2:40pm T43 Electron Mobility in Doped Semiconductors

G. Kaiblinger-Grujin, H. Kosina, and S. Selberherr
Institute for Microelectronics, TU Vienna, Gusshausstrasse 27-29, 1040 Vienna, Austria

We introduce a new theoretical approach to study the dependence of the low-field electron mobility on the atomic number of the dopants in doped semiconductors. The charge distribution of the impurities is described within the Thomas-Fermi theory in the energy functional formulation. By means of a variational principle one obtains a unique charge distribution for each dopant. It can be shown that the failure in the past to describe successfully the different mobilities for different dopants lies in the neglection of the spatial extension of the electron charge density. The corresponding atomic form factor of the charge distribution in Fourier space is significantly different for different dopants, especially for acceptors. The Schwinger amplitude which is superior to the 2. Born approximation is used to calculate the scattering rates. It can be shown that the screening process and the effective scattering potential is a function

of the atomic and electronic number of the impurities. Hence the Debye screening length and the cross section depends on the species of dopants.

Monte Carlo simulations including all important scattering processes have been performed for silicon, GaAs, and InP in the doping concentration range from 10^{15} cm^{-3} to 10^{21} cm^{-3}. The agreement with experiments is excellent. Our results confirm not only the experimental data of the mobility enhancement of minority electrons by a factor of about two compared to majority electrons in degenerated semiconductors but also the generally lower electron mobility in arsenic-doped silicon compared to phosphorus-doped silicon. We derived a theoretical transport model which for the first time explains the electron mobility for different dopants. As all quantities are analytical expressions it is well suited for device simulations.