Pressure dependence of Raman modes in double wall carbon nanotubes (DWCNTs) filled with 1D nanocrystalline CdSe semiconductor

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The preparation of highly anisotropic one-dimensional (1D) structures confined into carbon nanotubes (CNTs) is a key objective in nanoscience. In this work, capillary effect was used to fill double wall carbon nanotubes (DWCNTs) with crystalline CdSe in the ordered phase. The samples are characterized by high resolution transmission electronic microscopy (Fig. 1) and Raman spectroscopy.

In order to investigate their structural stability and unravel the differences induced by intershell interactions, unpolarized room temperature Raman spectra of radial and tangential modes of DWCNTs filled with 1D nanocrystalline CdSe excited with 514 nm were studied at high pressures. The tangential optical phonon modes of the carbon nanotubes are sensitive to the in plane stress and split into a contribution associated with the external and internal tube The Raman spectra of radial, tangential and second order modes was measured in the filled DWCNT.

In the low wavenumber region we observed several phonons which correspond to the inner and outer radial modes of DWNTs and the confined LO and TO CdSe phonons . From the analysis of the radial phonons we obtain the diameter of the inner and outer carbon nanotubes ($0.91<d_{inner}<1.37$ nm, $1.59<d_{outter}<2.05$ nm) and also the chiralities. Using the spatial confined optical phonons model we determined the diameter of the CdSe nanowire (0.88 nm). By comparing the frequencies values of the tangential modes of the filled nanotubes with empty DWCNTs a red shift is observed that is related to charge transfer, in this case electrons, from CdSe to the carbon nanotube.

Under pressure up to 16 GPa we found a pressure coefficient of 5.7 $cm^{-1}GPa^{-1}$ for the internal tube and 7 $cm^{-1}GPa^{-1}$ for the external one. In addition, the tangential band of the external and internal tubes broadens and decreases in amplitude. All findings lead to the conclusion that the outer tube acts as a protection shield for the inner [1] [2].

Under pressure 1D nanocrystaline CdSe undergo a wurtzite to rock salt phase transition analogous to that observed in bulk CdSe [3]. We will discuss the effect that this phase transition has on the frequencies of the vibration modes of the double wall carbon nanotubes.

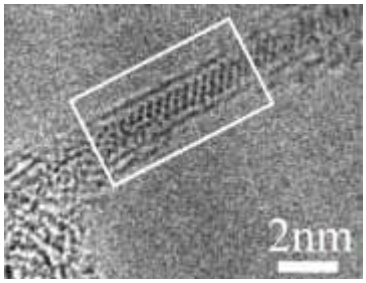

Figure 1. HRTEM image of DWCNTs filled with 1D nanocrystalline CdSe

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