Band Diagram Study of Different Epitaxies and Estimation of the Influence on the Device Characteristics for Indium Phosphide and Gallium Nitride Based HEMTs

Semester project, ETH Zürich, D-ITET, MWE laboratory (Prof. Bolognesi)
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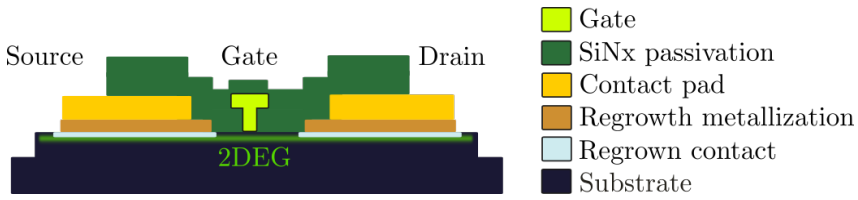
Student name:	Michael Baumann
Studies:	Master in Electrical Engineering and Information Technology
Project:	Semester project: 250 - 300 hours, 8 credit points (description here)
Office location:	ETH Hönggerberg
Office requirements:	Computer to carry out simulations
Starting date:	10.10.2016

Contents

1 Project Description

The goal of this semester project is to gain intuition about band diagram engineering for two different kinds of material classes and practical limits which have to be considered when a HEMT is to be fabricated on them.

In a HEMT the foremost purpose of the epitaxial structure is to create a two-dimensional electron gas (2DEG) with a sheet carrier density n_S and mobility of this carriers μ which should be as high as possible. Once this electron gas is created ohmic- (source and drain) and Schottky-contacts (gate) are fabricated on the wafer. The success of the fabrication of this contacts is characterized by the ohmic contact resistance R_C and reverse-bias leakage currents I_{leak}. Different epitaxies and choice of metallizations of source, drain and gate will facilitate or prevent the easy fabrication of one of these contact types.



The figure shows the simplified geometry of a GaN-HEMT. GaN is a wide-band gap material, which makes the fabrication of good ohmic contacts is an issue. This leads to the need for a "regrowth" in which the existing upper epitaxial layers are etched away and highly Si-doped GaN is regrown into the resulting recess.

The goal is to simulate the band diagrams of used epitaxial layer structures in Silvaco Atlas, explain them intuitively and create a table with possible advantages and disadvantages of each for the practically relevant quantities (n_S, μ, R_C, I_{leak}).

Experimentally, this semester project offers the student to gain experience in the characterization and measurements of high-speed and high-breakdown transistors.
REFERENCES ARE YET TO COME [?]

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, ...) are stored on a network drive of the MWE.

☐ **Introduction:**
- ☐ Get to know the simulator
- ☐ How to create the electron gas in GaN and InP HEMTs? What leads to the very different mobilities for the two materials? Why is GaN used for high breakdown transistors and InP for space applications (low noise transistors)?

☐ **Main part:**
- ☐ Create a literature database of the most-commonly used epitaxial layer combinations: Why are they so successful? Intuitively explain the band diagram.
- ☐ Choose some specific epitaxies which were designed to mend a certain issue (e.g. introduction of the AlN spacer in the AlInN/GaN HEMT).
- ☐ Theory of ohmic and Schottky contact fabrication + implementation in the simulator
- ☐ Comparison of ohmic and Schottky contact fabrication theory with experimental results

☐ **Outlook:** Can you come up with your own epitaxial layer idea :)