

# Strategic Promotion of Nanotechnology R&D of Japan

Masahiro Takemura  
National Institute for Materials Science  
Japan

## Abstract

In the 2nd Science and Technology Basic Plan (2001 – 2005), the research area of nanotechnology and materials is designated as one of the 4 prioritized areas in funding. Following this plan, MEXT and METI, the main funding ministries, and their organizations, JSPS, JST, NIMS, RIKEN, NEDO, and AIST have been promoting their research programs. The highlights of their programs are the Leading Projects by MEXT, the Nanotechnology Virtual Laboratories by JST, the Focus 21 by METI, the Nanomaterials & Processing Sub-Program by NEDO, and so on. Besides, in order to encourage interdisciplinary, interorganizational, and international collaboration among researchers, the Nanotechnology Support Project was started by MEXT in 2002. The project has two missions: informational support and common use facility support. The Nanotechnology Researchers Network Center of Japan is responsible for informational support, and 14 universities and national research institutes are responsible for common use facility support.

## Nanotechnology R&D Policy of Japan

Nanotechnology is now recognized worldwide as one of the key issues in science and technology in the 21<sup>st</sup> century. For sustainable economic development and comfortable and safe life of the people, the Japanese government is committed to strong support for science and technology research. In March, 2001, the Second Science and Technology Basic Plan (2001-2005) was decided by the Council for Science and Technology Policy (CSTP), whose chairperson is the Prime Minister (Government of Japan, 2001). The Basic Plan assigns strategic priority in R&D to basic research and 4 prioritized areas in funding: life sciences, information and telecommunications, environmental sciences, and nanotechnology & materials science/technology. In nanotechnology & materials science, CSTP exemplified 5 fields: nano-devices & materials for next-generation communication systems (information technology), materials for the environment & energy-saving (environment), nano-biology for new medical care technologies & biomaterials (biotechnology), underlying technologies such as fabrication and analysis/simulation technologies (generic technology), and novel materials with innovative functions (materials) (CSTP, 2001).

Following this plan, the government funding for R&D on nanotechnology & materials science was increased from \$731 million (\$1 = ¥110) in FY 2001 to \$778 million in FY 2002 (CSTP, 2003) and reached \$855 million in FY 2004 (CSTP, 2004). The Ministry of Education,

Culture, Sports, Science and Technology (MEXT) and the Ministry of Economy, Trade and Industries (METI) are the main funding ministries. Their R&D organizations for nanotechnology are shown in Figure 1. MEXT has two funding agencies and two research institutes: the Japan Society for the Promotion of Science (JSPS) (JSPS, 2003), the Japan Science and Technology Agency (JST), the National Institute for Materials Science (NIMS), and the Institute of Physical and Chemical Research (RIKEN) (MEXT, 2004). JSPS supports basic research with grant-in-aid for scientific research, and JST coordinates challenging research which will need 10 to 20 years for industrial application. NIMS and RIKEN are mainly in charge of generic technology. On the other hand, METI has one funding agency and one research institute: New Energy and Industrial Technology Development Organization (NEDO) (METI, 2004a and METI, 2004b) and National Institute of Advanced Industrial Science and Technology (AIST) (AIST, 2004a). Both organizations are in charge of flagship type research which will need 5 to 10 years for industrial application. Furthermore, the Nanotechnology Support Project (NSP) (Nanonet, 2004) and the Nanotechnology Business Creation Initiative (NBCI) (NBCI, 2004) are also shown in Figure 1. NSP was started by MEXT in April, 2002, which is introduced in the next section, and NBCI, a consortium of more than 300 private companies, was founded with a help of METI in October, 2003.

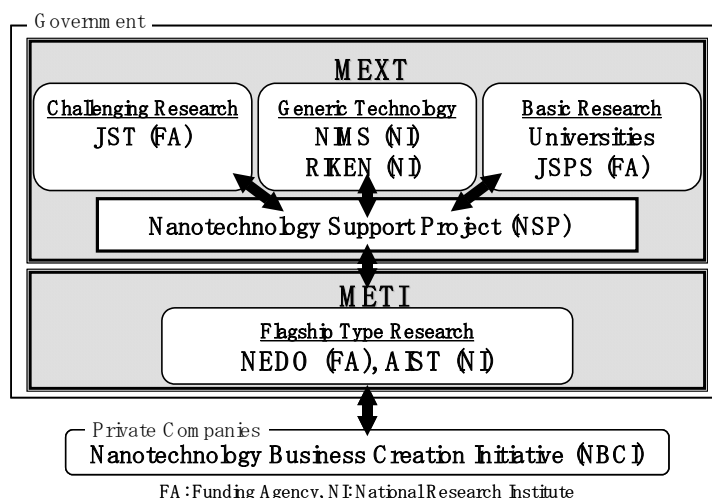


Figure 1. Nanotechnology Research, Development and Business Organizations in Japan

The overall pictures of programs supported by MEXT and METI are shown in Figure 2 and Figure 3, respectively (MEXT, 2004 and METI 2004b). Both ministries have several highlights of research programs such as the Leading Projects by MEXT (MEXT, 2004), the Nanotechnology Virtual Laboratories by JST (JST, 2003 and JST, 2004), the Focus 21 by METI, and the Nanomaterials and Processing Sub-Program by NEDO (METI, 2004a and METI, 2004b). Both Leading Projects and Focus 21 are the parts of the Research and Development Projects for Economic Revitalization, whose specific subjects as shown in Table 1 and Table 2, respectively, for which inter-organizational and interdisciplinary collaboration is

necessary. The Nanotechnology Virtual Laboratories has 10 research areas as shown in Table 3. In FY 2004, there are 7 to 19 research teams in each research area, and the total number of the teams is 106. JST dispatches both funds and researchers to the teams. The Nanomaterials and Processing Sub-Program consists of materials projects, processing projects, metrology projects, and systemization projects, all of which work interactively as shown in Figure 4.

Besides, in terms of technology transfer, intellectual properties, and centers of excellence, there are also several programs in which nanotechnology is involved (Government of Japan, 2001).

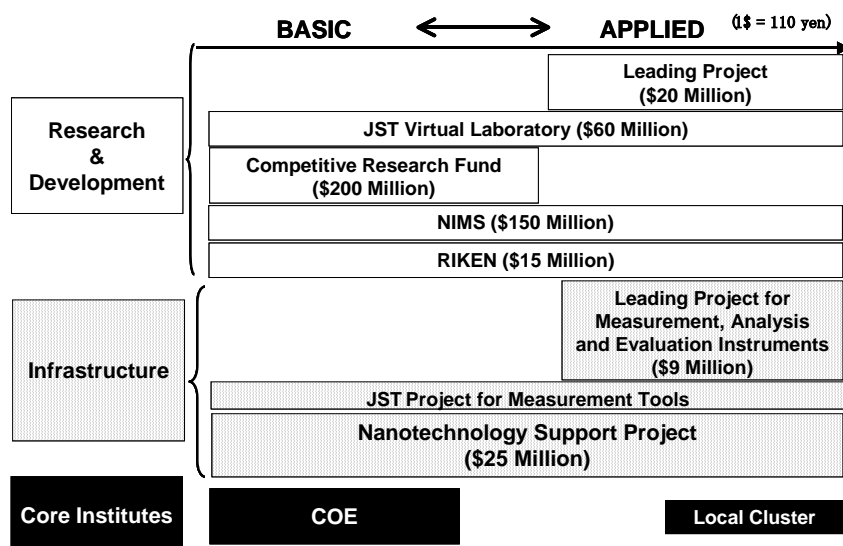


Figure 2. Main Nanotechnology Programs by MEXT - From Basic to Applied and Challenging Research (MEXT, 2004)

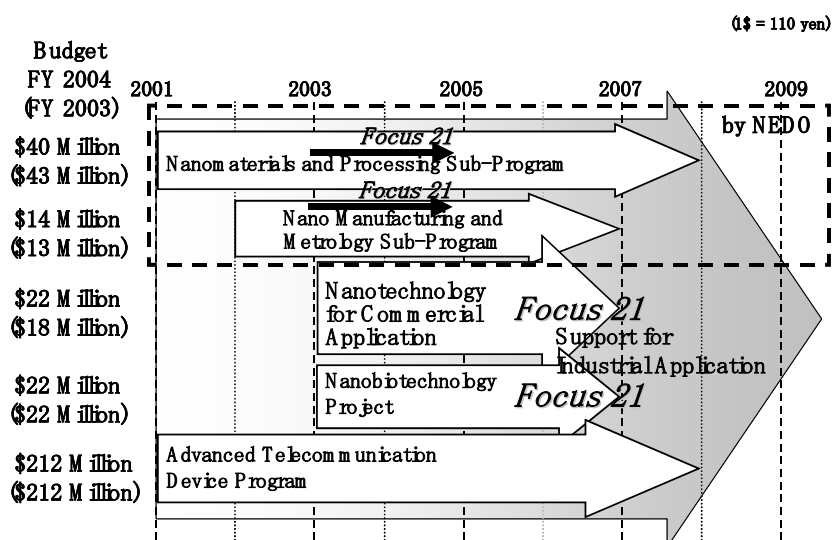


Figure 3. Main Nanotechnology Programs by METI  
- Creation of New Markets & Industries in 10 Years (METI, 2004b)

Table 1. R&D subjects of Leading Projects by MEXT (MEXT, 2004b)

Field	Subject
Life science	Development of artificial organs and artificial sensory organs that utilize nanotechnology - human body building
Information technology	New elemental device development utilizing nanotechnology
	Realization of advanced semiconductor manufacturing technology such as extreme ultraviolet (EUV) development
Environment	Next-generation fuel cell
Instruments	Development of measurement, analysis, and evaluation equipment which will lead next-generation scientific technology

subjects of Focus 21 by METI (METI, 2004)

Program	Subject
Nanomaterials and processing sub-program	Advanced nanocarbon application
Nanomanufacturing and metrology sub-program	Full color rewritable paper using functional capsules
Nanotechnology for commercial application	Advanced diamond technology
	Carbon nanotube FED
	Advanced nano glass for devices
	High strength nano glass for displays
	High efficiency UV emitting semiconductors
Nanobiotechnology project	Advanced nanobio devices
	Screen technology using nanoparticles
	Nanobio chip for protein interaction analysis
	Nano-encapsuled artificial erythrocytes
	Cell tissue fabrication using nanomanufacturing
	Nano medical devices

Table 3. Research areas of Nanotechnology Virtual Laboratories by JST (JST, 2004)

Field	Research area
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Information technology	Creation of ultrafast, ultralow power, super-performance nanodevices and systems
	Creation of nanodevices/system based on new physical phenomena and functional principles
	Nano factory and process monitoring for advanced information processing and communication
	Creation and application of nano-structural materials for advanced data processing and communication
Life sciences	Creation of bio-device and bio-systems with chemical and biological molecules for medical use
	Creation and application of “ soft nano-machine” , the hyperfunctional molecular machine
	Creation of novel nano-material/system synthesized by selforganization for medical use
Environment & energy	Creation of nano-structured catalysts and materials for environmental conservation
	Development of advanced nanostructured materials for energy conservation and storage
Interdisciplinary research	Creation of innovative technology by integration of nanotechnology with information, biological, and environmental technologies

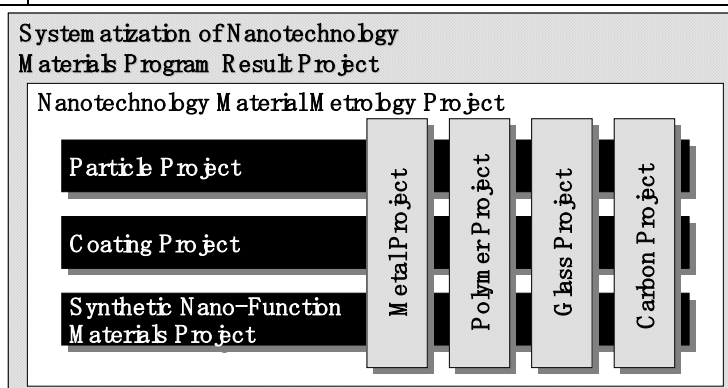


Figure 4. Nanomaterials & Processing Sub-Program by NEDO

- For Establishment of Fundamental Technology and Knowledge Platform (METI, 2004b)

### Nanotechnology Support Project

In nanoscience and nanotechnology, one of the most important roles of the national government is the creation of researcher network for the promotion of the collaboration among researchers from different research backgrounds. Based on this thought, MEXT started the Nanotechnology Support Project (NSP) in 2002. It is a five year project whose annual budget is \$25 million in FY 2004 (MEXT, 2004). The Nanotechnology Researchers Network Center of Japan (Nanonet) was founded as the core institution for the project. It is also one division of

NIMS.

NSP has two missions: informational support and common use facility support. Nanonet is responsible for informational support. Its specific tasks are as follows (Nanonet, 2004).

**(1) To collect and provide information on nanotechnology R&D.** Information on researchers, institutes, programs, patents, reports, and events is provided through its website (<http://www.nanonet.go.jp>) and e-mail newsletters, the Japan Nanonet Bulletin (JNNB), which are published every two weeks both in Japanese and English and have about 7,300 registered readers.

**(2) To organize symposia and workshops.** The biggest symposium organized by Nanonet is “Japan Nano”, held in February or March every year. Besides, 23 domestic and international conferences were organized or supported by them in FY 2003.

**(3) To organize international programs.** Bilateral researcher exchange programs and symposia have been regularly conducted with the USA, the UK, and Sweden, and France. Especially with the USA, NSF-MEXT joint symposia are held almost every half a year (Takemura, 2004).

**(4) To provide education and training opportunities.** Nanonet encourages researchers to diversify their fields by seminars such as “Nano-bio School”. For public including kids, educational materials such as a video, “The Adventure of Nano”, and comic books for the introduction of nanotechnology are prepared (Nanonet, 2003).

On the other hand, common use facility support is conducted by 14 universities and national research institutes as Shown in Figure 5. To researchers outside the institutes, they give opportunities to use 4 types of large scale, cutting edge facilities: ultra-high voltage TEMs, synchrotron radiation, nano-foundries group, and molecular synthesis and analysis. The features of the facilities are shown as follows (Nanonet, 2004).

**(1) Ultra-high voltage TEM group.** They supply the world’s highest voltage (3000 kV), the world’s highest resolution (0.1 nm), in-situ observation, ion implantation, atomic discrimination, magnetic domain observation, and so on.

**(2) Synchrotron radiation group.** SPring-8 is the world's largest third-generation, whose storage ring parameters are as follows. Electron energy: 8 GeV, characteristic photon energy: 28.9 keV, current: 100 mA, number of insertion devices: Max 38, circumference: 1,436 m, number of beamlines: Max 62 (JASRI, 2004).

**(3) Nano-foundries group.** With photo lithography, electron beam lithography, and other tools, they can satisfy the various needs of users such as several nanometer level ultrafine pattern, composite structure, and high aspect ratio structure.

**(4) Molecular synthesis and analysis group.** They help the analysis of nanostructures from various viewpoints such as mass, chemical molecular bond, magnetic property, nanoelectric state, photo-induced reactions.

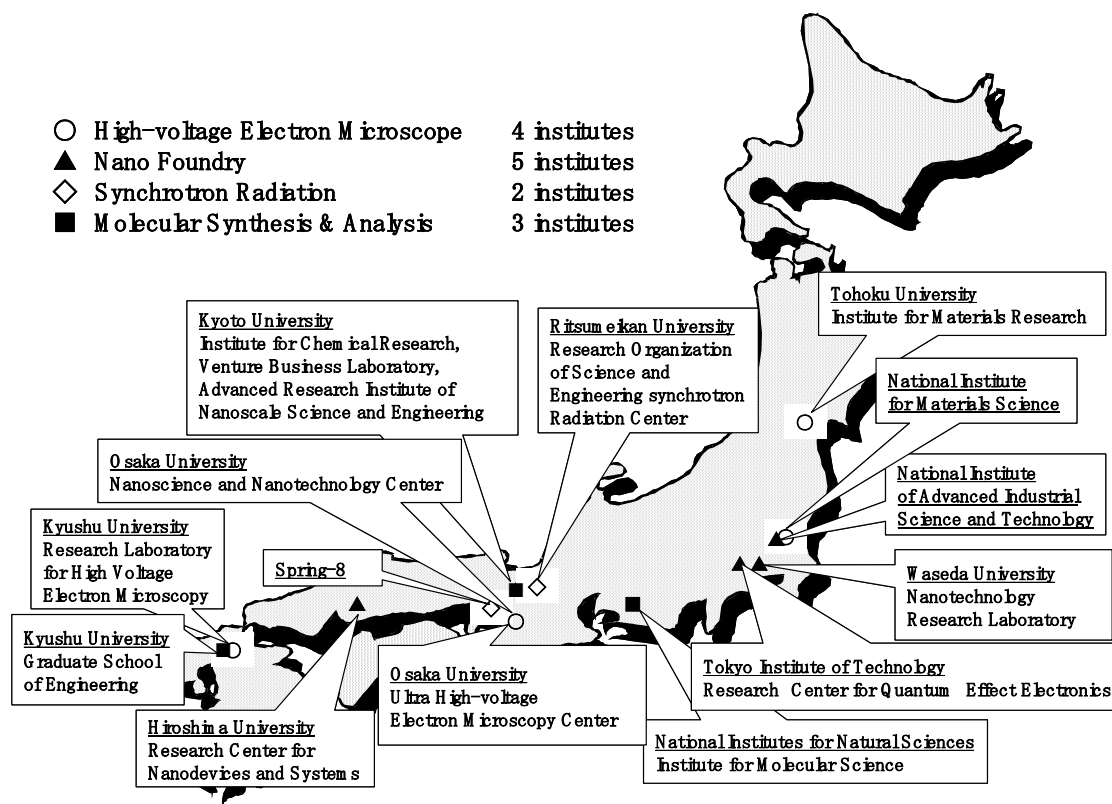


Figure 5. Common Use Facility Network of Nanotechnology Support Project  
 (Nanonet, 2004)

The total number of users are 804 in FY 2003, which increased by 60 % over the previous year. The percentages of numbers of users from universities, public institutes, and private corporations are 56 %, 16 %, and 28 %, respectively. The whole cost including user fees are covered by the project. Not only opportunities to use these facilities, they also give instructions to users and organize symposia and workshops to present their achievements. Nanonet also provides information and consultation on the facilities.

### Towards the future of nanotechnology in Japan

CSTP has begun to prepare the 3rd Science and Technology Basic Plan for the next 5 years from FY 2006. Through these processes, the future expected from the success of nanotechnology should be more clearly described for public. Besides the acceleration of R&D for industrial application, efforts for societal implications of nanotechnology will be more important. NIMS and AIST are proactive in coordinating activities such as workshops on human health, environmental, ethical, and societal issues of nanotechnology, in which institutes responsible for human health and environmental protection are also involved (AIST, 2004b).

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