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High pressure Raman scattering studies on doped double wall carbon nanotubes

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Abstract –The vibrational properties of doped double-wall carbon nanotubes (DWNTs) were investigated by high pressure resonance Raman spectroscopy. We studied pristine DWNTs, Br_2- and H_2SO_4-doped DWNTs for different pressure transmitting medium (paraffin oil and NaCl). We find that in all cases, the outer tube is mechanically supported through its interaction with the inner tube, leading to higher collapse pressures than in the corresponding SWNT

Carbon nanotubes exhibit striking properties regarding their geometrical and electronic structure. Their electronic structures can be tuned by external variables such as doping, strain, and hydrostatic pressure.[1-4] Most of the high-pressure Raman scattering studies of carbon nanotube systems have been performed on single-walled (SWNT) nanotubes. However, there has recently been a large increase of interest in double-walled carbon nanotubes (DWNTs). The DWNT system is unique because it is an intermediate structure between SWNTs and MWNTs. Since DWNTs have only two tubes and the diameters of the outer tubes are often similar to those of SWNTs, the quantum confinement effects are almost as prominent as in SWNTs.

In this work we investigate the vibrational properties of doped double-wall carbon nanotubes (DWNTs) by high pressure resonance Raman spectroscopy. We studied pristine DWNTs, Br_2- and H_2SO_4-doped DWNTs for different pressure transmitting medium (paraffin oil and NaCl). We find that in all cases, the outer tube is mechanically supported through its interaction with the inner tube, leading to higher collapse pressures than in the corresponding SWNT. The collapse pressure depends on the type of dopant as indicated by the behavior of RBM showed in Fig. 1(a) and (b). Nevertheless, the onset of the outer tube collapse leads to a cascade-type collapse of the inner tube at pressures much lower than expected for a SWNT of the same diameter. These ideas could be used for the modeling of the mechanical stability of MWNT. The outer tube of the DWNT systems is modified in different ways by the combination of chemical/pressure interaction. In particular, the mechanical resistance of the DWNT system can be improved in the case of H_2SO_4-doping. On the other hand, the inner tube behavior under compression is almost unaffected by the presence or not of chemical doping. DWNT appear then as excellent candidate materials for the engineering of nanotubes based composite materials, with a decoupled role of the inner and outer tubes: the outer tube ensuring the chemical coupling with the matrix and the inner tube acting as mechanical support for the whole system.

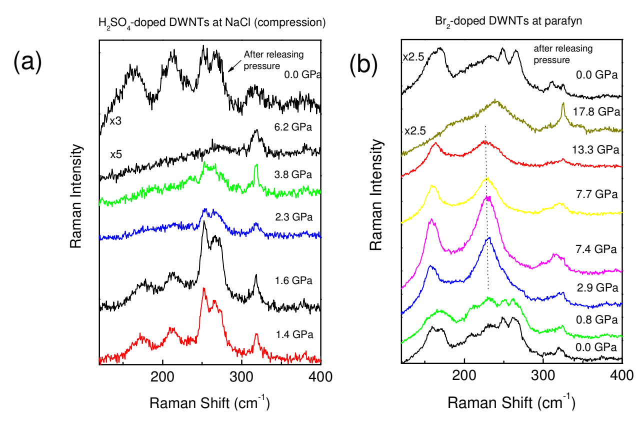

Figure 1: Radial Breathing mode of H_2SO_4 (a) and Br_2 (b) doped DWNTs as a function of hydrostatic pressure.

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References

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