Raman Study of Phonon Softening in Individual Metallic Single Wall Nanotubes

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We have studied the Breit-Wigner-Fano (BWF) lineshape and frequency of the G− Raman mode in individual metallic nanotubes as function of the Fermi level position. Single wall carbon nanotubes are grown from dispersed nanoparticles and are doped electrostatically by means of a polymer electrolyte gate. The frequency of the G− phonon in metallic tubes is very sensitive to the position of the Fermi level. As the Fermi level is tuned below and above the Fermi point, a semiconducting like G-band is recovered both in terms of frequency and linewidth. Near the Fermi point, the downshift of the G− frequency with respect to that of semiconducting tubes reaches a maximum of up to 50 cm$^{-1}$. The doping and diameter dependence of the phonon softening are explained in terms of electron phonon coupling.