STUDIES OF HOT ELECTRON TRANSPORT IN SEMICONDUCTORS USING SOFT X-RAY PHOTOEMISSION

E. Cartier, A. Ekland, F. R. McFeely and M. V. Fischetti
IBM Research Division
Thomas J. Watson Research Center
Yorktown Heights, NY 10598

Abstract

Monte Carlo transport simulations have been used to analyze novel hot electron transport experiments. The experiments are based on soft x-ray induced core level spectroscopy and have been used to study the energy dependent hot carrier transport in AlGaAs and Si. The simulations are based on a Monte Carlo reconstruction of the experiment. In the experiment, photoelectrons produced by synchrotron radiation propagate from excitation sites inside the semiconductor to the surface, where they are emitted and subsequently detected. The energy of this internal electron source can be varied via the photon energy. As the electron energy was lowered through the threshold for impact ionization, the Al 2p core level in AlGaAs and the Si 2p line in Si showed significant broadening. This line broadening transition clearly marks the boundary between impact ionization dominated transport and an energy regime in which electron-phonon scattering dominates. A quantitative analysis of the broadening transition was achieved by using semiclassical Monte Carlo simulations to reconstruct the core level spectra. Comparison of these simulations to be experimental data allows the determination of the energy dependent impact ionization rates near the impact ionization threshold and serve to test absolute calculations of electron-phonon scattering rates and impact ionization rates of hot electrons in semiconductors at energies from 1 to 5 eV. This energy range is not accessible by most device measurements.