Raman study of hydrogenated and fluorinated single-wall carbon nanotubes

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The Raman spectra of the hydrogenated and fluorinated single-wall carbon nanotubes (SWNT) were measured at normal conditions. Arc-discharge SWNT of ~1.5 nm diameter and ~90 wt.% purity were exposed to hydrogen at P_{H2}=5 GPa and T=350°C for 18 h, then at T=450-500°C for 10 h resulting in SWNT-H with the H uptake of 5.5 wt.%. Purified HipCO SWNT of 0.7-1.2 nm diameter were fluorinated at 150°C for 2-4 h using the 10% fluorine-helium atmosphere admixed with hydrogen at a controlled 3:1 F_2/H_2 ratio. The stoichiometry of the SWNT-F samples was $C_{2.5}F$, according to the SEM/EDX elemental analysis.

The Raman spectra of initial arc-discharge and HipCO SWNT differ in the RBM and G-band structure due to a scatter in the tubule diameter (Fig.1). Narrow peaks and a weak D-band around 1350 cm^{-1} indicate a high structural order of pristine SWNT. In contrast, as-prepared SWNT-H and SWNT-F show broad peaks and intense D-bands. A giant luminescent background features the SWNT-H spectrum; it decreases after sample annealing at 550°C in vacuum or at 330°C in air. Total removal of hydrogen recovers the initial SWNT spectrum, which evidences recovery of the structural order close to initial.

The spectrum of SWNT-F annealed at 345°C shows similar changes as concerns decreasing structural disorder upon removal of fluorine. The D-band intensity, however, remains relatively high, which may be related to the residual structural disorder due to another-type defects created during annealing the sample in air.

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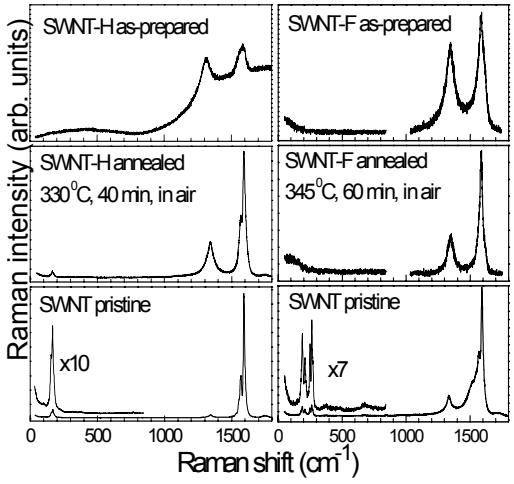

Figure 1. Raman spectra of pristine SWNT, SWNT-H and SWNT-F.