Research on Novel Light-Element Nanostructures

Light-element nanomaterials are of current interest and significance in condensed matter physics, materials science and engineering because of their unique structural features and outstanding physical and chemical properties. The novel properties of carbon nanostructures, including nanotubes, nanofibers and films, can be manipulated by chemical doping and size effects, which provides opportunities for their nanoelectronic, optoelectronic and other important applications.

Lately, a group of researchers led by CAS Member WANG Enge at the CAS Institute of Physics (IOP) won a second prize from the State Natural Science Award for their achievements on novel light-element nanostructures. In their research, the team synthesized novel carbon, carbon nitride and boron carbonitride nanostructures via chemical vapor deposition technique, manipulated the atomic and electronic structures of the carbon nanostructures by chemical doping, and discovered some novel properties of them.

The team synthesized six kinds of novel light-element nanomaterials, including carbon nitride (CN) nanobells, single-walled boron carbonitride (BCN) nanotubes, BCN films, highly oriented BCN nanofiber arrays, self-assembly of carbon nanohelics, and tubular graphite nanocones. They also successfully achieved structural manipulations of

Figure 1: Microwave plasma enhanced chemical vapor deposition system developed by the team for the involved experiments.

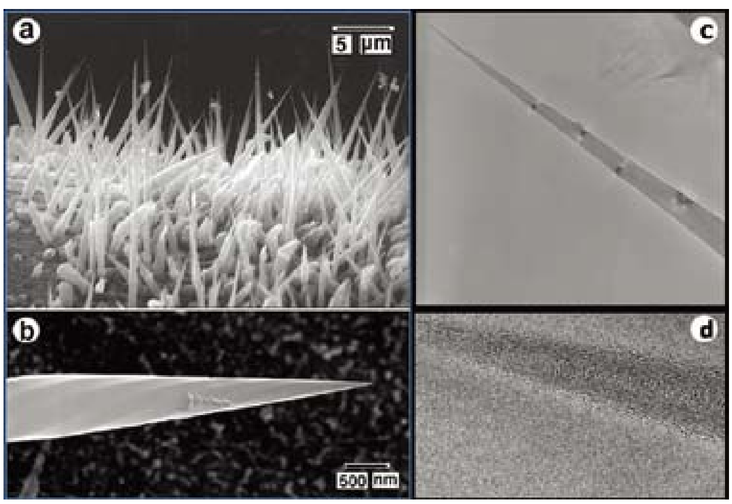

Figure 2: Tubular graphite nanocones synthesized by the team.

several important light-element nanomaterials, including separation of individual nanobells from their polymerized state and high-yield product, as well as direct growth of CN/C and BCN/C nanotube junctions with sharp interfaces. In addition they developed a nitrogen-incorporated low-temperature chemical vapor deposition technique, and with its aid discovered that the multi-walled carbon nanotubes tend to grow along several dominated chiral angles.

Furthermore, the team identified and studied several important novel properties in the prepared nanomaterials, for example the electronic transport properties of B and N co-doped carbon single-walled nanotubes. They discovered that more than 97% of the doped nanotubes are pure semiconductors, forming a contrast with the un-doped SWNTs, which are only 70% semiconductors. The researchers found obvious rectification characteristics in the individual BCN/C nanotube junctions, and strong blue photoluminescence in BCN nanofibers. The team further achieved a high lithium storage performance in CN nanobell sample.

Resulting from their systematic studies on the field electron emission of several kinds of light-element nanomaterials, the team established a theory on the "top-side emission" mechanism in the polymerized CN nanobells.

From 1995 to 2007, the project published 52 papers in international journals, including 20 in *Appl. Phys. Lett.* (APL), five in *Phys. Rev. B* (PRB), one in *Phys. Rev. Lett.* (PRL), three in *J. Am. Chem. Soc.* (JACS), one in *Science* and five review papers in *Prog. Mater. Sci.* and other journals. These papers have been cited over 1,800 times, and some of the results are highlighted by the websites of Nature Asia Materials, American Chemical Society and UK Physical Society. On the other hand, during this period they presented 10 invited talks or plenary talks in important international conferences such as APS March meeting and MRS fall meeting. They have so far held two Chinese patents.

CAS Member Prof. WANG Enge took charge of the whole project, and Profs. BAI Xuedong, YU Jie, MA Xucun, and LIU Shuang contributed to the project as major researchers.

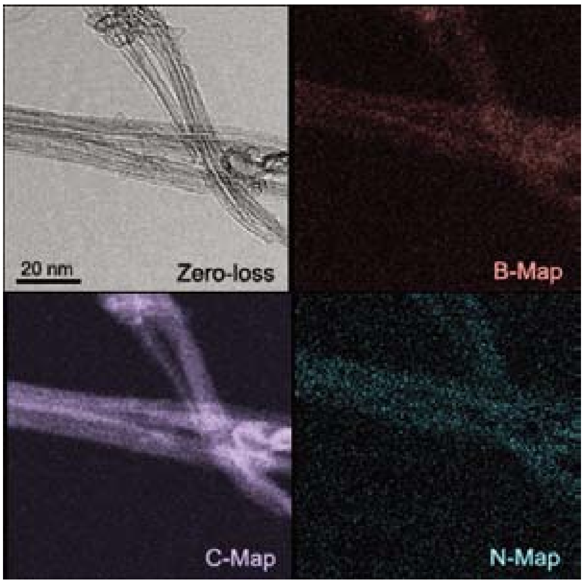

Figure 3: Single-walled B-C-N nanotubes. The team identified and studied several important novel properties in prepared nanomaterials, including the electronic transport properties of B and N co-doped carbon single-walled nanotubes.

The team led by CAS member Prof. WANG Enge (first from left on front).