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Tuning the Conductivity of Semiconductor Nanostructures by Dielectric Engineering ANIRUDDHA KONAR, DEBDEEP JENA, University of Notre Dame — Electron transport properties in semiconductor nanoscale quantum structures grown by bottom-up techniques can be fundamentally different from those grown by epitaxial methods. Transport properties in 1D nanotubes and nanowires and 2D nanoscale thin films are strongly affected by carrier-impurity interactions mediated by the dielectric environment of the nanostructure. We show that by suitable dielectric engineering of this environment, electron mobility in 1D and 2D semiconductor nanostructures can be enhanced by 1-2 orders of magnitude. The enhancement takes place only when the smallest length scale of the nanostructure is less than the effective Bohr radius of the bulk semiconductor. The enhancement in mobility occurs predominantly due to a large damping of Coulombic scattering, which results in a reduction of electron scattering rates. When the dielectric constant of the environment is changed from 1 (air) to 100 (high-k oxide dielectric), the Coulomb scattering rate decreases from 700/ps to 4/ps for a 1D nanowire, and from 66/ps to 3/ps for a 2D sheet. When other scattering mechanisms such as surface roughness and phonon scattering are considered, we find that the total conductivity of the nanostructures can be enhanced by 1-2 orders of magnitude by coating them with high-k dielectrics.

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