State-of-the-Art micro materials models in MINIMOS-NT

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Considerable effort was spent on our two-dimensional device simulator MINIMOS-NT to get it ready for simulation of devices with high complexity and specifity in respect to materials, geometries, etc. Many of the existing physical models (band gap, mobility, thermal conductivity, energy relaxation times, specific heat, etc.) were refined, some of them were replaced by promising new ones, and many new models were added as well. Being an ancestor of the well-known MOS device simulator MINIMOS [1], its experience with Si devices was inherited. Thereby, MINIMOS-NT became a generic device simulator accounting for a variety of micro-materials, including IV group semiconductors, III-V compound semiconductors and their alloys, and non-ideal dielectrics.

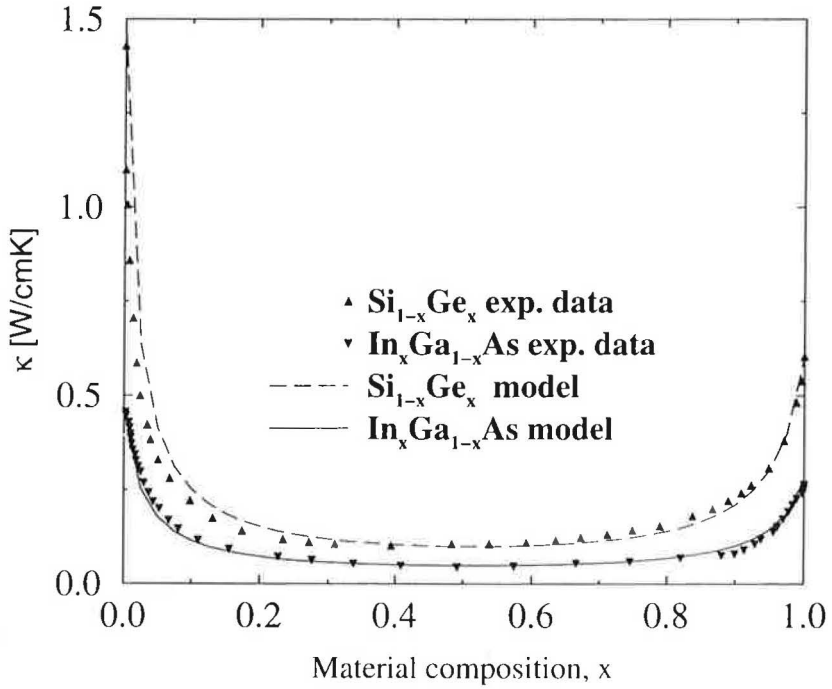

Figure 1: Material composition dependence of the thermal conductivity at300K.

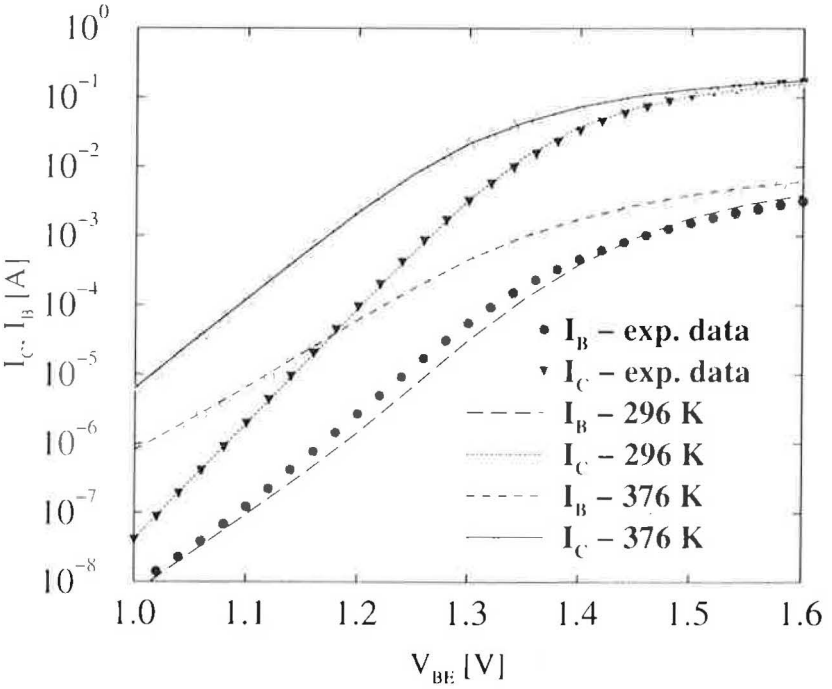

Figure 2: Forward Gummel plots at VCB = 0 V. Comparison with measurements at 296 K and 376 K.

For example, in Fig. 1 we present our model for the thermal conductivity κ_L applicable to all relevant diamond and zinc-blende structure semiconductors. The temperature dependence of κ_L is modeled by a simple power law which gives a good agreement with experimental data [2]. In the case of alloy materials $A_{1-x}B_x$ it varies between the values of the basic materials (A and B). The model is used for device simulation with self-heating by solving the lattice heat ow equation self-consistently with the energy transport equations (system of six partial differential equations).

Several applications of industrial interest employ devices operating in a wide temperature range. Therefore, our models have been designed to meet this challenge in addition to the conventional Si applications. MINIMOS-NT has been successfully used for simulation of heterostructure devices, e.g. High Electron Mobility Transistors (HEMTs) and Heterojunction Bipolar Transistors (HBTs) [3]. For example, in Fig. 2 we present the simulated forward Gummel plot for an AlGaAs/GaAs HBT compared to experimental data. The simulation results at 376 K demonstrate the ability of MINIMOS-NT to reproduce correctly the thermal device behavior.

References

[1] S. Selberherr, A. Schütz, and H. Pötzl, »MINIMOSIA Two-Dimensional MOS Transistor Analyzer«, IEEE Trans.Electron Devices, vol. ED-27, no. 8, pp. 1540-1550, 1980.

[2] P. Maycock, »Thermal Conductivity of Silicon, Germanium, III-V Compounds and III-V Alloys«, Solid-State Electron., vol. 10, pp. 161-168, 1967.

[3] V. Palankovski, S. Selberherr, and R. Schultheis, »Simulation of Heterojunction Bipolar Transistors on Gallium-Arsenide«, in Simulation of Semiconductor Processes and Devices, (Kyoto, Japan), pp. 227-230, 1999.

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