Energy-transport equations coupled with heat transport for semiconductor devices

*Peter Kristöfel** (TU Wien), *Ansgar Jüngel* (TU Wien)

As a result of the miniaturization in modern semi-conductor devices it is essential to study models which consider termperature effects. One well known example is the energy-transport model (see e.g. [1]), which is given in the drift-diffusion formulation by

$$\partial_t g_1 - \mathrm{div}_x J_1 = -R, \qquad J_1 = \nabla_x g_1 - \frac{g_1}{T}\nabla_x V,$$

$$\partial_t g_2 - \mathrm{div}_x J_2 = -J_1 \cdot \nabla_x V + W - \frac{g_2}{g_1}R, \qquad J_2 = \nabla_x g_2 - \frac{g_2}{T}\nabla_x V,$$

$$\lambda^2 \Delta_x V = g_1 - Dop.$$

Here g_1, g_2, J_1 and J_2 denote the electron and energy densities and their respective current densities, V is the potential and T the electron temperature, and all six quantities depend on x and t. The energy term $W(g_1,T)$ models collission processes, R generation and recombination effects. Dop describes the doping profile, and λ is a scaling parameter.

The heat transport equation is given by

$$\rho_L c_L \partial_t T_L - \mathrm{div}_x(\kappa_L \nabla T_L) = H,$$

where T_L is the lattice temperature, ρ_L the density, κ_L the heat conductivity and c_L the heat capacity, respectively. For a suitable heat generation term H (see e.g. [2]) this equation couples to the energy-transport model and all equations together are then solved with a mixed, hybrid, adaptive finite element method. Some results for the one- and two-dimensional case will be presented and the influence of boundary conditions (see e.g. [3]) will be discussed.

[1] A. JÜNGEL: *Transport Equations for Semiconductors*. Lecture Notes in Physics No. 773. Springer, Berlin, 2009.

[2] G. WACHUTKA: Consistent treatment of carrier emission and capture kinetics in electrothermal and energy transport models. *Microeletronics Journal.* **29** (1995), 307–315.

[3] A. YAMNAHAKKI: Second order boundary conditions for the drift-diffussion equations of semiconductors. *Mathematical Models and Methods in Applied Sciences.* **5**, No. 4 (1995), 429–455. North Holland, 1983, pp. 147–156.