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Pressure Effects on Single Wall Carbon Nanotube Bundles

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We report high pressure Raman studies on single wall carbon nanotube bundles under hydrostatic conditions using two different pressure transmitting media, alcohol mixture and pure water. The radial and tangential modes show a blue shift when SWNT bundle is immersed in the liquids at ambient pressures. The pressure dependence of the radial modes is the same in both liquids. However, the pressure derivatives $d\omega/dP$ of the tangential modes are slightly higher for the water medium. Raman results are compared with studies under non-hydrostatic conditions and with recent high-pressure X-ray studies. It is seen that the mode frequencies of the recovered sample after pressure cycling from 26 GPa are downshifted by ~7–10 cm^{-1} as compared to the starting sample.

Introduction Currently single wall carbon nanotubes (SWNT) are receiving focussed attention as they are ideal candidates for future nanoscale electronic and mechanical devices due to their unique structural and electronic properties [1]. SWNT are unusually tough materials bearing enormous flexibility in terms of complete structural reversibility [2, 3]. Other remarkable properties include one-dimensional conduction, tunability between semiconducting and metallic states [1], electric field induced electron emission [4–6] and unique capillary behavior [7, 8]. The electronic properties of SWNT can be controlled by the structure of nanotubes, by various deformations of their geometries and also by intertube interactions. The vibrational properties get influenced by the intertube interactions between the nanotubes arranged on a two-dimensional triangular lattice [9]. These interactions can be tuned by applying external pressures. In addition, high-pressure experiments provide information about structural stability and pressure-induced phase transitions. Raman spectroscopy is a powerful probe to study the pressure effects getting reflected in the vibrational spectra of the SWNT. There are two prominent features in the Raman spectra of nanotubes: one at low frequencies near ~170 cm^{-1} associated with the symmetric radial breathing mode of the tubes and the other near ~1590 cm^{-1} corresponding to the tangential C–C stretching vibration. The radial mode frequency depends sensitively on the diameter of the tubes and intertube interactions [10].

The elastic properties of nanotubes are highly anisotropic [11, 12]. The tube is extremely rigid along the tube axis as expected because any distortion along the axis is equivalent to the in-plane distortion of graphite. The elastic modulus along the radial