Electron-phonon Coupling in Metallic Carbon Nanotubes Observed by Raman Scattering

Janina Maultzsch[*], Yang Wu[*], Ernst Knoesel[†], Bhupesh Chandra[**], Mingyuan Huang[**], M. Y. Sfeir[‡], Louis E. Brus[‡], J. Hone[**] and Tony F. Heinz[*]

[*]*Depts. of Physics and Electrical Engineering, Columbia University, New York, NY 10027*
[†]*Dept. of Physics, Rowan University, Glassboro, NJ 08028*
[**]*Dept. of Mechanical Engineering, Columbia University, New York, NY 10027*
[‡]*Dept. of Chemistry, Columbia University, New York, NY 10027*

Abstract. The high-energy Raman modes of metallic carbon nanotubes are known to have a distinct broad line shape, sometimes described by a Fano model. Yet it has been controversial whether this is an intrinsic property of metallic nanotubes or whether it is induced by bundling effects, interaction with substrates, etc. Here we present Raman experiments on freely suspended nanotubes, with their metallic character determined independently using Rayleigh scattering and Raman scattering of the radial breathing mode. We show that individual metallic carbon nanotubes do have broadened and Fano-like Raman lines, although the broadening varies depending on the chiral index. The metallic Raman line shape can thus be interpreted as due to strong coupling between the optical phonons and low-lying electronic excitations, as has been predicted theoretically. By applying a gate voltage, we shifted the Fermi level of the nanotube, reducing the number of available electronic excitations. The resulting Raman lines are narrower and upshifted, corresponding to reduced electron-phonon coupling.

REFERENCES

1. Y. Wu, J. Maultzsch, E. Knoesel, M. Huang, M. Y. Sfeir, L. E. Brus, J. Hone, and T. F. Heinz, *Phys. Rev. Lett.* (in print 2007).