

## **Trends in NanoCarbon R & D and Business**

### ***-Summary of International Symposium on NanoCarbons 2004, Nagano, Japan, Nov. 15-18<sup>th</sup>***

The International Symposium on NanoCarbon 2004 ISNC2004 was held during Nov. 15-18<sup>th</sup> in Nagano initiated by Prof. Morinobu Endo and organized by the Faculty and Engineering, Shinshu University located in Nagano. The event was chaired by Prof. Morinobu Endo and Prof. Eiichi Yasuda (Tokyo Institute of Technology) and sponsored and sponsored by Japan Society for the Promotion of Science (JSPS), Ministry of Education, Culture, Sports, Science and Technology (MEXT), Nagano Prefecture, Shinshu University, Foundation of Advanced Technology Institute (ATI), The Carbon Society of Japan, Nagano Techno-Foundation and others.

The event has a very high level International Advisory Board which include Prof. C.A. Bernardo (Portugal), Prof. M.S. Dresselhaus (USA), Prof. T. Enoki (Japan), Prof. M. Inagaki (Japan), Prof. H.W. Kroto (UK), Madame A. Oberlin (France), Prof. F. Beguin (France), Prof. M. Terrones (Mexico), Prof. S.K. Ryu (Korea) and Prof. K.S. Yang (Korea).

There were 400 registered attendants at the ISNC and over 10% are from overseas, about 50% from Japanese industry. The three and half day conference consists of oral session during the day, poster sessions in the early evening and small company exhibition area. The topics covered from basic research (synthesis & process, characterizations, mechanical, chemical and physical properties, high-end computation/simulation, and so on) to applications (storage, bio-diesel, Li-Ion batteries, SPM probes, ULSI interconnects, thermal & electrical conductors, capacitors, nanothermometer, composites) in fields of energy, aerospace, electronics, medical and tools. The nanocarbon presented at the conference include Carbon Nanotubes (SWCNT, DWCNT and MWCNT), fullerene C60, C60 to C90 and other nanostructures including nanodiamond, peapods and others.

There were a number of breakthroughs and new discoveries reported at the conference. In particular, the "Super Growth"- Highly Efficient Synthesis of Impurity-Free Single Wall Carbon Nanotubes` presented by Dr Kenji Hata from AIST, where he demonstrated H<sub>2</sub>O helps in mass producing SWCNT using CVD with purity as high as 99.98% (more details about Hata`s group, please see the upcoming interview article at APNW). Other impressive achievements include

- a) `Spinning Carbon Nanotube Fibre/Ribbons Out of A Hot-Furnace` presented by Dr Ya-Li Li from University of Cambridge, where he demonstrated a direct spinning process (fibres/ribbons of CNT can be spun directly from the gas stream in a CVD reaction) which opens a novel approach in producing continuous nanotube fiber/ribbons and macroscopic objects using one step process;
- b) `Carbon Nanotubes Containing Gallium as Low Temperature Nanothermometer` presented by Dr Y. Bando from Japan National Institute of Materials Science (NIMS), where he showed his group`s recent discovery of Ga encapsulated in CNT can be used as the world`s smallest thermometer for measuring low temperatures;

- c) `Synthesis and Characterization of Nano-peapods Encaging Fullerenes` by Prof. H. Shinohara from Nagoya University, where he presented the GdC<sub>82</sub> peapods exhibit ambipolar FET behavior with both n- and p-channels easily accessible by simple electrostatic gates. This behavior has never been observed for C<sub>60</sub> peapods;
- d) `Current Induced Phenomena for Carbon Nanotube` by Prof. Yoshikazu Nakayama from Osaka Prefecture University, where he presented his group research on current induced phenomena for the processes of cutting, sharpening and plastic deformation;
- e) `Dispersed Ultrananocrystalline Diamond (DUNCD)Particles` by Dr Eiji Osawa from NanoCarbon Research Institute Ltd, where he showed Nanodiamond (DUNCD Colloid with higher than a few percent concentration) is pitch black;
- f) `Magnetic Properties of Carbon Nanotubes: The Role of Negative and Positive Curvature` by Prof. Terrones from IPICYT, Mexico, where he presented their discovery of large magnetic moments in coalesced C<sub>60</sub> fullerene (peapod-like corrugated nanotubes) and Haeckelite-tubules (structures containing heptagons, hexagons and pentagons of carbon);
- g) and others
- h) Details for the ISCN04 can be found at its website : <http://endomoribu.shinshu-u.ac.jp/nanocarbons2004>

The nanocarbon research community is hoping to discover more applications in order to support and simulate further development in the field. The challenges in the nanocarbon field are a) Control of Chirality of CNT, b) Atomically Order Synthesis of Nanocarbon and others.

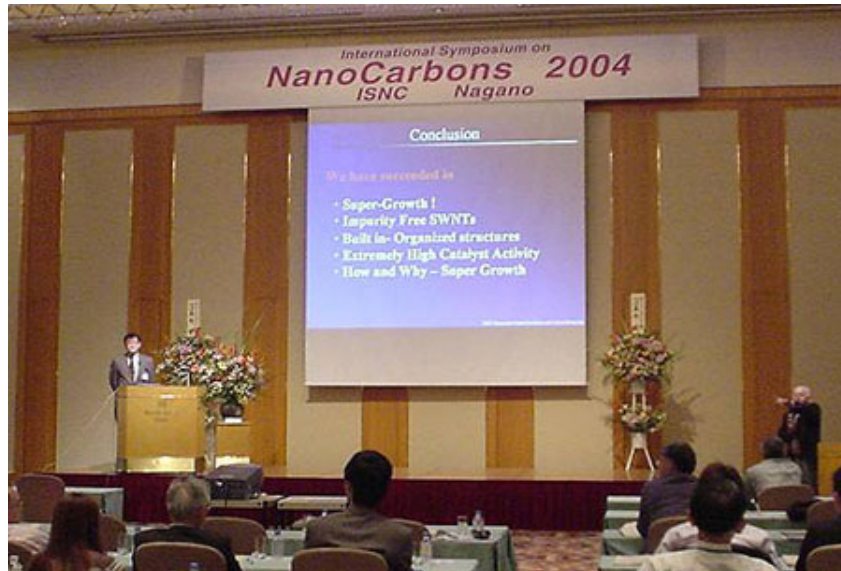
There were discussions in terms of societal implications of nanocarbon which include

1. Inform the public about the development in nanocarbon R & D
2. Consider R & D in long term and short benefits to the society
3. Excite the young generation including children and enhance human resource development (Sir Kroto particularly emphasized this in his presentation)
4. Promote industry applications (e.g. Nano Catheters developed by Prof. Endo's group, MWCNT applications in Golf club head and tennis rackets, composite materials, Li-ion batteries and etc.)

In the exhibition area during the ISNC2004, companies such as Bussan Nanotech Research Institute (Mitsui & Co), Seiko Instruments Inc (SII) Nanotechnology (showing the Micro Injection Molded Gear (using Carbon Nano Fiber), MEFS (Prof. Endo and Showa Denko's joint venture company focusing on intellectual property management and research in nanocarbon, more details in the upcoming authors's interview on MEFS), Tokyo Seiden Corporation (producing High Frequency Super Inductors for micro-gas turbines, battery fuel generators, solar power generators, wind-powered generators, and so on), RF Systems (producing Endoscopic Capsule, battery free and swallowable CCD camera), Showa Denko (producing Vertical Growth Carbon Fiber, VGCF, so called Endo Fiber, for Li-Ion Battery applications in mobile devices), Fuel Cell Development

Information Center (FCDIC) and Prof. Endo's Laboratory (developing 'Endo Car' using Nanocarbon materials).

This report is based on the author's attendance and interview at the workshop, the conference proceeding and Prof. David Tomanek's Concluding Remarks.



Dr Kenji Hata from AIST gave a talk on "SuperGrowth"-Highly Efficient Synthesis of Impurity-Free SWCNT.



Poster Session

*Asia Pacific Nanotech Weekly*, Vol.3, article #3 (2005).

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Dr H. Nakamura from RIST Japan gave a talk on `Nanotechnology with High End Computing`.



Prof. H. Shinohara from Nagoya University presented `Synthesis and Charaterization of Nano-Peapods Encaging Fullerene`.



Prof. David Tomanek from Michigan State University gave the `Concluding Remarks`.



The conference host, Prof. M. Endo closed the conference by acknowledging the corporate sponsors.



A snapshot of the VIP at the Conference Banquet: Sir H.W. Kroto (1<sup>st</sup> on the left), M.S. Dresselhaus (2<sup>nd</sup> on the left), E. Osawa (5<sup>th</sup> from the left), M. Endo (6<sup>th</sup> from the left), Sasaki (8<sup>th</sup> from the left).