Finite-size effects in the electrical transport properties of single bismuth nanowires

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Single bismuth nanowires with diameters ranging between 150 nm and 1 μm were fabricated by electrochemical deposition in single-pore membranes. Using three different parameter sets of temperature and voltage, three groups of wires, each with a different mean grain size, were created. By measuring the electrical resistance of each nanowire individually, resistance-versus-diameter data enable us to assort the Bi nanowires in three different groups characterized by three distinct mean specific electrical resistivities. Each of these three groups is also characterized by a common mean grain size predetermined by the correspondent set of deposition parameters. Thus the results demonstrate that the resistivity is determined mainly by electron scattering at grain boundaries. Resistance-versus-temperature curves display a nonmonotonic behavior. The calculated charge carrier mobility saturates at low temperatures and is one to two orders of magnitude smaller than in bulk material depending on wire diameter and crystallinity. This saturation is attributed to finite-size effects.