# Preface

With recent developments in semiconductor technology, several mathematical models have been established to analyze and to simulate the behavior of electron flow in semiconductor devices. Among them, a hydrodynamic, an energy-transport and a drift-diffusion models are frequently utilized for simulation in the industry. The present paper concerns the mathematical analysis on these three models, especially in the singular limits where the two physical parameters, the momentum relaxation time and the energy relaxation time, tend to zero. These limits are called relaxation limits of which analysis makes clear relations among the above models. To investigate this problem, we firstly study the time global solvability and asymptotic behaviors of solutions for both of the hydrodynamic and the energy-transport models. Precisely, we show the solutions to these two models converge to corresponding stationary solutions, respectively, as time tends to infinity. For these solutions, the relaxation limit analysis is carried out. Precisely, we prove that the time global solution for the hydrodynamic model converges to that for the energy-transport model as a momentum relaxation time tends to zero. Moreover, it is shown that the solution for the energy-transport model converges to that for the drift-diffusion model as an energy relaxation time tends to zero. Finally, by letting both relaxation times tend to zero in the hydrodynamic model, the solution converges to that for the drift-diffusion model. In these limit procedures, initial layers appear in the solution since an initial data is not necessarily in "momentum equilibrium" nor "energy equilibrium". The initial layers are, however, shown to decay exponentially fast as the relaxation times tend to zero. They also decay exponentially fast as time tends to infinity. For all the results above, the initial data can be taken arbitrarily large in the suitable Sobolev space provided that the relaxation times are sufficiently small since the drift-diffusion model, a limited system, is a coupled system of a uniformly parabolic equation and the Poisson equation. These results are obtained by time weighted energy methods, which also play an essential role to handle the initial layer.

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