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Modifying inter-tube bonding, and doping, in carbon nanotubes

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Doping carbon nanotubes is essential for tuning their physical properties. Improved $in-situ$ and post-synthesis methods have succeeded in preparing carbon nanotubes with novel electronic, vibrational, thermal and mechanical properties. For example, we have recently reported a superconducting transition temperature of ~ 12 K in thin films of boron-doped single-walled carbon nanotubes. Detailed Raman studies showed the presence of charged defects in the nanotube framework which leads to modified electron and phonon energies. In this talk, we present evidence for the formation of inter-tube bonding in nanotubes when subjected to the spark plasma sintering (SPS) process. The combined results of x-ray powder diffraction, Raman spectroscopy, scanning electron microscopy and high resolution transmission electron microscopy show that the nanotubes largely retain their individual tubular morphology. In turn, these inter-tube connections influence the overall electrical resistivity, thermoelectric power and thermal conductivity of the SPS-ed samples. In particular, the magnitude of the electrical resistivity as a function of SPS temperature exhibits a percolative behavior while the low temperature lattice thermal conductivity shows a crossover in the sample dimensionality. These results are discussed in terms of the quasi 1D metallic nature of carbon nanotubes, the packing density and the electron-phonon coupling. Results for SPS-ed samples in the presence of dopants (such as boron) will also be discussed.