CATHODOLUMINESCENCE EMISSION FROM CARBON NANOTUBES AND ITS SENSITIVITY WITH CONTAMINANT CONCENTRATION

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Carbon nanotubes (CNTs) have attracted many attentions for their electrical and optical properties. There are two kinds of carbon nanotubes single walled carbon nanotubes (SWNT) and multi walled carbon nanotubes (MWCNT). Multiwalled nanotubes (MWNT) are more complex systems composed of several (typically 10 to 20) concentric graphite shells[1-2]. In principle the shell of a MWNT can have different chiralities[3]. A major obstacle to study the CNTs has been the diversity of tube diameters, chiral angles, and aggregation states in nanotubes sample obtained from the various preparation methods. Theory predicts, to first order, that two-thirds of SWNTs on a mat are semiconductors. Semiconducting nanotubes have a band gap in momentum space with a diameter/chirality dependent energy. In a direct band gap semiconductor the probability of light emission from electron-hole recombination is high. But it was only recently that SWNTs were found to emit light from interband recombination of electron-hole pair[4-5]. O' Connell et al. in 2002[4] find that photoluminescence intensity is reduced by aggregation of the isolated nanotubes, they presume that the presence of metallic nanotubes within a bundle quenches electronic excitation on an adjacent semiconducting tube, preventing its luminescence.

Upon illumination, infrared photoluminescence (PL) was detected from the ensemble of isolated nanotubes in solution[6-7] and ensembles of bare SWNTs suspended in air also emit band gap PL[6-7]. The PL spectrum of an individual SWNT in air at room temperature has a single asymmetric peak while ensemble measurements are a superposition of many PL peaks from many different specie.

Theory predicts that the electronic structure of a SWNT depends on the diameter and on the chiral angle describing its construction from a graphene sheet[8]. Quasi one-dimensionality causes the electronic density of state to have a series of sharp van Hove maxima at energies depending mainly on tube diameter. For the semiconducting tubes

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the DOS is therefore sharply peaked at the band gap. Theoretically, nanotubes should show strong band gap photoluminescence.

Spectrofluorimetric measurements[4] on SWNTs have revealed distinct electronic and emission transitions for different semiconducting nanotube species. By combining these results with resonance Raman data, each optical transition has been mapped to a specific (n, m) nanotube structure. Optical spectroscopy can be used to determine the detailed composition of bulk CNT samples.

Luminescence emission induced both by heating (TL) and by ion bombardment (IL) has demonstrated that MWNT carbon nanotubes exhibit an appreciable luminescence signal and, moreover, that the presence of several peaks are common in spectra obtained by different techniques. Such peaks are originated by intrinsic defects in the crystal lattice[9].

In this work luminescence emission induced by electron bombardment (Cathodoluminescence, CL) has been performed on bundles of single walled (SWCNT) and multi walled (MWCNT) carbon nanotube. We compare the CL spectra with the spectra obtained by ion (IL) and thermo-luminescence (TL) on multiwalled carbon nanotube bundles and our conclusions are supported by TEM and SEM analysis of our samples. We observe that several peaks are common to SWNT and MWNT and that all the peaks are removed by heating the samples at temperature of 600-700 K. We assign each peak to an external impurities as confirmed in the TEM and SEM result analysis. Moreover the impurity concentration can be obtained from the study of peak temporal decay under electron bombardment. From our study this technique is revealed to be a suitable tool to control the cleanliness of carbon nanotube samples.

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