Self-Evaluation Report for Interim Evaluation
World Premier International Research Center Initiative (WPI)

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Report Abstract (2 pages)

1. Center size

As of March 31, 2011, there are 232 members at MANA, of whom 197 are researchers. There are 113 non-Japanese researchers, or 57% of the total, far exceeding the final target of 30% set for the WPI Program and making MANA a truly global research center. There are 38 female researchers, comprising 19% of the total, which has risen significantly from the 13 (11%) at the end of FY2007.

28 researchers with outstanding skills and experiences have been appointed as Principal Investigators (PI) from within and outside NIMS (NIMS: 20, Satellites: 8). The 28 PIs have been assigned as follows. Nano-Materials: 9; Nano-System: 11; Nano-Green: 6; Nano-Bio: 2.

MANA has established six satellites at the following domestic and foreign institutions: Univ. of Tsukuba, Tokyo Univ. of Science, Univ. of California Los Angeles (UCLA), Georgia Institute of Technology, Univ. of Cambridge, and the French National Center for Scientific Research (CNRS). These satellites are involved in research in each of the fields at MANA and serve as venues for training MANA's young researchers.

2. Science level

As of March 1st, 2011, NIMS ranked 5th in the world for the number of institutional citations in the materials science field over the last 5 years according to the Thomson Reuters' ESI Database. About 50% of the aforementioned citations are from articles written by scientists affiliated with MANA. Given the ratio of MANA-affiliated scientists in NIMS (18%), one can see that MANA's contribution is great.

In FY2010, important research achievements began bearing fruit, and the number of reports appearing in newspapers suddenly increased by approximately three times. Particularly noteworthy of these achievements are the following:

- Photocatalyst materials leading to artificial photosynthesis
- Novel transistor with power consumption reduced to one-millionth
- World's highest performance thin film capacitor
- Groundbreaking electrolyte materials for micro-solid oxide fuel cells

MANA possesses the MANA Foundry, which is installed with the finest equipments. Moreover, MANA's researchers have access to much of the internationally cutting-edge and top-performance research facilities possessed by NIMS. In addition, MANA has located itself within NIMS's newest building. And it is expected that field integration will move ahead even further when the new research building is completed in 2012.

3. Interdisciplinary research activities

Aiming to promote integrated research by young researchers, MANA launched the MANA Fusion Research Program. Some of the projects have been selected for the Funding Program for Next Generation World-Leading Researchers and Grant-in-Aid for Young Scientists A, while some research outcomes have been reported on widely in newspapers and online news sites.

As of March 2011, MANA Seminars have been held a total of 199 times. At these seminars, researchers from both within and outside MANA present hot research topics and engage in discussions with MANA researchers of different fields. Thus each seminar comes into its own as a true "melting pot." As a result, the seminars are playing a role in promoting field integration.

MANA implements a "camp"-type approach called "Grand Challenge Meetings" that bring together researchers from different fields. These meetings have proven to be highly beneficial in fusing various fields and motivating young researchers to tackle new challenges.

4. Globalization of the institution

In addition the majority of MANA's researchers being foreign nationals, many researchers from around Japan and overseas visit MANA. In this way, MANA is becoming an international research center that attracts researchers from around the world. Thus far, MANA has signed MOUs with 29 overseas research institutions, and it is pursuing joint research and personnel exchanges based on them. MANA is promoting the building of a network linking nanotech bases throughout the world, with MANA serving as the hub.

ICYS is firmly established as a gateway to success for permanent researchers of NIMS. Many researchers from around the world apply for ICYS whenever regular international recruitment drives are held.

The MANA Administrative Section provides full technical and clerical supports to all researchers regardless of nationality and age and has nearly realized its mission of providing an environment in which researchers can devote themselves exclusively to their research.

5. Organizational reform

A system is established whereby three executives—the Director-General, Chief Operating Officer, and Administrative Director—hold discussions as necessary and make quick decisions regarding MANA's operation.

It is clearly mentioned in NIMS's third five-year plan that MANA will promote some areas of system reform (internationalization and human resources development) within NIMS. NIMS, the host institution, began a program to raise the English language skills of all young permanent administrative employees in FY2010. This program is intended to spread MANA's use of English as an official language to all areas of NIMS.

6. Collaboration with universities

Since MANA is a part of a public research center and not a university, we strive to collaborate with universities. MANA held 18 workshops with foreign and domestic universities by March 2011 with the aim of promoting research exchange and boosting MANA's name recognition in order to scout for talent.

In addition, NIMS operates the "NIMS Graduate Schools" with the Univ. of Tsukuba, Hokkaido Univ., and Waseda Univ. 20 MANA researchers serve as professors for this program, and they are currently supervising 31 PhD students. MANA also accepted 25 students from 8 foreign universities with which International Joint Graduate School Agreements were concluded. We have also accepted 89 internship students, 80 of whom were foreigners.

7. Cultivating young researchers

The 3D (Triple-Double) System is extremely effective for cultivating young researchers by research guidance by more than one mentor (Double-mentor) to enhance independence, having more than one discipline (Double-discipline) to strengthen interdisciplinary background knowledge, and multiple affiliations (Double-affiliation) to strengthen an independent spirit. Many of MANA's young researchers have successfully advanced their careers either within or outside NIMS, having been promoted to NIMS group leaders or to positions at other research institutions.

8. Securing research subsidies

In the past 3.5 years, MANA researchers have secured 7.82 billion yen in research funding. Each year, MANA's researchers continue to capture large-scale competitive funding, and the amount of external funds they acquire is growing steadily. The amount of external funding acquired in FY2010 has increased by 1.63 times compared to FY2008.

9. Efforts to improve points indicated as requiring improvement

1) <u>Making clear the distinctiveness of science being pursued in MANA</u>

MANA publishes a scientific literature that explains nanoarchitectonics by targeting not only researchers but also the general public. MANA also publishes special features on MANA in journals of original papers by major MANA scientists in order to spread the word on the nanoarchitectonics concept's distinctive characteristics and to raise recognition of MANA.

2) <u>Needs for grand challenge to create new materials science</u>

To take on "grand challenges," MANA has started a "camp"-type approach called "MANA Grand Challenge Meetings," and creates a climate for fusing differing fields and motivating young researchers to tackle new challenges. Also, starting in FY2011, MANA has implemented the "MANA Grand Challenge Research Program" to nurture research that is highly creative yet risky.

3) <u>Reinforcement of nano-bio field</u>

In September 2010, we newly named Dr. Takao Aoyagi as the field coordinator and a Principal Investigator of nano-bio, and reviewed both our research content and framework in this field.

Research target has changed to the creation of biomaterials that make possible "materials therapy," in which the material itself encourages sustained healing of biological tissue. And as for research implementation framework, MANA appointed Dr. Guoping Chen of NIMS and Prof. Françoise Winnik of the Univ. of Montreal to serve as new PIs, thereby forming a staff of four PIs.

1. Summary of Center Project

<Initial plan>

The purposed center aims 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".

"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. 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. 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 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. 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.

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. The center also utilizes this "melting pot" environment to foster young researchers, contributing to the main body of NIMS by providing young staff researchers. Finally, the center will adopt unique systems to thoroughly promote the integration of different fields and to foster young researchers.

<Current status>

Nanoarchitectonics is a new paradigm for materials development that shifts the focus from the conventional analytical view of the nano-scale world to an integrated view, in which nano-scale structural elements are combined to manifest new functions that cannot be ascertained through analysis alone, and reconfigures nanotechnology to that end.

To realize the concept of nanoarchitectonics, MANA is working on reconfiguring five key technologies: controlled self-organization, chemical nanomanipulation, field-induced materials control, atom/molecule novel manipulation, and theoretical modeling and designing. As the front-runner in nanoarchitectonics, MANA is engaged in the development of innovative new materials in the four research fields of Nano-Materials, Nano-System, Nano-Green and Nano-Bio.

To conduct this work, 28 researchers with outstanding skills and experiences have been appointed as Principal Investigators (PI) from within and outside NIMS (NIMS: 20, Satellites: 8). The 28 PIs have been assigned as follows. Nano-Materials: 9; Nano-System: 11; Nano-Green: 6 ; Nano-Bio: 2.

As of March 31, 2011, there are 232 members at MANA. 197 of these are researchers, of which 113, or 57%, are non-Japanese researchers. 38, or 19%, of 197 researchers are female, and we boosted this percentage by 7 points by hiring 16 female researchers in the past year.

With 169 young scientists hailing from 22 countries, we have successfully created an environment in which a diverse group of young researchers can mutually hone their skills in the spirit of friendly rivalry. Six of these young scientists have been promoted to group leaders, and 16 ICYS (postdoctoral) researchers have been hired as permanent NIMS researchers. Many young researchers have secured positions at other research institutions, and in this way, MANA is fulfilling its objective of cultivating the next generation of excellent young researchers.

<Future prospects>

To realize a sustainable society in the 21st century, MANA will create new materials and systems and continue making breakthroughs in green innovation and life innovation.

MANA will maintain a size of around 25 Principal Investigators and 200 total researchers in an effort to create a center where revolutionary research is achieved amid friendly rivalry in a "melting pot" environment of men and women of all ages, various nationalities and differing disciplines.

2. Center’s Research Activities

2-1. Initial plan

<Research fields>

The 21st century is, without doubt, the century where humanity, for the first time in its experience, recognizes the 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 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.

<Research objectives>

The research objective to be achieved 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.)
   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:

DNA chip materials (nanopiller array, etc.)

Biomaterials (regenerative materials, etc.)

Technologies used in nanoarchitectonics can be roughly classified into 4 techniques, i.e. i) controlled self-organization, ii) field-induced materials control, iii) chemical nanomanipulation, and iv) atom/molecule novel manipulation; in addition, v) theoretical and computational approach is quite important for conducting research effectively (see Fig.1).

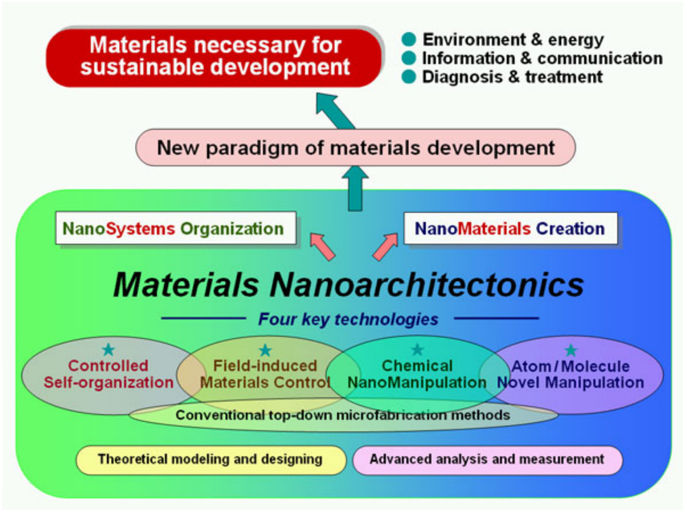

Fig. 1: New paradigm in material development through materials "nanoarchitectonics"

2-2 Research results to date

2-2-1 Center's research activities and results (within 8 pages)

Since its inauguration in 2007, MANA has advocated a new technological system named "materials nanoarchitectonics", which intends to innovate conventional nanotechnology and cause a paradigm shift in the methodology of materials research and development. Material nanoarchitectonics is, in short, a new technological system that creates a novel functionality by arranging nanoscale structural units in an intended configuration with special attention paid to mutual interactions among the nanoscale structural units. Basically, materials nanoarchitectonics is composed of five key technologies, i.e. i) controlled self-organization, ii) field-induced materials control, iii) chemical nano-manipulation, iv) atom/molecule novel manipulation, and v) theoretical modeling and designing.

At the time of its inauguration in 2007, MANA organized five research groups corresponding to the five key technologies i)-v) mentioned above. In 2008, however, the organization was reshuffled into the present four research fields, i.e. 1) Nano-Materials, 2) Nano-System, 3) Nano-Green, and 4) Nano-Bio Fields for the purpose of clarifying relations with MANA and the society (see Fig. 2).

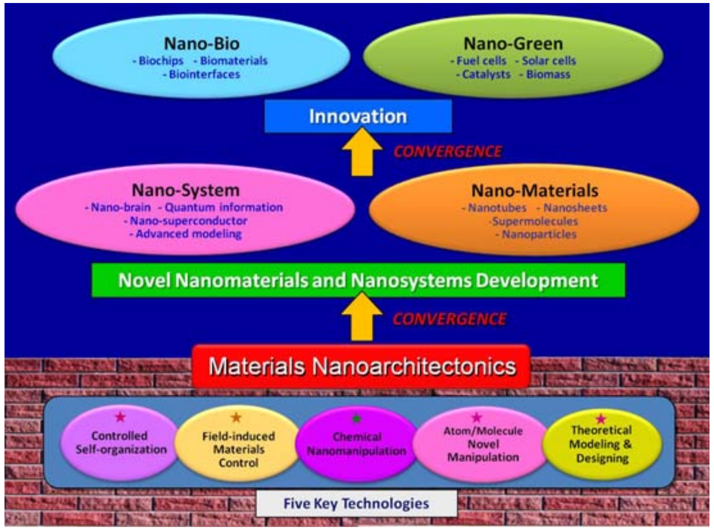

Fig. 2: Research Target of MANA

A look at data concerning MANA's research performance shows that, in terms of numbers of papers and patents issued, MANA has seen remarkable improvement in its performance since its early days. MANA's maturation is also seen in the number of highly regarded awards its researchers have garnered (e.g. Feynman Prize in nanotechnology, Honda Frontier Award, Tsukuba Award, etc.). In addition, MANA announces highly noteworthy research achievements to the press in a proactive and timely manner. In FY2007, its first year of existence, MANA issued only 30 press announcements; however, in FY2010, this number had nearly tripled to 89. Such growth demonstrates the momentum with which MANA's research activities are expanding remarkably.

Concrete research activities in each of the four research fields of MANA are as follows.

Nano-Materials Field

In this field, we planned to create inorganic and organic nanoscaled materials, seeking new or enhanced physical and chemical properties. A range of synthetic techniques based on vapor- and solution-phase processes were applied to synthesize various nanotubes, nanowires, nanosheets, and nanoparticles as 1D, 2D and 3D nanomaterials, respectively. A range of characterization techniques were applied to fully analyze their composition and structure, and explore their physicochemical functionalities including electronic, magnetic, optical, chemical and mechanical properties. Particular stress was focused on advanced physical-property measurements on individual nanoscaled materials using our sophisticated TEM and SPM systems. Furthermore, we developed new nanostructured materials by organizing the nanoscaled materials or combining them with other foreign substances via soft-chemical or colloid processes. To realize these assembly processes or "Materials Nanoarchitectonics", fundamental key technologies such as controlled self-organization, chemical nanomanipulation, field induced materials control and atom/molecule novel manuipulation have been utilized. These experimental approaches were supported by theoretical modeling and designing. Through this approach, we attempted to realize sophisticated functionalities useful in various applications, which cannot be attain with bulk conventional materials.

As for 1D nanomaterials, we have successfully synthesized a wide variety of inorganic nanotubes and nanowires including BN, ZnO, ZnS, CdS, In_2Se_3, and Si, through various synthetic methods using the chemical nanomanipulation. We found that the obtained 1D nanomaterials exhibited useful thermal, electronic, and optical properties. One of the highlight achievements is the development of CVD process to produce high-purity BN nanotube at a high speed. Lithium oxide was found very effective to grow four or five walled nanotubes with a diameter of about 10 nm. This process enables to yield one gram of the nanotubes in one day under optimized conditions. Furthermore, we demonstrated that BN nanotubes could be homogeneously dispersed into various polymer matrix, which is involved by mixing a mat of BN nanotubes with polymer, drying, and then hot-pressing at 100-200^{o}C. Through this simple process, the nanotube content could increased to be as high as about 30 wt%. Because of superior thermal property of BN, the obtained polymeric nanocomposite materials showed a high thermal conductivity up to 3-5 W $m^{-1}K^{-1}$ as well as an enhanced mechanical property. These features indicate great promise of these materials as a heat sink, and collaboration with industry toward its practical application has started.

A "Nanofactory Instruments" TEM-AFM holder inside a JEM-3100FEF (JEOL) 300 kV field-emission TEM (Omega Filter) has been utilized to probe physical properties of individual nanomaterials. Typically C or BN nanotube was clamped between the conductive AFM Si cantilever and W electrode, which was moved backward at a controlled displacement of 100-300 nm to record the force on the nanotube. Tensile strength of ~100 GPa and 33 GPa was determined for the first time for single-walled C nanotube and multi-walled BN one, respectively. More interestingly, enhancement in electrical conductivity of BN nanotube was found by bending it in a similar measurement. Furthermore, we demonstrated "nanopipet" action of C nanotube. An extremely small mass release corresponding to 10^{-12} g of CuI could be controlled by applying electrical field between CuI filled C nanotube and W electrode. These properties and behaviors of nanotubes have been disclosed for the first time through our advanced nanoanalysis techniques.

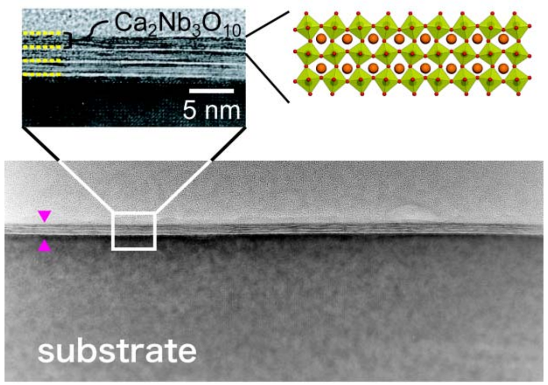

Fig. 3: Cross-sectional TEM image for a 3-layer film of Ca2Nb3O10 nanosheet

2D nanomaterials such as nanosheets have been synthesized via a unique process involving chemical exfoliation of layered compounds. Layered titanates, in which some portion of Ti site is substituted for by magnetic elements, were delaminated by intercalating quaternary ammonium ions. The resulting unilamellar nanosheets of $Ti1_{-x}M_xO_2$ (M= Co, Fe, Mn) were found to show ferromagnetic and magneto-optical properties. Various layered perovskites were synthesized and exfoliated into a series of nanosheets, typically $Eu_{0.56}Ta_2O_7$ and $Ca_2Nb_3O_{10}$, which exhibit a range of functionalities including photocatalytic, photoluminescent, and dielectric properties. In addition to these anionic oxide nanosheets, oppositely charged hydroxide nanosheets were synthesized as a new member of functional nanosheets: Layered double hydroxides (LDHs), particularly those composed entirely of transition metal ions were synthesized via our newly developed process involving topotactic oxidation of brucite-type microcrystals preformed via homogeneous precipitation. The well-developed hexagonal-shaped platelet microcrystals of LDHs thus derived were exfoliated into unilamellar hydroxide nanosheets, $M_{1-x}^{2+}M'_x{}^{3+}(OH)_2$ where M = Co, Ni, Fe, Zn, M' = Co, Fe, with a thickness of 0.8 nm by action of organic solvents such as formamide. These nanosheets were found to exhibit redox activities and magneto-optical properties. We discovered a new class of layered hydroxide based on rare-earth elements that can be produced via homogeneous precipitation of corresponding salts. The compounds show anion-exchange properties and a dodecylsulfonate-exchanged form was successfully delaminated into unilamellar sheets of $Eu(OH)_{2.5}xH_2O$, which showed photoluminescent property.

These oxide and hydroxide nanosheets are obtained as monodispersed colloid and useful as unique 2D functional building blocks. We demonstrated that oxide nanosheets could be assembled layer-by-layer onto various substrates by applying electrostatic self-assembly method and Langmuir-Blodgett deposition. Under optimized conditions, neat tiling of nanosheets could be attained and their repetition led to highly-ordered multilayer structures. We have demonstrated that the films could find various applications: The films of $Ca_2Nb_3O_{10}$ and $Sr_2Nb_3O_{10}$ nanosheets (see Fig. 3) showed superior dielectric and insulating properties (ε_r = 210-230, J_c <10^{-7} A cm^{-2} at 1 V), which is the top performance among those for other dielectric materials including $Ba_{1-x}Sr_xTiO_3$. Joint research with companies to develop various applications is now under way. Most recently we found that ferroelectricity was evolved via hetero-assembly of $LaNb_2O_7$ and $Ca_2Nb_3O_{10}$ nanosheets. Although each component is dielectric, the combination produced ferroelectric behavior. The soft interface between two-types of nanosheets constructed by nanoarchitectonics may be responsible for this intriguing result.

Various nanoarchitecture systems based on organics have been tailored by organizing designed functional organic molecules based on the concept of supermolecular assembly. For example, we developed a method that can make an optimal structure to distinguish between T (thymine) and U (urasyl) with an extremely similar structure (one-CH_3-group difference) by synthesizing a molecule called armed cyclononane, and using it to form a membrane on a water surface and appropriately deforming it by fine tuning with compression to shape into an optimal structure. This method was proved successful in achieving a maximum of 64 times the precision for distinguishing these two nuclear acid bases with each other under optimized surface pressure. Such precise recognition cannot be done even with natural DNA and RNA, because they use the same adenine residue for recognition of T and U. Therefore, it may be said that recognition capability of this system exceeds that of nature. This strategy could also be performed using the surface of a flexible polymer or gel and could be applied for precisely analyzing gene sequences of DNA and detecting genetic disorders. This methodology has been developed as Hand-Operating Nanotechnology by this group, which technology allows arraying of molecular machines and other functional molecules as a membrane on an interface and enables simple manual manipulation of the membrane such as compression to allow nanometer level movement control of functional molecules. As generalization of this methodology, chiral resolution of amino acids and precise discrimination of nucleotides are similarly achieved by changing monolayer components.

Nano-System Field

In this field, we pay special attention to novel functionalities created by mutual interactions among individual nanostructures and construct nano-systems that utilize the created functionalities effectively by making full use of nanoarchitectonics. We have so far focused our research mainly on three categories, i.e. 1) the development of innovative nanoelectronic devices that enable highly advanced information processing and communication beyond the present status, 2) the realization of novel nanoscale evaluation methods useful for the above-mentioned development, and 3) theoretical studies that support or lead the experimental work. Regarding the innovative nanoelectronic devices, in order to surpass the limitations of the present CMOS devices, we have developed various novel nanoelectronic devices by the use of solid and polymer electrolytes, superconducting materials, graphene, and organic materials. Furthermore, we have tried to materialize neuromorphic nanosystems made of inorganic materials for novel information processing and storage, which will innovate today's computer in algorithm and architecture. As for the novel nanoscale evaluation methods, we have developed several techniques helpful for nanoarchitectonic research. That is, multi-probe scanning-probe microscopes (MPSPM) that can observe signal transmission in a nanosystem , a novel type of spin-polarized scanning tunneling microscope for nanoscale spin detection, an ultra-sensitive molecular sensor that can detect a single molecule at any designated positions at a spatial resolution of ~50 nm, and an ultra-sensitive and ultra-parallel molecular sensing system. Theoretical studies have been focused on the exploration of novel nanodevices and nanosystems using superconductors and relevant materials and on the analysis of dynamic chemical processes related to both the construction and operation of molecular nanosystems. In both cases, close collaboration with experimental studies have been made. In these three categories of research in the Nano-System Field, the following concrete results were obtained.

With regard to the atomic switch we developed years ago, further remarkable progress was seen recently in the following five aspects. 1) The atomic switch was greatly improved in stability and reliability for practical use and combined with CMOS devices to realize a compact-sized field-programmable cell-based integrated circuit (a next-generation integrated circuit); this work was done in collaboration with NEC Corp. (Fig. 4a). 2) Although the atomic switch was originally developed as a 2-terminal switch, we succeeded to develop a 3-terminal atomic switch (atomic transistor); this expands the field of use of the atomic switch considerably. 3) Interestingly it was revealed that the atomic switch had learning abilities (both short-term memory and long-term potentiation) similarly to a synapse in a neural network, so that we tried to materialize neuromorphic networks using the atomic switches, and a good prospect was obtained. 4) We succeeded in developing a new type of atomic switch that uses not a solid electrolyte but a polymer-based electrolyte; this indicates that a flexible circuit consisting of atomic switches can be made. 5) A photo-sensitive atomic switch was successfully developed by using photo-sensitive molecules, indicating that an artificial retina can be made in the future. These results 1)-5) clearly show that the atomic switch has bright future regarding its application to various technologies.

A surprising fact was found as to a thin film of C_{60} molecules. Namely, it was revealed that we can dimerize or trimerize local C60 molecules by using a scanning probe biased at a certain voltage and that the formed dimer or trimer can be decomposed into original C_{60} monomers merely by changing the polarity of the bias voltage. By using this remarkable phenomenon, we demonstrated that single-molecule-level ultra-high-density data storage (~200 Tbit/in^2) was possible (Fig. 4c). Another surprising nano-chemical phenomenon was found and used. Namely, we have succeeded to wire two linear conductive polymer molecules (polydiacetylene, PDA) to a single functional molecule (phthalocyanine, Pc) with ‘chemical soldering’ (firm covalent bonding) between the PDA and Pc molecules (Fig. 4b). This opens up the bright future as to the realization of molecular electronics.

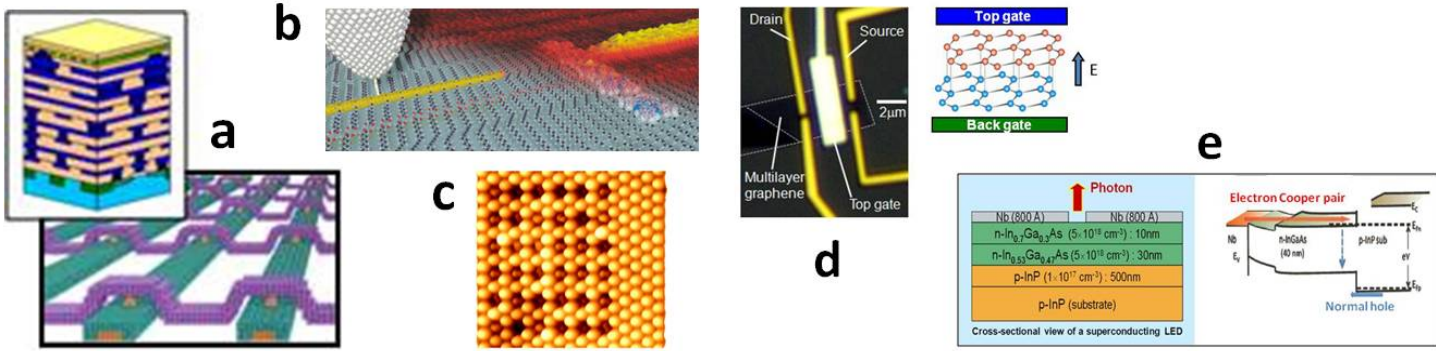

Fig. 4: Integration of atomic switches (a), molecular wiring and ‘chemical soldering’ (b), single-molecule level data storage using C_{60} (c), a gaphene device (d), and a superconducting light emitting diode (e).

We developed novel nanoelectronic devices using graphene or an organic material. As for the former, it was revealed that a graphene bilayer becomes a semiconductor with a band gap when a strong electric field is applied. A field-controlled electronic device based on this effect was constructed (Fig. 4d). Two revolutionary nanoelectronic devices using superconducting materials were also developed. One is ultra-sensitive superconducting quantum interference device (SQUID) in which a semiconductor quantum dot is used in each Josephson junction; even a single spin can be detected by this SQUID. The other is a superconducting light-emitting diode (LED) in which an electron Cooper pair in a superconductor recombines with normal holes in a semiconductor, emitting a pair of photons entangled quantum mechanically (Fig. 4e). Both devices will be useful for quantum information processing.

Various nanoscience and nanotechnology studies such as those described above will be accelerated by developing various new nanoscale evaluation methods. From this point of view, we developed the following five new methods. 1) Multi-probe scanning-probe microscopes (MPSPM) having independently driven 2, 3, or 4 probes; not only the internal structure of a nanosystem but also signal transmission among any different nanostructures in the nanosystem can be observed. 2) A novel spin-polarized scanning tunneling microscope (SPSTM), where no magnetic tip is used and the circular polarization of emitted light is measured; nanoscale local spin detection is possible by this method. 3) An ultra-sensitive molecular sensor that can detect a single molecule at any designated positions at a spatial resolution of ~50 nm; this will be helpful in various bioscience studies. 4) An innovative ultra-sensitive and ultra-parallel molecular sensing system with the use of piezoresistive membranes; this method will enable to detect/identify hundreds of different molecules at the same time and make a great contribution to medical diagnosis. 5) A new type of the scanning tunneling microscope (STM) in which a local sample area just below the STM tip can be irradiated with energy-tunable synchrotron-radiation X rays; elemental analysis is possible at any points in an image observed by the STM.

As for theoretical research, remarkable results were obtained regarding a) the emission of THz electromagnetic waves from an oxide high-temperature superconductor having a stack of intrinsic Josephson junctions, b) a new nanosystem that can observe the creation of a pair of electrons entangled quantum mechanically, c) the dye sensitization of solar cells, and d) novel molecular logic gates.

Nano-Green Field

In this field, we are trying to solve one of the most important and challenging problems for chemists/material scientists, that is the construction of efficient energy/materials conversion systems. In natural systems, solar energy is used to efficiently convert chemical substances to those with high energy and chemical substances are efficiently converted to work and other compounds based on well ordered arrangement of organic and biological molecules with various functions such as photon absorption, electron relay, and catalyst, i.e. enzyme. On the other hand, inorganic materials are mainly used for energy/materials conversion in modern technology and the efficiency and durability of these systems are still need to be improved.

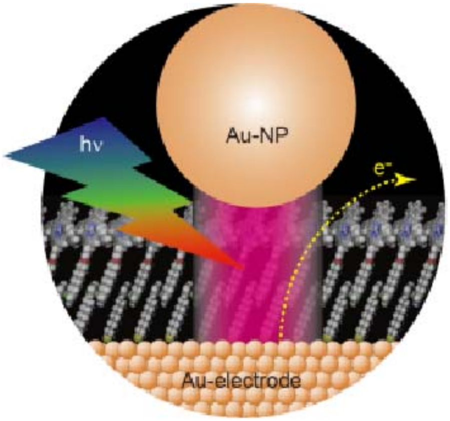

Fig. 5: Schematic illustration of plasmonic enhancement of photo-induced electron transfer at self-assembled monolayer by the introduction of gold nanoparticle.

Main research direction of the groups in Nano Green Field is to construct highly efficient interfacial energy/materials conversion systems by arranging metal, semiconductor and organic molecules with atomic/molecular resolution based on the concept of “surface nanoarchitechtonics”. Specifically, we have been carrying out :1) construction of photoenergy conversion interfaces by arranging atoms, molecules and nanoclusters in ordered manner based on rational design, 2) construction of chemical energy conversion interfaces by epitaxial growth of solid oxide, 3) establishment of fundamental techniques to form highly efficient catalysts by arranging atoms and molecules at will, and 4) experimental and theoretical investigations of interfacial structure and electron transfer processes in high lateral and time resolution.

We have achieved several important progresses in conversion from photoenergy to electricity or chemical energy. One of the most important issues in photoenergy or solar energy conversion is to utilize wide range of solar spectrum. In this respect, novel dyes for dye sensitized solar cell to absorb near infrared light and novel photocatalyst (Ag_3PO_4) for water oxidation under visible light illumination were developed. Also plasmonic enhancement of photoinduced uphill electron transfer in a molecular monolayer system was demonstrated by introducing gold nanoparticles, which act as optical antenna for near infrared light, on top of a self-assembled monolayer of porphyrin-ferrocene coupling molecule formed on a gold surface (Fig. 5).

The conversion of photoenergy to chemical energy, i.e., artificial photosynthesis, is more difficult than that to electricity as it requires highly efficient and selective reactions at the interface in addition to the requirements for the conversion of photoenergy to electricity. We have established a method for room temperature synthesis of mesoporous $ZnGa_2O_4$, which is capable to reduce CO_2. We have also developed highly efficient photoelectrochemical hydrogen generation and CO_2 reduction systems by assembling molecular layer with electron transfer function and metal complexes with catalytic activity on silicon surface.

If natural energy such as solar and wind energy is used, the gap between the demand and supply is huge both in time and location and the development of efficient energy storage/transportation system is critical. Secondary battery and fuel cell are the key devices in this respect. Although secondary battery is the most advanced energy storage system, there are many problems such as efficiency and safety to be solved and we are developing all solid state Li-ion battery. When hydrogen is generated by solar energy as a fuel, fuel cell, which converts hydrogen to electricity, is required. In both cases, the key for the improvement of cell performance is the higher conductivity of the electrolytes and the control of interfacial structure.

Pulsed laser deposition (PLD) technique is employed to deposit well ordered metal oxide thin films such as solid electrolytes for solid oxide fuel cell and Li ion battery as well as cathode and current collector for Li ion battery. For example, highly textured Y-doped barium zirconate film, which exhibits the highest ionic conductivity in intermediate temperature region was prepared and μ-solid oxide fuel cell was constructed (Fig. 6). High quality $LiCoO_2$ cathode film and $SrRuO_3$ single crystal current collector acting as a substrate for epitaxial growth were also prepared by PLD.

It is very important to establish universal methods to arrange atoms and molecules at will so that highly efficient catalysts for specific reaction can be prepared based on rational design. In this regard, novel methods for solid phase synthesis of metal-organic molecule array targeting electrocatalysts for fuel cells and for preparation of atomically mixed alloy catalysts using multinuclear metal complexes as substrates were established.

To construct highly efficient interfacial energy conversion system, it is also essential to have in situ techniques to determine the structure at solid/liquid interfaces with high lateral and time resolution. Sum frequency generation spectroscopy was developed and novel gap-mode Raman scattering was proposed to determine the interfacial molecular structure. Femto second visible pump-IR probe technique was used to follow the interfacial electron transfer dynamics.

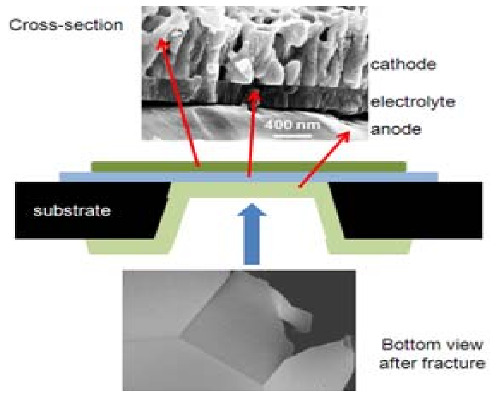

Fig. 6: Schematic illustration and SEM image of a μ-solid oxide fuel cell.

Nano-Bio Field

In this field, the research objective is to vigorously promote the development of new functional biomaterials and medical devices. In cooperation with outside medical institutions, we plan to continue developing technologies for the medical industry through an active fusion of biotechnology with a wealth of knowledge in the field of materials science. The target is the development of biomaterials utilizing Nanoarchitectonics strategy. The smallest unit of the human body is the “cell.” The body is constructed from “tissue,” which consists of groups of cells and the matrices which support them, and “organs,” which are tissues that are organized so as to demonstrate functions. Thus, the body is made up of extremely complex nanostructures and a hierarchical organization of those nanostructures. Moreover, as the living body consists variously of hard tissues such as bone and teeth, and soft tissues such as skin, blood vessels, and organs, the artificial materials for repairing these tissues also span a wide range. Therefore, introducing the concept of nanotechnology in the design and construction of artificial materials, and reproducing intricate structures which are closer to those in the human body, are extremely effective strategies for constructing biomaterials for treating disease.

We have employed self-assembling mechanism to nanoparticle preparation, viz., amphiphilic block copolymer (MW<10 kDa) self-assembled to form core-shell type nanoparticle with 30-40 nm. Such self-assembling nanoparticle can be metabolized after disintegration in non-specific area. One of the other ideas was to combine ON-OFF regulation by certain stimulation. These nano-devices based on” Nanoarchtectonics” strategy worked well in our nano-therapeutic study.

Nitrogen oxide is known to play versatile roles in vivo. Excessive NO generation reported to cause antitumor effect in vivo. We started to design new polymer micelle based NO-photodonor for novel anticancer chemotherapy. PEGylated polymer micelles containing 4-nitro-3-trifluoromethylphenyl units within the core moiety were prepared, and their photo-triggered nitric oxide (NO)-generating ability was confirmed by electron spin resonance (ESR) spin-trapping and the Griess method. These micelles were found to be able to deliver exogenous NO into tumor cells in a photo-controlled manner and showed an NO-mediated antitumor effect, indicating the usability of this molecular system in NO-based tumor therapy.

In order to assess the photo-induced NO-mediated antitumor effect of the ND micelles, in vitro examination was performed using HeLa cells. Figure 7 shows the change in the viability of HeLa cells as a function of the concentration of NO-micelles. Without UV light irradiation, the NO-micelles showed a relatively lower cytotoxicity, and the 50% inhibitory concentration (IC50) was found to be 4.9 mg mL-1. This might be due to the existence of the biocompatible PEG outer layer at the surface of the NO-micelles.

Upon UV light irradiation, the cytotoxicity of the NO-micelles was enhanced with the increase in irradiation time, and a significant decrease in the IC50 value of the ND micelles was confirmed (after 3-min irradiation (6.12 J cm-2) IC50 = 1.9 mg mL-1, after 10-min irradiation (20.4 J cm-2) IC50 = 0.2 mg mL-1). It should be noted that the fluencies of the UV light employed in this experiment did not affect the viability of HeLa cells in the absence of NO-micelles, indicating that the photo-induced enhancement of the cytotoxicity of the NO-micelles was caused by the photoproducts, NO and polymer-bonded oxyl radicals. Oxyl radical and its degradation products are known to exhibit no significant cytotoxicity, which strongly emphasize that the liberated NO works mainly to an antitumor effect in a photo-controlled manner.

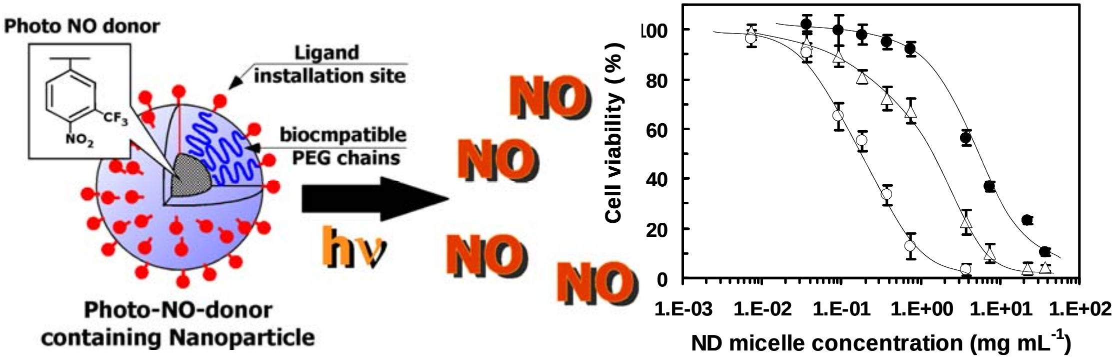

Fig. 7: Schematic illustration of polymeric micelle based NO-photodonor for novel anti-tumor chemotherapy(upper). (a) Viability of HeLa cells treated with NO-micelles at various concentrations with (open symbol) or without (filled circle) UV light irradiation

On the other hand, developmental research on a drug-eluting stent which effectively avoids restenosis is continuing to conduct. Stents are widely used to expand blood vessels when constriction (stenosis) of a blood vessel occurs due to atherosclerosis, but recurrence of stenosis (i.e., restenosis) had been a problem with conventional stents. Therefore, we developed an Am80-loaded drug eluting stent by incorporating the drug Tamibarotene (Am80), which has a proven record of clinical use, in a citric acid-crosslinked alkali-treated gelatin polymer matrix, which displays antithrombogenic and endothelialization properties. A large amount of Am80 is slowly released during the first 1-2 weeks after expansion of the stent, when the inflammatory response is strong, and drug release continues for 8 weeks. When the prepared Am80-eluting stent was left for 2 weeks in a coronary artery of a pig, satisfactory endothelialization was observed, and absolutely no formation of clots (thrombus) was detected. As a result, it was found that tissue which is virtually indistinguishable from the surface of a healthy blood vessel can be formed stably. This new stent was shown to suppress restenosis over the long term, and animal experiments are now progressing steadily. Early commercialization is expected.

Field-crossing fusion research in MANA

In MANA, field-crossing fusion research is regarded as highly important. Various research results along this policy are seen in what was described in the previous sections. Apart from it, we established the "MANA Fusion Research Program", which makes special financial support to encourage cross-disciplinary research with potential to establish an unexplored new research field for young scientists. In 2009, 6 Projects have been selected from 18 applications. A total amount of 10 million yen was allocated for each project (for 2 years). In the following, 4 examples of the fusion research projects are shown.

1. *<u>Highly-functionalized Si-related energy conversion materials fabricated by self-organization</u>*

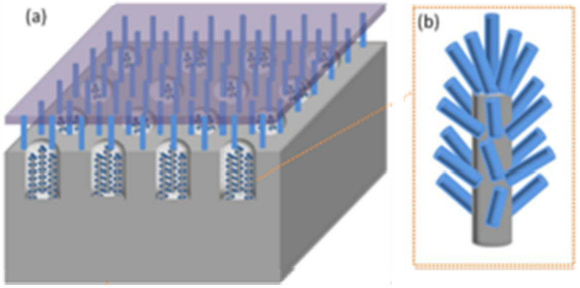

Fig. 8 Schematics of a n-ZnO/p-Si 3D hetero-junction in a holey array structure (a) and the model of an individual ZnO/Si 3D junction inside the hole (b).

The development of the next-generation high-efficiency solar cells using functionalized Si and other semiconductor nanostructures has been carried out by the fusion of top-down and bottom-up techniques, namely, lithographic techniques and chemical self-organization methods, resulting in the construction of unique 3D structures with heterojunctions of n-ZnO/p-Si. We fabricated a new type solar cell composed by Si and ZnO. n-ZnO/p-Si 3D heterojunctions, which would enhance the light absorbance and trapping, were made inside each single Si micro-holes via a hydrothermal chemical method. The Si micro-holes were created by lithographic techniques. The transparent n-ZnO layer helps solar light effectively introduce into Si micro-holes. In particular, the sensitivity to the UV light increased by using n-ZnO layers. In order to improve the conversion efficiency of the new solar cells, the crystallinity of ZnO nanostructures and the n-ZnO/p-Si heterojunctions shoud be controlled. In addition to this, another hybrid structures using 0D Si nanocrystals as light absorbers and 1D Si nanowires as transport passways of light induced carriers will be required. By optimizing the structures, we aim to fabricate new Si-related solar cells, which have higher conversion efficiencies than the theoretically estimated limitation value (28%) for bulk Si.

The new ideas and concepts obtained in the MANA Fusion project have currently led to a new project named “Funding Program for Next Generation World Leading Researchers (NEXT Program)”.

2. Understanding of photocleavage reaction at solid surface and development of new biointerfaces

Some aromatic compounds are photocleaved at specific chemical bonds upon absorption of near UV light. Of these, 2-nitrobenzyl group is the most common photocleavable functional groups and have been applied to a wide range of biological and organic synthetic purposes. Although this reaction has been used on solid surfaces as well as in aqueous or organic solvents, the reaction mechanisms have been only extensively studied for the compounds dissolved in solutions. In this project, we addressed the reaction mechanisms of the 2-nitrobenzyl group on solid surfaces. Our team was composed of three MANA independent scientists who have different research background, *i.e.*, analytical biochemistry, spectroscopy, and computational physics. Such interdisciplinary collaboration is essential, because the major difficulties in this topic were systematic surface engineering, analyses of soft matter at interfaces and theoretical discussion of the excited state chemistry. By sharing the results obtained in each part, we intended to reconsider the way of surface engineering, analysis, and calculation very often to accelerate this collaboration.

We synthesized several photocleavable compounds, which formed self-assembled monolayers (SAMs) on gold or silicon oxide surfaces. These compounds were used for dynamic cell patterning and photo-induced protein delivery. When the substrates functionalized with the photocleavable compounds were analyzed by UV-Vis and IR spectroscopy, we were not able to observe nitroso compound by the photoirradiation, which were the major photoproduct in solutions. Furthermore, the conversion rate (or quantum yield) was inversely-correlated to the surface density of the photocleavable compounds. To further investigate the reaction mechanisms of the 2-nitrobenzyl group on solid surfaces, we are now developing a time-resolved UV-Vis spectrometer. In addition, the interpretation of the above-mentioned finding in the interfacial effects on the photocleavage reactions by first-principles calculation is under way.

3. Highly sensitive nanomechanical sensor having nano-sieve for medical, biological, security, and environmental applications

“Sensitivity” and “Selectivity” are the fundamental requirements for any kinds of sensors, while it is a challenge to fulfill both of them on a single sensor platform with convenient features for actual applications. In the present project, we focus on a cantilever array sensor and try to overcome this challenging issue by fusing different expertise. Since the sensing process is based on an interaction between sensor surface and target molecules, this selectivity issue will never be solved without the fusion of materials engineering with molecular-level precision. Mesoporous materials have nano-scale pores which can fit with various molecules depending on the pore size, potentially working as a nano-sieve on the sensor surface, while it has never been applied to cantilever sensors because of the difficulty in functionalization on a “cantilever” structure. Thus, the goal of this project is to enhance both sensitivity and selectivity of a piezoresistive cantilever sensor with an effective fusion of sensor mechanics and materials engineering into a single platform.

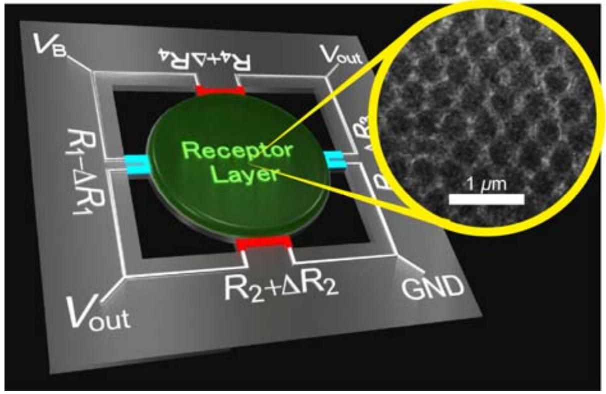

Fig. 9 Newly developed Membrane-type Surface stress Sensor (MSS) coated with a mesoporous carbon film.

For better sensitivity and for easier functionalization of sensor surface with mesoporous materials, we made a comprehensive optimization of a piezoresistive cantilever. Breaking the bounds of common practice of “cantilever”, we finally developed a Membrane-type Surface stress Sensor (MSS; Fig.9). For experimental verification of the sensitivity, we microfabricated the MSS chip and demonstrated more than 20 times higher sensitivity than that of conventional piezoresistive cantilevers even with the first prototype chip, already reaching the similar sensitivity with the optically read-out cantilevers. The symmetrical geometry of MSS without a free-end allows much easier handling for functionalization of the sensor surface (*i.e.* the center membrane) with mesoporous materials. Accordingly, we succeeded in functionalizing the surface of MSS by a mesoporous carbon film as shown in the inset of the Figure. We are now trying to verify the enhanced selectivity due to the sieving effects of the mesoporous film covered on MSS.

The present sensor having enhanced sensitivity and selectivity is expected to open a new era of sensors for various fields including medical, biological, security, and environmental applications.

4. Fusion of nano-fabrication and organic synthesis toward the control of nanostructures and electrical properties in grapheme

Since the successful exfoliation of single-layer graphene sheets in 2004, correlative research on this new material has attracted enormous interest. Attention has focused on the edge structures of graphene sheets, because of their potential impact on the material's electronic properties. The purpose of this study is to control edge structures at molecule or atomic scales in graphene, toward future quantum devices. We try to develop new fabrication process that combines the top-down nanofabrication and organic synthesis to control the edge of graphene sheets by chemical modification. Through advances in fabrication and characterization building on our fusion research, it may become possible to make quantum nanodevices so small that they approach the molecular scale.

In this research, a selective oxidant was introduced for oxidizing of graphite and graphene. Graphene is a one-atom-thick planar sheet of sp^2-bonded carbon atoms that are densely packed in a honeycomb crystal lattice. But not all six membered carbon rings are composed of sp^2-bonds. At the edges of graphene, some carbon rings may be composed of both sp^2 and sp^3 bonds. In this case, these rings with sp^3 bonds defects will be easier to be attacked under suitable chemical conditions. Our selective weak oxidation modification occurred only at the edges of the graphene sheet and –COOH and –OH and other functional groups were introduced to the edge structures as confirmed by thermogravimetric analysis (TGA), Raman mapping measurements, and X-ray Photoelectron Spectroscopy (XPS) analyses. These experimental results are important step toward the control of edge structures in graphene. We will apply the chemical modification to the device fabrication process as a future work.

2-2-2 Research Achievements (Enter the total number and number per year in each of the below blocks.)

Total: 1545

FY2007-2008	444	FY2009	522	FY2010	579

Data are available for calendar year and not Fiscal Year

B. Invited lectures, plenary addresses (etc.) at international conferences and international research meetings

Total: 766

FY 2007-2008	282	FY 2009	237	FY 2010	247

C. General lectures at international conferences

Total: 241 oral 423 poster

FY 2007-2008	oral	poster	FY 2009	oral	poster	FY 2010	oral	poster
	85	135		75	139		81	149

D. Invited lectures at domestic scientific societies and research meetings

Total: 458

FY 2007-2008	177	FY 2009	149	FY 2010	132

E. General lectures at domestic scientific societies and research meetings

Total: 233 oral 489 poster

FY 2007-2008	oral	poster	FY 2009	oral	poster	FY 2010	oral	poster
	93	195		80	167		60	127

F. Books (e.g., scientific, specialized volumes)

Total volumes: 51

FY 2007-2008	16	FY2009	26	FY2010	9

Data are available for calendar year and not Fiscal Year

G. Industrial property rights

Total: 64 registered 191 being processed

FY 2007-2008	registered	processed	FY 2009	registered	processed	FY 2010	registered	processed
	20	84		14	60		30	47

H. Major awards received (including those formally announced)

Total: 114

FY 2007-2008	30	FY 2009	39	FY 2010	45

2-3 Future Policy and Concrete Plans (within 4 pages)

MANA will deepen research concepts concerning materials nanoarchitectonics, establishes new paradigms in materials research, and continually endeavors to develop new materials needed to realize a sustainable 21st-century society. Above all else, MANA intends to contribute in a major way to society's future by introducing exceptional new materials as practical resources within the next few years. These materials will be connected with a broad range of unique research achievements produced by MANA over the years, among them nanosheets, nanotubes, molecular switches, atomic switches, molecular devices, superconducting devices, visible light photocatalysts, and artificial bones. MANA sees taking on "grand challenges" that freely utilize nanoarchitectonics as its foremost mid-to-long-term policy. In line with this view, MANA is turning its attention to room temperature nano-superconductors, brain neural network-type inorganic nano-network circuits, artificial nano-photosynthesis systems, and nano-energy (i.e., dynamic, thermal, and chemical power generation at the nano-scale). MANA believes that making these technologies reality will require fusion research achieved through close cooperation among four research fields, i.e., 1) nano-materials, 2) nano-system, 3) nano-green, and 4) nano-bio. With this in mind, MANA established the "MANA Fusion Research Program" with focus on young researchers. This program has produced outstanding results since its start two years ago. MANA also plans to launch a new program called the "MANA Grand Challenge Research Program".

<Research fields>

In the field of **Nano-Materials**, intensive research activities have been conducted all over the world to create new nanoscaled materials over the past decade. Actually, a wide variety of nanotubes, nanowires, nanorods, nanosheets and nanoparticles have been successfully synthesized and many new properties and phenomena have been found. These research works have opened new scientific fields producing many innovative achievements and breakthroughs. However, main attention in the syntheses of these nanomaterials has been directed to size and shape in a nanometer scale. We all know that tuned composition and structure of materials are key factors to develop sophisticated functionalities or even to attain new and unique physical properties. But such viewpoint has been mostly overlooked in the syntheses of nanomaterials. Thus, we plan to focus on finely designing composition and structure as well as shape and dimensionality (1D, 2D, 3D) to create new nanomaterials (may be called the second-generation nanoscaled materials). We expect that doping, control of oxidation state, intentional introduction of defects and distortions etc. will lead to development of new and sophisticated functionalities and their fine control. Actually we have several examples which show great promise of this strategy. For example, we reported the chemical fluorination of BN nanotube, which resulted in enhancement of electrical conductivity, suggesting transformation from insulator to semiconductor. We also demonstrated that incorporation of magnetic elements such as Co, Fe, Mn into Ti oxide nanosheet gave rise to room-temperature ferromagnetic properties. Interestingly the magneto-optical performance of the nanosheet films was found to be highly dependent of magnetic element, its content and substitution mode. This means that we can control the magnetic properties by tuning the composition of the nanosheets. On the basis of these encouraging data, we expect that more new functionalities can be achieved in various nanoscale materials with tailored composition and structure. Another important issue to be pursued is to develop more advanced techniques for Material Nanoarchitectonics. Needless to say, precisely controlled organization of nanomaterials and their hybridization with various functional species will be a key to develop new functional materials and devices with the state-of-art functionality, which cannot be realized with a single-phase material. Chemical processes are expected to be essentially important and effective particularly for controlled organization and combination of nanomaterials at a nanometer scale range. We have a range of such techniques as a fundamental tool, for example, electrostatic self-assembly, Langmuir Blodgett deposition, etc. We plan to customize them for effective organization and hybridization of target nanomaterials and species. We will also attempt to develop a new process manipulating various chemical interactions, which work between nanomaterials and combining species. Furthermore, control over arrangements and orientations of nanomaterials and other components will be explored by application of magnetic or electric field in the chemical processes. On the basis of the above-mentioned strategy, functional nanomaterials with tailored composition and structure and their designed organization into well controlled nanostructures, we will attempt to develop new nanostructured systems and nanodevices, which can contribute the advancement of next-generation electronics and solution of energy/environmental issues to realize sustainable human society.

In the field of **Nano-System**, its research direction will be unchanged basically, since a lot of remarkable results and promising seeds have appeared along the research direction in the past four years. Namely, the following three categories of research will be continued: 1) the development of innovative nanoelectronic devices that enable highly advanced information processing and communication beyond the present situation, 2) the realization of novel nanoscale evaluation methods helpful for the above-mentioned development, and 3) theoretical and computational studies that support and lead the experimental work. However, more grand challenging researches will be performed on the basis of our results obtained so far. Namely, we are going to make remarkable contributions to the realization of MANA's mid-to-long-term grand challenges, i.e., the realization of room-temperature superconducting nano-systems, neuromorphic nano-network circuits made of inorganic materials, artificial photosynthesis using novel nano-systems, nano-energy generation (i.e., chemical, thermal, and mechanical generation of energy at the nano-scale).

With regard to the atomic switch we developed, it was found that the plastic change of internal structure of the atomic switch depends on the temporal pattern of input signals, showing a similarity with the synapse of neurons. We therefore tried to construct a certain network of atomic switches for the purpose of neuromorphic signal processing and obtained a good prospect. We will keep trying to perform this grand challenge with enthusiasm.

We have succeeded in developing a unique technique to apply a certain strong field to a micro-to-nano-scale local area of a given sample. We are going to use this technique to create novel superconducting nano-systems with a high transition temperature such as room temperature as a wish.

Artificial photosynthesis is no doubt one of the ultimate goals of science and technology. We are going to perform this grand challenge on the basis of our recent research achievements on plasmonics. Namely, we will apply our remarkable experience and expertise on the plasmonics of low-dimensional metallic nanostructures to the efficient use of solar energy in artificial photosynthesis. Specifically, a series of novel nano-antenna systems that are effective in the wavelength region of visible light will be developed and evaluated.

As for nano-energy generation, we will start the research with a feasibility study of novel nano-batteries having a structure similar to that of the atomic switch. We have already obtained a good preliminary result.

Nanoarchitectonic studies such as those described above will be accelerated by various new nanoscale evaluation methods, so that we regarded it as important to develop new nanoscale evaluation methods by ourselves. We will develop new methods that can make not only nanoscale structural and chemical analyses but also nanoscale functionality evaluation.

Theoretical and computational studies are also regarded as important in Nano-System Field. Considerable collaboration between theoreticians and experimentalists has been done successfully and it produced a lot of fruitful results. Also, interesting new superconducting quantum-effect devices has been proposed theoretically. It will be nice if such devices are materialized by experimentalists in Nano-System field.

In the field of **Nano-Green**, the demand for the development of renewable energy sources, efficient energy storage and transportation systems, material conversion processes of high efficiency and selectivity should increase more and more, particularly after the Great East Japan Earthquake. In this respect we will continue present effort 1) to construct efficient photoenergy conversion interfaces by arranging atoms, molecules and nanoclusters in ordered manner based on rational design, 2) to construct chemical energy conversion/storage interfaces by well controlled processing, 3) to establish fundamental techniques to prepare highly efficient catalysts for chemical processes with high selectivity by arranging atoms and molecules at will, and 4) to investigate experimentally and theoretically interfacial structure and electron transfer processes in high lateral and time resolution.

Ultimate goal of “Photoenergy Conversion Interfaces” is to achieve artificial photosynthesis. Photocatalyst and photoelectrochemical system for water splitting and CO_2 reduction will be developed based on not only the band, i.e., bulk property, engineering, but also precise arrangement of atoms and molecules on the surface, i.e., “surface nanoarchitechtonics”. In this respect, atom and molecular catalysts for selective CO_2 reduction are under development. In addition, organic solar cell of high efficiency and stability will be also developed. For example plasmon coupled photoelectric energy conversion and polymer electrolyte/ionic liquid based dye sensitized solar cell will be studied.

Ultimate target of “Chemical Energy Conversion Interfaces” is to realize all solid state rechargeable battery. Although Li-ion battery has many useful characteristics, the use is still limited to relatively small devices because of low energy/power density and concern for safety. All solid state battery is ideal as far as safety is concerned. However, low conductivity of solid state electrolyte make the total efficiency quite low. We will further tune the PLD method so that we can precisely carry out controlled epitaxial deposition of electrode and electrolyte of Li rechargeable battery with high energy/power density and safety. To achieve much higher energy/power density, new generation battery such as Li/air will be investigated. Li/air battery has very high theoretical energy/power density but due to very slow reactions, real performance is still very low. Elemental processes will be studied and catalyst for air electrode will be developed.

As mentioned above, the key for the highly efficient photoenergy and chemical energy conversion systems is the development of suitable “ Highly Efficient Catalysts”. Since most reactions proceed with multi-steps, it is essential to arrange atoms and molecules, which enhance the rate of each elemental step, in order. Thus, we will develop novel methods to achieve this goal. Bottom-up approach, i.e., chemical synthesis, is employed to prepare alloy catalyst using multinuclear metal complexes and metal-organic molecules and nitrogen-doped carbon catalyst using aromatic molecules. Also to increase atom efficiency and stability of catalyst, novel method to confine molecular catalyst within molecular layer is developed.

To carry out above mentioned studies, “Interfacial Structure and Electron Transfer Dynamics”, should be understood and, therefore, monitoring of processes at solid/liquid interfaces with lateral resolution with atomic/molecular dimension and time resolution of femtosecond is required. Furthermore, in situ determination of electronic structure is essential. As far as geometric structure is concerned, in situ STM/AFM and surface x-ray scattering techniques are now routinely used. Although we have femtosecond visible pump IR probe system for time resolved study in solution, it is not possible to monitor the surface process with such a high time resolution. For this purpose, femtosecond visible or IR pump sum frequency generation (SFG), which is surface sensitive process, pump system will be developed. For in situ determination of electronic structure, XPS system using hard X-ray with a newly developed in situ XPS cell is under construction.

In the field of **Nano-Bio**, we have been studying such as biocompatible materials aiming at artificial organs, scaffolds for regenerative medicine, effective diagnosis and so on. Looking ahead to the next decade, biomaterials research is surely growing because of overcoming the recent high-cost regenerative medicine. Recently, much attention have been paid to treatment using ES cells or iPS cells, however they need many clinicians, researchers or supporters, cell processing facilities and so on. On the other hand, very convenient and low-cost treatments without cells are actually required in medical clinic. Therefore, we intend to promote material-oriented research, so-called, “materials therapy”. Therefore, Nano-bio field deal with such as “smart nanoparticles”, “hybrid biomaterials with organic, ceramic and metallic materials”, “Novel matrix for cell function control”, “nano-medicine based on nano-assembly”, “photochemistry-based DDS and cell function control”using artificial materials by well-designed based on Nanoarchitectonics strategy.

First one is smart nano-particles for treatment of acute and chronic disease. As described above, nanoparticles are very promising materials in diagnosis and treatment as “nano medicine”. Diagnosis of biomarkers in very early stage is effective to minimally invasive treatment. Second one is hybrid biomaterials by combination polymeric, metallic and ceramic materials. Through the development drug eluting stent, we could catch up the potential about joining between different kinds of materials. The combination of plural kinds of materials is critical to innovative biomaterials. Last one is matrix design in nano- and micro-structure for cell function control. Recent cell biological studies suggest the environmental condition surrounding cells would closely relate to the rate of growth or direction of differentiation, and so on. That is to say, artificial designing of environment in cell culture would enable to control the cell functions.

Nano-medicines such based on nano-assembly continuously are studied about through precisely molecular design for bio-imaging and minimally invasive therapy. As photochemistry-based DDS and cell function control, one is Infrared irradiation-induced targeted drug-delivery and imaging systems. UV/Vis light cannot be used in-vivo due to its low tissue penetration range and high toxicity. In contrast, IR irradiation is safe and reaches far deeper in tissues. We will prepare gold nanourchins and nano frames (generator of localized plasmons) and modify their surface to couple photo cleavable groups (2-nitrobenzyl ester) bearing (i) fluorescent dyes as model compounds and (ii) selected drugs or peptides. In addition to creating localized plasmon to trigger photoreactions, the IR radiation could also be used to image the nanoparticles via 2-photon imaging, a possibility that will be explored. Third one is "Photochemically-tailored patterned interfaces for the detection and recruitment of endothelial progenitor cells (EPC) for therapeutic applications". Photopatternable interfaces will be prepared following known procedures to generate domains of various shapes and sizes suitable for amplification of EPC (from mice and eventually patients). The photopatterns will be modified as cell colonies form and grow in order to induce further amplification. The EPC will be harvested and assayed for therapeutic applications. In parallel, we will develop photopatterned microarrays as diagnostic tools for early detection of restenosis. The assay will rely on the differential adhesion and activation of EPC on specific polymer substrates.

<Research objectives>

In the **Nano-Materials Field**, we attempt to synthesize more than 20 new nanotubes, nanorods, nanosheets and nanoparticles with highly tuned composition and structure, in which we expect new phenomena or enhanced physicochemical properties. The library of 1D, 2D and 3D nanoscaled materials will be greatly enriched. In the second stage, we will develop so-called "chemical nanotechnology" or "soft nanoarchitectonics" , which enables to assemble and organize the nanoscaled materials into highly controlled nanoarchitectures via room-temperature wet-chemical processes based on soft-chemistry, colloid chemistry and supermolecular chemistry. Through this approach, we will design various functional materials and nanodevices, which can contribute to the advancement of electronics and energy/environmental technologies.

Selected research targets are as follows; 1) high-performance capacitor devices workable at a low power consumption, 2) transparent heat sink substrates with superior mechanical strength and high thermal conductivity, 3) drug delivery system having a sustainable drug release in automatic ON and OFF mode.

In the **Nano-System Field**, we will complete a prototype of neuromorphic nano-network computational systems composed of inorganic atomic switches. Also, our new method to wire a single functional molecule with conductive linear polymer wires will be utilized for the realization of single-molecule diode, switch, transistor, etc. Furthermore, we will keep trying to realize new nanoelectronic devices using graphene and organic films, a superconducting light emitting diode that can generate a pair of photons entangled quantum mechanically, and a superconducting quantum interference device (SQUID) with an ultra-high sensitivity. A superconducting nano-system, in which a certain strong field is applied to a nano-sized material that we wish to change into a high-temperature superconductor, will be realized. For the realization of artificial photosynthesis, we will make a flank attack based on our much experience and expertise on the plasmonics of low-dimensional metallic nanostructures. Regarding new nanoscale evaluation methods, we will complete 1) multi-probe scanning-probe microscopes (MPSPM) with 2-4 independent probes, 2) a novel spin-polarized scanning tunneling microscope (SPSTM) using a nonmagnetic probe, 3) an ultra-sensitive molecular sensor that can detect a single molecule at any designated positions, 4) an ultra-parallel molecular sensing system with the use of a piezoresistive membrane array, and 5) a new type of scanning tunneling microscope (STM) in which a local sample area below the STM tip is irradiated with energy-tunable synchrotron-radiation X rays. Theoretical studies are performed to support and lead various experimental studies described above. They include the analysis of various nanoscale chemical and physical processes and the prediction of novel superconducting quantum-effect devices.

In the **Nano-Green Field**, we will focus on the following research objectives;1) Artificial photosynthesis system will be constructed utilizing novel photocatalyst, confined molecular catalyst, and plasmonic antenna and water splitting without sacrificial reagent should be realized. 2) Organic solar cell of new structure will be developed using redox polymer. 3) Novel structure for all solid Li-ion battery with electrolyte of high conductivity will be prepared by pulse laser deposition. The power density should be several times of the present value. 4) Catalyst for methanol oxidation will be prepared by adsorption of multinuclear metal complexes followed by thermal decomposition. The turn over frequency per metal atom should be several times of conventional Pt electrode. 5) New method to prepare confined molecular catalyst for hydrogen evolution and CO_2 reduction will be developed so that turn over frequency per metal atom of several times of conventional Pt electrode for HER and high selectivity for CO_2 reduction should be achieved.

In the **Nano-Bio Field**, bio-materials based on Nanoarchitectonics technologies are expected to give an impact to recent medicine and contribute clinical use actually. As outcome from the results of research subjects, we aim at two clinical trial of artificial bone comprising composite of hydorxyapatite and collagen and drug eluting stent in “Novel matrix for cell function control ”and “hybrid biomaterials with organic, ceramic and metallic materials” , respectively. These now are in animal experiments and clinical trials will be done after confirmation of their efficiency in vivo. In terms of drug delivery systems, we intend to develop PEGylated polymer micelles and to verify the effectiveness of a PEGylated polymer micelle-based NO photodonor system for tumor treatment by animal experiments. In vitro test, they have already showed clear efficacy and using tumor-bearing mouse or rat, the anti-tumor activity are tested. Moreover, the efficiency of inflammatory-suppressing particles derived from smart materials, cell function control matrix using biodegradable polymers and Photo-chemistry DDS and imaging with infrared are confirmed using cultured cells.

< Major changes >

No major changes.

3. Management

<Initial plan>	<Efforts to date and current state>
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 3 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.	1) Composition of administrative staff In April 2010, the Administrative Section added an Outreach Team to the three teams in operation since inception—Planning Team, General Affairs Team and Technical Support Team. There are currently 21 staff in total, and all are fluent in English.
✓ **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).	✓ **Planning Team**: This three-person team administers research plans and achievements, liaises with overseas satellites, builds networks, and plans and holds symposia. Since this team deals with foreign researchers and overseas research institutions often, its leader is a non-Japanese permanent employee from 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	✓ **General Affairs Team**: This team of 12 clerical staff provides total support for creating an environment in which researchers can devote themselves to their research regardless of nationality or age. Staff are not assigned according to duties, but to specific research groups or groups of young scientists, which allows them to provide careful support while handling a wide range of administrative duties. An experienced former NIMS administrator who is familiar with clerical duties and providing support to foreign researchers has been assigned as team leader.

NIMS.

- ✓ **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 will 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.

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

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

- ✓ **Technical Support Team**: A four-person team of experienced veterans from NIMS and the private sector support research by maintaining shared research equipment, providing assistance and guidance during experiments and ensuring safety control. They also serve as consultants to foreign researchers when they file their applications for competitive external funding. The team leader is a former NIMS researcher.
- ✓ **Outreach Team**: To garner public support for science and technology and strengthen wide-ranging publicity for WPI activities, this team strives to bolster interactive communication initiatives in addition to disseminating information via traditional media, the web and Center publications. The team currently consists of two members, and the leader, who possesses excellent outreach skills, was hired from outside of the Center.

2) Decision-making system

On October 1, 2008, a Chief Operating Officer was assigned to work under the Director-General in order to reduce the burden on the Director-General and to allow for more efficient and speedier Center management. The Administrative Director oversees administrative duties, while the Chief Operating Officer supervises research. In light of the Center's administrative issues, the MANA Executive Meeting was put in place to allow the Director-General, Chief Operating Officer and Administrative Director to confer at any time to make snap decisions on Center management. This meeting was held 39 times in FY2009 and FY2010.

The Center keeps meetings to the absolute minimum so that researchers may devote themselves to research, but Principle Investigators' Meetings and Center-wide meetings are held occasionally to facilitate communication throughout all levels of the Center. All meetings are held in English.

There are currently five external stakeholders serving as Center Advisors. They provide advice on overall Center management and invaluable suggestions on individual research projects, as well as cooperate with our outreach activities by serving as lecturers in science seminars geared toward elementary and junior high school students.

3) Allocation of authority between center director and host institution

Director-General: The Director-General possesses the authority to allocate Center resources such as budget funds and space. He also

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.	possesses authority to hire or renew contracts of Principal Investigators—except for permanent NIMS staff members—young scientists and other postdoctoral researchers and fixed-term administrative staff. **President**: The President, as the person in charge of the Center's host institution NIMS, provides maximum support to the Center while respecting the administrative rights of the MANA Director-General to the fullest extent. However, the President reserves the right to appoint permanent NIMS staff members to work at the Center based on the opinions of the Director-General.

< Future policy and concrete plans >

1) Composition of administrative staff

We will maintain the current four-team structure of Planning, General Affairs, Technical Support and Outreach of the Administrative Section. While the Center receives aid from its host institution NIMS to operate the MANA Foundry, the Administrative Section of MANA provides advice on foundry systems, operation and maintenance.

2) Decision-making system

Due to its effectiveness, we will maintain the administrative structure based on the three top positions of Director-General, Chief Operating Officer and Administrative Director. Since the Principal Investigator's Meeting and Center-wide meetings are important for facilitating communication, we will hold them at slightly more frequent intervals to the extent that they do not hinder research.

3) Allocation of authority between center director and host institution

We will not alter the current allocation of authority. In FY2011, the Director-General was made a member of the NIMS Steering Committee (a body equivalent to a management council) and may participate in discussions on NIMS administration. This is expected to further enable communication between NIMS and MANA.

4. Researchers and center staffs, satellites, partner institutions

4-1. Number of researchers in the “core” established within the host institution

All members

	Goal set in proposal	Results at end of FY 2008	Results at end of FY 2009	Results at end of FY 2010	Final goal (Date: Oct., 2014)
Researchers	167 <84, 50%> (Oct, 2011)	165 <86, 52%> [13, 7.9%]	181 <94, 51.9%> [22, 12.2%]	197 <113, 57.4%> [38, 19.3%]	200 < 120, 60%> [50, 25%]
Principal investigators	27 <10, 37%> (Oct, 2011)	30 <10, 33%> [1, 3%]	30 <9, 30%> [1, 3.3%]	28 <9, 32%> [1, 3.5%]	25 < 10, 40%> [3, 12%]
Other researchers	140 <74, 53%> (Oct, 2011)	130 <73, 56%> [14,11%]	151 <85, 56.3%> [21, 13.9%]	169 <104, 61.5%> [37 ,21.9%]	175 < 110, 63%> [47, 27%]
Research support staffs	20	13	16	16	12
Administrative staffs	22	19	17	19	18
Total	209	197	214	232	230

Other matters of special mention

- ✓ To strengthen Nano-Bio, Prof. Winnik from the University of Montreal was appointed in April 2011 as a Principal Investigator.
- ✓ Prof. Traversa, a full professor of Materials Science and Technology from the University of Rome, was successfully hired as a full-time PI (appointed in January 2009).
- ✓ There are many instances of young researchers successfully securing positions, including the appointment of MANA Scientist Dr. Tang as a Dean at the Hebei University of Technology and the appointment of ICYS-MANA Researcher Dr. Sanchez as a group leader at the Leibniz Institute for Solid State and Materials Research Dresden.

4-2. Satellites and partner institutions

<Initial plan>	<Collaboration to date>
i) Satellites 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.	i) Satellites MANA has established satellite labs in other research institutions to which external Principal Investigators are affiliated. There are currently six MANA satellites at the following domestic and foreign institutions: University of Tsukuba, Tokyo University of Science, University of Cambridge, University of California Los Angeles (UCLA), Georgia Institute of Technology, and the Centre National de la Recherché Scientifique (CNRS; French National Center for Scientific Research) Center for Material Elaboration & Structural Studies (CEMES). These satellites are involved in research in each of the fields at MANA and serve as venues for training MANA's young researchers.
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.	**University of Tsukuba:** In the Nano-System Field, Professor Kadowaki conducts cutting-edge research on quantum nanoscience using high temperature superconductors. Together with two researchers and five graduate students, he is working on the following topics: elucidation of the mechanism of terahertz radiation after the discovery in the nano-fabricated mesa structures of high temperature superconductor $Bi_2Sr_2CaCu_2O_{8+d}$ single crystals, basic research on the topological insulators and the detailed electronic states of superconductors with multi-degree of freedoms. He also conducts joint research with PI Dr. Hu. In the Nano-Bio Field, Professor Nagasaki researches new nano-bio imaging and materials design for nanodiagnoses and treatment and evaluates of the attributes of these materials with the aim of creating novel biotools. Professor Nagasaki engages in research with a group that includes three postdoctoral researchers, as well as two lecturers, 11 PhD students and 17 Master's students from the University of Tsukuba satellite. He also conducts joint research with the new PI, Prof. Winnik (University of Montreal), and MANA Independent Scientist Dr. Nakanishi. The largest NIMS Graduate School (mentioned below) is at the University of Tsukuba, where MANA has 10 faculty members and 13 PhD students who engage in research activities at MANA.
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.	**Tokyo University of Science:** PI Prof. Hideaki Takayanagi is based in Tsukuba and has offices and research space at MANA. Together with three MANA Research Associates (postdoctoral) and two assistant professors and graduate students from the Tokyo University of Science, he has developed the nano-SQUID, or nano superconducting quantum interference device,

	and conducts research in the Nano-Systems field on new superconducting devices. He also conducts joint research on quantum transport phenomena with a NIMS group.
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.	**University of Cambridge:** PI Prof. Mark E. Welland conducts research in the Nano-System field on the application of biologically-inspired materials to highly efficient solar cells. University College London (UCL) was added as a new partner to the Interdisciplinary Research Collaboration (IRC) in Nanotechnology, and University of Cambridge's Prof. Welland is conducting experiments while UCL's Dr. David Bowler is handling calculations. In July 2009, the University of Cambridge held a joint workshop with MANA. Dr. Bowler and MANA Independent Scientist Dr. Tateyama visit each other's labs frequently and engage in research exchange. MANA also serves as a venue for student development. MANA accepted three graduate students from this satellite and plans to hold the Japan-UK-US Nanotechnology Summer School at the University of Cambridge satellite in September 2011.
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.	**University of California Los Angeles (UCLA):** PI Prof. James K. Gimzewski conducts research in the Nano-System field on the development of hardware-based, physically intelligent neural networks through a synergy of biological inspiration and advanced solid-state nanoelectronics. Prof. Gimzewski has visited MANA 11 times in 3.5 years, spending a total of 157 days in Japan. He continues joint research on new neurocomputation circuits that use the learning functions of atomic switches. In January 2010, Prof. Gimzewski appeared on the NHK TV program "Proposal for the Future", and his joint research with MANA was featured in the program. UCLA has become a hub for cultivating young researchers, graduate students and young administrators: MANA Research Associates (postdoctoral) were dispatched from October 2008 to March 2009, the Japan-UK-US Nanotechnology Summer School was held in July 2009, and MANA administrative staff was sent as interns from October 2010 to March 2011.
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	**Georgia Institute of Technology (GIT):** PI Prof. Zhong Lin Wang conducts research in the Nano-Materials field on photonic structures provided by nature and nanogenerators for harvesting mechanical energy. There is a rich history of personnel exchange between MANA and GIT. Prof. Wang is the mentor to MANA Independent Scientist Dr. Fukata, who has visited GIT 9 times for a total of 16 weeks. Together they conduct joint

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.	research on nano devices and have published their results in *ACS Nano*. Prof. Wang's postdoctoral student is now Dr. Fukata's MANA Research Associate. **CNRS:** PI Dr. Christian Joachim conducts research in the Nano-System field on the design, synthesis and atom manipulation of nano-calculating units and the theory of surface electronics interconnections. To date, MANA has held two research exchange events at CEMES. A joint CEMES-MANA workshop was held in October 2009 to promote cooperation between computational scientists and experimental scientists, and a Japan-France workshop on nanomaterials was held in November 2010. One graduate student from CEMES came to MANA between August and October 2009 to conduct research under the supervision of scientists at MANA.
ii) 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 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.	ii) Partner institutions In April 2009 MANA launched a joint research with the Indian Institute of Chemical Technology (IICT) to conduct research on nano-porous catalyst materials. MANA provided 5 million yen to IICT over 2 years and collaborated with IICT's outstanding researchers with the aim of speeding up this research. The joint research helped to add the functions into the materials fabricated at MANA, with nano metal and metal oxide particles. Eleven papers have been published from this project. Several visits of scientists from both MANA and IICT were exchanged and an international workshop was conducted at IICT. In addition, NIMS opened up an overseas office at the University of Washington in Seattle, USA in April 2008. MANA PI Dr. Kenji Kitamura made this office the base for his activities and conducted joint research to match the needs of US counterparts while promoting exchange among researchers, students and administrative staff. Dr. Kitamura also set up the venture company NIMBUS Technologies LLC (NIMBUS) in June 2009. The aim is to turn PI Kitamura's research output—i.e., his medical infrared light source and terahertz light source—into a business in the United States. One of MANA's missions is to become a hub and build a network connecting the world's nanotechnology centers. As such, the Center has concluded MOUs with 29 research institutes around the world (Europe: 13, Asia: 9, North America: 5, South America: 1, Middle East: 1) and is currently engaged in joint research and personnel exchange.

<Future Policy and Concrete Plans>

i) Satellites

MANA requested three-year activity reports from its six satellites (University of Tsukuba, Tokyo University of Science, University of Cambridge, University of California Los Angeles (UCLA), Georgia Institute of Technology, and CEMES-CNRS (French National Center for Scientific Research) and upon reviewing them, found that each satellite is making progress in cultivating young scientists while shouldering important aspects of Center research. For this reason, MANA will renew agreements with each institution.

In addition, MANA plans to add the University of Montreal—home of newly appointed PI Prof. Winnik—as a new satellite institution in FY2011.

To further promote joint research between satellite PIs and MANA researchers, plans are in the works to build labs for satellite PIs in the new MANA Building in FY2012.

ii) Partner institutions

Joint research with the Indian Institute of Chemical Technology (IICT) and the contract for the office at the University of Washington both concluded in March 2011, but MANA will continue cooperating on research with both institutions based on the personal networks developed to date.

To bolster the Nano-Bio field, the Biomedical Innovation Laboratory is opened in the Institute of Advanced Biomedical Engineering and Science at the Tokyo Women's Medical University in FY2011. By conducting cell and animal tests on the new biomaterials developed at MANA, we aim to establish basic technologies for the design of new biomaterials.

To ensure that MANA becomes a hub for the world's nanotechnology centers, we will extend research cooperation and personnel exchange with key research institutions around the world. In particular, we will proactively dispatch young scientists at MANA to these institutions.

5. Summary of center’s research environment

<Initial plan>	<Progress to date>
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.	1) Environment in which researchers can devote themselves to their research The MANA Administrative Section provides full technical and clerical support to all researchers regardless of nationality and age and has nearly realized its mission of “providing an environment in which researchers can devote themselves exclusively to their research by exempting them from other duties”.
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).	**Clerical work support system in English:** There are 21 staff in the Administrative Section and all of them are fluent in English. Since more than half of MANA’s researchers are foreign nationals, the 4 teams cooperate—using English as the language—to provide all researchers with quick-acting, far-reaching, Japanese-style service regardless of nationality.
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 Japanese researchers and to clerical staff to improve their English capabilities (operation to make all documents bilingual will be completed by March 2008).	**Making paper work bilingual**: All major guidebooks, documents and the intranet are almost entirely bilingual, and there is a strict policy of conducting meetings and email communication in English. To encourage foreign researchers to apply for Grant-in-Aid and other external competitive funding, we provide instructions and support for completing applications in English.
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	**Assistance for daily life**: MANA subcontracts settling-in support for foreign researchers to the Japan International Science and Technology Exchange Center (JISTEC), and expenses for this are borne in full by

the spouse to eliminate various barriers that foreigners encounter when they come to Japan. Full-time staff will be hired (October 2007).	NIMS. MANA also runs its own Japanese language and Japanese culture classes for foreign researchers. Over the past three years a total of 315 researchers have participated in Japanese language classes, while a total of 462 researchers have participated in Japanese culture classes which are held about once per month.
Patent specialist: For the convenience of foreign researchers to make patent applications in Japanese, we will hire English proficient patent specialists.	**Patent specialist**: MANA employed a part-time patent specialist who was fluent in English until FY2009, and he worked to turn MANA research output into protected intellectual property. A full-time patent specialist from NIMS took over these duties in FY2010. To date, MANA has filed for 166 Japanese patents and 25 foreign patents.
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.	**Providing sufficient technical staff and facilitating access to equipment**: The Technical Support Team of the Administrative Section currently employs 4 staff to provide assistance with experiments and facility maintenance. Three of the 4 staff are retired NIMS researchers and business engineer who are extremely well-versed and fluent in English. They serve as excellent advisors to all the young foreign and Japanese researchers. In addition, we added 25 shared facilities since MANA was launched to bolster the research infrastructure.
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 2 of the external PIs (Takayanagi and Yaghi) conducting research at MANA and PI Dr. Traversa appointed in FY2009 were granted startup research funding. As for satellites, the 4 domestic PIs and 4 overseas PIs were allocated research funding ranging from 10 to 20 million yen per year. The 14 Independent Scientists were each granted 3 million yen per year and the 14 ICYS*-MANA Researchers were each granted 2 million yen per year in startup research funding. 45 MANA Scientists have been assigned to work under the NIMS PIs and are each granted 1 million yen per year in research funding. *ICYS: International Center for Young Scientists

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.	3) Postdoctoral positions through open international solicitations
Securing young researchers including post-doctorates	**Securing young researchers including post-doctorates:** There are 2 postdoctoral researcher positions at MANA: ICYS-MANA Researcher and MANA Research Associate. The former are independent postdoctoral researchers who conduct research on their own accord without supervisors and positioned as a career path to NIMS tenure-track researchers. In other words, young researchers must start as ICYS-MANA Researchers in order to secure permanent positions, and MANA's host institution NIMS regularly recruits internationally for ICYS-MANA Researchers. The latter are regular postdoctoral researchers assigned to PIs or Independent Scientists. Supervisors search for candidates, and appointments are determined upon a screening by MANA's top executives.
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.	**International open recruiting**: Since MANA's founding, there have been six international open recruitment drives for ICYS-MANA Researchers, and 19 ICYS-MANA Researchers have been hired from among a total of 426 applicants.
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	**Multi-national young researcher group:** As of March 2011, MANA has 15 ICYS-MANA Researchers, of which 9 are foreigners. There are 64 MANA Research Associates, of which 56 are foreigners. In total, there are 79 postdoctoral researchers, of which 65 (82%) are foreigners. MANA has achieved a truly multinational group of young postdoctoral researchers.

(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 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.

Securing Junior Researchers (graduate students): NIMS operates the "NIMS Graduate Schools" having concluded agreements with the University of Tsukuba, Hokkaido University and Waseda University, and graduate students are taught advanced research by NIMS researchers on the frontlines of their fields. As of March 2011, 20 scientists at MANA are teaching in the NIMS Graduate Schools. Students in the NIMS Graduate Schools who possess especially outstanding skills are appointed as Junior Researchers and are paid a salary for their contribution to NIMS research. As of March 2011, there are 31 Junior Researchers working at MANA, of which 28 are foreigners.

Number of MANA members at the NIMS Graduate Schools

School	No. of Faculty	No. of Students
University of Tsukuba	10	13
Hokkaido University	5	13
Waseda University	5	5

University of Tsukuba Graduate School: In September 2009, the school established a Master's curriculum in which students can take all of their required credits in English. The objective is to attract outstanding foreign students from the Master's program to the NIMS Graduate Schools.

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.

International Joint Graduate School: The International Joint Graduate School is a program in which PhD students from renowned universities around the globe spend several months to one year researching under the supervision of NIMS researchers. By March 2011, MANA has brought in 25 students from Moscow State University (Russia), Charles University and the University of Pardubice (Czech Republic), Warsaw University of Technology (Poland), Xian Jiaotong University (China), Yonsei University (Korea), Jawaharlal Nehru Centre for Advanced Scientific Research and Anna University (India).

Internships: NIMS established an internship system to proactively accept students from universities throughout Japan and the world which have not concluded agreements with NIMS and provide them with opportunities to partake in materials and nanotechnology research. By March 2011 MANA has accepted 89 interns, of which 80 have been foreigners. MANA has welcomed 11 US students from the NSF's National Nanotechnology Infrastructure Network (NNIN) Research Experience for Undergraduates (REU) Program.

Human resource development of young researchers

Melting pot cultivation: As of March 2011 MANA has 169 young researchers* from 22 countries. MANA has achieved an environment where capable multi-national youths gather at one center from around the world, and develop their talents through friendly competition.

*Young researchers: MANA Scientists, Independent Scientists, ICYS-MANA Researchers, MANA Research Associates, graduate students.

Mentor system: MANA Scientists and Independent Scientists can propose which mentors they would like to work with. ICYS-MANA Researchers are first provided with an environment in which they can conduct self-motivated research, after which mentors are assigned. In this manner we have created a system in which we maintain respect for young researchers' autonomy while providing them with research advice.

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 Double-mentor, Double-discipline and Double-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.	**Human resource development with the 3D system:** Since the 3D System is extremely effective for cultivating a wide array of young researchers with global perspectives, MANA decided to expand the system beyond MANA Scientists and Independent Scientists to also cover ICYS-MANA Researchers starting FY2009. Thus far in FY2009 there are 32 researchers on this system.
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.	**Career development:** By April 2011 two MANA Scientists and four Independent Scientists have been promoted to group leaders and 12 ICYS-MANA Researchers had been appointed as NIMS permanent researchers. In this manner, MANA is realizing its aim of cultivating outstanding young researchers for the next generation. There are also many cases of MANA's young researchers moving up the career ladder, with one MANA Scientist appointed as a Dean at the Hebei University of Technology and one ICYS-MANA Researcher appointed as a group leader at the Leibniz Institute for Solid State and Materials Research Dresden. In this way, MANA is playing an important role in the career development of its young researchers.
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 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	4) Administrative personnel who can facilitate the use of English in the work process MANA is almost the perfect environment for providing swift administrative services to all researchers, be they Japanese or foreign. Staff in the Administrative Section possess the experience and know-how to handle any situation. One researcher even remarked, "I have conducted research at several institutes in the United States and Europe, but MANA has the best research environment." MANA staff also play a central role in leading regular English orientations and lab tours for newly appointed NIMS researchers. To ensure that new researchers can begin their research at NIMS immediately, they provide

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, 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.

information required for research, such as work regulations, benefits, research administration (equipment purchasing, official trips etc.), intellectual property, research ethics, applications for external funding, safety, etc., and tours of the primary research facilities.

In addition, there is a policy of conducting meetings and email communication in English, and all major guidebooks, documents and the intranet are almost entirely bilingual.

In FY2010 MANA's host institution, NIMS, began a full-fledged effort to bolster staff English proficiency by having all young permanent staff members under the age of 40 sit TOEIC examinations and providing additional correspondence education and overseas language training depending on their scores. A program to send outstanding performers with TOEIC scores of 700 or higher as interns to MANA's satellite at UCLA for six months was also initiated, and MANA Administrative Section staff member Matsumoto was the first person selected for the program.

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

All primary MANA researchers, including PIs, are permanent NIMS researchers. Every year, permanent NIMS researchers are subject to a personal performance evaluation that takes into account papers, patents and other research output. For papers, the higher impact journals in which they are published, the more points are awarded. Also, first-authored works are granted more points than co-authored works. Regarding patents, more points are awarded for registered patents than for patent applications, and even more points are awarded if a patent ends up licensed. Performance evaluation results are reflected in the following year's bonus, with high scoring researchers receiving higher monetary awards based on the number of points received. In the 2010 performance evaluation of 399 NIMS permanent researchers, 13 of the top 20 researchers were affiliated to MANA (8 PIs, 2 MANA Scientists, and 3 Independent Scientists), thus demonstrating the outstanding performance of MANA researchers.

The total amount of bonuses throughout NIMS is calculated on a zero-sum basis, and MANA researchers with excellent performance receive 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 m².

Space for experimentation: We will provide office space and laboratory rooms in the Nano Biomaterial Research Building only for

bonuses that exceed the average. For example, a PI and an Independent Scientist who performed outstandingly in 2010 will be awarded performance bonuses in 2011 that are respectively 2.5 times and 4 times the NIMS standard.

The MANA Evaluation Committee is comprised of 10 external stakeholders, and Professor Cheetham of the University of Cambridge acts as Chairman. The Committee has met twice to date, on March 12, 2008 and March 10, 2010, to evaluate MANA research activities and administration. MANA formulates Action Plans based on the Committee's suggestions and proposals, as it did with suggestions from the WPI Program Committee.

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

Since October 1st, 2008 the entire 13,000 m^2 of the old Nanomaterials and Biomaterials Research Building was allocated to MANA, and the main researchers are all stationed there. As such, it was renamed the MANA Building. About 600 m^2 of additional lab and office space was also built outside of the MANA Building for newly appointed PIs.

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.

MANA renovated the cafeteria, presentation corner and discussion corner in the corridor on the 5th floor of the MANA Building to enhance the melting pot atmosphere.

Furthermore, funds for the construction of a new MANA Building were approved in the first supplementary budget for FY2009. At 6,000 m^2, the new MANA Building will be located directly to the south of the existing MANA Building, and is slated for completion by the beginning of 2012. The building will have a "Melting Pot Zone" with a cafeteria, and promote further interaction among the 4 Fields of Nano-Materials, Nano-System, Nano-Green and Nano-Bio. MANA expects this will invigorate center activities.

In addition, NIMS delinked the nano-patterning line in the MANA Building which was part of the NIMS Nanotechnology Innovation Center, in order to establish the directly-operated MANA Foundry in April 2009. The MANA Foundry has 12 staff, and its objective is to further promote the creation of new materials and systems using nanoarchitectonics. MANA Foundry operating expenses are covered entirety by the MANA's host institution, NIMS.

We also improved research infrastructure by adding 25 shared research facilities through March 2011 (Total investment: 430 million yen).

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

The MANA International Symposium is growing larger every year, and the 4th symposium held in March 2011 attracted more than 400 participants. We also hold regular workshops, but the number of workshops planned and implemented by young researchers is increasing, including a workshop on Dirac Electron Systems in FY2010, inviting Nobel Prize winner Dr. Novoselov.

FY 2007-2008: 10 meetings

Major examples (meeting title and place held)	Number of participants
MANA International Symposium 2008 Date: Mar. 10 to 13, 2008 Venue: Tsukuba	Domestic: 154 Overseas: 108
MANA International Symposium 2009 Date: Feb. 25 to 27, 2009 Venue: Tsukuba	Domestic: 175 Overseas: 135

FY 2009: 13 meetings

Major examples (meeting title and place held)	Number of participants

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%. 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

Symposium on Frontiers in Nanotechnology and Materials 2009 Date: Oct. 23, 2009 Venue: Tsukuba	Domestic: 108 Overseas: 43
MANA International Symposium 2010 Date: Mar. 3 to 5, 2010 Venue: Tsukuba	Domestic: 191 Overseas: 135

FY 2010: 8 meetings

Major examples (meeting title and place held)	Number of participants
Japan-France workshop on nanomaterials Date: Nov. 3 to 5, 2010 Venue: CEMES (CNRS), Toulouse, France	Domestic: 30 Overseas: 45
MANA International Symposium 2010 Date: Mar. 2 to 4, 2011 Venue: Tsukuba	Domestic: 276 Overseas: 130

8) Other measures, if any

Invitation of foreign researchers: MANA has 3 researcher invitation programs to ensure that MANA is a research center that attracts all levels of researchers from around the world.

NIMS Open Research Institute Program: This program is run by NIMS and brings together all levels of researchers from young researchers to highly regarded scientists. By March 2011, 125 researchers were invited to MANA by this program.

MANA Short-Term Research Program: This is an original MANA program that invites faculty members from foreign research institutes who can conduct joint research with MANA researchers. Invitees stay at MANA for 1 to 3 months. By March 2011, 33 researchers were invited by this program.

JSPS Invitation Program: This program was funded by the first supplementary budgets for FY2009 and was held this fiscal year only. Pairs of globally-active scientists and young researchers were invited with the aim of cultivating young researchers and internationalizing the research environment. By adding NIMS subsidies MANA invited 7 renowned researchers and 11 young researchers from the West at the beginning of 2010. MANA also held a stay-over workshop in late March 2010 when more researchers gathered by this program.

Furthermore, more than 200 researchers had been invited to MANA for 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.

seminars and collaborative discussions by March 2011.

Collaboration with Universities: The FY2008 Program Committee remarked, "Since MANA is not a university, MANA should place special effort into bringing in (graduate) students in various ways" to which MANA has responded by actively convening joint workshops with universities from around the globe. Many MANA researchers also hold teaching positions at universities and they put a great deal of effort into student education.

Joint Workshops: MANA held 18 workshops with foreign and domestic universities by March 2011. MANA aims to promote research exchange and boost MANA's name recognition in order to scout for talent.

Participation in University Education: As mentioned above, 20 scientists at MANA are teaching in the NIMS Graduate Schools that includes the University of Tsukuba, Hokkaido University, and Waseda University. MANA also has 6 scientists who are supervising students from other universities as Visiting Professors.

<Future Policy and Concrete Plans>

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

MANA has nearly completed an environment in which researchers can devote themselves exclusively to their research. Since most staff are fixed-term staff, we will pass on knowledge and know-how to ensure that the quality of service does not fall due to staffing changes.

2) Startup research funding

We will continue providing startup research funding to researchers appointed from outside of the center. We will purchase the necessary research equipments and build a lab for Professor Winnik, a PI newly appointed in FY2011 from the University of Montreal, to ensure she can begin her research at MANA immediately.

3) Postdoctoral positions through open international solicitations

Since ICYS has grown into a system that attracts outstanding young researchers from around the globe and cultivates them into permanent NIMS researchers, we will continue this program. Graduate students are another useful resource for important research, so we will continue accepting outstanding students from around the world via NIMS Graduate Schools, graduate school partnerships and internships.

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

MANA host institution NIMS began an initiative in FY2010 to boost the English proficiency of its permanent administrative staff. MANA will cooperate with NIMS on this project to help promote the anglification of clerical services at NIMS. The know-how that administrative staff gained from training sessions at UCLA and other institutions will be put to use to improve human resources development, research integration and other areas in administrative unit management.

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

We will switch the performance evaluation for researchers from a single year system to a system that averages scores over three years with the aim of enabling researchers to tackle challenging research topics. We will continue reflecting performance evaluation results in bonuses.

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

The new research building slated for completion in the spring of 2012 will contain offices, labs, and interaction space to promote interdisciplinary research and allow researchers to tackle major issues. We will also build labs for satellite PIs in the new research building to accelerate joint research between MANA researchers and the satellites.

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

The MANA International Symposium has gained traction and participant numbers are increasing year after year. We will continue holding the symposium as the premier research meeting which symbolizes MANA. In addition, we will hold joint workshops with leading research institutes around Japan and the world and encourage young researchers to plan and hold workshops on individual research themes.

8) Other measures, if any

The MANA Foundry, electron microscopes and some other laboratory equipments were damaged by the 2011 Great East Japan Earthquake, so we will take measures to ensure a quick and full recovery to the research environment. Researchers whose research was affected by the disaster will be sent to other research institutions around the globe so they can conduct their research until repairs are complete.

In addition, some foreign researchers are avoiding travel to Japan, so we will work to quickly repair equipments and conduct several publicity campaigns to reinvigorate the melting pot atmosphere—in which young researchers from around the world work together in a spirit of friendly competition—that existed before the disaster.

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

<Initial plan and goals at the interim evaluation>

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 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.

<Current assessment>

Based on the facts listed below, we believe our undertakings are making excelling progress toward achieving our goal of "becoming a top-echelon research base to which researchers from around the world wish to be associated."

- ✓ As of the present time, we have achieved the following among its five-year goals:
  1) According to the Thomson Reuters' ESI Database as of March 1st, 2011, NIMS ranked 5th in the world for the number of institutional citations in the materials science field over the last 5 years (January 2006 to December 2010). MANA has cleared one of 5-year mid-term objectives of ranking within the top 5 in the world.
  2) From the time of MANA's launch until March 31, 2011, 161 post-doctoral researchers and 68 graduate students have been involved in MANA research. Thus, MANA has reached its goal of training 100 and 50 researchers, respectively, after five year's time.

- ✓ As of the present time, we have achieved the following goals set for end of the project (after 10 years):
  1) NIMS is the No.1 institute in the materials science field in the institutional citation ranking in Japan.
  2) The amount of external funding acquired has increased by 1.63 times compared to FY2008.

- ✓ One of the five-year goals that have not been achieved is "10% of permanent researchers will be foreign nationals." Although achievement of this goal ahead of schedule was expected, four Chinese researchers were lured away by China's "Thousand Talents Program," which resulted in a step backward. As of March 31, 2011, 37 foreign permanent researchers are with NIMS. This figure amounts to 9% of the total.

- ✓ NIMS has largely achieved the WPI Program's "four goals."
  1) Science level
     - ✧ As stated above, NIMS ranked 5th in the world for the number of institutional citations in the materials science field over the last 5 years according to the ESI Database. About 50% of the aforementioned

- ✓ 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 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

citations are from articles written by scientists affiliated with MANA. Given the ratio of MANA-affiliated scientists in NIMS (18%), one can see that MANA's contribution is great.

- ✧ The achievements of researchers affiliated with MANA are receiving international recognition. MANA's Director-General, Dr. Aono, received the 2010 Feynman Prize in Nanotechnology. And, in November 2010, a research paper authored in 2008 by Dr. Ariga, a PI, became the world's most cited paper in the materials sciences field for the past two years.
- ✧ Four MANA researchers (Dr. Ariga, Dr. Pergolesi, Dr. Fabbri, and Dr. Taguchi) captured all the NIMS President's Research Award (Research Achievement Award, Research Encouragement Award) for 2011.
- ✧ In FY2010, important research achievements began bearing fruit, and the number of reports appearing in newspapers suddenly increased by approximately three times. Particularly noteworthy of these achievements are the following:
  - Photocatalyst materials leading to artificial photosynthesis
  - Novel transistor with power consumption reduced to one-millionth
  - World's highest performance thin film capacitor
  - NdFeB permanent magnets and exhaust gas catalyst to minimize rare-metal use
  - Groundbreaking electrolyte materials for micro-solid oxide fuel cells
- ✧ MANA possesses the MANA Foundry, which is installed with the finest equipments. Moreover, MANA's researchers have access to much of the internationally cutting-edge and top-performance research facilities possessed by NIMS. In addition, MANA has located itself within NIMS's newest building. And it is expected that field integration will move ahead even further when the new research building is completed in 2012.
- ✧ Each year, MANA's researchers continue to capture large-scale competitive funding, and the amount of external funds they acquire is growing steadily.

2) Interdisciplinary research activities

- ✧ Aiming to promote integrated research by young researchers, MANA launched the MANA Fusion Research Program. This scheme has produced significant results. Among them was the selection of research on a new highly efficient solar cell using Si nano-wires by Dr. Fukata for the Funding Program for Next Generation World-Leading Researchers (NEXT Program). And a revolutionary membrane-type surface stress sensor developed by Dr. Yoshikawa was widely reported 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.

on in newspapers and websites and selected for Grants-in-Aid for Young Scientists A.

- ✧ As of March 2011, MANA Seminars have been held a total of 199 times. At these seminars, researchers from both within and outside MANA present hot research topics and engage in discussions with MANA researchers. MANA strongly recommends young researchers from different fields to attend the seminars, and thus each seminar comes into its own as a true “melting pot.” As a result, the seminars are playing a role in promoting field integration.
- ✧ MANA implements a “camp”-type approach called “Grand Challenge Meetings” that bring together researchers from different fields. These meetings have proven to be highly beneficial in fusing various fields and motivating young researchers to tackle new challenges.

3) Globalization of the institution

- ✧ As of March 31, 2011, 197 researchers are affiliated with MANA. Of these, 113 researchers, or 57%, are foreign nationals. In addition, many researchers from Japan and abroad visit MANA. In this way, MANA is becoming an international research center that attracts researchers from around the world.
- ✧ ICYS is firmly established as a gateway to success for permanent researchers of NIMS. Many researchers from around the world apply for ICYS whenever regular international recruitment drives are held.
- ✧ The MANA Administrative Section provides full technical and clerical supports to all researchers regardless of nationality and age and has nearly realized its mission of “providing an environment in which researchers can devote themselves exclusively to their research by exempting them from other duties”.
- ✧ Thus far, MANA has signed MOUs with 29 overseas research institutions, and it is pursuing joint research and personnel exchanges based on them. One of MANA’s missions is to promote the building of a network linking nanotech bases throughout the world, with MANA serving as the hub.

4) Organizational reform

- ✧ MANA’s Director-General is granted the authority to handle all areas of MANA’s operation by NIMS’s President. A system is established whereby three executives—the Director-General, Chief Operating Officer, and Administrative Director—hold discussions as necessary and make quick decisions regarding MANA’s operation.
- ✧ All staff members in the Administrative Section are fluent in English. They provide all researchers with quick-acting, far-reaching,

	Japanese-style service regardless of nationality by using English as the common language. ✧ It is clearly mentioned in NIMS's third five-year plan that MANA will promote some areas of system reform (internationalization and human resources development) within NIMS. NIMS, the host institution, began a program to raise the English language skills of all young permanent administrative employees in FY2010. This program is intended to spread MANA's use of English as an official language to all areas of NIMS. ✧ NIMS, the host institution, fully understands the necessity and framework of the WPI Program, and provides the maximum amount of support by, for example, providing resources and transferring authority.

<Future Policy and Concrete Plans>

In order to foster leading-edge research, the seeds of which we believe will be produced by interdisciplinary or integrated research, we will continue to create a climate for taking on challenging topics and encourage institutional aspects that provide financial support for this climate, while at the same time constantly identifying innovative themes. The superior research achievements to be produced through this approach will undoubtedly lead to even higher numbers of citations and other numerical goals set by MANA at the time of its establishment.

In addition, we will strive to make the international research environment and young researcher training system that MANA is cultivating even more attractive and effective, and then work to spread them to NIMS and other research institutions. This approach should result in the achievement of numerical goals concerning the number of young researchers and foreign researchers set by MANA at the time of its establishment.

We will complete a network linking the world's nanotech bases, with MANA serving as the hub, in order to become a globally visible research center that attracts researchers from all parts of the globe.

7. Securing competitive research funding

<Initial plan>

i) Past record

We have been steadily obtaining an average of about 1.4 billion yen of external funds in recent years. In addition, the total amount of operational subsidies allocated 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".

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.

<Secured to date>

In the past 3.5 years, MANA researchers have secured 7.82 billion yen in research funding consisting of 3.19 billion yen in external competitive funding, 0.77 billion yen in private funding and 3.86 billion yen in research funding from NIMS.

Amounts secured for each fiscal year can be found in the table below. Please note that a half year's funding has been listed for FY2007.

Research Funding Secured (Millions of Yen)

Type	FY2007	FY2008	FY2009	FY2010	Total
External competitive funding	365	630	1,044	1,150	3,189
Private funding	57	227	233	251	768
Research funding from NIMS	628	1,041	1,141	1,051	3,861
Total	1,050	1,898	2,418	2,452	7,818

Major new types of external competitive funding secured over the past 3.5 years are as follows.

a) Basic Research Programs (CREST)

- T. Sasaki: Next-generation electronics using inorganic nanosheets (2008) [Budget: 167,863,800 yen]
- Y. Miyahara: Biotransistors with bio-functional nanostructured gates (2008) [Budget: 75,270,000 yen]
- L. Han: Device physics of dye-sensitized solar cells (2009) [Budget: 154,830,000 yen]
- K. Ariga: Dynamic interfacial nanotechnology (2009) [Budget: 88,465,000 yen]
- T. Hasegawa: Three-terminal nonvolatile device 'atom transistor' (2009) [Budget: 117,390,000 yen]
- M. Higuchi: Electrochromic color electric paper (2010) [Budget: 72,800,000 yen]

b) Basic Research Programs (PRESTO)

- N. Fukata: Vertical three-dimensional semiconductor devices (2007) [Budget: 49,270,000 yen]
- Y. Tateyama: Reaction design for redox reactions on solid/solution interfaces (2007) [Budget: 44,265,000 yen]
- M. Higuchi: Multi-color electrochromic functional materials (2007) [Budget: 44,135,000 yen]
- Y. Yamauchi: Next-generation magnetic record media (2008) [Budget: 106,600,000 yen]
- H. Noguchi: Light energy conversion (2010) [Budget: 45,240,000 yen]
- M. Yanagida: High efficient dye-sensitized solar cells (2010) [Budget: 40,690,000 yen]

c) Basic Research Programs (TRIP)
- E. Muromachi: New iron pnictide superconductors (2008) [Budget: 50,700,000 yen]

d) Grants-in Aid for Scientific Research A
- N. Ohashi: Mixed crystal self-supported wafer device by zinc oxides (2008) [Budget: 49,400,000 yen]
- K. Tsukagoshi: High-performance atomic film device (2009) [Budget: 47,060,000 yen]
- K. Hono: High spin-polarized magnetic materials (2010) [Budget: 45,370,000 yen]
- T. Nakayama: New functional scanning probes (2010) [Budget: 48,490,000 yen]
- Alexei Belik: Functional transition metal oxides (2010) [Budget: 47,970,000 yen]

e) Grants-in Aid for Scientific Research for Young Scientists S
- T. Nagao: Metallic nano-materials and infrared plasmons (2008) [Budget: 88,900,000 yen]

f) Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST)
- E. Muromachi: New superconductors and related functional materials (2010) [Budget: 205,000,000 yen]
- T. Taguchi: Optimized therapeutic strategies against cancer and cardiovascular disease (2010) [Budget: 80,000,000 yen]

g) Funding Program for Next Generation World-Leading Researchers (NEXT

	Program) • N. Fukata: Next-generation high efficiency solar cells using functionalized silicon nanostructures (2010) [Budget: 113,100,000 yen]

<Future Strategy>

To date, PIs have secured CREST and other types of external competitive funding individually, but going forward, we will aim to secure large-scale external competitive funding with joint proposals by PIs and other researchers for interdisciplinary research projects. To do this, we will establish an original MANA research support program to generate creative and challenging research topics, much in the same way that we linked our system for encouraging interdisciplinary research among MANA young scientists to the receipt of the Funding Program for Next Generation World-Leading Researchers (NEXT Program).

We will also focus energy on ensuring that foreign researchers—who comprise over half of MANA's corps of researchers—secure external competitive funding. While providing support to MANA's foreign researchers for securing more external competitive funding than before, we will actively apply for international joint research projects with PIs at our overseas satellites.

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

<Initial plan>	<Measures taken to date>
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.	NIMS reaffirms that it will acquire the necessary finances and inherit MANA for at least 10 years after the conclusion of the WPI Program through the NIMS Steering Committee (equivalent to a management council). In preparation for this, research being promoted by MANA has been incorporated into one of three priority R&D fields within NIMS's third five-year plan, which went into effect in April 2011. Moreover, NIMS is applying MANA's experiences in human resources development and internationalization in NIMS's activities as the core institute.

<Future Policy and Concrete Plans>

Together with NIMS management, MANA will study research fields and challenges to be continued as well as their implementation organization, structure, and size during the period of the third five-year plan, which will be in effect until March 2016.

MANA will work to pass on intangible assets, such as the melting pot culture, human resources development system, and know-how accumulated in the administrative section.

9. Host institution's commitment

<Initial plan>	<Progress to date>
-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 definitely incorporated into long-term strategies of the main body of NIMS in both aspects of research initiatives and supply of human resources.	-Provision in host institution's mid-to-long-term plan MANA's development of innovative new materials based on nanoarchitectonics was formally incorporated into one of the three priority R&D fields within NIMS's third five-year plan, which came into effect in April 2011. Moreover, highly capable young researchers that were trained by MANA are being sent to NIMS as tenured researchers, and MANA is positioned in the five-year plan as a center for training human resources with the skills to be active on the global stage. In this way, MANA is clearly positioned and has an important role in NIMS's third five-year plan with regard to two of NIMS's four missions; namely, promotion of fundamental research and training and improved qualification of researchers. Furthermore, the item "building international networks and bases for international research" within the five-year plan states that MANA's "experience in developing an international research environment and recruiting and training young researchers will be reflected on internationalization efforts made by NIMS as a whole." Thus, MANA's role in promoting some of NIMS's system reforms is clearly positioned in the five-year plan.
-Concrete Measures (1) Competitive grants obtained by researchers participating in the project and in-kind contributions, etc. 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	-Concrete Measures (1) Competitive grants obtained by researchers participating in the project and in-kind contributions, etc. Using operating subsidy, NIMS provided personnel expenses pertaining to some permanent researchers participating in MANA projects (MANA Scientists and engineers) and some fixed-term employees (post-doctoral researchers, junior researchers, and technical personnel). Regarding operating subsidy projects led by researchers participating as PIs from NIMS, the research expenditure for those projects was provided to MANA and the projects were implemented by MANA. Additionally, regarding those competitive funds obtained by participating researchers from NIMS that are consistent with the MANA's research plan, the portion corresponding to direct expense was provided to MANA, and these activities were implemented by MANA. Furthermore, startup expense and research expenditure were provided to PIs, Independent Scientists, and MANA Scientists in order to

Research Building in the Namiki District.

iv) 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 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.

(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

support the smooth start of research within MANA.

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

The Director-General of MANA is entrusted with authority for all areas of MANA's operation by the President of NIMS. In other words, the Director-General has authority in hiring, contract renewal, salaries, research expense, space allocation, and other matters concerning MANA researchers and administrative employees, excluding NIMS permanent employees.

(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

A system is established whereby a NIMS employee can be transferred to MANA, or a MANA employee to NIMS, when the Director-General of MANA requests the transfer, the employee agrees to the transfer, and the President of NIMS recognizes the need for the transfer. As of March 2011, 50 people have transferred from NIMS to MANA, and 32 have transferred from MANA to NIMS. Moreover, when MANA has needs in a particular field, NIMS also gives priority to allocating its permanent employees to MANA. As of March 2011, 15 permanent employees have been accepted by 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

As is mentioned in 5.4, NIMS is working to make operating systems throughout the organization bilingual, and has made the decision to raise the English abilities of its administrative staff. Since FY2010, NIMS has been placing priority on hiring employees with strong English ability. It also began full-scale correspondence education with schooling and overseas language training for all young permanent administrative employees. MANA is providing of the above operations experienced. We are planning to actively adopt the center's successful management systems to the main body of NIMS.

(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㎡ 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 ㎡ in total). We will provide approximately 1/2 span (20 ㎡) 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㎡) where they can devote themselves to research 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.

its full cooperation to this program by accepting trainees in its Administrative Section for on-the-job training in English, and providing UCLA (a MANA satellite) as an institution for overseas intern training.

In addition, NIMS changed its researcher performance evaluation by shifting the period for evaluation from the previous single-year basis to a three-year average. Because evaluations of performance now focus on a longer period, researchers are no longer pressured to produce achievements each year and are able to pursue their research in a more settled manner.

These reforms show that the various system reforms and efforts to change employee awareness that MANA has implemented within its organization thus far—such as an administrative and technical support structure in which use of English as the official language is widespread, and the fact that Independent Scientists have become proactive in tackling research integration and challenging topics due to their exemption from individual performance evaluation—are showing progressive penetration into the host institution.

(5) Accommodation of center's requirements for infrastructural support (facilities, e.g., laboratory space; equipment; land, etc.)

On October 1, 2008, NIMS provided its former Nanomaterials and Biomaterials Research Building (a total of 13,000 m^2) to MANA for use as its main research center. NIMS renamed the building the MANA Building. Furthermore, NIMS installed laboratories and office spaces for use by newly appointed PIs (approximately 600 m^2). It also enhanced research infrastructure by introducing 25 pieces of shared use equipments (total cost of 430 million yen).

In addition, NIMS detached the nano-patterning line in the MANA Building from the NIMS Nanotechnology Innovation Center, and placed the line under MANA's direct management as the MANA Foundry in April 2009. The entire amount of expenses pertaining to operation of the MANA Foundry is provided by the host institution.

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 has MANA's Director-General participate in NIMS's operation as a member of the NIMS Steering Committee (equivalent to a management council). This allows NIMS and MANA to enhance their communication, and sets up a structure through which MANA can more quickly draw out commitment from NIMS. It is also expected to have the effect of amplifying progressive systems being implemented by MANA in NIMS.

<Future Policy and Concrete Plans>

-Provision in host institution's mid-to-long-term plan

NIMS will continue to clearly position MANA's activities within NIMS's five-year plan as "good practices" in terms of both their research achievements and as approaches to human resources development and internationalization.

-Concrete Measures

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

As in the past, NIMS will continue to apportion portions pertaining to operating subsidy project research expenses and direct expenses of competitive funds for research that are consistent with the MANA's research plan to MANA. MANA will be responsible for implementing said research.

In addition, NIMS will use operating subsidy to provide startup expenses and research expenses to researchers newly participating in MANA.

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

The maximum degree of discretion in personnel and budget implementation is provided to MANA's Director-General. This will continue to be the case in the future.

(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

Personnel exchanges with the host institution (NIMS) are conducted actively and smoothly, and with respect for MANA's intentions. Personnel metabolism has a role in MANA's invigoration, and this will remain the case in the future.

(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

Approaches to raise the English-language ability of NIMS administrative personnel will support further English language reinforcement, change the attitudes of administrative personnel by reaching beyond simple improvement of language skills by including on-the-job training and imparting of knowledge, and contribute to NIMS's internationalization.

As for performance evaluation, although steps will be taken as necessary to create an even better system, the current system—in which performance evaluation is conducted for all of NIMS researchers and then the results are reflected on bonuses—is seen as the best approach given the salary cap that is placed on NIMS.

And as for the decision-making system, the current three-pronged structure will be continued, with attention given to the opinions of NIMS management, advisors, and others to ensure that no arbitrary decisions are made.

(5) Accommodation of center's requirements for infrastructural support (facilities, e.g., laboratory space; equipment; land, etc.)

The current problem of insufficient space will be resolved with the completion of a new research building at the beginning of 2012. However, NIMS will continue to support operation of the MANA Foundry, introduction of large equipments, and other activities.

(6) Support for other types of assistance

The hotline with NIMS management will be maintained and serve as a means for supporting MANA's operation and discussion on system development, etc.

- What the host institution is /will do to support/sustain the operations of the center (include support activities already underway)?

1. Over the next 5 years

NIMS's third five-year plan, which came into effect in April 2011, positions research being promoted by MANA as priority R&D and states that MANA's human resources development and internationalization approaches will be linked to system reform in NIMS. Because this is also in preparation for inheriting MANA (which was launched during the second five-year plan) even after the conclusion of the WPI program, the next five years will, in accordance with the plan, take MANA to an even higher place among the world's top institutions.

2. After the period of WPI project funding ends

The NIMS's fourth five-year plan, which will start from April 2016, will inherit systems cultivated by MANA and launch research projects and organizations that follow MANA's precedents, while remaining based on achievements under the third five-year plan.

10. Efforts to improve points indicated as requiring improvement by Program Committee and results of such efforts

-Points specified as needing improvement (as noted in Item 3 “Points that need improvement” in the FY2009 follow-up results)	-Efforts to improve them and results *If you have already described these in other parts of this report, please indicate where for reference.
✓ Making clear the distinctiveness of science being pursued in MANA.	MANA publishes books that explain nanoarchitectonics as well as collections of scientific papers by major MANA researchers. MANA-issued books include scientific literature written not only for researchers but also the general public. Among them is a book titled *Nanoarchitectonics: How to Architect Supreme Materials*, which is co-authored by Dr. Aono, the Director-General of MANA, and Dr. Ariga, a PI. This book will be published by Iwanami Science Library during 2011. As for collections of scientific papers, we publish special features on MANA in journals of original papers in order to spread the word on the nanoarchitectonics concept’s distinctive characteristics and to raise recognition of MANA. At the present time, we plan to place special features in two journals, *Science and Technology of Advanced Materials (STAM)*, which is edited and issued by MANA’s host organization, NIMS; and *Advanced Materials*, which is published by John Wiley & Sons, Inc. The former is scheduled to be published in August 2011, and the latter in January 2012.
✓ Needs for grand challenge to create new materials science.	To take on “grand challenges,” we must create a climate for doing so and have the supporting institutional aspects required. As for creating the proper climate, we started a “camp”-type approach called “MANA Grand Challenge Meetings.” These meetings have proven to be highly beneficial in fusing differing fields and motivating young researchers to tackle new challenges. Consequently, we will make them a regular event in the future. Specific challenges presented at the meetings include room temperature nano-superconductor, artificial nano-photochemical system, brain computer, and nano-energy generation. And, beginning in FY2011, we have been implementing the “MANA Grand Challenge Research Program” to nurture research that is highly creative yet risky. The scheme seeks to cultivate results by setting one year nurturing period, evaluating results after this one year, and then further nurturing those areas that show promise.
✓ Reinforcement of nano-bio field.	In September 2010, we newly named Dr. Takao Aoyagi as the field coordinator and a Principal Investigator of nano-bio, and reviewed both our

	research content and framework in this field. In the area of research content, we made a dramatic change in course. We shifted from our conventional emphasis on invention of functionalized bio devices to creation of biomaterials that make possible “materials therapy,” in which the material itself encourages sustained healing of biological tissue. And as for research implementation framework, we appointed Dr. Guoping Chen of NIMS and Prof. Françoise Winnik of the University of Montreal to serve as new PIs, thereby forming a staff of four PIs. At the same time, we merged NIMS’s Biomaterials Center into MANA’s nano-bio field, and assigned 17 full-time MANA Scientists. Prof. Winnik runs laboratories in both MANA and the University of Montreal (satellite), and she is scheduled to conduct research within MANA for as many as five months of each year. Moreover, MANA set up the Biomedical Innovation Laboratory in Tokyo Women's Medical University’s Institute of Advanced Biomedical Engineering and Science so that Nano-Bio scientists can conduct cellular and animal experiments on biomaterials that are newly developed by MANA to establish basic design technologies for novel biomaterials. They also join in a research project of the “Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program)” being implemented by Tokyo Women's Medical University.

11. Efforts to improve points indicated as requiring improvement in the Project Progress Verification Report and results of such efforts

-Points specified as needing improvement (extracted from the FY2009 Project Progress Verification Report)	-Efforts to improve them and results *If you have already described these in other parts of this report, please indicate where for reference.
✓ Metabolism of PIs is needed to keep the present activity.	In line with NIMS's third five-year plan, which started in April 2011, six PIs were dismissed and three PIs were appointed to form a staff of 25 PIs. The three newly appointed PIs are scientists who are active on the international stage, and they are expected to make significant contributions toward vitalizing MANA.
✓ MANA should start thinking about the next MANA research project, generation distribution of the scientists, and new system of human-resource development.	As is mentioned in "10. Efforts to improve points," MANA began extracting "grand challenging" research themes by holding a brainstorming "camp." And, since FY2011, MANA has been implementing a research grant designed to nurture research that is highly creative yet risky. MANA will use the outcomes of this grant to identify next-generation research projects. Like the PIs, MANA sought to metabolize young researchers by replacing a considerable number of MANA Scientists and Independent Scientists in April 2011. As for the 3D system, which has been successful as a human resources development scheme, MANA will further develop it by combining it with a long-term overseas dispatch program (mentioned below) in order to further enhance its effectiveness.
✓ MANA should give lots of chance for young researchers to work in foreign good institute or university for 1 or 2 years. It is very important experience for the young researchers to touch different culture of research methodology. The combination of research attitude of Japanese style and foreign style is necessary to create new consideration (innovative and "crazy" ideas) and cultivate new findings.	NIMS formulated a policy of actively sending young researchers overseas to receive training for periods of up to two years, and it began putting the policy into practice in FY2011. The policy seeks to instill in young researchers a desire to take on new challenges through immersion in overseas training, and as such, it largely addresses the point indicated as requiring improvement. In line with the policy, MANA will launch a program that will select a number of young researchers from each PI group as well as Independent Scientists each year, and then send them to leading nanotechnology research institutes in the US and Europe for extended periods of time.
✓ MANA also needs to increase the success rate of Tenure Track to 50-60% (at present ca. 30% of the ICYS posdocs) in order to get more talented young scientists.	Keeping the majority of ICYS Researchers as permanent members of NIMS is extremely difficult. On top of NIMS's limited recruitment structure, this is because, as is described in "5.3 Career Development," MANA

	encourages ICYS Researchers to develop their careers in domestic and overseas research institutes. Nonetheless, thus far, the permanent selection rate of ICYS Researchers that apply for permanent status in NIMS exceeds 50% (28 researchers applied, 16 researchers accepted or scheduled to be accepted). NIMS will continue to broaden international recognition of ICYS and to recruit and foster superior young researchers.
✓ Access to students is extremely important. All PIs should be encouraged to establish university connections.	As is mentioned in 5.3 and 5.8, the majority of PIs serve as professors at the NIMS Graduate Schools, where they are in constant contact with graduate students. Moreover, all PIs actively accept students through the International Cooperative Graduate Schools and internships.
✓ MANA should establish a procedure to nominate their best scientists and research for international awards and prizes (for example for the Kavli Prize in Nanoscience).	MANA has created a commendation recommendation committee that systematically works to facilitate receipt of international awards by MANA researchers. As an achievement of 2010, Director-General Dr. Masakazu Aono was awarded with the Feynman Prize in Nanotechnology.
✓ The ethos for active dialogue in conferences should be intentionally promoted based on the “melting pot”.	As of March 2011, MANA Seminars have been held a total of 199 times. At these seminars, researchers from both within and outside MANA present hot research topics and engage in discussions with researchers at MANA. MANA strongly recommends young researchers from different fields to attend the seminars, and more and more Japanese researchers are speaking at them. As a result each seminar comes into its own as a true “melting pot.”
✓ The relation between NIMS and MANA is still unclear. Many PIs do not distinguish MANA from NIMS. If MANA is a center of excellence within NIMS and MANA cannot survive without the support of NIMS, one should not introduce an artificial separation but one should discuss for example common investments in the infrastructure.	As is mentioned in “3. Management,” MANA is entrusted with a certain amount of authority from NIMS. MANA runs its own fixed-term researcher system and research grant, and decisions regarding satellite operation and distribution of research space are left to MANA’s discretion. MANA is also taking various actions with NIMS, including enhancement of the MANA Foundry for shared benefit and joint operation of a new research building scheduled to be completed in 2012.

12. Project Expenditures

FY2007 (the exchange rate used: JPY/USD=120)

i) Overall project funding

Cost Items	Details	Costs (10,000 dollars)
Personnel	Center director and Administrative director	13
	Principal investigators (no. of persons):13	63
	Other researchers (no. of persons):96	206
	Research support staffs (no. of persons):22	23
	Administrative staffs (no. of persons):20	34
	Total	339
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons):6	3
	Cost of dispatching scientists (no. of persons):2	4
	Research startup cost (no. of persons):11	26
	Cost of satellite organizations (no. of satellite organizations):2	25
	Cost of international symposiums (no. of symposiums):1	3
	Rental fees for facilities	0
	Cost of consumables	31
	Cost of utilities	64
	Other costs	136
	Total	292
Travel	Domestic travel costs	2
	Overseas travel costs	5
	Travel and accommodations cost for invited scientists (no. of domestic scientists):3 (no. of overseas scientists):16	8
	Travel cost for scientists on secondment (no. of domestic scientists):0 (no. of overseas scientists):0	0

Ten thousand dollars

WPI grant		775
Costs of establishing and maintaining facilities		0
Cost of equipment procured		1197
High-resolution 3D digitizer		
Number of units: 1	Costs paid:	19
Focus controllable laser annealing system		
Number of units: 1	Costs paid:	18
Silicon deep etching system		
Number of units: 1	Costs paid:	36
Wafer cleavage system		
Number of units: 1	Costs paid:	11
High resolution CCD camera for the atom observable TEM		
Number of units: 1	Costs paid:	13
Electric-operated valve for purified water cooling system		
Number of units: 1	Costs paid:	11
Field emission scanning electron microscope		
Number of units: 1	Costs paid:	19
Maskless lithography system		
Number of units: 1	Costs paid:	27
Environment controllable scanning probe microscope		

	Total	15
Equipment	Depreciation of buildings	61
	Depreciation of equipment	233
	Total	294
Other research projects	Projects supported by other government subsidies, etc.	90
	Commissioned research projects, etc.	336
	Grants-in-Aid for Scientific Research, etc.	20
	Total	446
Total		1386

Number of units: 1 Costs paid: 10

Operation controlling system for power supply of hybrid magnet

Number of units: 1 Costs paid: 13

Others 1020

ii) Costs of Satellites and Partner institutions

Cost Items	Details	Costs (10,000 dollars)
Personnel	Principal investigators (no. of persons):0	
	Other researchers (no. of persons):0	
	Research support staffs (no. of persons):1	
	Administrative staffs (no. of persons):0	
	Total	0
Project activities		0
Travel		1
Equipment		23
Other research projects		2
Total		26

FY2008 (the exchange rate used: JPY/USD=120)

i) Overall project funding

Ten thousand dollars

Cost Items	Details	Costs (10,000 dollars)
Personnel	Center director and Administrative director	30
	Principal investigators (no. of persons):18	147
	Other researchers (no. of persons):140	478
	Research support staffs (no. of persons):12	30
	Administrative staffs (no. of persons):21	85
	Total	770
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons):41	9
	Cost of dispatching scientists (no. of persons):1	3
	Research startup cost (no. of persons):29	100
	Cost of satellite organizations (no. of satellite organizations):10	118
	Cost of international symposiums (no. of symposiums):1	3
	Rental fees for facilities	0
	Cost of consumables	33
	Cost of utilities	148
	Other costs	63
	Total	477
Travel	Domestic travel costs	2
	Overseas travel costs	15
	Travel and accommodations cost for invited scientists (no. of domestic scientists):20 (no. of overseas scientists):89	37
	Travel cost for scientists on secondment (no. of domestic scientists):2 (no. of overseas scientists):17	4
	Total	58
Equipment	Depreciation of buildings	220
	Depreciation of equipment	796
	Total	1,016
Other research	Projects supported by other government subsidies, etc.	325
	Commissioned research projects, etc.	152

WPI grant		851
Costs of establishing and maintaining facilities		71
Repairing facilities :Installation of Additional Laboratory	Costs paid:	71
Cost of equipment procured		834
Atoomic Layer Deposition Apparatus		
Number of units: 1	Costs paid:	29
Time-lapse analysis system		
Number of units: 1	Costs paid:	32
Catalyst characterization laboratory		
Number of units: 1	Costs paid:	8
Super Solar Simulator		
Number of units: 1	Costs paid:	13
Flat-type Vacuum Evaporator		
Number of units: 1	Costs paid:	13
Impedance Meter		
Number of units: 1	Costs paid:	6
Glove Box System		
Number of units: 3	Costs paid:	27
In-Air Type Photoemission Spectroscope		
Number of units: 1	Costs paid:	24
Spectrum Sensitivity Measuring Apparatus		
Number of units: 1	Costs paid:	18
Muffle furnace		
Number of units: 4	Costs paid:	9
Hybrid Microscope		
Number of units: 1	Costs paid:	10
Multi Spectro Plate Reader		

projects	Grants-in-Aid for Scientific Research, etc.	20	Number of units: 1	Costs paid: 6
	Total	497		
Total		2,818	Others	639

ii) Costs of Satellites and Partner institutions

Cost Items	Details	Costs (10,000 dollars)
Personnel	Principal investigators (no. of persons):2	
	Other researchers (no. of persons):13	
	Research support staffs (no. of persons):13	
	Administrative staffs (no. of persons):3	
	Total	38
Project activities		8
Travel		5
Equipment		33
Other research projects		61
Total		145

FY2009 (the exchange rate used: JPY/USD=100)

i) Overall project funding

Ten thousand dollars

Cost Items	Details	Costs (10,000 dollars)
Personnel	Center director and Administrative director	35
	Principal investigators (no. of persons):18	212
	Other researchers (no. of persons):147	804
	Research support staffs (no. of persons):10	48
	Administrative staffs (no. of persons):20	86

WPI grant	1,475
Costs of establishing and maintaining facilities	0

	Total	1185
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons):50	16
	Cost of dispatching scientists (no. of persons):2	4
	Research startup cost (no. of persons):32	233
	Cost of satellite organizations (no. of satellite organizations):10	156
	Cost of international symposiums (no. of symposiums):1	5
	Rental fees for facilities	0
	Cost of consumables	27
	Cost of utilities	165
	Other costs	73
	Total	679
Travel	Domestic travel costs	1
	Overseas travel costs	20
	Travel and accommodations cost for invited scientists (no. of domestic scientists):16 (no. of overseas scientists):125	62
	Travel cost for scientists on secondment (no. of domestic scientists):1 (no. of overseas scientists):16	4
	Total	87
Equipment	Depreciation of buildings	269
	Depreciation of equipment	825
	Total	1094
Other research projects	Projects supported by other government subsidies, etc.	755
	Commissioned research projects, etc.	364
	Grants-in-Aid for Scientific Research, etc.	128
	Total	1247
Total		4292

Cost of equipment procured		847
High speed and High precision mapping photoluminescence system		
Number of units: 1	Costs paid:	32
Absolute PL quantum yield measurement device		
Number of units: 1	Costs paid:	9
Zeta-potential and particle size distribution measurement device		
Number of units: 1	Costs paid:	11
Spectroscopic ellipsometer		
Number of units: 1	Costs paid:	26
High resolution depth profile X-ray micro spot size photoelectron		
Number of units: 1	Costs paid:	63
Electrochemical SPM Systems		
Number of units: 1	Costs paid:	16
Color 3D Laser Scanning Microscope		
Number of units: 1	Costs paid:	16
Preparative MPLC System		
Number of units: 1	Costs paid:	5
Super centrifuge		
Number of units: 1	Costs paid:	4
High-temperature attachment for X-ray diffraction machine		
Number of units: 1	Costs paid:	30
Electron Spin Resonance Measurement System		
Number of units: 1	Costs paid:	4
Pulse Laser Deposition System		
Number of units: 1	Costs paid:	46
Lease of the supercomputer		
Number of units: 1	Costs paid:	95
Others		490

ii) Costs of Satellites and Partner institutions

Cost Items	Details	Costs (10,000 dollars)
Personnel	Principal investigators (no. of persons):1	
	Other researchers (no. of persons):19	
	Research support staffs (no. of persons):28	
	Administrative staffs (no. of persons):1	
	Total	81
Project activities		10
Travel		5
Equipment		18
Other research projects		43
Total		157

FY2010 (the exchange rate used: JPY/USD=100)

i) Overall project funding

Cost Items	Details	Costs (10,000 dollars)
Personnel	Center director and Administrative director	35
	Principal investigators (no. of persons):20	222
	Other researchers (no. of persons):153	814
	Research support staffs (no. of persons):6	34
	Administrative staffs (no. of persons):24	104
	Total	1209
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons):46	13
	Cost of dispatching scientists (no. of persons):3	7
	Research startup cost (no. of persons):20	77
	Cost of satellite organizations (no. of satellite organizations):8	122

Ten thousand dollars

WPI grant		1,350
Costs of establishing and maintaining facilities		13
Repairing facilities (Number of facilities:1 , 84 m²)	Costs paid:	13
Cost of equipment procured		535
ESR		
Number of units: 1	Costs paid:	30
Sputtering system		

	Cost of international symposiums (no. of symposiums):1	5
	Rental fees for facilities	0
	Cost of consumables	30
	Cost of utilities	170
	Other costs	73
	Total	497
Travel	Domestic travel costs	1
	Overseas travel costs	13
	Travel and accommodations cost for invited scientists (no. of domestic scientists):15 (no. of overseas scientists):122	50
	Travel cost for scientists on secondment (no. of domestic scientists):7 (no. of overseas scientists):11	4
	Total	68
Equipment	Depreciation of buildings	269
	Depreciation of equipment	743
	Total	1012
Other research projects	Projects supported by other government subsidies, etc.	867
	Commissioned research projects, etc.	392
	Grants-in-Aid for Scientific Research, etc.	176
	Total	1435
Total		4221

ii) Costs of Satellites and Partner institutions

Cost Items	Details	Costs (10,000 dollars)
Personnel	Principal investigators (no. of persons):1	
	Other researchers (no. of persons):18	
	Research support staffs (no. of persons):27	

Number of units: 1	Costs paid:	31
Picosecond Pulse laser		
Number of units: 1	Costs paid:	12
AFM		
Number of units: 1	Costs paid:	10
Multi-source sputtering system		
Number of units: 1	Costs paid:	24
Impedance Analyzer		
Number of units: 1	Costs paid:	10
Cell adhesion measuring device		
Number of units: 1	Costs paid:	15
Sample Carrying System		
Number of units: 1	Costs paid:	20
Electrode Preparation System		
Number of units: 1	Costs paid:	8
Desktop scanning microscope		
Number of units: 1	Costs paid:	5
RHEED		
Number of units: 1	Costs paid:	5
Compact probe microscope		
Number of units: 1	Costs paid:	6
Lease of the supercomputer		
Number of units: 1	Costs paid:	91
Others		268

	Administrative staffs (no. of persons):4	
	Total	86
Project activities		9
Travel		4
Equipment		6
Other research projects		20
Total		125