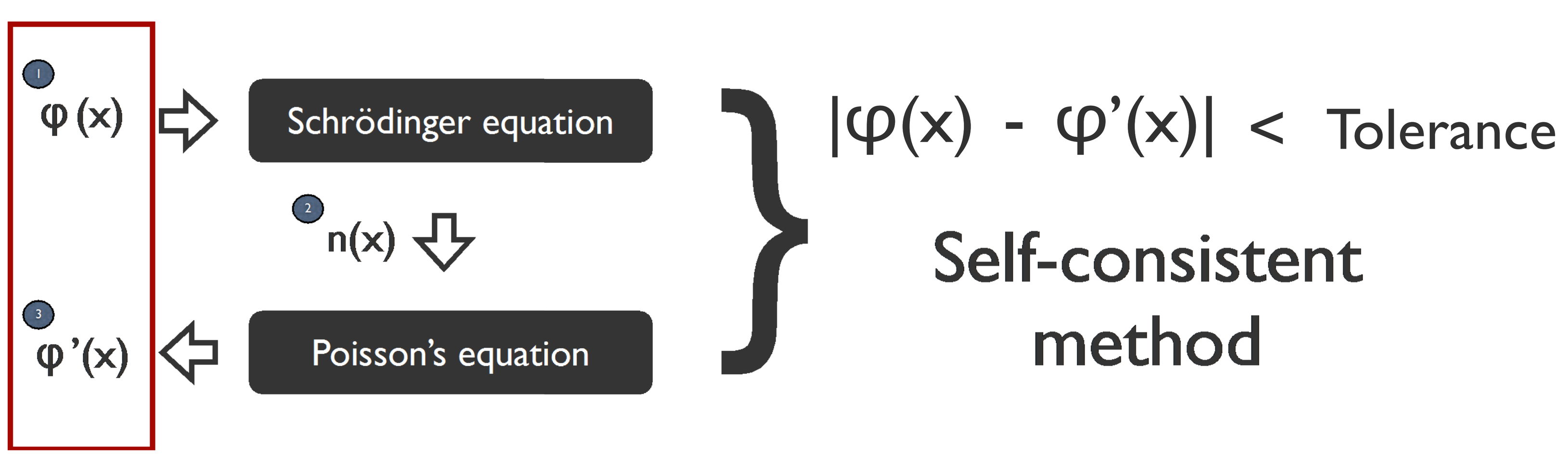
Simulation Process

We use NEMO5, which is a simulator developed by Professor Klimeck's team in Purdue University to simulate quantum transport of TFET.

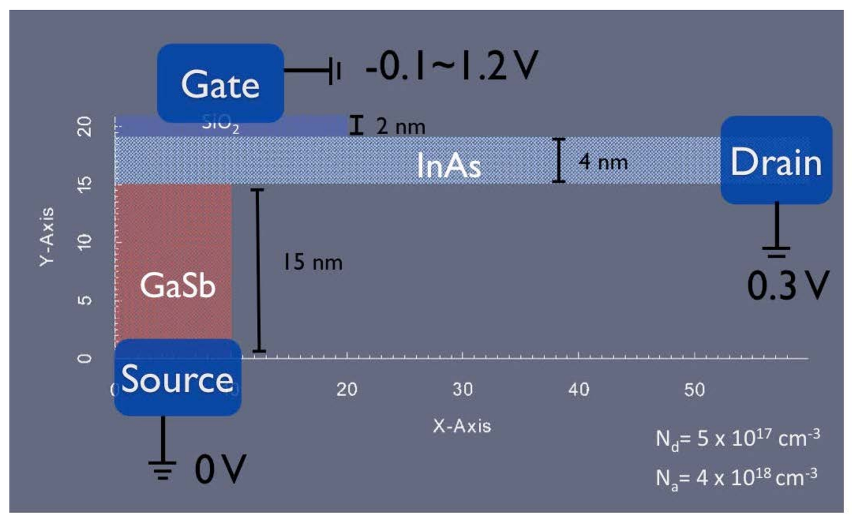
SETTINGS



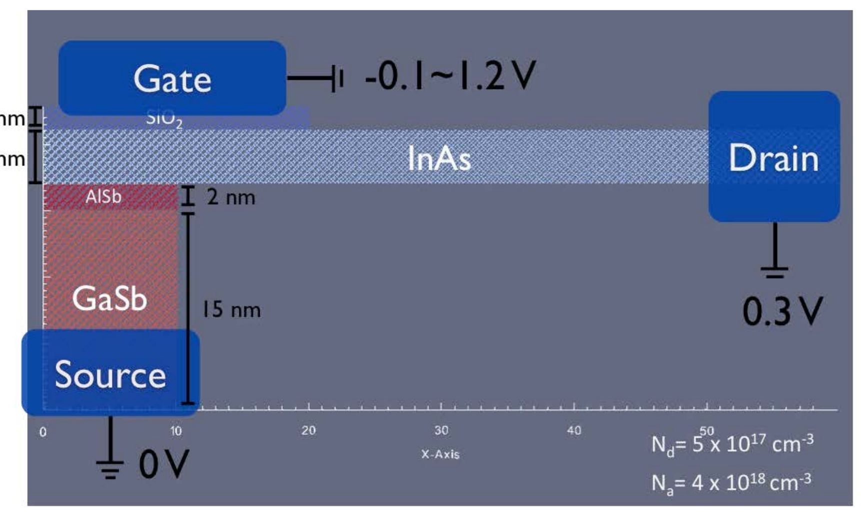
CALCULATION



Device Structure



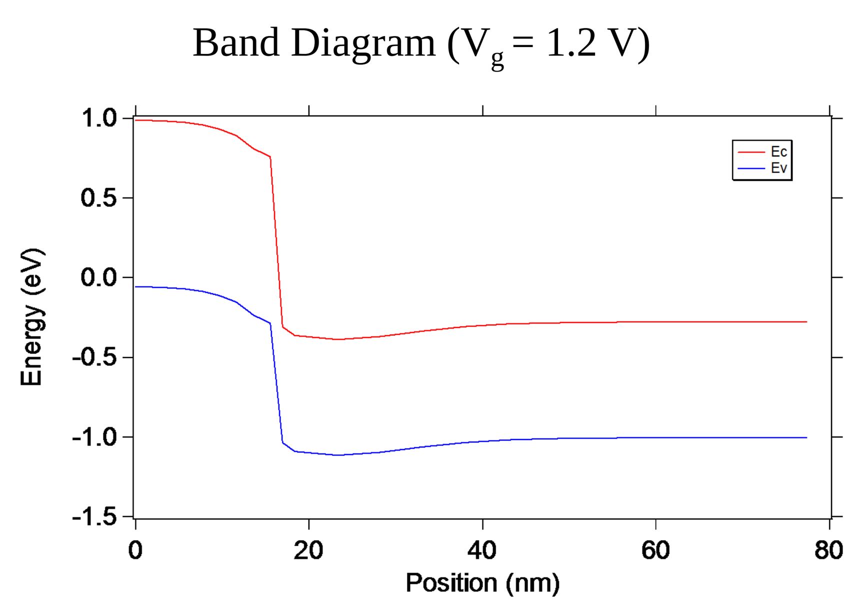
(InAs-GaSb TFET)

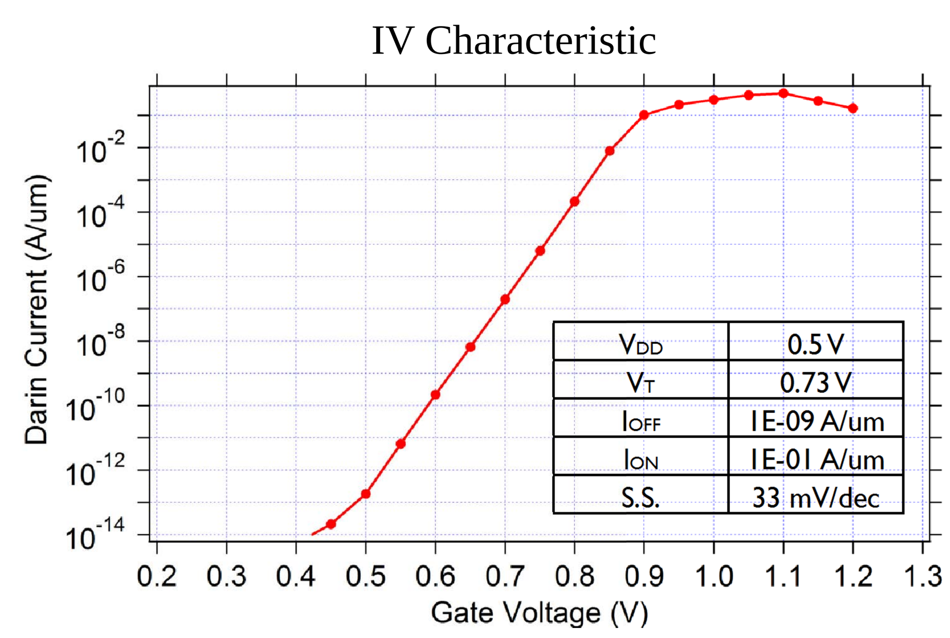


(InAs-AlSb-GaSb TFET)

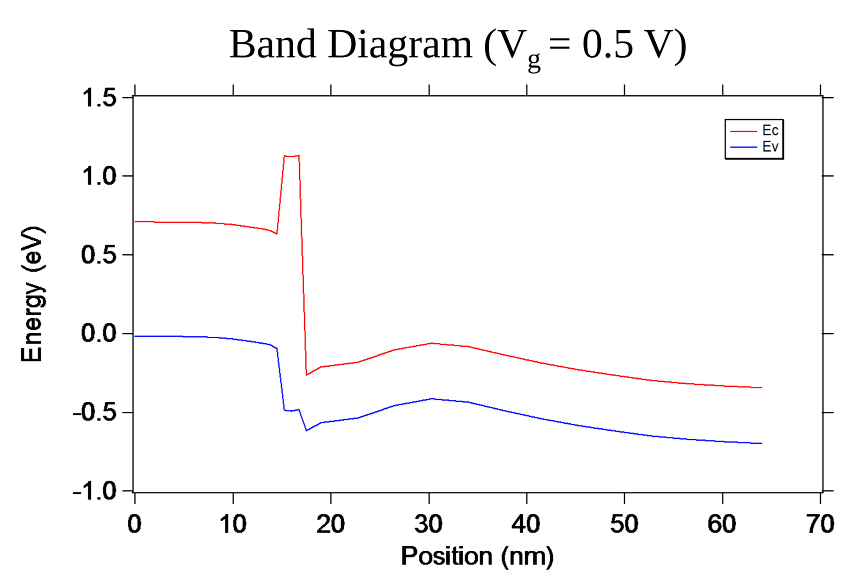
Results

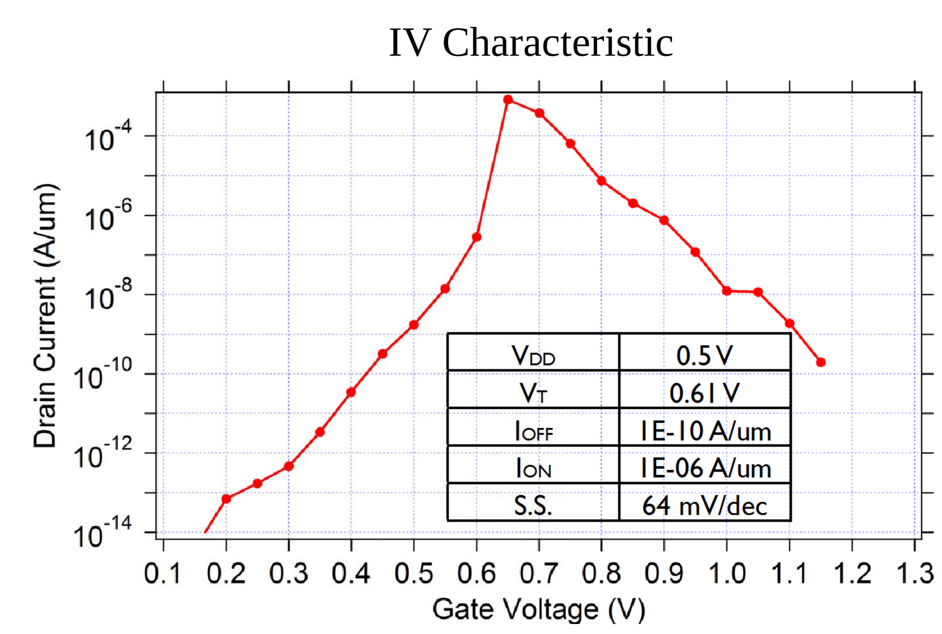
InAs-GaSb TFET





InAs-AlSb-GaSb TFET





Conclusion

The result shows that our device (InAs-GaSb) is able to reduce the sub-threshold swing (S.S) to 33 mV/dec under ideal condition. Although it is easier to manipulate band alignment with an insulator, it actually decreases the probability of tunneling so that S.S of the second device (InAs-AlSb-GaSb) increases to 64 mV/dec.

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