ANALYSIS OF σ AND π BOND IN THE SINGLE WALLED CARBON NANOTUBES BUNDLES

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Introduction

The identification of single-walled carbon nanotube (SWNT) bundles [1] is a great progress on the SWNT research since the SWNTs in the bundle usually have uniform diameter and similar properties. Effect of curvature-induced strain on the covalence in the isolated SWNT has been explored [2], which indicates that σ bond was different from those in the graphite and multi-walled carbon nanotube observed in the electron energy loss spectrum (EELS). However, the bond in SWNT bundles is not discussed yet.

In this presentation, we will investigate the bond structure of the SWNT and SWNT bundles using EELS and X-ray photoelectric spectrascopy (XPS).

Experimental

The SWNT bundles in this study were prepared by catalytic decomposition of hydrocarbons, and the detailed experimental procedures were described elsewhere [3].

The SWNT and SWNT bundles were analyzed by FEG TEM HF-2000 with a GATAN imaging filtered system, which can be used as parallel EELS analysis. The point resolution of this FEG TEM is 0.23nm, which is enough to resolute graphite sheet (0002). Bulk of SWNT bundles was carried out by XPS.

Results and Discussion

The SWNT in a bundle was reported to have a triangular packing tubes [1]. Fig.1 is a high-resolution transmission electron microscope (HRTEM) image, which shows the structure of an end of the SWNT bundle. The tubes self-organized into bundles and formed a two-dimension close-pack lattice. The diameter of the SWNT here is about 3nm and the distance between SWNT about 1nm. The inset is a FFT transformation of such end-structure of SWNT bundles. This configuration proves that SWNTs have a hexagonal arrangement in the bundles. This may result of the reaction between SWNT in the bundle.

The diameters of our SWNT are larger (See Fig.1 and Fig.2a) than those synthesized by other methods [1]. After two-dimensional graphite sheet was rolled into a hollow tube, the σ bond in the SWNT was distorted in comparison with that in graphite [2], and EELS can distinguish their difference. Fig.2 is a typical SWNT with a diameter 2.5 nm (a) and corresponding EELS profile (b). The peak between 290 and 310 eV is characteristic structure of σ bond of SWNT [2]. It can be recognized that the σ* peak split into 2 peaks. However the profile change is not clear [4]. The peak at 285 eV is the characteristic π* peak. A bulk consisting of many SWNT bundles, was measured by XPS. Fig. 3 is a XPS profile from the SWNT bulk. The inset is enlargement of XPS profile in the energy range of 290 eV and 340 eV. It is very interesting that the energy of σ* peak in the SWNT bulk (from XPS) is different from that of a SWNT (From EELS). This may imply that the interaction between the SWNTs to form SWNT bundles, and further to form SWNT bulk may cause the bond-structure changed.

Summary

The formations of SWNTs cause the σ bond modulation because of the distortion of the σ bond in the graphite sheet. The interaction of SWNTs in the bulk may cause the bond structure changed further.

Acknowledgement

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Reference

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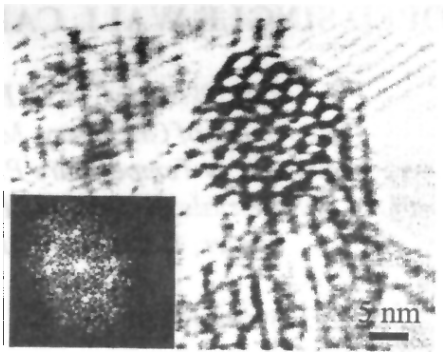

Fig.1 High resolution TEM image of the end of a SWNT bundle and its FFT transformation of the end of SWNT bundle

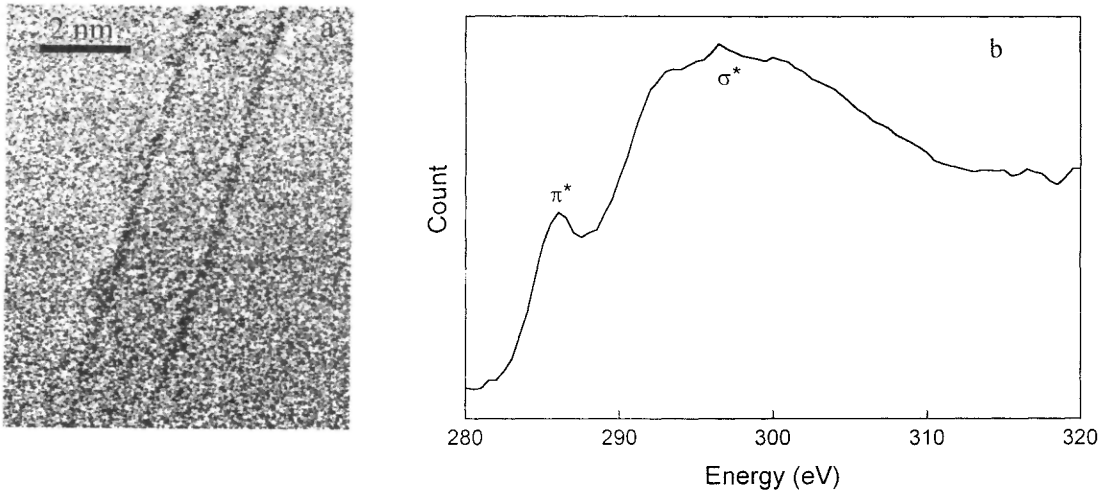

Fig.2 (a) High resolution TEM image of a SWNT with 2nm diameter and (b) its EELS spectrum

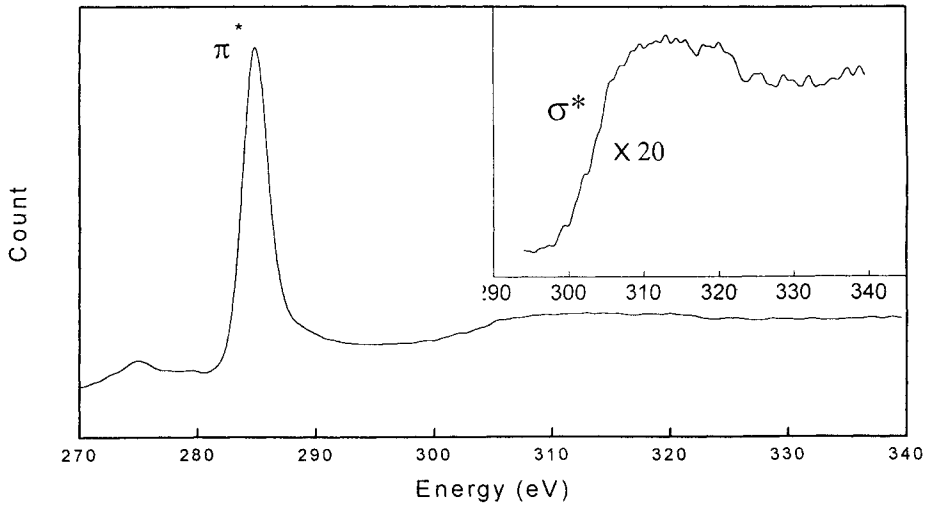

Fig. 3 XPS profile of a SWNT bulk