

ASIA NANOSCIENCE AND NANOTECHNOLOGY DEVELOPMENT

Chunli Bai

Chinese Academy of Sciences, China

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Contents

1. Nanotechnology policy in China
2. Nanotechnology policy in Japan
3. Nanotechnology policy in Korea
4. Nanotechnology policy in Singapore
5. Nanotechnology policy in India

Glossary

Bibliography

Biographical Sketch

Summary

Nanoscience and nanotechnology are widely seen as having huge potential to bring benefits in areas such as biotech and drug development, environmental protection, information and communication technologies, clean energy and power, the production of stronger, lighter materials and so on. They are attracting rapidly increasing investments from governments and from businesses in many parts of the world. Asia, as a rapid development area, is earliest one engaging nanoscience and technology in the world and has been a great success. Behind the success, the strategic plan for R&D and S&T policy from government are a key point for the expedition of nano-research and application, although the investments are also important.

Asia, with more than half of the world's population and including some of the fastest growing economies, has a large and motivated population, and a large and growing market. An increasing number of overseas educated Asian scientists, engineers and industrialists are taking greater leadership in the advancement of nanotechnology across the region. Japan, Korea, and Taiwan are recognized as industry leaders of nanotechnology commercialization, especially in precision instruments, advanced materials and electronics manufacturing. China, India would be excellent research partners thanks to their excellent research capabilities. Hong Kong is attractive in terms of financing R&D and also in locating R&D headquarters to take advantage of its vicinity to China – a potential manufacturing base. Singapore provides an efficient and strategic location that protects IP and focuses strongly on financing specific

nanotechnology applications. It provides excellent funding and business development support from both government and the private sector. Over the last ten years (1999-2009) the region has experienced fast and exciting developments in nanotechnology.

The development policies of nanoscience and nanotechnology are different for the every country in Asia, for example, China adopts all-around development policy similar to USA, Japan emphasizes particularly on application, and Korea focuses on nanotechnology related to electronics and semiconductor. In this report, we try to analysis the policy of nano-development for represented countries from the aspects of development history, organization, policy characteristics and so on.

1. Nanotechnology Policy in China

1.1. Mainland China

1.1.1. A Brief History of Nanotechnology

Research activities in the field of nanoscience and nanotechnology have flourished in China in the past decade. Because of the encouraging achievements made by Chinese researchers in both fundamental research and industrial applications there is an increasing awareness in China of the potentials of nanotechnology. In this chapter we will provide an overview of the efforts in China to develop research in nanotechnology.

China is one of the few pioneering countries in nanoscience research. Dating back to the 1980's to the present, Chinese scientists have explored nanoscience and -technology in areas ranging from nanomaterials, nano-devices, and nano-biology to nano-characterization and -fabrication. Since 2001 nanotechnology has been prioritized as a strategic research field by the Chinese government. The Ministry of Science & Technology (MOST), the National Natural Science Foundation of China (NSFC), the Chinese Academy of Sciences (CAS) and the Ministry of Education (MOE) have been and continue to be the principal funding government agencies.

China has made a number of breakthroughs in the studies on nanomaterials and related fundamental researches. The most representative ones are one-dimensional materials such as carbon nano-tubes, nano-metals, and single molecule detections. China's efforts in fundamental nano-research have earned recognition from the international scientific community, as will be discussed later in this chapter. As of the late 1990s, applied nano-research entered into a stage of rapid development and has expanded to include societal impact and industrialization. However, though research on nano-scale devices has received a lot of attention in China, appreciable differences still exist between China and developed countries in the area of nano-devices and industrialization.

As an emerging multidisciplinary scientific field, nano-science and -technology provide

a brand new platform of new possibilities and opportunities for technology innovations in many fields. The integration of fundamental research with applied research, coupled with exceptionally high expectations of the potentials of nanotechnology, have been remarkable features of the development in nanoscience and technology in China over the past two decades.

The initiation of nano-research in China can be traced back to the mid- and late 1980's when scanning probe microscopy (SPM) was introduced and developed in China as a novel technique to analyze surface structures with nanometer scale resolution. The importance of the technique was soon recognized and generated broad interest in studying a wide range of materials at nanometer scale. Researchers at CAS and universities have developed several versions of SPM and several research groups have demonstrated the fabrication of nanoscale features on surfaces using this technique. In addition, studies of a range of single molecules and molecular assemblies, with the aim to advance the ultimate resolution power of materials surfaces, have also been very encouraging. These exploratory studies have helped stimulate an awareness of the research of nano-science and -technology in China and the need to develop new techniques for revealing novel properties of nano-structures.

Material research dedicated to ultra-fine oxide particles was also approaching nanometer scale in the late 1980s at about the same time as the development of the SPM and novel properties associated with this scale were discovered. The direct applications of these pioneering activities led to the founding of a number of enterprises with products from scanning probe microscopes to coating related merchandise. Even though these manufactured products have not had significant commercial success, the experiences have provided hope for future entrepreneurship based on new intellectual properties. There are numerous indicators of the advancement of the nanoscience movement in China. Since 1990, tens of international and national nanotechnology conferences have been organized in China, including important early gatherings like the 7th International Conference on Scanning Tunneling Microscopy (1993), the 4th International Conference on Nanometer-Scale Science and Technology (1996), ChinaNano2005, ChinaNano2007, and ChinaNano2009. Scores of cooperation agreements have been signed between Chinese and foreign research institutions and enterprises. In recent years, the number of nano-related scientific articles by Chinese scholars has increased and today, Chinese scholars rank high in international statistics indicating the volume of published nanoscience papers. Patent applications and technological transfer are increasing. Among China's "Top 10 Science and Technology Advances in the News" of 2005, two were related to nanoscience and nanotechnology.

In spite of all the progress made in the last two decades, China has a long way to go to catch up to the leading nanotechnology nations. China is still lacking in key technological innovations. China still has a limited infrastructure for nanoscience and nanotechnology research. Moreover, intellectual property protection as well as

environmental and workplace safety have only recently begun to be prioritized.

1.1.2. Administration and Implementation Sectors

In China, the National Steering Committee for Nanoscience and Nanotechnology oversee national policy and planning in these arenas. The committee was set up in 2000, among other organizations, by MOST, the State Development and Planning Commission, MOE, CAS, the Chinese Academy of Engineering, and NSFC.

MOST, NSFC, and CAS are main resource to fund nanoscience-related work and activities. Moving forward in nanoscience and nanotechnology requires a particularly wide spectrum of skills and knowledge. As such, a number of interdisciplinary research centers have been established to promote and facilitate collaborations between various institutions in a particular region by sharing of resources. The demand for multidisciplinary research platforms with components assembled from academia and industry and that also have educational functions has become especially strong in recent years. According to incomplete statistics, more than 50 universities, 20 institutes of CAS, and over 762 industry enterprises have engaged in nanoscience and nanotechnology R&D in China.

1.1.3. Policies for Nanoscience and Nanotechnology Development

In the 1990s, support for the development of nanoscience and nanotechnology increased substantially, largely through several major initiatives.

- (1) **“Climbing Up” Project.** In 1990, State Science and Technology Commission (SSTC) launched the nearly decade-long "Climbing Up" project on nanomaterial science.
- (2) **National Basic Research Project.** In 1999, the Ministry of Science and Technology (MOST), whose predecessor was the SSTC, started a national basic research project entitled "Nanomaterial and Nanostructure" and has been funding basic research on nanomaterials, such as nanotubes, ever since.
- (3) **National High Technology Plan.** The plan encompasses many categories of technology, has included a series of projects for nanomaterial applications.
- (4) **Nano-Research Program.** In 2001, NSFC launched a plan for nano-research and supported over 100 programs.
- (5) **Nano-Key Research Plan.** Nanoscience and nanotechnology is one of the four important scientific research plans in the guidelines on national medium- and long-term program for S&T development (2006-2020). The other three is Protein research, Quantum modulation, Developmental and reproductive research.
- (7) **Nano-base.** CAS set up nano-base for promoting the nanoscience and technology in CAS.

(8) Setting up National Centers

Since 2000, China created three National Centers for Nanotechnology:

- National Center for Nanoscience and Technology in Beijing
- National Center for Promoting and Developing Nanotechnology, Shanghai
- National Nano-Commercialization Base in Tianjin

1.1.4 Policy Characteristics

- To enhance the basic and applied research to increase the creative ability and form creative system for long term progress of nano-science and technology in China.
- Nanotechnology essentially demands an approach that improves traditional products-nanomaterials, nanocomposites etc.
- A strategic approach at the national level will be required to find new industrial applications for the technology — nano-bio and nano-device.

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Biographical Sketch

Prof. Chunli Bai is Executive Vice-president of the Chinese Academy of Sciences (CAS), Vice-president of the China Association for Science and Technology (CAST), and President of the Graduate University of CAS with more than 34000 postgraduate students.

His research areas involve the structure and properties of polymer catalysts, X-ray crystallography of organic compounds, molecular mechanics and EXAFS research on electro-conducting polymers. In the mid-1980s, he shifted his research orientation to the field of scanning tunneling microscopy, and

molecular nanotechnology. Prof. Bai has a long list of scientific publications and has won more than twenty prestigious awards and prizes for his academic achievements. Because of his meritorious service, he was elected a member of CAS and a fellow of the Academy of Sciences for the Developing World (TWAS) in 1997. He is also foreign associate of the US National Academy of Sciences, foreign member of Russian Academy of Sciences, honorary fellow of the Royal Society of Chemistry, Indian Academy of Sciences, and honorary doctor or honorary professor in several universities abroad. Prof. Bai now serves as the chief scientist for the National Steering Committee for Nanoscience and Technology and Chairman of China National Center for Nano-science and technology.

In his social activities, he is president of Chinese Chemical Society, vice president of TWAS, president of the Federation of Asian Chemical Societies. He is the member of the International Editorial Adversary Board of JACS, *Angewandte Chemie*, *Advanced Materials*, *Chemical Physics Letters*, and etc.

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