FY 2007 WPI Project Progress Report
World Premier International Research Center (WPI) Initiative

Host Institution	National Institute for Materials Science	Host Institution Head	Teruo Kishi
Research Center	International Center for Materials Nanoarchitectonics Project	Center Director	Masakazu Aono

Summary of center project progress

A. Creation of a Research Organization

As planned, a Director-General, an Administrative Director and three Deputy Directors-General were appointed, and 22 Principal Investigators (including Director-General and Deputy Directors-General, 15 from NIMS and 7 from Satellites) were hired or transferred to MANA. 15 MANA Scientists were assigned to work under the supervision of the Principal Investigators. With the aim of utilizing NIMS large-scale and shared facilities, 10 researchers were selected from among the NIMS staff permanent scientists to serve as MANA Chief Scientists. Six of NIMS permanent engineers were assigned to MANA. The research organization was created by assigning 37 MANA Reesearch Associates (i.e. postdoctoral researchers), 26 Junior Researchers (i.e. participating graduate student researchers), 11 administrative staff (secretaries et al.) and 19 technical staff (technicians etc.) to serve under the direction of the Principal Investigators.

This organization serves as a career development track for young researchers. Eleven of the most promising of NIMS young permanent researchers were selected to serve as MANA Young Scientists. In addition, ICYS-MANA was established as a continuation of the ICYS project that was completed at the end of fiscal 2007. ICYS-MANA Researchers for this project were recruited internationally. Including members who transferred from the ICYS Project, the appointment of ten researchers from 7 countries has been finalized.

B. Research Activities

To achieve MANA research objectives, research was focused on the 4 key technologies of atom/molecule novel manipulation, field-induced material control, chemical nanomanipulation and controlled self-organization as well as on Theoretical modelling and designing to support these areas. Many achievements have been made.

C. Management

(1) In order to manage 1) strategic issues concerning MANA development and NIMS systems reforms and 2) day-to-day technical support and administration for MANA scientists, the Systems Reform Office and the MANA Administration Office were established within the administrative arm of the Center. (2)Under the leadership of the Director-General, a venue for discussion of center management issues, the Principal Investigators' Meeting, was established. (3) An Evaluation Committee was established and its first meeting was held. Advisors were selected. (4) The MANA Steering Committee was launched as a means for NIMS to provide support to the Center.

D. Composition of Center Scientists

An organization comprised of 170 individuals (157 in research section) was created with foreigners accounting for 35% of the total.

E. Satellites

Preparations are underway for the establishment of 6 satellites.

F. Facilities and Operations

- Continuing in the tradition of ICYS, a management system has been devised in which English is the official language.
- Startup research subsidies were allocated to external Principal Investigators and Young Scientists.
- Evaluation and salary systems were adjusted to reward research achievement.
- Research space was secured and nanofoundries were upgraded.
- The First MANA International Symposium was held.

G. Current Assessment

According to the self-evaluation, the project is proceeding as planned.

H. Securing Competitive Research Subsidies

The expected amounts of both operations subsidies and external competitive research subsidies have been secured. The Center expects to secure the same amounts in FY2008.

I. Commitments from the Host Institution

(1) Salaries for Chief Scientists and administrative staff participating in the MANA Project were allocated from operations subsidies. (2) Research subsidies for Principal Investigators and Chief Scientists were also allocated from operations subsidies to provide for smooth start to MANA research activities. (3) Necessary budgetary measures were taken to provide MANA with its own space on the 4^{th} and 5^{th} floors of the Nanomaterials and Biomaterial Research Building.

J. Other

Launched the MANA homepage (http://www.nims.go.jp/mana/)

1. Summary of center project

<Initial plan>

Most technologies that support our society have been realized through the development of new materials. This has been true throughout the ages. For example, Edison's electric light bulb was realized using bamboo from Kyoto 100 years ago, information and communication technologies in the past 50 years have been supported by silicon, the recent development of blue-light emitting devices was achieved using a semiconducting GaN compound, new fertilizers and agrochemicals have played a critical role in enabling a large increase in food productivity. Furthermore, materials science is a field in which Japan can best show its abilities. It is also clear that Japan's many successes in key industries including automotive, electrical machinery, and electronics have been supported by its great ability to develop materials.

Various technologies realized through the development of materials have brought about numerous benefits to humanity and contributed to improving welfare. However, several of these technologies are responsible for such serious problems as global warming and environmental pollution. In addition, rapid global industrial expansion, which is supported by technological development, is generating a new crisis -- a depletion of resources and energy sources. The 21st century is the period during which humanity, for the first time, has recognized the enormity and limits of the planet earth, and the future of humanity depends substantially on whether or not we can sustain development under the severe restrictions of energy, environment, resources and food. Serious problems caused by technologies can not be solved by abandoning technologies but only by further technological development. To solve the current global crisis, it is of critical importance to promote strongly cooperative research beyond national borders, thus concentrating the wisdom of scientists and engineers from across the world. Japan has the responsibility to assume a leading role in this endeavor.

The concept of a world premier research center that we propose here is designed from the viewpoints of the essential necessity of materials and the importance of an international cooperative system for solving problems. The purpose of the center is to develop and offer new materials that contribute to a sustainable development. For this purpose, excellent researchers, especially young researchers who will create a future, will join the center from across the world and perform intensive research under an internationally-open environment, based on a new materials development system "nanoarchitectonics (see below)". National Institute for Materials Science (NIMS) is the most appropriate research institute to take the initiative for the center as the host institution.

<Results/progress/alternations from initial plan>

This section has not changed since the time of application.

Overview of Achievements and Progress

A. Creation of a Research Organization

As planned, a Director-General, an Administrative Director and three Deputy Directors-General were appointed, and 22 other Principal Investigators (including Director-General and Deputy Directors-General, 15 from NIMS and 7 from Satellites) were hired or transferred to MANA (The new appointment in FY2008 of Professor Gerber from the University of Basel is nearly final. Administrative procedures for this are being conducted. The Center is also advertising internationally in publications such as *Nature* in order to attract top class scientists).

15 MANA Scientists were assigned to work under the supervision of the Principal Investigators. With the aim of utilizing NIMS large-scale and shared facilities, 10 researchers were selected from among the NIMS staff permanent scientists to serve as MANA Chief Scientists. Six of NIMS permanent engineers were assigned to MANA. The research organization was created by assigning 37 MANA Research Associates (i.e. postdoctoral researchers) , 26 Junior Researchers (i.e. participating graduate student researchers), 11 administrative staff (secretaries et al.) and 19 research staff (technicians etc.) to serve under the direction of the Principal Investigators and Chief Scientists.

One of the characteristics of MANA that needs further development is the continuation of the NIMS International Center for Young Scientists (ICYS) concept. The Center has focused on building systems to cultivate young scientists and to develop their career paths. In particular, eleven of the most promising of NIMS young permanent researchers were selected to serve as MANA Young Scientists. In addition, ICYS-MANA was established as a continuation of the ICYS project that was completed at the end of fiscal 2007. ICYS-MANA Researchers for this project were recruited internationally. Including members who transferred from the ICYS Project, the appointment of ten researchers from 7 countries has been finalized.

This melting pot of ICYS-MANA Researchers with diverse nationalities, cultures and research fields is expected to lead to breakthroughs. In order to cultivate a broad outlook and interdisciplinary sense in the MANA Young Scientists and Young Scientists and ICYS-MANA Researchers, the Center is following the 3-D system (Double-Affiliation, Double-Discipline, Double-Mentor). In other words, they affiliate to one other center aside from MANA, they have 2 Principal Investigators as mentors and they specialize in 2 fields. Mentor candidates and affiliation to other institutions for MANA Young Scientists are being investigated. Preparations to implement the 3-D system are underway.

(1) World's top-level organization

NIMS is one of the world's largest research institutes (see the table below) where basic research in materials is conducted comprehensively, and it has an international reputation for excellence based on its past research accomplishments, human resources, and facilities. We now rank 12th in the world for the number of citations of research papers in the past 10 years in the materials science field. However, over the past 5 years, we rank 6th in the world, which indicates that the research activities in NIMS increased dramatically after it changed to an independent administrative institution in 2001. We also have an excellent record for numbers of research papers, average impact factor, and other indices (see the figure).

Table: Personnel composition in NIMS

Position		Number	
		Total	(Foreigner)
Permanent Employee	Researcher	400	(28)
	Engineer	49	(0)
	Administrative staff	100	(0)
	Subtotal	549	(28)
Post-doc. etc.		661	(150)
Guest Researcher		285	(44)
Total		1495	(222)

Three advisors and 10 evaluation committee members were appointed and the first Evaluation Committee Meeting was held in March 2008 to advise the Center on its management.

B. Research Activities

To achieve MANA research objectives outlined at the time of application, research was focused on the 4 key technologies of atom/molecule novel manipulation, field-induced material control, chemical nanomanipulation and controlled self-organization as well as on theoretical modelling and designing to support these areas. Of special note are the achievements listed below.

i)Atom/Molecule Novel Manipulation

- Reversible control of local polymerization and depolymerization in thin films of C_{60}
- Optical waveguide of In_2O_3 single nanofiber
- Materials dependence of an atomic switch
- Manipulation of Nanostructure by External Stress-Strain Field

ii)Field-induced Material Control

- Development of nano half metals
- THz Laser Realized in Single Crystal High-Temperature Superconductors
- Highly orientated ceramics by in situ observation of alignment process and by rotation magnetic field
- Ferroelectric domain engineering
- New microwave effect on a superconductor-semiconductor junction
- Spin-injection effect in a ferromagnetic-semiconductor/superconductor junction

iii)Chemical Nanomanipulation

- Development of a novel visible-light-active photocatalyst
- Synthesis of new photofunctional nanosheets
- Development of a prototype drug delivery system based on a halide-filled Carbon nanotube
- Si nanowire semisphere-like ensembles as field emitters

iv)Controlled Self-Organization

- Design of pH-sensitive drug carrier effective for multi-drug resistant tumor cell lines
- Development of mesoporous nanocompartment films
- Molecular recognition based on transistor-concept
- Search of half-metallic materials with high spin polarization
- Microstructural characterization of sintered magnets
- Development of new methodology for characterization of electronic states in nanopowder
- Control of self-organization behavior at the heterointerface with polar crystals

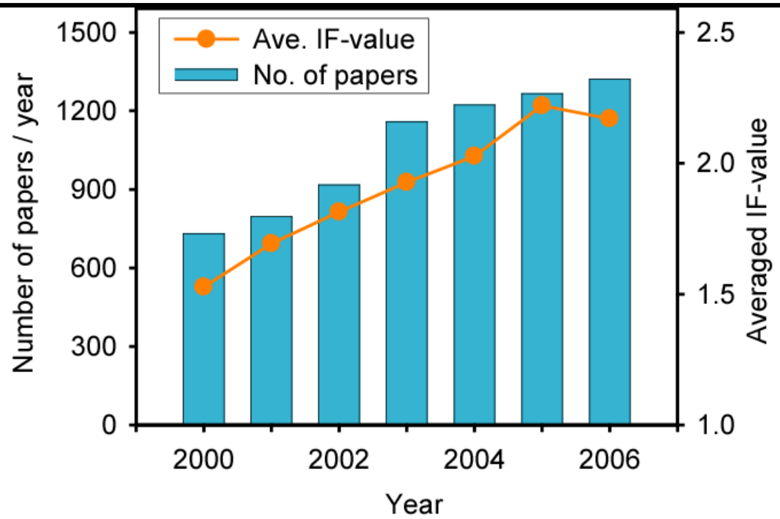


Figure: Number of papers and average impact factor of NIMS

(2) Internationally-open management

We established the International Center for Young Scientists (ICYS) in 2003, and over the center's 5 year operation we have accrued a great deal of experience in the organization of an internationally-viable research environment including the organization of a multinational group of young researchers and in the use of English as the official language, as well as in realizing an interdisciplinary research environment.

(3) Cooperation with overseas research institutes

We have various international cooperative relationships with key research institutes around the world. This includes summer schools that have been held regularly in cooperation with Cambridge University and the University of California for promotion of scientific exchange and fostering of young researchers.

(4) Joint graduate school

We have been actively fostering young researchers and developing cooperation with domestic and foreign universities through various activities including acceptance of graduate students by domestic and international Joint Graduate School Programs, as well as initiation of the University of Tsukuba Graduate School in NIMS (The Doctoral Program in Materials Science and Engineering of Graduate School of Pure and Applied Science, University of Tsukuba). Also, we offer "junior researcher" position for an excellent graduate student.

v)Theoretical Modelling and Designing

・Design for half-metallic antiferromagnet

C. Management

(1) Composition of the Administrative Unit

Since the time of application, the Center has further developed the structure of the administrative unit which has been organized as follows. We feel that this organization will provide effective management and sufficient support for the scientists as well as help realize administrative reforms at main body of NIMS.

・Systems Reform Office and the MANA Administration Office were established within the administrative arm of the Center

・The following five teams were established in the Systems Reform Office (As a rule Systems Reform Office staff serve concurrently as NIMS staff in order to concurrently manage MANA and standardize NIMS systems reforms)

I)Planning and Strategy Team（NIMS Office : Integrated Strategy Office）: Formulates strategic plans and proposals for the promotion the MANA Project and NIMS systems reforms.

ii)Human Resources Development Team（NIMS Office : Human Resources Development Office）: Recruits MANA researchers, cultivates research leaders for NIMS, establishment of a tenure track system, secures outstanding graduate student researchers

iii)International – Domestic Collaboration Team（NIMS Office : International Affairs Office）: Manage Satellites, World Nanotechnology Research Institute Forum, other international conferences, various research collaboration with external partners.

iv)Evaluation Team（NIMS Office : Evaluation Office）: Evaluation of the MANA Project, MANA-internal evaluation, MANA researcher evaluation

v)Public Relations Team（NIMS Office : Public Relations Office）: Public relations

・The following 2 teams were established in the MANA Administration Office.

i) Administrative Support Team: Provides administrative support to MANA scientists (order processing, purchasing, official trips, outside work, lifestyle support, English interpreting etc.)

ii) Technical Support Team: Provides technical support to MANA researchers (device maintenance, analysis, measurement, patent support etc.)

(2) Decision-Making System within the Center

・ Under the strong leadership of the Director-General, a venue for discussion of center management issues, the Principal Investigators' Meeting, was established.

(5) Technology transfer
We have been active in industrial cooperation, to grasp social needs and to promote technology transfer, through various activities including establishing a “platform” system to conduct collaborative research with enterprises and holding evening seminars (every week) for researchers in companies (see the figure below for results of funding given from the industrial world).

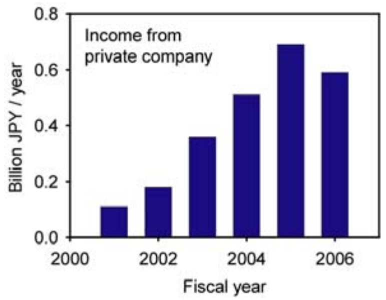


Figure: Funding from industry

Characteristics of NIMS in terms of performance and potential of research and development are as follows.

(1) Synthesis of materials
Internationally first-rate research accomplishments and potential concerning synthesis and processing of materials (For example, the world's first diamond synthesis by plasma CVD method, discovery of Bi-Sr-Ca-Cu high-Tc superconductors, synthesis of superplastic ceramics).

(2) World’s largest research facilities
Various high-performance large-scale facilities relating to synthesis, structural observation and physical property measurements, which are without equal anywhere in the world (high magnetic field facility, high magnetic field 1 GHz NMR, ultrahigh-pressure synthesis facility, high-resolution high-voltage electron microscope, Nano Foundry, etc.)

(3) Advanced nanotechnology
Top-level performance and potential in research fields of nanotechnology relating to synthesis, control, processing, and structural and physical property measurements in nanoscale (synthesis and applications of various new nanotubes and nanosheets, atomic switch for integrated circuits, various advanced nanoscale measurement devices, etc.)

- An Evaluation Committee comprised of 10 internal and external experts was established and the first meeting was held on March 12th, 2008. Advice on MANA management and research plans was received.
- Three Advisors were appointed to provide advice on the overall management of the Center.

(3) Division of Duties between the Director-General and Host Institution Representatives
- Systems were built so that the Director-General can display leadership in Center management (See (2)).
- The MANA Steering Committee consisting of the NIMS President, NIMS Vice Presidents, , the Director-General and the Administrative Director of MANA , etc. was established, and support systems for Center operation at host institutions were put in place. The first MANA Steering Committee Meeting was held on January 8th, 2008 to examine the status of MANA and discuss NIMS support policies.

D. Composition of Center Scientists

An organization comprised of 170 individuals (157 in research section) w created with foreigners accounting for 35% of the total.

E. Satellites and Partner Institutions

(1)Satellites
MANA establishes Satellites as organizations for the assignment of external guest Principal Investigators. Preparations for establishment are progressing without much trouble.

University of Tsukuba
Professor Kazuo Kadowaki and Professor Yasuo Nagasaki, Graduate School of Pure and Applied Sciences
Funded research contracts were signed with both professors and operations expenses for the Satellite was allocated from the MANA budget. Respectively the professors’ research fields are “High Temperature Superconductivity and Nanoelectronics” and “New Nanobioimaging and Materials Design for Nanodiagnoses and Treatment”. We anticipate that this will become a major Satellite for these research fields and for the supervision of MANA Young Scientists.

Tokyo University of Science
Professor Hideaki Takayanagi, Department of Applied Physics
The major projects at this Satellite are research into nanotechnology for new superconducting devices and supervision of MANA Young Scientists. To concurrently encourage research at both the Tokyo University of Science and

There is no equivalent independent material research institute that possesses those three characteristics. In the center proposed here, we will promote such research that is difficult to perform in other institutions, by closely linking these three characteristics as well as developing a new technology system "nanoarchitectonics". Meanwhile NIMS will perform its duty as a comprehensive research institute for materials science, targeting all materials including metals, ceramics, organic polymers, composite materials, by using various approaches from various fields including materials science, chemistry, physics, biological science, and life science. We are planning to send NIMS's most experienced researchers from various fields to the center, as well as to invite there top level researchers from around the world, in order to conduct basic research for materials, combining the fields of materials science, chemistry and physics.

The development of new materials required in the 21st century can not be realized without a paradigm shift of materials development. The center will realize the paradigm shift through a new materials development system that is named "nanoarchitectonics". "Nanoarchitectonics" is a technology system for arranging nanoscale structural units-- in other words, a nanostructure unit as a group of atoms and molecules-- in an intended configuration. This technology system can be roughly classified into two fields: "establishment of nanomaterials" and "establishment of nanosystems". A typical example of the former is one recent achievement of NIMS, where new composite materials consisting of nanosheets and heterogeneous substances were synthesized for the first time by soft-chemical layer-by-layer processing of nanosheets that were had been prepared in advance using a soft-chemical delamination technique of layered materials. With the enhancement of this method, it will be possible to synthesize various new materials that show unique functions. A typical example of the latter is the development of a nanoelectronics circuit. At present, challenging electronic devices are produced experimentally, using carbon nanotubes and functional molecules. In the "establishment of nanosystems", these devices are required to be integrated and linked as a system. This will open the new way to the development of innovative devices. On the other hand, key technology components in nanoarchitectonics are "artificial" self-organization", "field-induced material control", "chemical nanomanipulation", and "atom/molecule novel manipulation". In addition, theoretical and computational approach is quite important for conducting research effectively.

Nanoarchitectonics is an exceedingly dominant method for realizing innovative functions and performance that keep up with complex requirements for materials. The center will make the best use of this technology with the aim of developing new materials that contribute to sustainable development.

MANA, a dispatch contract was signed between Professor Takayanagi and NIMS, research space at NIMS was secured and budget monies allocated. Professor Takayanagi is now able to conduct his research at NIMS.

University of Cambridge

Prof. Mark E. Welland , Director, Cambridge Nanoscience Center

The major projects at this Satellite are research into the creation and measurement of new nanostructures and the supervision of MANA Young Scientists. An MOU and a joint research agreement will be signed in early fiscal 2008. Funds will be allocated and activities at the Satellite are expected to begin in earnest soon.

UCLA

Prof. James K. Gimzewski , Director, The Nano/Pico Characterization Lab, UCLA

The major projects at this Satellite are research into the fusion of nanotechnology and biotechnology and nano X-ray systems as well as the supervision of MANA Young Scientists.

An MOU was concluded between UCLA and MANA in order to establish the Satellite on-site. We are now stepping up efforts to sign a joint research agreement in early fiscal 2008. Funds will be allocated based upon the agreement and activities at the Satellite are expected to begin in earnest soon.

Georgia Institute of Technology

Prof. Zhong Lin Wang, Director, Center for Nanostructure Characterization (CNC)

The major projects at this Satellite are research into electronic materials and the supervision of MANA Young Scientists. An MOU and a joint research agreement will be signed in early fiscal 2008. Funds will be allocated and activities at the Satellite are expected to begin in earnest soon.

CNRS

Prof. Christian Joachim, Center for Material Elaboration & Structural Studies (CEMES) -CNRS, Toulouse

The major projects at this Satellite are theoretical research of new nanostructure functions and the supervision of MANA Young Scientists. An MOU and a joint research agreement will be signed in early fiscal 2008. Funds will be allocated and activities at the Satellite are expected to begin in earnest soon.

(2) Collaborative Institutions

To strengthen collaborative ties with other institutions, the Center plans to establish the World Nanotechnology Research Institute Forum (WNRIF). Preparations for its launch are underway.

To strengthen ties will global partners, MANA and the University of

Namely, the goal of research in the center is the "development of innovative materials that enable new technologies required for the realization of a sustainable society in the 21st century", with a new paradigm of materials development based on nanoarchitectonics. To be more specific, we set the three objectives as shown below together with the main types of materials to be studied intensively.

1) Development of innovative materials related to environment, energy and resource

Examples:
Superconducting materials (superconducting diamond thin film, etc.)
Battery materials (materials for solid state rechargeable batteries, etc.)
Catalysts (visible light active photocatalyst, etc.)

2) Development of innovative materials for nanoelectronics that lead to innovations in information and communication technology

Examples:
Quantum information device materials (novel quantum-bit materials, etc.)
Atomic electronics materials (materials for novel atomic switches, etc.)
Photonic device materials (quasi phase matching element material, etc.)

3) Development of innovative materials that enable the development of new technologies for diagnosis, treatment and renaturation.

Examples:
DNT chip materials (nanopiller array, etc.)
Biomaterials (regenerative materials, etc.)

To realize the paradigm shift in materials development and achieve the objectives of research, we will start the project, selecting form NIMS and other domestic and overseas institutes 22 principal investigators who have the most excellent abilities and careers. During the project, we will find additional principal investigators, including Asian (non Japanese) researchers, resulting in a final total of about 27. (Indeed, it has been decided that a distinguished Swiss researcher will join the center from 2008 if this proposal is accepted. Moreover, we will make efforts to increase the number of female principal investigators (although there is only one at the present stage.) Under the principal investigators, the center will arrange the lineup consisting of about 200 staff in total including technical staff, and select and organize excellent young researchers.

Regarding managerial operation, the center will succeed and develop the

Washington have agreed to the establishment of a MANA (NIMS) Office at the University of Washington. We are now stepping up efforts to sign a joint research agreement.

F. Facilities and Operations

- Continuing in the tradition of ICYS, a management system is being devised in which English is the official language. Experience ICYS staff with excellent English proficiency have been retained for the MANA project.
- Startup research subsidies were allocated to external Principal Investigators and Young Scientists.
- 10 Postdoctoral researchers were secured through an international recruitment drive.
- Evaluation and salary systems were adjusted to reward research achievement.
- Research space was secured and nanofoundries upgraded.
- The First MANA International Symposium was held.

G. Current Assessment

According to the self-evaluation, the project is proceeding as planned.

H. Securing Competitive Research Subsidies

The expected amounts of both operations subsidies and external competitive research subsidies have been secured. The Center expects to secure the same amounts in FY2008.

I. Commitments from the Host Institution

MANA was established to take the lead in research for NIMS as a whole. NIMS is providing maximum support to achieve this goal. MANA also serves as a proving ground for future NIMS tenured researchers, so NIMS has transferred some of its outstanding young researchers to MANA to enhance research capacity. In this manner, MANA and NIMS are building a solid collaborative relationship. In particular, the following support has been provided.

i) Salaries for Chief Scientists and administrative staff participating in the MANA Project were allocated from operations subsidies of NIMS.

ii) Most research subsidies for NIMS researchers serving as Principal Investigators on the operations subsidy project were allocated to and utilized for MANA. In addition, a portion of the competitive research funds that NIMS researchers working for MANA secured were allocated directly to MANA in accordance with the Center's research plan. Research subsidies for Chief Scientists were also allocated from operations subsidies to provide for smooth start to MANA research activities

iii) It has been decided that conference rooms, the old library and storage rooms in the Administration Building on the Namiki site will be renovated into concepts from the International Center for Young Scientists (ICYS) program, which is now being operated by NIMS. NIMS established ICYS in 2003 supported by the "Program for Fostering Strategic Research Centers", a Special Coordination Fund for Promoting Science and Technology of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Operating ICYS, where talented young multinational researchers gather to study independently in a "melting pot" environment with mixing of different research fields and different cultures, we have been conducting cutting-edge research and nurturing research leaders of the next generation, as well as promoting the internationalization of NIMS's main body using a spillover effect. The basic concepts of ICYS are as follows:

(1) Research center consisting of multinational groups of young researchers
(2) Internationalized management using English as the official language
(3) Promotion of interdisciplinary research in a "melting pot" environment with mixing of different research fields and different cultures
(4) Research management that respects the ideas of individual researchers.

ICYS has been given high marks for its activities, as receiving an "A" in a comprehensive evaluation using a 4-point scale "ABCD" in the interim assessment conducted by the MEXT.

Utilizing the experience of ICYS, the center will establish a "melting pot" research environment, gathering excellent young researchers from various countries. The center will respect the novel and freewheeling ideas of young researchers as much as possible and the "melting pot" research environment will be an ideal incubation apparatus for such ideas. As detailed later, the center also utilizes this "melting pot" environment to foster young researchers, contributing to the main body of NIMS by providing young staff researchers. In addition to the basic concepts of ICYS, the center will adopt unique systems, such as the examples shown below, to thoroughly promote the integration of different fields and to foster young researchers.

Mentor system: Principal investigators will be positioned as "mentors" and will decide the basic direction of research leading young researchers with, as far as possible, respect for their research ideas.

3D system (Double-mentor, Double-discipline, Double-affiliation system): Young researchers will belong to two organizations (center plus satellite or cooperative institute), have two disciplines and be led by

laboratories in order to provide MANA with its own space on the 4th and 5th floors of the Nanomaterials and Biomaterial Research Building. According to the renovation plan, MANA is expected to move into the 4th and 5th floors sometime in fiscal 2008 once a new location for the devices currently housed there has been determined.

J. Other

(1) Establishment of the MANA homepage.
http://www.nims.go.jp/mana/

(2) Creation of the MANA logo (See Figure 1)

Figure 1 : The MANA Logo

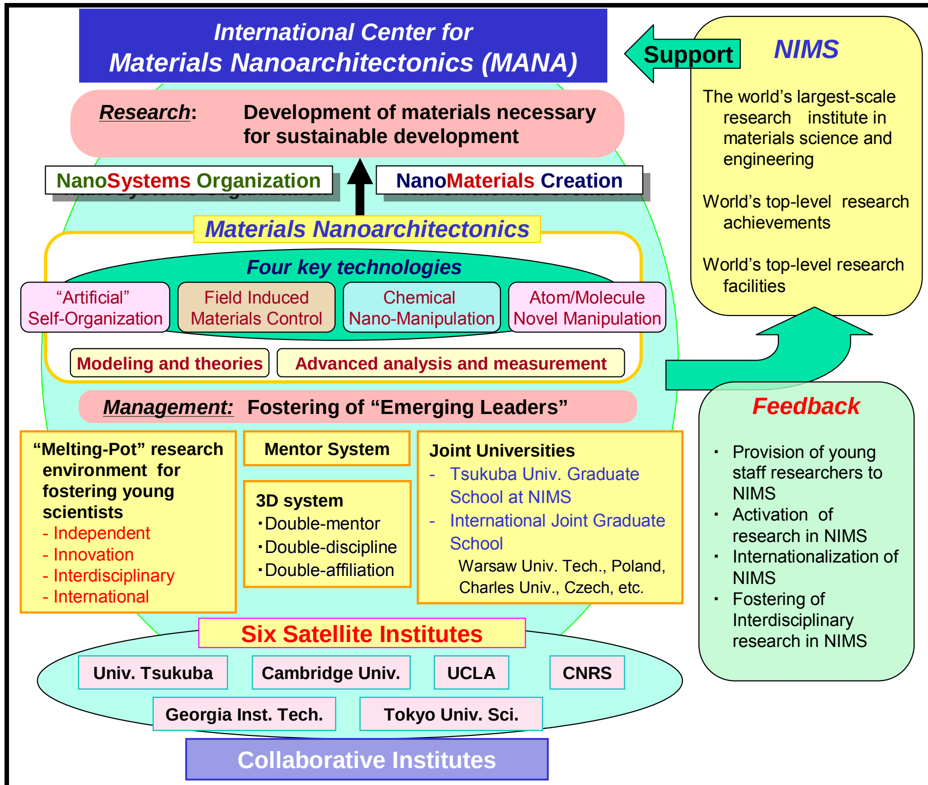
two mentors. This rule aims to promote interdisciplinary alliances among different fields and to foster far-sighted researchers with an interdisciplinary background.

Active cooperation with universities:

The center will accept many graduate students, especially foreign graduate students, who can contribute to conduct the center's research as junior researchers and to enrich the "melting pot" environment, by improving and expanding the University of Tsukuba Graduate School in NIMS and International Joint Graduate Schools with foreign universities as well as by utilizing other invitation programs for students.

One of the characteristics of the center is that it will be definitely incorporated into the long-term strategies of the main body of NIMS, which is the host institution. The research objectives of the center are perfectly consistent with the mid-to-long term objectives of NIMS, and therefore, the center will play a principle role to lead the main body of NIMS by carrying out these objectives in a radically accelerated manner. We expect that, not only the center itself, but NIMS as a whole, can finally attain a top ranking position internationally. On the other hand, the center will also undertake a role to nurture research leaders of the next generation taking advantage of the center's international and interdisciplinary atmosphere. We have decided that, if this proposal is realized, NIMS's new staff researchers with tenure will be chosen, in principle, from young researchers of the center. Thus, the center will be positioned as an organization to supply human resources to the main body of NIMS. Therefore, it is quite important from the viewpoint of NIMS that the center undertakes the role of fostering of researchers in addition to the implementation of cutting-edge research. We should be able to activate the whole of research at NIMS, supported by these two actions of the center.

The gathering of a multinational, multicultural and multidisciplinary group of young researchers under the leadership of world class principal investigators (mentors) is the most important part of the center's structure. Formation of such a group is difficult within the main body of NIMS and this "melting pot" research system of the center will be a stimulating environment for scientific breakthroughs.



2. Research fields

<Initial plan>	<Results/progress/alternations from initial plan>
The 21st century is, without doubt, the century where humanity, for the first time in its experience, recognizes the enormity and limits of the earth. The future of humanity depends on whether or not we can find a way to sustain development, under severe restrictions of energy, environment, resources and food. To solve this common issue for all humanity, the most dominant field of research that Japan can contribute will be in materials science. Materials form the basic foundation that supports all technologies, and is the area where Japan can best show its abilities. In fact, the many successes of Japan in key industries such as automotive, electrical machinery, and electronics have been realized by the development of materials. It is self-evident that industries and society of Japan will be depending on materials in the 21st century, and it is also true that "sustainable development" is not possible without an innovation	Research is being conducted according to the fields stipulated at the time of application, and we are striving to create a research-friendly environment. No areas need to be changed when compared to the documentation provided at the time of application.

in materials. Materials science is actually the lifeblood for human beings.

For the development of new materials that will be required in the 21st century, the center is working to realize a paradigm shift in materials research through a new materials development system named “nanoarchitectonics”. “Nanoarchitectonics” is a technology system to arrange nanoscale structural units -- in other words, a nanostructure unit as a group of atoms and molecules-- in an intended configuration. This technology is critical for development of nanotechnology, beyond the stage of nanoscience. “Nanoarchitectonics” is also a typical interdisciplinary field that relates widely to such fields as material science, physics, and chemistry.

3. Research objectives

<Initial plan>

a) Research Objectives

The development of new materials required in the 21st century can not be realized without a paradigm shift in materials development. The center will realize this paradigm shift through “nanoarchitectonics”, which is a new technology system for arranging nanoscale functional structural units, such as a group of atoms or molecules, in an intended configuration. The research objective to be achieved by materials development based on nanoarchitectonics is:

“Development of innovative materials required for the realization of a sustainable society in the 21st century”.

To be more specific, we set the following three objectives (issues to be studied intensively are shown as examples).

1) **Development of innovative materials related to environment, energy and resource**

Examples:
Superconducting materials (superconducting diamond thin film, etc.)
Battery materials (materials for solid state rechargeable batteries, etc.)

<Results/progress/alternations from initial plan>

This section has not changed since the time of application.

Achievements and Progress

1. Creation of a Research Organization

A Director-General, an Administrative Director and three Deputy Directors-General were appointed, and 22 other Principal Investigators (including Director-General and Deputy Directors-General, 15 from NIMS and 7 from Satellites) were hired or transferred to MANA (The new appointment in FY2008 of Professor Gerber from the University of Basel is nearly final. Administrative procedures for this are being conducted. The Center is also advertising internationally in publications such as *Nature* in order to attract top class scientists).

15 MANA Scientists were assigned to work under the supervision of the Principal Investigators. With the aim of utilizing NIMS large-scale and shared facilities, 10 researchers were selected from among the NIMS staff permanent scientists to serve as MANA Chief Scientists. Six of NIMS permanent engineers were assigned to MANA. The research organization was created by assigning 37 MANA Research Associates (i.e. postdoctoral researchers), 26 Junior Researchers (i.e. participating graduate student researchers), 11 administrative staff(secretaries et al.) and 19 technical staff (technicians etc.) to serve under the direction of the Principal Investigators.

One of the characteristics of MANA that needs further development is the

Catalysts (visible light active photocatalyst, etc.)

2) **Development of innovative materials for nanoelectronics that lead to innovations in information and communication technology**

Examples:
Quantum information device materials (novel quantum-bit materials, etc.)
Atomic electronics materials (materials for novel atomic switches, etc.)
Photonic device materials (quasi phase matching element material, etc.)

3) **Development of innovative materials that enable the development of new technologies for diagnosis, treatment and renaturation.**

Examples:
DNT chip materials (nanopiller array, etc.)
Biomaterials (regenerative materials, etc.)

b) Research plan

As stated at the beginning of this document, requirements for new materials to realize new technologies required in the 21st century are advancing, and the development of new materials that can respond to such requirements can not be realized without a paradigm shift in material development. Our research center aims to realize this paradigm shift through a new technology system that is named “nanoarchitectonics”.

Prior to an explanation of “nanoarchitectonics”, we would like to confirm the appropriateness of the vision that nanoscale structural control is important to create new functions, which has been accepted widely, regardless of whether it is macro structural material, micro electronic device material, inorganic materials, organic materials, or biomechanical materials. Through a remarkable development over these recent 20 years in nanoscience and nanotechnology, it was verified in many instances that new functions can be created by controlling structures at the nanoscale.

It was hoped that that dreamlike development would be awaiting us in the future of remarkable developments in nanotechnology. However, recently a question has arisen relating to whether nanotechnology is really developing as expected. The question arose coincidentally by the recent recognition that a

continuation of the NIMS International Center for Young Scientists (ICYS) concept. The Center has focused on building systems to cultivate young scientists and to develop their career paths. In particular, eleven of the most promising of NIMS young permanent researchers were selected to serve as MANA Young Scientists. In addition, ICYS-MANA was established as a continuation of the ICYS project that was completed at the end of fiscal 2007. ICYS-MANA Researchers for this project were recruited internationally. Including members who transferred from the ICYS Project, the appointment of ten researchers from 7 countries has been finalized.

This melting pot of ICYS-MANA Researchers with diverse nationalities, cultures and research fields is expected to lead to breakthroughs. In order to cultivate a broad outlook and interdisciplinary sense in the Young Scientists and ICYS-MANA Researchers, the Center is following the 3-D system (Double-Affiliation, Double-Discipline, Double-Mentor). In other words, they affiliate to one other center aside from MANA, they have 2 Principal Investigators as mentors and they specialize in 2 fields. Mentor candidates and affiliation to other institutions for Young Scientists are being investigated. Preparations to implement the 3-D system are underway.

Three advisors and 10 evaluation committee members were appointed and the first Evaluation Committee Meeting was held in March 2008 to advise the Center on its management.

Figure 2 shows MANA’s organizational chart. The number of members in the research arm of MANA is listed in Table 1.

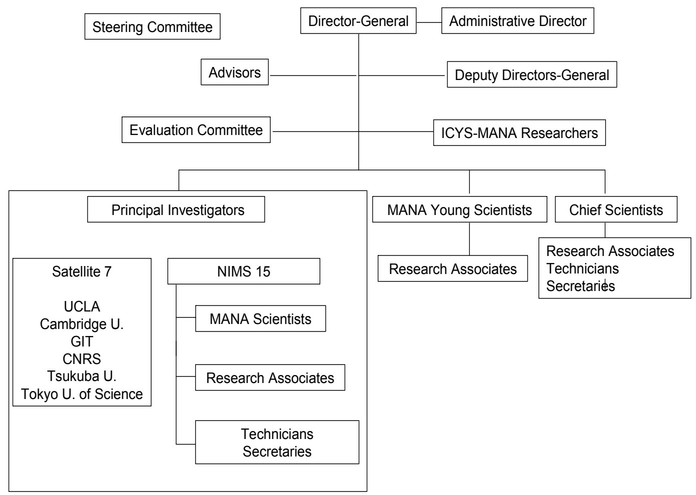


Figure 2: MANA Organizational Chart (Research Section)
Table 1: Number of Members: Research

sort of breakthrough is inevitable for the practical use of nanotechnology, beyond the nanoscience level. Such a breakthrough will be made by pioneering a new technology system for creation of a new function of the whole unit, by arranging individual nanostructual units that have useful functions in an intended configuration. Such a technological system is called "***Nanoarchitectonics***".*

* Note: The word "***Nanoarchitectonics***" in this context was first used at the First International Symposium on Nanoarchitectonics Using Suprainteractions (NASI-1) for which Dr. Aono (Prospective Center Director) served as chairman. The second symposium, NASI-2, was held in Los Angeles and chaired by Professor Jim Gimzewski of UCLA (one of the chief researchers of this research center), and the third symposium NASI-3 is scheduled to be held in Cambridge and will be chaired by Professor Mark Welland of Cambridge University (also one of the chief researchers of this research center).

"Nanoarchitectonics" is a technological system to arrange nanoscale functional structural units as a group of atoms and molecules in an intended configuration. The purpose is to produce a new function of the whole unit through concerted interaction between nanostructures, so it is needless to say that fundamental research in the related materials science field is included. Nanoarchitectonics can be roughly classified into two fields, "NanoSystem Organization" and "NanoMaterials Creation" (See Figure 1). A typical example of the "NanoSystem Organization" is the development of a nanoelectronics circuit. Challenging electronic devices are produced experimentally, using carbon nanotubes, functional molecules, etc., but the practical use is impossible without a technology to integrate and link these devices into a system. A typical example of the "NanoMaterials Creation" is synthesis of a new material that does not exist in nature by combining and laminating heterogenous substances with "nanosheets" that were obtained by chemical exfoliation from a layered material. With the enhancement of this technique, it will be possible to synthesize various new materials that show interesting functions.

Position	No.	No. of Foreigners
Director-General(*cum* PI)	1	
Deputy Director-General(*cum* PI))	3	
Principal Investigator（NIMS）	11	3
Principal Investigator（Satellites）	7	4
Chief Scientists	10	
MANA Scientist	15	2
MANA Young Scientists	11	2
ICYS MANA Researcher	-	-
MANA Research Associate	37	30
Junior Researcher	26	12
Engineers	6	
Contract Technical Staff	19	6
Administrative Staff	5	
Contract Administrative Staff	19	1
Total	170	60

i) Director-General
ii) Administrative Director
iii) Deputy Directors-General
iv) Principal Investigators (PI)
v) Chief Scientists
Permanent researchers that conduct MANA research using NIMS large-scale and shared facilities and equipment.
vi)MANA Scientists
Permanent researchers that conduct research under the direction of the Principal Investigators.
vii) MANA Young Scientists
Permanent young researchers who conduct independent research (and receive advice from Principal Investigators and other mentors as needed)
viii)ICYS-MANA Researchers (Independent Postdoctoral Fellows)
Postdoctoral fellows who conduct independent research (and receive advice from Principal Investigators and other mentors as needed)
ix) MANA Research Associates（Postdoctoral Fellows）
Postdoctoral Fellows that conduct research under the direction of the Principal Investigators.
x) Junior Researchers
Graduate student researchers that participate in research.
xi) Engineers

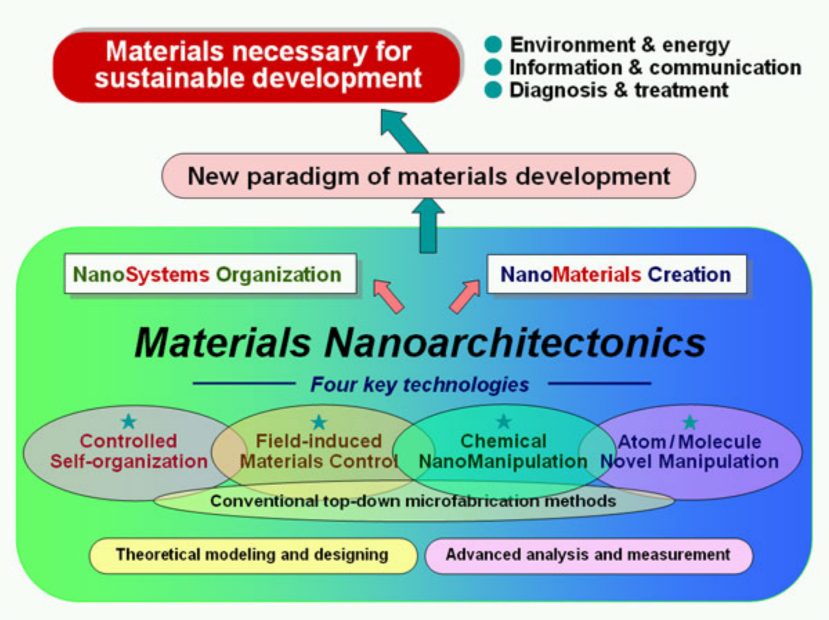


Figure 1: New paradigm in material development through materials "nanoarchitectonics"

Technologies used in nanoarchitectonics can be roughly classified into 4 techniques: (1) atom/molecule novel manipulation; (2) chemical nanomanipulation, (3) field-induced material control; and (4) "artificial" self-assembly and organization ("artificial" means "controlled" or "guided"); see Figure 1. In addition, theoretical and computational approach is quite important for conducting research effectively. The capabilities and features of each technique are illustrated in Figure 2, using actual examples (all of these examples are selected from the world's first research of their kind performed at NIMS).

Novel atom/molecule manipulation is a method to control the configuration or the coupling state of individual atoms and molecules using proximity probes including scanning tunneling microscope (STM) and atomic force microscope (AFM). This method has excellent advantages unsurpassed by other methods, in terms of arbitrary operation on single atoms and molecules, although there is a disadvantage in terms of time consumption when handling a number of atoms and molecules. However, it is thought to be better to use the advantages of this method and overcome the disadvantage, rather than abandon this method because of its disadvantage. This disadvantage may be conquered by massively parallel use of probes combined

Specialists that improve upon research technology.

xii) Contract Technical Staff

Technicians that provide research supports for the MANA Researchers.

xiii)Administrative Staff

Staff that provide administrative supports for the MANA Researchers

xiii) Contract Administrative Staff

Contract Staff that provide administrative supports for the MANA researchers

2. Research Activities

To achieve MANA research objectives, research was focused on the 4 key technologies of atom/molecule novel manipulation, field-induced material control, chemical nanomanipulation and controlled self-organization as well as on theoretical modeling to support these areas. Many achievements have been made as shown below.

(1) Atom/Molecule Novel Manipulation

Reversible control of local polymerization and depolymerization in C_{60} thin films

By positioning an STM tip about 1 nm above a thin film of C_{60} molecules formed on a conductive substrate, and applying an appropriate bias voltage to the STM tip, we can polymerize C_{60} molecules just below the STM tip. If the STM tip is scanned parallel to the C_{60} film, polymerization of C_{60} molecules occurs along the scan line. Interestingly, by scanning the STM tip again along the same line and applying a different appropriate voltage, the polymerized C_{60} molecules can be completely depolymerized. Based on these remarkable findings, we have demonstrated that a single-molecule-level ultradense memory of the order of 100 Tb/in^2 can be realized.

Optical waveguide of In_2O_3 single nanofiber

Optical properties of a single semiconductor nanofiber were measured using a scanning near-field optical microscope (SNOM) equipped with a local light irradiation system. One end of the In_2O_3 nanofiber was locally illuminated by laser beam via an optical fiber with an aperture. Luminescence and waveguide properties were measured at the other end of the nanofiber using the SNOM. Waveguiding behavior of the nanofiber was clearly observed. The results suggest that In_2O_3 single nanofibers can be effectively used as waveguide elements in integrated photonic applications, such as for optical input/output and optical logic gates.

Material dependence of atomic switch

with self-organization of materials. Chemical nanomanipulation is a method to control nanoscale substances by skillfully utilizing chemical equilibrium states and non-equilibrium states in a liquid or solid phase, temporally and spatially. This method enables nanomanipulation of various substances. Field-induced materials control is a method which uses changes in physical states dexterously through the intervention of electric fields, magnetic fields, electromagnetic fields (light, X-ray), and stress fields. Such efforts have been made conducted to date, but the research center will actively endeavor to pioneer new methods. To cite an example, NIMS found that the positions of molecules which are able to move relatively freely on a substrate can be immobilized by X-ray irradiation with a wavelength specific to those molecules, after arranging the molecules in an intended configuration. "Artificial self-assembly and organization is at the opposite end of the above atom/molecule novel manipulation. The latter is an artificial method to forcibly manipulate individual atoms and molecules, but this method relies on interactive forces specific to atoms and molecules. Hence, diverse effective nanoarchitectonics may be realized by the successful combination of both methods. Many studies in this research center will be related to the task of combination.

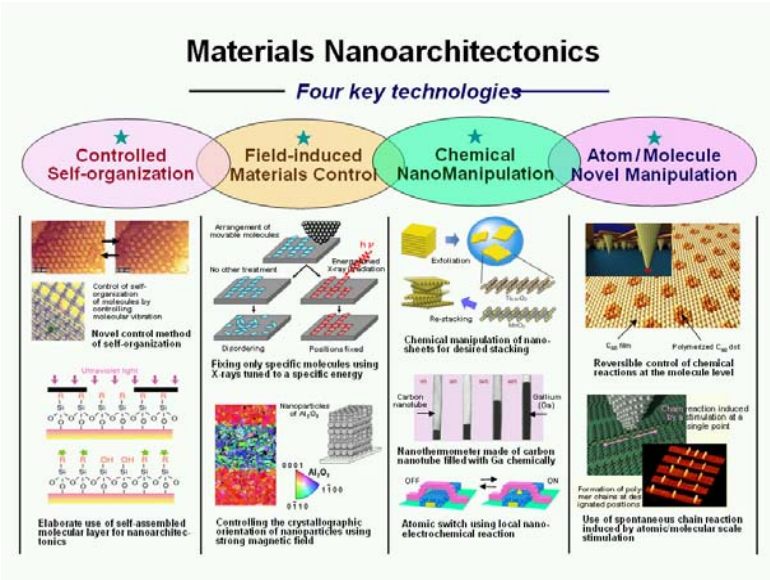


Figure 2: Illustration of materials nanoarchitectonics

Making full use of the above nanoarchitectonics concept, the center will endeavor to realize a new paradigm shift in material development. It would

Operating properties of an atomic switch can be controlled by changing the stoichiometry of the mixed conductor, which is a key material of the atomic switch. Atomic switches with varied stoichiometry copper sulfide were fabricated, and their electrical properties were measured. Only the atomic switch with excess copper ions in the mixed conductor achieved satisfactory switching behavior. The results suggest that switching properties, such as operating bias voltage and switching speed, can be designed by controlling the stoichiometry. This could be a first step for device engineering of the atomic switch.

Manipulation of Nanostructure by External Stress-Strain Field

Stress and strain field applied internally or externally to certain materials provides them with novel functionality and structure. In fact, a strain field applied to bulk silicon can cause a significant change in its electronic state and, subsequently, carrier mobility. Thus, the exploration of materials that can exhibit novel nanofunctionality stimulated by the application of stress field is a new frontier for nanomaterials research. For this purpose, we developed a scanning tunneling microscope (STM) that can apply a controlled stress field to sample surfaces in ultrahigh vacuum and at variable temperatures (*Nanotechnology* 2008). Using this technique, we confirmed domain redistribution on the Si(100) surface induced by applying uniaxial tensile stress and strain at elevated temperatures, where an intrinsic double-domain structure changed to a quasi single-domain one. Further improvement of the stress-field STM and *in-situ* measurement technique will promote the clarification of atomistic mechanisms and exploration of novel stress-induced nanofunctionalities.

(2) Field-induced Materials Control

Discovery and growth of nano-half metal

A novel spintronic material was discovered and its crystal was grown. The crystal (chemical formula is NaV_2O_4) consists of atomic-sized chains, and first-principles calculations indicated that each chain is half metallic (namely, conducting spins are 100% polarized). However, the crystal does not show the properties expected of a half-metal. Analyzing the magnetic and electrical properties observed for the half-metallic chains, it became clear that the half-metallic chains are alternately aligned with anti-parallel half-metallic chains. The spatial distribution on a nano-scale of the fully polarized spins is phenomenologically different from the nature of a half-metal. Thus, we gave the material the new name of "nano-half metal" to distinguish the novel crystal from regular half metals. Since the nano-half metal is expected to be useful for spin-hall applications, further studies are in progress.

THz Laser Realized in Single-Crystal High-Temperature Superconductors

We recently succeeded in fabricating a mesa with dimensions of ~1 be difficult to achieve such a study based on nanoarchitectonics, if it were not conducted in a research institute above a certain size endowed, which possesses excellent human resources, experience and facilities. Thus, NIMS is a highly appropriate research institute for promoting such studies. This will be detailed in the following paragraph.

To realize the above-mentioned paradigm shift in materials development and to achieve the above-mentioned research objectives, we will start the project, selecting form NIMS and other domestic and overseas institutes 22 principal investigators who have the most excellent abilities and careers. During the project, we will find additional principal investigators including Asian (non Japanese) researchers resulting in final number of about 27. (Indeed, it has been decided that a distinguished Swiss researcher will join the center from 2008 if this proposal is accepted. Moreover, we will make effort to increase number of female principal investigator though it is only one at the present stage.) Out of 22 principal investigators, 14 investigators are from NIMS, the host institution, and 8 investigators are from external institutions. Regarding the 8 investigators from external institutions, 5 investigators are from abroad and 3 investigators are from Japan. 7 of 22 principal investigators are foreign national investigators. 16 of the 23 principal investigators are internationally known top-class investigators (asterisks denote these people). Figure 3 illustrates how these principal investigators will be involved in the establishment of the new paradigm shift in material development through nanoarchitectonics as well as in the research stated in the above 1) to 3) research objectives.

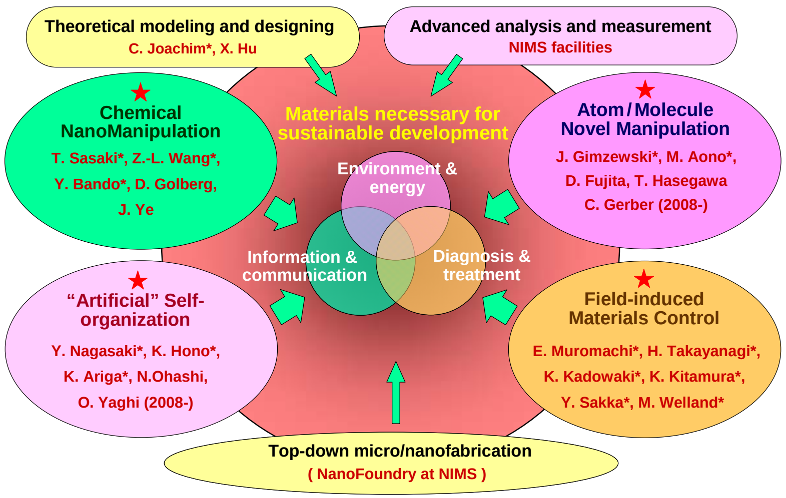


Figure 3: Research Implementation System

micron thick and about 50 microns wide from a high-quality single-crystal copper-oxide superconductor, generating strong, continuous and coherent electromagnetic waves at a frequency of 0.5–2.5 THz by DC current operation (refer to L. Ozyuzer et al., Science 318, 1291 (2007)). $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212) single crystals have the strongest degree of two-dimensionality among high-temperature superconductors due to the two-dimensional CuO_2 planes in the crystal structure, which are responsible for the superconductivity. These CuO_2 planes are alternately stacked with insulating Bi_2O_2 layers, forming a densely packed layer stack of Josephson junctions with atomic-scale thickness (~1.5 nm). This is referred to as an intrinsic Josephson junction. This intrinsic Josephson junction is 1 micron thick and consists of about 650 Josephson junctions that work together coherently, resulting in immense total power proportional to the square of the number of Josephson junctions. It is noted that this phenomenon is very similar to the laser operation in optics. An output power of 5 μW can be realized at present. A better understanding of the laser action taking place in the intrinsic Josephson junctions as well as improvement of the output power would foster the development of a wide range of applications that include not only physical and chemical analyses, but also biological, pharmaceutical, food chemical, toxicological, medical and diagnostic, environmental monitoring, high-speed communications, defense, homeland security, etc.

Highly orientated ceramics by in-situ observation of alignment process and by rotating magnetic field

The alignment process of particles with anisotropic weak magnetic susceptibility was successfully observed in situ up to 13 T by means of a laser microscope system developed at NIMS. In the diluted suspension, the rotation time normalized by viscosity was found to be expressed by the function of particle size and was successfully analyzed by considering Brownian motion. This finding has clarified the previously uncertain alignment process of particles in a strong magnetic field and is expected to improve the fabrication of textured materials. Moreover, a novel system was developed for electrophoretic deposition under a rotating magnetic field, whereby aligned particles are deposited and consolidated through external stimulation by means of both direct current and rotating magnetic field. Although one-directional orientation of AlN ceramics was not achieved under a static magnetic field, one-directional orientation with the c-axis plane was successfully achieved under the rotating magnetic field.

Ferroelectric domain engineering

In a study on ferroelectric domain engineering, we explored the photocatalytic function using our lithium niobate template that has a spontaneous polarization pattern in nanoscale. So far, the photocatalytic function via

c) Past results

Past results of NIMS, the host institution, are summarized as follows, concerning results necessary to form a world premier research center.

<Material synthesis>

In terms of materials synthesis and control, NIMS has achieved excellent results and gained experience that is unsurpassed anywhere in the world, and which has been nurtured over many years. The following shows examples of this.

1) First successful fabrication of diamond thin films by plasma assisted chemical vapor deposition
2) Ultrahigh-pressure synthesis of single-crystal diamond
3) Discovery and structural identification of bismuth oxide high-temperature superconductors
4) Growth of single-crystal dielectrics of the world's largest size and highest quality, A venture company which was founded on this research has grown to become an enterprise with a capital of 281,000,000 yen (as of July 2006)
5) Basic research and practical use of an excellent electron emission material of single-crystal lanthanum hexaboride
6) Development of various super-heat-resistant alloys, the development of "super steel", which is unparalleled by any other in the world
7) Development and practical use of coiled wire fabrication technology of high-temperature superconducting materials
8) Discovery of the cobalt oxide superconductor
9) Development of super high-speed plastic ceramics
10) Production of the superconducting diamond films
11) Construction of various nanostructures by means of manipulating atoms and molecules since the inauguration of the Aono Atomcraft Project under the ERATO program organized 18 years ago
12) Discovery and application of atomic switches resulting from atomic and molecular manipulation
13) Formation of conductive polymer chains at desired locations by chain polymerization
14) Development of memory with bit density greater than 100 Tb/in^2 by using C_{60} molecules
15) Development of a nanothermometer using carbon nanotubes
16) Discovery and use of metal oxide nanosheets with useful functions

photovoltaic effect of lithium niobate was observed when the template was irradiated under ultraviolet light having a wavelength shorter than 320 nm. In this research, we designed the impurity level between the band gaps by doping particular components into lithium niobate single crystals. As a result, the same photocatalytic effect, which is the deposition of Ag nanoparticles in $AgNH_3$ solution preferentially on the +Z domain surface of the template, can be observed even under irradiation of visible GaN LD light having a wavelength of 410 nm.

Moreover, by means of FIB, thin single crystals of lithium niobate were successfully fabricated to form self-standing photonic crystals and ferroelectric domain structures. This is expected to be an effective method for fabricating microscopic integrated optical devices.

New microwave effect on superconductor-semiconductor junctions

We are presently working on superconducting photo-emitting diodes in which electron Cooper pairs and holes are injected into a semiconductor quantum dot and are expected to recombine simultaneously into photon pairs in the quantum dot. In order to enhance Cooper pair injection, we prepared a sample with a superlattice structure in the neighborhood of the superconductor-semiconductor interface, which was found to show oscillatory differential resistance as a function of bias voltage upon microwave irradiation.

The junction structure is S/Sm/Superlattice/n-GaAs/Superlattice/Sm/S, where S denotes a superconducting niobium (Nb) electrode and Sm denotes a 5-nm-thick GaAsNSe semiconductor layer. The superlattice structure consists of two layers of GaAs(2 nm)/GaAsNSe(2 nm) and three layers of GaAs(1 nm)/GaAsNSe(1 nm).

Upon 1.715-GHz microwave irradiation, d*V*/d*I* oscillates with applied bias voltage. It is also noteworthy that the oscillation of d*V*/d*I* (differential resistance) causes a more significant reduction of d*V*/d*I* at zero bias voltage. We found that d*V*/d*I* oscillates only at voltages lower than ~3 mV, which coincides with the superconducting gap of niobium (Nb) electrodes. We speculate that this oscillation is due to the modulation of Andreev reflection probability related to superlattice phonons, which has not been reported so far.

This discovery provides new physics in that the Andreev reflection is modulated by phonons excited in the superlattice structure. It also shows the controllability of barrier strength at the superconductor/semiconductor interface by microwave irradiation.

Spin-injection effect in ferromagnetic semiconductor/superconductor junctions

Since the Andreev reflection process is sensitive to carrier spin, it is a very effective method for detecting the spin-injection effect. We confirmed the spin-injection effect by injecting current into a superconductor/semiconductor junction from a ferromagnetic semiconductor InMnAs electrode.

17) Realization of semiconductor quantum dots, of which even the internal structure is controlled, by droplet epitaxy

<The world’s largest research facilities>

We are equipped with a series of large high-performance facilities related to structural observation and measurement of material properties that are unique in the world. The following shows examples.

1) World’s strongest magnetic field generator
2) Ultra high-voltage, high-resolution transmission electron microscopes
3) World’s highest-frequency nuclear magnetic resonance (NMR) spectrometer using the strong magnetic field generator
4) Ultrahigh-pressure generator that can be used even for the fabrication of artificial diamond
5) Exclusive beamline at the synchrotron radiation facility (SPring-8)
6) High-current metal ion beam generator

<Advanced nanotechnology>

We hold records achieved by a series of unique high-level nanotechnology-related research facilities relating to nanoscale synthesis, control, process and measurement of materials. The following shows examples.

1) Synthesis of various novel nanotubes
2) Synthesis of novel nanosheets
3) Construction of atomic switches
4) Synthesis of functional supramolecules
5) Development of multiprobe scanning probe microscope (nanotester)
6) Development of scanning tunneling microscope that works at extremely low temperatures, in strong magnetic fields, and in ultrahigh vacuum
7) Development of computational science including the development of a new “order N” method

There are no other equivalent independent material research institutes that are equipped with these three attributes. We suggest that a world premier research center promoting nanoarchitectonics-related research, that would be difficult to implement at other institutions, can be created by integrating these three characteristics.

The differential conductance of a superconductor/semiconductor (Nb/InAs) junction has a dip structure around the zero bias voltage due to the superconducting proximity effect. It was shown that the dip structure disappears with increasing injection current from ferromagnetic semiconductor InMnAs. This phenomenon is explained by the inverse proximity effect, whereby the magnetic exchange field is induced in the Nb electrode due to the exchange field in InAs, which is also induced by the spin-polarized injection current from the InMnAs electrode.

This is the first observation of the inverse proximity effect and leads to a new field in spintronics research.

(3) Chemical NanoManipulation

Development of a novel visible-light-active photocatalyst

A “green” chemistry process for environmental purification is realized on a novel visible-light-active photocatalyst $(Ag_{0.75}Sr_{0.25})(Nb_{0.75}Ti_{0.25})O_3$, developed by tuning the band structure of $AgNbO_3$-$SrTiO_3$ solid solution. This mixed-valent solid-solution perovskite exhibits strong oxidative potential for efficient photocatalytic decomposition of acetaldehyde (CH_3CHO) – a common indoor air pollutant – at ambient temperature. The enhanced photocatalytic activity of $(Ag_{0.75}Sr_{0.25})(Nb_{0.75}Ti_{0.25})O_3$ is attributed to the modulated band structure constructed by a hybrid conduction band of the empty (Ti 3*d* + Nb 4*d*) orbitals and a hybrid valence band of the occupied (O 2*p* + Ag 4*d*) orbitals. The new photocatalyst is expected to lead to practical applications for indoor air purification through further modification of surface nanostructure. Published on the Web 02/12/2008 in JACS as a communication.

Synthesis of new photofunctional nanosheets

We have successfully synthesized new photofunctional nanosheets such as $La_{0.90}Eu_{0.05}Nb_2O_7$, $Eu_{0.56}Ta_2O_7$ and $Cs_4W_{11}O_{36}$ through soft-chemical delamination of precursory layered compounds. The former two exhibit very intense photoluminescence thanks to efficient energy transfer in the nanosheets. The latter shows highly efficient photochromatic properties due to the ultimately wide surface area of a two-dimensional nanosheet. These features suggest promising potential in applications including display devices.

Development of prototype drug delivery system based on a halide-filled carbon nanotube

Carbon nanotubes have been proposed as ideal tools to deliver substances at the nanoscale level with potential applications ranging from nanopipettes to targeted drug delivery systems. In particular, the latter would require the pulsed release of small drug amounts with parallel reading of the system properties under soft physiological conditions. Towards this aim, a vast number of materials have been successfully encapsulated within carbon nanotubes, but there is still a lack of reliable mechanisms for controlling the release of contents on-demand and to completion.

For the first time, using an integrated STM-TEM setup, we demonstrated that attogram-level quantities of copper iodide can be sequentially discharged from within carbon nanotubes using controlled (hundreds of *mv* range) electrical pulses. This approach further provides readable output signals (both visual, i.e. HRTEM imaging, and non-visual, i.e. electrical resistance modulation), which enable the continuous and real-time evaluation of the system's filling ratio.

Si nanowire semisphere-like ensembles as field emitters

Silicon is the most important semiconducting material for electronic technology whose integration into information technology and data processing has led to one of the greatest industrial successes of the 20th century. In order to achieve implementation in nanotechnology, Si nanowire arrays have been synthesized by adopting certain template-based and lithographic techniques as well as using metal catalysts. However, the lithographic techniques are expensive and template removal would complicate the application of nanostructures, while catalytic metal particles may become electron and hole traps in Si. This poses a serious contamination problem for Si complementary metal oxide semiconductor (CMOS) device fabrication.

We describe the successful synthesis of dense silicon semisphere-like ensembles consisting of numerous nanowire arrays. The assemblies were fabricated using a simple and optimized thermal evaporation technique that does not require a growth-directing template or metal catalyst. All nanowires within the semispheres are single-crystalline, monodispersed, well-aligned and uniformly distributed. The typical density of nanowires in an array is close to 4×109/cm2. Due to their aligned nature and high aspect ratio, these are ideal structures for field emission devices. Measurements show that the as obtained Si nanostructures possess a turn-on field of ~7.3 V/μm and field enhancement factor of ~424. Field emission is superior to that of many other previously reported Si emitter types, such as silicon cone arrays (13–16.5 V/μm), Si nanowires (13 V/μm), and single-crystalline Si microtips (15 V/μm). The present low cost and straightforward method could be employed to synthesize many other interesting Si (or other semiconductor) arrays/ensembles on a large scale, valuable for nanoscale electric and optoelectronic devices.

(4) Artificial Self-Organization

Design of pH-sensitive drug carrier effective for multidrug-resistant tumor cell lines

A pH-sensitive PEGylated nanogel was prepared by emulsion copolymerization of 2-(N,N-diethylamino)ethyl methacrylate (EAMA) with heterobifunctional poly(ethylene glycol) bearing a 4-vinylbenzyl group at the α–end and a carboxylic acid group at the ϖ–end (CH_2 = CH–Ph–PEG–COOH; Mn = 8,000) in the presence of potassium persulfate and ethylene glycol dimethacrylate (1.0 mol%) as the crosslinker. Loading of the anticancer drug doxorubicin (DOX) into the pH-sensitive PEGylated nanogel was carried out by means of solvent evaporation method. The antitumor activity of the DOX-loaded, pH-sensitive, PEGylated nanogel against the human hepatoma cell line HuH-7, which is a natural drug-resistant tumor line, was superior to that of both free DOX and the DOX-loaded, pH-insensitive, PEGylated nanogel, suggesting that the pH-sensitive PEGylated nanogel represents a promising nanosized carrier for anticancer drug delivery systems in vivo.

Development of "mesoporous nanocompartment films"

Layer-by-layer assembly of mesoporous capsules having a mesoporous wall and empty interior provided the globally novel "mesoporous nanocompartment films". These thin films are capable of water and drug molecule entrapment, for which evaporation surprisingly showed an automatic "stop and release behavior" through a self-feedback mechanism. The obtained materials are expected to be used in innovative drug delivery systems,

Molecular recognition based on transistor concept

Langmuir monolayers of host molecules having a chiral twisting structure were subjected to chiral discrimination of amino acids dissolved in the subphase. Chiral recognition efficiency (output, drain) by the host molecules (input, source) can be freely modulated by intermediate stimulus (gate) such as surface pressures and co-existing ions. Molecular recognition based on the transistor concept was first proposed with these obtained results.

Search of half-metallic materials

Search of half-metallic materials with 100% spin polarization at room temperature is strongly desired for future development of spintronic devices. We measured the spin polarization of a wide variety of quaternary Heusler alloys using the point-contact Andreev reflection method and found that the substitution of Cr for Fe and Fe for Mn in Co_2FeSi and Co_2MnSn Heusler alloys, respectively, is quite effective in enhancing the spin polarization at low temperature. Based on these results, we proposed that these could be promising half-metallic materials for developing spintronic devices such as CPP-GMR.

Microstructural characterization of sintered magnets

We carried out multi-scale microstructural characterization of Nd-Fe-B based sintered magnets with trace addition of Cu using SEM, TEM and three-dimensional atom probe (3DAP) in order to understand the coercivity mechanism of high-performance permanent magnets for hybrid car motors. The trace addition of Cu was found to be effective in forming distinct grain boundary layers of a few tens of nm that continuously envelope individual $Nd_2Fe_{14}B$ grains. We also investigated the microstructure of ultrafine-grained Nd-Fe-B sintered magnets to understand the reason for the sudden drop in coercivity below 2.5 μm grain size. As a result, we have clarified the mechanism for the coercivity drop in ultrafine-grained microstructures, and this information will be utilized for designing the process to obtain high coercivity in ultrafine-grained Nd-Fe-B sintered magnets.

Development of new methodology for characterization of electronic states in nanopowder

Controlling the self-organization phenomena of nanopowder is of great importance, because this technology may enable us to enhance the performance of environmental materials such as photocatalysts, and miniaturization and functionalization of electronic components to be utilized for high-performance and large-scale integration of IT devices. In order to clarify the self-organization mechanism of nanopowder, which we had already discovered, and develop the technology for controlling the self-organization behavior, we must establish a methodology for evaluating the properties of nanopowder. Therefore, we are investigating a new technology for observing the electronic structure in nanopowder, such as characterization of the donors and acceptors. As a result, we developed a basic concept appropriate for the characterization of nanopowder. That is, utilizing the charge transfer phenomena from nanopowder to silicon substrate by means of bonding. Namely, we reproduce the electronic state in nanopowder in a silicon wafer, and characterize the electronic response from the silicon wafer, which is a “copy” of the electronic state in the nanopowder. This method is expected to be a very simple and practical technique for evaluating the electronic structure in nanopowder.

Control of self-organization behavior at the heterointerface with polar crystals

Consideration of spontaneous polarization is very important when fabricating electronic or optical devices using ferroelectric or piezoelectric polar crystals. Actually, nitride semiconductors, e.g., gallium nitride, are of a wurtzite-type structure having spontaneous polarization, and this polarization influences the electron transport in devices. Thus, we have to consider spontaneous polarization in these materials and control the polarization of crystals when fabricating electric and optical devices. We must develop the technology to achieve polarity control during crystal growth and the device fabrication process. Recently, we found some self-organization phenomena that show polarity inversion during epitaxy of polar semiconductors. For example, the addition of dopant causes changes in the chemical state of the heterointerface and achieves polarity inversion of the crystals. Details of the mechanisms for these polarity inversion phenomena are under investigation. We expect that the utilization of such organization behavior may achieve fabrication of electric devices showing high performance and construction of complex structures of higher hierarchy.

(5) Theoretical modeling and designing

Design for half-metallic antiferromagnet

We theoretically designed a novel material dubbed as half-metallic antiferromagnet (HMAFM), a material conductive in (only) one spin channel while exhibiting zero macroscopic magnetization. According to first-principle calculations, the spin of the mobile carrier doped into an insulating ferrimagnetic cuprate is fully polarized due to the strong coupling among d-electrons, and cancels out the spin magnetization of the parent material. A half-metal can generate infinite magnetoresistance and is thus mostly appropriate for spintronics. An HMAFM has been long sought since it is more ideal for high-density integration of devices due to zero stray magnetic fields.

4. Management

<Initial plan>

1) Composition of administrative staff

Starting in 2003, NIMS has about five years experience in research, using English as the official language of ICYS activities. Therefore, it has the advantage of being able to perform both efficient and international administrative operation by making the best use of its experience and know-how acquired in ICYS. All the documents regarding, for example, office routine regulations, purchase of items, and official trips are today already available both in Japanese and English. As a result, an environment of supporting documentation is close to perfection so that foreigner researchers can devote themselves to their study without a language barrier.

Based on the experience in ICYS, we will establish three groups including planning, general affairs, and technical assistance for efficient operation of the administrative division with the use of English as the official language. Further segmentation of the administrative division into planning group, personnel group, general affairs group, accounting group, supplies group, etc. would adversely affect improvements in efficiency and would impose inconvenience especially to foreigners. It is important to establish an administrative system where each person can handle clerical work as widely as possible.

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- **Planning Group:** Responsible for operations regarding employment and planning, such as recruiting, as well as employment of young researchers such as postdoctoral researchers, regular performance evaluation of researchers, holding of symposiums, and public relations as well as publication. Run by about five staff members under the supervision of the planning group leader (a middle-ranking researcher of NIMS)
- **General Affairs Group:** Responsible for general affairs, accounting, and clerical work regarding researchers' attendance record, payroll, official trips, and purchase of supplies. Run by about 15 staff members under the supervision of the general affairs group leader (assign a NIMS employee who has good experience with ICYS). Especially, with the aim of reducing clerical work for researchers, we will hire about 10 secretaries, who will carry out all the clerical work for researchers. The secretaries hired as staff members of the general affairs group must have English language skills equivalent to a TOEIC score of 850 points or more. In addition, five administrative staff will join to the center from NIMS.

<Results/progress/alternations from initial plan>

1) Composition of administrative staff

Since the time of application, the Center has further developed the structure of the administrative unit which has been organized as follows. We thnk that this organization will provide effective management and sufficient support for the scientists as well as help realize administrative reforms at main body of NIMS.

- In order to manage i) strategic issues concerning MANA development and NIMS systems reforms and ii) day-to-day technical support and administration for MANA scientists the administrative arm of the Center was divided in two.
- As such, the Systems Reform Office and the MANA Administration Office were established to handle the division of responsibilities (Figure 3).
- The following five teams were established in the Systems Reform Office (As a rule Systems Reform Office staff serve concurrently as NIMS staff in order to concurrently manage MANA and standardize NIMS systems reforms)
  - i)Planning and Strategy Team（NIMS Office : Integrated Strategy Office）: Formulates strategic plans and proposals for the promotion the MANA Project and NIMS systems reforms.
  - ii)Human Resources Development Team（NIMS Office : Human Resources Development Office）: Recruits MANA researchers, cultivates research leaders for NIMS, establishment of a tenure track system, secures outstanding graduate student researchers
  - iii)International – Domestic Collaboration Team（NIMS Office : International Affairs Office）: Manage Satellites, World Nanotechnology Research Institute Forum, other international conferences, various research collaboration with external partners.
  - iv)Evaluation Team（NIMS Office : Research Evaluation Office）: Evaluation of the MANA Project, MANA-internal evaluation, MANA researcher evaluation
  - v)Public Relations Team（NIMS Office : Public Relations Office）: Public relations
- The following 2 teams were established in the MANA Administration Office.
  - i)Administrative Support Team: Provides administrative support to MANA scientists (order processing, purchasing, official trips, outside work, lifestyle support, English interpreting etc.)
  - ii)Technical Support Team: Provides technical support to MANA researchers (facilities maintenance, analysis, measurement, patent

・**Technical Assistance Group:** Responsible for technical assistance work such as maintenance and control of shared devices used in the center, services in response to requests from researchers, and research assistance. A system will be established so that routine experiments can be conducted by technicians as much as possible. For this purpose, approximately 15 persons who are former NIMS's researchers (retirement people with a Ph.D degree) with good research backgrounds and English speaking proficiency are employed at the final stage for establishment of a system capable of high-level technical assistance. In addition, five technical assistants will join to the center from NIMS.

2) Decision-making system

The center, as its basic principle, intends to establish a decision-making system that can support strong leadership of the center director. In addition, the center intends to minimize the number of meetings in its operation so that the researchers can devote themselves to their studies.

Principal investigators meeting: The principal investigators meeting will be held on a regular basis (about once every month) and will be led by the center director. Matters concerning center operation in general wil be discussed and reported under the full leadership of the center director. Also, the principal investigators must clearly communicate the intentions of the center director to all the young researchers and graduate students concerned.

Advisors: The center will take advice on the management and other issues from knowledgeable outsiders.

3) Allocation of authority between center director and host institution

support etc.)

Figure 3: MANA Administrative Organization

2) Decision-making system

- Under the strong leadership of the Director-General, a venue for discussion of center management issues, the Principal Investigators' Meeting, was established.
- An Evaluation Committee comprised of 10 internal and external experts was established and the first meeting was held on March 12th, 2008

Members:
Anthony Cheetham (Cambridge U.)
Manfred Ruhle（Max-Planck）
Louis Schlapbach (EMPA)
Horst Hahn (Karlsruhe)
Rodney Ruoff (U. Texas.)
Yoshio Nishi（Stanford U.）
Morinobu Endo（Shinshu U.）
Kazunori Tanaka（JST）
Kazuhito Hashimoto（U. Tokyo）
Takuzo Aida（U. Tokyo）

- Three advisors were appointed to provide advice on the overall management of the Center.

Advisors:
Heinrich Rohrer
Harry Kroto
C. N. R. Rao

Director of the center: The director of the center will be given authority over the center's operation in general. In other words, the center director will have authority in employment, renewal of contracts, payroll, research expenses, and space allocation for researchers including senior and young researchers of the center, etc. who are invited to the center, except for those who are enrolled in the main body NIMS. His authority also includes employment and renewal of contracts administrative staff members of the center, except for those who are enrolled in the main body NIMS. **President:** The president, as the responsible person of the host institute, supports the center operation to the fullest extent, while respecting the authority of the director over the operation of the center. However, upon some situations such as receipt of any advice from the Steering Committee and NIMS Executive Board, the president can make personnel changes to the center director, principal investigators invited from external organizations, etc. Further, according to need, he must take various additional measures necessary for the center operation including, for example, improvement of the experimental space and additional assignment of NIMS researchers.	3) Allocation of authority between center director and host institution ・ The decision-making systems in 2) were built so that the Director-General can display leadership in Center management ・ The MANA Steering Committee consisting of the NIMS President, NIMS Vice Presidents, the Director-General and the Administrative Director of MANA, etc. was established, and support systems for Center operation at host institutions were put in place. The first MANA Steering Committee Meeting was held on January 8th, 2008 to examine the status of MANA and discuss NIMS support policies.

5. Researchers and center staffs

i) “Core” to be established within host institution

Principal investigators

	At beginning	Planned for end of FY 2007	Final goal (Date: month, year)	Results at end of FY 2007	April, 2008
Researchers from within host institution	14	14	16 (Oct. 2011)	14	14
Foreign researchers invited from abroad	4	4	7 (Oct. 2011)	5	5
Researchers invited from other Japanese institutions	3	3	4 (Oct. 2011)	3	3
Total principal investigators	21	21	27	22	22

All members

	At beginning	Planned for end of FY 2007	Final goal (Date: month, year)	Results at end of FY 2007	April, 2008
Researchers <Number of foreign researchers among them and their percentage> [Number of female researchers among them and their percentage]	90 <56, 40%>	140 <56, 40%>	167 <84, 50%> (Oct. 2011)	121 <53,44%> [13, 11%]	131 <61, 47%> [13, 10%]
Principal investigators <Number of foreign researchers among them and their percentage> [Number of female researchers among them and their percentage]	21 <7, 32%>	21 <7, 32%>	27 <10, 37%> (Oct. 2011)	22 <7, 32%> [1, 5%]	22 <7, 32%> [1, 5%]
Other researchers <Number of foreign researchers among them and their percentage> [Number of female researchers among them and their percentage]	69 <24, 40%>	118 <41, 47%>	140 <74, 53%> (Oct. 2011)	99 <46, 46%> [12, 12%]	109 <54, 50%> [12, 11%]
Research support staffs	17	17	20 (Oct. 2011)	25	25
Administrative staffs	20	20	22 (Oct. 2011)	24	24
Total	177	177	209 (Oct. 2011)	170	180

ii) Satellites

<Initial plan>

The center intends to promote effectively top world-level research that is appropriate to the world's center of substance and material research. At the same time, with the aim of fostering young researchers on the international level, it will collaborate actively with domestic and foreign research institutes. The center establishes two kinds of affiliates which are satellite institutes and collaborative institutes. The satellite institutes will serve as center's branches. On the other hand, based on the MOU agreement, the collaborative institutes carry out collaborative research and personnel exchange with the center.

Recently, NIMS has successfully organized the World Materials Research Institute Forum for global networking of materials institutions. Learning from this, the center will organize a World Nanotechnology Research Institute Forum and make efforts in global networking and global research collaboration in the field of nanotechnology and nanomaterials. Moreover, by participating in "Nanotechnology Network Japan Program (MEXT Innovation Support Program)" in which NIMS is deeply involved, the center will strengthen domestic network with Japan's nanotechnology related institutes.

Satellite Institutes: Research institutes to which principal investigators invited from external organizations belong are referred to as the satellite institutes. By December, 2007, the center plans to set up satellite institutes at the University of Tsukuba, University of Cambridge, UCLA, Georgia Institute of Technology and CNRS. The satellite institutes will play an important role in conducting research and are expected to be bridgeheads of the center.

- **University of Tsukuba:** Professor K. Kadowaki and Professor Y. Nagasaki are world leading researchers on superconductivity and organic chemistry, respectively. Their two satellite laboratories are set up in the University of Tsukuba with the intention of complementing the center's research activity and they will be bridgeheads of the center for the University of Tsukuba. Each of the laboratories will have stationed a few young researchers who are hired by the center to conduct research.

  For the purpose of human resources cultivation, NIMS has already set up a Doctoral Program in Materials Science and Engineering at the Graduate School of Pure and Applied Sciences, University of Tsukuba. The center will accept many graduate students who can contribute to the research of the center as the junior researchers, utilizing this collaboration system with the University of Tsukuba.

<Results/progress/alternations from initial plan>

MANA establishes Satellites as organizations for the assignment of external guest Principal Investigators. Preparations for establishment are progressing smoothly.

University of Tsukuba

Funded research contracts were signed with 2 professors to create MANA Satellites at the University of Tsukuba. Operations expenses for the Satellite were allocated from the MANA budget. In addition to the supervision on MANA Young Scientists, the major research activities at the Satellites will be as follows.

i) Professor Kazuo Kadowaki, Graduate School of Pure and Applied Sciences, Institute of Materials Science

Research Topic : Prof. Kadowaki conducts cutting edge nanoscience research on the use of high temperature superconductivity. He creates nanostructures by microscopically sculpting high quality single crystal superconductors. He controls the operation of quantum coherences through the use of Josephson junctures. The aim of his research is to further build upon the field of nanoarchitectonics

	ii) Professor Yasuo Nagasaki, Graduate School of Pure and Applied Sciences, Department of Materials Science/ Graduate School of Comprehensive Human Sciences, Frontier Medicine Course Research Topic : Professor Nagasaki's research focuses on new nanobioimaging and materials design for nanodiagnoses and treatment. He evaluates the attributes of these materials with the aim of creating novel biotools.
・**Tokyo University of Science:** Professor Takayanagi, who is a world distinguished researcher of superconducting devices, will join the center, conducting the superconducting-device related research. NIMS is not very strong in this field. This satellite will be a bridgehead of the center to conduct joint research with the Tokyo University of Science.	**<u>Tokyo University of Science</u>** *Professor Hideaki Takayanagi, Department of Applied Physics* The major projects at this Satellite are research into nanotechnology for new superconducting devices and supervision of MANA Young Scientists. To concurrently encourage research at both the Tokyo University of Science and MANA, a dispatch contract was signed between Professor Takayanagi and NIMS, research space at NIMS was secured and budget monies allocated. Professor Takayanagi is now able to conduct his research at NIMS.
・**University of Cambridge:** Professor Mark Welland, as Director of Interdisciplinary Research Center in Nanotechnology (IRC) of UK, is a world leader in nanoscience as well as in nanotechnology, especially with a focus on superfine processing by using an electron beam and creation of nanostructures. He has also served as a scientific adviser to the UK Prime Minister. He will join the research activities at this center with regard to the study of nanostructure fabrication. This satellite will play an important part in conducting the research of the center and will be a bridgehead of the center for the University of Cambridge.	**<u>University of Cambridge</u>** *Prof. Mark E. Welland , Director, Cembridge Nanoscience Centre* The major projects at this Satellite are research into the creation and measurement of new nanostructures and the supervision of MANA Young Scientists. We are currently negotiating the following 2 points and have nearly reached an agreement. An MOU and a joint research agreement will be signed in early fiscal 2008. Funds will be allocated and activities at the Satellite are expected to begin in earnest soon. i) By signing an MOU between the University of Cambridge and MANA, we will make an official declaration of the establishment of a MANA Satellite. ii) By signing a joint research agreement between the University of Cambridge and MANA, we will allocate budget money to the University of Cambridge to begin Satellite operations.
・**UCLA:** Professor James Gimzewski is very well known as the researcher who has established the foundation of today's nanoscience and nanotechnology at the IBM Zurich Research Laboratory immediately after the invention of the scanning tunneling microscope. After moving to UCLA several years ago, he launched a study concerning fusion of nanotechnology and biotechnology and has performed ingenious research including his recent invention of a desktop size fusion device. He participates in the center's research concerning manifestation of new functions of nanostructures and their measurement, playing an important role in the project. This satellite will be a bridgehead of the center for UCLA.	**<u>UCLA</u>** *Prof. James K. Gimzewski , Director, Nano/Pico Characterization Lab, UCLA* The major projects at this Satellite are research into the fusion of nanotechnology and biotechnology and nano X-ray systems as well as the supervision of MANA Young Scientists. An MOU was concluded between UCLA and MANA in order to establish the Satellite on-site. <u>Article 2C</u> To conduct research of this Cooperation Agreement, NIMS will establish a satellite institute at CNSI within NIMS's Materials Nanoarchitectonics (MANA) Project. We are now stepping up efforts to sign a joint research agreement in early fiscal 2008. Funds will be allocated based upon the agreement and activities at the Satellite are expected to begin in earnest soon.

・ **Georgia Institute of Technology:** Professor Z. Wang is an outstanding researcher in the field of nanotechnology, who is ranked among the world's top 25 by having a total number of article citation of over 15,000. In particular, his discovery of the ZnO nanobelt has drawn attention as a new material applicable in piezoelectric elements and in biosensors (total cited numbers: 1,519 times). This satellite will contribute to the project mainly in the electronic materials field and will be a bridgehead of the center for the Georgia Institute of Technology. ・**CNRS:** Professor Christian Joachim is the leading authority who has clarified the electronic states of nanostructures, especially the electronic state of functional molecules, by means of first-principle calculations. On the other hand, by organizing a group consisting of experimentalists and theorists, he is now devoted to the realization of single-molecule devices. He is expected to join this research center for theoretical study of new nanostructure functions, leading the theoretical research. This satellite will be a bridgehead of the center for CNRS.	**<u>Georgia Institute of Technology</u>** *Prof. Zhong Lin Wang, Director, Center for Nanostructure Characterization (CNC), Georgia Tech* The major projects at this Satellite are research into electronic materials and the supervision of MANA Young Scientists. We are currently negotiating the following 2 points and have nearly reached an agreement. An MOU and a joint research agreement will be signed in early fiscal 2008. Funds will be allocated and activities at the Satellite are expected to begin in earnest soon. i) By signing an MOU between the Georgia Institute of Technology and MANA, we will make an official declaration of the establishment of a MANA Satellite （We have nearly reached an agreement on the draft document）. ii) By signing a joint research agreement between the Georgia Institute of Technology and MANA, we will allocate budget money to the Georgia Institute of Technology to begin Satellite operations. **<u>CNRS</u>** *Prof. Christian Joachim, Center for Material Elaboration & Structural Studies (CEMES) -CNRS, Toulouse* The major projects at this Satellite are theoretical research of new nanostructure functions and the supervision of MANA Young Scientists. We are currently negotiating the following 2 points and have nearly reached an agreement. An MOU and a joint research agreement will be signed in early fiscal 2008. Funds will be allocated and activities at the Satellite are expected to begin in earnest soon. i) By signing an MOU between CEMES and MANA, we will make an official declaration of the establishment of a MANA Satellite. ii) By signing a joint research agreement between the CEMES and MANA, we will allocate budget money to CEMES to begin Satellite operations.
iii) Partner institutions **Collaborative Institutes:** These institutes are expected to serve as sites for collaborative research with the center as well as exchange and training of young researchers. Among about 130 institutes in Asia, Europe, North America, East Europe, etc. with which NIMS already has MOU agreements, approximately 30 major institutes including, for example, Institute of Physics, Chinese Academy of Science (China), KAIST (Korea), Max Planck Institute (Germany), Charles University (Czech), and UCSB (U.S.) are serving as the collaborative institutes. It is further planned that MOU agreements will be signed with an additional 10 institutes by December, 2007 and with a further additional 20 institutes by December, 2008. **Overseas Offices:** With the aim of strengthening overseas	<Results/progress/alternations from initial plan> ・ To strengthen collaborative ties with other institutions, the Center plans to establish the World Nanotechnology Research Institute Forum (WNRIF). Preparations for its launch are underway. We have not made any progress in concluding MOUs, but we plan to do this as we work on organizing WNRIF. ・ To strengthen ties will global partners, MANA and the University of Washington have agreed to the establishment of a MANA (NIMS) Office at the University of Washington. We are now stepping up efforts to sign a joint research agreement. Once the agreement has been signed we will open the office and allocate operations fees to the University of Washington.

collaborations of the center and NIMS, overseas offices will be set up in UCSB, University of Washington and others. They are expected to conduct recruiting and investigation into the current research trend overseas. In particular, they will play roles in obtaining US-governmental funds from organizations such as DARPA and NSF and will also serve as liaisons for foreign personnel, for foreign enterprises, and for collaboration with overseas universities.

6. Summary of center's research environment

<Initial plan>

1) Environment in which researchers can devote themselves to their research

The following factors are required to establish an environment where researchers can devote themselves to their research: 1) to develop a clerical work support system, so that paperwork for business trips or the purchase of supplies can be promptly processed in support of the researchers' work; 2) to provide researchers with sufficient technical staff for the maintenance of equipment, services in response to requests from researchers or assistance in experiments; 3) to minimize the frequency of conferences for the improvement of communication; 4) to provide assistance to researchers and their family for their life in Japan when necessary. Since half of the researchers at the center will come from abroad, we will develop a system to manage the use of English as the official language so that foreign researchers can devote themselves to research without having to deal with a language barrier.

Clerical work support system in English: Through five years' experience at ICYS, a clerical work support system using English as the official language has been implemented, so we will allocate those experienced people to the center as clerical staff, and we will hire new non-permanent staff under the experienced clerical staff. English proficient secretaries will be hired under principal investigators to handle clerical services in response to requests from researchers (10 secretaries by the end of December 2007, and 20 in total by the end of March, 2008).

Make paper work bilingual: All documents such as forms will be in Japanese and in English, so that the burden of paperwork on researchers will be reduced. Further, translators and/or interpreters will be on the staff to support foreign researchers. In addition, English education will be given to both young researchers and senior

<Results/progress/alternations from initial plan>

1) Environment in which researchers can devote themselves to their research

- The ICYS **administrative support** system operated in English will be carried over to MANA in April. We are making preparations for this by arranging staff assignments. We were able to hire 16 part-time administrative staff members that are fluent in English.
- We are making good progress with the **bilingual paperwork system** from ICYS. We intend to expand the scope of this system in the future. We also plan to improve English education for the Japanese researchers and staff.
- We outsourced **daily life assistance** to an expert company and hired specialists to serve as the MANA contact points.
- We retained the English-proficient **patent specialists** from ICYS for MANA.
- The technical support team that we developed for ICYS will be carried over to MANA and improved. We will create a system where MANA researchers can freely use the world-class large-scale equipment owned by NIMS. We have hired 6 technicians to date.

Japanese researchers and to clerical staff to improve their English capabilities (operation to make all documents bilingual will be completed by March 2008).

Assistance for daily life: We will improve the support system for foreign researchers and their families to set themselves up for living in Japan, such as housing search, medical care, education and job search for the spouse to eliminate various barriers that foreigners encounter when they come to Japan. Full-time staff will be hired (October 2007).

Patent specialist: For the convenience of foreign researchers to make patent applications in Japanese, we will hire English proficient patent specialists.

Providing sufficient technical staff and facilitating access to equipment: We will establish a system where researchers can use freely the latest large-scale international level research equipment owned by NIMS (High Voltage Electron Microscopy, High Magnetic Field Magnet, Spring-8 dedicated beam line and Nano Foundry) for their research, by provision of sufficient technical staff. Further, we will promote shared use of other advanced equipment. We will also provide researchers with sufficient assistance, such as research assistants, who will undertake routine experimental procedures. For those technical staff and others, we are going to hire about 15 people including researchers retired from NIMS (total 15; 5 by the end of December 2007, another 5 by March 2008 and 5 by the end of December 2008). In addition, five technical staff will join the center from NIMS.

2) Startup research funding

We will provide start-up research funds to researchers invited from external organizations so that they can launch their own laboratories immediately. We will grant a start-up fund of about 200,000 dollars to principal investigators invited from external organizations who conduct their research at NIMS. Those principal investigators who work in satellite research institutes will be allocated an annual research fund of 100,000 dollars. Young researchers such as post-doctorates will be allocated a start-up research fund as necessary to an amount of up to 100,000 dollars. On average, one principal investigator will conduct research with a group of 6 young researchers including 2 post-doctorates, 2 NIMS researchers and 2 junior researchers (graduate students).

2) Startup research funding

In fiscal 2007, 2 of the guest Principal Investigators who joined to conduct NIMS research were granted ¥15,000,000 each in startup research funds. Upon the conclusion of their contracts, these funds were granted to the 2 Principal Investigators that will run Satellites at the University of Tsukuba. 11 MANA Young Scientists were granted ¥5,000,000 each in startup research funds. A research organization was built by assigning 37 MANA Research Associates (i.e. postdoctoral researchers), 26 Junior Researchers (i.e. participating graduate student researchers), 11 administrative staff(secretaries et al.) and 19 research staff (technicians etc.) to serve under the direction of the NIMS Principal Investigators.

3) Postdoctoral positions through open international solicitations

International recruitment of ICYS-MANA researchers commenced

3) Postdoctoral positions through open international solicitations

Securing highly capable young researchers including post-doctorates is vital to the operation of the center in view of human resource development. Fortunately, we have been able to, in the ICYS project, select about 50 highly capable young researchers from about 25 countries, out of 1000 applicants from about 70 countries. By utilizing ICYS' recruiting know-how accumulated to date, we will secure capable young researchers. Further, we will promote securing graduate students and provide them with sufficient research guidance.

Securing young researchers including post-doctorates

International open recruiting: We will conduct international open recruiting through international publications such as "Nature" and by the recommendation from the principals of more than 130 research institutes which NIMS is affiliated with. Young researchers refer to those who obtained their Ph.D within the last 10 years. Asian countries such as China, India, etc. will be promising counties from which to recruit excellent young researchers and students. In addition, we will make our best effort to employ female young researchers and students.

Multi-national young researcher group: Through ICYS activities, we have proven that the international environment created by young multi-national researchers from different fields, cultures and races (at ICYS, this kind of international environment is referred to as a "Melting Pot") is vital to both the research activities and human resource development of young researchers. Therefore, the center will also establish young multi-national researcher groups in different fields. We will hire about 60 post-doctorates from more than 20 different nations (total of about 60: 30 by March 2008 and another 30 by March 2009).

Application method and recruitment:
Applicants will propose a three year research plan in the application form. We will conduct the selection by weighing originality of the research plan and potential of the candidate as a researcher through two steps; screening of the application documents and interviewing (about 5% is assumed as the ratio of successful applicants). Applicants will be invited to the center for an interview, and have a one hour interview from which we will decide if the applicant will be accepted (the recruitment committee will consist of about 6 principal investigators headed by the center director as the committee chair). The employment period shall be two years, but renewal of the contract

immediately after launching MANA. Advertisements were placed in international publications such as *Nature* as well as on the MANA homepage. The deadline for applications was set in mid-December, and 38 applications were received from around the globe. After a document screening, this number was narrowed down to 11 interview candidates, of whom 3 passed (1 each from Japan, China and India). In addition to these 3, 4 successful candidates from a similar recruitment drive and 3 researchers retained from the ICYS Project will begin in April. Of the 10 researchers, 8 are foreigners. We intend to continue recruiting outstanding postdoctoral researchers in the future.

We also hired 37 MANA Research Associates (i.e. postdoctoral researchers)to assist the Principal Investigators, Chief Scientists and MANA Young Scientists. 27 of these researchers are foreigners so we have already achieved our goal of creating a multinational group of young researchers.

We hired 26 Junior Researchers, of whom 12 are foreign. We are currently in negotiations with the University of Tsukuba regarding the creation of a Master's Program curriculum in which all required credits must be completed in English. The target start date for this program is sometime in fiscal 2009.

We have reached an agreement to begin an **international collaborative graduate school** with the Chinese Academy of Sciences Ningbo Institute of Materials Technology and Engineering. We are also in discussions with Russia's Moscow State University.

We have just queried the MANA Young Scientists on who they would prefer as mentors. We are about to enter negotiations with the candidates to secure them as mentors.

The ICYS-MANA Researchers mentioned above will be given space for independent research, and each will be assigned with a mentor. We have created a researcher mentoring system that respects that independence of young researchers.

for another year may be granted after appraisal of the results. The reason we limit the employment period to 3 years at maximum is because we give priority to career improvement of post-doctorates and alike so that we can promote recruitment to NIMS' research staff.

Securing the junior researchers (graduate students)

Graduate School of University of Tsukuba: At the Doctoral Program in Materials Science and Engineering, Graduate School of Pure and Applied Sciences, University of Tsukuba, which is jointly managed by NIMS and University of Tsukuba, we have made extensive efforts towards internationalization such as the implementation of an entrance examination in English since April 2004, the year we accepted the first students. As a result, the majority of doctorial course students at present come from abroad. By extending this system, we will secure capable graduate students from foreign countries such as China and India and make them conduct research as the junior researchers. Upon creation of the center, instructors at University of Tsukuba and instructors at the Doctoral Program in Materials Science and Engineering will take charge of the master's course program by supplementing each other, and an English curriculum will be prepared in a manner that allows students to take all the requisite courses in English. Further, we will provide a world-class research assistantship to all the graduate students as NIMS junior researchers, so that we can provide an environment in which students can concentrate on their studies and research without worrying about their tuition or the cost of living.

International Joint Graduate School: By expanding the International Joint Graduate School Program which NIMS already has with Charles University in Czech and Warsaw University of Technology in Poland, we will allow capable graduate students to participate in research under the supervision of principal investigators at the center.

Human resource development of young researchers: Fostering capable young researchers under the world's top class principal investigators is one of the remarkable features of the center. For that purpose, at the center, we will further expand the activities at ICYS.

Fostering in the Melting Pot: We will develop an international environment where capable multi-national youths gather at one center from around the world, and develop their talents by receiving stimulation there. For that purpose, we will assemble about 60 post-docs of different nationalities from more than 20 countries in one place.

Mentor system: In order to enhance independence of young researchers who obtained their Ph.D within the last 10 years, top world-class principal investigators will become their mentors and give advice regarding their research while respecting the researchers' own initiatives. Through the five year experience in ICYS, this mentor system proved to be quite effective for young researchers to enhance their independence, widen their research scope and show creativity.

Foster human resources by 3D system: A human resource development called 3D system will be established to enhance independence of young researchers and develop extensive interdisciplinary knowledge and experience. The 3D system stands for <u>D</u>ouble-mentor, <u>D</u>ouble-discipline and <u>D</u>ouble-affiliation; meaning: Research guidance by more than one mentor to enhance independence, having more than one discipline to strengthen interdisciplinary background knowledge, and multiple affiliations to strengthen an independent spirit. We will carry out fostering of young researchers by utilizing satellite institutes as well as with the cooperation of overseas' cooperating organizations because the 3D system cannot be achieved by NIMS alone. We will also use the 3D system to promote human resource development of the junior researchers (graduate students) who belong to the center.

Career development: As a result of the abovementioned human resource development at the center, we will not only hire young researchers as permanent staff researchers at NIMS, but we will provide also them an associate professor's position or alike in research institutes either in Japan or abroad, to further their career development.

4) Administrative personnel who can facilitate the use of English in the work process

As mentioned previously, through the ICYS project NIMS has experienced research work using English as the official language, and therefore we have already trained clerical staff and have accumulated know-how. In using English as the official language, the keys for success lies in

4) Administrative personnel who can facilitate the use of English in the work process

MANA has gained invaluable know how from the ICYS Project on how to manage research with English as the official language and how to train and educate staff. We have retained 5 experienced ICYS staff members for the MANA Project.

In pursuit of a **bilingual environment**, MANA will also use **Life in NIMS, NIMS** the improvement of the clerical staff's English proficiency, rather than of researchers' English proficiency, and the preparation of paper work materials in English. In Japan, bilingual documentation and communication in English and Japanese are effective. At the center, about 5 clerical staff members who have experience in ICYS will participate in the plan. To make English the official language, we will prepare the following items:

Life in NIMS: We will make a booklet "*Life in NIMS*" (approx. 30 pages) with full information on procedures for coming to Japan as well as on life in Japan. We will partially revise a booklet made for ICYS.

NIMS Research Guide: We will make a booklet about information on NIMS research activities (approx. 50 pages). We will partially revise a booklet made for ICYS.

Bilingual documentation of various paper works: We will make bilingual documentation of paper work for business trips, purchase of supplies, salary, regulations and others (approx. 100 pages). ICYS has already prepared such documentation, so we will revise those.

Principal investigators meeting: The meeting will be held once a month in English.

Intranet: The office communication through the Internet in the center will be done bilingually in English and in Japanese.

5) Rigorous system for evaluating research and system of merit-based compensation

At the center, we will develop a different salary scale from that of NIMS's main body, and will establish a flexible compensation package to secure excellent researchers and to provide them appropriate treatment. We will expand the system, which we have implemented in ICYS, including an annual salary system.

Annual salary system: Salary system for fixed-term principal investigators invited from external organizations or fixed-term young researchers such as post-doctorates will be an annual salary system. Because an annual salary system has already been introduced in ICYS, we will make full use of the experience. Annual salaries of the fixed-term principal investigators invited from external organizations will be in a range of 80,000 to 180,000 dollars,

Research Guide and other documentation that was created for ICYS. These will be revised as needed, and we will promote the creation of other bilingual documentation.

5) Rigorous system for evaluating research and system of merit-based compensation

Unlike NIMS, the Center has designed a salary system that rewards outstanding research achievement.

Annual Salary: Adhering to the ICYS system, fixed-term researchers are paid on the annual salary system. The annual salary for fixed-term principal investigators invited from external organizations will range from ¥15,000,000 to ¥20,000,000 depending on their achievements. The annual salary for ICYS-MANA Researchers will be ¥5,350,000 at the time of appointment. A performance review will be conducted after one year in which researchers will be scored as Poor, Standard, Good or Excellent. The results of this evaluation will be reflected in the annual salary from the 2nd year.

depending on their performance. Salaries of the fixed-term young researchers such as post-doctorates will be more than ca. 40,000 dollars, and will be assessed by their performance.

Assessment of the salary and renewal of contract: The center director shall evaluate research performance of young researchers to determine their salary for the next year. Salary shall not be based on seniority but on research performance, so as to be able to generate differences of more than about 50% in bonus among researcher of the same age group based on their performance.

Performance evaluation committee: The committee evaluates the research performance of young researchers once each year (the center director chairs the committee, and several principal investigators are included). They will assess the renewal of contract, salary and research budget for the next fiscal year.

The center evaluation committee: We will set up a center evaluation committee which consists of external experts (about 8 people, about 50% of whom are foreigners. An external expert will be appointed to act as chair) to evaluate the management of the center and research activities. At the same time, they will conduct performance assessments of the center director and principal investigators. The NIMS president will determine the annual salary of the center director after receiving a report from the center evaluation committee. The term of a principal investigator shall be 5 years, with a mid-term assessment in the 3rd year. Moreover, those who have shown excellent performance at the 5-year assessment will be allowed an extra five year of affiliation. For purposes of rejuvenation, about 1/4 of the principal investigators in total shall be replaced 5 years after the establishment of the center, to introduce new research fields, and to prevent the center from becoming inflexible.

However, salaries for researchers who belong to the center and are affiliated to NIMS shall be borne by NIMS, according to the results of the assessment from the center.

6) Equipment and facilities, including laboratory space, appropriate to a top world-level research center

Space of the center: For the research activities at the center, NIMS will provide total space of approximately 10,000㎡.

Space for experimentation: We will provide office space and

Assessment of the salary and renewal of contract : Since only 6 months have passed in the initial year since startup, no assessment will be made to be reflected on the salary for FY2008.

Performance evaluation committee : To be held at the end of fiscal 2008.

Center Evaluation Committee : A committee of 10 external evaluators (6 from foreign institutions, 4 from Japanese institutions) met on March 12th for their first meeting (6 members were in attendance). Since only 5 months had passed since the opening of the Center, the committee focused its evaluations on MANA's objectives, plans and management policy. Evaluations of researcher performance will be conducted in future meetings.

6) Equipment and facilities, including laboratory space, appropriate to a top world-level research center

NIMS agreed to provide 5,000 m² of space, i.e. the entire 4th and 5th floors of the Nanomaterials and Research Building, for the Center. Main researchers will be assigned here starting in April. The rooms currently being used by ICYS Researchers will be allocated as offices for Principal Investigators and MANA Young Scientists. We are currently making arrangements to provide office space to postdoctoral researchers and students.

laboratory rooms in the Nano Biomaterial Research Building only for young researchers, including post-doctorates, who conduct their research independently (about 4,000 ㎡ in total). We will provide approximately 1/2 of that as experimental space. We will provide necessary and sufficient space to principal investigators invited from external organizations.

Single-occupied office and cafeteria: We will provide young researchers with a single-occupied office (approx. 12㎡) where they can devote themselves to research and to have a comfortable living environment. Also, to realize an ideal Melting Pot environment, we will put all the office rooms together in one place, and secure enough space for casual talks, including a cafeteria. At the center, we will utilize single occupied offices which are currently used by ICYS, and additionally will prepare approximately 10 rooms to cover shortfalls.

Research equipment: We will secure world's top-level advanced facilities with high commonality (for example, next-generation ultra high resolution electron microscope), in cooperation with NIMS in a well-planned manner.

7) International research conferences or symposiums held regularly to bring world's leading researchers together

To show that the center is one of the top world-level centers in the material science field, we will hold an international research conference once a year (a conference with 300 attendants). Furthermore, we will hold workshops as needed to provide leading world researchers in this field with opportunities to exchange information. Also, every summer we will open a summer school to foster young researchers.

8) Other measures, if any

The most remarkable feature of the center will be not only that the center sends excellent leading world research results generated by top world-level principal investigators and subordinate young researchers, but that the center is a human resource development center where young researchers will be fostered and improve their careers to become future leaders. It is also a feature of the center that it respects young researchers' fresh and innovative ideas, as well as those of principal investigators. To realize these features, the proportion of foreigners among young researchers shall be more than 50%.

Once new locations are secured for the facilities and equipment unrelated to MANA, which are currently housed on the 4^{th} and 5^{th} floors of the Nanomaterilas and Biomaterial Research Building, MANA will move in and have sole access to this space for its experiments, sometime in fiscal 2008.

The cafeteria on the 5^{th} floor will be used as space to realize the Melting Pot Environment, a carryover from ICYS.

In fiscal 2007, approximately ¥1.3 billion yen was invested to install the nanofoundries required for MANA research. We plan to install electron microscopes and related equipment in fiscal 2008.

7) International research conferences or symposiums held regularly to bring world's leading researchers together

The Center's first International Symposium was held from March 10^{th} to 13^{th}, 2008. 191 participants, including MANA PIs and Young Scientists, gathered from around the world. An international summer school will be held at MANA on July 28th to August 1st in cooperation with two MANA satellites, Cambridge and UCLA. Also, we are making preparations through our link up with NNIN in the United States to host 5 American students at MANA over the summer break.

8) Other measures, if any

As of March 31, 2008, 46 of the 89 (or 52%) MANA Young Researchers are foreign.

Position	Number	No. of Foreigners
MANA Young Scientist	11	2
MANA Scientist	15	2
NIMS Postdoctoral	37	30
NIMS Junior	26	12
Total	89	46

Efforts continue in the following areas in order to maintain the legacy of the ICYS Project and to make MANA an even more internationally attractive research

Our strength lies in the 5-year experience of the ICYS project, which we can improve and extend for further development, for example, research management using English as its official language and know-how in human resource development for young researchers.

We have to keep the following points in mind to create an internationally attractive research environment:

- **Use English as the official language**: By eliminating the language barrier, we need to establish a system where foreign researchers can do all their works without the need for understanding Japanese.

- **Ensure independent research activities:** We will provide young researchers an environment where they can carry out their research independently. For that purpose, we will appoint world-leading principal investigators to be their mentors, to encourage young researchers to become independent. Further, we will provide young researchers with sufficient assistants such as technical staff so that they can proceed with their research independently, by receiving help to use common equipment and to get assistant services for work.

- **High salary standard:** We will provide higher salaries than in NIMS to motivate young researchers.

- **Utilization of world-leading equipment in NIMS:** We will establish a system where researchers can use the world's most advanced leading large-scale equipment such as High Magnetic Field, Nano Foundry, Spring-8 dedicated beam line, High Voltage Electron Microscopy, which are available at NIMS.

center.

English as the Official Language : We have retained some of the ICYS support staff that assisted foreign researchers on that project. They will begin working for MANA in April. We are fully prepared.

Ensuring Independent Research Activities : We have made arrangements to hire support staff as assign mentors to young researchers. Everyone will transfer to the new office in April to begin full-scale support.

High Salary Standards : We have guaranteed MANA Young Scientists higher monthly salaries and bonuses than NIMS Researchers. ICYS-MANA Researchers will be paid higher salaries than the standard for typical postdoctoral researchers.

Utilization of World-Leading Equipment at NIMS : We have bolstered the technical support team to provide foreign researchers and all MANA scientists with easy access to NIMS state-of-the-art large-scale equipment.

7. Criteria and methods used to evaluate center's global standing

<Initial plan>

i) Criteria and methods to be used for evaluating the center's global standing in the subject field

To evaluate the center's global standing in the materials science area, we can use indicators such as number of papers accepted by renowned journals, ratio of researchers that are considered worthy of being named the world's top level researchers, the number of foreign researchers employed, the total external grants obtained, the number of cooperative research projects with

<Current assessment>

Judging from the progress that has been made, the project is proceeding as planned. In this self-evaluation, we feel that a good start has been made in order to meet our goals laid out for 10 years in the future.

・ An organization comprised of 170 individuals (157 in research) was created w foreigners accounting for 35% of the total.
・ A research organization centered around Principal Investigators was established. Systems to cultivate young scientists and to develop their career

private sector corporations, the number of patents applied and granted, the conditions of patents exploited, the number of invited talks at major international conferences, and the number of academic society awards received. The ranking of the number of citations of papers in the field of materials science presented by ISI can be a strong indicator to evaluate research institutions, although its effectiveness is debatable in the academic community.

ii) Results of current assessment made using said criteria and methods

- According to the ISI's ranking of research organizations based on the total number of citations in the field of materials science over the past 10 years, NIMS, which is the host institution of the center, was ranked the 12th in the world as of May 2007, while it was ranked 31st in 2003 when NIMS first appeared in the ranking. This is a clear indicator of how NIMS has improved its standing in the last four years. When comparing paper citations over the five years before becoming an independent administrative institution (1996-2000) and the five years after becoming an independent administrative institution (2002-2006), NIMS ranked 6th, up from the 31st in the world. This means that the recent organizational reforms after becoming an independent administrative institution six years ago drastically increased its research achievements. NIMS publishes about 1,300 papers a year, only one third of which is in materials science and the rest of which is in the fields of physics, chemistry or biotechnology. Nevertheless, NIMS gained a high standing in the materials science discipline.

- The principal investigators from NIMS gained external grants of 1,358 MJPY in FY2006 alone. In terms of the amount of the external funds gained, the center is equivalent to the world's top level.

- The number of the external grants gained by NIMS, which will be the host institution of the center, is growing every year. Particularly, the growth of the grants from private sector corporations is noticeable with a total amount of more than 500 MJPY in FY2006.

- In the last several years, the number of foreign researchers employed by NIMS has increased dramatically. Around 200 foreigners join NIMS as post-docs or graduate students every year. This indicates that NIMS is an open and attractive international

paths have been built.

- To achieve MANA research objectives, research was focused on the 4 key technologies of nanoarchitectonics as well as on theoretical modeling to support those areas. Many achievements have been made
- The Systems Reform Office and the MANA Administration Office were established in the administrative arm of the Center. Under this system we have streamlined management, provided scientists with sufficient support and created a model for NIMS systems reforms.
- Under the leadership of the Director-General, a venue for discussion of center management issues, the Principal Investigators' Meeting, was established.
- An Evaluation Committee was established and a meeting was held. Advisors were selected and the MANA Steering Committee was launched. Systems for Center management are now in place.
- Preparations are underway for the establishment of 2 domestic and 4 overseas satellites.
- The expected amounts of both operations subsidies and external competitive research subsidies have been secured. The Center expects to secure the same amounts in FY2008.
- Continuing in the tradition of ICYS, a management system is being devised in which English is the official language. Experienced ICYS staff with excellent English proficiency have been retained for the MANA project.
- Evaluation and pay-scale systems were adjusted to reward research achievement.
- MANA research space was secured and nanofoundries were upgraded.
- MANA is received sufficient support from NIMS in terms of research space and funding.

institute for foreign researchers.

iii) Goals to be achieved through the project (at time of interim and final evaluations)

At the point of Mid-term evaluation (5 years later):

- NIMS, the host institution of the center, will rank within top-5 in the materials science field according to the world's institute ranking of ISI based on the number of citations in the past five years.

- The center will have secured 100 young researchers and 50 graduate students from all over the world.

- About 10% of the permanent employees will be foreigners in NIMS.

At Ex-post evaluation（10 years later）:

- The center will be a high status research center for materials science, which many researchers all over the world aspire to join.

- NIMS will rank within the top-3 in the ISI ranking based on citations in the last five years. Since the citation ranking is advantageous for large institutions, it is impossible to exceed in numbers giant institutes such as Chinese Academy of Sciences or Max-Plank Institute, Germany because of the size difference. Therefore, NIMS set its goal to be in the world's No.3 (which corresponds to No.1 among single institutions).

- NIMS will be the No.1 institute in the materials science discipline in the institute citation ranking in Japan.

- The numbers of total external grants obtained, cooperative research projects, and of collaborative research grants by private businesses will be 1.5 times greater than at present.

- For the ten-year period, the center has secured about 200 young researchers and 100 graduate students from all over the world.

- This center will function as a research center for growing "Emerging Leaders" in materials science. Researchers in this center will promote their careers and about 50 of them will get permanent positions in NIMS, and another 50 at overseas and domestic universities or research institutes after staying for some time in this center as graduate students or post docs.

- About 20% of the permanent employees will be foreign researchers in NIMS.

8. Securing competitive research funding

<Initial plan>

i) Past record

The table below shows the actual amount of external funds in recent years obtained by the candidates for principal investigators who are affiliated to NIMS. The funds listed are research funds for which respective researchers are enrolled as principal investigators, and external funds obtained as public competitive funding offered by the national government, etc. and those which were obtained in joint research whose funds are offered by private corporations.

Table: Actual external funds obtained by candidates for principal investigators
(Unit : Million yen)

Name	FY2002	FY2003	FY2004	FY2005	FY2006
Masakazu Aono	58	169	179	412	276
Yoshio Bando	41	493	801	812	792
Eiji Muromachi	0	0	8	7	10
Kenji Kitamura	116	103	119	4	8
Takayoshi Sasaki	47	77	36	9	53
Kazuhiro Hono	90	107	93	51	116
Katsuhiko Ariga	0	0	0	4	12
Yoshio Sakka	69	28	31	25	18
Xiao Hu	2	2	1	0	2
Naoki Ohashi	2	1	15	26	2
Dmitri Golberg	0	0	9	4	0
Jinhua Ye	50	68	60	12	22

<Results/progress/alternations from initial plan>

The expected amounts of operations subsidies for Principal Investigators were secured. The Center expects to secure the same amounts in FY2008. Likewise, the expected amounts of external competitive research subsidies were secured. No funding for fiscal 2008 has been secured yet, but we do not foresee a major shift in the amount of funding that we expect to secure.

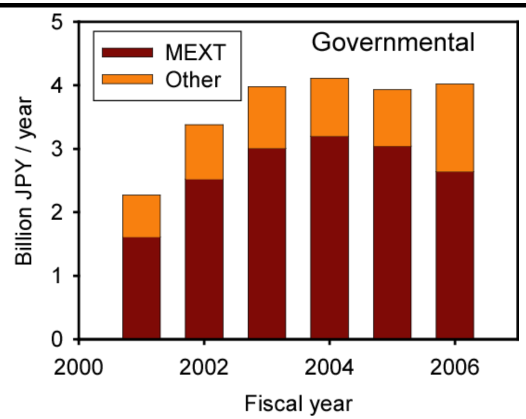
As shown in the above table, we have been steadily obtaining an average of about 1.4 billion yen of external funds in recent years. In addition, the funds distributed as operational subsidies of the host institutions are shown in the table in the next page. In recent years, the total amount of operational subsidies allocated and the external funds obtained is remaining at the level from 0.8 to 1.4 billion yen.

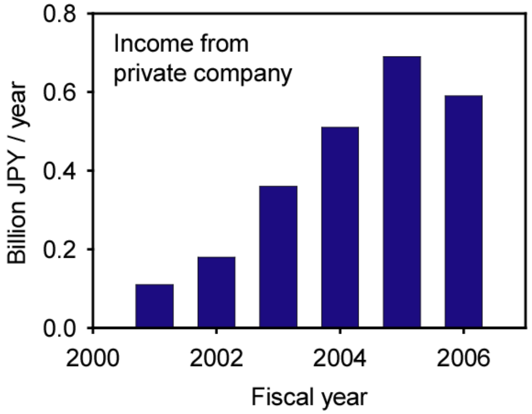
The averaged effort (b/a ratio in Appendix II) of the prospective principal investigators is about 80 %. Therefore, the expected amount of the fund that the prospective principal researcher get for the activity of this center is 1.7-2.2 billion yen every year. This value is nearly equivalent to the amount of requested funding shown in the form of "3. Appropriation Plans".

Table: Budget of operational subsidies of candidates for principal investigators (Unit : Million yen)

Name	FY2002	FY2003	FY2004	FY2005	FY2006
Masakazu Aono	108	133	129	127	40
Yoshio Bando	114	195	171	134	81
Eiji Muromachi	85	75	106	46	48
Kenji Kitamura	255	280	190	312	63
Takayoshi Sasaki	126	127	84	88	64
Kazuhiro Hono	67	54	48	213	95
Katsuhiko Ariga	0	23	20	211	25
Yoshio Sakka	18	17	25	23	47
Xiao Hu	7	14	21	20	19
Naoki Ohashi	10	5	20	20	82
Dmitri Golberg	0	0	0	0	22
Jinhua Ye	9	16	9	9	50

As a reference, the funds of host organizations as a whole obtained from government and private sector corporations, etc. are as follows.





ii) Prospects after establishment of the center

In FY 2007, the Nanotechnology Network Project by the Ministry of Education, Culture, Sports, Science and Technology starts, so that we can receive funds for maintenance and operation of advanced shared equipment. The shared equipment operated by the fund may be used for this center project, and therefore, the material amount of external funds obtained will be higher than now estimated.

Furthermore, the number of talented young researchers has increased recently with drastic increase of research achievements. The funds they obtain will continue to grow in the future.

As stated in the Commitment from the Host Institution attached separately, we assume the funds needed by those core principal investigators can be sufficiently secured as before, by continuing to allocate research funds to principal investigators from the operational subsidies.

9. Other important measures taken to create a world premier international research center

<Initial plan>	<Results/progress/alternations from initial plan>
Others After project funding ends, NIMS will support the center financially so that the center can maintain its activities at least for 10 more years. It is quite sure that the main body of NIMS will actively adopt center's successful management systems. The concept of the center is really unique and its experience will be very helpful not only for the main body of NIMS but for other institutions in Japan when they attempt to build their own research centers. We would like to stress our valuable experiences obtained from the ICYS project. The center will succeed and develop the managerial operation in ICYS and this is our great advantage to realize the world premier research center in addition to our novel materials research technology of nanoarchitectonics.	The ICYS project finished in fiscal 2007, but ICYS-MANA was established to carry over the achievements and experience gained.

10. Host institution's commitment

<Initial plan>	<Results/progress/alternations from initial plan>
-Provision in host institution's mid-to-long-term plan Looking from NIMS's point of view, the center is designed as an organization undertaking the two following roles, classified roughly: (1) an advanced research organization to conduct basic research for materials, fusing fields of materials science, chemistry and physics; (2) an organization to foster researchers who will create the future of material research in an international and interdisciplinary atmosphere. The objective related to (1) is the "development of innovative materials to realize a sustainable society", and this is perfectly consistent with the 2nd midterm objectives and midterm plan of NIMS. Accordingly, the center can be positioned as an organization which will play a principle role to lead the main body of NIMS by carrying out the research in a radically accelerated manner. On the other hand, to put (2), the fostering of researchers, as the other pillar of the concept is a very important point of the center, from the standpoint of NIMS. We have decided that, if this proposal is realized, NIMS's new staff researchers with tenure will be chosen, in principle, from young researchers of the center. Thus, the center is also positioned as a place to foster NIMS's future research staff with tenure. Therefore, the center is	-Provision in host institution's mid-to-long-term plan MANA was established to take the lead in research for NIMS as a whole. NIMS is providing maximum support to achieve this goal. MANA also serves as a proving ground for future NIMS tenured researchers, so NIMS has transferred some of its outstanding young researchers to MANA to enhance research capacity. In this manner, MANA and NIMS are building a solid collaborative relationship. In particular, the following support has been provided.

definitely incorporated into long-term strategies of the main body of NIMS in both aspects of research initiatives and supply of human resources.

-Concrete Measures

(1) Competitive grants obtained by researchers participating in the project and in-kind contributions, etc.

NIMS will support the center in the following manner.

i) Labor costs of permanent staff (such as researchers with tenure and clerical staff) and non-permanent staff that join the center from NIMS will be allocated from operational subsidies and other funds of NIMS except for those who are fully enrolled in the center.

ii) As for projects with operational subsidies that are handled by researchers who join the center from NIMS as senior researchers, we will allocate an equivalent amount of the research funds to the center to implement the project at the center. Among competitive grants obtained by researchers who joined from NIMS, we will allocate an amount equivalent to the direct costs to the center, if the research plan is consistent with that of the center.

iii) We will secure sufficient space mainly at the Nano/Biomaterial Research Building in the Namiki District.

Other than the above, we will give additional assistance for budgeting and space as the need arises.

(2) System under which the center's director is able to make substantive personnel and budget allocation decisions

The center director is given authority for the center's general operation by the president of NIMS. In other words, the center director has the authority to employ, renew contracts, make payroll decisions, determine research expenses, and allocate space for researchers who are invited to the center, except for NIMS permanent staff. His authority also includes employment and renewal of contracts of administrative staff members, except for NIMS permanent staff. If the center director makes the request and the NIMS president confirms its necessity, NIMS personnel are allowed to move to the center. If these are required to be secured, we will make the necessary rule in NIMS's internal regulations.

(3) Support for the center director in coordinating with other departments

-Concrete Measures

(1) Competitive grants obtained by researchers participating in the project and in-kind contributions, etc.

i) Salaries for Chief Scientists and administrative staff participating in the MANA Project were allocated from operations subsidies.

ii) Most research subsidies for NIMS researchers serving as Principal Investigators on the operations subsidy project were allocated to and utilized for MANA. In addition, a portion of the competitive research funds that NIMS researchers working for MANA secured were allocated directly to MANA in accordance with the Center's research plan. Research subsidies for Chief Scientists were also allocated from operations subsidies to provide for smooth start to MANA research activities

iii) It has been decided that conference rooms, the old library and storage rooms in the Administration Building on the Namiki site will be renovated into laboratories in order to provide MANA with its own space on the 4^{th} and 5^{th} floors of the Nanomaterials and Biomaterial Research Building. This will also serve to house devices for external researchers. According to the renovation plan, MANA is expected to move into the 4^{th} and 5^{th} floors sometime in fiscal 2008.

(2) System under which the center's director is able to make substantive personnel and budget allocation decisions

The NIMS President has delegated overall Center management to the Director-General. The Director-General has authority for hiring, renewing contracts, disbursing salaries and research funds and allocating space for all Center staff and researchers except for those on the NIMS mandatory retirement system.

(3) Support for the center director in coordinating with other departments

at host institution when recruiting researchers, while giving reasonable regard to the educational and research activities of those departments NIMS personnel are allowed to move to the center if the center director requests it and he/she accepts the request and the NIMS president confirms its necessity. As stated above, the center will play a role to supply young staff researchers with tenure to the main body of NIMS. Conversely, it does not basically produce any problem that necessary human resources are supplied from the main body of NIMS to the center. We believe such mobility of human resource between the center and the main body of NIMS may stimulate both organizations	at host institution when recruiting researchers, while giving reasonable regard to the educational and research activities of those departments At the request of the Director-General and if the researcher agrees, the NIMS President—when he deems it necessary—may allow NIMS researchers to transfer to MANA. This system is already in place, and 11 Young Scientists and 15 MANA Researchers have been transferred to MANA.
(4) Revamping host institution’s internal systems to allow introducing of new management methods (e.g., English-language environment, merit-based pay, top-down decision making) unfettered by conventional modes of operation We have already experienced in pioneering operations of English use as the official language, clerical work support system in English, creation of bilingual clerical documents, annual salary system, researcher’s performance evaluation, salary assessment, renewal of contracts, etc. at the International Center for Young Scientists (ICYS). There is no problem in adopting such a flexible and distinctive management style which can be seen as an extension of the above operations experienced. We are planning to actively adopt the center’s successful management systems to the main body of NIMS.	(4) Revamping host institution’s internal systems to allow introducing of new management methods (e.g., English-language environment, merit-based pay, top-down decision making) unfettered by conventional modes of operation Using English as the official language and operating a performance-based pay system are aspects of ICYS that will be continued and improved upon in MANA. These systems are almost ready to begin operation. The salary regulations have been amended so that the salary system used with the ICYS-MANA Researchers (postdoctoral researchers) can be switched to a performance-based system. For Principal Investigators and permanent NIMS researchers, the NIMS Evaluation System that has already been established will be used to reward achievement.
(5) Accommodation of center’s requirements for infrastructural support (facilities, e.g., laboratory space; equipment; land, etc.) For the research activities at the center, we will provide a space, approximately 10,000 m^2 for study, mainly at the Nano/Biomaterial Research Building in the Namiki District. The space will be used to secure the following: **Space for experimentation:** We will provide laboratory space at the Nano Biomaterial Research Building for young researchers such as post-doctoral fellows who will proceed with their research independently (about 4,000 m^2 in total). We will provide approximately 1/2 span (20 m^2) as their experimental space. We will provide necessary and sufficient space to principal investigators invited from external organizations. **Single-occupied office and cafeteria:** We will provide young researchers with a single-occupied office (approx. 12 m^2) where they can devote themselves to research	(5) Accommodation of center’s requirements for infrastructural support (facilities, e.g., laboratory space; equipment; land, etc.) Necessary measures were taken to provide MANA with its own space on the 4th and 5th floors of the Nanomaterials and Biomaterial Research Building. This space will be used to provide external guest Principal Investigators and MANA Young Scientists will lab space, offices and a cafeteria.

and to live in a comfortable environment. Also, to realize an ideal Melting Pot environment, we will put all the living rooms together in one place, and secure enough space for casual talks, including a cafeteria. At the center, we will utilize single-occupied offices which are currently used by ICYS . We will allow researchers at the center to freely use research equipment and facilities such as Nano Foundry that NIMS possesses, and will make an effort to accommodate their needs for the use as a priority. Furthermore, we will secure world's top-level advanced facilities with high commonality, in cooperation with the center in a well-planned manner. (6) Support for other types of assistance We assume that the center project is extremely effective in activating the whole of NIMS, so we are willing to make efforts for the smooth implementation to the fullest. NIMS is expecting that the center will play a principle role in leading the main body of NIMS. However, this does not mean that NIMS intends to exploit the center to solve NIMS's specific issues such as the aging researcher population. Such problems should be, of course, solved through NIMS's own efforts. Actually, NIMS is expecting the center to play just two roles, i) leading of the main body of NIMS by carrying out research in a radically accelerated manner and ii) fostering of NIMS's future research leaders with establishment of NIMS's tenure-track system.	(6) Support for other types of assistance NIMS expects MANA to i) conduct and speed up cutting edge research on nanotechnology and nanomaterials in order to lead NIMS research and ii) cultivate the next generation of materials researchers in a global and interdisciplinary environment, i.e. provide NIMS with leading researchers and establish a NIMS tenure track system. We feel that the Center has made an excellent first step in this direction.

11. FY 2007 funding

(Exchange Rate: JPY/USD=120)

Cost Items	Details	Costs (ten thousand dollars)
Personnel	Center director and Administrative director	14
	Principal investigators (no. of persons): 13	62
	Other researchers (no. of persons): 96	204
	Research support staffs (no. of persons): 22	22
	Administrative staffs (no. of persons): 20	34
	Total	336
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons): 5	1
	Cost of dispatching scientists (no. of persons): 3	5
	Research startup cost (no. of persons): 11	11
	Cost of satellite organizations (no. of satellite organizations): 3	25
	Cost of international symposiums (no. of symposiums): 1	2
	Rental fees for facilities	0
	Cost of consumables	39
	Cost of utilities	62
	Other costs	136
	Total	281
Travel	Domestic travel costs	1
	Overseas travel costs	5
	Travel and accommodations cost for invited scientists (no. of domestic scientists): 4 (no. of overseas scientists): 18	8
	Travel cost for scientists on secondment (no. of domestic scientists): 0 (no. of overseas scientists): 0	0
	Total	14
Equipment	Depreciation of buildings	61
	Depreciation of equipment	182
	Total	243
Other research projects	Projects supported by other government subsidies, etc.	373
	Comissioned research projects, etc.	388
	Grants-in-Aid for Scientific Research, etc.	28
	Total	789
Total		1, 663

Dollars (Exchange Rate: JPY/USD=120)

WPI grant for FY 2007		775
Costs of establishing and maintaining facilities in FY 2007		0
Cost of equipment procured in FY 2007		423
Name of equipment: High-resolution 3D digitizer		
Number of units: 1	Costs paid:	19
Name of equipment: Focus controllable laser annealing system		
Number of units: 1	Costs paid:	18
Name of equipment: Silicon deep etching system		
Number of units: 1	Costs paid:	35
Name of equipment: Wafer cleavage system		
Number of units: 1	Costs paid:	11
Name of equipment: High resolution CCD camera for the atom observable TEM		
Number of units: 1	Costs paid:	13
Name of equipment: Electric-operated valve for purified water cooling system		
Number of units: 1	Costs paid:	11
Name of equipment: Field emission scanning electron microscope		19
Number of units: 1	Costs paid:	
Name of equipment: Maskless lithography system		
Number of units: 1	Costs paid:	26
Name of equipment: Environment controllable scanning probe microscope		
Number of units: 1	Costs paid:	10
Name of equipment: Operation controlling system for power supply of hybrid magnet		
Number of units: 1	Costs paid:	13
Others		248

12. Efforts to improve points indicated as requiring improvement in application review and results of such efforts

-Points specified as needing improvement	-Efforts to improve them and results
1) Strategies on how the new center will make NIMS a world-class center should be elaborated. It is recommended that MANA/NIMS introduce more creative and innovative thinking in doing research and executing management so as to transform it into a true center of excellence. NIMS's strong support for MANA is indispensable for the success of program.	1) MANA has made a good first step in creating one of its strong points, i.e. a group of young interdisciplinary and multicultural researchers. This project would be very difficult to conduct at the main body of NIMS. By altering our initial selection of Principal Investigators to 1 foreigner and 2 Japanese, we were able to get younger researchers more involved in MANA, and we built and even stronger team. As mentioned in "10. Commitments from the Host Institution," we have taken every measure to receive support from NIMS.
2) Although it was explained, in the hearing, that MANA is necessary for countering some of the persisting issues within NIMS including the issue of aging researchers, it should be noted that the WPI support is not intended to mitigate the host institution's problems. Independent efforts, such as restructuring, on the part on NIMS to address its own problems should be clearly articulated.	2) MANA is not being used to solve NIMS' issues with ageing researchers.
3) The panel is not fully satisfied with the responses made during the hearing process. The prospective center director should strengthen his ability to communicate his own ideas clearly and persuasively in English.	3) A plan has been proposed to provide the Japanese staff of MANA with English training.
4) There are many good material scientists in Japan. Domestic network should be strengthened for the expansion and growth of MANA.	4) With regard to domestic research institutes, we added Tokyo University of Science to the list of institutions from the initial plan and established a Satellite to promote research there. We are also considering establishing Satellites or collaborative graduate schools with Hokkaido University and Kyushu University to name a few.
5) Further expansion of the participation of female as well as Asian scientists, fellows, and graduate students is needed, and such programs need to be developed quickly.	5) We have approved the appointment of several Asian researchers as MANA Young Scientists and MANA Research Associates. We also hired 1 female MANA Young Scientists. It is a fact that very few females apply for the MANA Research Associates positions, so we need to redouble our efforts to hire a sufficient number.
6) How MANA can make more breakthroughs that NIMS cannot achieve without it should be made clearer.	6) We feel that one of the keys to MANA's success will be the creation of "a group of young interdisciplinary and multicultural researchers," and we have taken a good first step toward achieving this goal. We are confident that young researchers working in tandem with Principal Investigators will lead to breakthroughs.
7) Comment from the reviewer: NIMS should make use of its merits as a	7) As mentioned in 4), we are promoting ties with several Japanese and foreign

non-university research institution. MANA should be structured in such a way as to enjoy good relationships with outside organizations including universities and corporate research institutions.	universities. We will establish Satellites at Japanese and foreign universities, and we are proactively involved in exchange activities with other universities. For example, we have reached an agreement to begin an international collaborative graduate school with the Chinese Academy of Sciences Ningbo Institute of Materials Technology and Engineering, and we are also in discussions with Russia's Moscow State University.