4.3.2 Simulation of n-GaAs/N-AlGaAs Heterojunction

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Introduction
Simulation of semiconductor devices play a major role in device development, because of time and cost saving. Therefore a simulator is needed which is able to simulate the given device. Recently, heterostructure devices, such as heterojunction bipolar transistors (HBT) or heterojunction field effect transistor (HFET), have stimulated great interest because of their potential for high-speed, high-frequency and monolithic integration of amplifiers and optical components like pin-diodes. Simulating these devices is a big challenge because of their special behavior at the heterojunction. In contrast to homojunction devices with continious bandstructure, for a abrupt heterojunction it is necessary to extend the established diffusion model to meet the requirements of a heterojunction. The current transport across the abrupt heterojunction interface is usually predominated by the thermionic emission mechanism, which is compareable to the behavior of a metal-semiconductor Schottky contact.

In this work we compare simulation results of Horio et. al. [1] and simulation results of our inhouse simulator (ATLAS from Silvaco). The comparison and calibration of the simulator with different sources is very important for the understanding of the simulation process and also for device understanding. With a prooven simulation technique an engineer is able to develop new devices and optimize existing ones.

Simulation Environment
In the paper from Horio et.al. [1] is a model described which is similar the same used in our inhouse software from Silvaco [2]. In this work we compare the simulations of a n-GaAs/N-AlGaAs heterojunction device, described in the work of Horio et.al. [1] and our simulator. We used the given device dimensions (fig. 1), material parameters, and model parameters given in the paper.

Fig. 1 Device structure for discussed results
Results

Horio et.al. compare in his work the influence of the presented model and discussed the physical reliability. In fig. 2 the current-voltage characteristic for an n-GaAs/N-AlGaAs diode is shown, calculated using the thermionic emission model, well known diffusion model, and our results. As seen in both cases, our results show a good agreement to those calculated from Horio. In congruence with him the thermionic emission model calculated a smaller current density, at a given voltage, than the diffusion model, because the thermionic emission mechanism limits the transport process over the heterojunction. As known the thermionic emission mechanism becomes important in the case, when high barriers for majority carriers are present, also recognised at metal-semiconductor Schottky contacts. Fig. 3 shows the band diagram of the two cases, with and without thermionic emission model. Our calculated results are plotted each case 0.5 eV higher for a better synopsis. If they are plotted in the right manner, the agreement is as that good as also show in the current-voltage characteristic (fig. 2).
Conclusion

The presented comparison gives more security to the used simulator and demonstrates the importance of the thermionic emission model.

References:
