Bachelor Thesis Task in the NanoEngineering Program (NE)

Topic: Development of a Quaternary InGaAsP Intermediate Layer for Use in the Collector of InP DHBTs

Task:

In the field of BHE, double heterojunction bipolar transistors (DHBTs) for high-frequency applications based on the indium phosphide semiconductor material system are being investigated. One of the most critical parameters for the performance of DHBTs is the structure of the indium phosphide collector to InGaAs base junction. The conduction band discontinuity that occurs here causes a blockade of the collector current, negatively affecting the speed and linearity of the transistor. One possible approach to solving this problem is the growth of an indium-gallium-arsenide-phosphide (InGaAsP) intermediate layer. By combining four different elements, it is possible to vary the bandgap and lattice constant separately in InGaAsP. Thus, such an intermediate layer can be grown lattice-matched to InP while choosing the bandgap to minimize the conduction band discontinuity.

The semiconductor layers for the HBTs can be produced on-site using metal-organic vapor phase epitaxy (MOVPE). However, the growth of InGaAsP is complex, as the incorporation of group V materials is highly non-stoichiometric and strongly depends on the chosen process parameters. Therefore, intensive characterization of the layers is necessary during process development to identify suitable growth parameters.

The aim of this work is to characterize MOVPE-grown InGaAsP layers using high-resolution X-ray diffraction, photoluminescence, and atomic force microscopy measurements to determine appropriate process parameters for the use of InGaAsP layers in DHBTs. Initially, individually grown InGaAsP layers will be examined in terms of lattice mismatch, bandgap, and material quality to draw conclusions about stoichiometry. After determining the basic parameters, the influence of n-doping with silicon on properties such as stoichiometry and defect density of the layers will be investigated. Finally, the process parameters will be studied in a layer stack similar to that of a DHBT to verify whether the identified parameters for the growth of InGaAsP are compatible with the entire process. The focus will be on the sharpness of the material transitions as well as the impact of the InGaAsP layer on the subsequent layers.