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Nanotechnology Activities in Thailand: Present and Future Perspectives

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ABSTRACT

The current situations of nanotechnology in the advanced industrial countries, the USA, the European Union, and Japan, are introduced to cast contrasting light on the recent development and promotion of nanotechnology in Thailand, especially the recent establishment and planned roles of the National Nanotechnology Center. A brief overview of the current situation and future perspectives of Nanotechnology in Thailand is given from the authors' view.

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INTRODUCTION

According to the ground-breaking lecture "There is Plenty of Room at the Bottom" in 1959 by Professor Richard P. Feynman, Physics Nobel Laureate, many researchers, scientists and engineers were fascinated with potential marvelous discoveries if somebody could design and invent instruments, materials, devices, and so on at the atomic or molecular level. Feynman indicated that a novel instrument was a necessity, especially for manipulating and measuring the "small things". By nature, nanotechnology, covering both science and engineering, is perhaps the most multidisciplinary of all scientific disciplines in the 21st century. Nanotechnology is associated with the nanometric-scale science and technology, in which one nanometer (nm) is one billionth of a meter – about one 80,000th of the average diameter of a human hair. Although the definition of nanotechnology is not universal or precise, its most significant feature is "phenomena related to one or more dimensions in the 0.1-100 nm range".

Nowadays, nanotechnology is accepted world-wide as a powerful tool capable of making objects not yet envisioned. Nanotechnology has the potential to change the faces of technology in the past centuries – leading to 'the next industrial revolution.' Nanotechnology is expected to prolong developed countries' technological dominance and to stimulate developing countries' competitiveness in the world market. Progress in nanotechnology research is moving at a rapid pace world-wide. At present, the United States is a leader in the synthesis, chemicals, and biological fields. Europe has an advantage in the dispersions, coatings, and instrumentation whereas Japan is said to be strong in nanodevices and consolidated nanostructures.

Currently, numerous nanotechnology products are already commercialized. For example, copper nanoparticles are found in automotive lubricant that effectively reduces engine wear, and sunscreen lotion contains effective UV-absorbing titanium dioxide nanoparticles. In the automotive industry, nanocomposites are added to car bumpers to make it 50 percent lighter and twice as resistant to denting and scratching. Computer hard disk drives based on giant magneto-resistance (GMR) are available, and so on.

Nanotechnology has recently attracted the close attention of not only scientists and engineers but also economists and politicians in both the developed and developing countries. The USA, several European nations and a number of Asian countries have all set up and implemented their own national nanotechnology initiatives (NNI). Unsurprisingly the government of Thailand is formulating its own NNI to promote and accelerate nano science and technology as an important instrument of future economic growth and international competitiveness.

PRESENT SITUATION OF NANOTECHNOLOGY DEVELOPMENT IN TECHNOLOGICALLY ADVANCED COUNTRIES

The present world nanotechnology situation is fiercely competitive. Most industrialized countries and several developing ones create and promote centers or networks of excellence in specific areas of nanotechnology over the past few years. The technologically advanced countries display distinctively brilliant nanotechnology competency. Table 1 presents an overall comparison of the current leader in each major region – the United States, the Europe Union, and Japan – in the various areas: synthesis and assembly, ultra-thin films, nanodevice, ultra-precision engineering, nanobiotechnology, dispersion and coating, and high surface materials.

Table 1 Comparison of nanocompetent areas of the major players

	U.S.	EU	Japan
Synthesis and assembly	■		
Ultra-thin films			■
Nanodevice			■
Ultra-precision engineering	■		
Nanobiotechnology*	■	■	
Dispersion and coating*	■	■	
High surface materials	■		

*The U.S. and EU appear to be rather on par in this area.

The United States

The U.S. expects nanotechnology to lead to significant advantages in this strategic technology, thus maintaining and improving her position in the future world marketplace. In January 2001, the National Nanotechnology Initiative (NNI) was announced as a top priority in federal research by President Clinton soon after the President's Committee of Advisors on Science and Technology (PCAST) strongly endorsed the establishment of the NNI as a part of fiscal year (FY) 2001. The goals of the NNI are as follows:

1. Conduct research and development (R&D) to realize the full potential of this revolutionary technology.
2. Develop the skilled workforce and supporting infrastructure needed to advance nanotechnology R&D.
3. Better understand the social, ethical, health, and environmental implications of the technology.
4. Facilitate transfer of the new technology into commercial products.

An immense budget is allocated for the NNI to coordinate the multi-agency Federal R & D programs in nanotechnology. In FY 2004, President Bush requested a budget of 849 million USD for nanotechnology R&D across all of the agencies that participate in the NNI. The budget represents an increase of ca. 10 percent over the amount appropriated by the Congress in FY 2003. Table 2 shows the NNI budget as categorized by agencies, more than half of which is allocated to the National Science Foundation (NSF) and the Department of Defense (DOD). In short, the U.S. strongly emphasizes nanotechnology R & D for national security and fundamental research, especially in the initial stage.

Table 2 NNI budget overview by agency

Agency	2001	2002	2003	2004 (Request)
National Science Foundation	150	204	221	249
Department of Defense	123	224	243	222
Department of Energy	88	89	133	197
National Institutes of Health	40	59	65	70
National Institute of Standards and Technology	33	77	66	62
National Aeronautics and Space Administration	22	35	33	31
Others	8	9	9	18
Total	464	697	770	849

A novel investment mode, known as the grand challenges of the NNI, focuses on 9 areas having high potential to realize significant economic, governmental, and social impact. The nine areas are:

1. Nanostructured Materials by Design
2. Manufacturing at the Nanoscale
3. Chemical-Biological-Radiological-Explosive Detection and Protection
4. Nanoscale Instrumentation and Metrology
5. Nano-Electronics, -Photonics and –Magnetics
6. Healthcare, Therapeutics, and Diagnostics
7. Efficient Energy Conversion and Storage
8. Microcraft and Robotics
9. Nanoscale Processes for Environmental Improvement

European Union

Germany, Sweden, Switzerland, and the U.K started their own nanotechnology projects about five years ago. The European Commission (EC) supports and promotes nanotechnology research as an important tool to improve the quality of life and to achieve real sustainable development. The EC launched the current sixth Framework Program – FP6 (2002-2006) with a budget of 17.5 billion euros for Research and Technological Development (RTD). Nanotechnology is the third thematic priority (TP3) of FP6, entitled "nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices" funded at 1,300 million EUR. In reality, TP1, life sciences, genomics and biotechnology for health, and TP2, information society technologies, also contain nanoscience and nanotechnology projects. An estimation of the overall nanotechnology investment in Europe by the EC is 700 million euros per annum.

Active networking between EU member states is indispensable for nanotechnology RTD, so the European Union (EU) sponsored the Thematic Network, the Nanoforum that provides a comprehensive source of information on all areas of Nanotechnology – research programs, technological developments, funding opportunities and future activities – to the business, the scientific and social communities. The aim of the Nanoforum is to provide a linking framework for all nanotechnology activities within the

European Community. The European Nanoforum currently consists of six partners as follows:

1. The Institute of Nanotechnology (ION) of the UK
2. The Center for Innovation in Micro and Nanotechnology of France
3. CMP Cientifica of Spain
4. VDI of Germany
5. Malsch Techno Valuation of the Netherlands
6. Nordic Nanotech of Denmark

Japan

The Japanese government started funding nanotechnology R&D projects in the 1980s via the Japan Science and Technology Agency (JST) and in the 1990s via the Ministry of Economy, Trade and Industry (METI). Increasing her global competitiveness through nanotechnology R&D is considered essential for the revitalization of the Japanese economy. Therefore, the Government of Japan set nanotechnology and materials as one of the four top-priority areas in the second five-year Science and Technology Basic Plan (2001-2005) alongside life sciences, information and communications, and environmental sciences.

Her national budget on nanotechnology R&D has been the highest in the world, substantially via METI and the Ministry of Education, Culture, Sports, Science and Technology (MEXT). METI supports R&D projects through the New Energy and Industrial Technology Development Organization (NEDO) and the National Institute of Advanced Industrial Science and Technology (AIST). MEXT promotes research conducted by the Japan Society for the Promotion of Science (JSPS), JST, the National Institutes for Materials Science (NIMS), the Institute of Physical and Chemical Research (RIKEN) and other organizations. In addition, the National Research Network Center of Japan (NRNCJ) funded over 30 million USD annually by MEXT provides core facilities, information services and technology transfer support for Japanese research, supports and organizes coordinated domestic and international workshops and conferences in Japan. In FY 2004, MEXT requests 33.34 billion yen and METI, 53.72 billion yen for supporting nanotechnology projects.

There are two interesting characteristics of nanotechnology R&D in Japan. One is the setting up of NRNCJ to provide national nanotechnology services, including the necessary facilities, instrument centers and information service centers similar to the European Nanoforum. The second feature is the systematization of nanotechnology materials programs, thus leading to synergism and resulting in futuristic novel materials.

CURRENT STATUS OF NANOTECHNOLOGY IN THAILAND

In the aftermath of its most severe financial crisis in 1997, Thailand had to promptly develop the capability to identify, promote and invigorate niche industries and products for sustainable development and national competitiveness in the global market. Science and technology (S&T) development was adopted as one of the indispensable key strategies for Thailand to make her economy and society more robust and competitive. Nanotechnology development is expected to stimulate Thailand to leapfrog in key areas of S&T. Admittedly Thailand is short of high-caliber S&T human resources, research experience in nanotechnology, essential research infrastructure, research coordination among the academia, government and private sectors, and financial resources. As a consequence, the most effective strategy for her nanotechnology development is to set up comprehensive national nanotechnology initiatives.

Establishment of National Nanotechnology Center

Recognizing the importance of nanotechnology to the development of human resources and national competitiveness, the Cabinet of the Government of Thailand on November 19, 2002, ordered the Ministry of Science and Technology (MOST) and the Ministry of Information and Communication Technologies (MICT) to coordinate and jointly investigate the feasibility of nanotechnology promotion and development in Thailand. In response, MOST assigned the National Science and Technology Development Agency (NSTDA) to tackle this crucial task. As a result, the establishment of a brand new National Nanotechnology Center (NANOTEC) under the umbrella of NSTDA was proposed and won approval from the Cabinet on August 13, 2003. Figure 1 illustrates the relationship between NSTDA, NANOTEC, and the other 3 existing national centers.

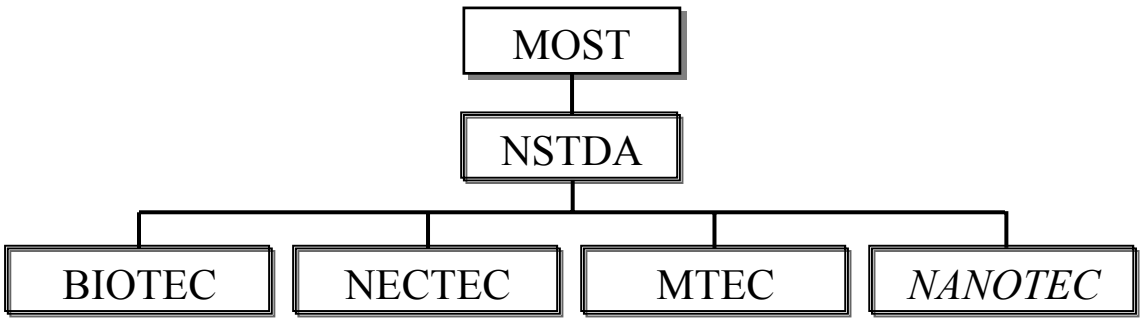

Figure 1 Organizational Structure of NSTDA

In its first five-year plan, NANOTEC is requesting a total operating budget of 910 million baht (about 22 million dollars) for the execution of its nanotechnology activities, including human resources development, promotion of nanotechnology R & D, and investment in research facilities and infrastructure. The mission of NANOTEC encompasses the following:

1. Prepare a comprehensive national road map on nanotechnology for Thailand.
2. Act as a national coordinating body between the academia, government and private sectors, and promote their linkages.
3. Set up collaborative research network by assembling and producing a critical mass of high-caliber researchers and educators on nanotechnology.
4. Identify and focus on niche areas and products in nanotechnology, thus enhancing Thailand's international competitiveness.
5. Disseminate and transfer new and existing knowledge in nanotechnology to the industrial and governmental sectors.
6. Carry out research in selected core, or common, areas of nanotechnology.
7. To facilitate nanotechnology research needs, set up and provide analytical and testing services that require expensive sophisticated analytical instruments.

Current Status of Nanotechnology R & D in Thailand

Several government agencies actively support and/or are involved in S&T research and development in Thailand, for examples, NSTDA, the Commission on Higher Education (the former Ministry of University Affairs), the Ministry of Education (MOE), MICT, the National Research Council of Thailand (NRCT), and Thailand Research Fund (TRF).

As shown in Figure 1, there are three fully-fledged national centers besides NANOTEC under the umbrella of NSTDA. They are the National Metal and Materials Technology Center (MTEC), the National Electronics and Computer Technology Center (NECTEC) and the National Genetic Engineering and Biotechnology Center (BIOTEC). All three national centers are conducting a number of R&D projects in, or closely related to, Nanotechnology. They also provide research grants to other agencies and laboratories.

Meanwhile, many national universities under the supervision of the former MUA are conducting research on a wide range of topics in nano science and technology. In addition, MUA also promotes the establishment of various Collaborative Research Networks (CRN) in selected S&T fields, including Clean Technology, Particle Technology, Catalysis, Medical Engineering, and Nanotechnology. Recently MUA provided special grants for universities to carry out R&D projects, including nanotechnology R & D, that would enhance the international competitiveness of Thailand.

In coordination with MOST, MICT was assigned by the Cabinet to investigate the suitability and feasibility of nanotechnology, and if appropriate, to jointly come up with concrete policy, measures and actions on nanotechnology for submission to the Cabinet. Established only 1 year ago, MICT has not announced any big nanotechnology R&D projects.

Designated by the Cabinet as the national body responsible for making national research policy and screening/evaluation of research projects submitted by other government agencies, NRCT is entrusted to make recommendations and give comments on research issues upon request. Although NRCT now neither conducts research nor grants research funds, it has important roles to play with respect to the successful implementation of the NNI of Thailand.

Similarly, TRF, whose objectives include the build-up of professional researchers and promotion of the research community, does not conduct any in-house research but mainly acts as a granting agency. There are several types of research grants such as Senior Research Scholar Projects and Advanced Research Scholar Projects. Some of its recent grants are provided to support research projects in nanotechnology.

HRD in Nanotechnology

Accelerated human resources development (HRD) in nanotechnology is key to the success of nanotechnology development and application in Thailand. With the exception of a few elective courses in certain universities, e.g. CU, MU, and AIT, there is no full-fledged curriculum or regular degree program in nanoscience or nanotechnology in Thai universities. Without a critical mass of qualified human resources, the multi-prong mission of NANOTEC as well as nanotechnology development and application in Thailand would certainly stumble, if not fail. To create synergism, it has been proposed that NSTDA (NANOTEC) promotes the development of a novel international tri-partite Masters Program in nanotechnology, which combines the strengths of NSTDA in terms of R&D capability and research facilities, of leading Thai institutions in terms of coursework and degree granting authority, and of advanced foreign institutions in terms of advanced education. Once successfully implemented, the Masters Program should be followed by a similar PhD Program.

Recently, the Cabinet has approved a 5-year plan of MOST to provide 1,500 full-expense scholarships for Thai students to go abroad to advance their study in S&T. The plan also earmarks 200 scholarships for NSTDA to recruit candidates in the field of Nanotechnology. After graduation these 200 scholarship recipients are obligated to work for NSTDA and its four national centers.

FUTURE PERSPECTIVES OF NANOTECHNOLOGY IN THAILAND

The 9th 5-year National Social and Economic Development Plan (2002-2006) prescribes an ambitious research investment goal of 0.40% of the gross domestic production (GDP). Forecast for 2006 predicts the GDP will reach 6 trillion baht, which translates to research investment of at least 24 billion baht. Even this unlikely-to-be-achieved value is still significantly less than those of the advanced industrial countries. Therefore Thailand's limited budget must be spent in the most appropriate and effective manners. Currently NANOTEC is assigned by the Cabinet to prepare a comprehensive Masters Plan for National Nanotechnology Initiatives (NNI). The most important parts of the Masters Plan will be Human Resources Development and R&D Strategy in nanotechnology.

Imitating the successful roles of the European Nanoforum and NRNCJ of Japan, NANOTEC must rapidly provide core facilities and instruments for supporting nanotechnology research in Thailand, collect and disseminate nanotechnology R&D information, including advanced instruments and recent nanotechnology research projects in every university and government agency, and share key information with other Asian countries.

Simultaneously, NANOTEC is finalizing the details of its organizational structure and recruiting high-caliber management staff and researchers. Another key strategy is to make full use of international and regional cooperation in Nanotechnology. NSTDA has recently created new collaborations and/or strengthened existing ones with Japan, the USA, EU, Australia, Russia, Taiwan, South Korea and so on.

CONCLUSION

As a latecomer to the important field of Nanotechnology, Thailand has to put in a tremendous amount of investment and effort in order not to fall further behind. Hopefully Thailand would be able to develop its HRD, identify and develop certain niche areas and products, and enjoy to a significant extent some of the potential benefits of Nanotechnology. Because nanotechnology is highly cross-disciplinary, nanotechnology R&D should aim at synergistic programs. Progress in nanotechnology development is expected to contribute not only to stable economic growth but also to sustainable national development, including a better environment and a higher quality of life. It goes without saying that real success in nanotechnology development needs active collaboration between governmental, academic and industrial sectors.

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