Discovery of Carbon Nanotubes: Their Impact to Academia and Industry

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In 1991 the carbon nanotubes (CNTs) were discovered [1, 2], which have a nano-meter sized tubular structure of a hexagon network of carbon atoms. Their unique properties in various aspects have attracted many researchers in a wide range of fields from academia and industry. Basic scientists tied to understand their unique properties theoretically and experimentally. Industrial people looked for industrial applications of the CNTs. In other words the CNTs have initiated nanoscience and nanotechnology that were a global trend in the 21st century materials science.

The lecture starts with introducing the background of the discovery with an emphasis on the importance of a high resolution transmission electron microscopy (HRTEM). Without this material characterization technique the CNT would not have been found simply because of no alterative instrument which could visualize such a nanostructures material. In this sense the lecturer (discoverer) was very lucky to have been working on HRTEM for many years and having ample experiences with nanostructured materials before the discovery, so that he did not miss the chance when he came across the CNT during working on other carbon materials one day. People call this type of discovery “Serendipity”.

After describing its capabilities in solving atomic structures of nano-carbon materials and CNTS by giving a few examples of HRTEM studies, dynamic observations of structural transformation of CNTs at the atomic level resolution will be presented[3], which has been made possible by a spherical aberration corrected HRTEM which has been developed recently in several laboratories. The last part of the lecture will be covering electron energy loss spectroscopy (EELS) and energy filtered imaging of nanocarbon materials on the *individual atom* basis. Here the electrons used for the imaging are not elastically scattered ones but inelastically scattered electrons which come from not the valence electron but the core-electrons bound by individual atoms. Their energy analysis allows us to identify the elements which are responsible for the inelastically events [4, 5]

1) S. Iijima, *Nature*, **354**, 56 (1991).
2) S. Iijima, et al., *Nature*, 363, 603(1993).
3) C. H. Jin, et al., PRL, **102**, 195505 (1)-(4) (2009).
4) K. Suenaga et al., Nature, **468,** 1088 (2010).
5) K. Suenaga et al., Nature Photonics (2012).