ETH zürich

Semester Project

Millimeter Wave Electronics Laboratory, D-ITET

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Simulation of Next Generation of InP High Electron Mobility Transistors (HEMTs)

Project Description

The semester project goal is to expand the existing 2D DC simulation model for MWE InP High Electron Mobility Transistor using the commercial device simulator SILVACO ATLAS. This project requires understanding the 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 applications 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, decreasing the gate-to-channel distance leads to a desirable higher gain, but also leads to undesirably higher gate leakage currents.

The MWE-laboratory has a tradition of collaborating with the 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.

For this reason, this semester project will focus on further development of the existing 2D DC simulation model of a standard HEMT and investigate the influence of different material compositions and thickness on both DC and RF performances. The work will include the simulation of InP HEMTs with InAs based channels, a structure which enabled some of the fastest transistors in the world, and MOSHEMTs, which are believed to play an important role in the near future.

Thesis Description

1. **Introduction**
   - Get to know the simulator.
   - Understand the parameters in the existing HEMT model.
2. **Main part**
   - Reproduce measured S parameters for the standard HEMT structure.
   - Literature study about physical parameters of several materials grown on InP and already utilized in MWE.
   - Investigate influence of several channel materials (InAs, InAsP, InP…) on HEMT performance.
   - Implement new materials with their parameters into the existing HEMT model and compare with measured data.
3. **Outlook**
   - Can you come up with your own epitaxial layer idea?

You will

- Obtain competitive experience working on the world-leading-level low-noise transistors.
- Run simulations in Silvaco Atlas TCAD environment, using our simulation server ‘Ezekiel’.
- Learn about cutting-edge research in semiconductors: band-gap engineering, nano-fabrication in a cleanroom, material growth limitations, device optimization, high frequency measurements…