The Future of Continuously Developing Nanocarbons

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Nanocarbon cross-field technologies

At the beginning of July, the NT03 international conference on carbon nanotubes (CNT) was held at Seoul National University in South Korea. This conference emphasized on the fundamental research of carbon nanotubes such areas as carbon nanotube growth and simulations; structural evaluation using Raman spectroscopy, photoabsorption and emission spectroscopies; electronic properties; electron transportation; processing and evaluation of electronic devices; characteristics of gas and bio-molecular adsorption, and also discuss some applications to field emission displays (FEDs); scanning probes; and fuel cells. Carbon nanotube-related conferences in general tend to be characterized by interdisciplinary research across a range of fields from basic to applied research.

Report on the formation of 6-mm long and 2-nm diameter nanotubes

Both theoretical and experimental research has revealed the variation of electronic properties of carbon nanotubes depending on their diameter or helical structure. This feature is quite characteristic for carbon nanotubes and is not seen in ordinary materials. As well as being of interest as a natural phenomenon of molecular devices, it also has potential for the future of the electronics industry. One of the research projects that attracted interest at NT03 was a report by Liu et al. from Duke University on the growth of single-wall carbon nanotubes that reach lengths of 6 mm with diameters of around 2 nm. These carbon nanotubes, whose growth direction can be controlled, represent a revolutionary breakthrough. It was shown that the application of this carbon nanotube can lead to more accurate electronic property and transportation experiments, and production of multiple-array of transistors. In addition, there is a sense that structural materials that use the superior mechanical properties of carbon nanotubes (for example, bundled rope out of carbon nanotubes) are now very close. Applications that utilize the nanospace at the inside of carbon nanotubes would include light waveguides and super-ionic conductor tubes. While it is not yet clear when these industrial applications will be realized, carbon nanotube science is advancing steadily.

Top runner of carbon nanotube display

In the recess halfway through the conference, four American professors and I were invited to the Samsung Advanced Institute of Technology (SAIT), where we took the opportunity to observe at first-hand R&D into field emission displays (FEDs). Our guide was SAIT's vice-president Dr. Jong Min Kim, who has overall responsibility for FED development. While this was my third visit to SAIT, the six-inch FEDs that I had observed two years before had now developed into 32-inch full-color television screens. Samsung said it hoped to commercialize these within two years, and I am convinced that carbon nanotube FEDs are viable. Plasma displays (PDPs) generate heat similarly to electric ovens but we confirmed that it was naturally possible to touch the glass of a FED screen without getting burned.

Development of special electron microscope

To show the perspective of nanotechnology, I would like to briefly introduce research that I am personally interested in. In nanotechnology, it is essential to develop nanoscale material metrology methods in tandem with the nanotechnology development. This is why we develop special electron microscopes that we call "ultimate elemental analysis device". We have already succeeded in detecting single atoms inserted into the nanospace of carbon nanotubes.

Expanding fields of nanotube applications

Finally, in the nanotech materials field, research is being carried out into fabrication and application to fuel cell electrodes of carbon nanohorns that resemble carbon nanotubes. Applications to biotechnologies that utilize good affinity of nano-carbon material with organisms also fall within the scope of my research. Specifically, I am working on adsorbing bacteriophages that present certain DNA base sequences into the nano-carbon surfaces and evaluating their selective adsorption characteristics.

AIST's Nanotechnology : Technical Development Outlook

Kazuo IGARASHI, *Research Coordinator*

"Full-Research" from nanotechnology

AIST is developing a policy of merging subdivided areas of knowledge and establishing an integrated system in which a wide range of researchers from different fields can work on specific research topics. With "Type-II Basic Research"[1] as the core axis, continuous research, from "Type-I Basic Research"[2] up to development, will be performed as "Full-Research". By relating this to its liaison functions with industry, government, and universities, AIST hopes to boost the development of industrial technology. "Full-Research" is involving in the integration of a wide range of research fields, so that AIST is advantageous. Nanotechnology holds out great promise as one of the core technologies of this approach.

From nanotechnology, to nano-industry

In nanotechnology research, there are three main needs: a strong need to produce new concepts by merging different research fields together, the need for a concentrated approach focused on clear goals, and the need for close collaboration among researchers under strong leadership. In addition to the nanotechnology, materials, and manufacturing fields, AIST embraces such fields as life-science, information technology, energy, environment, standards and metrology, and has developed an environment conducive to cross-field joint research with researchers from outside the nanotech field. Promoting interdisciplinary joint research with researchers in the above areas, AIST aims to establish an industrial infrastructure — nano-industry — from nanotechnology. AIST also promotes the establishment of the special research style in nanotechnology, the computer-aided nanotechnology, by encouraging its talented human resources in computational science to participate in nanotechnology-related research.

Fierce development competition needs smooth technology transfer

Technology licensing is an important issue for AIST. Because that nanotechnology is regarded as one of the "aces in the hole" reinforcing the competitiveness of Japanese industry, it is vital to promote nanotechnology research with concrete views for practical and industrial applications. Nanotechnology includes many research fields that need long-term perspective and a considerable period to come to fruition, but there are also many fields where basic research can find quick practical application. By the liaison of its research departments, Intellectual Property Division, TLOs (AIST Innovations), and the Innovation Center for Start-ups, AIST is building a system that can provide rapid support across the whole spectrum, from the search for promising research results, to their implementation.

Rapidly boosting nanotech development

To rapidly boost nanotechnology development, we believe it is necessary to train nanotech personnel and actively appeal to industry. Through the Nanoprocessing Partnership Program and the Innovative MEMS Business Support Program, we are stepping up technical support of researchers in industry, providing with the latest nanoprocessing and measurement equipments and as well showing the operation know-hows. We also plan to exhibit in various nanotechnology-related trade fairs and actively organize nanotechnology seminars.

AIST has been a world-leading pioneer in nanotechnology through pursuing several nanotechnology-related projects such as the Atom Technology Project, accumulating a range of results and know-how. In its history, AIST has made it clear that nanotechnology is not only for the hi-tech world but also extends to energy-saving and environment friendly technologies, new biotechnologies, and innovative production processes that result in high-quality component materials. Based on the research results achieved to date, AIST will continue to aim for further breakthroughs that contribute to the development of the nanotechnology industry.

1) Type-II Basic Research: Motivated by certain economic and social needs, research that combines various pieces of already established universal knowledge (including theories, natural laws, principles, and theorems), performs repeated observations, experimentation, and theoretical calculations, and by these methods and results derives regular and universal knowledge and a specific path to realize certain goals.
2) Type-I Basic Research: Research to discover, interpret, and form universal theories (including natural laws, principles, and theorems) through observation, experimentation, and theoretical calculation of unknown phenomena.