

The `Secret` Behind “Super Growth” of SWNT *-Interview on the “Super Growth” Team at AIST, Japan*

Prior to the release of the publication in Science Vol 306, Nov. 19th 2004 (p1362-4) titled `Water-Assisted Highly Efficient Synthesis of Impurity-Free Single-Wall Carbon Nanotubes`, I have learnt about this `surprising` breakthrough in Single Wall Carbon Nanotubes (SWNT) synthesis at the Tsukuba Nanotechnology Research Workshop (see APNW article Nov.2004, presented by Dr Motoo Yumura) and ISNC 2004 in Nagano (See APNW Jan. 2005) in Nov. 2004. This article summarizes the interview on main authors of the paper Dr Kenji Hata, Dr Don Fubata and Dr Sumio Iijima in Dec. 2004.

It has been one of the grand challenges in Carbon Nanotube R & D and commercialization to find a way for mass producing pure SWNT. A team at the Research Center for Advanced Carbon Materials (RCACM), National Institute of Advanced Industrial Science and Technology (AIST), Japan, led by Dr Kenji Hata, has demonstrated a `magic` way with the help of water, for mass producing pure SWNT. The team has discovered that well controlled amount of water enhances drastically the catalytic activities during the chemical vapor deposition synthesis of single walled carbon nanotubes (SWNT) and resulting in massive growth of superdense and vertically aligned nanotubes forests with heights up to 2.5mm (in 10 minutes time) which can be easily separated from the catalysts (see pictures at the end of the article). The purity of the produced SWNT is above 99.98%. Their method is not only highly efficient, but also controllable, repeatable, scalable and being able to produced patterned and highly organized intrinsic nanotubes structures and in macroscopic scale. The efficiency of the water assisted catalyst is 2000 times of High-pressure Carbon Monoxide (HiPco). This highly efficient growth method is called by the team “Super Growth”.

The “Super Growth” team is very young, started in April 2003 when Dr Kenji Hata was hired as an Invited Senior Scientist by Dr Sumio Iijima, Director of the Research Center of Advanced Carbon Materials of AIST and Program Leader of the METI/NEDO program on Nano Carbon Nanotechnology. Prior to returning to Japan and joining AIST, Dr Kenji Hata spent 2 years at Prof. Charles Lieber`s group in Harvard University during 2001-2003 where he was working with the world`s leaders in CNT synthesis such as Jason Hafner and C. C. Chen. During that period Prof. Lieber`s group were at its one of the most productive periods.

Dr Hata was given sufficient funding (within less than 2 years, he has access to USD 3million) to set up his group including hiring competent scientists (he has a total of 8 staff at the moment and is in the process of expanding), state of the art equipment and facilities (such as the AIST NanoFabrication facilities). More importantly, he said, `I was given the Freedom to decide what I would like to pursue in my research which is quite different from my previous research environment`. He first hired another expert in nanostructures and STM from the USA, Dr Don Futaba who has become a key partner of Hata in developing the “Super Growth” . With no previous track record in the field of nanocarbon, Dr Hata and his young team started working on the synthesis of CNT, and within a year, they achieved the “Super Growth”.

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Considering his physics background Dr Hata was initially advised to work on device application of CNT by Dr Motoo Yumura, a Chief Senior Scientist in Research Center for Advanced Carbon Materials (RCACM), he believes he needs first to strengthen his materials expertise in order to be successful in device applications. He therefore started to work on CNT synthesis and plan long term research. `The best choice for research is the areas/directions that will survive in the long run`, said Hata, `I feel like the captain of a ship and our team are demonstrating a new way to conduct research in AIST and to become the world leader in nanotechnology R & D`. The “Super Growth” breakthrough has justified his initial idea. `We published the first and the best CNT paper`, claimed Dr Hata.

Kenji acquired his PhD in Applied Physics from University of Tokyo 1996. He subsequently joined University of Tsukuba as an assistant professor until 2001 he went to work at Charles Lieber`s group until March 2003. Throughout the past 7 years of research prior to joining AIST in April 2003, Kenji acquired strong expertise in low temperature Ultra High Vacuum Scanning Tunneling Microscopes, expertise in low and high temperature measurements. In addition he has expertise in first principle calculations, Optics, Nanofabrications and nano structures and materials characterization, and developments (design and drawings) of UHV and CVD chambers.

Two key points for success of Dr Kenji Hata`s team

- a) Acquiring the Simulation of the USA Research Culture (Pursuing Dynamics, competitiveness and Efficiency)
- b) Generously Supported Financially by the Japanese government funding
- c) State of the art instrument and infrastructure in AIST
- d) Having Dr Sumio Iijima as a mentor and continued advice and support
- e) The Freedom in Research Culture in Japan and Excellent Research Staff

The “Super Growth” would not be possible without Kenji`s mentor, Dr Sumio Iijima. Dr Iijima believes good people make the difference given sufficient funding and facilities at AIST. As the Director of the Research Institute of Advanced Carbon Materials (RCACM), his first priority is to find good people to work in the center. He said he was fortunate to have found Dr Kenji Hata who is ambitious, dynamic and with good exposure in the USA.

Regarding to the high expectation on nanocarbon research in recent years, Iijima believes that we should conduct responsible research in nanoscience and technology and not to misled the public and be honest with what we are able achieve.

He also stressed that we should continue to develop more sophisticated tools (such as SPMs) to advance Nanoscience and Technology R & D so that we can visualize characterize and manipulate better nanoscale objects, recalling how Dr Iijima discovered CNT over 10 years using the world`s most advanced Scanning Electron Microcopies (SEM) at that time.

The key partner of Hata in the “Super Growth”, Dr Don Futaba stressed to apply

“Super Growth” Method in the following main directions:

1. Extend research field opportunity beyond the limitation of the current CVD method, which means, a) to producing oriented, long macroscopic nanomaterials without being limited in size like other current nanomaterials manufacturing, b) Opening up new field of application such as in biological areas.
2. Keyword is Macroscopic and Device manufacturing.

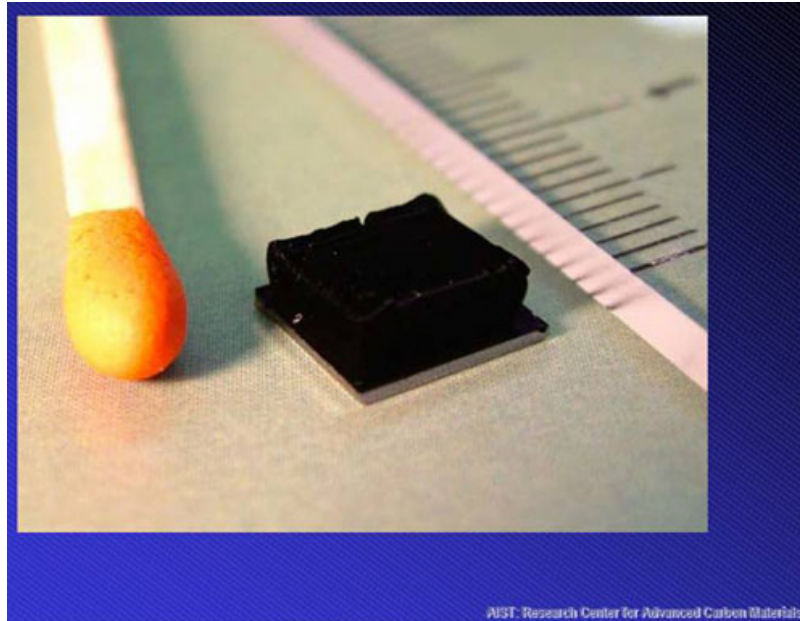
Since their publication in Science in, “We have further improved the growth process in extending lifetime of the catalyst and enhance further growth rate.” Dr Don Futaba said during the interview with the author.



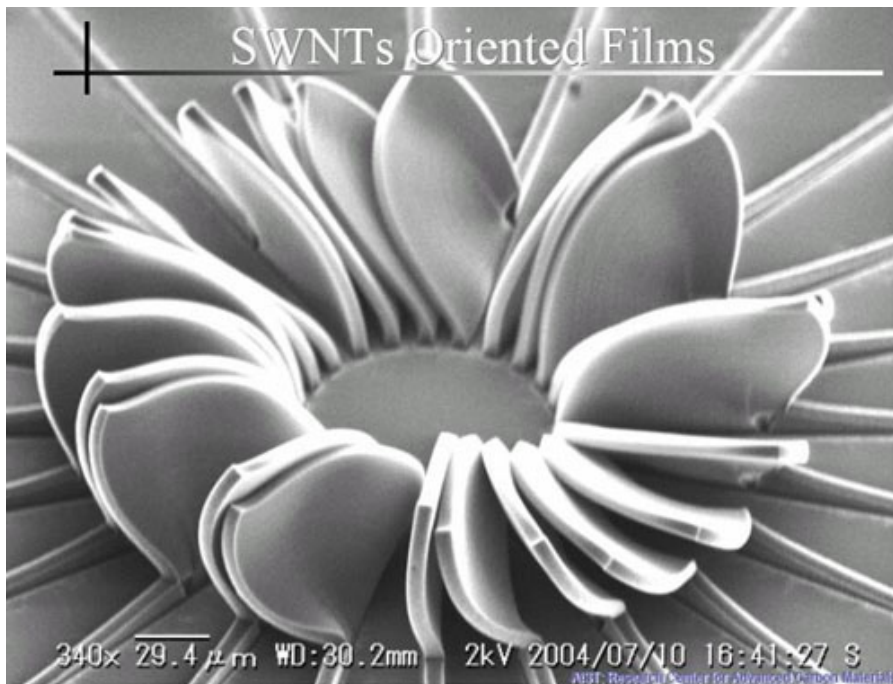
Group Photo of the “Super Growth” Team

From left to right starting from the front

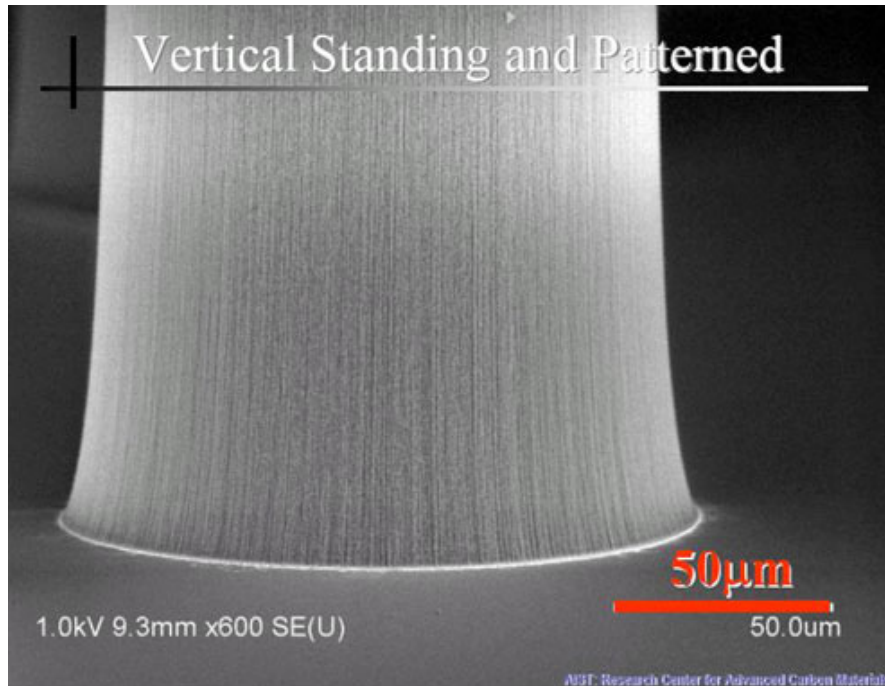
Tatsunori Namai, Dr. Kohei Mizuno Middle; Prof. Sumio Iijima, Dr. Motoo Yumura, Top; Dr. Takeo Yamada, Dr. Don N. Futaba, and Dr. Kenji Hata.



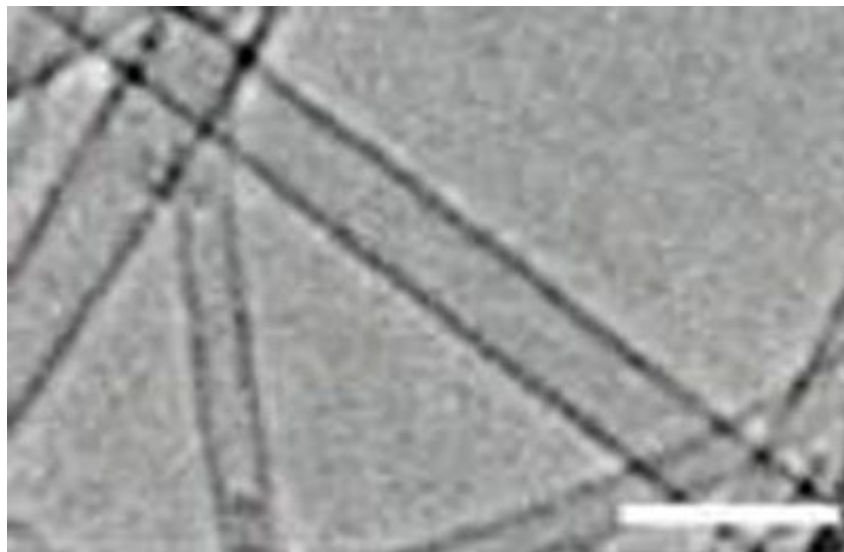
Macroscopic Easy Removed of CNT
(Courtesy of Dr Don Futaba)



(Courtesy of Dr Don Futaba)



(Courtesy of Dr Don Futaba)



High Resolution of TEM Image of the SWCNTs (Scale Bar:5nm) (from Science Vol306, Nov. 2004 p1362)

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