Resonant Raman Spectra from One Carbon Nanotube

Personnel

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The structure of each single wall carbon nanotube is specified by its diameter and chiral angle, which are uniquely determined by two indices (n,m). Because of the unique relation between the electronic structure and the (n,m) indices, we have been able to non-destructively determine the (n,m) structural indices for small diameter semiconducting and metallic single wall carbon nanotubes (see Figure 17) by measuring their Radial Breathing Mode (RBM) frequencies and the energy of the singularity in the electronic joint density of states of this one-dimensional system. A number of other features in the Raman spectra of isolated carbon nanotubes (see Figure 18) are also sensitive to the diameter and chirality of the nanotubes and therefore can be used to corroborate the (n,m) assignments made with the radial breathing mode.

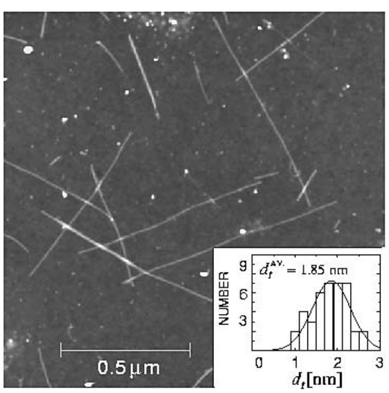

Fig. 17: Atomic force microscopy images of the sample showing isolated single wall nanotubes grown from the vapor phase. The inset shows the diameter distribution of this sample (dt = 1.85 ± 0.62 nm).

The (n,m) indices are important because of the sensitive dependence of the physical properties of the nanotubes on (n,m), as for example, nanotubes are metallic if n-m = 3q and are semiconducting if n-m ± 1 = 3q. The Raman spectra of isolated carbon nanotubes allow observation of both non-dispersive features, and other spectral features that are dispersive, showing a large change in Raman frequency as the laser excitation energy is changed. Study of the dispersive features in the Raman spectra of nanotubes have provided new interpretations for the harmonics and combination modes in the Raman spectra of graphite and carbon nanotubes.

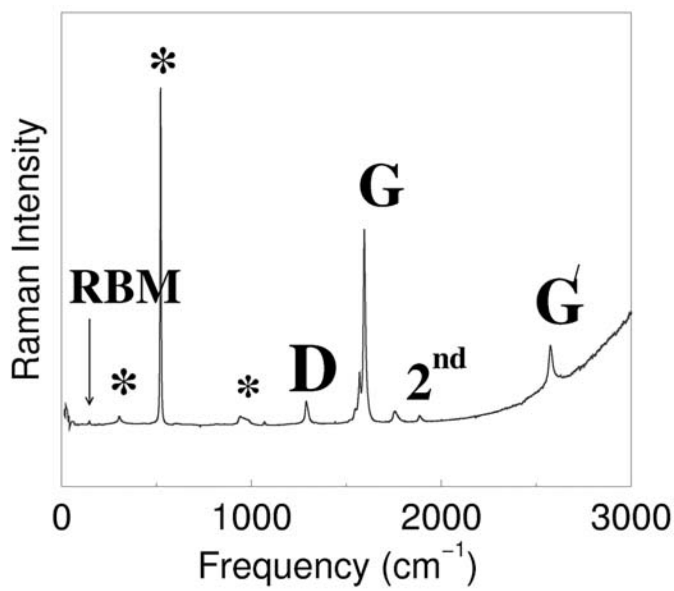

Fig. 18: Raman spectrum from one nanotube taken over a broad frequency range using Elaser = 785 nm = 1.58 eV excitation, and showing the Radial Breathing Mode (RBM), the D-band, the G-band, second-order modes, and the G′-band. The features marked with `' at 30 cm-1, 521 cm-1, 963 cm-1 are from the Si/SiO_2 substrate and are used for calibration of the nanotube Raman spectrum.*