

2D Simulation of InP High Electron Mobility Transistors

Semester project, ETH Zürich, D-ITET, MWE laboratory (Prof. Bolognesi)
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Studies:	Master in Electrical Engineering and Information Technology
Project:	Semester project: 250 - 300 hours, 8 credit points (description here)
Office location:	ETZ K84
Office requirements:	Computer to carry out simulations
Starting date:	01.03.2017

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1 Project Description

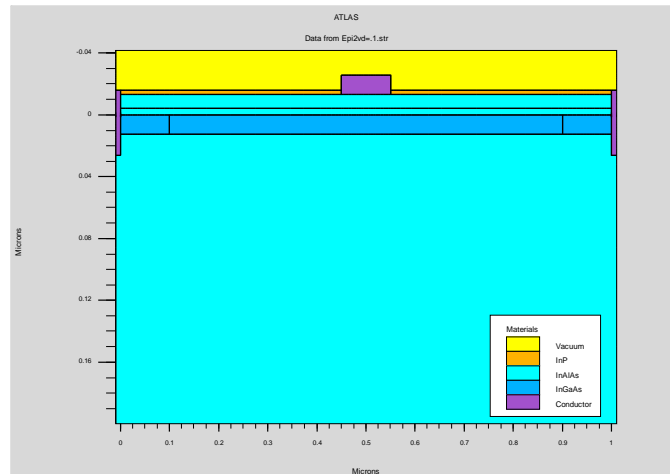
The goal of this semester project is to expand the existing 2D DC simulation model for MWE grown and fabricated InP High Electron Mobility Transistor using the commercial device simulator SILVACO ATLAS. This project requires understanding underlying physics and operation of a HEMT device, as well as analyzing measured DC and RF data.

InP HEMTS are of great interest for high-gain and low-noise application both at room and cryogenic temperatures. Their great performance is based mainly on excellent channel layer properties such as high electron mobility and high electron saturation velocity. Device geometry also plays a key role in device performance where even a simple change often leads to having to consider several tradeoffs: for example gate-to-channel distance when decreased leads to desirable high gain, but also leads to undesirable high gate leakage.

MWE-laboratory has a tradition of collaborating with European Space Agency in manufacturing and characterizing devices for cryogenic amplifiers which are later implemented in their Deep Space Antennas. However, the experimental determination of the influence of different parameters like layer thickness and material composition on the DC and RF performance of a transistor requires considerable time and financial resources.

Thus, device simulations are needed to give an idea about the implications of these parameters. In this sense, SILCAVO ATLAS is the software whose features are more appropriate for our context. Atlas is a physically-based two and three dimensional device simulator that predicts the electrical behavior of semiconductor devices at specified bias conditions. It enables to define structures using a simple command language and generate simple meshes directly.

The transport model which is used to simulate the electron behaviour in the channel has a great impact on the results. Drift Diffusion is a common model used because of its simplicity, leading to short simulation times and good convergence. To accurately simulate effects like high field mobility, velocity overshoot and impact ionization, the carrier temperature should be taken into account, which requires the implementation of the Energy Balance model.



Simulated structure of an InP HEMT.

For this reason, this semester project will focus on further development of the existing 2D DC simulation model of a standard HEMT towards reproducing its RF measurements and as a later step investigating the influence of different materials and thickness on both DC and RF performance.

2 Organisation and Working packages

- Preparation of a written report and presentation.
- Please make sure that after you have finished your thesis all files (data, latex, simulations, report, presentation...) are stored on a network drive of the MWE.

Introduction:

- Get to know the simulator.
- Understand the parameters in the existing HEMT model.

Main part:

- Reproduce measured S parameters for the standard HEMT structure.
- Investigate influence of several geometry parameters on HEMT performance.
- Do literature study about physical parameters of several materials grown on InP and already utilized in MWE.
- Implement new materials with their parameters into the existing HEMT model and compare with measured data.
- Use Energy Balance Model to get more precise results.

- Outlook:** Can you come up with your own epitaxial layer idea?