

Within the NAHDEVI project we merged on the personal level four research groups out of France and Austria, as well as on the scientific level two significant advances in the area of nanowire (NW) heterostructure and tunnel field-effect transistors (FETs). The final goal of this project was the realization of compositionally and doping modulated Si/Ge axial NW heterostructures as well as silicide/germanide-semiconductor heterojunctions and their integration in novel electrical nanodevices. Within the austrian part of the project we developed a synthesis procedure for metal/semiconductor NW heterostructures with abrupt interfaces. Combining e.g. self-aligned NiSi source contacts and NWs that feature an axial n-type/intrinsic doping junction we demonstrated a multi-mode FET device. This unique device dynamically configures the mode of operation by either changing the dual-gate configuration or just by inverting the drain bias. Very recently we demonstrated the formation of a unique axial Al/Ge NW heterostructure enabled by a thermal induced exchange reaction between Ge NWs and Al contact pads due to the substantially different diffusion behavior of Ge in Al and vice versa. Integrating these Al-Ge-Al NW heterostructures into back-gated FETs we demonstrated unambiguous signatures of negative differential resistance even at room temperature attributed to intervalley electron transfer. Modulation of the transfer rates, manifested as a large tunability of the peak-to-valley ratio and the onset of impact ionization is achieved by the combined influences of electrostatic gating, geometric confinement, and heterojunction shape on hot electron transfer and by electron-electron scattering rates that can be altered by varying the charge carrier concentration in the NW FETs. The experimental work has been supported by numerical simulation. A new method of modeling band-to-band tunneling has been developed. The method makes use of an effective tunneling barrier that is extracted from the self-consistent valence band and conduction band profiles. The barrier exhibits valence band properties on one side and conduction band properties on the other. The locations of the transition are derived from momentum conservation. After computing the injection eigenmodes at the contacts, the propagating waves through the three-dimensional device structure are calculated using the quantum transmitting boundary method. The 3D band-to-band tunneling algorithm has allowed us to study the effect of various device parameters on the tunneling current. The Doping profiles in tunneling devices have been found to impact the tunneling current significantly. A realistic 3D doping profile is required as the tunneling barrier responds to the details of device geometry as well as the doping distribution. Furthermore, the 3D algorithm has been used to study direct/indirect heterojunctions and the possibility to design the tunneling device in a way to avoid the problems related to the quality of the heterojunction, by moving the tunneling barrier away from the physical interface. The tunneling currents of 3D devices with doping pockets and gate overlap/underlap have been examined.