3-D Simulation and Modelling of the Deep Centres Effect on the Transport Phenomena Inside a GaAs Semi Insulating $P^+\nu N^+$ Structure

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Three-dimensional simulation is currently an essential tool for the study of small geometry devices. The resulting analysis, which we are going to show in the present study (at equilibrium, under direct and reverse bias) corresponds to a stationary mode and for a significant concentration of recombining centres and traps. The introduction of traps or deep levels into a semiconductor can lead to a complexity in the interpretation of the transport mechanisms. We have focused the study around the influence of these deep centres on the charge transport inside a PνN diode based on semi-insulating Gallium arsenide material (SI-GaAs) that presents a significant concentration of impurities at deep levels. The effects of deep centres are taken into account through the mechanisms of recombination and the storage of a significant space charge, where we saw the influence of the presence of these levels on the distributions of electrostatic potentials and on the free carriers distributions at equilibrium and under direct and reverse bias by adopting a new concept and a novel investigation of the trapping model based on a combined numerical method, the Newton-Gummel modelling (the conduction inside the PνN structure). We have limited validation of this model at the weak injection.

1. Main results

- The shapes as well as the magnitude's orders of various simulations of the potential, the free carrier distribution, the electric field, and the space charge distribution are in agreement with the one-dimensional results and analytical calculations.
- Our simulated results depend strongly on the number of discretization points used in the calculation.
- We have developed a model allowing the simulation of the space charge on the first contact $P^+ \nu$.
- At direct polarization (10kT/q), we have noticed a reduction in the electrostatic potential, a reduction in the electric field, and an augmentation of electrons and holes distributions, which occurs at the contact P^+- ν in order to maintain the electric neutrality since there is a significant hole injection from P^+ to ν.
- At reverse bias, we noticed a significant fall of the potential on the first contact, a diminution of carrier density in particular, when going towards the zone N. We arrived at certain results for detecting the nature of the traps levels introduced (hole or electron traps).
- We found effects which have the traps levels, as well as the density of these deep levels on the phenomenon of conduction through the structure PνN.

2. Conclusion

Our partial conclusion is that Gummel Algorithm is preferable at equilibrium state due to its convergence. In another part, Newton method is recommended such as in polarisation. Thus, Gummel and Newton algorithms are combined to permit a better computing convergence.

The finite difference method used in the simulation can be combined to the finite elements to detect each point in the structure as a proposition to a future studies.