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

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Report Abstract

Since its launch in October 2007, WPI-AIMR has focused its efforts on establishing a world-class materials science research center. As a result, in the last three-and-a-half years, many world-class research outcomes have been produced successfully, and the system reform has been achieved as shown below.

"Science Level"

The research levels of AIMR in the materials field have always been the highest in the world. Research papers written by its researchers have frequently been published in high-impact journals. In addition, the number of papers cited by other researchers has also always been among the highest. AIMR full-time PIs have published 3225 papers in the last 10 years, of which 85 (2.61%) were in the top one percent most cited papers (for reference, 1.01%, the entire Tohoku University; 1.21%, the Institute for Materials Research of Tohoku University; on a global basis, 2.59%, NASA; 3.25%, Max Planck). The fact that its researchers have received the international scientific awards shown below since its establishment serves as strong evidence of its exceptionally high level: Arthur C. Cope Scholar Award of the American Chemical Society, Membership of the National Academy of Engineering, James C. McGroddy Prize for New Materials of the American Physical Society, Oliver E. Buckley Condensed Matter Prize of the American Physical Society, The International Rubber Conference Organization Medal, Centenary Prize of the Royal Society of Chemistry, Unilever Award of the American Chemical Society, A. E. Alexander Lecture Award of the Colloid and Surface Chemistry Division of the Royal Australian Chemical Institute, Humboldt Research Award, and Project selected in the Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST) Program of the Japan Society for the Promotion of Science (in detail, see p.44; the section of "6. Criteria and methods used to evaluate center's global standing").

"Globalization of the Institution"

As of March 31, 2011, there are 33 PIs, of whom 14 PIs or 42% are from foreign countries. The Center invites applications from associate professors, assistant professors and post-docs from around the world, among whom outstanding researchers are selected as members. In response to the rapid increase in the number of foreign researchers, AIMR has English-speaking administrative staff available so as to assist their research and daily activities.

As for overseas satellite institutions, AIMR signed a collaboration agreement in 2008 with the University of Cambridge, in 2009 with the Institute of Chemistry, Chinese Academy of Sciences, and in 2010 with the University of California, Santa Barbara. In FY 2010 interdisciplinary exchange was added to the requirements for selecting a satellite in order to differentiate the satellite agreement from other partnership agreements. Also in 2010, the GI^3 (Global Intellectual Incubation and Integration Laboratory) program specifically designed to further promote international partnerships was established. In February 2011, the fourth annual workshop was held. Since the first workshop in February 2008, overseas PIs, and WPI adjunct professors and adjunct associate professors gathered and made substantive discussions to reconfirm the objectives for the WPI-AIMR.

"Interdisciplinary Research Activities"

Our research center provides the "Fusion Research Proposal Program" to help researchers promote interdisciplinary fusion research. Under the program, funds intended to be used as seed money for starting research that is expected to be developed through interdisciplinary collaborations are provided to groups of PIs and groups of young researchers. These researchers are offered an opportunity to make a poster presentation of results from their projects at Tea Time so that the results can be shared with other researchers and inspire more new ideas for fusion research. AIMR has also frequently organized seminars in order to discuss current hot topics in materials science, physics, chemistry and device area, to improve mutual

understanding between the scientists and initiate fusion research activities. These efforts have gradually been rewarded by highly commendable results (Cluster structures of polymers and BMG and their relationships with manifestation of functions. Phys. Rev. Lett., 106, 125504, 2011; New hybrid materials by fusing ideas introduced in Physics Today, 2011; Electronic states common to graphene, iron-based superconductors and topological insulators introduced in Physics Today, 2011).

"Organizational Reform"

We adopt a top-down management approach, instead of a collegial approach such as a faculty council system, allowing the Center Director to make decisions so as to address Center-related issues promptly on a case-by-case basis. In addition to the top-down decision making system, the executive committee consisting of the Center Director, Administrative Director and the leaders of the four research groups was formed in October 2009, and PI liaison meetings and monthly staff meetings attended by assistant professors and higher executives have been held.

The Administrative Division was also reformed. In the reform, the position of full-time Deputy Administrative Director was created. The Administrative Division was divided into four administrative sections: general affairs, international academic/research cooperation, accounting, and property management. In addition to the administrative staff, technical staffs were also assigned into three groups: one in charge of facilities, one in charge of networks, and one in charge of safety control. The Management Office for Safety and Health was made into an independent unit so as to be fully engaged in the health management of researchers and the safety management of laboratories. Ten English-speaking associated staff members were also assigned to help with administrative tasks.

AIMR exerted its effects on the host institution. More specifically, AIMR provides an extra allowance to full-time PIs with the aim of offering an environment similar to that provided to distinguished professors in the United States. After our adoption of this system, the host institution followed suit and established the "Tohoku University Distinguished Professor System." AIMR's performance-based allowance system for researchers has also been incorporated in the host institution's allowance system.

The host institution is also considering adopting an AIMR system where special recognition is given to an outstanding young researcher as an independent investigator. The host institution has also incorporated the GI^3 system described above and a summer school program that is being planned into their exchange programs for researchers. The use of English as the primary language at AIMR has also helped expand the use of English throughout the entire host institution.

"Mid- to Long-Term Objectives"

AIMR has focused its efforts on creating new materials science using innovative atomic and molecular control methods through "fusion research" and other interdisciplinary approaches, resulting in some outstanding results. Through successful research outcomes achieved by each research group, we have recognized the importance of focusing on functions of a wide range of materials. Innovative functional materials that give a future vision to the human society can be created only by recognizing the process from atoms and molecules through to materials, devices and systems as a complex layered system and by elucidating the mechanism of the manifestation of functions in layers and between layers with a function as an indicator. In order to achieve common understanding transcending existing frameworks, we have reached the conclusion that a mathematical viewpoint is necessary to abstract and universalize individual research results. In this context, it has been decided to invite a mathematician as a PI in order to establish a mathematics unit and form an interface layer. Our mid-term goal is to provide a basis for common understanding among the existing four research groups so that they can reach a unified perspective and long-term goal is to create revolutionary *Green Materials* through contribution to "energy harvesting," "energy saving" and "environmental clean-up." As a long-term perspective, WPI-AIMR will seek to ensure a stable energy supply for future generation and provide the basis for environmental conservation using new materials that would radically change the value of life, taking the lead in showing what a future society should be like.

After completing this program, achievements made by the center are planned to serve as a base for developing the Tohoku University Advanced Institute for Materials Science, which is intended to play a leading role in the promotion and internationalization of advanced research.

1. Summary of Center Project

<Initial plan>

The main objective of the Center is to promote the development of new materials under a world-leading organization for interdisciplinary research in functional materials, by use of an innovative method of atomic and molecular control, departing from the typical approaches and moving towards the next generation. In addition to basic research, the Center will pursue (1) the creation of new compounds and materials with innovative functions which exceed existing ones, (2) the construction of devices based upon a new fundamental paradigm, and (3) the promotion of applied research projects on materials and systems architecture that will generate direct societal impacts. In addition, the Center will establish innovations in understanding diverse material functions through the creation of new basic materials and compounds which brings significant benefits for the future of humanity.

A wide range of materials including metals, semiconductors, superconductors, ceramics, and organic and biological compounds will be the subjects of our investigation, aiming at the creation of innovative functions: (1) the creation of new structural materials, electronic materials, nanomolecular materials, materials for surface and interface systems, and materials having molecular assembling properties; (2) the development and elaboration of these materials leading into devices and systems; and (3) the construction of new architectures, using these devices and materials leading to the betterment of society. Synergy between the above three stepwise strategies is anticipated, and the merging of the five research fields (physics, chemistry, materials science, electrical engineering, and mechanical engineering) is strongly thrust to the forefront, and thereby we are convinced that the WPI Research Center for Atom·Molecule·Materials must be established at Tohoku University. “From atom and molecule to social welfare through materials” is the guiding principle for the center as outlined in the detailed items on the research theme and the organization of the center.

<Current status>

Based on the basic concepts shown in (1), (2) and (3) on the left, basic and applied researches are being carried out smoothly.

In order to establish the WPI research center’s status as a unique research organ by clearly differentiating itself from existing Institute for Materials Research in line with a request filed by the Program committee in FY2009, the scope of AIMR research activities are going to expand and include not only hard materials fields but also soft materials fields. By doing so, the new Center is to become the world’s top research institute in the field of materials science. Furthermore, we have disseminated this new goal both at home and abroad. We have recruited young and talented PIs in the field of soft bio-devices from Harvard University and the Hong Kong University of Science and Technology. Tohoku University Professor Matsue, known to have expertise in this field, was also recruited as a PI to step up research in the field, which is said to be promising in terms of future materials. Also recruited was a junior PI from Texas A&M University, who has been posted for research in the Materials Physics group.

UCL Professor Shluger, who has participated in the project as PI since the foundation of the Center, has been strongly committed to AIMR research as a theorist. He stays three months of each year in Sendai, in order to stay committed to the research.

The four foreign researchers have undertaken research and experimental activities at their laboratories in Sendai.

The three basic fields covered under materials science are physics, chemistry and bioengineering. Each researcher tends to focus on one of the three basic fields. However, each one has been strongly encouraged to add one more field to his or her research activities as a way of promoting research fusion between different fields. More specifically, the researchers have been strongly requested to step up research activities in PhysChem-Material, ChemBio-Material, and PhysBio-Material, as well as in the existing Phys-Material and Chem-Material fields. As a means of promoting concretely fusion research at the Center, we have launched a subsidy program called Fusion Research Proposal Program, in which promising research projects are eligible for start-up funds. A joint seminar was launched in FY2008 in order to accelerate fusion research by providing researchers with opportunities to conduct such studies. The number of such seminars held for each month increased to about two (every other Friday) in FY2009. Items to be discussed at the seminar are decided by the planning committee while reflecting opinions of young researchers. In FY2010, young researchers began to take charge of operating the seminar, with each research group asked to present the progress of its fusion research activities. Also, in September 2009, a weekly Friday Tea Time was launched. In August 2010, researchers began to present the results of their research activities under the Fusion

	Research Proposal Program to other research groups to promote information sharing on their activities. As fusion research has been firmly progressing, methods developed by the Center to control atoms and molecules have been confirmed to be right and legitimate. Meanwhile, new research approaches have come to be recognized as being possible regarding functions of atoms, molecules and clusters. Under these circumstances, a new system that can provide new hints to each research group by giving universal and abstract descriptions based on past achievements has become necessary. Based on this idea, in March 2011, the Center established a new unit specializing in mathematics, for which the Chair of the Mathematics Institute of the Graduate School of Science, Tohoku University was recruited as a PI. The new unit is intended to promote materials science through the active use of mathematical viewpoints. PIs at the Center held discussions and agreed to set a goal in January 2011 of promoting the production of Green Materials as a special target outcome of the Center's social contribution.

<Future prospects>

Our world faces great challenges that involve the energy, environmental problems for the future generation. AIMR aims to play a role in addressing them with scientific basis. Under the world's top-level organization, we will try to develop new material using a future-oriented innovative atom- and molecule-controlling method that goes beyond conventional ideas and conducting collaborative and fusion researches, more precisely,

1) We try to discover principles lying between the structures and functional manifestation common to different kinds of materials.

2) We will establish a new scientific principle in materials science and to build a basis for "predicting" a new function and a new material based on the established principle

3) We will create *Green Materials* that contribute to "Energy Harvesting," "Energy Saving" and "Environmental Clean-up"

Based on this, we will create revolutionary materials that can make enormous impacts on building a foundation for a safe and rich livelihood and eventually contribute to human society.

By strengthening partnership with overseas institutions, we will try to establish an internationally visible Center. The Center is basically operated under top-down decision-making from its director. We will endeavor to implement reform in a bid to build a globally top-level Center while exchanging views with the International Advisory Board. By working together with relevant divisions, we will aim to set up a top-level international research institute at Tohoku University that can attract eminent scholars from all around the world.

2. Center's Research Activities

2-1. Initial plan

<Research fields>

Fused areas subject to our research activity are chemistry, materials science, electronic engineering, precision and machinery engineering, and physics. The key phrase for such research is "from atoms and molecules to material."

<Research objectives>

Materials science is a particularly important field for Japan, which is declaring itself to be a country to be built and propelled by scientific advancement. It is not too much to say that Japan is ahead of other countries in the field of materials science. Especially renowned in materials science is Tohoku University, whose research level in that field has been recognized to be high, not only by itself but also by other research organizations. Therefore, the university needs to maintain the current levels of research activity in order to stay ahead of universities in Europe and the United States. Over the coming 10 years, The Center is determined to produce new materials and compounds that have innovative and useful functions by promoting fusion research covering the five fields, and to make social contribution.

2-2 Research results to date

2-2-1 Center's research activities and results

The results of the research over the three-and-a-half years since the establishment of WPI-AIMR are summarized as follows. The first section provides an overview of the research activities at WPI-AIMR including the relationship between research groups. In the next section, the specific research results are covered, as well as the fusion of different study fields and their contribution to society. Finally, the last section covers the results of the fusion researches.

1. Overall Research Activities

Researchers from a wide range of materials science fields are gathered at AIMR to conduct researches at the global cutting edge under the key phrase "From Atoms and Molecules to Materials." Matter and materials show us vastly different scales, spanning eight to ten orders of magnitude, from atoms and molecules to actual materials. Among these we have identified many layers of matter (Hierarchy) that are dominated by different laws of physics. Solving the relationship between the layers and controlling those microscopic layers to obtain target macroscopic properties of the materials comprise the ultimate demands of materials science and present a noble challenge. With the invention and development of high-resolution electron microscopes and scanning tunneling microscopes, as well as atomic force microscopes with atomic and molecular levels of resolution, attempts to observe and grasp microscopic pictures at atomic and molecular levels and application of the results to the control of physical properties are becoming a reality and have been aggressively promoted in each field. However, we have not yet obtained results that would really provide a unified solution to the development of new materials by controlling atoms and molecules. To deal with this challenge, AIMR organized a research system at the time of its establishment, which is far richer in content compared to conventional organizations as follows:

1) Inviting researchers from different fields including atoms, molecules, materials, and devices to bridge the layers from microscopic to macroscopic scales.

2) Inviting researchers of various materials such as bulk metallic glasses (BMG), ceramics,

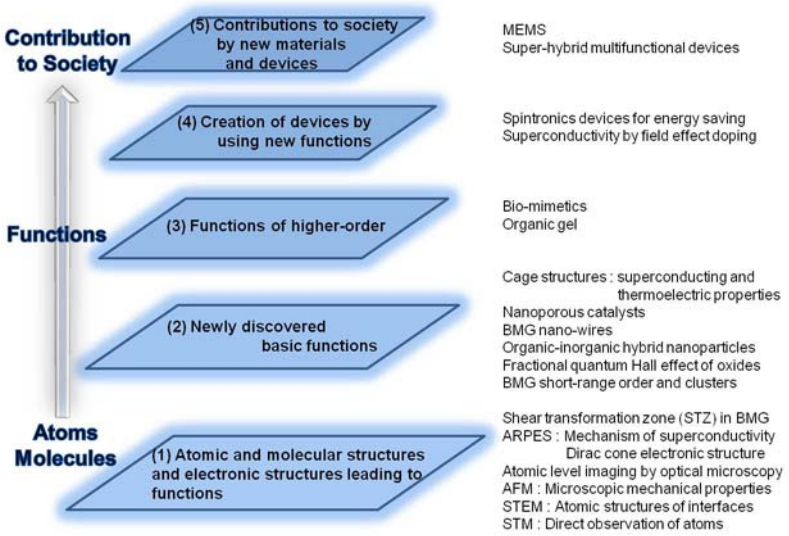

Figure 1 Hierarchy of the outcome of AIMR. The labels (1)-(5) correspond to the numbers used in the next section **2**. Each outcome is listed on the right side.

polymers, and biomaterials to promote common understanding of different materials from theory to application.
Under this system, it is possible to handle problems that cannot be solved in each field, by sharing and complementing the knowledge and technology of different fields. Based on this strategy, AIMR has pursued researches by exchanging unsolved problems among fields through Joint Seminar Series, holding Tea Time discussions, and using the Fusion Research Proposal Program. Our ultimate goal is to try to merge all fields of materials science by breaking down the barriers between the fields, materials, and laboratories. To attain this goal, we tried to manifest a sense of merger by organizing four groups: Bulk Metallic Glasses, Materials Physics, Soft Materials, and Device/System. The results of this trial will be discussed in the second section; the overall picture is illustrated in Figure 1. The in-depth understanding at the atomic and molecular levels is leading to new findings, which will enable the creation of new materials and devices. There are already signs of results that are expected to contribute to society such as the invention of Green Materials for supplying energy and protecting the environment. In addition, we are beginning to find some common viewpoints (e.g., similar mechanisms of functions) across different types of materials and fields through this hierarchical research process. As indicated in 2-3 "Future Policy and Concrete Plans," the results of the research have led us to conclude that the minimum unit of functions (Functons) is the basics of creating materials. The direction of the new materials science AIMR is planning to establish is beginning to take shape.

2. Main Research Results

Corresponding to the purpose of establishing AIMR, contributing to society by creating new materials through the understanding and control of atoms and molecules, the major results of our research will be described in the order from micro to macro: **(1) Atomic and Molecular Structures and Electronic Structures Leading to Functions**; **(2) Newly Discovered Basic Functions**; **(3) Functions of Higher-Order**; **(4) Creation of Devices by Using New Functions**; and **(5) Contributions to Society by New Materials and Devices**.

(1) Atomic and Molecular Structures and Electronic Structures Leading to Functions

One of the requirements for attaining the purpose of AIMR is to analyze the structures of matter at the atomic and molecular levels, and to fully understand the mechanism of functional manifestation of materials. AIMR has investigated atomic and molecular level structures using the most advanced scanning tunneling microscopy (STM) and scanning transmission electron microscopy (STEM) and made in-depth analysis of the electronic structure of bulk materials with angle resolved photoelectron spectroscopy. We also diligently observed the atomic positions of hydrogen, one of the important elements of the target materials, by using a neutron beam as a probe. Since it is important to evaluate the interaction among nanomaterials, biomolecules, and other materials, we have developed a method for analyzing the responses in the sliding direction between materials, which has deepened understanding of the material-to-material interactions. In addition, we have been developing a method for first principle theory calculation for in-depth understanding of the relation between atomic-level structures and functions. The major research results obtained from such efforts are described below.

Direct Observation of Atoms with STM

We used scanning tunneling microscopy (STM) to observe oxide materials such as $SrTiO_3$ and TiO_2, and wide-gap semiconductors such as β-Ga_2O_3, which are attracting attention as new electronic devices, and scanning tunneling spectroscopy (STS) to investigate the electronic structure of each atom. We are developing a method for creating flat surfaces and thin films at the atomic level, and direct investigating the behavior of doped impurities.

K. Iwaya, T. Ohsawa, R. Shimizu, T. Hashizume and T. Hitosugi, Atomically resolved surface structure of $SrTiO_3$(001) thin films grown in step-flow mode by pulsed laser deposition. *Applied Physics Express* 3, 075701 (2010).
K. Iwaya, R. Shimizu, H. Aida, T. Hashizume and T. Hitosugi, Atomically resolved silicon donor states of β-Ga_2O_3. *Applied Physics Letters* **98**, 142116 (2011).

Direct Observation of Surface or Interface Atomic Arrangement with STEM

We have succeeded in accurately determining surface or interface atomic arrangements by improving the measurement technique with scanning transmission electron microscopy (STEM) and comparing the measurements with the results of the first principle theory calculation. More specifically, we have realized the determination of the surface structure of titanium oxide that is used to promote by acting as a catalyst, the visualization of yttrium atoms that are doped into the aluminum oxide crystal grain boundary, the determination of the atomic arrangement on the interface between SiC and Ti_3SiC_2 including that of the carbon atoms, the direct observation of the lattice

distortion of the oxide thin film that has a layered structure of lanthanum, strontium, titanium, etc., and the elucidation of electronic properties based on observation. These research results provide an important clue that throws light on the relationship between structures and functions.

N. Shibata, A. Goto, S.-Y. Choi, T. Mizoguchi, S. D. Findlay, T. Yamamoto and Y. Ikuhara, Direct imaging of reconstructed atoms on TiO_2 (110) surfaces. *Science* **322**, 570–573 (2009).

N. Shibata, S.D. Findlay, S. Azuma, T. Mizoguchi, T. Yamamoto and Y. Ikuhara, Atomic-scale imaging of individual dopant atoms in a buried interface. *Nature Materials* **8**, 654–658 (2009).

Z. Wang, M. Saito, S. Tsukimoto and Y. Ikuhara, Interface atomic-scale structure and its impact on quantum electron transport. *Advanced Materials* **21**, 4966–4969 (2009).

Z. Wang, M. Okude, M. Saito, S. Tsukimoto, A. Ohtomo, M. Tsukada, M. Kawasaki and Y. Ikuhara, Dimensionality-driven insulator–metal transition in A-site excess non-stoichiometric perovskites. *Nature Communications* **1**, 106 (2010).

Measurement of the Mechanical Characteristics of a Micro Area with AFM

We have conducted detailed measurements on the phase separation of block copolymers using atomic force microscopy (AFM). Conventionally, this type of research mainly uses transmission electron microscopy (TEM), which provides only structural images and also have a significant drawback in that the electron beam damages the specimen. Early attempts with AFM also had a serious problem in that the microprobe deformed the polymer. However, with technological development for compensating the distortion of the cantilever and displacement of the sample scanner, it is now possible to obtain mechanical characteristics including adhesiveness and stiffness (Young's modulus) in a micro area, as well as structural data. It has become clear that the development of measurement technology with AFM can be applied to the measurement of micro-viscosity distribution of bulk metallic glass (BMG) as described in the fusion research.

D. Wang, S. Fujinami, K. Nakajima and T. Nishi, True surface topography and nanomechanical measurements on block copolymers with atomic force microscopy. *Macromolecules* **43**, 3169–3172 (2010).

Y.H. Liu, D. Wang, K. Nakajima, W. Zhang, A. Hirata, T. Nishi, A. Inoue and M.W. Chen, Characterization of nanoscale mechanical heterogeneity in a metallic glass by dynamic force microscopy. *Physical Review Letters* **106**, 125504 (2011).

Wide-Area Atomic Level Dynamic Imaging with Optical Microscopy

Monatomic steps with a height of 0.25 nm on Au (111) surfaces during electrochemical dissolution can be seen for the first time by a laser confocal microscope combined with a differential interference contrast microscope (LCM-DIM) in wide-area. Successively recorded LCM-DIM images with atomic step resolution indicate that many reactions at solid/liquid interfaces can be revealed with a real time.

R. Wen, A. Lahiri, M. Azhagurajan, S.-I. Kobayashi and K. Itaya, A new *in situ* optical microscope with single atomic layer resolution for observation of electrochemical dissolution of Au (111). *Journal of the American Chemical Society* **132**, 13657–13659 (2010).

Electronic Structure Analysis Using ARPES: Elucidation of the Superconducting Mechanism

We study the electronic structure and its relation to the novel properties in a variety of highly functional materials by using the world-best resolution angle-resolved photoemission (ARPES) spectrometer constructed at Tohoku University. Focusing on the high superconducting transition-temperature of graphite intercalation compound C_6Ca, we found that the energy gap specific to the superconductivity opens in the interlayer band located between the carbon atomic layers. This suggests the importance of the stacking of graphite sheets for the manifestation of superconductivity. Our research group has also studied iron-based high-temperature superconductors found in 2008. We discovered that iron-based superconductors have a characteristic electronic structure called Dirac cone, where a pair of conical bands touch at the top around the Fermi level, in a quite similar manner to graphene. This discovery provides a significant clue for elucidating the superconducting mechanism. The Dirac-core band dispersion has also been observed by our group in topological insulators, suggesting that the Dirac core is universal and ubiquitous for graphene, iron-based superconductors, and topological insulators. These results were introduced in *Physics Today* (April 25, 2011) under the title, “Fashionable physics.”

K. Sugawara, T. Sato and T. Takahashi, Fermi-surface-dependent superconducting gap in C_6Ca. *Nature Physics* **5**, 40–43 (2009).

P. Richard, K. Nakayama, T. Sato, M. Neupane, Y.-M. Xu, J.H. Bowen, G.F. Chen, J.L. Luo, N.L. Wang, X. Dai, Z. Fang, H. Ding and T. Takahashi, Observation of Dirac cone electronic dispersion in $BaFe_2As_2$. *Physical Review Letters* **104**, 137001 (2010).

T. Sato, K. Segawa, H. Guo, K. Sugawara, S. Souma, T. Takahashi and Y. Ando, Direct evidence for the Dirac-cone topological surface states in the ternary chalcogenide $TlBiSe_2$. *Physical Review Letters* **105**, 136802 (2010).

Experimental Elucidation of an STZ in BMG

Since bulk metallic glasses (BMG) consist of a uniform amorphous phase, it has no grain boundaries or crystal defects, resulting in strength far greater than that of normal crystalline metals. However, it has brittleness because there is no dislocation movement. We have conducted an experimental characteristic evaluation of the shear transformation zone (STZ) to elucidate the mechanism of plastic deformation. The STZ is a nano-scale volume zone that plastically flows when stress is applied. It is thought that the concentration of stresses to a local STZ creates a shear zone, which leads to mechanical destruction and low ductility. We have developed a new method called "rate-jump nanoindentation" to measure the response of BMG against a micro-size diamond penetrator with nano-scale force and deformation resolutions. Using this method, we have succeeded in determining the activation volume that participates in the plastic flow of the atomic clusters in an STZ, as well as demonstrating the correlation between the STZ and ductility.

D. Pan, A. Inoue, T. Sakurai and M.W. Chen, Experimental characterization of shear transformation zones for plastic flow of bulk metallic glasses. *Proceedings of the National Academy of Sciences* **105**, 14769–14772 (2008).

(2) Newly Discovered Basic Functions

With the development of atomic and molecular level analyses and expansion of the targets of analysis to include upper (macro-side) layers, the minimum functional units such as BMG clusters, organic and inorganic hybrid nanoparticles, and cage-type structures that are directly responsible for the function of real materials have been found. The minimum units that provide such functions will be explained and called a "functon" in the section 2-3 Future Policy and Concrete Plans.

Discovery of a Short-Range Order and Cluster in BMG

It had been thought for a long time that the structure of BMG had no long range order and that its atomic arrangement was basically random. We have found that adding a small amount of silver to copper-zirconium BMG dramatically increases glass-forming performance. To determine the major causes, we investigated the in-depth atomic arrangement of silver-bearing copper-zirconium BMG using extended x-ray absorption fine structure (EXAFS) spectroscopy of SPring-8. The investigation revealed that there were two types of structures: a shell-like cluster that was rich in zirconium to which silver was connected, and a cluster that was rich in copper as a whole. It also suggested that atomic-scale ununiformity was effective for improving glass-formation performance. We also observed the Zr-Ni-based BMG using a scanning transmission electron microscope (STEM) and we succeeded in obtaining an electron diffraction patterns from atomic clusters with narrow electron beams. This indicates that the structure of BMG is not completely random but consists of atomic clusters in short-range order.

T. Fujita, K. Konno, W. Zhang, V. Kumar, M. Matsuura, A. Inoue, T. Sakurai and M.W. Chen, Atomic-scale heterogeneity of a multicomponent bulk metallic glass with excellent glass forming ability. *Physical Review Letters* **103**, 075502 (2009).

A. Hirata, P. Guan, T. Fujita, Y. Hirotsu, A. Inoue, A. R. Yavari, T. Sakurai and M.W. Chen, Direct observation of local atomic order in a metallic glass. *Nature Materials* **10**, 28-33 (2011).

Fractional Quantum Hall Effect in an Oxide Material

We have confirmed a fractional quantum Hall effect in an oxide material for the first time in the world by depositing magnesium oxide zinc thin film on zinc oxide by atomic-level precision control. An extremely thin and smooth interface is required to realize a quantum transport phenomenon in which two-dimensional electrons move freely according to quantum mechanics. However, it has been thought to be difficult to actualize quantum transport phenomena in oxide-based materials that tend to contain impurities and defects. We have a long experience of atomic-level control of oxides. This research has succeeded in suppressing electron scattering by putting this technology to full use to create a high-quality oxide interface (with electron mobility six times higher than conventional mobility) comparable to some leading-edge semiconductors, and in observing the fractional quantum Hall effect. This result suggests the possibility of the future application of oxide materials such as zinc oxide to quantum calculation.

A. Tsukazaki, S. Akasaka, K. Nakahara, Y. Ohno, H. Ohno, D. Maryenko, A. Ohtomo and M. Kawasaki, Observation of the fractional quantum Hall effect in an oxide. *Nature Materials* **9**, 889–893 (2010).

Organic/Inorganic Hybrid Nanoparticles

Three-way catalysts such as CeO_2 are widely used for cleaning automobile emission. It has been known that controlling the exposed surfaces, as well as the crystalline structure and size is important for improving the catalytic activity. However, it has been considered difficult to expose active or unstable surfaces in nanosizes. The authors proposed to use supercritical water to solve the problem, since at the supercritical temperatures and pressures, the organic molecules mix homogenously with the aqueous metal solution and attach to the most reactive cubic faces of small CeO_2 crystals, hindering growth in that direction. The nanoparticles obtained by newly proposed supercritical hydrothermal synthesis method have (100) surfaces, making them the most active. We evaluated their Oxide Storage Capacity (OSC) (a catalyst activity index) and found that they have OSC at low temperatures, which is not shown in normal catalysts. This result suggests the relationship between the function and the shape and exposed surfaces, as well as sizes. Future expectations include the development of Green Materials and environmental clean-up catalysts.

J. Zhang, H. Kumagai, K. Yamamura, S. Ohara, S. Takami, A. Morikawa, H. Shinjoh, K. Kaneko, T. Adschiri and A. Suda, Extra-low-temperature oxygen storage capacity of CeO_2 nanocrystals with cubic facets. *Nano Letters* **11**, 361–364 (2011).

Metallic Glass Nanowires

In the nanotechnology field, many excellent research results have been reported on the one-dimensional structure of carbon nanotubes, semiconductor nanowires, etc. These are all made up of crystalline materials. However, nanosized crystalline materials generally have numerous defective points such as dislocations, point vacancies, twins, and grain boundaries. They form the starting points of destruction under mechanical stress concentration as well as active spots in chemical reaction environments. Our AIMR research group has succeeded in creating nanowires that use the superplastic deformation characteristic of metallic glass at high temperatures. Since these nanowires have no defective sites commonly found in crystalline materials, their length can be extended. In addition, in the fusion research with the micro electro mechanical system (MEMS) laboratory, the resonance measurement of metallic glass nanowires has revealed the modulus of elasticity at nano-levels, which suggests application to nano-resonators.

K.S. Nakayama, Y. Yokoyama, T. Ono, M.W. Chen, K. Akiyama, T. Sakurai and A. Inoue, Controlled formation and mechanical characterization of metallic glassy nanowires. *Advanced Materials* **22**, 872–875 (2010).

Nanoporous Catalysts

It is becoming clear that nanoporous metals created by electrochemical treatment (dealloying treatment) function as highly efficient catalysts. This research used nanoporous gold that was obtained by selectively dissolving the silver part of a gold-silver alloy, and revealed that the oxidation reaction of organic silane compounds was promoted at room temperature, and the catalyst can be reused multiple times without degradation of catalytic property. Conventional attempts have created gold nanoparticles supported on a substrate. However, particle has a short life owing to agglomeration and the recovering process was cumbersome. Our nanoporous metallic catalyst has great expectations for future applications.

N. Asao, Y. Ishikawa, N. Hatakeyama, Menggenbateer, Y. Yamamoto, M.W. Chen, W. Zhang and A. Inoue, Nanostructured materials as catalysts: Nanoporous-gold-catalyzed oxidation of organosilanes with water. *Angewandte Chemie International Edition* **49**, 10093–10095 (2010).

Phonon Engineering Using a Cage-Type Structure: High-Temperature Superconductivity and Thermoelectric Conversion Materials

New phonon engineering based on atomic vibration in a cage-type structure has suggested a method providing for high T_c superconductivity. Such phonons are also important for designing high-performance thermoelectric materials. Superconducting materials have the prospect of saving energy and thermoelectric materials are attracting attention as effective means for creating energy in the future. This research used a unique substance that includes barium as guest atoms in a cage-type structure that consists of a silicon or germanium network, and investigated in detail the relationship between the free motion of barium atoms inside the cage (so called anharmonic rattling phonons) and physical properties. In more specific, we compared two types of clathrates, $Ba_{24}Si_{100}$ and $Ba_{24}Ge_{100}$, and found that substances with large cages and hence strong electron-lattice interactions have unexpectedly inferior superconductivity characteristics. This suggests the possibility of creating new superconductors by devising the design of the cage-type structure. Expectations for new thermoelectric conversion using electron-lattice interactions are also discussed.

J. Tang, J. Xu, S. Heguri, H. Fukuoka, S. Yamanaka, K. Akai and K. Tanigaki, Electron–phonon interactions of Si_{100} and Ge_{100} superconductors with Ba atoms inside.

Physical Review Letters **105**, 176402 (2010).

(3) Functions of Higher-Order

Piling up the hierarchical structure from a functional viewpoint leads to new functional materials that can be implemented as devices. Examples are as follows.

Bio-mimetics

We have succeeded in creating a new biomimetic surface by self-organization that consists of a metal–polymer hybrid structure that can both repel and absorb water droplets. We applied a chloroform solution with polystyrene as the main ingredient on a glass substrate, allowed water condensation on the surface in a high-humidity atmosphere, formed a honeycomb membrane with regularly arranged microvoids by vaporizing the chloroform and water droplets, and deposited nickel inside sections of empty voids on the honeycomb membrane by nonelectrolytic plating. Finally, we peeled off the top layer of the plated honeycomb membrane, which formed a hybrid structure in which micrometer-sized metal domes are distributed on the surface where polymer needles are arranged. Hydrophilic and hydrophobic domains coexist in this structure. The water droplets placed on its surface are repelled and also absorbed. By adjusting the metal dome density from 0% to 25%, it is possible to change the surface state from strongly water repellant to weakly water repellant, similar to rose petals that absorb water droplets. In future, it is expected to realize a surface whose wettability changes according to external stimulations, similar to living bodies.

D. Ishii, H. Yabu, & M. Shimomura, Novel biomimetic surface based on a self-organized metal–polymer hybrid structure. *Chemistry of Materials* **21**, 1799–1801 (2009).

Organic Gel

The helical structure of biomolecules such as DNA has been constantly attracting interest in the creation of new materials. This research has succeeded in developing thermally reversible gel by using pseudoenantiomers of helicene, which is a helical molecule. The research has mixed two types of helicene enantiomers slightly different in size, and created thermally reversible gel that liquefies at 110°C and gelates again when cooled to 25°C. It is possible to control the physical properties and create diversity in gel by adjusting the molecular size.

R. Amemiya, M. Mizutani and M. Yamaguchi, Two-component gel formation by pseudoenantiomeric ethynylhelicene oligomers. *Angewandte Chemie International Edition* **49,** 1995–1999 (2010).

(4) Creation of Devices by Using New Functions

Piling up functional units to fabricate new devices and new device structures leads to the creation of breakthrough functions. The discovery of the manifestation of superconductivity by charge doping (physical doping) with an electric double layer generated by a field effect was an epoch-making event that renovated the superconductivity methodology that had been mainly based on chemical doping. The tunnel magnetoresistance devices, of which AIMR has explored the frontiers in the world, are important for realizing the next-generation memory devices, and future developments are expected.

Manifestation of Superconductivity by Field-Effect Doping

Strontium titanate ($SrTiO_3$) is an insulator that does not normally conduct current. However, superconductivity was realized by injecting a large amount of electrons onto the surface of $SrTiO_3$ by "field-effect doping" that forms an electric double layer on the surface of the sample by applying gate voltage to an electrolyte solution. Conventional attempts include impurity doping, which involves charge injection using a chemical methodology. This research has achieved superconducting transition by field-effect doping for the first time in the world. The realization of superconductivity in a clean method without using impurities has significantly impacted both basics and applications.

K. Ueno, S. Nakamura, H. Shimotani, A. Ohtomo, N. Kimura, T. Nojima, H. Aoki, Y. Iwasa and M. Kawasaki, Electric-field-induced superconductivity in an insulator. *Nature Materials* **7**, 855–858 (2008).

Energy-Saving Spintronics Materials

Magnetoresistive random access memory (MRAM), which draws attention as a nonvolatile memory that contributes to the energy saving of digital equipment, uses tunnel magnetoresistive (TMR) devices as storage elements. As the device size is as small as several tens of nanometers in gigabit-class MRAM, thermal spin fluctuations

significantly disturb spin directions and lead to deterioration of device performance. To stabilize a spin direction, perpendicular magnetization films possessing a high magnetic anisotropy have been used. However, such films generate great magnetic friction when spins flip at high speeds, which requires a large current for writing information (power required to flip spins), creating a dilemma. This study has focused on the highly magnetically anisotropic manganese gallium alloy, succeeding in creating a new perpendicular magnetization magnetic thin film that has both high spin polarization and strong perpendicular magnetic anisotropy. Simultaneously, this new material had low magnetic friction characteristics that have been discovered from a real-time observation of spin precession of up to approximately 280 GHz. These results indicate the possibility of a rare earth- and noble metal-free manganese-gallium alloy becoming a Green Material for producing gigabit-class MRAM.

F. Wu, S. Mizukami, D. Watanabe, H. Naganuma, M. Oogane, Y. Ando and T. Miyazaki, Epitaxial $Mn_{2.5}Ga$ thin films with giant perpendicular magnetic anisotropy for spintronic devices. *Applied Physics Letters* **94**, 122503 (2009).

S. Mizukami, F. Wu, A. Sakuma, J. Walowski, D. Watanabe, T. Kubota, X. Zhang, H. Naganuma, M. Oogane, Y. Ando and T. Miyazaki, Long-lived ultrafast spin precession observed in manganese alloys films with a large perpendicular magnetic anisotropy. *Physical Review Letters* **106**, 117201 (2011).

(5) Contributions to Society by New Materials and Devices

The elucidation of the principle of functional manifestation, and the discovery and invention of new functions are beginning to yield results that will lead to the major goal of social contribution, or the creation of Green Materials.

Super-Hybrid Multifunctional Devices

In the creation of Green Materials, both the contribution of the materials themselves to the realization of a Green Society and the environmental feasibility of material production are important. AIMR has been working toward the development of new materials using supercritical "water" as a reaction solvent, and carving out the possibility of creating multi-functional hybrid materials that do not use hazardous chemical substances, and greatly contribute to reducing CO_2 emissions. To manifest the functions of several materials at the same time, it is necessary to control the interactions among the different materials. We have developed various inorganic nanocrystal-polymer hybrid materials by using organic modifications to manifest high affinity with polymers. The flexible plastic film that contains 90% or more boron nitride fine particles developed has high thermal conductivity but is also superior in insulation and adhesion, characteristics which are normally not compatible. Such new hybrid materials combining several characteristics that are normally incompatible are called "super hybrid materials." We are promoting university-industry collaboration with the aim of contributing to society through the creation of Green Materials, as well as technology transfer and human resource development. Our accomplishments won the Minister of MEXT Award at 8th Industry-Academia-Government Collaboration Honor Program on June 5, 2010. They are also introduced in *Physics Today* (February 16, 2011) under "Molecules to materials."

Micro Electro Mechanical System (MEMS)

The Esashi Group conducting the research and development of MEMS is very large in scale. The groups of MEMS's developed have been applied to many products and their social contribution is significant. The results of AIMR have been brought about by Assistant Professor Y. C. Lin and T. Gessner PI. They have been developing mainly packaging technology. Recently, they succeeded in developing wafer-level packaging technology using nanoporous metals. They have also made achievements in MEMS development with particular emphasis on optical scanners based on bulk metallic glass (BMG) thin films. In addition to the successful molding production using the high formability of metallic glass, they have realized an optical scanner that can be used for very small (approximately 1 mm) endoscopes by creating a metallic glass thin film by sputtering. This technology makes use of the superior mechanical characteristics of metallic glass such as its strength. They are also cooperating with a company to develop new endoscopes that introduce driving technology based on piezoelectric thin films. They can obtain tomographical images of subcutaneous tissues such as the stomach and gullet using a near infrared ray, which are expected to be applied to early detection of cancer. In addition to reducing medical costs and promoting health, these diagnosis tools will also play important roles in maintaining industrial infrastructures. They enable the long and safe operation of systems, which leads to saving natural resources and energy. As these examples indicate, MEMS technology takes the central role in contributing to the realization of a green sustainable society by introducing new functional Green Materials into devices created by field fusion at AIMR.

3. Fusion Researches and Generation of Common Understanding through Fusion

Under the objective of the "discovery of new scientific principles by the assembly and fusion of the world's top-level researchers, and the creation of new functional

materials based on those principles," AIMR is conducting researches through the fusion of different fields, and has frequently provided opportunities for researchers of different materials and devices to exchange information and have discussions for elucidating phenomena. These activities have revealed common viewpoints for creating new materials and fields of science. Whether the materials are metals, polymers, or ceramics, similar structures and mechanisms (e.g., STZ of BMG and CRR of glass polymers as shown in the following sample fusion research) have been found, which suggests the existence of some common principles. For the structural formation process, which manifests such functions, similarities have been found among different systems such as BMG, polymer processing, and nanoparticle synthesis (e.g., the relation between quenching rate and phases, and the existence of a metastable phases). Taking a bird's eye view of the various functional manifestation mechanisms in different materials, one can find the minimum unit structure of functional manifestation (this will be called a "Functon" in 2-3. Future Policy and Concrete Plans) in various types, sizes, and structures of materials. In some cases, the combination of these structures creates a system that manifests device functions. We have also gained common understanding on the possibilities of describing the basic principles of new functional manifestation with the interactions among the functions.

Four typical examples of fusion researches are described in the following.

BMG + Soft Materials (Polymers) → Discovery of Common Physical Facts

One example of fusion research that is expected to lead to the creation of new materials worth mentioning is the results of the BMG Group and the Soft Materials (Polymer) Group. It has been becoming clear that in BMG, shear transformation zones (STZs) of several nanometers that generate during plastic deformation have great effects on mechanical characteristics. The latest research by the BMG Group has revealed the existence of cluster structures of several angstroms in BMG (Nature Materials **10**, 28-33, 2011). Based on the existence of short- range order and lack of long-range order, it is assumed that BMG has structural fluctuations and many defective regions, which lead to heterogeneity in a similar scale as STZs. The Polymer Laboratory of AIMR has succeeded in mapping the energy dissipation derived from the viscosity in micro-areas using AFM (Macromolecules **43**, 9049-9055, 2010) and this method was applied to investigate the heterogeneity in BMG. The analysis revealed that the nonuniform structure of the viscosity measured in BMG had a distinctive scale of 2.5 nm, which matched that of STZs. Therefore, the inhomogeneous distribution of viscosity and STZs are deeply related, which suggests that they dominate the macroscopic characteristics of metallic glasses.

One interesting thing is that the measurement and analysis methods developed for polymers could be applied as they were to BMG. This suggests the existence of common principles between BMG and polymers. More specifically, there is a possibility that what is called a "cooperatively rearranging region (CRR)" in polymers is essentially the same as or very similar to a STZ of BMG, despite having different names. There are great expectations that solving this issue will lead to the discovery of common principles and new physical facts that bridges different material systems.

Y.H. Liu, D. Wang, K. Nakajima, W. Zhang, A. Hirata, T. Nishi, A. Inoue and M.W. Chen, Characterization of nanoscale mechanical heterogeneity in a metallic glass by dynamic force microscopy. *Physical Review Letters* **106**, 125504 (2011).

Metallic Materials Science + Catalyst Chemistry → Creation of Nanoporous Catalysts by Dealloying Treatment

In recent years, nanoporous metals, which are formed by dealloying treatment, have been attracting attention. Their creation has been tried in various alloy systems including BMG. At AIMR, it is becoming clear that a deallyoing-treated nanoporous metal functions as a high-efficiency catalyst through fusion research with the Soft Materials Group. For example, nanoporous gold that is obtained by selectively dissolving the silver part of a gold-silver alloy promotes the oxidation reaction of organic silane compounds at room temperature, and the catalyst can be reused multiple times without degradation of its catalytic property. Therefore, AIMR, where metallic material researchers and organic synthesis and catalyst chemists work side by side, has succeeded in reviewing the functional manifestation of materials from various viewpoints, and leading to their development.

T. Fujita, L.H. Qian, K. Inoke, J. Erlebacher and M.W. Chen, Three-dimensional morphology of nanoporous gold. *Applied Physics Letters* **92**, 251902 (2008).

N. Asao, Y. Ishikawa, N. Hatakeyama, Menggenbateer, Y. Yamamoto, M.W. Chen, W. Zhang and A. Inoue, Nanostructured materials as catalysts: Nanoporous-gold-catalyzed oxidation of organosilanes with water. *Angewandte Chemie International Edition* **49**, 10093–10095 (2010). (This paper has been listed in Section 2.)

BMG + Device/Systems (MEMS) → Development of Metallic Glass Nanoresonators

As opposed to crystalline nanomaterials in which defective sites are essential, metallic glasses have no dislocations or grain boundaries. When it is heated above the glass transition temperature, the viscosity suddenly drops, enabling super plastic deformation, i.e., "glassworking," which enables the creation of long nanowires. The

fusion research with the MEMS Laboratory of the Device/System Group has succeeded in the derivation of a Young's modulus with the resonant measurement of the metallic glass nanowires. There are expectations in the evaluation of the mechanical characteristics in nano-scales and the application to nanoresonators. This is an example of fusion that ideally connects the process of creating materials under atomic and molecular-level control to the implementation of devices.

K.S. Nakayama, Y. Yokoyama, T. Ono, M.W. Chen, K. Akiyama, T. Sakurai and A. Inoue, Controlled formation and mechanical characterization of metallic glassy nanowires. *Advanced Materials* **22**, 872–875 (2010). (This paper has been listed in Section 2.)

Thermal Synthesis of Supercritical Water + Polymer Chemistry → Creation of Super Hybrid Materials

AIMR is developing technology for creating new materials by reacting substances that do not normally mix, in a supercritical hydrothermal reaction field. We are carving out a method for creating organic-inorganic multi-functional hybrid materials. It has been impossible to bond arbitrary organic molecules with inorganic nanocrystals. We could also fix organic-modified inorganic nanocrystal particles (cerium oxide) synthesized on a device substrate using a ligand exchange reaction. Fixing inorganic particles on a substrate is essential technology for creating devices by printing. The fusion of various fields has been promoting the creation of new super hybrid materials as well as the development of new application fields using those materials.

D. Hojo, T. Togashi, D. Iwasa, T. Arita, K. Minami, S. Takami and T. Adschiri, Fabrication of two-dimensional structures of metal oxide nanocrystals using Si substrate modified with 3,4-dihydroxyhydrocinnamic acid. *Chemistry of Materials* **22**, 1862–1869 (2010).

2-2-2 Research Achievements

A. Refereed papers (published or accepted for publication)

Total: 810

FY 2007-2008	306	FY 2009	233	FY 2010	271

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

Total: 501

FY 2007-2008	175	FY 2009	189	FY 2010	137

C. General lectures at international conferences

Total: 285 oral 243 poster

FY 2007-2008	oral	poster	FY 2009	oral	poster	FY 2010	oral	poster
	100	59		84	90		101	94

D. Invited lectures at domestic scientific societies and research meetings

Total: 738

FY 2007-2008	339	FY 2009	215	FY 2010	184

E. General lectures at domestic scientific societies and research meetings

Total: 475 oral 342 poster

FY 2007-2008	oral	poster	FY 2009	oral	poster	FY 2010	oral	poster
	168	113		173	109		134	120

F. Books (e.g., scientific, specialized volumes)
Total volumes: 185

FY 2007-2008	89	FY 2009	45	FY 2010	51

G. Industrial property rights
Total: 87 registered 125 being processed

FY 2007-2008	registered	processed	FY 2009	registered	processed	FY 2010	registered	processed
	45	69		24	33		18	23

H. Major awards received (including those formally announced)
Total: 69

FY 2007-2008	20	FY 2009	16	FY 2010	33

2-3 Future Policy and Concrete Plans

<Research fields>

More effort will be placed on integrating the existing four research groups: bulk metallic glasses (BMG), materials physics, soft materials, and device/system construction; and a mathematical viewpoint will be added to explore new scientific principles and new way to create functional Green Materials based on the principles. (See Figure 2)

AIMR has taken an "interdisciplinary fusion" approach to fulfill its objective: "to create new functional materials based on new scientific principles that have been developed through concerted efforts of the most outstanding researchers in different disciplines from around the world and thereby to contribute to creating fulfilling lives for people in the future." Its efforts have been focused on promoting cutting-edge research that has gained high international recognition, and on providing researchers specializing in different types of materials and devices with frequent opportunities for information exchange and discussions (seminars) crossing over the research areas. As a result, as described in "2-2-1 Center's research activities and results, 3. Fusion Researches and Generation of Common Understanding through Fusion," we have successfully identified a common perspective that should be developed in order to establish a new materials science transcending existing concepts. AIMR's primary efforts in the immediate future need to be focused on encouraging researchers in the four research groups to promote more intensely than ever the elucidation of deeper principles that cover a wide range of materials science; on further developing results from their interdisciplinary fusion research so as to identify common principles behind various materials-related phenomena and thereby to build a basis to create new scientific principles; and on seeking a way to return the achievements to society.

Our world faces great challenges that involve the energy, environmental problems for the future generation. In order to address them with scientific basis the importance of the integration of a wide range of disciplines has also been indicated internationally. At least in the field of materials science, however, no attempt has been made either in or outside of Japan to "create a new academic discipline" that provides a universal explanation transcending the difference in kinds of materials and layers by integrating chemistry, materials science, electronics, precision mechanical engineering, physics and mathematics. In the following section, the background behind this new research policy will be reviewed and a more specific direction and plan will be described.

— Common Recognition Achieved Through Fusion —

Materials science is a discipline to elucidate the properties of matter according to functions. It has been observed that there is a similarity in the structure and the pattern of the manifestation of functions even among different materials, such as metals, polymers and ceramics (e.g. BMG clusters and polymer). It has become common

understanding that incorporation of information obtained from the development of a material into development of another material can significantly promote the development of a new material. AIMR's research on the process of forming a microstructure in a material that is necessary to obtain the function of the material in the final form has gained high international recognition. Through its research, a similarity in the process of forming a structure in BMG processing, polymer processing and nanoparticle synthesis (e.g. a relationship between quenching and phase change rate and presence of metastable phases) has been identified and researchers have discussed the underlying common principles. An overview of the mechanisms of the manifestation of various functions in different materials allows us to understand that there are many kinds of minimum unit structures that deliver a function of a material according to type, size and structure. In this report we name the minimum unit of function a "Functon." A Functon that delivers a function may sometimes be an atom or a molecule. A cluster structure may also serve as a Functon. There are some cases where the higher-order network structure of the cluster generates a function. In other cases, a device function is obtained by a system built by combining these structures. Through interdisciplinary discussion at AIMR, a common recognition of the possibility of describing basic principles in terms of abstract notion of Functons regardless of the kinds of materials and layers of hierarchical structures has brewed. Basic principles here may include the principle behind the emergence of a new function through interactions of functions in different layers.

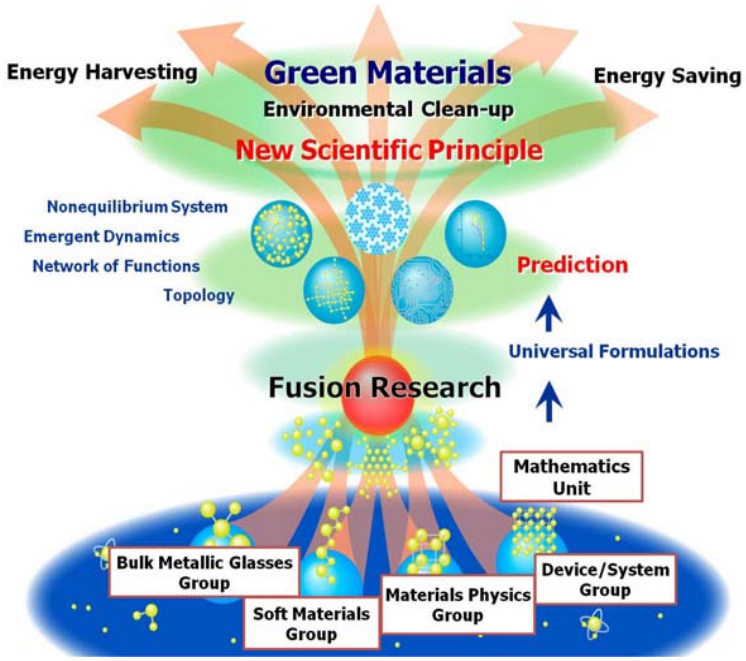

Figure 2 Schematic diagram showing the future policy of AIMR. Overlooking from the mathematics view point enables us to extract universal principles common to any materials. By using the derived universal formulae, new functions can be predicted and the green materials for energy harvesting, energy saving and environmental clean-up can be created.

— Recognition of Issues and a New Scope —

Towards its common goal of creating Green Materials, AIMR has made a number of successful achievements in cutting-edge research by weaving "warp" in various colors (research on the hierarchy of each kind of material). As a result, the common recognition described above that is necessary to create a material beyond existing concepts has brewed.

This kind of viewpoint has been reached only because AIMR has promoted research to identify hidden hierarchical structures of different materials concurrently and, at the same time, provided its researchers with opportunities for conducting "fusion research" and interdisciplinary discussions. In order to further develop this viewpoint to discover new scientific principles of materials science, we now need to weave a weft into the warp mentioned above to connect "principles." Through research so far conducted, we have reached an understanding that the "weft" we need is a common basis or a common descriptive language that will dramatically accelerate the identification of a universal principle and elucidation of a hidden structure.

As stated above, after our discussion over the last three and a half years, we have located warp into which we should weave a weft. We now believe that a fabric woven from both warp and weft would be "innovative materials science" that could not have been achieved only with warp.

— Strengthening of the Interdisciplinary Fusion System and Specific Issues —

Researchers at AIMR have been engaged in research to elucidate the principle of a hierarchy from atoms and molecules through to materials in their specialized fields separately (warp). As we have recognized the necessity of a "mathematical viewpoint" (weft) to better understand and describe the underlying universal principles and abstract structures transcending the difference in kinds of materials and layers, it has been decided to invite mathematicians to participate in our project. In addition, the interface layer will be strengthened. (See Figure 3.)

We will be continuing our efforts to elucidate principles lying between structures and functional manifestation in different materials, which will serve as warp, and take the lead in developing methods for developing innovative materials based on the principles to be elucidated. It is our ultimate goal to create new materials that ensure a stable energy supply and environmental conservation for future generation. Each of the four research groups will focus, for example, on

elucidation of mechanisms based on comprehensive understanding of phonon/charging/spinning with a focus on the geometric superstructure of matter in high-temperature superconductivity, thermoelectric conversion material, and photoelectron dispersion and development of material without energy dissipation; innovative catalysts; physical properties/organic chemical synthesis: development of flexible electronic materials through interdisciplinary fusion research on device physics; elucidation of the mechanism of the manifestation of physical properties of metallic glass and topological invariants using a cluster model; creation of new amorphous materials through identifying a universal principle covering all nonequilibrium materials; prediction/designing of physical properties/layer behaviors and dynamic structure formation based on understanding of the hierarchy of block copolymers and nanoparticle dispersions; synthetic high-performance thermal conduction conversion devices using hybrid materials that concurrently demonstrate functions that are traded-off against each other; next-generation SiC devices using functions that will be identified through research at AIMR; next-generation automobiles, etc.; micro electromechanical systems (MEMS); creation of green materials/devices through the development of tunnel junction technology that realizes high-speed spintronics; new-generation biomimetics based on the elucidation of structure (form)-function correlations and systematization of self-assembling processes.

In concurrence with these research activities, interdisciplinary fusion will be activated with mathematics as a catalyst so as to elucidate common principles, which will serve as a weft.

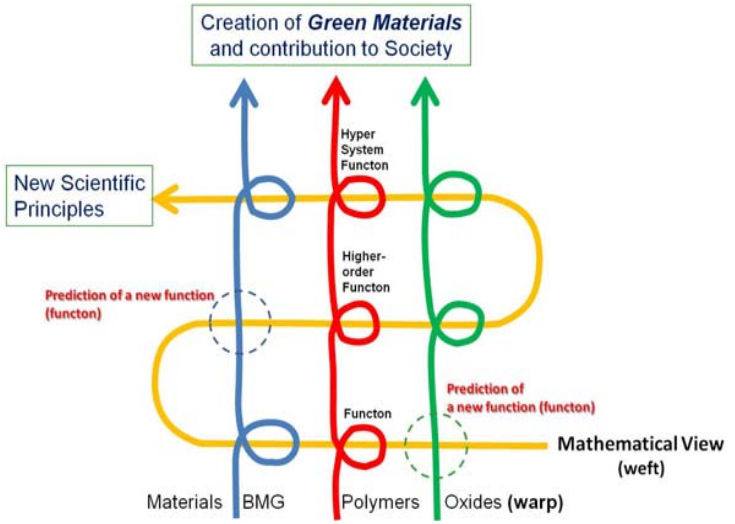

Figure 3 Schematic diagram explaining a textile (new materials science) made from warp (materials) and weft (mathematics). From bottom (micro) to top (macro), many material properties and functions (Functons) have been discovered so far in each material system. However, many unknown Functons are sure to still remain. By overlooking from the mathematical view point and universal formulation, unknown Functons can be predicted. The role of mathematics is to combine different materials as "weft" and develop the new scientific principles which lead to the creation of the green materials.

— Understanding of Hierarchical Structures and Challenging Structure Formation —

What is difficult with materials science is the fact that different sizes and different physical laws are present in a mixed manner. Material is regarded as a complex system and the mechanism of the manifestation of its function is organized as a hierarchy of functions. Functions consisting of atoms/molecules are regarded as a network and a new function is generated by a higher-order network consisting of homogeneous or heterogeneous mixture of functions. With this new perception, material is abstracted. Through this process, a common principle behind all kinds of materials can be described universally or advanced mathematical concepts/theories can be applied. It is expected that, among different materials or materials from different layers, a principle that has been identified for a material can be applied to another material so as to overcome a problem and significantly accelerate the development of a new material. This approach can also been used to identify the principle behind the manifestation of functions and the structures of materials that have otherwise been difficult to be identified.

In addition, deep understanding of the hierarchy mechanism of function manifestation can significantly improve the control to be performed, allowing the process of challenging structure formation, including multi-layered structure formation through the formation of a nonequilibrium dynamic structure. This will enable us to initiate the development of environmentally stable, and sensitive at the same time, multifunctional materials, which is a big challenge.

— Materials Science as an "Inverse Problem" that Predicts the Desired Function —

While "matter science" involves a direct problem-solving approach, which is applied to understand the connection from atoms and molecules on the micro level through to higher-level layers, "materials science" involves an inverse problem-solving approach, which is applied to find out what is necessary to obtain a desired function in an

effort to develop a new material that delivers a function that is needed by society. In materials science, it is necessary to develop a method for solving a complex inverse problem involving more than one layer. In this context, our emphasis will be placed more on enhancing mathematical/theoretical science perspectives in order to establish materials science as an inverse problem, which will serve as a basis for developing new methods for designing materials and predicting new functions and materials.

<Research objectives>

The following objectives have been added to the initial research objectives:
1) To elucidate principles lying between structures and functional manifestation common to different kinds of materials and materials in different layers and to create advanced materials with innovative functions based on the elucidated principles.
2) To establish a new scientific principle in materials science and to build a basis for "predicting" a new function and a new material based on the established principle
3) Thereby, to create Green Materials that contribute to "Energy Harvesting," "Energy Saving" and "Environmental Clean-up."
Based on this, we will create revolutionary materials that can make enormous impacts on building a foundation for a safe and rich livelihood and eventually contribute to human society.

< Major changes >

1) In our efforts to elucidate the mechanisms of functional manifestation and structure formation in research aimed at creating new materials using different kinds of materials, more emphasis will be focused on identifying principles common to different materials and correlations between structures, functions and layers. To achieve this objective, a mathematical viewpoint will be added to identify common principles behind all kinds of materials and all layers and to elucidate common mathematical principles, and eventually to establish a new path to "materials science research added with a mathematical viewpoint."

2) The direction of research on material creation, that of research on individual materials' structures, and that of research on the manifestation of functions in materials (warp) have been well coordinated toward the same goal. To further accelerate the elucidation of common principles, a mathematical viewpoint (weft) will be added to enhance the entire research system. To support these research activities, the interface layer where mathematics is integrated into the four groups engaged in creating materials will be improved.

3) In the second phase, Director Yamamoto is scheduled to be replaced by a new director.

4) The objective of the center was described as "the application of achievements in society" in the initial plan. This has been redefined as follows to make it clearer: creation of green materials for "energy harvesting," "energy saving" and "environmental clean-up" with the aim of contributing to solving environmental issues.

3. Management

<Initial plan>

1) Composition of administrative staff

Our administrative staff provide logistic support which allows researchers to conduct their studies flawlessly. We also intend to actively invite eligible experts who can handle proactive research development, and together with the researchers, aid in the expansion of research results. Consequently, this formation can significantly contribute to the Center's research goal activities.

Specifically, daily routines such as in accounting, human resources and research

<Efforts to date and current state>

1) Composition of administrative staff

When the Center was established in FY2007, highly professional administrative staff in the fields of accounting, personnel affairs and support for research activities were recruited from Tohoku University to work for the Center. In addition, employees who worked at the headquarters of the university for such fields as law and regulation, personnel affairs, salary payments, finance, support for research activities and international exchange were named to concurrently work for the

support are managed by highly experienced staff who can accomplish their duties without difficulty. They will be selected mainly from intramural administrative staff. To satisfy the requirements for the Center's official language, which is English, staff who have supportive abilities in English language will be preferentially assigned, and external staff with a good command of English are also planned to be recruited. Besides the duties above, a Program Officer, Project Manager, and other senior positions will be occupied by excellent and experienced personnel from various fields including researcher evaluation, international research coordination, activating expansion of and public relations for research results, and planning and support of research workshops. We will proactively hire diverse professionals; not only experienced at the University, but also from the private sector and non-Japanese with international experience, former researchers etc., utilizing an annual salary system.	Center to reinforce administrative work at the Center. Also recruited at the time of the foundation of the Center were quasi-regular employees who have proficiency in English language in order to complement administrative work that needs to be conducted in English. As a way to help the administrative director, deputy administrative director was appointed. In FY2008, the overall administrative work division significantly expanded, being grouped into four subdivisions – general affairs, international academic/research cooperation, accounting, and property management. At the Center, the deputy administrative director was previously an employee who was dispatched from the university. But under the new system, a person taking such a post at the Center exclusively works for the Center to manage its administrative work. Quasi-regular employees proficient in English language were posted to work as administrative staff at the Center to smooth the execution of duties in English. In FY2009, posts in charge of facility operations, network operations and safety management were created at the Center to provide logistical support to those engaged in research activities there. Those in charge of safety management were posted independently of those in charge of the remaining two operations, and the safety management office was created for those in charge of safety management to ensure the health of researchers and their safety in laboratory work. Initially, the head of the administrative division was chosen from among the professors at the university. But the practice was abolished on October 1, 2009 and the post became an exclusive post for an administrative staff at the Center. Since April 1, 2010, a researcher has been appointed to act as an outreach manager in charge of planning and coordination at the Center in light of the importance of outreach activities. In March 2011, a researcher (associate professor) was appointed deputy administrative director at the Center in charge of research affairs, bringing the number of deputy heads to two. This is to allow the administrative division to grasp the research activities and meet needs of researchers. Since June 2010, an outside company has been entrusted to provide housing-related services to foreign researchers. This enables the Center to provide the service to foreign researchers, by putting more emphasis on support to research activities.
2) Decision-making system In the bid for a rapid and flexible decision making process, we will not specifically launch a decision making organization, but set up a top-down command system governed by our Center Director. Aimed at support for a Center Director's top-down decision making system, an International Advisory Board, which includes Nobel Laureate board members, is to be established directly under the Center Director position. We will also develop a	2) Decision-making system As in the case of FY2010, we continue to refrain from setting up a consensus-based decision-making organ in line with our initial plan. Instead, we continue to adopt a top-down system with the Center Director taking charge of decision making, which enables operations to work in a flexible and speedy manner. In order to disseminate the intentions of the Center Director and smoothen its business operation, the Executive Committee was established in October 2009,

proper environment utilizing Internet technology, so that the Center Director and board members can effectively exchange and share their views together on implementation of system reform and other issues for creation of a world premier international research center. Also, the university will implement a taskforce team in the Administration Bureau, led by the Office of the President, which will activate environmental improvements for Center Director top-down management to bring flexible approaches, and revisions and betterment of the university's system at the Center Director's request.	which is composed of the Center Director, the Administrative Director and four research group leaders. The move came along with the appointment of a new administrative director. PI liaison meeting, which had been held only when necessary, has continued to be convened almost every month since autumn 2010, and has had full-fledged discussion on the direction of research activities. In addition, we have decided to convene a staff meeting, consisting of assistant professors and those with higher rankings, every month since March 2011. This is designed to have the intentions of the Center Director reflected in the entire part of the Center and promote information sharing within the entire Center. An early holding of an International Advisory Board was recommended in Project Verification Report. In line with the recommendation, a Board meeting was convened on February 24, 2011, where the Center Director had heated discussion with members over the direction of the Center. Meanwhile, in October 2010 the host institution adopted a system in which the executive director in charge of research affairs and the Center Director can hold in-depth discussion, the Center can receive sufficient support from the host institution and the Center can produce ripple effects in Tohoku University. We also inaugurated an in-house council in June 2010, which consists of the heads of four departments and institutes at Tohoku University deeply related to the Center and the Center Director. The council offers advice on various issues involving the Center from the viewpoint of Tohoku University.
3) Allocation of authority between center director and host institution To secure the independence of the center administration, the host institution will limit its authority to extremely important items such as the appointment and dismissal of the Center Director, and leave all other personnel, budget execution and other items effectively under the discretion of the Center Director. For personnel matters, the host institution will only retain authority over the appointment and dismissal of the Center Director, and have all other personnel items within the center including the employment of lead researchers determined by the Center Director. The budget allotted to the center (personnel expenses and non-personnel expenses) will be turned over in its entirety for free execution at the judgment of the Center Director, and it will be possible to carry over funds allocated for budget items that are not implemented by the end of the fiscal year to the subsequent fiscal year.	3) Allocation of authority between center director and host institution As done in the previous fiscal year, operation of the Center was, as agreed on initially, based on a final decision by its director. Therefore, the Center has maintained its independence from the host institution in terms of operation and management. Meanwhile, the host institution is granted decision-making authority in very limited important matters such as election and dismissal of the director. In addition, the Center Director has the right to make a final decision on the recruitment of researchers and also has discretion in budget execution.

< Future policy and concrete plans >

1) Composition of administrative staff

We plan to inaugurate the International Relations Unit, within the administrative division, tasked to promote international exchange and to manage a range of work to support foreign researchers – from accepting them and assisting their research activities to dealing with their procedural matters – in a unified manner. Under the unit chief, the support of foreign researchers will be reinforced after the reform of administrative division in the summer of 2011.

2) Decision-making system

As a way to support the Center Director, the post of Deputy Director will be created, who is to be chosen from among researchers, early in FY2011. Meanwhile, the resignation of some International Advisory Board members will be accepted, due to their old age and tight schedule. In return, one person, who is a Nobel Prize Laureate, will be added to the Board.

3) Allocation of authority between center director and host institution

The Executive Vice President in charge of research affairs of Tohoku University will take charge of coordination with the Center to promote their collaboration.

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: month, year)
Researchers	120 <38, 32%>	83 <33, 40%> [5, 6%]	129 <70, 54 %> [10, 8%]	136 <68, 50%> [14, 10%]	146 <73, 50%> [22, 15%]
Principal investigators	30 <12, 40%>	29 <11, 38%> [0, 0%]	32 <15, 47%> [0, 0%]	33 <14, 42%> [2, 6%]	33 <14, 42%> [2, 6%]
Other researchers	90 <26, 29%>	54 < 22, 41%> [5, 9%]	97 <55, 57%> [10, 10%]	103 <54, 52%> [12, 12%]	113 <59, 52%> [20, 18%]
Research support staffs	53	13	33	42	50
Administrative staffs	40	26	29	24	24
Total	213	122	191	202	220

Other matters of special mention

"GI^3 (Global Intellectual Incubation and Integration) Laboratory" was inaugurated in FY2009 to motivate prominent researchers (including graduate students) to converge on AIMR from all over the world. The laboratory is designed to become a center of the brain circulation where researchers specializing in materials science can undertake internationally collaborative and fusion research activities. The GI^3 system has led to active exchange with researchers from countries all over the world.

Acceptance of researchers made in the past: 7 senior researchers (professors and associate professors) in FY2009 and also 7 in FY2010
: 8 young researchers (assistant professors, post-docs, graduate students) in FY2009 and 11 in FY2010

The following are examples of prominent researchers studying on a full-time basis who are part of the global brain circulation of researchers.

Name(Nationality), Position at AIMR, Duration of appointment at AIMR, from (Former affiliation) to (Affiliation after AIMR)
1) P. Sushko (Russia), Assoc. Prof., 04/23/08–12/31/08, from Researcher at UCL (UK) to Royal Society University Research Fellow, UCL (UK)
2) P. Richard (Canada), Assist. Prof., 04/09/08-07/16/11, from Post-doc at Boston College (U.S.A) to Assoc. Prof. at Institute of Physics, Chinese Academy of Sciences

(China)
3) L. Gu (China), Post-doc, 10/01/09-03/31/11, from Researcher at Max-Planck-Institut (Germany) to Professor at Institute of Physics, Chinese Academy of Sciences (China)
4) P-F. Guan (China), Post-doc, 08/02/08-03/31/11, to Post-doc fellow at Johns Hopkins University (U.S.A)
5) S. Gonzalez (Spain), Post-doc, 08/10/02-11/05/10, to Researcher at Autonomous University of Barcelona (Spain)
6) C. Jung (Korea), Post-doc, 11/26/08-08/31/09, to Researcher at Chungnam National University (Korea)
7) J. Tang (China), Assist. Prof., 04/01/09-03/31/11, Professor at Sichuan University (China)
8) K. Mckenna (UK), Assist. Prof., 04/01/09-present, will be appointed to be a lecturer at University of York in September 2011 (UK)
9) M. Ramalinghan (India), Assist. Prof., 03/24/10-10/15/10, to Assoc. Prof. at INSERM (France)
10) A. Seidi (Iran), Post-doc, 04/01/10-02/15/11, to Technical staff at Okinawa Institute of Science and Technology, DNA Sequencing Center (Japan)
11) C. Qin (China), Assist. Prof., 04/01/08-09/13/10, to Full Professor at School of Materials Science and Engineering, Hebei University of Technology (China)
12) B-M. Teo (Singapore), Post-doc, 12/01/10-present, from Research Assoc. at The University of Melbourne (Australia)
13) T. Makino (Japan), Lecturer, 01/01/08-03/31/11, to Researcher at RIKEN (Japan)
14) K. Horigane (Japan), Post-doc, 04/01/08-03/31/11, to Research Associate at University of Virginia (U.S.A)
15) K. Ueno (Japan), Assist. Prof., 04/01/08-03/31/11, to Associate Professor at the University of Tokyo (Japan)
16) K. Iwaya (Japan), Assist. Prof., 10/01/08-present, from Researcher at University College London (UK)
17) T. Osawa (Japan), Assist. Prof., 04/01/09-present, from Researcher at Pacific Northwest National Laboratory, U.S Department of Energy (U.S.A)
18) N. Aoki (Japan), Assist. Prof., 04/01/11-present, from Assist. Prof. at Kyoto University (Japan)

4-2. Satellites and partner institutions

<Initial plan>

i) Satellites

<Collaboration to date>

i) Satellites

Institution (1) **University of Cambridge**

-Role

Joint research is conducted through the promotion of two-way exchanges of researchers, with the main themes of the research on “Non-Equilibrium Materials and Soft Materials”.

-Personnel composition and structure

Alan Lindsay Greer (PI), Bill Jones (Adjunct Professor), Shantanu Madge (post-doc)

-Collaborative framework

A European satellite was launched at the University of Cambridge in FY2008 to promote joint research with the BMG group in Europe. In FY2009, the European satellite institution played a major role in holding an international conference on metallic glasses in Grenoble, France.

Agreement of academic exchange was concluded with the department of materials science and the metallurgy of the University of Cambridge. In January 2011, another agreement was concluded with the department of chemistry of the University of Cambridge. The conclusion of the agreement

with the department of physics is also foreseen in the near future. As a whole, AIMR has a wide range cooperation scheme in the field of materials science, chemistry and physics at Cambridge.

A collaborative network with another European BMG group (Alain Reza Yavari) is expanding, with its operational base located at the University of Cambridge.

As part of our joint research framework, we have accepted students who are set to take a doctoral course soon as a visiting scientist.

Laura Martin：October 11, 2010 to January 23, 2011

Weichich Lin：November 1, 2010 to March 14, 2011

Institution (2) **Institute of Chemistry, Chinese Academy of Science**

-Role

Joint research is conducted through the promotion of two-way exchanges of researchers, with the main themes of the research on “Molecular Nanotechnology and Devices”.

-Personnel composition and structure

Li-Jun Wan (PI), Rui Wen (post-doc)

-Collaborative framework

Agreement of academic exchange was concluded in April 2010 and a ”WPI-AIMR-ICCAS Joint Symposium” was held at the Institute of Chemistry, Chinese Academy of Sciences in October, 2010.

As part of our joint research framework, we have accepted Fei-Fei Cao, a Chinese student who is taking a doctoral course as a visiting scientist. She stayed with us between January 14, 2010 and April 14, 2010.

Institution (3) **University of California, Santa Barbara**

-Role

Joint research is conducted through the promotion of two-way exchanges of researchers, with the main themes of the research on “Organic Electronics and Condensed Phase Phenomena”.

-Personnel composition and structure

Fred Wudl (Adjunct Professor)

-Collaborative framework

Under the Memorandum of Understanding between Tohoku University and the University of California, Santa Barbara, Guidelines for the Exchange of Researchers between AIMR and CNSI (California NanoSystems Institute) was agreed in November 2010.

ii) Partner institutions

Institution (1) **University of Wisconsin-Madison**

-Role

Joint research in nanophysics

-Personnel composition and structure

Max G. Lagally (PI)

-Collaborative framework

Promotes joint research in nanophysics. Arranges postdoctoral researcher and assistant professors, etc.

Institution (2) **Grenoble Institute of Technology**

-Role

Joint research into bulk metallic glasses

-Personnel composition and structure

Alain Reza Yavari (PI)

-Collaborative framework

Promotes joint research into bulk metallic glasses. Arranges postdoctoral researchers and assistant professors, etc.

Institution (3) **IBM Thomas J. Watson Research Center**

-Role

Joint research in nanophysics

-Personnel composition and structure

Rudolf M. Tromp (PI)

-Collaborative framework

Promotes joint research in nanophysics. Specifically, arranges postdoctoral researchers and assistant professors, etc., whose main work centers on research

ii) Partner institutions

Institution (1) **University of Wisconsin-Madison**

-Role

Joint research on materials physics

-Personnel composition and structure

Since the establishment of the Center until December 2010, Max G Lagally has participated in the collaborative project as a PI.

-Collaborative framework

PI had been posted to promote joint research on materials physics.

Institution (2) **Grenoble Institute of Technology**

-Role

Joint research on bulk metallic glasses

-Personnel composition and structure

Alain Reza Yavari (PI), Konstantinos Geogarakis (assistant professor), Kateryna Chornokhvostenko (technical assistant, November 4, 2008 to January 31, 2009)

-Collaborative framework

Joint research on bulk metallic glasses is conducted. Yavari has frequently visited WPI, promoting the BMG group's joint research project. The Grenoble Institute of Technology has served as a collaborative institution which is working with the European satellite set up at the University of Cambridge in 2008. Therefore, we have placed an added emphasis on researcher exchange with the Grenoble institute.

As a way of promoting research collaboration, Geogarakis has been posted to Sendai as an assistant professor. As part of our joint research framework, we have accepted a student who is taking a doctoral course at the Yavari research group at the Grenoble Institute of Technology as a visiting scientist.

Moustafa Aljerf : January 14, 2010 to April 14, 2010

Institution (3) **IBM Thomas J. Watson Research Center**

-Role

Joint research on materials physics

-Personnel composition and structure

Rudolf M. Tromp (PI), Abdullah Al-Mahboob (assistant professor)

-Collaborative framework

We have promoted joint research on materials physics. As a way of promoting research collaboration, Al-Mahboob was posted to Sendai as an assistant professor. However, Tromp resigned as PI on October 1, 2008 as the IBM

into surface physics and surface chemistry.

Institution (4) **University of Massachusetts Amherst**

-Role

Joint research into high polymer chemistry and soft materials

-Personnel composition and structure

Thomas P. Russell (PI)

-Collaborative framework

Promotes joint research into high polymer chemistry and soft materials. The partners in Japan should be PIs Nishi and Shimomura. Arranges postdoctoral researchers and assistant professors, etc.

Institution (5) **Chemnitz University of Technology**

-Role

Joint research into MEMS

-Personnel composition and structure

Thomas Gessner (PI)

-Collaborative framework

Promotes joint research into MEMS. The main partner in Japan is PI Esashi, and other engineering system researchers will participate. Arranges postdoctoral researchers and assistant professors, etc.

Institution (6) **University College London**

-Role

Joint research into surface physics and theoretical research

institute launched a research project in which he was required to work exclusively. On the same day, Al-Mahboob moved to the Hashizume group, marking the end of our partnership with the IBM institute.

Institution (4) **University of Massachusetts Amherst**

-Role

Joint research on high polymer chemistry and soft materials

-Personnel composition and structure

Thomas P. Russell (PI), Shane Harton (post-doc)

-Collaborative framework

Joint research is conducted on high polymer chemistry and soft materials. As part of our joint research framework, we have accepted students who are taking a doctoral course at the Russell research group at the University of Massachusetts as visiting scientists.

Li Le : October 1, 2008 to March 9, 2009

Katheleen McEnnis : November 16, 2009 to December 16, 2009

Institution (5) **Chemnitz University of Technology**

-Role

Joint research on MEMS

-Personnel composition and structure

Thomas Gessner (PI) , Yu-Ching Lin (assistant professor), Jae-Wang Lee (post-doc)

-Collaborative framework

Joint research is conducted on MEMS. As a way to establish a collaborative research system, Lin, an assistant professor and Lee, a post-doc, have been posted in Sendai. As part of our joint research framework, we have accepted both young researcher and graduate student at the Gessner research group at the Chemnitz University of Technology, as visiting scientists.

Marco Haubold: August 9, 2011 to December 21, 2011; March 17, 2010 to April 5, 2010; January 4, 2011 to January 28, 2011

Felix Gabler: November 23, 2010 to March 11, 2011

Frank Roscher: November 16, 2009 to April 2, 2010; February 12, 2011 to March 11, 2011

Lin Weichih: November 10, 2010 to March 14, 2011

Jörg Frömel: March 8, 2011 to March 14, 2011

Institution (6) **University College London**

-Role

Joint research on surface physics and theoretical research

-Personnel composition and structure Alexander Shluger (PI) -Collaborative framework Promotes joint research into surface physics and theoretical research. The main partner in Japan is the theory group (PIs Tsukada and Tokuyama), and an experiment system group will be added. Arranges postdoctoral researchers and assistant professors, etc.	-Personnel composition and structure Alexander Shluger (PI), Thomas Trevethan (assistant professor),Keith McKenna (assistant professor), Peter Sushko (associate professor - April 1, 2008 to December 31, 2008, adjunct associate professor - January 1, 2011 to present) -Collaborative framework Joint research is conducted on surface physics and theoretical research. As a way to establish a collaborative research system, two assistant professors – Trevethan and McKenna – have been posted to Sendai. Shluger stayed in Sendai for three months, having established a joint research structure within AIMR. As part of our joint research framework, we have accepted researchers who were taking a doctoral course, at the Shluger research group at the University College London, as visiting scientists. Matthew Watkins: February 1, 2010 to February 28, 2010; July 16, 2010 to July 31, 2010 Gilberto Teobalde: June 28, 2010 to July 3, 2010
Institution (7) **University of Cambridge** -Role Joint research into bulk metallic glasses -Personnel composition and structure Alan Lindsay Greer (PI) -Collaborative framework Promotes joint research into bulk metallic glasses. Arranges postdoctoral researchers and assistant professors, etc.	Institution (7) **University of Cambridge** Refer to satellite institutions listed above
Institution (8) **Institute of Chemistry, Chinese Academy of Science** -Role Joint research in nanochemistry and surface chemistry -Personnel composition and structure Li-Jun Wan (PI) -Collaborative framework Promotes joint research in nanochemistry and surface chemistry. Arranges postdoctoral researchers and assistant professors, etc.	Institution (8) **Institute of Chemistry, Chinese Academy of Sciences** Refer to satellite institutions listed above
Institution (9) **Pennsylvania State University** -Role Joint research in nanophysics -Personnel composition and structure	Institution (9) **University of California, Los Angeles** -Role Joint research on materials physics -Personnel composition and structure

Paul S. Weiss (PI)

-Collaborative framework

Promotes joint research in nanophysics. Arranges postdoctoral researchers and assistant professors, etc.

Institution (10) **Johns Hopkins University**

-Role

Joint research into bulk metallic glasses

-Personnel composition and structure

Kevin J. Hemker (PI)

-Collaborative framework

Promotes joint research into bulk metallic glasses. Arranges postdoctoral researchers and assistant professors, etc.

Institution (11) **Tsinghua University**

-Role

Joint research in nanophysics

-Personnel composition and structure

Qi Kun Xue (PI)

-Collaborative framework

Promotes joint research in nanophysics. Arranges postdoctoral researchers and assistant professors, etc.

Institution (12) **Tokyo Institute of Technology**

-Role

Joint research into high polymer chemistry, soft materials, and the properties of high-polymer solid state materials

-Personnel composition and structure

Toshio Nishi (PI)

-Collaborative framework

Promotes joint research into high polymer chemistry, soft materials, and the

Paul S. Weiss (PI)

-Collaborative framework

We have formed a partnership with UCLA for research collaboration, as Weiss (PI) moved to the university from Pennsylvania State University. We are conducting joint research on materials physics.

Institution (10) **Johns Hopkins University**

-Role

Joint research on bulk metallic glasses

-Personnel composition and structure

Kevin J. Hemker (PI)

-Collaborative framework

We are conducting joint research on bulk metallic glasses. As part of our joint research framework, we have accepted a student who is taking a doctoral course at the Hemker research group at Johns Hopkins University as a visiting scientist

Amit Pandey: Match 10, 2010 to April 4, 2010,

Institution (11) **Tsinghua University**

-Role

Joint research on materials physics

-Personnel composition and structure

Qi Kun Xue (PI), Hongwen Liu (assistant professor)

-Collaborative framework

Joint research is conducted on materials physics. As a way to establish a collaborative research system, Liu was posted as assistant professor on April 1, 2008. Also, we accepted the following two researchers as visiting professors for our research collaboration.

Chong-Yu Wang: November 15, 2007 to December 30, 2007;
August 2, 2008 to October 30, 2008

Jinfeng Jia: July 6, 2009 to October 5, 2009

Institution (12) **Texas A&M University**

-Role

Joint research on biophysics

-Personnel composition and structure

Winfried Teizer (PI), Daniel Oliveira (post-doc), Aurelien Sikora (post-doc), Kyongwan Kim (post-doc)

-Collaborative framework

We have formed a partnership with Texas A&M University following Teizer's

properties of high-polymer solid state materials. Arranges postdoctoral researchers and assistant professors, etc.

Institution (13) **Waseda University**

-Role

Joint research into solid-state properties theory

-Personnel composition and structure

Masaru Tsukada (PI)

-Collaborative framework

Promotes joint research into solid-state properties theory. Arranges postdoctoral researchers and assistant professors, etc.

Institution (14) **Advanced Research Laboratory, Hitachi Ltd.**

-Role

Joint research into the properties of solid-state surfaces and nanophysics

-Personnel composition and structure

Tomihiro Hashizume (PI)

-Collaborative framework

Promotes joint research into the properties of solid-state surfaces and nanophysics. Arranges postdoctoral researchers and assistant professors, etc.

Institution (15) **University of Tokyo**

-Role

Joint research into crystal interfaces and theory

-Personnel composition and structure

Yuichi Ikuhara (PI)

-Collaborative framework

Promotes joint research into crystal interfaces and theory. Arranges postdoctoral researchers and assistant professors, etc.

participation as PI on November 1, 2009. As a way of establishing a collaborative research system for biophysics, three post-docs – Oliveira, Aurelien and Kim – have been posted in Sendai.

Institution (13) **Harvard University**

-Role

Joint research on bio-devices

-Personnel composition and structure

Ali Khademhosseini (PI), Murugan Ramalingam (assistant professor - March 24, 2010 to October 15, 2010, associate professor at partnership university - October 16, 2010 to present); Seidi Azadeh (post-doc - recruited on April 1, 2010, resigned on February 14, 2011); Serge Ostrovidow (post-doc); Song Chen (post-doc)

-Collaborative framework

We have formed a partnership with Harvard University following Khademhosseini's participation as PI on November 1, 2009. As a way of establishing a collaborative research system for bio-devices, two post-docs – Ostrovidow and Chen – have been posted to Sendai.

As part of our joint research framework, we have accepted a young researcher at University of Sydney.

Nasim Annabi: November 29, 2010 to February 2, 2011

Institution (14) **Hong Kong University of Science and Technology**

-Role

Joint research on Bio-devices

-Personnel composition and structure

Hongkai Wu (PI), Li Lei (post-doc – recruited on June 24, 2010, resigned on December 23, 2010), Xuetao Shi (post-doc), Haijun Yu (post-doc), Haixin Chang (post-doc)

-Collaborative framework

We have formed a partnership with Hong Kong University of Science and Technology following Wu's participation as PI on November 1, 2009. As a way of promoting joint research on Bio-devices, Shi, Yu and Chang have been posted to Sendai.

Institution (15) **Advanced Research Laboratory, Hitachi Ltd.**

-Role

Joint research on surface physics and materials physics

-Personnel composition and structure

Tomihiro Hashizume (PI - October 2007 to March 31, 2010), Taro Hitosugi (associate professor), Katsuya Iwaya (assistant professor), Takeo Osawa

(assistant professor), Nobuyuki Fukui (post-doc)

-Collaborative framework

Joint research is conducted on surface physics and materials physics. Associate professor Hitosugi, assistant professor Iwaya, assistant professor Osawa and post-doc Fukui have been posted as a way of building a solid research system. Following Hashizume's resignation as PI, associate professor Taro Hitosugi has led his research group since April 2010 as an Independent Investigator.

Institution (16) **University of Tokyo**

-Role

Joint research on crystal interfaces and theory.

-Personnel composition and structure

Yuichi Ikuhara (PI), Susumu Tsukimoto (lecturer), Mitsuhiro Saito (assistant professor), Zhongchang Wang (assistant professor), Lin Gu (post-doc)

-Collaborative framework

Joint research is conducted on crystal interfaces and theory.

Lecturer Tsukimoto, assistant professor Saito, assistant professor Wang and post-doc Lin have been posted in order to build a solid research system.

<Future Policy and Concrete Plans>

i) Satellites

Institution (1) **University of Cambridge**

-Role

Joint research will be conducted continuously through the promotion of two-way exchanges of researchers, with the main theme of non-equilibrium materials and soft materials.

- Composition of personnel, structure

Alan Lindsay Greer (PI), Bill Jones (Adjunct Professor), Shantanu Madge (post-doc)

- Framework of collaboration

Upon the conclusion of Agreement with Department of Chemistry, Dr. E. Reisner, a fellow of the University Lecturer & EPSRC Career Acceleration, and Dr. M. Kato (post-doc) of the same university were to have been invited to the Center in April 2011. However, it has been postponed due to the major earthquake that struck eastern Japan.

A joint symposium on materials physics and soft materials is scheduled to be held at the University of Cambridge in June 2011.

As part of joint research framework, young researchers including PhD students will be accepted AIMR as visiting scientists.

Institution (2) **Institute of Chemistry, Chinese Academy of Sciences**

-Role

Joint research will be conducted continuously through the promotion of two-way exchanges of researchers, with the main themes of the research on molecular nanotechnology and devices.

- Composition of personnel, structure

Li-Jun Wan (PI), Rui Wen (post-doc), Zhang Xu (post-doc, appointment has been postponed due to the disaster that struck eastern Japan on 11 March, 2011. It is rescheduled for July 2011.)

- Framework of collaboration

As part of joint research framework, young researchers including PhD students will be accepted at AIMR as visiting scientists.

Institution (3) **University of California, Santa Barbara**

-Role

Joint research will be conducted continuously through the promotion of two-way exchanges of researchers, with the main theme of organic electronics and condensed phase phenomena.

- Composition of personnel, structure

Fred Wudl (Adjunct Professor)

- Framework of collaboration

The Center Director is scheduled to visit UCSB in May 2011 and will discuss on more concrete research prospect.

Institution (4) **School of Engineering, University of Tokyo (Newly-established)**

-Role

Joint research will be conducted with the main theme of quantum-phase electronics.

- Composition of personnel, structure

Masashi Kawasaki (Adjunct Professor)

- Framework of collaboration

Joint research will be conducted on quantum-phase electronics.

ii) Partner institutions

Institution (1) **University of Wisconsin-Madison**

-Role

Joint research on materials physics

-Personnel composition and structure

John H. Perepezko (Adjunct Professor)

-Collaborative framework

As part of joint research framework, young researchers including PhD students will be accepted at AIMR as visiting scientists.

Institution (2) **Grenoble Institute of Technology**

-Role

Joint research on bulk metallic glasses

-Personnel composition and structure

Alain Reza Yavari (PI), Konstantinos Geogarakis (assistant professor)

-Collaborative framework

Joint research on bulk metallic glasses will be conducted continuously. Yavari has frequently visited WPI-AIMR, promoting the BMG group's joint research project. The Grenoble Institute of Technology has served as a collaborative institution which is working with the European satellite set up at the University of Cambridge in 2008. Consequently, an added emphasis is put on researcher exchange with the Grenoble Institute of Technology.

As a way of promoting research collaboration, Geogarakis has been placed in Sendai as an assistant professor.

As part of joint research framework, young researchers including PhD students at the Yavari research group at the Grenoble Institute of Technology will be accepted at AIMR as visiting scientists.

Yaofeng Guo is scheduled to work at AIMR for about 2 months in FY2011.

Institution (3) **University of Massachusetts Amherst**

-Role

Joint research on high polymer chemistry and soft materials

-Personnel composition and structure

Thomas P. Russell (PI)

-Collaborative framework

Joint research on high polymer chemistry and soft materials will be conducted continuously.

As part of joint research framework, young researchers including PhD students at the Russell research group at the University of Massachusetts Amherst will be accepted at AIMR as visiting scientists.

Katheleen McInnis and Kyle Bryson are scheduled to work at AIMR for about 2 months each in FY2011.

Ran Hayward is scheduled to work at AIMR for about two weeks in FY2011.

Institution (4) **Chemnitz University of Technology**

-Role

Joint research on MEMS

-Personnel composition and structure

Thomas Gessner (PI) , Yu-Ching Lin (assistant professor), Jae-Wang Lee (post-doc)

-Collaborative framework

Joint research on MEMS will be conducted continuously.

For strengthen the collaborative relationship, Lin and Lee are placed in Sendai. As part of joint research framework, young researchers including PhD students at the Gessner research group at the Chemnitz University of Technology will be accepted at AIMR as visiting scientists.

Jorg Fromel is scheduled to work at AIMR from May 11, 2011 to November 30, 2011.

Institution (5) **University College London**

-Role

Joint research on surface physics and theoretical research

-Personnel composition and structure

Alexander Shluger (PI), Thomas Trevethan (assistant professor), Keith McKenna (assistant professor), Peter Sushko (Adjunct Associate Professor)

-Collaborative framework

Joint research on surface physics and theoretical research will be conducted continuously.

For strengthen the collaborative relationship, Trevethan and McKenna are placed in Sendai. As part of joint research framework, young researchers including PhD students at the Shluger research group at the University College London will be accepted at AIMR as visiting scientists.
In the spring of 2011, a UCL administrative staff was scheduled to visit AIMR. However, it will be postponed until the autumn of the same year due to the disaster that struck eastern Japan on 11 March, 2011.

Institution (6) **University of Cambridge**

Refer to satellite institutions listed above

Institution (7) **Institute of Chemistry, Chinese Academy of Sciences**

Refer to satellite institutions listed above

Institution (8) **University of California, Los Angeles**

-Role

Joint research on materials physics

-Personnel composition and structure

Paul S. Weiss (PI)

-Collaborative framework

Joint research on materials physics will be conducted continuously. As part of joint research framework, young researchers including PhD students at the Weiss research group at the University of California, Los Angeles will be accepted at AIMR as visiting scientists.

Patrick Han is scheduled to stay at AIMR for 3-5 weeks in FY2011.

John C. Thomas is scheduled to work at AIMR for 2-4 weeks in FY2011.

Institution (9) **Johns Hopkins University**

-Role

Joint research on bulk metallic glasses

-Personnel composition and structure

Kevin J. Hemker (PI)

-Collaborative framework

Joint research on bulk metallic glasses will be conducted continuously.
As part of joint research framework, young researchers including PhD students at the Hemker research group at the Johns Hopkins University will be accepted at AIMR as visiting scientists.

Institution (10) **Tsinghua University**

-Role

Joint research on materials physics

-Personnel composition and structure

Qi Kun Xue (PI), Hongwen Liu (assistant professor)

-Collaborative framework

Joint research on materials physics will be conducted continuously.

For strengthen the collaborative relationship, Liu is placed in Sendai as an assistant professor. As part of joint research framework, young researchers including PhD students at the Xue research group at the Tsinghua University will be accepted at AIMR as visiting scientists.

Institution (11) **Texas A&M University**

-Role

Joint research on biophysics

-Personnel composition and structure

Winfried Teizer (PI), Daniel Oliveira (post-doc), Aurelien Sikora (post-doc), Kyongwan Kim (post-doc)

-Collaborative framework

Joint research on biophysics will be conducted continuously.

For strengthen the collaborative relationship, Oliveira, Sikora and Kim are placed in Sendai. As part of joint research framework, young researchers including PhD students at the Teizer research group at the Texas A&M University will be accepted at AIMR as visiting scientists.

Kelley Reaves is scheduled to work at AIMR from June 1, 2011 to August 19, 2011.

Andrew Liao is scheduled to work at AIMR from June 15, 2011 to August 18, 2011.

Institution (12) **Harvard University**

-Role

Joint research on bio-devices

-Personnel composition and structure

Ali Khademhosseini (PI), Serge Ostrovidow (post-doc), Song Chen (post-doc), Samad Ahadian (post-doc)

-Collaborative framework

Joint research on bio-devices will be conducted continuously.

For strengthen the collaborative relationship, Ostrovidow, Chen and Ahadian are posted in Sendai. As part of our joint research framework, young researchers including PhD students at the Khademhosseini research group at the Harvard University will be accepted as visiting scientists.

Vahid Hosseini is scheduled to work at AIMR from May 19, 2011 to March 31, 2012.

Institution (13) **Hong Kong University of Science and Technology**

-Role

Joint research on bio-devices

-Personnel composition and structure

Hongkai Wu (PI), Xuetao Shi (post-doc), Haijun Yu (post-doc), Haixin Chang (post-doc)

-Collaborative framework

Joint research on bio-devices will be conducted continuously.

For strengthen the collaborative relationship, Shi, Yu and Chang are placed in Sendai.

Institution (14) **The University of Tokyo**

-Role

Joint research on crystal interfaces and theory

-Personnel composition and structure

Yuichi Ikuhara (PI), Susumu Tsukimoto (lecturer), Mitsuhiro Saito (assistant professor), Zhongchang Wang (assistant professor), Chunlin Chen (post-doc)

-Collaborative framework

Joint research will be conducted on crystal interfaces and theory.
For strengthen the collaborative relationship, Tsukimoto, Saito, Wang and Chen are placed in Sendai.

5. Summary of center's research environment

<Initial plan>

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

We will arrange the environment so that the researchers participating at this Center can devote themselves exclusively to research to the greatest possible extent. The environment the Center provides for PIs is similar as that provided for Distinguished Professors in the US.

We will make arrangements so that the researchers themselves will not be involved in the managerial work of the host institution, provide detailed time management (effort management) for the researchers, and otherwise secure ample time for the researchers to engage in research at this Center as much as possible.

We will also prepare strong staff backup for accounting, personnel, research support, liaison and public relations work so that the researchers can devote themselves to research. The function of staff will be to implement various procedures and management tasks on behalf of the researchers. In addition to individuals who will perform day-to-day accounting and other administrative tasks, we will assign as program officers other individuals with outstanding experience in fields such as researcher evaluation, international research coordination, the ordered development of research findings, the publication of research findings, and the planning and support of research conferences. To these ends, in addition to utilizing university staff, we will make use of the annual salary system to actively employ individuals with experience in the private sector, foreigners (individuals with international experience), distinguished researchers, and other diverse personnel. We will also assign the technical staff required for the smooth progress of the research.

Besides the scientific and research issues, it is necessary to provide PIs not only

<Progress to date>

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

We pledge that during an initial application phase researchers will be guaranteed a research environment as being promised to "distinguished professors" in the United States.

Such treatment firstly consists of financial incentives provided to full-time PIs of the Center, who are given a monthly allowance of ¥100,000. In addition, performance-based special allowances, divided into four ranks according to the achievements made, began to be paid in FY2009. This reflects the Center's efforts to improve the pay system in favor of employees as well as enhancing further motivation for researchers to study hard. Also, additional incentive money is given to recipients of renowned science awards for a period of one year on top of their basic salary. This incentive system, divided into two ranks, was applied to one researcher in FY2009.

A measure is being taken to ensure that researchers at the Center can spend long hours for research activities. Specifically, researchers who had worked at the host institution (Tohoku University) before the Center was established are basically not required to engage in management-related clerical works sought at the host institution. This measure has been implemented steadily thanks to the continued request of the Center Director to the head of relevant departments.

As part of efforts to provide logistical support to researchers, three categories of technical staff at the Center are assigned – safety management, facility management, and networking. This system, continuing from last year, enables researchers to focus on research activities. These technical staff is trying to improve the research environments in buildings housing research offices while coordinating needs of the researchers and the providers concerned. In light of the

with sufficient facilities and space in laboratories, but also with an enjoyable living environment at home, especially for people from abroad. We will do our best to arrange a comfortable environment.

2) Startup research funding

At the discretion of the Center Director, the necessary start-up funds will be provided in cases when the invited researchers require funds to continue their own research vigorously when they are initially transferred to the center.

We will also promptly provide the invited researchers with opportunities for brainstorming and research and information exchange with Tohoku University researchers and for examining the potential for joint research at the university, support their access to common university experimental and other facilities, and otherwise support the vertical advance of their research.

3) Postdoctoral positions through open international solicitations

(Recruitment Method)

In the recruitment of post-doctoral researchers, we will secure superior international personnel via international recruitment using Tohoku University's website (English and Japanese), international scientific journals, and Tohoku University's overseas bases, specifically as follows:

(1) International recruitment via Tohoku University's website (English and Japanese)
(2) International recruitment through recruitment advertisements in *Nature*, *Science* and other international scientific journals, and in the publications of academic societies in which the lead researchers are members
(3) International recruitment via the website of the JREC-IN (Japan Research Career Information Network) personnel database (English and Japanese) administered by the Japan Science and Technology Agency
(4) International recruitment using Tohoku University's US office, China office, and other overseas offices and bases, and by asking renowned universities worldwide to post the recruitment information on their websites, including global universities which have academic exchange agreements with Tohoku University (119 institutions), and members of university consortia (The Association of East Asian Research Universities [AEARU], etc.)
(5) Other international recruitment utilizing the international networks that the lead researchers have developed in each academic field.

need to maintain the convenience of researchers from foreign countries, almost all documents handled by the Center have adopted English formats.

2) Startup research funding

Start-up money is used to procure basic devices and equipment regarded as indispensable of promoting research activities at the Center.

Research projects eligible for seed money and start-up funds are those that are expected to produce the desired effects under the strategic Fusion Research Proposal Program. In the first half of FY2009, 13 projects (4 fusion-research projects by PIs and 9 fusion-research projects by young researchers) were accepted, and in the second half, 14 projects (4 fusion-research projects by PIs and 10 fusion-research projects by young researchers) were accepted. During FY2010, 3 projects by PIs and 14 projects by young researchers were accepted. The results of the 17 projects adopted in FY2010 were presented by posters at a Tea Time meeting.

3) Postdoctoral positions through open international solicitations

As done last year, postdoctoral posts at the Center were internationally advertised this year using various media such as web sites and WPI-AIMR News, to enable the Center to secure human resources with outstanding ability. 60 applications were presented both from Japan and abroad, of which 15 were formally approved as postdoctoral researchers in FY2010.

In recruiting postdoctoral researchers at the Center, application documents were checked by preliminary screening, conducted by the relevant PIs. Interviews were then held to further narrow down the candidates. The Center Director was in charge of giving the final decision.

The number of postdoctoral researchers from foreign countries currently stands at 28, accounting for 76% of the 37 postdoctoral researchers working at the Center. 3 postdoctoral posts have been given to women.

(Employment Screening Method)

Post-doctoral researcher employment screening committees comprised of several members will be organized for each lead researcher, with the lead researcher serving as the committee chairperson. The post-doctoral candidates will be determined through an initial selection by examination of documents and a secondary selection by interviews. The final employment decisions will be made by the Center Director. This process will positively employ post-doctoral researchers with superior results in interdisciplinary research as well as in their field of specialization, in order to promote comprehensive interdisciplinary research efforts.. The Center Director will directly make the employment decisions to secure promising post-doctoral researchers in accordance with the center concept.

(Employment of Female Researchers)

We have an employment plan that the percentage of female researchers including postdoctoral fellows among all the researchers of WPI reaches at least 10%, hopefully, in between 10 and 20%.

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

We will prepare an environment which permits researchers to carry out their work duties in English.

We will prepare an environment whereby the exchanges between researchers and administrative staff can always be conducted in English right from the launch of the center by assigning multiple staff members to each section who can perform their work duties in English.

To these ends, we will assign university staff with superior English skills, in addition to expertise in such fields as accounting, personnel and research assistance, as administrative staff on a priority basis. Additionally, to supplement the English abilities of those staff, we will also secure administrative staff who are proficient in English by utilizing dispatched workers and the annual salary system to employ outside personnel, to assign to the center administrative staff who can execute work duties in English.

Furthermore, we will arrange systematic opportunities for administrative staff to participate in English training and constantly improve their English ability (including English in areas of expertise).

Documents for internal use that must be filled out personally by the researchers will be prepared in English, so that the foreign researchers will be able to submit all relevant documents.

We will also incrementally boost the ability to use English in the performance of duties at the center, and progressively shift to a system whereby English will

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

Employees with English proficiency work as administrative staff at the Center. They were chosen from among those with high professional expertise in such areas as accounting, personnel affairs and support to research activities, who have been working at Tohoku University as administrative staff. In order to support these workers, people who have proficiency in English have been newly recruited as quasi-regular employees. The employees with quasi-regular employment status are assigned work related to international publicity and safety management. As a result, the Center's administrative function has been improved in the execution of duties involving the use of the English language. The English-speaking employees facilitated speedy dissemination of information related to the spread of the new influenza in FY2009 and appropriate actions in the wake of natural disasters in FY2010.

To further improve the English-speaking ability of administrative staff, language training is provided to them at outside school.

Forms and documents written in English are available for the application of the Fusion Research Proposal Program. Information on such services has been disseminated to foreign researchers, providing added convenience.

When applying for Grants-in-Aid for Scientific Research (KAKENHI), researchers are generally supposed to fill an application form posted on the web. However, these application procedures are written only in Japanese. In response to this inconvenience, the Center has prepared and distributed English versions of the application manual and other relevant documents. Using these documents, the

become the official language for all meetings inside the center and English will be used whenever possible for all documents drafted inside the center.

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

As for the evaluation of researchers, Tohoku University has already stipulated a university-wide method for the assessment of individual faculty, with a researcher evaluation scheme at each department. The performance of center researchers will be strictly evaluated in accordance with this system, and the researchers' salary assessments (pay-raise system and diligence allowance) and incentives such as priority allocation of research funds will be determined based on the evaluation results. For salaries in particular, in addition to the active adoption of the annual salary system, special allowances will be granted to researchers who make outstanding contributions.

We will establish an international advisory board, including Nobel Prize recipients as members, and an external evaluation board. They help to evaluate not only the research of individual PI but also the system and organization of the WPI center.

Additionally, "invitation allowances" (maximum period of 5 years) will be granted to prominent invited researchers from outside the host institution in accordance with their research accomplishments and most recent salaries.

Moreover, new systems will be introduced including a "Fellow Professor" (tentative name) system for professors playing leading roles in the research, as well as a system for preparations payments or contract conclusion payments to provide additional incentives when trying to attract Nobel Prize–class researchers, etc.

Tohoku University's "University Professor System" will also be actively used for the invitation of prominent researchers.

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

To prepare a facilities environment suitable for a global top-level center, the host institution will operate a new core facility (building) for the center's activities so it can be used from around April 2008 as a target date. This facility will be equipped with flexible water supply and drainage equipment, air conditioning equipment, and power sources so that it can be a research space that meets the respective room arrangement, equipment, apparatus and other usage

Center aggressively solicited foreign researchers for new research funding. In FY2009, applications from 6 foreign researchers were approved. In FY2010, 21 out of 26 eligible foreign researchers applied for funding. In FY2011, 19 out of 26 eligible foreign researchers have applied for funding so far.

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

As done last fiscal year, all researchers at the Center were evaluated based on their past performances, including the number of research papers publicized, the amount of external research funds, awards received and research achievements over the past three years. Evaluation is made once every year and the results determine the researchers' promotion and salary. Performance records are also used to determine whether or not the researcher's employment contract is to be renewed following its expiry.

Based upon the partnership with Thomson Reuters in July 2010, registration of a researcher ID is required for all PIs, which is helpful in evaluating researchers' performance.

A full-time PI is paid a monthly allowance of ¥100,000, a step introduced at the time of the foundation of the Center. On top of this, all researchers are eligible for incentive money to be paid based on their performance. 4 ranks are set for such money: ¥80,000 per month for an S-ranked researcher, ¥60,000 for an A-ranked researcher, ¥40,000 for a B-ranked researcher, and ¥20,000 for a C-ranked researcher. For this fiscal year, 2 researchers became eligible for S and 6 for A.

An annual salary contract has been introduced for those recruited from an entity other than the host institution. The margin of the annual salary increase for such employees is more flexible than that for regular employees. The Center Director has discretion in determining a pay rise for annually contracted employees based on their performance and ability. If a researcher receives a world-renowned science award, an extra amount of money – ¥5 million yen for a top-class award and ¥3 million for another award – is added to his or her annual salary the following year. Under the system, introduced in FY2009, one researcher became eligible in the same year.

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

At the end of 2007, a building exclusively used by the Center for WPI research activities was constructed, marking the completion of the first-phase project. This was followed by the completion of the second-phase construction project at the end of FY2008. In FY2009, the entire complex began to operate for the WPI project. In May 2009, an open-house event was held. By September of that year, internal engineering work, such as the installation of a Helium recovery room,

demands of the individual researchers. Considering the great importance of information exchange and brainstorming among the researchers, the researchers' office wing will be arranged with a library section, discussion corners and other spaces where the researchers can gather in a central zone, with the individual offices located on the outskirts of this common area. The security arrangements will ensure safety by zone, covering each research room or each department and the entire building. Energy conservation equipment will be adopted to mitigate pressure on research funds.

In addition to this new building, research space in existing buildings will also be used to conduct the business of center research. In those cases as well, while there will be some limitations on the room arrangements, the research rooms and offices will be upgraded as deemed suitable for a global top-level center with improvements based on the above approach, starting with reinforcement of the structures' earthquake resistance.

Private-sector facilities will also be actively utilized to flexibly secure sufficient research space in accordance with the progress of the research.

Arrangements will be made to provide the researchers with priority access to high-performance electron microscopes and other state-of-the-art research equipment through close coordination with the Technology Center for Research and Education Activities and other related Tohoku University organizations.

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

We will advance international development via researcher and other personnel exchanges and institutional relations for international joint research by positively utilizing Tohoku University's US office, China office, 11 liaison offices and other overseas offices and bases, and via liaison with global universities which have academic exchange agreements with Tohoku University (119 institutions), and members of university consortia (The Association of East Asian Research Universities [AEARU], and Top Industrial Managers for Europe [TIME]).

Specifically we will first organize an international materials cooperation support committee among leading global universities to advance research on the topic "new substances and materials from atomic and molecular control, and

was completed. Offices and laboratories for 6 PIs were also transferred to the new building, and their research activities commenced. Rooms used for seminars as well as rooms used by professors and guest professors have been housed in the building, which serves as the main research venue for WPI-AIMR. The WPI-AIMR building sets aside an "innovation" space where researchers can share information with others, promote personnel exchange and engage in brainstorming sessions. This special space has been used for a Friday Tea Time meeting every week since September 2009, enabling interaction between researchers from different professional fields.

At present, a new 9,000 m^2 building, which will serve as WPI-AIMR's main building, is under construction under the third-phase project, financed by the 2009 supplementary budget. This building was to have been completed at the end of FY2010, but the completion has been postponed due to the natural disaster that hit eastern Japan on March 11, 2011. The building is to start operating in the autumn of 2011. Upon completion, 10 PIs and young researchers invited from foreign countries and those currently working at the Aobayama campus are set to move to the new building. As a result, PIs will concentrate on the Katahira campus, effectively promoting fusion of research activities.

With the start of operation at the WPI-AIMR building constructed under the first-phase and second-phase projects, the current space available for WPI-AIMR activities totals 14,300m^2. The space is divided into a 2,500m^2 section, which became exclusively used by the Center after being strategically used by both the Center and the host institution following the renovation of existing facilities, a 4,500m^2 section, which has continued to be used for educational purposes (education to students) by PIs who had belonged to the host institution before the establishment of the Center, a 300m^2 section, used by administrative staff of the Center exclusively, and a 7,000m^2 section, used for WPI-AIMR activities.

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

FY 2007-2008: 2 meetings

Major examples (meeting title and place held)	Number of participants
WPI & IFCAM Joint Workshop (The 2008 WPI-AIMR Annual Workshop) "Challenge of Interdisciplinary Materials Science to Technological Innovation of the 21st Century" (February 18-19, 2008, Sendai, Miyagi)	Domestic: 139 Overseas: 17

functional innovation" and establish a structure to advance research and development under international institutional cooperation.

Then, using this international consortium along with Tohoku University's existing global network described above, we will arrange periodic opportunities for mutual exchange including the short-term overseas dispatch of center researchers and the invitation of global researchers to Japan, hold pacesetting cutting-edge international research conferences assembling top-level global researchers on a regular basis, and otherwise prepare an environment in which the center's researchers can engage in international research exchange, information exchange and brainstorming with the world's leading researchers.

The 2009 WPI-AIMR Annual Workshop (March 1-6, 2009, Zao, Miyagi)	Domestic: 140 Overseas: 29

FY 2009: 5 meetings

Major examples (meeting title and place held)	Number of participants
Workshop WPI-INPG-EUROPE (August 25-28, 2009, Grenoble, France)	Domestic: 20 Overseas: 50
The 2010 WPI-AIMR Annual Workshop (March 25-27, 2010, Sendai, Miyagi)	Domestic: 154 Overseas: 41

FY 2010: 5 meetings

Major examples (meeting title and place held)	Number of participants
WPI-AIMR-ICCAS Joint Symposium (October 29, 2011, Beijing, China)	Domestic: 7 Overseas: 31
The 2011 WPI-AIMR Annual Workshop -Cutting-edge Functional Materials for Green Innovation- (February 21-24, 2011, Sendai, Miyagi)	Domestic: 184 Overseas: 32

<Summary of achievements to date>

The European satellite held a conference called Workshop WPI-INPG-Europe between August 25 -28, 2009 in Grenoble, France. Participating in the workshop were renowned Japanese and European researchers specializing in metallic glass. The workshop was organized and chaired by professor Yavari of CNRS-INPG in Grenoble, who also serves as PI of the Center.

We also held an International Conference on Advanced High-Temperature and High-Strength Structural Materials jointly with the Hong Kong University of Science and Technology during October 4-8, 2009. Professor C.T. Liu, who concurrently serves as professor at the Center, chaired and organized the conference, in which renowned researchers specializing in hard material took part.

We also held a joint symposium on soft materials with the division of Advanced Material Sciences (AMS) at the Pohang University of Science and Technology (POSTECH) in Republic of Korea on June 18, 2010. **(**AMS was

8) Other measures, if any

We will advance the following approaches to build a center that compiles and advances the latest global information and research, and attracts the top minds initiating dramatic scientific developments.

(1) We will establish an international advisory board, including Nobel Prize recipients as members. The names of the members are following; Dr. Hans H. Rohrer (Switzerland, 1986 Physics Nobel Laureate), Prof. Herbert Gleiter (Director, Institute for Nanotechnology Research, Karlsruhe), Prof. Robert J. Silbey (Dean, College of Science, MIT), Prof. Robert J. Birgeneau (Chancellor, Univ. California, Berkeley), Prof. Bing-Lin Gu (President, Tsinghua Univ. Beijing), Prof. K. Osterwalder (President, The UN University and President, ETH Zurich), Mr. Tadashi Onodera (President, KDDI Corp). They will report directly to the Center Director to support top-down type decision making by the Center Director. The Center Director and the international advisory board will organically cooperate and exchange opinions, and positively implement reforms to promote a global top-level research center. Further, the evaluation of accomplishments of researchers, which will be carried out every year, and the other evaluation events such as the recruitment of postdoctoral fellows will be adopted for the Korean WCU (World Class Universities) program, equivalent to WPI program.) In addition, on October 29 in the same year, we sponsored a joint symposium with the Institute of Chemistry, Chinese Academy of Sciences over soft materials.

Also co-sponsored by the Center were an international symposium on engineering and neo-biomimetics, chaired by PI Shimomura; Super Green 2009, organized and chaired by PI Adschiri; the first International Symposium on Super-Hybrid Materials, chaired by PI Adschiri; and the International Workshop on High Performance Ceramics for Sustainable Life, coordinated by PI Chen.

Since the foundation of the Center, annual WPI-AIMR workshops have been held four times to provide top Japanese and international researchers and researchers working at WPIs with opportunities to deepen their discussions, drawing favorable reaction from various quarters. A theme set under the FY2010 workshop was “Cutting-Edge Functional Materials for Green Innovation,” which dealt with specific social contributions to be made by the Center.

In February, 2011, an Australian Colloid and Interface Symposium was held in Hobart, Australia, where the Center took the initiative of sponsoring an ACIS-WPI Workshop for local researchers to explain WPI programs and research activities by AIMR, MANA and iCeMs. The event provided the Center with opportunities to publicize its research activities, paving the way for further joint research projects in the future.

8) Other measures, if any

(1) Of the Advisory Board members, Dr. Rohler, Dr. Bednorz, Dr. Gleiter, and Dr. Narayanamurti visited the Center and held informal sessions with other researchers and conducted first-hand inspections of research groups and their activities at the Center. They also exchanged views with the Center Director of the Center and offered advice on some issues.

The International Advisory Board convened a meeting on February 24, 2011 and discussed the direction of research the Center was to take in the future.

(2) The Center organizes a joint seminar in order to provide researchers with opportunities to share information on fusion research and discuss the theme. The way of conducting such a seminar was revised in FY2010 in order to give young researchers more chances to express their views and opinions. Specifically, an organization committee has been set up to conduct a seminar. Not only senior researchers but also young researchers have been included in the committee where themes and lecturers favored by young researchers have been selected for seminars while the content of the seminars has been expanded. The seminars are held twice a month and a young researcher is basically obligated to attend the seminar. Since September 2009, this seminar and the Friday Tea Time have been

performed based on advice of peer reviewers consisted of top class researchers from abroad and from domestic institutes.

(2) We will arrange a flat research organizational structure with as few hierarchical relations as possible to create an environment where even young researchers can develop their own ideas.

(3) We will provide young researchers with research support from senior mentors and otherwise promote the organic development of research.

(4) We will assign the necessary technical staff to ensure the smooth development of research apparatus to support superior state-of-the-art research and creative research.

(5) We will prepare a system to provide highly detailed lifestyle and education advice to support the daily life in Japan of foreign researchers at the center and the education of their children. For example, concerning schooling and education of researchers' children, Tohoku International School (having kindergarten, elemental school, junior high school, and high school) accepts children from abroad, so researchers can focus their research without being bothered by educational problem. Further we consider about possibility for supporting the expenses for children's education. Not only Tohoku International School, but also the ordinary schools nearby Tohoku University are used to accepting children from abroad. We contact the regional public organizations, which founded such schools, and intend to ask them cooperation on the acceptance and education of children from abroad.

linked together, further enhancing academic interaction between participating members.

(3) The Fusion Research Proposal Program enables young researchers to interact with researchers belonging to different research groups for further joint research and fusion research. The outcomes of such research are announced at a Friday Tea Time meeting.

(4) The WPI-AIMR Awarding System, introduced in April 2010, is designed for the Center Director to commend researchers for awards received at academic groups outside the Center. The commendation system is to give outstanding young researchers motivation for research activity.

(5) Technical staff in charge of three fields – safety management including safe export control, networking operations and facilities – have continued to work for the Center on a full-time basis, allowing researchers to focus on research activities. Professional expertise provided by these staff played a major role in rehabilitation work in areas affected by the March 11 earthquake that struck eastern Japan.

(6) Tohoku University plans to construct a facility at the Katahira campus to accommodate foreign researchers, using its own funds. The two-year construction project from FY2010, initiated by WPI-AIMR, will allow researchers at the Center to freely use the envisaged facility.

(7) In view of the importance of society's general support to research activities we have considerably accelerated outreach activities since FY2010. Specifically, one researcher was appointed to be an "outreach manager." Missions assigned to the person include compilation of a Japanese-language educational magazine *"Tohoku WPI Tsu-Shin"*, and active participation in such events as the Science and Technology Festa in Kyoto and Science Agora, along with participation in events sponsored by Tohoku University. WPI-AIMR News, a publication issued three times a year, has received high acclaim both at home and abroad. The publication received major coverage by *Physics Today*, a U.S. magazine, in February 2011. AIMResearch, an online site listing the most updated research achievements at the Center, has had readership from a wide spectrum of society, scoring an average of 2,400 page views per month.

(8) The Center planned to hold a WPI-AIMR Summer School to enhance its international visibility. However, it was forced to give up the plan when it was preparing to announce applications, due to the natural disaster that hit Japan. The Center will resume the plan sometime in the future.

<Future Policy and Concrete Plans>

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

In order to allow researchers to devote themselves to research activities, the Center plans to set up an International relation unit in charge of international affairs in summer 2011. The envisaged unit will deal with the entire process of accepting researchers in an integrated manner, from the arrival of researchers to supporting their research activities. With completion of WPI-AIMR main building in Autumn 2011, more active exchange of ideas between researchers is expected since all AIMR members can work at the Katahira Campus. The research environment will be arranged, which enables researchers to get new ideas and devote themselves to their research with provision of multi-purpose space which can be used for a researcher's discussions and outreach events, together with a common space where researchers can get together easily for discussions.

2) Startup research funding

The Fusion Research Proposal Program will be maintained in order to support promising researchers; however, only innovative research projects will be eligible for subsidies, with applicants subject to strict screening due to the popularity of fusion research in the Center.

3) Postdoctoral positions through open international solicitations

The Center will continue to solicit promising and outstanding foreign researchers internationally in order to give postdoctoral posts to such researchers.

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

We will continue to provide language training to administrative staff in order to improve their English skills. In the future, administrative staff may be dispatched to major international academic meetings along with the researchers concerned. In FY2011, UCL, with which the Center has formed a partnership contract, plans to send some of their administrative staff under an internship program. Such exchanges of administrative staff will be also strengthened in the future.

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

We will actively use the Researchers' ID system. The coverage of research projects by the news media will be an important asset in evaluating researchers' performances. Comprehensive assessment through peer-review by domestic and overseas prominent researchers will be taken into account.

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

Joint use of research facilities will be promoted at the Katahira campus, where researchers will gather. The ground floor of the new main building will be arranged with a multi-purpose space equipped with a large-scale display which can be used for exchanges of ideas between researchers and outreach events. In addition, WPI-AIMR took an initiative in building a facility to accommodate visiting foreign researchers next to its main building by making a strong request to the host institution. (The accommodation facility is set for completion in the summer of 2012 or later, behind schedule due to the major earthquake on March 11.)

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

Unique themes will continue to be chosen for annual workshops. The Center will support the Conference of the International Association of Colloid and Interface Scientists to be held at Tohoku University in May 2012 as part of efforts to back academic conferences committed by PIs.

8) Other measures, if any

We will further expand our outreach activities by increasing publicity at the levels of citizens and students in the regions. The multi-purpose space of the new main building can be used for events for citizens such as science café and it will also be scheduled to offer movie theaters and music concerts for researchers' families. We will realize the holding of Summer School, initially set to open in summer 2011, soon after external conditions have been met.

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

<Initial plan and goals at the interim evaluation>

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

We evaluate each PI and researcher by the following indicators; publication in internationally well-recognized top-class journals, citation number of those papers, invited and plenary lectures at the well-recognized international symposiums, receiving international awards, and acquisition of research funds. As possible as we can, we want to use numerical and objective factors for evaluation. The center's global standing is primarily evaluated by the ranking of institutions of each discipline, based on citation analysis made by ISI.

<Current assessment>

The number of papers released by full-time AIMR PIs came to 3,255 in the past 10 years (2000-2010). Of the total, 80 or 2.61% were among the top 1% of all papers released worldwide during the same period in rankings of quote citations. The percentage proportion of the top 1% papers for other Japanese institutions was 2.56% for JST, 2.49% for RIKEN, 1.21% for the Institute for Materials Research, Tohoku University and 1.15% for NIMS. Compared with these figures, AIMR's 2.61% is impressively high. The figure was also comparable to those of overseas institutions: 3.25% for Max Planck, 2.59% for NASA and 1.57% for CNRS, indicating that we have maintained the world's top level in research activities.

There is no major change in indexes and methods used to evaluate the performance of PIs. However, with a partnership, with Thomson Reuters since last fiscal year, PIs should get their "Researchers' ID" registered in the news agency so that the results of their research activities could be more accurately evaluated. Receiving an internationally recognized award is an important factor in assessing the performance of PIs. Listed below are internationally renowned awards received by our PIs during the first four years following the creation of the Center.

(1) Arthur C. Cope Scholar Award of the American Chemical Society (ACS) (2007, Yamamoto, AIMR Director)
(2) Membership of the National Academy of Engineering (NAE) (2008, Russell, PI; Inoue, PI)
(3) James C. McGroddy Prize for New Materials of the American Physical Society (APS) (2009, Inoue, PI)
(4) Oliver E. Buckley Condensed Matter Prize of the American Physical Society (APS) (2009, Miyazaki, PI)
(5) The International Rubber Conference Organization (IRCO) Medal (2009, Nishi, PI)
(6) Royal Society of Chemistry (RSC) Centenary Prize (2009, Yamamoto, AIMR Director)
(7) Unilever Award of the American Chemical Society (ACS) (2010, Khademhosseini PI)
(8) A. E. Alexander Lecture Award of the Colloid and Surface Chemistry Division of the Royal Australian Chemical Institute (2011, Kurihara, PI)
(9) Humboldt Research Award (2011, Ikuhara, PI)
(10) Esashi (PI)'s research project was selected in the Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST)

	Program of the Japan Society for the Promotion of Science.

<Future Policy and Concrete Plans>

We will continue to be strict about the evaluation of performance of PIs by using their Researchers' IDs. In the future, the web page will be created through which the outside parties can make search

The evaluation will be undertaken with transparency on the scientific level in the world by globally visible method such as receipts of internationally renowned awards and the number of papers in the top 1% in terms of quote citations, and the ISI Highly Cited Researcher list. As for the research which is challenging and needs much time to have the outcome, comprehensive assessment through peer-review by domestic and overseas prominent researchers can be taken into account.

7. Securing competitive research funding

<Initial plan>

i) Past record (dollars)

FY2002	10,554,000	FY2003	8,460,000
FY2004	14,689,000		
FY2005	12,439,000		
FY2006	10,528,000		
Total	56,670,000		

ii) Prospects after establishment of the center

The host institution constructs a new building for the WPI research center until April, 2008. The salary for PIs, who have been researchers at each institute or Faculty in TU, is essentially paid by TU, even after they join the WPI center. Further, the fund for research, setting up instruments and equipments necessary for research at the Center, renovation of research space and laboratory, and smooth management of the Center will be supported by TU. For this purpose, TU will prepare approximately 1700000 US $ annually.

Besides the supports from TU mentioned above, the PIs joining from TU have obtained the research funds of approximately 11000000 US $ from outside in 2006 fiscal year, so we expect that similar amounts of research funds (or even greater amounts) will be obtained by them in future.

<Secured to date>

Listed below are past records about obtained funds.

FY 2007	¥1,659,500,000
FY 2008	¥2,427,400,000
FY 2009	¥2,373,600,000
FY 2010	¥2,311,174,000

The amount of external research funds PIs obtain each year externally is the same as was initially projected.

The host institution provided ¥770,000,000 in FY2008 to help finance the second-phase construction of the WPI research center building (5,350m^2).

Listed below are external research funds drawing particular attention.

(1) Fund for World-Leading Innovative R&D on Science and Technology (FIRST Program) (JSPS)
Chief researcher: Professor Masayoshi Esashi
Project Period: March 10, 2010 to March 31, 2014
Total amount: ¥3,087,000,000

(2) Grants-in-Aid for Scientific Research: Specially Promoted Research (JSPS)
Chief researcher: Professor Tadahiro Omi
Project Period: April 1, 2010 to March 31, 2015
Total amount: ¥519,190,000

	(3) Grants-in-Aid for Scientific Research: Scientific Research (S) (JSPS) Chief researcher: Professor Akihisa Inoue Project Period: April 1, 2008 to March 31, 2013 Total amount: ¥178,210,000 (4) Grants-in-Aid for Scientific Research: Scientific Research (S) (JSPS) Chief researcher: Professor Masahiko Yamaguchi Project Period: April 1, 2009 to March 31, 2014 Total amount: ¥173,100,000 (5) Grants-in-Aid for Scientific Research: Scientific Research (S) (JSPS) Chief researcher: Professor Tadafumi Adschiri Project Period: April 1, 2008 to March 31, 2013 Total amount: ¥162,970,000 (6) Basic Research Programs: Core Research for Evolutional Science and Technology (CREST) (JST) Chief researcher: Professor Masatsugu Shimomura Project Period: October 1, 2008 to March 31, 2014 Total amount: ¥138,312,400

<Future Strategy>

We will secure at least the same amount of research funds from outside parties as we did in the past. We will step up efforts to publicize competitive research funds to researchers and work out specific strategies for that purpose. In addition, special effort will be given to obtain research funds offered from outside parties such as business corporations. During the second-phase period (2012 or beyond), we plan to replace several existing PIs with young and energetic PIs with outstanding abilities. We believe this kind of personnel reshuffle will help increase the amount of our fund raising from outside parties.

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

<Initial plan>

After the implementation term of this program is completed, the center will continue with its activities in order to enhance the potential for research at this center.

Also, within this program, we will actively introduce new research methods incorporating new concepts into the existing graduate course and research center at our university.

Noteworthy of Tohoku University, is its offering of the Institute for International Advanced Research and Education Organization (established in April, 2007) on basis of the 21st Century COE Program achievements. Incorporating the Institute for International Advanced Research and Education (initiated in April, 2006), it supports the graduate students who pursue integrated research; and the Institute for International Advanced Interdisciplinary Research (introduced in April, 2007) which promotes research in the many areas. We will initiate and develop a method reform and human resources cultivated in this center for enhancing the level of the fusional areas, fostered into the organization's activities, to rank as one of the best centers in the world. In order to insure that the research institutes collaborate intimately and to increase its research abilities of emerging or fusional areas, we contemplate about the reorganization and integration of existing graduate course and research center in our university as well.

<Measures taken to date>

1) Active use of system reform methods at the Center for reform of the host institution

When the applications to build the Center was submitted, the Center already proposed that PIs would be granted research environments as currently accorded to researchers with the title of "Distinguished Professor" in the United States. As a first step toward the implementation of the promise, full-time PIs at the Center have been paid a special monthly allowance of ¥100,000 since the foundation of the Center in October 2007. The step prompted the president of the host institution (Tohoku University) to decide to take a similar incentive step, called the "Tohoku University Distinguished Professor System," in December 2007, paying a special allowance to teachers and employees whose role at the university is regarded as indispensable in such fields as education, research and social contribution.

"Summer School" initiative and the GI^3 system of the Center have become a business model for a researcher-to-researcher exchange system currently being adopted at the host institution.

In addition, the Center's "Independent Investigator" system has been subject to consideration by the host institution, developing into another program aimed at creating an independency for young researchers at the University.

Moreover, we initiated to construct an accommodation facility for foreign researchers on a site next to the Katahira WPI-AIMR main building.

2) Partnership with research organizations within the host institution

Researchers at one of the unique organizations at the host institution – the Institute for International Advanced Interdisciplinary Research under the International Advanced Research and Education Organization – and young researchers recruited by global COE are allowed to conduct joint research with PIs at their laboratories at the Center. It is intended to develop human resources, especially young researchers, by deepening collaboration between the Center and research organizations within the host institution.

<Future Policy and Concrete Plans>

As described earlier, these measures have begun to produce specific positive effects on the host institution. The measures have yet to be implemented as early as initially sought, affected by the March 11 earthquake and ensuing tsunami that devastated northeastern Japan. Our focus in the immediate future is to construct a facility to accommodate foreign researchers and expand an independent status of young researchers.

We will utilize satellites set up in the United Kingdom, China and the United States as key leverage to spread academic collaboration not only in materials science but also in other many fields of natural sciences to cover the entire university. We will deepen collaboration with them so that the satellite would play a role of the outer organs of the host institution in the future, hoping that personnel exchange involving students and researchers will expand further along with recruiting activity.

The host institution is considering expanding the use of the English language. Meanwhile, the Center is requesting the host institution to conduct seminars and other

educational meetings in English while undertaking Japanese-to-English translation of documents.

We will keep contact with the host institution and other relevant departments and exchange views with them in order to spread ideas and actions initiated at the Center to others.

9. Host institution's commitment

<Initial plan>

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

Tohoku University will clearly stipulate the advance of research and organizational development based on this program as a priority in its interim plan. Specifically, the relevant section of Tohoku University's interim plan—2 Measures to Achieve Research Goals (1) Measures to Achieve Goals Concerning Research Levels and Research Results, Fields to be Addressed by the University on a Priority Basis—presently reads "Advance organizational development and promote research in basic research fields for which we have been recognized by the 21st Century COE Program and others on the basis of our performance and proposals for organizational restructuring." If the university is selected for this program, this passage will be amended to read "Advance organizational development and promote research in basic research fields for which we have been recognized by the World Premier International Research Center (WPI) Initiative, the 21st Century COE Program and others on the basis of our performance and proposals for organizational restructuring." and the university will give priority support to advancing research and organizational development based on this program.

-Concrete Measures

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

The host institution will provide the necessary space in accordance with the advance of the research and the expansion of the center's research organization by operating a new core facility for the center's activities so it can be used from around April 2008 as a target date, and research space will also be secured within the host institution's existing facilities. Additionally, the host institution will basically pay the personnel expenses of all researchers who were affiliated with the host institution prior to the formation of the center. Beyond that, the host institution will expend enough money each year on such items as research expenses and other researcher support, the installation of apparatus required for research at the center, the refurbishing of research space, and management, administration and other items required for the smooth execution of the center's

<Progress to date>

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

A medium-term plan developed by Tohoku University when the Center was established in FY2007 set specific goals for research standards and research achievements. Measures proposed to meet these goals include promoting innovative studies at WPI-AIMR, a world-class research base, to create advanced materials for practical application and giving priority to establishing an organizational framework for such studies. The same measures are also incorporated in the second-phase medium-term plan formulated at the end of March, 2010. Tohoku University's action plan, the "Inoue Plan," states, under the chapter <Achieve world-class status rapidly by focusing on specific areas of research>, "Take steps to reinforce the organization of WPI-AIMR, so that it may play a leading role as part of a top-class international research network." As the host institution, in this fiscal year Tohoku University clarified its policy for providing focused support for research and for establishing an organizational framework. The university continues to provide that support based on this policy.

-Concrete Measures

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

An existing building designed for comprehensive study of material and physical property, located in the Katahira district, has been renovated so that researchers being invited to WPI can start research activity smoothly upon recruitment. A new WPI building for research activity has been constructed under the first-phase and second-phase projects. The new WPI building provides space for PIs who had belonged to the host institution before the establishment of the Center, when they find a need to secure extra space at their laboratories for advanced study.

Thanks to sufficient financial support and support through provision of necessary goods, environments for research activities have been improved in various fields. Among such fields are payments of salary for PIs and administrative staff, financial support of research activities, installation of

research. Aside from that, the host institution will provide the researchers with priority access to the Technology Center for Research and Education Activities' high-performance electron microscopes and other research equipment and assistance so that the center can implement global top-level research.

In addition to this support from the host institution, the researchers who will participate in the center obtained approximately 11000000 US $ in outside funds in FY 2006, and they are projected to obtain an equal or greater amount of research funds once they are at the center. Thus overall the host institution fully expects to secure an amount of resources for the center that is equal or greater than the amount of support provided by this program.

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

To secure the independence of the center administration, the host institution will limit its authority to extremely important items such as the appointment and dismissal of the Center Director, and leave all other personnel, budget execution and other items effectively under the discretion of the Center Director.

For personnel matters, the host institution will only retain authority over the appointment and dismissal of the Center Director, and have all other personnel items within the center including the employment of lead researchers determined by the Center Director.

The budget allotted to the center (personnel expenses and non-personnel expenses) will be turned over in its entirety for free execution at the judgment of the Center Director, and it will be possible to carry over funds allocated for budget items that are not implemented by the end of the fiscal year to the subsequent fiscal year.

(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

After Tohoku University is selected for this program, the Council of Department Heads Concerned with the World Premier International Research Center (WPI) Initiative will continue to actively support the Center Director, meeting at his request and as otherwise needed to secure the cooperation of the related departments for the greater vitality of the center research activities.

facilities for smooth research operations at the Center, renovation of laboratories for expanded research space and financial backing for management of the Center.

As well as receiving financial support from the host institutions, researchers working at the Center obtained ¥2,311,162,000 of external funds in FY2010. In the process, the host institution has secured human resources whose prospective research-related value surpasses the sum it has paid for this program.

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

Authority given to the host institution regarding operations of the Center is limited to the appointment and dismissal of the Center Director. Authority for remaining matters – decision-making on all personnel affairs such as the approval of recruited PIs and flexible execution of budgetary items in connection with expenditures allotted by the host institution – is granted to the Center Director. This practice, promised by the president of the host institution in the initial stage, has been implemented steadily since the foundation of the Center.

Given the fact that English is the commonly used language at the Center, documents to be prepared there will use the English language. This is to be accompanied by efforts to enhance the language skills of relevant staff. The Center will be ahead of the host institution in preparing documents in English if this measure is implemented as pioneer case which will be diffused in the host institution.

(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 coordination committee set up within the host institution was designed to convene a conference attended by researchers within the institution. Coordination is actually handled by the conference, which is comprised of the chiefs of eight relevant departments of Tohoku University (the host institution). The conference, chaired by the president of the host institution, has been operating since the plan for establishing the Center was announced. After this program was adopted, the conference has remained under the leadership of the president of the host institution. The conference is convened on a non-regular basis, i.e., when the Center Director requests holding it. While cooperating with the relevant departments of the host institutions, the conference is prepared to give full support to the Center Director. In FY2009, the conference strongly requested the chiefs of

	the relevant departments to give consent to a proposal to transfer PIs to the Katahira campus from the Aobayama campus when the WPI research building is completed under the third-phase project. The conference approved the proposal as requested. Meanwhile, WPI-AIMR created an in-house council in June 2010. The council, consisting of the head of the relevant departments and institutes, is supposed to offer advice to the director of the Center from a broad perspective.
(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 plan to establish an international advisory board, including Nobel Prize recipients as members, which will report directly to the Center Director to support top-down type decision making by the Center Director. To these ends, the president of the host institution will make the necessary requests for cooperation from Nobel laureates. In addition, an environment will be established, including the use of Internet technologies, to facilitate swift consensus building and organic linkages between the Center Director and the international advisory board, and . Also, so that work at the center can be conducted smoothly in English, we will assign staff with superior English skills, in addition to expertise in such fields as accounting, personnel and research assistance, as administrative staff on a priority basis. To introduce a compensation system that reflects researchers' abilities, we will urgently examine the introduction of new systems including a "Fellow Professor" (tentative name) system aiming at balance with the salaries paid by universities in the Tokyo area for professors playing leading roles in the research, as well as a system for preparations payments or contract conclusion payments when absolutely necessary for the invitation of Nobel Prize class researchers, etc. Tohoku University's "University Professor System" will also be actively used to invite the world's cutting-edge researchers to the center. A standing task team will also be established with the office of the President taking the lead of it for rapid examinations and responses in cases when the Center Director requests the flexible administration, revision, improvement or adjustment of the host institution's systems, and the host institution will otherwise prepare an environment for the smooth conduct of top management by the Center Director.	(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 Among the Advisory Board members, Dr. Rohler, Dr. Bednorz, Dr. Gleiter and Dr. Narayanamurti visited the Center and held informal talks with other researchers there. These four foreign researchers also inspected offices used as laboratories. They exchanged views with the Center Director and offered advice to him. In February 2011, the Advisory Board held an international meeting in Sendai. The meeting provided an important clue with regard to the direction of research activities to be taken by the Center. Among the current members of the Advisory Board, one elderly member will be allowed to leave due to old age while others will also leave because of their tight schedule. In their place, one person, a Nobel Prize Laureate, will be accepted as a new member. When the Center was created, employees with certain qualifications were preferentially recruited from the administrative staff who had been working at the host institution. Such qualifications included the ability to execute duties in English and expertise in such professional fields as accounting, personnel affairs and logistical support. In addition, administrative workers with English proficiency were newly recruited, making it easier for foreign researchers to start work at the Center. To further improve their English skills, some administrative workers are given the opportunity to take an English language course operated by an outside language school. At the office in charge of safety management, safety education for newly accepted researchers is provided both in Japanese and English, providing full support to foreign researchers. We proposed during the initial application phase that researchers would be guaranteed a research environment equivalent to that promised to "distinguished professors" in the United States. The first such treatment was financial incentives provided to PIs working full-time for the Center, who are given a monthly allowance of ¥100,000. The step was introduced at the time of the foundation of the Center. In addition, performance-based special allowances, divided into four ranks according to

	achievements made, began to be paid in FY2009. All researchers are eligible for this incentive money. The four ranks set for this system are ¥80,000 per month for an S-ranked researcher, ¥60,000 for an A-ranked researcher, ¥40,000 for a B-ranked researcher, and ¥20,000 for a C-ranked researcher. Special money paid based on the systematic evaluation of researchers' performance was the first at the host institution. Also, additional incentive money is given to a recipient of renowned science awards. If a researcher receives a world renowned science award, an extra amount of money – ¥5 million yen for a top-class award and ¥3 million for other awards – is added to his or her annual pay the following year. Setting of the annual income for employees at Tohoku University is flexible, with the chief of each department having leeway in deciding the amount. Even under such a flexible annual pay system, however, the addition of up to ¥5 million yen would be the largest ever for the university.
(5) Accommodation of center's requirements for infrastructural support (facilities, e.g., laboratory space; equipment; land, etc.) The host institution will operate a new core facility (building) for the center's activities so it can be used from around April 2008 as a target date. Research space will also be secured within the host institution's existing facilities. To secure research space in accordance with the advance of the research and the expansion of the center's research organization, the center will be given priority use of joint-use space at the university or campus level, and the Facilities Preparation and Administration Committee will deliberate all items of concern regarding the use of research space and other facilities and accommodate the center's needs.	(5) Accommodation of center's requirements for infrastructural support (facilities, e.g., laboratory space; equipment; land, etc.) In FY2007, the host institution renovated a building designed for the comprehensive research of material and physical property. A new WPI-AIMR building for research activities was also constructed under the first-phase project to secure space for researchers who are invited to the WPI. In FY2008, a WPI-AIMR main building under the second-phase project was built. As a result, in FY2009, the host institution provided a total of 14,300m^2 to researchers being invited to the Center. Financed by the supplementary budget for FY2009, a WPI-AIMR main building under the third-phase project is now under construction. The construction site of this project was provided by the host institution. The host institution has provided large-scale facilities to AIMR researchers through Tohoku University's basic research center.
(6) Support for other types of assistance The Tohoku University action plan "Inoue Plan 2007 (Toward Becoming a World Leading University)" released in April 2007 already clearly stipulates that the university will apply for the World Premier International Research Center (WPI) Initiative as a measure for strengthening Tohoku University's research foundations as a research-centered university. Moreover, based on the results of the 21st Century COE Program, Tohoku University established the International Advanced Research and Education Organization (completed April 2007) comprising the Institute for International Advanced Research and Education (established April 2006), which supports graduate students pursuing interdisciplinary fields, and the Institute for International Advanced Interdisciplinary Research (established April 2007),	(6) Support for other types of assistance Aiming to become one of the world leading universities, Tohoku University is willing to accept academic evaluation by a third party. As part of these efforts, the European University Association (EUA) visited the university in October two years ago and made an on-the-spot inspection. In January last year, the Center was also subject to such inspection, accepting the EUA's evaluation visit in view of internationalization and promotion of fusion research.

which promotes interdisciplinary research by young researchers. The global COE Program at the University is advancing its activities in coordination with this Organization, and those activities will be smoothly transferred to this Organization when the COE Program is finished.

Tohoku University intends to provide the maximum support to the center as a special research zone within the host organization, arrange organic relations with the International Advanced Research and Education Organization, making them into vehicles for education and research and help us contribute, as one of the world's leading universities, to the development of our society.

<Future Policy and Concrete Plans>

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

After the WPI program is finished, we will set up a new research institute on materials science, tentatively called Tohoku University Advanced Institute for Materials Science, by reorganizing existing research institutes and research groups. The planned institution is expected to play a locomotive-like role in the host institution for its research activities in the most advanced fields and its internationalization.

-Concrete Measures

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

We will keep efforts so that researchers at the Center can continue to secure competitive research funds while the host institution will continue to provide goods and competitive funds to us. We will accept goods from the host institution and will respond flexibly to a possible request from the Aobayama district, devastated by the March 11 natural disaster, to use our laboratory space for their research activities, since the WPI-AIMR building in the Katahira district sustained minor damage.

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

A system will be maintained in which decision-making authority is given to the Center Director in the execution of duty relating to personnel affairs and budget allocation. The Center Director will maintain his autonomy from the host institution in these fields.

(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

For effective use of researchers within the host institution, coordination will be made on the budget execution and the provision of concurrent posts while taking into account their educational and research activities at other departments.

(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

English-fluent administrative staff will be assigned continuously, and we will reform our administrative division in summer 2011 to realize a unified service for foreign researchers. A performance-based pay system has been already established within AIMR. Ripple effects under this system are gradually spilling over into the host institution where the pay scale change is still slight between comparable employees. Departments at the host institution are increasingly adopting a top-down decision-making system, although their switch to the new system is gradual, depending on the situation of each department.

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

Since all researchers can work at Katahira campus, we will promote an efficient use of facilities.

(6) Support for other types of assistance

- 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

In view of creation of new materials science, the host institution will step up collaboration with the Center in the deployment of human resources. During the second phase (2012 or beyond), several PIs will be replaced by young and energetic PIs with outstanding talent. The host institution is supposed to give full support to this personnel change.

2. After the period of WPI project funding ends

The president of the host institution clearly said at an opening session for the 2011 WPI-AIMR Annual Workshop that the Center will become a core of the research complex together with other existing Research institutes and Departments of the University, following the completion of the current research program. After the program ends, the current facilities, including small research groups, will be reshuffled and reorganized into an advanced institute, which is expected to become an outpost for Tohoku University's research activities in the most advanced field and internationalization. The planned Advanced Institute is most likely to become a driving force to make Tohoku University "the World Leading University," as claimed by the host institution.

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
(1) Clear mission statement and a roadmap toward creating new material science	(1) In response to the direction provided by the Program Committee, we had a discussion with PIs and young researchers, while seeking advice from PD and PO, and decided to incorporate a mathematical viewpoint in our efforts to create a new materials science. In March 2011, we appointed the Chair of Mathematics Institute of Graduate School of Science, Tohoku University, a distinguished mathematician, as a PI of AIMR. In addition, we have chosen the creation of Green Materials, taking into account our academic excellence, as a specific target outcome to contribute to society. The road map was established to clearly indicate the process to Green Materials which realizes, "Energy Harvesting", "Energy Saving", and "Environmental Clean-up". See "2-3 Future objectives and specific plans" and Figures 2 and 3 for details of our future plan.
(2) Reinforcement of NanoChemBio or soft-material research	(2) The NanoChemBio Group was renamed as the Soft Materials Group and reorganized to specialize in interface physical chemistry and organic soft/hybrid materials. The newly formed group is focusing its research efforts on supercritical methods, surface chemistry, catalysts, and organic synthesis, in which AIMR excels. One PI specializing in biodevices was added to the Device/System Construction group in November 2010.

	In the Device/System Construction Group there are now two PIs and two junior PIs who are engaged in biodevice-related research. Soft materials-related research is also conducted by a junior PI in the Materials Physics Group. For particularly outstanding research results, see [Organic/inorganic hybrid nano/micro particles], [Nanoporous catalysts], [Biomimetics], [Organic gel] and [Super-hybrid materials] in "2-2-1 Research activities and outcomes." These outcomes will be further developed in the next phase.
(3) Strategy for establishing oversea satellites	(3) With regard to overseas satellites, the following two new features have been added in order to differentiate them from other partner institutions: (1) interdisciplinary exchange and (2) two-way exchange. More specifically, in the partnership with the University of Cambridge, an exchange program on "Non-Equilibrium Materials and Soft Materials," will be promoted with the Departments of Chemistry and Physics in addition to the Department of Materials Science & Metallurgy. The Institute of Chemistry, Chinese Academy of Sciences and AIMR will strengthen an exchange program on "Molecular Nanotechnology and Devices." In 2011, AIMR will start an exchange program on "Organic Electronics and Condensed Phase Phenomena" with the University of California, Santa Barbara.
(4) Improvement in the leadership of the center director	(4) An in-house council to provide advice from the standpoint of the entire university to the Director was formed within the university in June 2010. PI meetings had been held about once a month since October 2010 to communicate the Center Director's intentions thoroughly and exchange opinions until March 2011, when the PI meeting was expanded to include staff and renamed as a staff meeting, which is held regularly once a month. The staff meeting will also contribute to the hearing of young researchers' opinion. The Deputy Director will be appointed in the FY 2011 and the organization will be reformed in such a way that the Director and Deputy Director are able to cooperatively strengthen the management of the Center and can establish a top-level research center in the world smoothly. All those measures taken such as convening of staff meeting, the appointment of the Deputy Director and the establishment of the road map written above were realized under a strong leadership of the Center Director.

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
(1) Formulation of a long-term strategy	(1) See 10-(1) above.
(2) Early holding of meeting of the International Advisory Board	(2) The International Advisory Board Meeting was held on February 24, 2011, to

	discuss the future direction of AIMR. Valuable pieces of advice, including the one about the importance of basic research, were presented. The members generally agreed upon the matters described in 10 (1) - (3).
(3) Strengthening of Director's decision – making authority	(3) See 10-(4) above.
(4) Integration of young researchers with researchers abroad	(4) Young researchers are encouraged to be actively involved in research activities in overseas research institutions. More specifically, they will be required to make a short stay there.

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 Administrati e director	12
	Principal investigators (no. of persons): 29	96
	Other researchers (no. of persons): 12	17
	Research support staffs (no. of persons): 1	0
	Administrative staffs (no. of persons): 16	15
	Total	140
Pr ject activities	Gratuities and honoraria paid to invited principal investigators (no. of persons): 0	0
	Cost of dispatching scientists (no. of persons): 0	0
	Research startup cost (no. of persons): 4 Groups	0
	Cost of satellite organizations (no. of satellite organizations):1	0
	Cost of international symposiums (no. of symposiums): 2	5
	Rental fees for facilities	0
	Cost of consumables	3
	Cost of utilities	0

Ten thousand dollars (Exchange Rate: JPY/USD=120)

WPI grant 472

Costs of establishing and maintaining facilities in FY 2007 251

Establishing new facilities: Integration Lab Bldg. "Phase II"
(Number of facilities: 2,600m²) Costs paid: 251

Repairing facilities
(Number of facilities: , m²) Costs paid: 0

Others 0

Cost of equipment procured in FY 2007 230

Nano Indenter
Number of units: 1 Cos s paid: 13

High-speed AFM
Number of units: 1 Costs paid: 13

AFM
Number of units: 1 Costs paid: 9

HPES System
Number of units: 1 Costs paid: 10

Laser Amplifier System
Number of units: 1 Costs paid: 13

SoC Test System
Number of units: 1 Costs paid: 9

Glovebox System

	Other costs	95
	Total	103
Travel	Domestic travel costs	2
	Overseas travel costs	8
	Travel and accommodations cost for invited scientists (no. of domestic scientists): 33 (no. of overseas scientists): 32	9
	Travel cost for scientists on secondment (no. of domestic scientists): 5 (no. of overseas scientists): 0	1
	Total	20
Equipment	Depreciation of buildings	0
	Depreciation of equipment	254
	Total	254
Other research projects	Projects supported by other government subsidies, etc.	0
	Commissioned research projects, etc.	537
	Grants-in-Aid for Scientific Research, etc.	82
	Total	619
Total		1,136

Number of units: 1 Costs paid: 9
LP-CVD
Number of units: 1 Costs paid: 17
Scanning Nano Indenter
Number of units: 1 Costs paid: 11
PLD System
Number of units: 1 Costs paid: 9

Others 73units 117

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): 0	
	Administrative staffs (no. of persons): 0	
	Total	0

Project activities		1
Travel		3
Equipment		0
Other research projects		0
Total		4

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

i) Overall project funding

Ten thousand dollars (Exchange Rate: JPY/USD=120)

Cost Items	Details	Costs (10,000 dollars)
Personnel	Center director and Administrative director	16
	Principal investigators (no. of persons): 29	147
	Other researchers (no. of persons): 54	282
	Research support staffs (no. of persons): 13	34
	Administrative staffs (no. of persons): 26	24
	Total	503
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons): 66	15
	Cost of dispatching scientists (no. of persons): 0	0
	Research startup cost (no. of persons): 0	0
	Cost of satellite organizations (no. of satellite organizations):0	0
	Cost of international symposiums (no. of symposiums): 1	2

WPI grant 1,251

Costs of establishing and maintaining facilities in FY 2008 792

Integration-Lab Bldg. Ⅱ
(Number of facilities:3,346m²) Costs paid: 648

Re airing facilities
(Number of facilities: , m²) Costs paid: 0

Others 144

Cost of equipment procured in FY 2008 919

Electron Microscope:
Number of units:1 Costs paid: 64

Analyti al Tran mission Electron Microscope:
Number of units:1 Costs paid: 183

MPMS:
Number of units:2 Costs paid: 58

Fs Laser Amplifier System:

	Rental fees for facilities	0
	Cost of consumables	30
	Cost of utilities	1
	Other costs	193
	Total	241
Travel	Domestic travel costs	7
	Overseas travel costs	19
	Travel and accommodations cost for invited scientists (no. of domestic scientists): 30 (no. of overseas scientists): 3	6
	Travel cost for scientists on secondment (no. of domestic scientists): 8 (no. of overseas scientists): 2	5
	Total	37
Equipment	Depreciation of buildings	25
	Depreciation of equipment	292
	Total	312
Other research projects	Projects supported by other government subsidies, etc.	68
	Commissioned research projects, etc.	133
	Grants-in-Aid for Scientific Research, etc.	408
	Total	609
Total		1,707

Number of units:1 Costs paid: 52
Spectrophotometer:
Number of units:2 Costs paid: 21
Solid-Liquid Interface AFM:
Number of units:3 Costs paid: 37

Nano Indenter:
Number of units:1 Costs paid: 13
VLSI test System:
Number of units:2 Costs paid: 19
HPES System:
Number of units:1 Costs paid: 10
High-Resolution AFM:
Number of units:2 Costs paid: 10

HPES System:
Number of units:1 Costs paid: 18

Others 444

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): 7	
	Research support staffs (no. of persons): 0	
	Administrative staffs (no. of persons): 0	
	Total	28
Project activities		13
Travel		10
Equipment		0
Other research projects		0
Total		51

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

i) Overall project funding

Ten thousand dollars (Exchange Rate: JPY/USD=100)

Cost Items	Details	Costs (10,000 dollars)
Personnel	Center director and Administrative director	27
	Principal investigators (no. of persons): 19	233
	Other researchers (no. of persons): 88	447
	Research support staffs (no. of persons): 20	54
	Administrative staffs (no. of persons): 24	106
	Total	867
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons): 11	12
	Cost of dispatching scientists (no. of persons): 2	2

WPI grant	1,350
Costs of establishing and maintaining facilities in FY 2009	732
Establishing new facilities (Number of facilities: 6,600m²) Costs paid:	656
Repairing facilities (Number of facilities: , m²) Costs paid:	0
Others	76
Cost of equipment procured in FY 2009	1,091
Multi-Beam System Number of units:1 Costs paid:	94

	Research startup cost (no. of persons): 37	69
	Cost of satellite organizations (no. of satellite organizations): 0	0
	Cost of international symposiums (no. of symposiums): 3	24
	Rental fees for facilities	0
	Cost of consumables	75
	Cost of utilities	21
	Other costs	99
	Total	302
Travel	Domestic travel costs	5
	Overseas travel costs	23
	Travel and accommodations cost for invited scientists (no. of domestic scientists): 76 (no. of overseas scientists): 35	13
	Travel cost for scientists on secondment (no. of domestic scientists): 3 (no. of overseas scientists): 4	3
	Total	44
Equipment	Depreciation of buildings	76
	Depreciation of equipment	799
	Total	875
Other research projects	Projects supported by other government subsidies, etc.	0
	Commissioned research projects, etc.	1,197
	Grants-in-Aid for Scientific Research, etc.	266
	Total	1,463
Tota		3,551

Sample Carrying System
Number of units:1 Costs paid: 16
Ultra-High Quality Vacuum Chamber
Number of units:1 Costs paid: 15
High-Temp. Vacuum Autoclave
Number of units:3 Costs paid: 15
Compact Kneading Machine
Number of units:1 Costs paid: 14
CL Measurement System
Number of units:1 Costs paid: 13
Excimer Laser
Number of units:1 Costs paid: 12
Sputtering System
Number of units:1 Costs paid: 11
Parallel Computing System
Number of units:1 Costs paid: 10
High-Speed Scanner
Number of units:1 Costs paid: 7
Others 884

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): 10	
	Research support staffs (no. of persons): 0	
	Administrative staffs (no. of persons): 0	
	Total	53
Project activities		16
Travel		12
Equipment		0
Other research projects		0
Total		81

FY2010 (the exchange rate used: JPY/USD=85)

i) Overall project funding

Ten thousand dollars (Exchange Rate: JPY/USD=85)

Cost Items	Details	Costs (10,000 dollars)
Personnel	Center director and Administrative director	33
	Principal investigators (no. of persons): 19	262
	Other researchers (no. of persons): 97	584
	Research support staffs (no. of persons): 16	53
	Administrative staffs (no. of persons): 22	110

WPI grant		1,588
Costs of establishing and maintaining facilities in FY 2010		235
Establishing new facilities (Number of facilities: 6,600m²)	Costs paid:	235
Repairing facilities (Number of facilities: , m²)	Costs paid:	0
Others		0

	Total	1,042
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons): 12	20
	Cost of dispatching scientists (no. of persons): 0	0
	Research startup cost (no. of persons): 29	99
	Cost of satellite organizations (no. of satellite organizations): 0	0
	Cost of international symposiums (no. of symposiums): 1	28
	Rental fees for facilities	0
	Cost of consumables	15
	Cost of utilities	29
	Other costs	87
	Total	278
Travel	Domestic travel costs	1
	Overseas travel costs	8
	Travel and accommodations cost for invited scientists (no. of domestic scientists): 44 (no. of overseas scientists): 29	10
	Travel cost for scientists on secondment (no. of domestic scientists): 1 (no. of overseas scientists): 2	1
	Total	20
Equipment	Depreciation of buildings	125
	Depreciation of equipment	852

Cost of equipment procured in FY 2010 523

Super-high vacuum compound deposition system
Number of units:1 Costs paid: 18

Preparation chamber for device fabrication
Number of units:1 Costs paid: 14

High repetition rate streak camera
Number of units:1 Costs paid: 14

Supercritical Hydrothermal Nano-particles Synthesis System
Number of units:1 Costs paid: 13

Fluorescence Microscope
Number of units:1 Costs paid: 12

Nano-Laser Meter
Number of units:1 Costs paid: 9

Annealing furnace
Number of units:1 Costs paid: 8

Pressure vessel for high-purity crystal growth
Number of units:1 Costs paid: 8

φ20 high temperature autoclave
Number of units:1 Costs paid: 7

Variable Normal Load Friction and Wear Measurement System
Number of units:1 Costs paid: 7

Others 413

	Total	977
Other research projects	Projects supported by other government subsidies, etc.	0
	Commissioned research projects, etc.	1,872
	Grants-in-Aid for Scientific Research, etc.	371
	Total	2,243
Total		4,560

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): 20	
	Research support staffs (no. of persons): 0	
	Administrative staffs (no. of persons): 0	
	Total	96
Project activities		21
Travel		13
Equipment		0
Other research projects		0
Total		130