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Collisional-Induced Resistivity of Carbon Nanotubes

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A single-walled carbon nanotube (SWNT) is often mentioned as one of the strongest materials known. In tension along the tube axis, this statement is correct. However, the tube is "soft" in the radial direction, i.e., deformation or squash modes which give rise to an oscillating elliptical cross section have freq's in the range 20-30 cm^{-1}. Here, we present results of an *in situ* electrical transport study (thermoelectric power (S) and resistivity (ρ)) of bundled SWNTs exposed to a series of gases (He, Ar,Ne,Kr,Xe;CH_4,N_2). Unusually strong and remarkably systematic changes in these transport properties are observed as the nanotubes undergo collisions with these atomic and molecular gases. At fixed pressure and temperature, the changes in the transport parameters, i.e., ΔS and $\Delta\rho$, are observed experimentally to exhibit an $\sim$ $M^{1/3}$ behavior. At fixed temperature, ΔS and $\Delta\rho$ saturate in the range 0.3-0.5 atm,, with the saturation pressure depending on M. Results of molecular dynamics that simulate the gas-nanotube collision show that the maximum deformation of the tube wall and the radial kinetic energy transfer to the tube wall also exhibit this $M^{1/3}$ behavior. It appears that the transient deformation or "dent" caused by the collisions may provide new scattering mechanism for itinerant electrons in the tube walls. These dents ring as the fundamental "squash" mode of the tube wall. The pressure p_{sat} at which ΔS and $\Delta\rho$ can be shown to be consistent with the tube pressure at which co-existing dents first begin to overlap.