ATIP06.046: Nanotechnology Infrastructure in China

ATIP/China

ABSTRACT: China is currently in the process of constructing centers for the exploitation of nanotechnology in Beijing, Shanghai, Tianjin, and elsewhere. This report introduces some of the influential scientists who are involved in heading these centers, and their views on nanotechnology in China are briefly presented in an interview format. With the completion of these new centers, which is scheduled to be in the near future, China will have the infrastructure in place to begin challenging the West's lead in the field of nanotechnology.

KEYWORDS: Advanced Materials, Government Funding, Government S&T Policy, Materials, Nanotechnology, Physics, Photonics/Optoelectronics, Regional S&T Overviews, Semiconductors

COUNTRY: China

DATE: 8 November 2006

REPORT CONTENTS

1. INTRODUCTION

This report provides an update to the following previously published ATIP reports on nanotechnology in China:

- "ATIP02.049: Update of Nanotechnology in China"
- "ATIP03.054: Nanotechnology Organizations and Programs in China"

The present report examines the primary issues for the proliferation of nanotechnology in China, based on information gathered through conversations with senior members of the Chinese Academy of Sciences (CAS) as well as other key players in China's nanotechnology initiatives. Their views on nanotechnology in China are briefly presented in a question and answer (Q&A) format.

END OF REPORT ATIP06.046a

[The remaining sections of this report are available to ATIP subscribers]

ATIP06.046 (continued): **Nanotechnology Infrastructure in China**

EXECUTIVE SUMMARY

- The construction of nanotechnology centers in Beijing and Shanghai will be completed in 2007. A third center in Tianjin will be completed in 2008, as well as another center in Suzhou.
- The National Center for Nanoscience and Technology (NCNST) in Beijing, led by Professor Chunli BAI, focuses on basic research.
- The National Engineering Research Center for Nanotechnology (NERCN) in Shanghai, led by Dr. Jie HAN (a Chinese American), works on applied research and technology transfer both within China and overseas.
- The newest center in Tianjin, the Nanotechnology Industrialization Base of China (NIBC), serves as an incubation center for small companies; the mission is to commercialize ideas developed by the other centers.
- Dr. Hui YANG, former Vice-Director of the Institute of Semiconductors, Chinese Academy of Sciences (IS, CAS), will head the new center in Suzhou.
- Nanotechnology will be used to bridge the quality of life "gap" between people living in the rural and urban parts of China. The increasing gap in both the income and the expectations of rural and urban inhabitants has become a major issue for government policy makers.
- Chinese scientists trained abroad are increasingly returning to China, and play a pivotal role in international collaborations. This trend has been accelerating in recent years.

IMPACT & ASSESSMENT

This report is based on conversations with some of the key people involved in nanotechnology research and policy making in China. Their comments offer a valuable insight to the often contradictory statistics on nanotechnology in the country. The confidence of young scientists and the dramatic improvements in the science and technology (S&T) infrastructure are signs of the greater role that China will play in the development and exploitation of nanotechnology. Programs initiated a few years back are seeing fruition in the form of actual buildings, equipment and manpower for implementing the projects. China's leading scientists are confident of being able to compete with Western nanotechnology programs in the area of basic research. One senior nano-scientist, who travels to China frequently, commented that:

"If the number of publications is an indicator then, yes, China can compete with the West on basic research. However, it will not have an impact on the West for the next five years at least. The genuine breakthroughs will take time, but my visits to China lead me to conclude that, given the availability of the new hardware and wealth of manpower being injected into the Chinese effort, it is a matter of when and not if, the Chinese will produce commercially useful molecular nano-robots or report on a discovery equivalent to that of carbon nanotubes. The main deficiencies in the Chinese system are technology transfer from the lab to industry and patent rights."

2. NANOTECHNOLOGY CENTERS IN CHINA

According to statistics from China's Ministry of Science and Technology (MOST), the Chinese government assigned ~US$300 million to nanotechnology-related projects during the time period from 2001-2006. Approximately 70 academic institutes of the CAS (Figure 1) and more than 100 industrial establishments currently participate in this research and development (R&D).

Figure 1. Central building of the Chinese Academy of Sciences (CAS) in Beijing.

Nanotechnology will be used as a tool to nurture industries to develop products aimed at improving the quality of life of China's huge population, as well as reducing the politically unacceptable socioeconomic gap between the country's urban and rural areas. The emphasis is on the utilization of nanotechnology in generating solutions to problems related to energy supply and distribution, maintaining a clean environment, and diseases such as SARS and Avian Flu.

A statistical analysis of nanotechnology funding in China can be found in the previously released ATIP report, ATIP03.054: Nanotechnology Organizations and Programs in China," as well as in a recent article written by Professor Chunli BAI, Executive Vice President of the CAS and Director of the NCNST in Beijing, and published in *Science* 309:61 (July 1, 2005). Nanotechnology activities in China are currently focused in three principal geographical locations: Beijing, Shanghai, and Tianjing.

2.1 Beijing (NCNST)

The National Center for Nanoscience and Technology (NCNST), led by Professor Chunli BAI, was launched with an investment of US$10 million in December 2003 by the CAS and both Peking and Tsinghua Universities, with support from the National Development and Reform Commission, MOST, the Ministry of Education, and the Natural Science Foundation of China (NSFC). The emphasis at NCNST is on basic research, with approximately 150 R&D staff working on nano-fabrication and devices, nano-materials structures, nano-biotechnology, and nano-medicine. There are future plans to incorporate research on proteionics, photonics, and quantum computing. Construction of the center's buildings will be completed in 2007 (Figure 2).

Figure 2. Artists drawing of the completed NCNST in Beijing.

The government agencies responsible for public health and the environment are currently showing interest in the activities of the NCNST.

2.2 Beijing (LBENN)

The Laboratory for Biological Effects of Nanomaterials and Nanosafety (LBENN) was opened in Beijing on June 22, 2006. LBENN was jointly established by the NCNST and the Institute of High Energy Physics (IHEP), CAS. IHEP is a multidisciplinary research organization equipped with advanced facilities. Cooperation between NCNST and IHEP is expected to create synergy in order to advance the overall level of research in the multidisciplinary field involving nanotechnology, biology, chemistry, toxicology, physics, medicine, and other areas.

Research on bio-effects and the safety of nanomaterials has received attention in some countries, as it is related to nanotechnology applications, impacts on human health, and the possibility of new technologies that could be used in monitoring, analyzing, and even reducing pollution caused by nano- and micro-materials. At the opening ceremony for the LBENN, Professor BAI said that in addition to carrying out basic research, the laboratory plans to establish nanosafety evaluation methods and safety accreditation systems for nano-products in China.

China has been involved in research on bio-effects and nanosafety from the earliest stages. However, due to limited financial support, the level of Chinese research might not be seen as being on a par with that in the developed countries. Therefore, the foundation of LBENN represents an important initiative for systematic research in China.

2.3 Shanghai (NERCN)

The National Engineering Research Center for Nanotechnology (NERCN) emphasizes applied research and technology transfer within China as well as foreign industry. Construction of the center's buildings will be completed in 2007. Dr. Jie HAN, a Chinese American with previous experience as a technical director with the National Aeronautics and Space Administration (NASA) Ames Center for Nanotechnology in Moffett Field, California (United States), currently serves as the director of NERCN. The center is funded by both the central government and the Shanghai Municipal Government through the National Engineering Research Center for Nanotechnology Co. Ltd (SNERC), and supports a staff of approximately 150 people. R&D projects at the center include the topics of information technology, sensors for monitoring security, and biotechnology for monitoring the environment.

2.4 Tianjing (NIBC)

Officially announced in 2005, the Nanotechnology Industrialization Base of China (NIBC) in Tianjing is the latest addition to China's nanotechnology network. Nanotechnology-related work at this coastal city, located ~100 km from Beijing, is centered on technology transfer. The NIBC houses small manufacturers in support of efforts to incubate and develop ideas from the other centers for commercialization. Although the NIBC has approximately 150 technical staff members, there are also many support staff working on the development of applications for nanotechnology at the other centers.

According to Prof. Chen WANG, deputy director of NCNST, the Tianjing center has a pivotal role to play in knowledge transfer from the development to the commercial sector.

2.5 Suzhou (Institute of Nanotech and Nanobionics)

In addition to the centers listed above, there are other new facilities that have just opened or are about to open shortly. One of these is mentioned below.

The CAS, eastern China's Jiangsu province, and Suzhou city will jointly establish a new research institute, the Institute of Nanotechnology and Nano-bionics, with a total investment of RMB 393 million (approximately US$49 million). The ceremony to sign an agreement among three parties was held on September 17, 2006.

The new institute will be established in the Zuzhou Industrial Park and occupy 66,000 square meters. Dr. Hui YANG, former Vice Director of the CAS Institute of Semiconductors, is in charge of the preparation work for the new institute. He has established himself in semiconductor materials and GaN-based devices. The Suzhou Institute is expected to begin operation in 2008 and employ approximately 700 people via open recruitment from both mainland China and abroad.

The Institute will focus on following four areas and emphasize interdisciplinary research.

1. Nano devices and related materials
2. Nano biotechnology and medicine
3. Nano-bionics
4. Nano biosafety technology

Although construction is not yet complete, the preparatory group has rented a workshop located at the Institute of Semiconductors as well as a laboratory located at Nanjing University to develop processes for electronic/optoelectronics devices and conduct nano-biotechnology and medicine research.

3. KEY SCIENTISTS AND ENGINEERS

This section lists a few of the key people in Beijing and Shanghai who are responsible for implementing nanotechnology R&D in China.

- Prof. Chunli BAI

A chemist, who worked on scanning probe microscopy in 1985 at the California Institute of Technology (Caltech) in Pasadena (US), Prof. BAI has played a key role, both as a scientist and as a government advisor, in nanotechnology research in China. He is currently with the CAS Institute of Chemistry and serves as the director of NCNST in Beijing.

- Prof. Chen WANG

Prof. WANG is a physicist who currently works with the CAS Institute of Chemistry and serves as the deputy director of NCNST in Beijing. ATIP recently conducted an interview with Prof. WANG regarding his opinion of nanotechnology in China, excerpts from which are provided below.

Q: What are the main issues to resolve in the development of nanotechnology in China?
WANG: "We want to create and support fledgling industries in areas related to energy, environment, and health, but we are also aware that fundamental research is important. I think we can compete in basic research with programs launched as part of the US National Nanotechnology Initiative (NNI). In the short term, technology transfer will be the major issue. We cannot create an industry based only on nanotechnology. We must incorporate other industries. It will be a complicated process."

Q: What is the structure of NCNST, and how do you collaborate with other institutes?
WANG: "NCNST is part of a 'Public Technology Platform' comprised of nanoscience and nanotechnology facilities of Peking University, Tsinghua University, the Institute of Physics (CAS), the Institute of Chemistry (CAS), the Medical Center of Peking University, and the Institute of High Energy Physics (CAS). Although funding for equipment is not an issue, we set up the Platform so we do not waste resources on purchasing the same equipment at different institutes. For example, we share equipment with the Foxconn Nanotechnology Centre of Tsinghua University. So, we have excellent equipment as well as students.

Q: Do you have plans for international collaboration?
WANG: "NCNST has signed several international memoranda of understanding, including a framework for China-France cooperation in nanoscience and technology and the China-Germany Memorandum on Nanotechnology and Nanomaterials. Good personal communication between individuals will be important in achieving the goals of the collaborations. We have scientists here who have returned from overseas and their participation will be critical in these international programs. We are also conducting contract research with international companies. Our government encourages us to interact with overseas industry."

Q: What about issues related to intellectual property (IP) rights?
WANG: "This is an important factor in the proliferation of nanotechnology-based products in China. We have a standard contract and industry seems happy with the contents. We consider this Center as being a neutral place where academia and industry can interact. We want people to test their ideas here."

Q: How do you think the general public views nanotechnology in China?
WANG: "We are a developing country. Public acceptance of our research is very important for us."

- Prof. Zhong-can OU-YANG

Prof. OU-YANG currently serves as the Director of the CAS Institute of Theoretical Physics and as a senior advisor to the Chinese government on S&T. His primary areas of research are organic thin films for liquid crystal displays (LCDs) and related devices. Excerpts from an interview ATIP recently conducted with Prof. OU-YANG regarding nanotechnology in China are provided below.

Q: In 2000, Chinese scientists were second after the US in the number of publications on nanotechnology. What is the reason for this huge increase in publication over the last few years?
OU-YANG: "Scientists are being increasingly evaluated on the number of their publications, especially in high impact journals. So, there is more incentive to publish. However, I think too much emphasis on the numbers of publications puts a lot of pressure on the younger scientists. They should be given more time to conduct research. At the moment it is relatively easy to write a paper in nanomaterials such as nanotubes, because you just have to change conditions for synthesis, which yield different looking structures, which appeal to the editors of journals."

Q: Have you noticed new trends in international collaborations?
OU-YANG: "Apart from US and EU, we have an increasing number of collaborations with Taiwanese scientists. I am also collaborating with scientists in Japan."

- Prof. Zhong-Xian ZHAO

Prof. ZHAO is an experimental physicist at the CAS Institute of Physics (IOP), shown in Figure 3 below, who focuses on the growth and characterization of high-temperature superconductors. In 1987, Prof. ZHAO was the third person in the world to produce HTc superconductors. He has a very well-equipped laboratory and utilizes molecular beam

epitaxy for growth of HTc films - including (Pr,Ca)Ba2Cu3O7, which has a Tc ~115K, the highest reported for this type of material. The IOP has 400 full-time staff.

Prof. ZHAO

Figure 3. Main building of the Institute of Physics, Beijing, CAS.

ATIP recently conducted an interview with Prof. ZHAO regarding nanotechnology in China, and his answers are briefly presented below.

Q: What are the main problems you envisage with your research here and the new nanotechnology centers being set-up in China?
ZHAO: "Efficient use of resources will be becoming increasingly important as the funding increases. We must prevent redundancy. Another issue will be motivating and attracting high-quality scientists, but I am confident that we have excellent facilities and offer our staff many benefits including subsidized housing."

Q: What levels of funding do you have for your research at the IOP, and what in your view are the key areas that will benefit from future government funding?
ZHAO: "We have an annual budget of US$20 million per year, with 20% used on salaries. Last year, we published 27 papers in *Physics Review Letters*, three in *Nature*, and four in *Science*. So we are doing good work. The life sciences is better funded than physics for obvious reasons, such as the SARS and bird flu. Chemistry receives more funding than materials, again to tackle diseases."

Q: What are your opinions about technology transfer in China?
ZHAO: "Firstly, the meaning of patents in this country is not well understood. So technology transfer takes a lot of effort. IP issues are the major problems, but patent applications in China are increasing annually. "

- Prof. Jing-Feng LI

Photo from Prof. LI's website

A professor with the Department of Materials and Engineering at Tsinghua University in Beijing (see Figure 4), Jin-Feng LI studied for both his Master of Science (MS) and doctoral degrees at Tohoku University. He became a member of the faculty at Tsinghua in 2002. Prof. LI is one of a growing number of Chinese scientists returning from overseas to tenured positions at Chinese universities. ATIP recently conducted an interview with Prof. LI regarding his views on nanotechnology in China.

Figure 4. Offices at the science park adjacent to Tsinghua University, housing spin-offs and international industries.

Q: What are the attractions for Chinese scientists overseas to return to China?
LI: "Here, the university supports children's education, my apartment is large and I was able to buy it at much reduced rates due to my position at the university. I am also playing a major role in the development of China's science and technology base. The salary of a professor is much less than the West, but I can still live comfortably because of the low cost of living. In the West and Japan, the highest position you can hope for is full professor. There are very few opportunities beyond that. In China, there is also the possibility of becoming an 'academician,' which is a much higher status than professor. As an academician, you are given many privileges, such as the use of chauffer-driven cars and membership in important government policy committees. Also, Tsinghua has a worldwide reputation of excellence in science and technology. We have many industrial spin-offs and we are well funded."

ATIP Comment: At a good university such as Tsinghua, the national government will pay salaries of ~US$5000/month, and the university can add another US$1,000/month, based on performance. Several universities have also reportedly created "million yuan professorships" – annual salaries equivalent to US$125,000 – to attract overseas scientists. In addition, professors can sometimes supplement salaries by becoming involved with large projects and independent consulting.

- Dr. Jie HAN

Photo from Dr. HAN's NASA website

Dr. Jie HAN, a Chinese American and nanotechnology entrepreneur, currently serves as the Director of NERCN in Shanghai. He is a leading scientist in the area of both computational and experimental nanotechnology, and he has more than 15 years of experience in nanotechnology, specializing in nanoelectronics for sensing and computing applications.

4. CONCLUSION

This report is based on conversations from ATIP interviews with some of the key people involved in nanotechnology research and policy making in China. Their comments offer a valuable insight into the often contradictory statistics on nanotechnology in the country. The confidence of young scientists and the dramatic improvements in the S&T infrastructure are signs of the greater role that China is expected to play in the development and exploitation of nanotechnology. Programs initiated a few years ago are coming to fruition in the form of actual buildings, equipment, and manpower for the implemention of these projects. China's leading scientists are confident of being able to compete with Western nanotechnology programs in the area of basic research.

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