MANA Progress Report

Facts and Achievements 2016

World Premier International (WPI) Research Center
International Center for Materials Nanoarchitectonics (MANA)

National Institute for Materials Science (NIMS)

Preface

Masakazu Aono
MANA Director-General
NIMS

The International Center for Materials Nanoarchitectonics (MANA) was established in October 2007 as one of the initial five research centers in the framework of the World Premier International Research Center Initiative (WPI Program), which is sponsored by Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). This year marks the tenth anniversary of the start of MANA. We are happy to see that MANA has grown to become one of the world's top research centers in materials science and technology and produced remarkable results in fields ranging from fundamental research to practical applications.

MANA is conducting research on the basis of the new concept "Nanoarchitectonics". This concept has been refined continuously by MANA's researchers and is now accepted around the world. As we follow this concept, MANA strives to extract the maximum value from nanotechnology for the development of appropriate materials for new innovative technologies. I humbly request your warm support as we continue our earnest efforts.

The MANA Progress Report consists of two booklets named "Facts and Achievements 2016" and "Research Digest 2016". This booklet "Facts and Achievements 2016" serves as a summary to highlight the progress of the MANA project. The other booklet "Research Digest 2016" presents MANA research activities.

Nano Revolution
for the Future

MANA Progress Report
Facts and Achievements 2016

1. WPI Progress Report: Executive Summary

In June 2016, MANA submitted a WPI Progress Report to the WPI Program Committee. The part entitled *World Premier International Research Center Initiative (WPI) Executive Summary (for Final Evaluation)* is reproduced below. During the 10 year period of WPI funding of MANA, this is the last Executive Summary. It has also been included in chapter 1 of the previous booklet *Facts and Achievements 2015* that has been produced in June 2016.

Host Institution: National Institute for Materials Science (NIMS)
Host Institution Head: Kazuhito Hashimoto
Research Center: International Center for Materials Nanoarchitectonics (MANA)
Center Director: Masakazu Aono

World Premier International Research Center Initiative (WPI) Executive Summary (for Final Evaluation)

A. Progress Report of the WPI Center

I. Summary

In the eight and a half years since it was established, MANA has grown to become one of the world's top research centers in the relevant fields and produced remarkable results in fields ranging from fundamental research to practical applications.

MANA's excellence can be found represented in several key indicators. Among these, A) 118 of MANA's papers are now among the top 1% most cited papers in the world; B) MANA has achieved an extremely high score of 2.42 for Elsevier's Field Weighted Citation Impact (FWCI), a new index created to "fairly compare the quality of papers published by research institutions that work in different fields" (both A and B refer to statistics for papers published between 2008 and 2015); and C) MANA's papers are printed in journals with an extremely high average Impact Factor (IF) of 6.25 (2015). MANA's scores for these indicators are superior to those of many world-class research institutions.

MANA has a unique characteristic compared to other materials science laboratories in the world. Its operations are based on a new concept: a new nanotechnology paradigm called "nanoarchitectonics". This unique concept is the key to MANA's achievement of its striking research results.

In eight and a half years, MANA has accomplished much outstanding research. Some representative examples include a) nanosheet technology and its applications, b) atomic switches and related devices, c) various unimolecular devices, d) highly efficient photocatalysts, e) highly sensitive / parallel molecular sensors (MSS odor sensors, etc.), f) diagnosis and treatment using nanoarchitectonics, g) transmission electron microscopes that can observe electrical, mechanical, and optical properties under high-resolution structural observation, and h) multiple-probe scanning probe microscopes that can measure electrical conductivity at the nanoscopic scale.

Over 50% of the researchers at MANA are non-Japanese, making it the most internationalized research center in Japan. MANA has succeeded in creating an almost perfect environment in that it expeditiously provides administrative and technical support to all MANA researchers, including non-Japanese researchers. MANA can give back to NIMS the obtained knowhow and experience of management an international research center. For example, English-language support for non-Japanese researchers within NIMS as a whole has been greatly improved.

In addition to the WPI program's four pillars, MANA has one extra pillar of its own: the cultivation of young researchers. MANA's systems of independent researchers (approx. 20% of permanent researchers), who pursue their own research topics without belonging to any specific group, and ICYS researchers (approx. 20% of post-doctoral scholars) have attained remarkable achievements.

Since FY 2012, MANA has been defined as one of NIMS's three research arms, and it is becoming a permanent presence within the NIMS research organization. NIMS also provides salaries for approximately 90 permanent staff and otherwise provides comprehensive support for MANA in many ways, something that will continue on into the future.

II. Items

1. Overall Image of our Center

<Vision and background>

When MANA was launched eight and a half years ago, nanotechnology (and the nanoscience on which it is based) was in a state of rapid development and becoming an essential pillar of materials science. It was in this context that we designed MANA with the intention of cultivating a world-class research center that would effectively employ nanotechnology to make powerful advances in the research and development of new materials. We were strongly aware of the common mistake of considering nanotechnology to be a continuation of conventional microtechnology, and moreover that nanotechnology's true power cannot be effectively harnessed unless nanotechnology is properly recognized as being qualitatively different from microtechnology. Thus, we established MANA's guiding vision as "Pioneering a new paradigm of nanotechnology to create a research hub for the best new materials development in the world". In order to concisely express this new technology paradigm, we coined the concept of nanoarchitectonics. This concept is described in more detail in the "Progress Report", but it serves to distinguish MANA's research from other nanotechnology research institutions. We at MANA are pleased to see that the nanoarchitectonics concept has begun to gain approval throughout the world.

<MANA today>

MANA was founded on research in four fields—Nano-Materials, Nano-System, Nano-Power, and Nano-Life—but in FY 2016 it established a new field, Nano-Theory. At present, MANA houses 25 principal investigators, 2 associate principal investigators, 75 permanent researchers, 72 post-doctoral researchers, and 36 students who conduct research in 5 fields. These researchers are supported by 29 administrative and technical staff. The present state of MANA can be summarized by the following five points:

- ★ Achieved world-class research activities
- ★ True international center with over half of researchers being of foreign nationality
- ★ Active fusion research that combines nanotechnology and other fields
- ★ Steadily fulfilling its responsibility to reform its host institution, NIMS
- ★ Training excellent young researchers who work throughout the world

<Future outlook>

Building on eight and a half years of experience and confidence, MANA pursues interdisciplinary, fusion research centered around the fusion of "theoretical research and experimental research", and the fusion of "nanotechnology (nanoarchitectonics) and life science". Our final objective is to develop through innovative technologies new materials that will shake up the world. There is tremendous potential for this goal to be realized.

2. Research Activities

< Remarkable research accomplishments>

As explained above, MANA's research is conducted in five fields (Nano-Materials, Nano-System, Nano-Power, Nano-Life, and Nano-Theory.) Below are the main accomplishments of each field of research.

A) Inventing nanosheet-based new materials: MANA developed and implemented creative nanosheet methods used to create a variety of new materials with novel and useful properties. The next step is to use these methods to create metamaterials and new superconductors.

B) Development of atomic switches and related devices/systems: The atomic switch operated by a completely different principle than traditional semiconductor devices. MANA invented the atomic switch and moved it toward practical application, where it brought innovation to things like AI and IoT. It was also discovered that atomic switches display functionality similar to synapses in the brain, and hence the next step is to create neutral network circuits made out of atomic switches.

C) Best high-efficiency artificial photosynthesis in the world: As an example of this, MANA has succeeded in achieving the artificial photosynthesis of methane. The next step is to use a variety of nanoarchitectonic systems to dramatically improve the efficiency of artificial photosynthesis.

D) High-sensitivity / parallel molecular sensors (membrane-type surface stress sensor (MSS)): MANA developed a molecular sensor that is a hundred times more sensitive than traditional molecular sensors, capable of distinguishing between healthy individuals and cancer patients by analyzing their exhaled breath. MANA is currently researching such applications.

E) Development of a revolutionary method of nanoscale measurement: MANA developed a transmission electron microscopy (TEM) that can measure electrical, mechanical, and optical properties in high resolution. MANA also developed multiple-probe (2/3/4 probes) scanning tunneling microscope (STM), atomic force microscope (AFM), and Kelvin probe force microscope that can measure electrical conductivity at the nanoscopic scale.

<MANA's three Grand Challenge research topics>

MANA has posted three Grand Challenge research topics:

- ★ Artificial brains based on nanoarchitectonics
- ★ Room-temperature superconductivity
- ★ Practical artificial photosynthesis

These are long-term research targets, but interesting results are already being achieved. Themes 1 and 3 were touched upon lightly in sections B and C on the previous page. Theme 2 has seen achievement in attempts to create superconductivity by introducing electrons and holes into insulators and semiconductors using field effects. In these attempts, researchers succeeded in metalizing diamond. Separately, it has been theorized that when heavy atoms such as gold are formed into a two-dimensional buckled honeycomb lattice and an electric field is applied perpendicularly, current will flow along its edge with zero resistance, even at high temperatures up to 600 K. Experiments are underway in an attempt to verify this theory.

<Applications of research achievements>

Most of MANA's fundamental research has led to research into applications conducted in cooperation with a variety of companies including NEC Corporation, Honda Motor Company, Murata Manufacturing Co., and Tokyo Chemical Industry Co. Additionally, MANA researchers applied for a total of 774 patents (541 domestic; 233 international) in the period between October 2007 and December 2015. Meanwhile, MANA registered 581 patents (441 domestic; 140 international) in this same period.

3. Interdisciplinary Research Activities

<Strategic initiatives>

MANA has established the following special funds in order to promote interdisciplinary research that fuses MANA's five fields (Nano-Materials, Nano-System, Nano-Power, Nano-Life, and Nano-Theory).

A) Fusion Research Program
B) Theory-Experiment Fusion Research Program
C) Nano-Life Fusion Research Program
D) Grand Challenge Program
E) Theory-Experiment Pairing (TEP) Program

Research topics were determined through a public submission campaign conducted among young MANA researchers. The final topics were selected by a selection committee.

<Representative achievements>

The following are representative achievements of MANA's interdisciplinary, fusion research.

- Broad-ranging nanosheet technology research; from fundamental research through application
  (Combination of Soft Chemistry, Materials Physics, and Electronic Device Technology)
- Broad-ranging atomic switch research; from fundamental research through application
  (Combination of Electrochemistry, Electronic Device Technology, and Neuroscience)
- Development and practical implementation of highly sensitive / parallel molecular sensors
  (Combination of Science on Animal Olfactory Organs, Nanoarchitectonics, and Medical Diagnosis)
- Development of efficient artificial photosynthetic systems
  (Combination of Photocatalytic Chemistry, Plant Photosynthesis, and Nanoarchitectonics)
- Nanoarchitectonic treatments for cancer and Alzheimer's disease
  (Combination of Medical Science and Nanoarchitectonics)
- Development of new superconductor devices
  (Fusion of theoretical and experimental research)

4. International Research Environment

<International Brain Circulation>

MANA has established satellite labs at research institutions to which external PIs belong. MANA Satellites are currently established overseas at 5 institutions including the University of California Los Angeles (UCLA), the Georgia Institute of Technology, the French National Centre for Scientific Research (CNRS) / Center for Materials Elaboration and Structural Studies (CEMES), the University of Montreal, and University College London (UCL). These satellites both play a role in MANA's research in various fields and are also training grounds for MANA's younger researchers. Furthermore, MANA is visited by large numbers of prominent researchers, young faculty students, and other researchers located both inside and outside of Japan. These numbers are increasing every year.

ICYS researchers are on a tenure track to becoming permanent NIMS research staff, and they are hired during twice annual international application phases. Applications have been received from 1,310 individuals over a period of nine years. 90 were hired and 45 of them were assigned to ICYS-MANA.

Of MANA post-doctoral scholars, 12 have been hired on as permanent NIMS research staff, while 198 have advanced to become researchers at universities and research institutions in Japan and around the world. Further, 27 individuals have been sent to private companies.

One of MANA's missions is to build a network of the world's nanotech research centers, of which MANA is the central hub. MANA has signed MOUs with 56 research institutions from 19 countries with which it engages in research and talent exchange.

<Support system for non-Japanese researchers>

All staff in MANA's Administrative Office speak English and provide comprehensive Japanese-style service to all researchers, regardless of age and nationality. However, we did not simply bring a foreign research environment into Japan; instead, we have built an "international research support system in Japan," where non-Japanese personnel can blend right in.

<Administrative support staff and appropriate support systems>

MANA has succeeded in creating an almost perfect environment in that it expeditiously provides administrative and technical support to all MANA researchers, including non-Japanese researchers. Some representative examples of this environmental support are the bilingualization of documents and communication, livelihood support, technical support, Japanese language classes, and Japanese cultural training.

<Other>

As one method of attracting and cultivating young researchers, MANA's systems of independent researchers (who do not belong to any specific group and pursue research independently) and ICYS researchers have produced great results.

In the interest of cultivating Japanese researchers of an international and interdisciplinary character, MANA encourages young Japanese researchers to take up long work residencies at major research institutions overseas. MANA has also established the YAMATO-MANA Program, the objective of which is to invite excellent young Japanese researchers to MANA and cultivate talent who will lead Japan's future.

5. Organizational Reforms

<Decision-making organization>

The center's Director-General has succeeded in gathering excellent researchers from around the world and building a research culture in which these researchers can work freely and easily while working hard and improving together. The Director-General has displayed strong leadership in his management of the center, including his work setting research policy, streamlining systems and organizations, implementing effective new policies, and distributing research resources. He has created an established global presence for the nanoarchitectonics concept by holding numerous research conferences, publishing special nanoarchitectonics editions of famous journals, distributing online newsletters, and other PR activities. Indeed, there is even happy news that the word "nanoarchitectonics" will be in the next revision to the famous and authoritative Japanese dictionary, *Kojien*.

<Administrative support staff and appropriate support systems>

MANA has succeeded in creating an almost perfect environment in its capacity to expeditiously provide administrative and technical services to all MANA researchers, including non-Japanese researchers.

<WPI program organizational reforms and their ripple effects>

<u>Organizational reforms at MANA</u>

(1) Strongly promoted interdisciplinary research by launching new research programs.

(2) Intensified internationalization at MANA through measures such as promoting bilingual administration and offering research and living support for non-Japanese researchers.

(3) Secured and cultivated young researchers by implementing ICYS, the 3D System, and others.

<u>Ripple effects on the host organization as a whole, etc.</u>

(1) The structure has been put in place to easily spread MANA's organizational reforms to the entirety of NIMS. In the NIMS Mid- to Long-Term Plan (7-year plan), MANA is defined as one of seven core research centers.

(2) Overall English ability at NIMS has been dramatically improved by the implementation of programs to improve the English ability of administrative staff, the translation of important documents and internal announcements into both English and Japanese ("bilingualization"), and other initiatives.

(3) Many excellent young researchers who came of age at MANA have been hired on at NIMS as permanent research staff.

(4) MANA's experience and achievements have spread to NIMS's other research centers: e.g., building design.

(5) Center management offices aspiring to be similar to MANA's Administrative Office have been set up at other NIMS research centers.

<Support from the host institution>

NIMS offers comprehensive support for MANA, providing staff, research funding, and research space to the program, as well as delegating management authority to the Director-General. Since MANA's founding, over 1.4 billion JPY annually has been allocated from NIMS's operational expense grants to pay for research projects and other project expenses necessary to the center's activities.

<Role in the host institution's mid/long term plans, etc.>

In its 3rd five-year plan that began in April 2011, MANA's work in the development of innovative new materials through nanoarchitectonics was recognized as a priority R&D area for NIMS, and MANA was defined as one of NIMS's three research arms: namely, the Nanoscale Materials Division. Further, in NIMS's 4th Mid- to Long-Term Plan (7-year plan), the "International Center for Materials Nanoarchitectonics (MANA)" is explicitly defined as one of NIMS's main research centers. NIMS is also methodically increasing the number of permanent researchers and administrative staff on board at MANA. Thus from April 2011 to March 2016, MANA added 18 permanent staff to its roster, meaning that as of the end of March 2016, MANA had a total of 89 permanent staff.

B. Progress Plan

1. Mid- to Long-term Research Objectives and Strategies Based on the Center's Research Results to Date

<Overview>

After analyzing MANA's research accomplishments over the past eight and a half years, the efficacy of two areas was brought into sharp relief: the fusion of "theoretical research and experimental research", and the fusion of "nanotechnology (nanoarchitectonics) and life science." Therefore, these two fusional areas will be the focus of intensive research in the future.

Additionally, analysis of progress on MANA's three Grand Challenge research themes shows that promising preliminary results are in the process of emerging, and hence this research will also be continued.

<Fusion of theoretical and experimental research>

As stated previously, MANA established in FY 2016 a fifth new field in addition to its four traditional fields of research: Nano-Theory. The Nano-Theory field will constitute a large group of 30 theoretical researchers. This means that approximately one in five MANA researchers will be a theoretical researcher.

Despite the fact that many interesting nanoscopic phenomena are accompanied by excited states, dynamic processes, and many-body effects, contemporary methods of first-principles calculation are not good at handling these elements. To overcome this obstacle, MANA will introduce bold yet appropriate methods of approximation to inspire new developments in theoretical research, which will serve to promote the fusion of theoretical and experimental research. Not only will the field of Nano-Theory serve to fuse theory and experimentation, it will also play a role in promoting interdisciplinary fusion research among MANA's four other fields of research, all of which have experimental research at their core.

<MANA's unique Nano-Life research>

MANA established the Nano-Life field with the aim of opening up a new field that combines MANA's world-best nanotechnology with the life science. One important characteristic of MANA is its environment, in which the best nanotechnology researchers and life science researchers work side-by-side to gain a thorough understanding of each other's fields. This distinctive characteristic of MANA's has recently begun producing remarkable results. In the extension period, MANA will take advantage of these circumstances to completely remodel the Nano-Life field. MANA aims to create new, never-before-seen things and systems by studying the functions of cells, sensory organs, and the brain, incorporating the knowledge gained through this into the best nanoarchitectonics technology. Conversely, MANA will also strongly promote the active utilization of the best nanoarchitectonics technology in Nano-Life research.

<MANA's Grand Challenge>

MANA has laid out three Grand Challenge research targets thus far, and it will continue this work in the future. The outlook for future accomplishments in these areas is quite positive.

Now, MANA is adding a fourth Grand Challenge research target that pertains to the fusion of nanotechnology (nanoarchitectonics) and life science:

★ Super bio-sensing

By combining multiple-probe scanning probe microscopy, ultrasensitive / massively parallel molecular sensors, luminescent nano-particle, nanotubes, and other nanoarchitectonics technology with elements of life science pertaining to cells and biomolecules, we hope to open up a new world of super bio-sensing that is unique to MANA.

2. Management System of the Research Organization

<Research organization management>

In April 2016, one year before the end of the 10-year project period of MANA, the next Mid-Term Plan (7-year plan) starts at NIMS and MANA implements structural reforms based on the following key points: Creating and filling the position of a new deputy director, replacing PIs, establishing the Nano-Theory field, strengthening the Nano-Life field, investing in Grand Challenge research, promoting innovative and challenging research, promoting joint research with universities and private companies, etc.

<Initiatives and planning for organizational reform>

Reforming NIMS: The administrative experience and unique administrative and technical support systems cultivated at MANA will be exported to NIMS.

Internationalizing NIMS and Other Japanese Research Institutions and Universities: NIMS will work to export MANA's research environment to other research institutions and universities outside of NIMS.

Expanding the international network: MANA has grown into a well-known world-class research center that attracts researchers from around the globe. MANA will expand its international network beyond just America, Europe, and other developed countries to include countries that are still developing in terms of R&D, encompassing many countries from all regions of the world. In this way, MANA will fulfill its role as a hub for global nanotechnology R&D and the cultivation of young researchers.

3. Center's Position within the Host Institution, and Measures Taken by Host Institution to Provide Resources to the Center

<Role of the center in the mid/long term outlook of the host institution>

NIMS's next Mid- to Long-Term Plan will be a 7-year plan, and it will begin in April 2016, one year earlier than the conclusion of the initial WPI project implementation period (10 years). Even after the end of the WPI program, MANA will continue to be NIMS's main nanotechnology research center, take in most of NIMS's theoretical researchers, and become an even more solidified international nanotechnology research hub. Specifically, beginning in April 2016 seven research centers will exist within NIMS, and one of those will be MANA. With the theoretical researchers transferring to MANA, the augmented superconductor, and four new hires reinforcing MANA's roster, MANA will grow into a major research center with permanent staff numbering 104—approximately 1/4 of all permanent research staff at NIMS.

<Host institution's action plan for maintaining and developing activities befitting of a world-class research center>

NIMS promises provide MANA with the following research resources, and to continue those basic activities on into the future.

i) Although NIMS declared that it would assign approximately 90 permanent NIMS staff to MANA as permanent employees (including principal investigators, associate principal investigators, group leaders, MANA researchers, independent researchers, and administrative staff), from April 2016 this will be greatly increased to a total of 104 staff.

ii) NIMS will contribute 1.6 billion JPY a year out of its management expenses grant to pay for MANA's research project costs, administrative costs, etc.

After the WPI program concludes, in addition to i) and ii) above, the following policies will be implemented:

iii) Post-doctoral scholars and other fixed-term staff hired using WPI grant funds will be replaced with others hired using external funding.

iv) Programs characteristic of MANA—such as young researcher training programs (ICYS, etc.), symposiums, and outreach activities—will be transferred to and implemented at NIMS.

v) NIMS will implement organizational reforms, scrutinizing and strengthening its own systems with reference to the administrative and technical support that are of especially high quality at MANA.

vi) NIMS is planning to create new open innovation mechanisms that utilize promising research accomplishments at MANA and moves them toward practical applications research. Also a new scheme of internationalization is under designing which enable MANA to develop sustainable international networking with a help of MANA satellites.

2. WPI Program and MANA

The content of Section 2.1 is mostly based on information published on the website of Japan Society for the Promotion of Science (JSPS) in December 2016 (www.jsps.go.jp/english/e-toplevel/), from the wpi brochure (edition May 2016) that can be downloaded from there (www.jsps.go.jp/english/e-toplevel/data/wpi.pdf) and from "Future Plan for WPI Program" (www.jsps.go.jp/english/e-toplevel/data/161121_WPI%20Future%20plan%20E.pdf) announced by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in November 2016.

2.1 World Premier International Research Center Initiative (WPI)

The World Premier International Research Center Initiative (WPI) was launched in 2007 by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in a drive to build within Japan *globally visible* research centers that boast a very high research standard and outstanding research environment, sufficiently attractive to prompt frontline researchers from around the world to want to work in them. These centers are given a high degree of autonomy, allowing them to virtually revolutionize conventional modes of research operation and administration in Japan. Japan Society for the Promotion of Science JSPS is commissioned by MEXT to conduct the program's grant selection and project assessment processes and to perform other administrative functions.

The WPI logo is shown in Fig. 2-1. The emblem of the WPI adopts the motif of a bird, symbolizing the program's driving concept of "upward flight". Undaunted by today's turbulent global climate of twisting and turning winds, the bird flies on steady, azure wings through the sky. In its beak, it carries a seed of new innovation. This radiant dot over the "i" also serves to light the path ahead in pioneering the frontiers of scientific discovery.

Fig. 2-1: WPI logo.

● Outline of WPI Program

Competition for securing the world's finest brains has intensified over recent years. For Japanese science and technology to play a leading world role, Japan will need to place itself more within the global flow of outstanding human resources while creating open research platforms that attract such talents and produce outstanding results.

The WPI provides concentrated support for projects to establish and operate research centers that have at their core a group of very high-level investigators. These centers are to create a research environment of a sufficiently high standard to give them a highly visible presence within the global scientific community – that is, to create a vibrant environment that will be strong incentive to frontline researchers around the world to want to come and work at these centers.

The WPI has four basic objectives

- advancing leading edge research
- creating interdisciplinary domains
- establishing international research environments
- reforming research organizations

To achieve these objectives, WPI research centers are required to tackle the following challenges:

Critical mass of outstanding researchers

- Bringing together top-level researchers within a host research institution
- Inviting top-notch researchers from around the world

Attractive research and living environment of top international standard

- Strong leadership by the center director
- English as the primary language
- Rigorous system for evaluating research and system of merit-based compensation
- Strong support function
- Facilities and equipment appropriate for a top world-level research center
- Housing and support for child education and daily living

To assist the WPI research centers in carrying out this mandate, the Japanese government provides them with long-term, large-scale financial support.

Long-run financial support from the government

- About ¥1.3-1.4 billion annually per center
  (The 3 centers selected in FY2012 each receive up to ¥0.7 billion per year.)
- 10-15 years of financial support
- Interim evaluation at 5-year intervals

Meaning of "highly visible research cernters." The WPI holds following vision with regard to the research centers being established.

- At least, 10-20 world-class principal investigators
- A total of at least 100-200 staff members
- At all times, at least 30% of the researchers from overseas

● Selected WPI Programs

The National Institute for Materials Science (NIMS) was one of the original five institutes selected for a WPI grant in FY2007 and later in October of that year, established the International Center for Materials Nanoarchitectonics (MANA). A sixth WPI center was added in FY2010 and 3 more WPI centers were selected in FY2012. The 9 WPI research centers with MANA being the only one not integrated into a university are summarized in Table 2-1 and shown in Fig. 2-2.

In FY2011, the five initial WPI centers that were launched in October 2007 each underwent an interim evaluation by the WPI program committee and entered the second 5 year term of operation in April 2012. In FY2014, the five initial WPI centers each applied for a possible 5-year extension after their initial 10-year supporting period ends in March 2017. The WPI Committee determined that all 5 WPI centers have achieved "World Premier Status" fully meeting the goals of the WPI program. On top of that, the committee concluded that Kavli IPMU from The University of Tokyo is the only WPI center that will receive WPI subsidy for five more years.

Table 2-1: The 9 WPI research centers (as of December 2016).

Host Institution	Center Name (Starting Date)	Center Director	Outline of the Center
Tohoku University	Advanced Institute for Materials Research (AIMR) (Oct 2007)	Motoko KOTANI	Establish a World-Leading Research Organization in Materials Science
The University of Tokyo	Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU) (Oct 2007)	Hitoshi MURAYAMA	Cross-Disciplinary Research Center for Addressing the Origin and Evolution of the Universe
Kyoto University	Institute for Integrated Cell-Material Sciences (iCeMS) (Oct 2007)	Susumu KITAGAWA	Creating a new field of integrated cell-material science in the mesoscopic domain
Osaka University	Immunology Frontier Research Center (IFReC) (Oct 2007)	Shizuo AKIRA	Observation of immune reaction - Unveiling dynamic networks of immunity -
National Institute for Materials Science	International Center for Materials Nanoarchitectonics (MANA) (Oct 2007)	Masakazu AONO	Materials Nanoarchitectonics - New paradigm of materials development -
Kyushu University	International Institute for Carbon-Neutral Energy Research (I^2CNER) (Dec 2010)	Petros SOFRONIS	The Grand Highway for a Carbon-Neutral Energy Fueled World
University of Tsukuba	International Institute for Integrative Sleep Medicine (IIIS) (Dec 2012)	Masashi YANAGISAWA	World-class institute for sleep medicine, aiming to solve the mechanism of sleep/wakefulness by conducting basic to clinical research
Tokyo Institute of Technology	Earth-Life Science Institute (ELSI) (Dec 2012)	Kei HIROSE	Globally-Advanced Interdisciplinary Research Hub for Exploring the Origins of Earth and Life
Nagoya University	Institute of Transformative Bio-Molecules (ITbM) (Dec 2012)	Kenichiro ITAMI	Changing the world with molecules: Synthetic Chemistry and Plant/Animal Biology

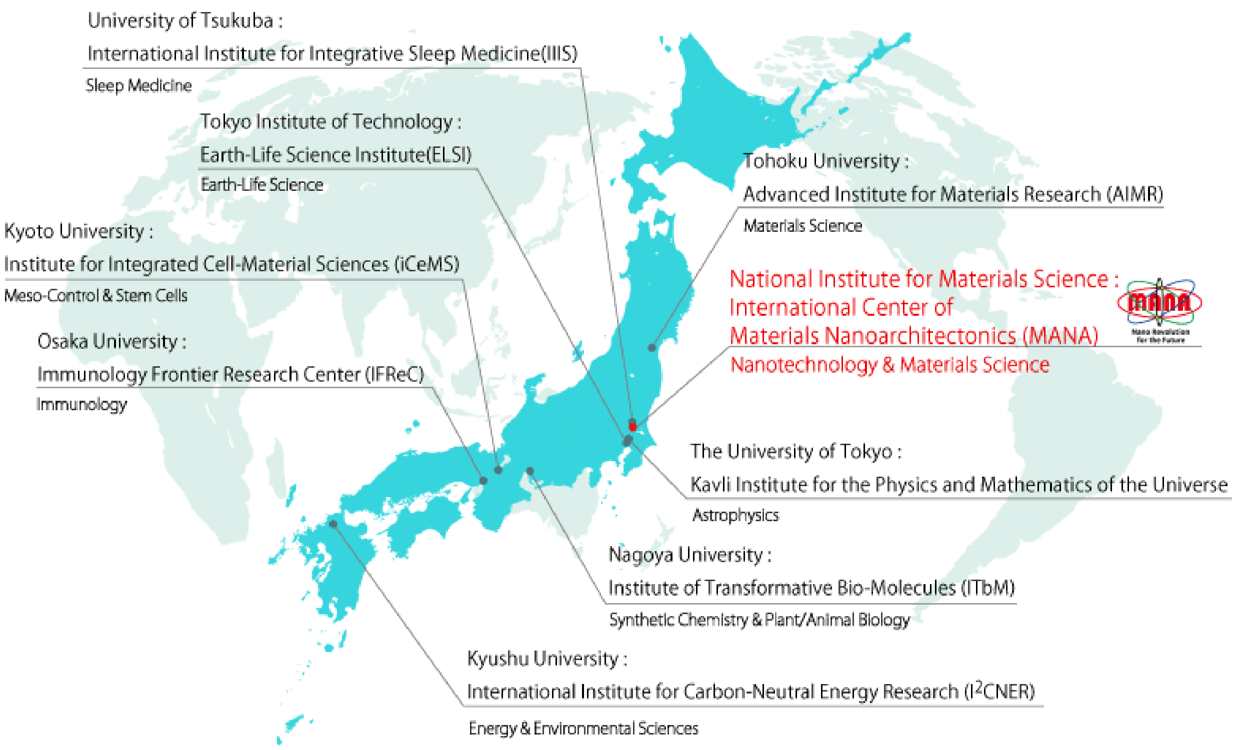


Fig. 2-2: Location of the 9 WPI research centers.

- **Outline of the 9 WPI Centers**

Advanced Institute for Materials Research (AIMR), Tohoku University

AIMR aims to establish a Premier Research Center for materials science, to reform the conventional Japanese system and to construct a visible center. To this end, the institute is assembling excellent researchers in the fields of physics, chemistry, materials science, bioengineering and electronic/mechanical engineering.

Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU), The University of Tokyo

Establishing a top-level research center visible worldwide for the most urgent issues of basic science such as dark energy, dark matter, and unified theories with a close collaboration of mathematics, physics and astronomy.

Institute for Integrated Cell-Material Sciences (iCeMS), Kyoto University

Our institute seeks to illuminate a chemical basis of cells, creating compounds to control processes in cells such as stem cells (materials for cell control) in addition to sparking cellular processes to create chemical materials (cell-inspired materials), to ultimately establish an integrated cell-material science.

Immunology Frontier Research Center (IFReC), Osaka University

IFReC presents innovative accomplishments in immunology through the interdisciplinary collaboration and participation of world-top immunology and imaging researchers.

International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science

MANA aims to create a new paradigm for materials development called “Materials Nanoarchitectonics” and in the field of the managing system focuses on “Melting pot environment”, “Fostering young scientists” and “Global Network”.

International Institute for Carbon-Neutral Energy Research (I^2CNER), Kyushu University

The mission of the Institute is to contribute to the creation of a sustainable and environmentally friendly society by advancing fundamental science to reduce CO_2 emissions and establish a non-fossil based energy carrier system.

International Institute for Integrative Sleep Medicine (IIIS), University of Tsukuba

The mission of IIIS is to be a multidisciplinary, international hub for the research to elucidate the fundamental mechanism of sleep/wakefulness, to develop strategies to regulate sleep, and to contribute to enhancement of world health through the combat with sleep disorders and associated diseases.

Earth-Life Science Institute (ELSI), Tokyo Institute of Technology

ELSI focuses the origins of Earth and life. Both studies are inseparable because life should have originated in unique environment on the early Earth. To accomplish our challenge, we establish a world-leading interdisciplinary research hub by gathering excellent researchers in Earth and planetary sciences, life science, and related fields.

Institute of Transformative Bio-Molecules (ITbM), Nagoya University

The goal of ITbM is to develop innovative functional molecules that make a marked change in the form and nature of biological science and technology (transformative bio-molecules). By merging synthetic chemistry, catalysis chemistry, systems biology, and plant/animal science, which are the strengths of Nagoya University, we aim to create cutting-edge science with potentially significant societal impact.

- **Future Plan for WPI Program**

(Announced by Basic Research Promotion Division, Research Promotion Bureau, MEXT in November 2016.)

Positioning of WPI Program and Current Status

- The aim of the WPI program is to build top world-level research centers that serve as hubs for the international circulation of the world's best brains.
  WPI is an ambitious program that hurdles borders and barriers encircling Japan.
- The program has 4 missions:
  (1) Advancing top-quality of science,
  (2) Advancing new science by fusing research domains,
  (3) Creating an international research environment,
  (4) Reforming research and administrative systems.
- Assessing WPI program's achievement of large successes
  The five centers selected in 2007 have achieved "world premier status".

Need for Long-term WPI Program Plan

- Significant results have been attained both in research achievements and research environment/system reform. These need to be continued.
- The long-term plan calls for increasing the number of WPI centers and further developing the WPI program.
- The principle is that the host institution sustains the center after its WPI grant ends.
- The WPI brand is a long-term asset that will need to be developed and sustained. To do so, **a new framework (WPI Academy)** is needed.

About the Number of New Centers to be Selected in Future

- Our aim is to recruit **two new centers in FY 2017** and more new centers after FY 2018.
- The number of new centers selected after FY 2018 may be adjusted based upon the state of their proposals and the results of existing centers' extension screen.
- Based upon the capacity of Japanese universities and research institutions, up to 20 centersmay be supported under the extended WPI program plan (see references).

Scale of New Centers and Requirements

- Scale of new centers
  Each center: ¥1 billion per year × 10 years (no extension), *may be changed from budgeting
  To attain critical mass as a "visible" research center, a minimum of 7-10 PIs (research group: 70-100) (WPI focus scale) is required.
  To encourage center independence after WPI funding ends, a system is put in place to gradually reduce the scale of center funding after their 5th year interim evaluation.
- Requirements
  Revamp existing organization - Create completely new center
  Clearly articulated plans for fostering young researchers such as including graduate students in projects.

Target Domains and points to be considered for selection

- Target domains
  Basic research fields in the natural sciences
    With FY2017 proposals, mathematics and information science will also be considered. (Mathematics and information science may be used or included as a project component. They may not be the main subject of a project.)
    Positive evaluation will be given to humanities/social science components and societal contributions.
- Application eligibility
  Host institutions that are in the middle of providing 10-year center support may not apply (Kyushu U, U Tsukuba, Tokyo Tech, Nagoya U).
    Regarding the host institutions of centers selected in 2007, rigid screening will be given to the state of support for their existing centers.

Establishing a WPI Academy

- Establishing a WPI Academy whose members will be centers that the WPI Program Committee judges to have attained "world premier status".
  Research institutes other than WPI centers may be screened by the Program Committee for Academy membership.
  Centers that become Academy members will periodically be evaluated by the Program Committee. (A center may be expelled if its project receives a low evaluation.)
  Academy-member centers will continue to receive detailed follow-up reviews by PDs and POs.
- Main functions of WPI Academy
  The Academy will cross-sectionally strengthen the WPI brand and facilitate networking throughout the WPI program.
  The Academy will accelerate and expand (using WPI-pioneered international networks) the international circulation of the world's best brains.
  The Academy will compile and distribute the results and experiences amassed through the WPI program to Japanese universities and research organizations.

(Reference) **Points to Consider in Deciding Number of Centers (1)**

- At least 18 universities and three national research and development agencies have goals similar to those of the WPI program
  Among the national universities, 16 have applied to MEXT for its "Global Top University" classification. 18 universities when adding Keio and Waseda Universities, which are participants in "Research University 11 (RU11)."
  3 designated national research and development institutes (RIKEN, AIST, NIMS)
- Universties/institutes that receive at least a ¥10-billion in operating subsidies from MEXT have the potential to establish a center
  Among the existing centers situated in universities, most of the universities received more than ¥30 billion in operating subsidies from MEXT.
  As exceptions, NIMS and Tokyo Tech established their centers with subsidies of ¥11.9 billion and ¥21.2 billion respectively.
  The Academy will compile and distribute the results and experiences amassed through the WPI program to Japanese universities and research organizations.

(Reference) **Points to Consider in Deciding Number of Centers (2)**

- Record of acquiring large-scale competitive funding
  An important factor is the thickness of the researcher layer including the possible center director and core PIs.
  24 institutions have 5 or more researchers who have been selected for grants under the following competitive funding systems.
    KAKENHI Grants-in-Aid (Specially Promoted Research, Scientific Research (S))
    JST Strategic Basic Research Programs (CREST, ERATO)
    Advanced Research and Development Programs for Medical Innovation (AMED-CREST)

2.2 MANA, the WPI Research Center at NIMS

- **What is MANA?**

The International Center for Materials Nanoarchitectonics (MANA) was founded in October 2007 as one of the original five centers under the World Premier International research Center Initiative (WPI) of Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). Wining critical acclaim for the research achievements of its first five year term, MANA advanced into its second five year term in April 2012. MANA's Vision and Mission are displayed in Fig. 2-3.

MANA's Vision

Toward a better global future:

Pioneering a new paradigm

in materials development

on the basis of "nanoarchitectonics"

MANA's Mission

Develop ground-breaking new materials on the basis of "nanoarchitectonics"

Create a "melting pot" where top-level researchers gather from around the world

Foster young scientists who battle against innovative research

Construct a world wide network of nanotechnology centers

Fig. 2-3: MANA's Vision and Mission.

- **What is Nanoarchitectonics?**

Nanotechnology plays an extremely important role in the development of new materials. Yet, nanotechnology tends to be misunderstood as a simple extension of the conventional microtechnology that has demonstrated great effectiveness in micro-fabrication of semiconductor devices - in other words, as a refinement of microtechnology. In fact, however, nanotechnology and microtechnology are qualitatively different. At MANA, we call the new paradigm of nanotechnology, which correctly recognizes this qualitative difference, "nanoarchitectonics".

The distinctive features of nanoarchitectonics can be summarized in the following four key points:

(1) "*Unreliability-tolerant reliability*" - In the world of microtechnology, structures can be constructed according to a design drawing or "blueprint". This is generally not possible in the world of nanotechnology because the world of nanotechnology is far smaller than that of microtechnology. In nanotechnology, thermal and statistical fluctuations become apparent, and at the same time, nanotechnology confronts the limits of the principles of control methods. Therefore, the viewpoint of realizing reliable functions with structures that contain ambiguity is important.

(2) "*From nano-functionality to nanosystem-functionality*" - Nanoscale structures (nanoparts) frequently display interesting new properties, but there are limits to their functionalities, either as individual units or as simple aggregates. Thus, creating completely new functionalities by effectively utilizing interactions among nanoparts of the same type or different types is important.

(3) "*More is different*" - In complex systems that consist of an enormous number of nanoparts, unexpected new functions often emerge in the system as a whole. Therefore, utilizing, and not overlooking, the phenomenon that "quantity changes quality" is another key point.

(4) "*Truth can be described with plain words*" - Finally, it is also necessary to pioneer a new theoretical field, which is capable of handling the three above-mentioned points. In this, it is necessary to construct a theoretical system that not only treats atoms, molecules, electrons, photons, spin, etc. on a first-principles basis, but also consciously introduces "appropriate bold approximation".

Based on this paradigm of nanoarchitectonics, MANA is engaged in a full range of research, from basic to applied, in five research fields: Nano-Materials, Nano-System, Nano-Power, Nano-Theory and Nano-Life (Fig. 2-4).

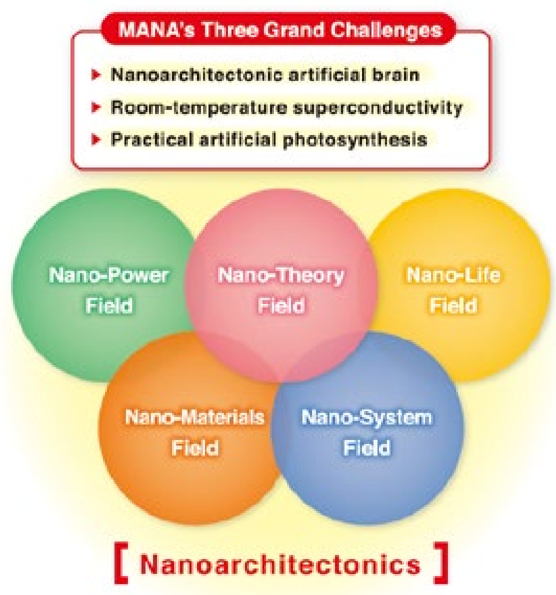


Fig. 2-4: MANA's 3 Grand Challenges and five research fields of MANA (as of December 2016).

- **Research Objectives of MANA**
  Research objectives for each of the five research fields of MANA are as follows.

Nano-Materials

Creating new materials and eliciting novel functions by sophisticated control of compositions and structures at the nano level

Making full use of MANA's advanced chemical synthesis technologies, beginning with soft chemistry, supermolecular chemistry and template synthesis, we are researching the creation of new nanomaterials such as nanotubes, nanowires, and nanosheets. Based on a wide range of material systems, spanning both organic and inorganic materials, we aim to discover novel physical properties and phenomena arising from size and shape in the nanometer range. MANA also develops and owns cutting-edge characterization facilities, including and integrated system of the transmission electron microscope with the scanning probe microscope, and is actively using these instruments for *in-situ* analysis of individual nanomaterials. In addition, we are promoting chemical nano- and mesoarchitectonics, in which these nanomaterials are precisely arranged, integrated and hybridized in the nano-to-meso range. By constructing artificial nanostructured materials in a designed manner, our aim is to create new materials that will exhibit advanced, innovative functions, and contribute to progress in a wide range of technological fields, including electronics, energy and the environment.

Nano-Materials Coordinator: Takayoshi Sasaki
• Soft Chemistry Group, • Functional Nanosheets Group, • Mesoscale Materials Chemistry Group, • Nanotubes Group, • Supermolecules Group, • Frontier Molecules Group, • Semiconductor Device Materials Group.

Nano-System

New nano-systems are changing the world: from artificial intelligence to energy and the environment, diagnosis and medicine

This research field is searching for various nano-systems that will express novel functions by the interaction of nanostructures with unique characteristics, and is engaged in research to utilize those new nano-systems systematically. Concretely, based on basic research on nanoscale materials, such as atomic and molecular transport and chemical reaction processes, polarization and excitation of charge and spin and superconducting phenomena, we are conducting research on atomic switches, artificial synapses, molecular devices, new quantum bits, neural network-type network circuits, next-generation devices, high sensitivity integrated molecular sensors and other new applied technologies. Since the development of new nanoscale measurement methods is also a high priority, we are developing multi-probe scanning probe miscroscopes and other cutting-edge instruments. We also attach great importance to interdisciplinary fusion-type research with other research fields in MANA.

Nano-System Coordinator: Masakazu Aono
• Nano-Functionality Integration Group, • Nanoionic Devices Group, • Thin Film Electronics Group, • Quantum Device Engineering Group, • Surface Quantum Phase Materials Group, • Nano-System Theoretical Physics Group, • Nano Frontier Superconducting Materials Group.

Nano-Power

High efficiency materials and energy conversion system for a sustainable society

The key to efficient use of solar energy is the arrangement of the molecules responsible for various functions such as electron transport or reaction. For example, when converting, storing and transporting energy in photothermal or thermoelectric conversion materials, secondary cells, next-generation transistors, etc., the efficiency of ion and electron transport has a large effect, and control of atoms and molecules at interfaces is essential. In realizing high selectivity and efficiency in catalysts, which are indispensable for resource- and energy-saving chemical processes, how atoms and molecules are sequenced on the catalyst surface is key. In short, the scientific basis for realizing a sustainable society is designing the interfacial atomic and molecular arrangement corresponding to a specific purpose and carrying out the actual arrangement as designed – in other words, "interfacial nanoarchitectonics". Based on the concept of interfacial nanoarchitectonics, researchers in the Nano-Power Field are engaged in research and development for high efficiency matter-energy conversion by free manipulation of atoms and molecules and control of nanostructures.

Nano-Power Coordinator: Jinhua Ye
•Photocatalytic Materials Group, •Photonics Nano-Engineering Group, •Thermal Energy Materials Group, •Nanostructured Semiconducting Materials Group.

Nano-Life

Innovation of biomaterials technologies by nanoarchitectonics to contribute to health and longevity

In the human body, many phenomena, such as replication and expression of generic information, signal transduction inside and among cells, and communication between cells and their extracellular environments, are important for maintaining the function of tissues and organs to support biological activities. Nano-scale structures, which are formed by assembly and disassembly of various types of molecules by truly ingenious methods, play a critical role in diverse vital phenomena. Thus, disturbance of nanostructure functioning may result in poor physical condition, disease, or even death. Our aim is to design and prepare functional biomaterials based on nanoarchitectonics and use them to detect, measure and control diverse vital phenomena and biological activities. We will elucidate the causes of various diseases and innovate groundbreaking technologies for diagnosis, prevention treatment, and tissue regeneration. By linking biomaterials innovation to advanced medical care, we will contribute to the realization of a safe and secure society where people enjoy health and longevity.

Nano-Life Coordinator: Guoping Chen
• Tissue Regeneration Materials Group, • Medical Soft Matter Group, • Nanomechanical Sensors Group, • Mechanobiology Group.

Nano-Theory

Understanding phenomena in the nanoscape region, predicting new phenomena and creating novel nanostructure materials

Nanospace is a world in which common sense does not apply, where extremely small atoms are in motion, and electrons fly about in an even smaller space. Moreover, when huge numbers of these atoms and electrons act in coordination, they come to display behavior markedly different from those of single electrons and atoms. Ways of thinking and methods that are not bound by everyday common sense – namely, quantum mechanics and statistical mechanics – are essential for a proper understanding of the phenomena that occur there, and further, for devising new materials. Key activities in the field of nano-theory, which help achieve an understanding of the myriad phenomena emerging in nanospace, include building fundamental theories behind these novel behaviors by incorporating quantum mechanics and statistical mechanics, using our supercomputing facilities to obtain quantitative numerical predictions and develop new and efficient calculation methods. Besides providing interpretations of results obtained in other nanofield areas, we aim at invoking the outcomes of our research to predict as yet unearthed phenomena and to propose new materials featuring novel properties.

Nano-Theory Coordinator: Taizo Sasaki
• Materials Properties Theory Group, • First-Principles Simulation Group.

- **WPI Evaluation of MANA**

One Program Director (PD) and nine Program Officers (PO), one for each WPI center, have been assigned by JSPS to conduct the follow-up activities. One deputy PD has been assigned since FY 2013 as well. With the assigned PO as its chair, a working group for each WPI center has been established under the Program Committee. Each group comprises about 5-6 specialists in the subject field. As a rule, about half of them are overseas members. Program Director (PD), Program Officer (PO) and Working Group members for MANA (current as of December 2016) are listed in Table 2-2.

The Evaluation of MANA by the WPI Program Committee consists of an annual 2-day site-visit at MANA and an annual Follow-Up Meeting. Primary Evaluation criteria are the Achievements of Science as well as the Implementation as a WPI Research Center. In FY2011, at the interim evaluation by the WPI Program Committee, MANA received a high score “A” and has entered the second 5 years of operation in April 2012. In FY2016, the 9th MANA Site Visit by the Program Committee members, PD, PO, international WG members, MEXT officials and JSPS secretariats was held in the auditorium of the WPI-MANA Building on July 21-22, 2016 (Fig. 2-5).

Table 2-2: Program Director (PD), Program Officer (PO) and Working Group members for MANA.

Program Director (PD): WPI Program	Toshio Kuroki	Senior Advisor, Research Center for Science Systems, JSPS
Deputy Program Director: WPI Program	Akira Ukawa	Deputy Director, RIKEN Advanced Institute for Computational Science
Program Officer (PO): MANA at NIMS	Gunzi Saito	Professor, Faculty of Agriculture, Meijo University
Working Group Member: MANA at NIMS	Yoshinobu Aoyagi	Senior Researcher, Research Organization of Science and Technology, Ritsumeikan University
Working Group Member: MANA at NIMS	Takehiko Ishiguro	Professor Emeritus, Kyoto University
Working Group Member: MANA at NIMS	Tadashi Matsunaga	President, Tokyo University of Agriculture and Technology
Working Group Member: MANA at NIMS	Hiroshi Katayama-Yoshida	Professor, Graduate school of Engineering Science, Osaka University
Working Group Member: MANA at NIMS	David L. Allara	Distinguished Professor Emeritus of Chemistry and Professor of Materials Science & Engineering Departments of Materials Science & Engineering, Pennsylvania State University, **USA**
Working Group Member: MANA at NIMS	Klaus von Klitzing	Director, Max Planck Institute for Solid State Research, **Germany, Nobel Prize laureate**



Fig. 2-5: The ninth MANA Site Visit in July 2016. Top, from left to right: Prof. Katayama-Yoshida*, Prof. Matsunaga*, Prof. Ishiguro*, Prof. Osada (Program Officer for AIMR), Prof. Kuroki (WPI Program Director), Prof. Saito (Program Officer for MANA), Prof. Ukawa (WPI Deputy Program Director), Prof. von Klitzing*, Prof. Aoyagi*, Prof. Allara*. (*: Group Members for MANA.) Bottom, from left to right: Prof. Hashimoto (NIMS President), Prof. Kuroki (WPI Program Director), Prof Saito (Program Officer for MANA), Prof. Aono (MANA Center Director).

3. Organization, Members and International Research Environment of MANA

3.1 MANA Organization and Members

- **Organization of MANA**

In order to realize the MANA concept, it is extremely important to establish efficient organizational operation. Fig. 3-1 shows an overview of the MANA organization. The role of MANA members are explained in Table 3-1.

The Director-General of MANA has authority over the center's operation in general. He possesses the authority to allocate Center resources such as budget funds and space. This includes employment and renewal of contracts for researchers and administrative staff members of the MANA center, except for those who are enrolled in the main body of NIMS.

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

In April 2015, the MANA Administrative Director Takahiro Fujita has been promoted to NIMS Vice President. Therefore, in May 2015, the MANA Principal Investigator Tomonobu Nakayama has been appointed as the new MANA Administrative Director. In April 2016, MANA has added "Nano-Theory" as a new research field.

The MANA Administrative Office has been established with three teams in October 2008 (*Planning Team*, *General Affairs Team*, *Technical Support Team)* and added an *Outreach Team* in April 2010. All staff of the MANA Administration is fluent in English.

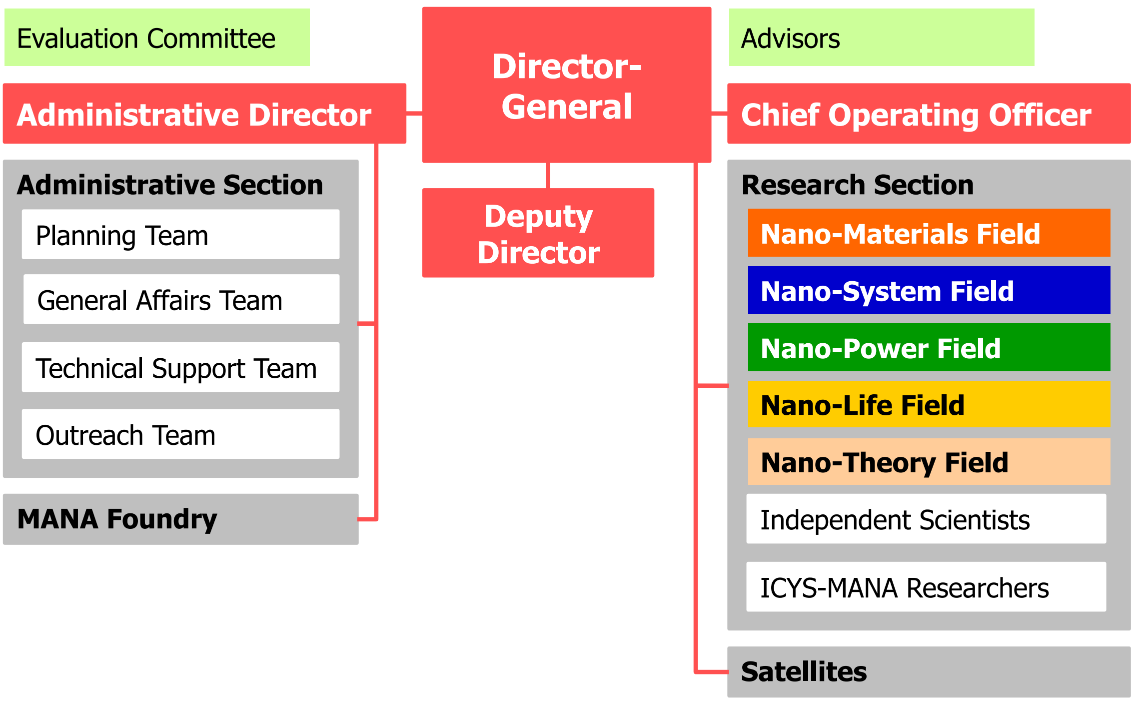


Fig. 3-1: Organization of MANA (as of January 2017).

Table 3-1: MANA members and duties.

Director-General Center oversight	**MANA Scientist** A researcher from NIMS who conducts research together with a Group Leader or Principal Investigator
Chief Operating Officer Assists the Director-General and supervises research	**MANA Independent Scientist** A younger scientist who can conduct his/her research independently in the 3D system
Administrative Director Takes orders from the Director-General and supervises clerical and administrative duties	**ICYS-MANA Researcher** A postdoctoral fellow selected from all over the world by open recruitment. He/she conducts his/her own research independently while receiving advice from mentors, Principal Investigators and Group Leaders
Principal Investigator (PI) An internationally known world top-class scientist who plays leading roles in achieving MANA research targets and in fostering younger researchers through mentoring. Principal Investigators are selected from NIMS and other domestic and overseas institutes	**MANA Research Associate** A postdoctoral fellow working with a Group Leader, a Principal Investigator or a MANA Independent Scientist
Group Leader A researcher who is leading a research group	**Graduate Student** A doctor-course student at an institution affiliated with NIMS. He/she participates in research at MANA under the tutelage of a Principal Investigator, Group Leader, MANA Scientist and/or a MANA Independent Scientist
Associate Principal Investigator (API) A young promising scientist, who is expected to perform his/her own research at a level comparable to Principal Investigators	**Research Support Staff** Technicians that support research work
Managing Researcher A senior researcher who conducts research suggested by the Director-General	**Administrative Staff** Staff that supports administrative duties

- **Workforce of MANA**

Table 3-2 shows the workforce of MANA as of January 1, 2017, consisting of 195 researchers and 29 technical and administrative staff. The proportion of foreign researchers is 46.2 % from 21 different countries (Table 3-3), showing MANA is now really international. The proportion of female researchers has reached 17.9%.

Appendix 7.1: MANA Top Management
Appendix 7.2: MANA Research Staff

Table 3-2: MANA workforce (as of January 1, 2017).

Position	Number	Non-Japanese	Female
Principal Investigators	26	8	2
Group Leaders	9	0	0
Associate Principal Investigators	2	1	0
Managing Researchers	2	0	0
Senior Scientist with Special Mission	1	0	0
MANA Scientists	65	9	7
Independent Scientists	7	2	2
ICYS-MANA Researchers *	9	6	0
MANA Research Associates *	39	33	11
JSPS Fellows *	14	14	5
Junior Researchers #	21	17	8
Technical Staff	11	0	3
Administrative Staff	18	1	14
Total	**224**	**91**	**52**

*: Postdocs #: Graduate Students

Proportion of Foreign Researchers: 46.2% (90/195)
Proportion of Female Researchers: 17.9% (35/195)

Table 3-3: MANA workforce with foreign nationality (as of January 1, 2017).

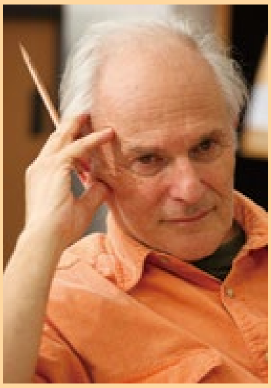
Region	Country	MANA PI	MANA Scientist*	Indep. Scientist	ICYS-MANA Researcher	Research Associate	JSPS Fellow	Graduate Student	Staff	Total
Asia	China	2	3	1	1	17	4	12		40
	India					10	1			11
	Korea		1			1	1	1		4
	Nepal		1			1				2
	Pakistan							2		2
	Indonesia							1		1
	Thailand		1							1
	Vietnam				1					1
Oceania	Australia						1			1
Europe	France	1			2	1	1			5
	UK	2	1				2			5
	Germany					1		1		2
	Russia	1	1							2
	Czech Rep.			1						1
	Greece					1				1
	Ireland				1					1
	Rumania				1					1
	Switzerland								1	1
	Ukraine						1			1
Africa	Egypt					1	1			2
America	Canada	1	1				1			3
	USA	1	1				1			3
Total		8	10	2	6	33	14	17	1	91

*: including, MANA API, Group Leaders, Managing Researchers, Researcher with Special Mission.

Sir Harold Walter Kroto (Nobel Laureate in Chemistry, 1996 / Professor, Florida State University), who was an Adviser to MANA, passed away on April 30th, 2016.

Sir Kroto had been an Executive Adviser of the International Center for Young Scientists (ICYS), the predecessor of MANA, since 2004, then subsequently made tremendous contributions to the development of MANA as an Adviser since our launch in 2007. He eagerly coached young scientists in MANA and periodically held science classes for children in Japan. His earnest encouragement enlightened all of us in MANA.

All of us at MANA sincerely pray that he may rest in peace. We would like to express our most heartfelt appreciation for his great contributions to us here at MANA, as we cherish the many wonderful memories we have of him. Thank you very much, Sir Kroto.



● **MANA Advisors**

MANA Advisors provide advice on overall Center management and invaluable suggestions on individual research projects. They also cooperate in MANA's outreach activities by serving as lecturers in science seminars geared toward elementary and junior high school students. In March 2016, three external experts were serving as MANA Advisors. In April 2016, three new MANA advisors were brought on to strengthen all research activities conducted at MANA. All of us at MANA are devastated by the said news that MANA Advisor, Sir Harold Walter Kroto, passed away end of April 2016. As of January 2017, MANA has appointed 5 Advisors and 2 International Cooperation Advisors (Appendix 7.3). The latter provide MANA with advice on joint research with overseas research institutes and the formulation of a global nanotech network.

Appendix 7.3: MANA Advisors and International Cooperation Advisors

● **MANA Evaluation Committee**

As of January 2017, the MANA Evaluation Committee is comprised of seven external experts headed by Prof. Cheetham of the University of Cambridge. To date, the committee has met four times, once each in 2008, 2010, 2012 and 2015, to evaluate the center's management and research activities. This committee provides advice and suggestions from a perspective that differs from that of the WPI program committee, producing action plans for MANA to follow. The fifth MANA Evaluation Committee meeting will be held at the beginning of March 2017.

Appendix 7.4: MANA Evaluation Committee

3.2 Attractive International Research Environment

MANA is one of the most internationalized research centers in Japan. MANA is firmly advancing the development of an outstanding international research environment in an effort to create a *highly visible research center.*

● **Training of Young Scientists**

MANA attracts outstanding young researchers from around the world for one reason: They know that if they come to MANA, they will be able to maximize their potential and advance to higher levels of performance. MANA has a very unique training system that helps young researchers find their future paths: the Triple Double (3D) System. The 3D System cultivates global perspective through interdisciplinary research.

Unique Triple Double (3D) System

Under the Triple Double, or 3D, System, researchers have two mentors (*Double Mentor*), are affiliated to two research institutions, (*Double Affiliation*) and conduct research in two fields (*Double Discipline*). This system is highly effective for developing the careers of young researchers and has garnered high acclaim from around the world.

• *Double Mentor*

By working with two world-class researchers, young researchers develop global perspective and add depth to their work.

• *Double Affiliation*

Young researchers develop a strong sense of autonomy and independence by working with multiple institutions.

• *Double Discipline*

Young researchers acquire knowledge in multiple fields to enhance the interdisciplinary nature of their research.

MANA Independent Scientists

MANA hires young researchers who have produced outstanding research achievements as MANA Independent Scientists. MANA uses the *Triple Double (3D)* system to train these future leaders. Independent Scientists are granted "independent" authority over their research. MANA provides these researchers with special support, providing them with an environment in which they can freely pursue independent research projects and opportunities to spend long periods of time at foreign research institutions as well as actively assisting them with interdisciplinary research and assigning them world-class researchers as mentors. Independent Scientists do not merely receive support from MANA. They also actively approach companies and government institutions to secure external research subsidies and must manage their own research funding. In this way, the top-tier research environment at MANA creates research leaders for the world. The "Independence" of Independent Scientists consists of the following:

• *Independent Authority over Research*

Just as the name implies, researchers are given independent discretion over their research. In Japan, there are almost no other research institutes that give this much authority and discretion to researchers in their 30s or early 40s. Thanks to this authority, Independent Scientists can decide their own intention and take action related to their own research themes.

• *Independent Research Budget*

Independent Scientists receive some funding from MANA, but not much. They must approach corporations and federal institutions on their own and take the initiative to acquire their own funding. In this way, they secure funding to enable them to conduct research freely and of their own accord.

• *Independent Action*

Meeting directly with the scientists who set the world standard getting to know them personally and listening to what they have to say might just be the most stimulating thing there is for researchers with future potential. Since the activities of Independent Scientists are very free, it is possible for them to conduct research abroad when and for as long as they require.

ICYS-MANA

With the aim of building an international research environment for young researchers and creating a unique system to guide them, the International Center for Young Scientists (ICYS) was set up by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2003 through the Special Coordination Funds for promoting Science and Technology and the Program for Encouraging the Development of Strategic Research Centers. The mission of ICYS was to gather excellent young researchers from different countries and specializations to a place where they can conduct research autonomously in a melting pot environment where they can stimulate one another and elicit as much of their youthful creativity as possible. This ICYS program received high marks and even after the conclusion of the program in 2007, the principle and system of ICYS continued as the NIMS International Center for Young Scientists.

ICYS is an organization that serves as a tenure-track system leading to permanent researcher positions at NIMS. ICYS is comprised of several subordinate organizations, one of which is ICYS-MANA. Researchers at ICYS are selected twice annually through an international application process. ICYS as a whole has received applications from 1,452 individuals over the past nine years (1,303 of which were non-Japanese individuals [i.e. 89.7% of the total]). Of these, 98 were hired, and a half of these (49) were assigned to ICYS-MANA.

● **Cutting-edge Research Facilities**

MANA's host institution, NIMS, has equipped itself with research equipment of outstanding quality during its history of more than 40 years, and MANA researchers are allowed to freely use this equipment. Among these facilities are various types of world-class ultra-high-resolution electron microscopes, a dedicated beamline at a synchrotron radiation facility (SPring-8), one of the world's most advanced ultra-high magnetic field generators (10 T), an ultra-high-resolution nuclear magnetic resonance (NMR) spectrometer, and an ultra-high pressurizer device (10-100 GPa). In addition, MANA researchers have access to more than 50 shared research facilities (Fig. 3-2) and can use these with the support of experienced English speaking staff from MANA Technical Support Team (TST). MANA is equipped with equipment like a special electron microscope that can observe electrical, mechanical, thermal, and optical properties under high-resolution structural observation; as well as a multiple-probe scanning probe microscope that can measure electrical conductivity at the nanoscopic scale. MANA also has a photoelectron spectrometer, a Raman spectrometer, a femtosecond laser spectrometer, and many other pieces of high-performance equipment.

In April 2009, MANA established a unique and excellent microfabrication facility called *MANA Foundry* with over 30 facilities for nano-fabrication and characterization to support nanoarchitectonics research (Fig. 3-2). MANA researchers can efficiently achieve the necessary microfabrication within the research center itself. Thirteen support staff are present. The clean room facility in the MANA Foundry consists of eight areas in its 234 m^2 floor space: Yellow Room (for drawing and photo lithography), Wet Process Area (for chemical treatment), Etching Area, Film Deposition Area, Nano Measurement Area (for characterization), Nano Analysis Area, Thermal Treatment Area, and Dicing & Wiring Area. MANA Foundry is capable of providing consistent process from test piece fabrication to structural observation and functional verification, including nano-gap electrode pattering by electron beam lithography system on complicated structures such as nano dots, nano wires and nano sheets that are made of various materials like organic, inorganic, magnetic, metal, insulator, superconductor and composite.

Fig. 3-2: Left: Shared research facility managed by MANA Technical Support Team. Middle: Clean room facility in the MANA Foundry. Right: Experienced secretaries offer support to help researchers complete their paperwork and start life in Japan.

- **Full Support for Researchers**

Fusion of different fields and cultures creates the possibility of innovation. MANA is pursuing a *melting pot environment* where world-class human resources from diverse fields or specialization and different nationalities and cultures can come together and work *under one roof* (Fig. 3-2). To foster such a melting pot environment more and more, MANA has increased the number of foreigners to over 50% of the MANA researchers. As part of the melting pot activity, researchers from MANA are requested to present their research field at the MANA seminars. When renowned researchers visit MANA, they held seminars to introduce their research projects to stimulate MANA researchers and promote interdisciplinary synergies. In 2016, MANA seminars were conducted with 13 speakers from NIMS and 60 invited renowned researchers from around Japan and the world (total 73 speakers).

Appendix 7.5: MANA Seminars

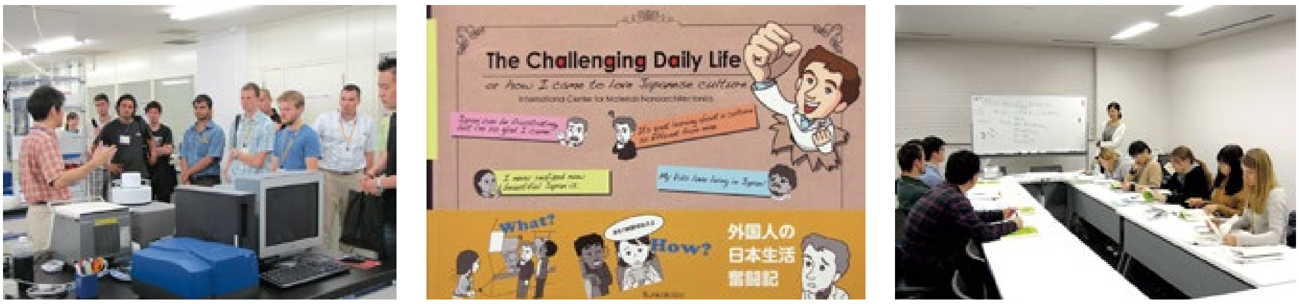


Fig. 3-3: Throughout support for non-Japanese researchers. Lab tour for newly joined researchers (left), a manga comic book with practical tips (middle), and Japanese language class for beginners (right).

All staff in MANA's Administrative Office speak English and provide comprehensive Japanese-style service to all researchers, regardless of age and nationality.

• *Removal of language barriers*

Almost all major guidebooks, documents, intranet services, and other information sources have been translated into both English and Japanese ("bilingualization"). The use of English is thoroughly enforced for all meetings, email contact, etc. In order to assist non-Japanese researchers in obtaining external competitive funding, the center distributes information in English on external funding sources and provides assistance with the application process. Efforts like this to remove language barriers are spreading throughout the entire NIMS organization.

• *Orientation*

At regular intervals, MANA staff provide English language orientation and lab tours for new NIMS researchers (Fig. 3-3). Staff work to ensure that researchers can get started with their work at NIMS as quickly as possible by providing necessary information on work regulations, benefits, supplies procurement, intellectual property, paper publication, research ethics, external funding application, and safety and hygiene, in addition to offering tours of the major research facilities.

• *Livelihood support*

MANA's host organization, NIMS, contracts with the Japan International Science and Technology Exchange Center (JISTEC) to provide livelihood support for non-Japanese researchers. JISTEC handles a wide range of activities, including procedures like residence registration, school enrollment and transfer, opening bank accounts, and moving house. JISTEC also provides relevant information about daily living, accompanies individuals to hospitals, and provides support in the event of an accident, in addition to other services.

• *Help to understand Japan*

MANA offers a comic book (Fig. 3-3), well-received by non-Japanese researchers beginning work at MANA, entitled *The Challenging Daily Life*, which offers solutions for problems encountered by non-Japanese researchers conducting research at a Japanese institution. Many directors, managers and research leaders at overseas research institutions have praised this comic book as a "helpful way of eliminating potential barriers faced when young researchers first come to Japan". MANA also offers non-Japanese researchers support including Japanese language classes and Japanese cultural training. Japanese language classes are divided into introductory and beginner levels, and are held in three terms throughout the year. Students hold a speech contest during the final lesson of each term. In 2016, 60 participants attended the Japanese language classes (Fig. 3-3). Japanese culture classes are offered at a pace of roughly once a month. Specialist instructors are invited to give lectures on traditional Japanese culture as shown in Fig. 3-4 and listed in Table 3-4. In 2016, 167 participants joined the Japanese culture classes.

Fig. 3-4: Japanese culture class events at NIMS in 2016. Top from left to right: Pottery, Kimono, Karate and Japanese Green Tea. Bottom from left to right: Origami, Indigo Dye, Japanese Drum (Wadaiko) and Calligraphy.

Table 3-4: Schedule of Japanese culture classes in 2016.

1	2016 Jan 22 **Sushi** (17 participants)	5	2016 May 27 **Kokedama** (11 participants)	9	2016 Sep 24 **Pottery** (10 participants)
2	2016 Feb 27 **Indigo Dye** (23 participants)	6	2016 Jun 25 **Origami** (18 participants)	10	2016 Oct 7 **Japanese Green Tea** (9 participants)
3	2016 Mar 18 **Kimono** (21 participants)	7	2016 Jul 23 **Nihoncha** (19 participants)	11	2016 Nov 25 **Calligraphy** (7 participants)
4	2016 Apr 27 **Karate** (6 participants)	8	2016 Aug 1 & Aug 4 **Japanese Drum (Wadaiko)** (15 participants)	12	2016 Dec 9 **Seal Carving** (11 participants)

• *Technical support*

Members of the Technical Support Team are knowledgeable, proficient in English, and provide great support for all the MANA researchers, especially for non-Japanese researchers. Additionally, the technical support team uses its specialized knowledge to gather and translate information on external funding into English. Especially for non-Japanese researchers, the team provides support of writing applications and reports in Japanese if Japanese documents are really required.

● **New Research Buildings**

In October 2008, the entire Nano-Materials and Biomaterials Research Building (13,000 m^2, 5-story) at NIMS Namiki site was allocated to MANA as the MANA Building, the primary space for MANA activities at which all major researchers and equipment were centralized. In March 2012, the new WPI-MANA Building (6,000 m^2, 5-story) was completed and the MANA research environment became even better. The new complex (Fig. 3-5) consists of two units - the WPI-MANA Building and the NanoGREEN Building – with the area between the two buildings serving as a free space where researchers can meet and discuss their work. It is a facility for world-class research on environmental and energy materials and nanotechnologies that brings together NIMS and outside researchers and private-sector engineers from Japan and abroad. The new complex is disaster-resistant and equipped with energy-saving and CO_2-reducing technology. Various measures have been taken to create a Melting Pot environment within the building, thereby promoting interdisciplinary research. The building received the rank of S, the highest possible rating, from CASBEE, a tool for assessing and rating the environmental performance of buildings.

The new complex employs the latest technologies, including a photocatalytic glass watering system, solar panels and sun louvers. Temperature, humidity and brightness are all controlled automatically to achieve energy efficiency while ensuring comfort. By linking solar panels, emergency generators and storage batteries into a network, MANA was the first institution in Japan to adopt a microgrid. The microgrid will provide seamless power to key facilities even if power is interrupted during a disaster. Even during long power outages, the solar panels and storage batteries can supply the necessary minimum amount of power. Under normal circumstances when various equipment is in operation, the system has a peak output of 90 kW. It is MANA's forward-looking attempt at developing a zero-energy building (ZEB).

Zero-Energy Buildings (ZEB)

ZEBs are buildings that use energy-saving technology and renewable energy to bring their net energy consumption as close as possible to zero.

In April 2016, the newly renovated *Theoretical Research Building* (519 m^2, 1-story, Fig. 3-5) at NIMS Namiki site was allocated to MANA to host researchers working for the newly established Nano-Theory field.

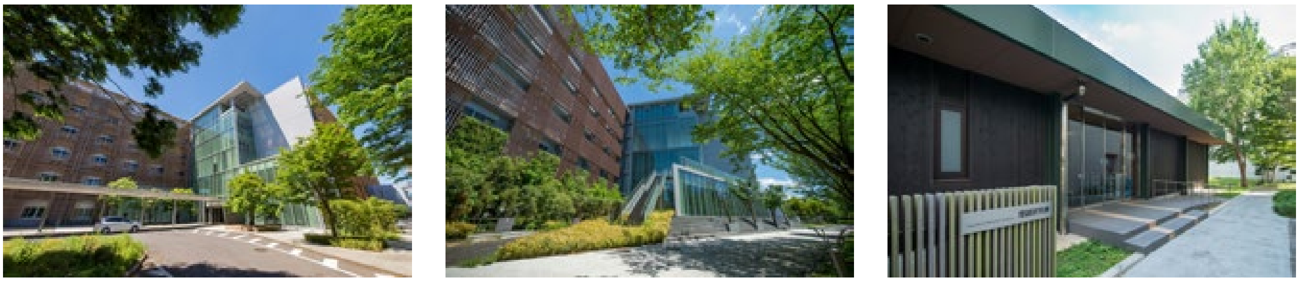


Fig. 3-5: The new complex consisting of the WPI-MANA Building (left) and NanoGREEN Building (middle). The newly renovated Theoretical Research Building (right).

4. Research Activities, Output and Achievements

4.1 Research Activities

● **Research Digest 2016**

For an overview of MANA research activities, please refer to yearly published booklet Research Digest (Fig. 4-1), which is part of the MANA Progress Report. Examples of typical research accomplishments of MANA are given in Section 4.3 of this chapter.

Fig. 4-1: Recent issues of the booklet Research Digest.

Table 4-1: Volumes of *MANA Research Highlights* published between FY2011 and FY2016.

Volumes	Fiscal Year
1-2	FY2011
3-6	FY2012
7-13	FY2013
14-21	FY2014
22-24	FY2015
25-31	FY2016

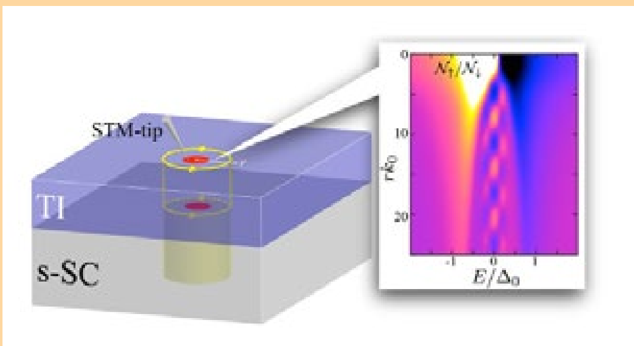
● **MANA Research Highlights**

Since FY2011, the online English newsletter *MANA Research Highlights* has been communicating remarkable MANA research achievements throughout the world. These newsletters are distributed to 2,000 to 3,000 media and science journalists, as well as 2,000 individuals on MANA's mailing list. Especially outstanding research achievements are communicated through the journal Science's third-party e-mail service to approximately 4,000 researchers located around the globe. For reasons including that papers highlighted by this service become the most downloaded, this is a powerful method of publicizing MANA's achievements to the world's scientific community. To date, 31 volumes of *MANA Research Highlights* have been published between FY2011 and FY2016 (Table 4-1). The information is available on the MANA website at www.nims.go.jp/mana/research/index.html . The volumes published in FY2016 are illustrated in Fig. 4-2.

Volume 25 (June 9, 2016)

Majorana Particles in Topological Superconductors: Search for illusive particles equivalent to their own anti-particles

Theoreticians at MANA report on the existence of Majorana-type particles based on analysis of independent scanning tunneling spectroscopy measurements on thin film of topological insulator bismuth telluride on substrate of superconducting niobium selenide. The findings are important for robust topological quantum computing.



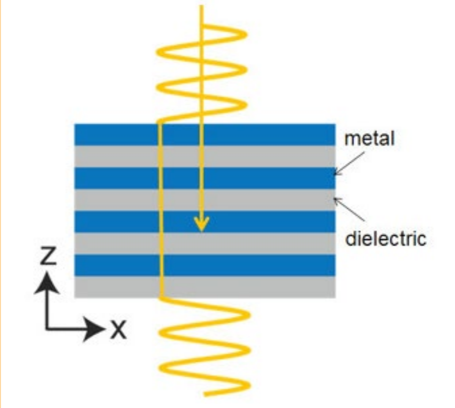
Schematic of Majorana particles localized inside the core of quantum vortex of a topological superconductor and the distribution of density of states of quasiparticle excitations based on the theoretical calculations.

Publication:
T. Kawakami, X. Hu,
Evolution of Density of States and a Spin-Resolved Checkerboard-Type Pattern Associated with the Majorana Bound State,
Physical Review Letters **115**(17), 177001 (2015).
doi: 10.1103/PhysRevLett.115.177001

Volume 26 (June 15, 2016)

Electromagnetic Metamaterials with Zero-refractive Index for Sub-wavelength Photonics

A new class of optical topological transitions in electromagnetic metamaterials induced by the non-locality of the electromagnetic response is reported.



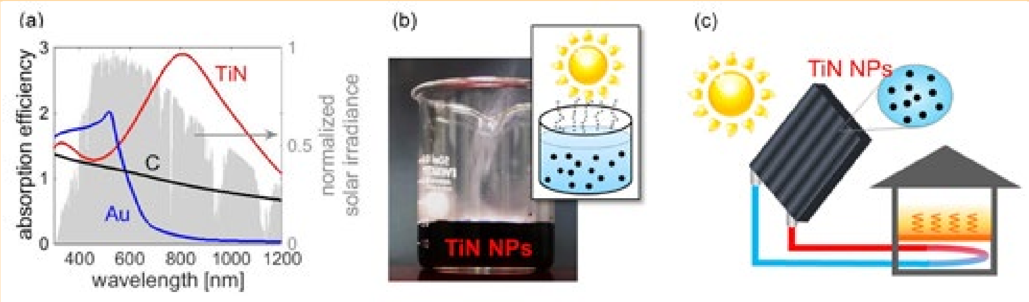
Schematic of light propagating through a hyperbolic metamaterial (HMM) in a critical state where the effective refractive index is zero. Blue and gray stripes represent metal and dielectric layers, respectively.

Publication:
S. Ishii, E. Narimanov,
Non-local Optical Topological Transitions and Critical States in Electromagnetic Metamaterials,
Scientific Reports **5**, 17824 (2015).
doi: 10.1038/srep17824

Volume 27 (November 29, 2016):

A Nanoparticle Boost for Solar-powered Water Heating

A highly-efficient, nanoparticle-based method for heating water and generating water vapor from sunlight is demonstrated by WPI-MANA scientists.



(a) Absorption efficiencies of single nanoparticles (left axis) made of TiN, gold (Au) and carbon (C). The right axis shows normalized solar irradiance. (b) Photograph showing vapor generating from water containing TiN nanoparticles (TiN NPs) in room temperature under the illumination of focused sunlight. The inset figure illustrates the photograph. (c) Schematic of a solar heater using TiN NP dispersed water.

Publications:
S. Ishii, R.P. Sugavaneshwar, T. Nagao,
Titanium Nitride Nanoparticles as Plasmonic Solar Heat Transducers,
Journal of Physical Chemistry C **120**(4), 2343 (2016).
doi: 10.1021/acs.jpcc.5b09604

Volume 28 (December 2, 2016)

Opening the Way to Mobile Olfaction with Nanomechanical Sensors

An alliance between six organizations is setting a de facto standard for smell sensors employing a small, sensitive and versatile sensor element called the Membrane-type Surface Stress Sensor (MSS).

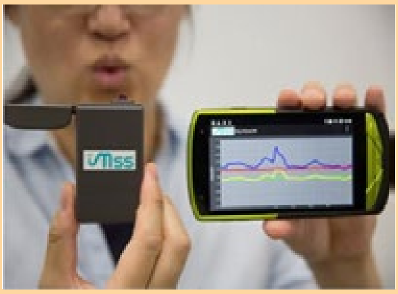
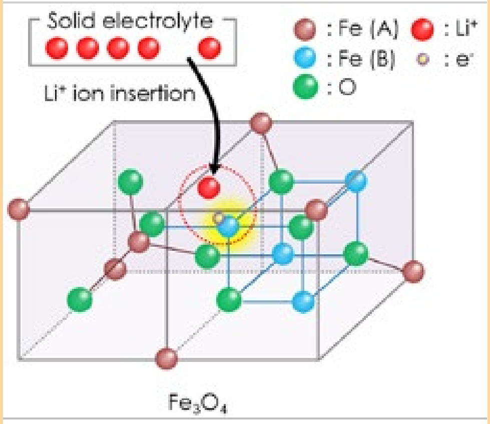


Image of a mobile olfaction device with the MSS.

Volume 29 (December 6, 2016)

Tuning Magnetic Properties for Better Data Storage

New high-density data storage and spintronic devices could be achieved by reversibly controlling the electrical and magnetic properties of thin films.



Schematic showing the chemical basis for a novel redox device that has been made by WPI-MANA researchers. The electrical and magnetic properties of the device can be adjusted and reversed by adding or removing lithium ions (Li^+) from a layer of magnetite (Fe_3O_4).

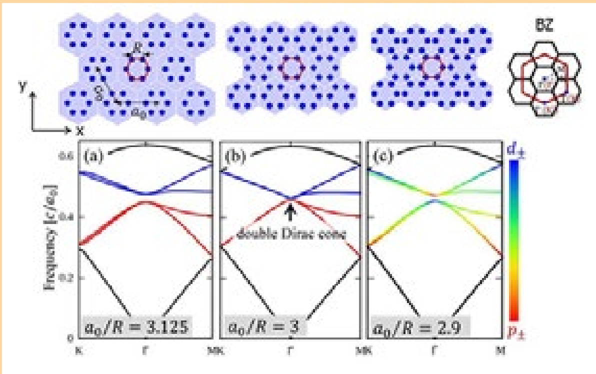
Publication:

T. Tsuchiya, K. Terabe, M. Chi, T. Higuchi, M. Osada, Y. Yamashita, S. Ueda, M. Aono,
In Situ Tuning of Magnetization and Magnetoresistance in Fe_3O_4 Thin Film Achieved with All-Solid-State Redox Device, ACS Nano **10**(1), 1655 (2016).
doi: 10.1021/acsnano.5b07374

Volume 30 (January 19, 2017)

Topological Photonic Crystal Made of Silicon

WPI-MANA researchers derive topological photonic states purely based on silicon, which can lead to the development of new functions and devices through integration with semiconductor electronics.



(Top) Schematic of photonic crystals consisting of nanorods derived from the honeycomb lattice viewed from above, and (bottom) the corresponding photonic bands.

Publication:

L.H. Wu, X. Hu,
Scheme for Achieving a Topological Photonic Crystal by Using Dielectric Material,
Physical Review Letters **114**(22), 223901 (2015).
doi: 10.1103/PhysRevLett.114.223901

Volume 31 (February 17, 2017)

Atomic Switch Reaching Outer Space

10-year journey of the atomic switch in nanospace is finally reaching practical use in space satellites several thousand kilometers above earth.

In 2001, the atomic switch was invented through an unconventional combination of a state-of-the- art scanning tunneling microscope (STM) and a small piece of Ag_2S ion/electron mixed conductor. To celebrate the practical use of the atomic switch, a memorial symposium will be held in March 2017.

Fig. 4-2: Volumes 25-31 of the newsletter *MANA Research Highlights*.

- **Advancing Fusion of Various Research Fields**

To encourage precursory, interdisciplinary research across MANA's different research fields, MANA has established the following internal special funds between FY2009 and FY2015:

- **Fusion Research Program (6 projects, FY2009 – FY2010)**

  This fund was opened to applications from young researchers under the belief that joint research by young researchers from disparate fields is especially important to planting the seeds of new research.

- **Grand Challenge Program (7 projects, FY2011 – FY2012)**

  This program solicited interdisciplinary research proposals that were innovative and "outside the box," in addition to being not necessarily limited to materials research.

- **Nano- Life Fusion Research Program (2 projects, FY2012 – FY2014)**

  Established to promote joint fusion research between Nano-Life researchers and researchers who specialize in other nanotechnology fields.

- **Theory-Experiment Fusion Research Program (10 projects, FY2012 – FY2014 and FY2013 – FY2015)**

  Applications were accepted over a period of two years in an effort to involve more theoretical researchers in MANA to guide and support MANA's experimental research.

- **Grand Challenge Meetings**

In 2011, MANA has started to hold retreat-style *Grand Challenge meetings*. The initial aim of the meeting was to encourage researchers working in different fields at MANA to brainstorm and discuss the kinds of research they aspire to, but the event led some young researchers to propose a Grand Challenge Meeting geared only to young researchers. Some twenty MANA researchers are selected from among those interested in joining this meeting and they engage in free discussions about future grand challenges at MANA at a remote country site for two days. Grand challenge meetings have been held in January 2011 (Miura peninsula), April 2012 (hot spring resort in Nasu), November 2012 (young researcher's meeting at Miura peninsula) and February 2015 (hot spring resort in Nasu). We have observed that these meetings are remarkably useful in triggering fusion research among MANA's scientists in different research specialties. The meetings were truly significant events that reflected the slogan posted in various places in the MANA Building, "The fruits of your research are proportional to the number of your conversations with others".

In November 2015, the 5th MANA Grand Challenge Meeting was held in Nasu together with The Institute for Solid State Physics (ISSP) of the University of Tokyo. In this ISSP-MANA Challenge Meeting, potential collaborations between cutting-edge researchers from the two institutions will be dug out by intensive brain-storming discussion throughout the two-day program.

In January 2016, the 6th MANA Grand Challenge Meeting was held together with Energy Forum in Tokyo University of Science (eF/TUS) in two parts at Tokyo University of Science (TUS) and one week later at MANA. The eF/TUS and MANA/NIMS are both questing better solutions for low energy consumption and energy harvesting on the basis of materials science. In this eF/TUS-MANA/NIMS Challenge Meeting, potential cooperation and collaborations between the two institutions were pursued by intensive brain-storming discussion.

- **Invitation of Foreign Researchers**

To ensure that MANA is a research center that attracts all levels of researchers from around the world, MANA uses 2 researcher invitation programs.

NIMS Open Research Institute Program / NIMS Global Collaboration fellowship Program:

In April 2016, the name of the invitation program has changed from *NIMS Open Research Institute Program* to *NIMS Global Collaboration Fellowship Program*. These programs are run by NIMS and bring together all levels of researchers from young researchers to highly regarded scientists. By March 2017, 179 researchers were invited to MANA by these programs.

MANA Short-Term Research Program:

This is an original MANA program that invites faculty members from foreign research institutes who can conduct joint research with MANA researchers. Invitees stay at MANA for 1 to 3 months. By March 2017, 90 researchers from 24 countries have visited MANA within this program.

4.2 Research Output

In the nine and a half years since it was established, MANA has grown to become one of the world's top research centers in the relevant fields and produced remarkable results ranging from fundamental research to practical applications.

Table 4-2: Number of MANA affiliated papers published 2016 in top journals with an impact factor 2015 higher than 8.

Name of journal	Journal impact factor 2015 *	Number of MANA papers 2016
Nature Nanotechnology	35.267	1
Chemical Society Reviews	34.090	4
Nature Chemistry	27.893	1
Energy & Environmental Science	25.427	1
Accounts of Chemical Research	22.003	2
Advanced Materials	18.960	8
Materials Today	17.793	1
Advanced Energy Materials	15.724	1
Nano Letters	13.779	8
ACS Nano	13.334	9
Nano Today	13.157	1
Journal of the American Chemical Society	13.038	8
Coordination Chemistry Reviews	12.994	1
Angewandte Chemie - International Edition	11.709	11
Nano Energy	11.553	10
Advanced Functional Materials	11.382	5
Nature Communications	11.329	6
Chemical Science	9.144	3
Materials Horizons	9.095	1
Nano Research	8.893	1
NPG Asia Materials	8.772	2
Biomaterials	8.387	5
Small	8.315	4
Current Opinion in Biotechnology	8.314	1
Journal of Materials Chemistry A	8.262	16

*: Source: Web of Science database, as of June 2016.

- **Research papers of MANA**

MANA's excellence can be seen in several key indicators analyzed by Thomson Reuters and Elsevier. Fig. 4-3 shows the number of MANA affiliated research papers in English published between October 2007 and December 2016 (information current as of January 2017) together with the average journal impact factor (IF) analyzed by Web of Science data base. Until December 2016, MANA has published a total of 3,840 papers in 466 different journals. The number of MANA papers published per year remained at a high value close to 470 papers between 2011, and 2015 and increased to 524 papers in 2016. The average impact factor (IF) of the journals in which MANA papers were published increased from 4.00 in 2008 to 6.25 in 2015. Of the 524 papers that MANA researchers published in 2015, 111 papers (or 21.2%) appeared in top journals with an impact factor 2015 higher than 8. The top journals are listed in Table 4-2. The 524 MANA papers published in 2016 are listed in Appendix 7-6 including *digital object identifier* (doi), *accession number* (WOS), and *electric identifier* (eid).

- The *digital object identifier* (doi) is a unique alphanumeric string assigned by a registration agency (the International doi Foundation) to identify content and provide persistent link to its location on the internet.
- The *accession number* (WOS) is a unique article identifier on Web of Science database.
- The *electric identifier* (eid) is a unique article identifier on SCOPUS database.

Appendix 7.6: MANA Research Papers 2016

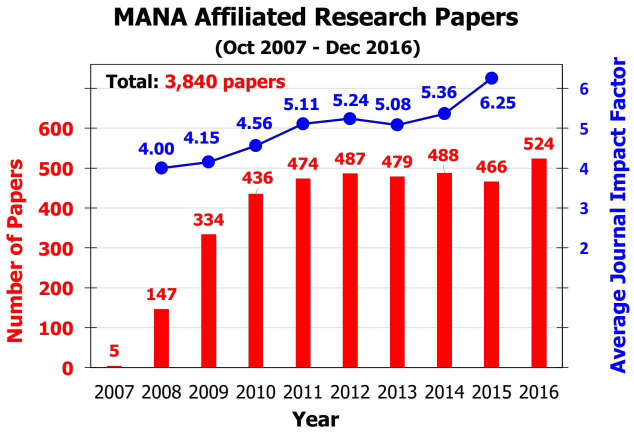


Fig. 4-3: Number of MANA affiliated research papers in English published between October 2007 and December 2016 and average journal impact factor (Source: Web of Science database, as of June 2016). Information current as of January 2017.

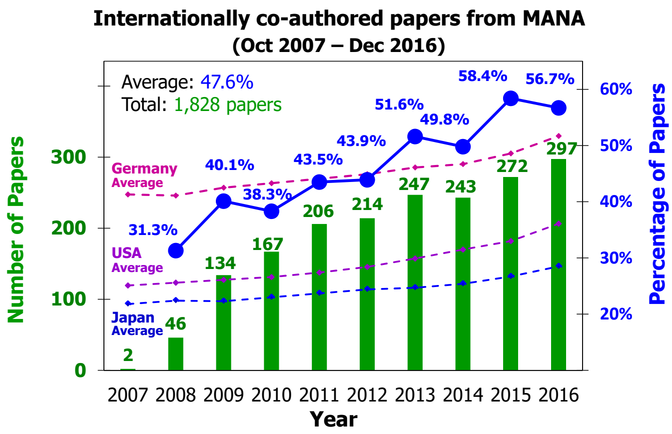


Fig. 4-4: Internationally co-authored papers of MANA published between October 2007 and December 2016. Information based on SCOPUS database. Source of national average: SciVal database, Elsevier B.V., downloaded in August 2016.

MANA researchers actively engage in joint research with other researchers both in Japan and around the world. This is supported by the fact that, of the 3,840 papers released by MANA until December 2016, 47.6% have featured international co-authorship (Fig. 4-4). The number of MANA papers featuring international co-authorship is increasing every year, and such papers accounted for a majority of MANA papers released since 2013. The high rate of international co-authorship of MANA became higher than that of Germany, which boasts one of the highest rate of international co-authorship in the world. This accomplishment demonstrates that MANA is successfully building an organization in which researchers of different countries can come to cooperate on research.

Essential Science Indicators of Thomson Reuters Web of Science compiles citation-based data sets for gauging performance of publications. *Highly Cited Papers* are ranked in the top 1% by citations for their field and year of publication. Of the total of 3,840 MANA papers, 142 papers (3.7%) are extremely high-profile entering the top 1% in the world by number of citations (source: Web of Science database, as of January 2017). The breakdown of the 142 MANA top 1% papers into Research Fields and Year published is illustrated in Fig. 4-5. MANA top 1% papers appeared in 51 different journals. The journals containing 5 or more MANA top 1% papers are listed in Table 4-3. MANA top 1% papers with more than 500 citations are shown in Table 4-4.

Web of Science: 142 highly cited (top 1%) MANA papers

Breakdown into Research Fields:*

Research Field	Percentage
Chemistry	43.7%
Materials Science	40.1%
Physics	14.1%
Pharmacology & Toxicology	1.4%
Engineering	0.7%
Total	**100.0%**

* Classified by Web of Science

Breakdown into Year published:

Year Published	Number of papers
2016	15
2015	19
2014	19
2013	17
2012	23
2011	13
2010	21
2009	10
2008	5
Total	**142**

Fig. 4-5: Breakdown of the 142 highly cited (top 1%) MANA papers into Research Fields (left) and Year Published (right).

Table 4-3: Journals containing 5 or more highly cited (top 1%) MANA papers.

Name of journal	Journal impact factor 2015 *	Number of MANA top 1% papers
Advanced Materials	18.960	19
Journal of the American Chemical Society	13.038	15
Advanced Functional Materials	11.382	9
Journal of Materials Chemistry A **	8.262	7
ACS Nano	13.334	6
Chemical Communications	6.567	6
Chemical Society Reviews	34.090	5
Chemistry - A European Journal	5.771	5
Chemistry of Materials	9.407	5

*: Source: Web of Science database, as of January 2017

**: including Journal of Materials Chemistry

Table 4-4: Top 1% MANA papers with more than 500 citations.

Number of citations *	MANA Top 1% paper
1,238	H. Tong, S. Ouyang, Y. Bi, N. Umezawa, M. Oshikiri, J. Ye, *Nano-photocatalytic Materials: Possibilities and Challenges*, Advanced Materials **24**(2), 229 (2012). doi: 10.1002/adma.201102752 WOS:000298788000008
844	Z.G. Yi, J. Ye, N. Kikugawa, T. Kako, S. Ouyang, H. Stuart-Williams, H. Yang, J. Cao, W. Luo, Z. Li, Y. Liu, R.L. Withers, *An orthophosphate semiconductor with photooxidation properties under visible-light irradiation*, Nature Materials **9**(7), 559 (2010). doi: 10.1038/nmat2780 WOS:000279014300017
725	K. Ariga, A. Vinu, Y. Yamauchi, Q.M. Ji, J.P. Hill, *Nanoarchitectonics for Mesoporous Materials,* Bulletin of the Chemical Society of Japan **85**(1), 1 (2012). doi: 10.1246/bcsj.20110162 WOS:000300469400001
630	D. Golberg, Y. Bando, Y. Huang, T. Terao, M. Mitome, C. Tang , C. Zhi, *Boron nitride nanotubes and nanosheets*, ACS Nano **4**(6), 2979 (2010). doi: 10.1021/nn1006495 WOS:000278888600004
545	K. Ariga, J.P. Hill, M.V. Lee, A. Vinu, R. Charvet, S. Acharya, *Challenges and breakthroughs in recent research on self-assembly*, Science and Technology of Advanced Materials **9**(1), 014109 (2008). doi: 10.1088/1468-6996/9/1/014109 WOS:000257128300019
543	K. Ariga, Y. Yamauchi, G. Rydzek, Q.M. Ji, Y. Yonamine, K.C.W. Wu, J.P. Hill, *Layer-by-layer Nanoarchitectonics: Invention, Innovation, and Evolution*, Chemistry Letters **43**(1), 36 (2014). doi: 10.1246/cl.130987 WOS:000329475000006

*: Source: Web of Science database, as of January 2017

Meanwhile, the company Elsevier B.V. has created a new index called the Field Weighted Citation Impact (FWCI) that adjusts the paper citation count by field of research to enable comparisons of the quality of papers released by research institutions in different fields. Fig. 4-6 compares the values of FWCI for MANA and various other institutes and universities in the world. MANA's FWCI of 2.41 is extremely high and means that MANA output is 141% more often cited than expected for the world average (FWCI =1). It is clearly the highest in Japan and reached a level of performance comparable to top-ranked universities in Europe and America.

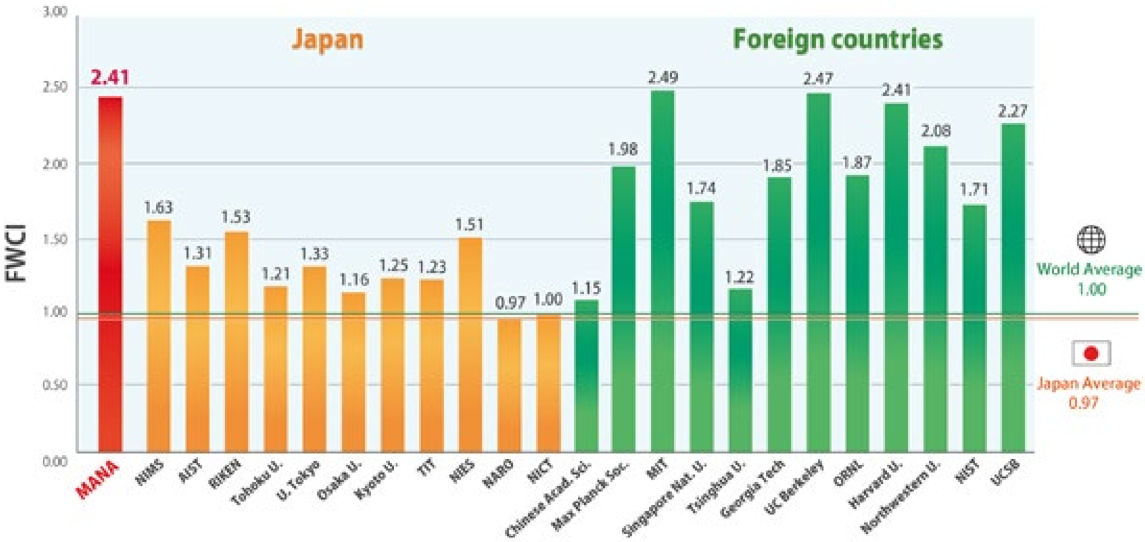


Fig. 4-6: Field Weighted Citation Impact (FWCI) of MANA and other institutions in the world. Source: SciVal database, Elsevier B.V., downloaded in September 2016. FWCIs were calculated for papers published between 2008 and 2015 (8 years).

- **MANA Journal Cover Sheets**

Since the launch of the MANA project in October 2007, MANA scientists have produced many Journal cover sheets of issues that contain their research paper. Different kinds of Journal cover sheets (Journal Front Cover, Journal Inside Front Cover, Journal Back Cover, Journal Inside Back Cover, Journal Frontispiece) related to papers with MANA Affiliation between October 2007 and December 2016 are listed in Appendix 7.7. Some examples from 2016 are shown in Fig. 4-7.

Appendix 7.7: MANA Journal Cover Sheets

Fig. 4-7: Examples of recent journal front covers related to MANA affiliated papers.

- **MANA Patents**

In addition to writing research papers, MANA researchers applied for a total of 823 patents (578 domestic; 245 international) in the period between October 2007 and December 2016. Meanwhile, MANA registered 642 patents (489 domestic; 153 international) in the same period (Fig. 4-8, Table 4-5). Recent patent applications and registrations (for Jan 2015 – Dec 2016) are listed in Appendix 7.8. All listed patent applications and patent registrations are or were partly or fully owned by NIMS.

Appendix 7.8: MANA Patents

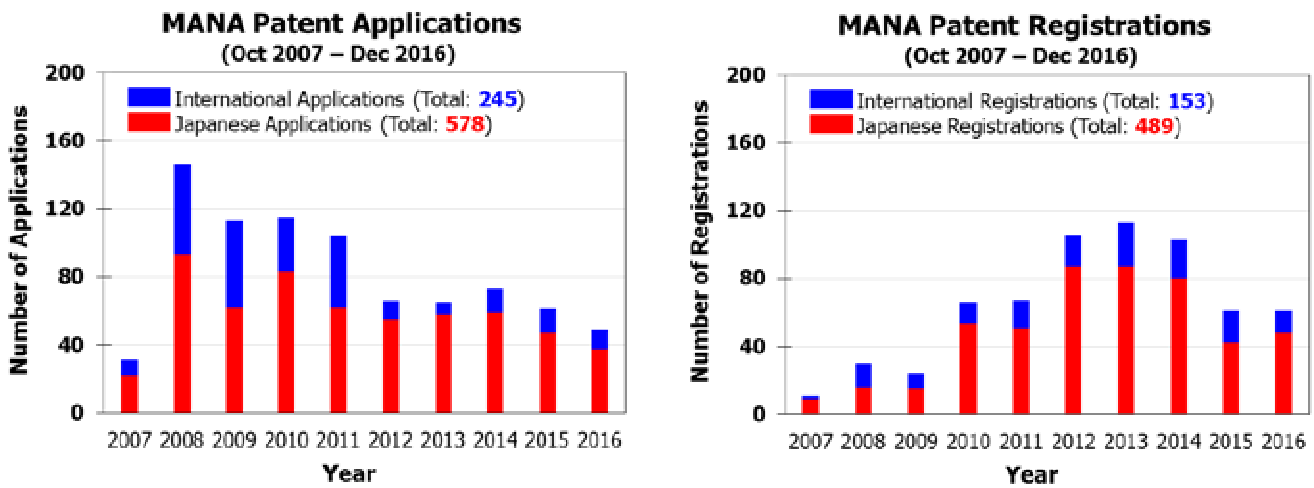


Fig. 4-8: Number of MANA patent applications and registrations between October 2007 and December 2016.

Table 4-5: Number of MANA patent applications and registrations.

	Total Number (2007 Oct – 2016 Dec)	Average Number (per year)
Japanese Patent Applications	578	62.5
Japanese Patent Registrations	489	52.9
International Patent Applications	245	26.5
International Patent Registrations	153	16.5

- **Commendations**

In 2016, MANA's renowned researchers again won several prestigious prizes and awards.

Europe's Rising Stars 2015 Award

In December 2015, MANA Satellite PI Christian Joachim won the Europe's Rising Stars 2015 Award (Fig. 4-9) for the set up and coordination of the European Integrated Research Project "AtMol" (Atomic Scale and Single Molecule Logic Gate Technologies, 2011-2014). The Stars of Europe competition rewards successful European projects initiated in France by a private or public coordinating body and completed during the year.

Research Project Award at nano tech 2016

In January 2016, the exhibition of research results obtained by MANA Principal Investigator Takao Mori on "Rare-earth free high efficiency thermoelectric material" was awarded the Research Project Award (Green Nanotechnology Award, Fig. 4-9) at the 15th International Nanotechnology Exhibition & Conference (nano tech 2016).

The Chemical Society of Japan (CSJ) Fellow Award

In February 2016, MANA Principal Investigator Kohei Uosaki received The Chemical Society of Japan (CSJ) Fellow Award for his significant contribution to the academic field of chemistry and chemical technology, the development of the industrial region and science education. The award ceremony has been held during the 96th Spring Meeting of CSJ in March 2016.

Tsukuba Science Education Meister

In July 2016, MANA Associate Principal Investigator Mitsuhiro Ebara was certified as Tsukuba Science Education Meister by Mr. Kenichi Ichihara, Tsukuba City Mayor (Fig. 4-9). The Meister Certification was established by Tsukuba city in order to praise the people at universities and public institutions who have made a remarkable accomplishment on science education in the city and Dr. Ebara has become the third certified person.

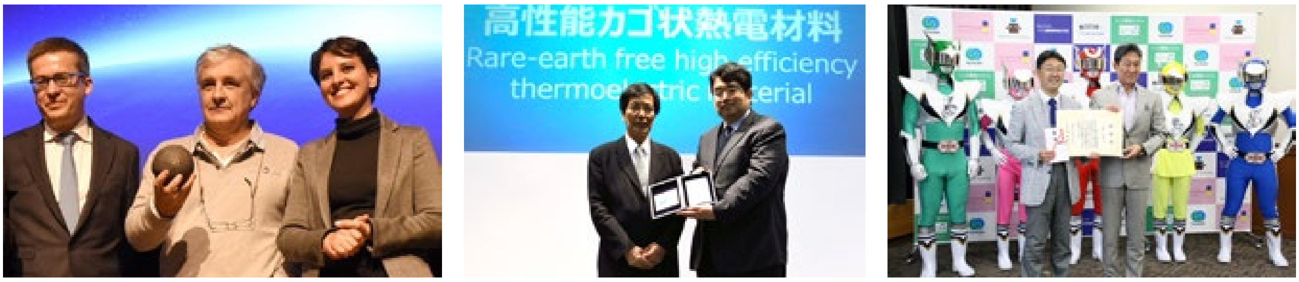


Fig. 4-9: Recent Award Ceremonies with researchers from MANA. Left: MANA Satellite PI Christian Joachim won the “Europe’s Rising Stars 2015” Award in December 2015. Middle: MANA PI Takao Mori received the “Green Nanotechnology Award” at the nano tech 2016 exhibition in January 2016. Right: MANA Associate PI Mitsuhiro Ebara was certified as Tsukuba Science Education Meister by Mr. Kenichi Ichihara, Tsukuba city Mayor in July 2016.

Korea Information Display Society (KIDS) Gold Award

In August 2016, MANA Independent Scientist Takeo Minari received the Gold Award of Korea Information Display Society (KIDS) for their research on “Ultra-High-Resolution Printing of Organic Thin-Film Transistors.” The award ceremony was held at the 16th International Meeting on Information Display (IMID 2016) in Jeju city, Korea.

Honorary Member of Materials Research Society of India (MRSI)

In August 2016, MANA Principal Investigator Katsuhiko Ariga has been selected as an honorary member of Materials Research Society of India (MRSI).

Fellow of the Royal Society of Chemistry

In September 2016, MANA Chief Operating Officer Yoshio Bando and MANA Principal Investigator Jinhua Ye have been admitted as Fellow of the Royal Society of Chemistry.

Fellow of the Royal Society of Canada

In September 2016, MANA Satellite Principal Investigator Françoise M. Winnik has been admitted as Fellow of the Royal Society of Canada (RSC).

ISI Highly cited researchers 2016 (Thomson Reuters)

ISI Highly cited researchers 2016 are authors of many highly cited papers in a certain research field in the Thomson Reuters Essential Science Indicators database. Thomson Reuters announced the members of this elite group that contains 6 Principal Investigators from MANA (Fig. 4-10) as follows: Field of *Materials Science*: Kastuhiko Ariga, Yoshio Bando, Dmitri Golberg, Jinhua Ye and Zhong Lin Wang. Field of *Chemistry*: Zhong Lin Wang and Yusuke Yamauchi. Field of Physics: Zhong Lin Wang.

NF Foundation R&D Encouragement Award

In October 2016, MANA Scientist Satoshi Ishii received the 5th NF Foundation R&D Encouragement Award for his research on “Highly efficient photothermal conversion utilizing nanoparticles”. A presentation meeting with the awardees has been held in November 2016. The award 2016 has been set up for “advanced measurement and analysis” and “environment and energy”.

NISTEP Award 2016

In December 2016, Principal Investigator Yusuke Yamauchi was selected as a one of winners of NISTEP Award 2016 for his research on “Various Synthesis of New Materials and Proposal of New Synthesis Techniques to Design New Inorganic Materials”. The National Institute of Science and Technology Policy (NISTEP) gives this award to researchers with excellent contributions to science and technology.

Fig. 4-10: 6 MANA Principal Investigators were selected as *ISI Highly cited researchers 2016* in the fields of Materials Science, Chemistry and Physics.

4.3 Research Achievements

Commemorating the 10th anniversary of MANA, the booklet "Research at MANA: 42 Selected Research Results" has been published in February 2017 (Fig. 4-11). In this section, the content of this booklet is summarized.

Fig. 4-11: Booklet Research at MANA published February 2017.

- **Research at MANA: 42 Selected Research Results (2007-2017)**

In this booklet, typical research results obtained by MANA in the 10 year period (2007 - 2017) are described. Over the whole period, MANA has conducted its research based on the own "nanoarchitectonics" concept. Although the research at MANA has been carried out in five research fields (Nano-Materials, Nano-System, Nano-Power, Nano-Life, and Nano-Theory), the 42 selected research results in this booklet are classified into the three categories: *I. Creation of New Fields of Research*, *II. Fusion of Interdisciplinary Research Fields*, and *III. Other Remarkable Research Results*.

	Research Results
I. Creation of New Research Fields	
★ **Nanosheet-based Nanoarchitectonics for Creating Novel Materials**	[1] - [2]
★ **Atomic Switch and Related Nanoarchitectonic Devices and Systems**	[3] - [5]
★ **Single-molecule-level Memory and Logic Devices**	[6] - [8]
★ **Innovative Nano- and Molecular-scale Characterization/Detection Methods**	[9] - [12]
II. Fusion of Interdisciplinary Research Fields	
★ **Nano-life Science Inspired by Nanoarchitectonics**	[13] - [16]
★ **Nanoarchitectonics Inspired by Nano-life Science**	[17] - [18]
★ **Fusion of Science and Practical Technology**	[19] - [20]
★ **Theory-Experiment 'Cross-linkage' for Exploring Novel Nanomaterials**	[21] - [24]
III. Other Remarkable Research Results	
★ **Creation of New Nanoscale Materials with Novel Functionality**	[25] - [29]
★ **Innovative Nano/Micro-scale Devices and Systems**	[30] - [36]
★ **Theoretical Exploration of Materials Properties**	[37] - [39]
★ **Nanoarchitectonics Related to Sustainable Energy and Environment**	[40] - [42]

I. Creation of New Research Fields

★ Nanosheet-based Nanoarchitectonics for Creating Novel Materials

[1] Synthesis of 2D nanosheets via massive swelling and exfoliation of layered crystals

T. Sasaki, Y. Ebina, R. Ma

We developed 2D oxide and hydroxide nanosheets by inducing enormous swelling of the starting layered materials. The swollen crystals were disintegrated into molecularly thin elementary layers with very high 2D anisotropy. The colloidal nanosheets were applied in "material nanoarchitectonics" to develop hierarchical materials with unique, advanced functionalities.

[2] Nanosheet architectonics: new 2D electronics beyond graphene

M. Osada, T. Sasaki

We developed high-k oxide nanosheets, an important material platform for ultrascale electronic devices and post-graphene technology. The new nanosheets (Ti_2NbO_7, $[Ca,Sr]_2Nb_3O_{10}$) provide the highest permittivity (ε_r = 210–320) of all known dielectrics in the ultrathin region (< 10 nm). Layer-by-layer engineering of these nanosheets enabled us to design 2D dielectric devices that cannot be achieved in graphene and other materials. Graphene is only the tip of the iceberg, and we are now starting to discover new possibilities afforded by 2D oxide nanosheets.

★ Atomic Switch and Related Nanoarchitectonic Devices and Systems

[3] High-performance gapless atomic switch and related nanoionic devices

K. Terabe, T. Tsuruoka, T. Tsuchiya, T. Hasegawa, M. Aono

We developed a quantized conductance gapless atomic switch utilizing ion migration. Quantized conductance was observed by controlling an atomic point contact between a metal filament and an electrode in the atomic switch with a simple metal–insulator–metal layered structure. Furthermore, an all-solid-state electric double-layer transistor (EDLT) based on a nanoionic device principle using ion migration was created for electrical modulation of superconducting critical temperature (Tc).

[4] Artificial inorganic synapses achieved using atomic switch technology

T. Tsuruoka, K. Terabe, T. Hasegawa, M. Aono

We demonstrated that atomic switches can emulate the synaptic plasticity underlying memory functions in the human brain. The change in the conductance of the atomic switch is considered analogous to the change in the strength of a biological synapse which varies according to stimulating input pulses. The atomic switch therefore has potential for use as an essential building block for neural computing systems.

[5] Atomic switch networks: nanoarchitectonic design of a neuromorphic system for future computing

J.K. Gimzewski, A.Z. Stieg, M. Aono

Through a conceptual convergence of nanoarchitectonics, neuroscience, and machine learning, we developed hardware-adaptive computing architectures based on deeply hierarchical networks of memristive elements. Atomic switch networks (ASNs) seek to realize revolutionary efficiency, performance, and robustness in high-performance computing by envisioning a new approach to intrinsic computing with target applications in embedded systems, mobile devices, robotics, and autonomous control. ASN devices have been used to demonstrate one of the first hardware implementations of pattern recognition and forecasting tasks without the need for preprogramming.

★ Single-molecule-level Memory and Logic Devices

[6] Single-molecule-level molecular memories for ultra-high density storage

T. Nakayama, M. Aono

Co-workers: M. Nakaya, S. Tsukamoto

Ultrahigh-density data storage has been considered to be one of the important outcomes by utilizing single-molecule manipulation with a scanning tunneling microscope (STM). However, there has been a crucial problem for many years; how to achieve reversible and repeatable control of a molecular bit to represent 0 and 1. We solved this long-standing problem by reversibly controlling bound and unbound states of C_{60} molecules at room temperature, and demonstrated actual bit operations at a bit density of 190 Tbits/in^2.

[7] Molecular wiring and single-molecular devices

Y. Okawa, M. Aono

Co-workers: Y. Tateyama, C. Joachim, M. Makarova, E. Verveniotis

We developed a novel method for single-molecular wiring using nanoscale-controlled chain polymerization on a molecular layer. This method, which we call "chemical soldering," enables us to connect single conductive polymer chains to single functional molecules via covalent bonds. We are investigating the electrical transport properties of the fabricated single-molecular devices. These studies will be an impor tant step in advancing the development of single-molecule electronic circuitry.

[8] Design of molecular quantum mechanical logic gates

C. Joachim, S. Srivastava, H. Kino

Based on quantum Hamiltonian computing (QHC), we have designed a 2-nm single-molecule ½ adder with 4 planar graphene nanopads. This molecule runs Boolean calculations with quantum-level repulsion, optimized destructive interference, and only 4 of its molecular electronic states. The QHC classical to quantum 2-input conversion is ensured by the rotation of two nitro chemical groups that can be activated by the tip of a scanning tunneling microscope (STM). From 0.1 to 2 μA, the ½ adder XOR and AND output currents are measured at the same low bias voltage.

★ Innovative Nano- and Molecular-scale Characterization/Detection Methods

[9] Multiple-probe scanning probe microscopes for material nanoarchitectonics

T. Nakayama, Y. Shingaya, O. Kubo, M. Aono

The novel properties of individual nanostructures and nanosystems, the outgrowth of material nanoarchitectonics, must be characterized using innovative instruments and methodologies. For this purpose, we developed multiple-probe scanning probe microscopes (MP-SPMs) and thus created a new class of nanoscale measurements enabling us to perform unique, indispensable nanomeasurements.

[10] Pioneering development of in situ transmission electron microscope techniques for direct property measurements on nanoscale materials

D. Golberg, N. Kawamoto, M. Mitome, Y. Bando

State-of-the-art in situ analytical methods of nanomaterial property measurements inside a high-resolution transmission electron microscope (TEM) were for the first time designed and implemented for mechanical, electrical, thermal, optical, optoelectronic, and cathodoluminescence characterizations of various nanoscale nitrides, oxides, sulfides, selenides, phosphides, and carbides. Clear atomic structure–functional property relationships were established, which is the "Holy Grail" of the material "nanoarchitectonics" concept and the entire material science field.

[11] Nanomechanical sensing technologies (MSS, AMA) for olfactory sensor systems

G. Yoshikawa, K. Shiba

Co-worker: G. Imamura

We developed novel nanomechanical sensing technologies, the Membrane-type Surface stress Sensor (MSS) and Aero-Thermo-Dynamic Mass Analysis (AMA). The comprehensive structural optimization and integration of nanomaterials as receptors led to the unique MSS structure with much higher sensitivity, stability, and compactness compared with conventional nanomechanical sensors. AMA enables nanoarchitectonic analyses of the fundamental properties (molecular weight) of gas samples under ambient conditions.

[12] Cathodoluminescence and electron beam-induced current characterization for nanomaterials and devices

T. Sekiguchi, J. Chen

Co-workers: K. Watanabe, Y. Cho

Nanoscale observations of material function, such as electrical and/or optical properties, are indispensable for nanoscience and nanotechnology. Thus, we developed scanning electron microscopy (SEM) and improved cathodoluminescence (CL) and electron beam-induced current (EBIC) techniques as well as secondary electron (SE) imaging.

II. Fusion of Interdisciplinary Research Fields

★ Nano-life Science Inspired by Nanoarchitectonics

[13] Smart nanofibers for cancer therapy

M. Ebara, T. Aoyagi
Co-worker: K. Uto

We developed a smart anticancer nanofiber that is capable of simultaneously performing thermotherapy and chemotherapy for treating malignant tumors. By tailoring the nanoarchitectures of polymer networks in the fiber, we demonstrated simultaneous heat generation and drug release in response to an alternating magnetic field (AMF). A 5–10-min application of AMF alone successfully induced cancer apoptosis in both in vitro and in vivo studies.

[14] Novel antioxidative nanomedicine for Alzheimer's disease

Y. Nagasaki

Excessively generated reactive oxygen species (ROS) are associated with age-related neurodegenerative diseases including Alzheimer's disease (AD). We investigated whether scavenging of ROS in the brain by orally administered redox nanoparticles (RNPs) facilitates the recovery of cognition in 17-week-old senescence-accelerated-prone mice. After treatment for 1 month, levels of oxidative stress in the brains of the mice were remarkably reduced by treatment with RNPs compared with those in mice treated with low-molecular-weight (LMW) nitroxide radicals, resulting in the amelioration of cognitive impairment with increased numbers of surviving neurons. Additionally, treatment with RNPs did not show any detectable toxicity.

[15] Photoactivating surfaces to resolve mechanoarchitectonics in collective cell migration

J. Nakanishi

Collective cell migration plays critical roles in various physiological and pathological processes. Therefore, understanding its regulatory mechanisms is important from both fundamental and applied biology viewpoints. We developed a photoactivatable gel substrate as a robust platform for resolving mechanoarchitectonics in collective cell migration.

[16] Nano- and microstructured biomaterials for regenerative medicine

G. Chen, N. Kawazoe

Nano- and microstructured biomaterials play an important role in regenerative medicine to control stem cell functions and to guide the regeneration of new tissues and organs. We developed a few types of highly functional biomaterials that mimic the nanostructured microenvironments surrounding cells in vivo. The biomaterials showed specific control of cell functions such as adhesion, spreading, proliferation, and differentiation and promoted tissue regeneration..

★ Nanoarchitectonics Inspired by Nano-life Science

[17] Silicon nanocrystals for bioimaging in the near-infrared biological optical window

F.M. Winnik
Co-workers: C. Sourov, G. Beaune, N. Shirahata

Functional water-dispersible near-infrared (NIR)-emitting nanoparticles (NPs) adapted for two-photon excitation cellular imaging were developed starting from octadecyl-terminated silicon nanocrystals (ncSi-OD) with narrow photoluminescence (PL) spectra free of emission tails and continuously tunable over the NIR biological window. Their PL quantum yields (QYs) exceed 30% and their PL lifetimes are 300 µsec or longer. The NPs, which are very low in toxicity, were internalized in cells and imaged in vitro.

[18] Artificial photosynthesis: natureinspired nanoarchitectonics for efficient solar–chemical conversion

J. Ye
Co-workers: Z. Yi, H. Zhou

We have been challenging artificial photosynthesis, which offers potential solutions for global warming and energy shortage issues. The new material Ag_3PO_4 with the world's highest quantum efficiency (approaching that of natural photosynthesis) in photocatalytic water oxidation was developed under unique material-designing guidelines. Sophisticated control of the surface/interface structure to mimic the structural and functional elements in nature enables efficient light harvesting, charge separation, and gas diffusion/conversion, making a big step toward achieving high-efficiency artificial photosynthesis.

★ Fusion of Science and Practical Technology

[19] Novel thermoelectric materials: steps toward the first wide-scale power generation from waste heat

T. Mori, N. Tsujii, I. Ohkubo
Co-worker: A.U. Khan

We achieved a >100% increase in the thermoelectric figure of merit ZT in the champion skutterudite material by utilizing phase diagrams to create surprisingly controlled, effective porosity in a material. As a novel principle, we also discovered thermoelectric enhancement in magnetic semiconductors like chalcopyrite. Novel nitrides are also proposed as a thermoelectrically superior new group of materials to extensively studied oxides, while novel borides were developed with excellent p, n control.

[20] Piezotronics and piezophototronics: novel nanomaterials and nanodevices

Z.L. Wang
Co-workers: K. C. Pradel, Y. Ding, X. Wen, W. Wu, F. Zhang

We pioneered in exploring the effect of piezopotential on the transport behavior of charge carriers in electronic and optoelectronic nanodevices. The new fields of piezotronics and piezophototronics were created by utilizing piezopotential inside material crystals as a "gate" potential to control charge carrier transport behavior for electronics and optoelectronics. For that purpose, we developed several novel materials/structures such as p-type ZnO nanowires, ZnO p–n homojunctions, and heterojunctions. The research results indicate potential applications in strain/force-triggered electronic devices, sensors, and logic units.

★ Theory-Experiment 'Cross-linkage' for Exploring Novel Nanomaterials

[21] Interface science of batteries, solar cells, and catalysts via supercomputer simulations

Y. Tateyama
Co-worker: K. Sodeyama

Atomic and electronic processes at buried interfaces are still open questions because of the difficulties in in-situ experimental observations as well as accurate calculations. We developed highly efficient first-principles sampling codes for large-scale supercomputers like the K computer and revealed the microscopic mechanisms of those interfacial issues such as redox processes, electric double-layers, and water dissociation in energy and environmental materials.

[22] Large-scale first-principles calculations and experiments for the design of nanoscale devices

T. Miyazaki, D. R. Bowler, N. Fukata

To enable first-principles electronic structure calculations using density functional theory (DFT) to be performed on systems that correspond to practical nanoscale devices and materials, we developed a world-leading linear-scaling DFT code: CONQUEST. Using CONQUEST, we conducted collaborative theory-experimental research on Si/Ge core-shell nanowires.

[23] Surface atomic-layer superconductors on silicon: macroscopic supercurrents and Josephson vortices

T. Uchihashi, X. Hu
Co-workers: S. Yoshizawa, T. Kawakami

We demonstrated that surface atomic layers on silicon can become superconducting by directly observing robust macroscopic supercurrents for the first time. In addition, our scanning tunneling microscope (STM) observations and theoretical calculations revealed the presence of Josephson vortices at atomic steps. These findings open a route for creating superconducting devices with Josephson junctions based on surface atomic-layer materials on silicon.

[24] Development of novel electrocatalysts for highly efficient energy conversion reactions: theoretical prediction and experimental proof

K. Uosaki, H. Noguchi
Co-workers: G. Elumalai, H.C. Dinh

Boron nitride (BN), an insulator with a wide band gap, supported on Au (BN/Au) is predicted theoretically and proved experimentally to act as an electrocatalyst for oxygen reduction reaction. Although BN/Au reduces oxygen to H_2O_2 by a 2-electron process, oxygen can be reduced to H_2O by a 4-electron process by decorating BN with Au nanoparticles. BN/Au also works as a hydrogen evolution reaction catalyst with efficiency close to that of Pt. Theoretical study shows that some *edge atoms provide energetically favored sites for intermediate adsorption.*

III. Other Remarkable Research Results

★ Creation of New Nanoscale Materials with Novel Functionality

[25] Boron nitride nanostructured materials: novel synthesis by "chemical blowing" and applications

Y. Bando, D. Golberg

The mass production of boron nitride (BN) low-dimensional materials at gram levels was successfully achieved via synthetic routes of "chemical blowing" and carbothermal reduction. Such abundant BN nanotube and nanosheet products were applied to advanced composite materials as fillers, especially for fabricating polymeric packaging materials with greatly enhanced thermal conductivity allowing for quick release of heat in diverse electronic devices.

[26] Nanoarchitectured porous materials with metallic walls

Y. Yamauchi

Nanoporous archi tectures wi th metal l ic wal ls are necessary for higher catalyt ic performance. A new "micelle-assembly" approach for the synthesis of mesoporous metals with a narrow pore-size distribution enables the synthesis of more complex mesoporous architectures with multifunctional properties, which cannot be achieved by conventional methods (i.e., hard- and soft-templating approaches).

[27] Chiral sensing: novel chiral solvating agents for nondiastereomeric determination of enantiomeric excess

J. Labuta, S. Ishihara, K. Ariga, J. P. Hill

We developed a unique family of prochiral chiral solvating agents (pro-CSA) for the determination of enantiomeric excesses (ee) of a wide range of chiral analytes including carboxylic acids, alcohols, amines, and ketones using nuclear magnetic resonance (NMR) spectroscopy. This is made possible by the weak interaction and consequent rapid solution exchange between analyte and pro-CSA and can be considered as the sampling of the average chirality of the analyte in solution.

[28] Quantum transport of electric field-induced carriers in diamond

T. Yamaguchi, H. Takeya, Y. Takano

We observed quantum (Shubnikov-de Haas) oscillations in diamond for the first time. This was achieved by the preparation of atomically flat hydrogen-terminated diamond surfaces and the accumulation of high-density hole carriers due to the electric-field effect using an ionic liquid. The observation of quantum oscillations indicated a high-mobility metallic state of diamond, which will open up rich fields of research from fundamental physics to device applications.

[29] Novel functional molecular liquids developed by alkyl-π engineering

T. Nakanishi

We developed novel ultimate-soft organic materials, i.e., room-temperature functional molecular liquids composed of a π-conjugated molecular unit bearing bulky, flexible branched alkyl chains. The studies of full-color tunable luminescent liquids and uncommon phase phenomena with the photoconducting property of liquid fullerenes are designed simply by controlling a balance of intermolecular interactions in the alkyl-π compounds, i.e., van der Waals and π–π interactions among adjacent molecules, or "alkyl-π engineering".

★ Innovative Nano/Micro-scale Devices and Systems

[30] Silicon-doped metal oxide thin-film transistor for next-generation power-saving flat displays

K. Tsukagoshi, T. Nabatame

We developed a promising material for an oxide thin-film transistor (TFT) to produce nextgeneration power-saving flat displays. Our silicon (Si)-doped metal oxide TFT (SiM-OxTFT) behaves as a very stable, high-performance TFT with a significantly suppressed off-state current.

[31] New high-k materials for future Ge field-effect transistors

T. Chikyow, T. Nagata, Y. Yamashita

Direct contact of high-k oxide on a Ge substrate was demonstrated with a TiO_2 buffer layer. Rutile TiO_2 was grown on p-type (100) Ge substrates at 420°C. During the deposition, originally formed GeO_2 *was decomposed, and Ge diffusion to*

TiO_2 was observed. By optimizing the growth conditions, Ge diffusion was minimized. HfO_2 was subsequently deposited on this TiO_2 to make HfO_2/TiO_2 stacked high-k layers. The electric property showed reduced leakage current, although a large threshold voltage shift was observed.

[32] Printed electronics: spontaneous patterning of high-resolution electronics

T. Minari

Fully printed electronics on a flexible substrate have attracted considerable interest owing to their high compatibility and ease of integration. We developed an ultra-high-resolution printing technique based on fluidic self-assembly, which enables selective deposition of a metal nanoparticle (NP) ink with a 1-μm feature size. We also employed a room-temperature fabrication procedure to prevent undesired distor tion of the heat-sensitive, flexible substrate. The technique thereby allows the large-scale fabrication of flexible electronics with 1-μm resolution at low cost.

[33] Novel concepts for III-V nitride optoelectronic devices

L. Sang

Benefiting from the wide, adjustable, direct bandgaps, high breakdown voltage, and high carrier mobilities, the III-V nitride semiconductor (GaN, InN, AlN, and their ternary and quaternary alloys) is not only a potential candidate for high-performance optical devices but also for high-power, and high-frequency electronic devices. However, there are still challenges in high-quality film growth and effective p-type doping, which hinders the development of nitride devices. Our research on InGaN-based ultraviolet photodiodes, intermediate-band solar cells, and p-channel field-effect transistors with a InGaN/GaN heterojunction structure is introduced here.

[34] Multifunctional electron tunneling devices with molecular quantum dots

R. Hayakawa, Y. Wakayama

Precise control of electron tunneling is critical for power-saving electronic devices. Our purpose was to develop electron tunneling devices based on a variety of molecular functions. Functional molecules were integrated into a Si-based architecture, aiming to bridge the gap between fundamental quantum effects and practical device engineering. Here, we demonstrate the fundamental mechanism, multilevel tunneling, and optical control of electron tunneling. These results were achieved by taking advantage of organic molecules as quantum dots.

[35] Photothermal energy conversion with novel plasmonics and metamaterials

T. Nagao, S. Ishii

Co-workers: T.D. Dao, T. Yokoyama

We developed a new class of nanomaterials/nanodevices with high photothermal conversion efficiency based on plasmonics and metamaterials. A new methodology for choosing appropriate compound materials was adopted to permit full-solar spectrum absorption for solar-heat generation. Our metamaterial perfect absorber can be applied for narrow-band infrared (IR) light sources with low energy consumption and for spectroscopic IR sensors, opening the way for new usages and demand in industrial quality control as well as in daily life.

[36] Graphene-based single-electron devices

S. Moriyama

We developed quantum nanodevices such as single-electron transistors in graphene, consisting of an isolated single atomic layer of graphite, as unrolled carbon nanotubes. The discovery of novel electron-transport characteristics in single- and several-layer graphene demonstrates that it is an attractive two-dimensional conducting material, not only as a new field in low-dimensional physics but also as building blocks of novel quantum nanodevices.

★ Theoretical Exploration of Materials Properties

[37] Exploring new frontiers of materials science in terms of topology

T. Kawakami, X. Hu

Because uncertainty caused by quantum fluctuations is unavoidable at nanometer scales, new schemes have to be created for achieving novel functionalities in nano systems. In order to take up this challenge, we are developing a new approach coined "topological nanoarchitectonics". One example is the quest for Majorana bound states (MBS) in topological superconductors, which can be exploited for robust quantum computation.

[38] Laser control of nondissipative electric current in topological materials

J. Inoue

We constructed a theoretical framework that enables discussion of matter and intense-light interaction, which is beyond the scope of conventional theories. Our theory predicts that laser irradiation can induce a phase transition in topological material, thereby leading to control of nondissipative electric current by tuning laser amplitude.

[39] Nature of the Mott transition

M. Kohno

The nature of the Mott transition is theoretically clarified: the Mott transition is characterized by freezing of the charge degrees of freedom, whereas the spin degrees of freedom remain active. This characteristic is contrasted with the conventional picture where the Mott transition was considered to be characterized in terms of single particles carrying spin and charge.

★ Nanoarchitectonics Related to Sustainable Energy and Environment

[40] Making the invisible enemy visible: naked-eye cesium detection

W. Nakanishi, K. Ariga

Co-workers: T. Mori, H. Komatsu, M. Akamatsu

Micrometer-level naked-eye detection of cesium (Cs) ions, a major source of contamination upon nuclear plant explosion, has been demonstrated. In this research, a substituted phenol compound containing an electron-accepting 4-nitrophenyl ether group was designed. The compound exhibited distinctive green fluorescence in the presence of Cs ions even in soil samples. This probe molecule is now commercialized and being applied for Cs ion detection in living cells.

[41] Solid-state lithium-ion batteries: nanoarchitecture at the cathode interfacial

K. Takada, T. Ohnishi, M. Osada, T. Sasaki

Solid-state batteries are anticipated to be a fundamental solution to issues in lithium-ion batteries originating from their liquid electrolytes. Because they have low power density, a challenge is achieving practical power by enhancing ionic conduction in batteries made of solids. Nanomaterials have not found their place in batteries, since they are too small to store energy electrochemically. However, interfaces are often highly resistive and thus rate determining in solid-state systems, where nanomaterials will find their niche.

[42] Silicene: novel two-dimensional material with spin–orbit interaction

R. Arafune

With the great success of graphene, a novel two-dimensional honeycomb lattice of silicon atoms, has emerged as a rising star. We succeeded in synthesizing silicene on Ag (111). Using several state-of-the-art techniques to characterize the solid surfaces, we revealed the geometric and electronic structure of the silicene on Ag (111).

5. Global Nanotechnology Network

5.1 MANA Satellite Network

Six out of the 26 MANA Principal Investigators (PIs) are visiting researchers from external research institutes. MANA has satellite laboratories at research institutions to which PIs are affiliated. As of January 2017, there are six MANA satellite laboratories, two in Europe, one in Japan and three in USA/Canada (Figs. 5-1, 5-2).

Researchers at the Satellites and MANA carry out joint research in nanoarchitectonics through frequent mutual visits and e-mail communications. In addition, the Satellites play a crucial role in training young researchers. MANA aims to serve as a global network hub for nanotechnology. The satellite laboratories promote innovative research as front-line bases of the global network and are an irreplaceable presence for MANA. To date, research at the MANA satellites has yielded 387 MANA affiliated papers (Fig. 5-3) or 10.1% of the total of 3,840 MANA papers. Many of these papers appeared in journals with a high impact, including Nature Materials, Nature Nanotechnology and Advanced Materials. From this viewpoint as well, the Satellites are making an important contribution to MANA's research results.

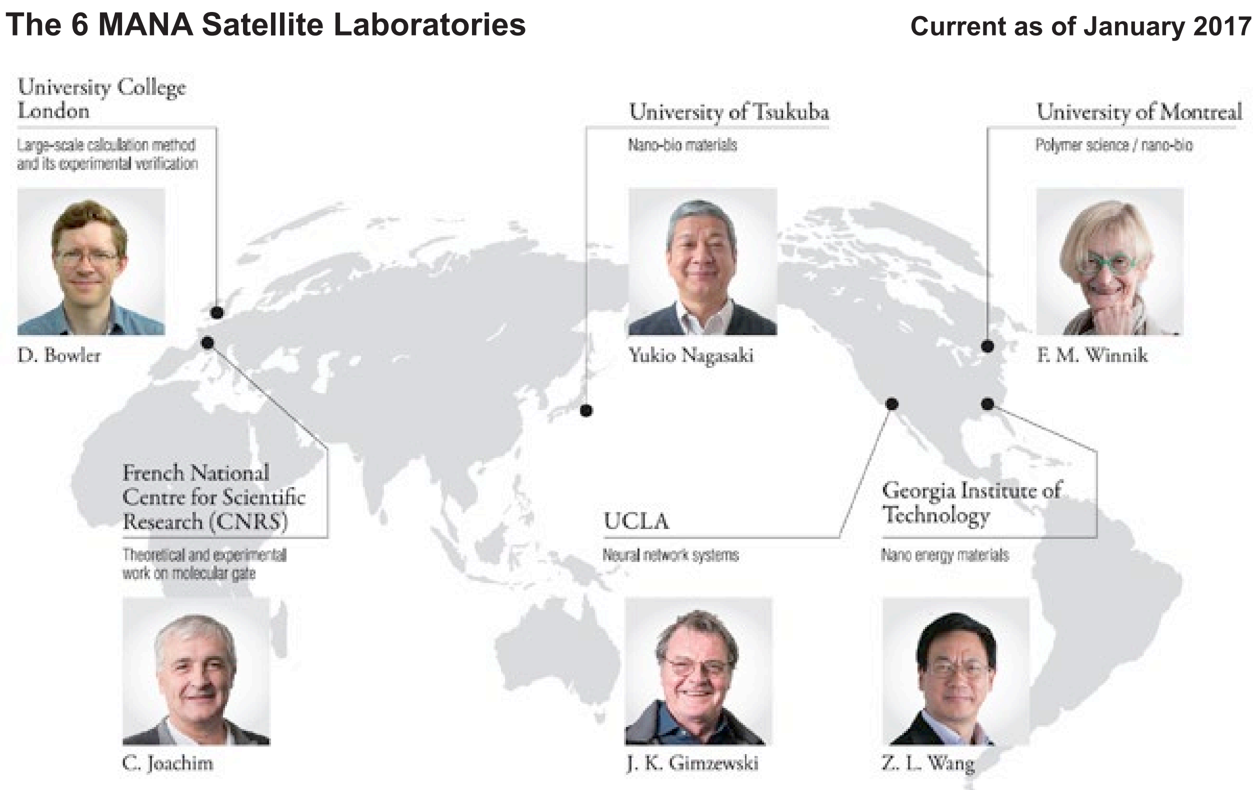


Fig. 5-1: The six MANA satellite laboratories.

● **Prof. James K. Gimzewski** of UCLA is a renowned nanotechnology researcher who received a Feynman Prize in 1997. At MANA, he is conducting Nano-System research on neural networks that is aiming at a creation of artificial brain. He has engaged in joint research projects on new neurocomputer circuits that utilize the learning capabilities of atomic switches. Prof. Gimzewski's research is frequently covered by NHK television programs. He also works hard on training and education for young researchers, graduate students, and young administrative staff by receiving post-doctoral scholars dispatched by MANA to UCLA, contributing greatly to the management of Nanotechnology Students' Summer School, and accepting MANA office staff as interns, among other efforts.

UCLA
USA

CNRS
France

UCL
UK

University of Tsukuba
Japan

Georgia Tech
USA

UdeM
Canada

Fig. 5-2: Location of the six MANA satellite laboratories. Top row from left to right: University of California Los Angeles, UCLA, (USA); CEMES/CNRS, Toulouse (France); University College London, UCL (UK). Bottom row from left to right: University of Tsukuba (Japan); Georgia Institute of Technology, GIT (USA); University of Montreal, UdeM (Canada).

● **Prof. Zhong Lin Wang** of the Georgia Institute of Technology is a highly active researcher whose papers, as of May 2016, have been cited over 90,000 times and have an H-index of 142. At MANA, he works in the Nano-Materials field and conducts research on photonic structures inspired by biological systems and nanogenerators that harvest mechanical energy. Prof. Wang is also he mentor of group leader Dr. Fukuta, who often visits the Georgia Institute of Technology to engage in joint research on nano-devices. There is also an exchange of personnel that takes place, as for example Prof. Wang's post-doctoral scholars later become Dr. Fukuta's post-doctoral scholars. Prof. Wang's work at the MANA Satellite has prompted Japanese companies to inquire about possible collaborations.

● **Prof. Françoise M. Winnik** of the University of Montreal is a world-renowned researcher in the fields of polymer chemistry, interface and colloid science, and nanoscience. She serves as the Executive Editor of Langmuir, the journal of the American Chemical Society. At MANA, Prof. Winnik works in the Nano-Life field and engages in a wide range of research, primarily focusing on the synthesis of new biocompatible polymers but also including various other interdisciplinary fusion research that utilizes nanotubes and nanoparticle materials developed by MANA researchers in other fields. Prof. Winnik operates labs at both MANA and the University of Montreal, but she is focused entirely on her MANA research with zero teaching obligations at the University of Montreal.

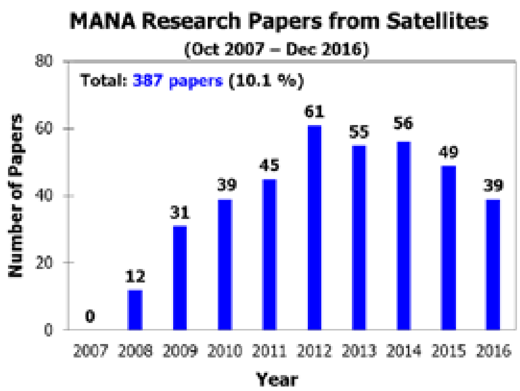


Fig. 5-3: MANA affiliated research papers from satellites.

● **Prof. Yukio Nagasaki** from Graduate School of Pure and Applied Sciences, University of Tsukuba, is working on polymers and biomaterials science. During last 30 years, he engaged in materials science especially in the field of biology, pharmaceutics and medical science. At MANA, Prof. Nagasaki works in the Nano-Life field and conducts research on biointerface, drug delivery system and nanomedicine. Prof. Nagasaki serves as Handling Editor of Biomaterials, Elsevier, and Associate Editor of Bulletin of Chemical Society, Japan. Further, he is working as a members of executive committee of Polymer Society, Japan, The Japan Society of Drug Delivery System, Japanese Society of Biomaterials, and Society for Free Radical Research, Japan. Prof. Nagasaki received the excellent Ph.D. thesis award from Inoue Foundation of Science in 1989, Young Researcher Award from Polymer Society, Japan in 1993, SPSJ Mitsubishi Chemical Award from Polymer Society, Japan in 2010, the Award of The Japanese for Ulcer Society (2014), the Award of Japanese Society for Biomaterials (2014) and the Nagai Award from The Japan Society of Drug Delivery System (2015).

● **Prof. David Bowler** from University College London is a computational physicist who models nanostructures of semiconductors, particularly on surfaces, and develops new techniques. He has two key strands in his research: close collaboration with experimental groups, and development of novel electronic structure methods. He has driven the development of the world-leading linear scaling DFT code, CONQUEST, in close collaboration with MANA PI Dr. Tsuyoshi Miyazaki. He works in the Nano-Theory field, where he combines the two parts of his research, using CONQUEST to model the structure and properties of core-shell nanowires fabricated by Dr. Naoki Fukata.

● **Prof. Christian Joachim** from CNRS-CEMES is a world-renowned computational scientist who won the Feynman Prize in 1997 and 2005. At MANA, he works in the Nano-System field and performs research on the design, manufacture, and atomic manipulation of nanocircuits, in addition to working on the theory of surface electron interconnection. He actively engages in joint research with MANA researchers and has produced several papers printed in *Nature Nanotechnology* and other top-tier journals. Prof. Christian Joachim announced to organize a molecule concept nano-car race at the CNRS MANA satellite in France. Teams from several countries, including MANA from Japan, will try this world smallest, most difficult and scientific car race.

5.2 International Nanotechnology Research Network

MANA signs Memoranda of Understanding (MOUs) with universities and research institutes around the globe in order to promote the creation of an international nanotechnology research network by way of joint research projects. A MOU agreement is valid for 5 years and can be renewed if both institutes agree. Between the launch in October 2007 and March 2017, MANA has concluded MOUs with 62 different institutions from 21 countries (Appendix 7.9, Table 5-1). 3 MOUs were renewed and 1 MOU was replaced. By March, 2017, 29 MOUs are valid, 32 have expired and 1 has been replaced. Photos of recent MANA MOU signing ceremonies in Tsukuba are shown in Fig. 5-4.

Appendix 7.9: International Cooperation

Fig. 5-4: MANA MOU signing Ceremonies in Tsukuba with Queensland University of Technology (QUT), Australia (November 2016, left) and Vidyasirimedhi Institute of Science and Technology (VISTEC), Thailand (October 2016, right). Photos from left to right: Prof. Scott Sheppard (Deputy Vice-Chancellor, International Development, QUT) and Prof. Masakazu Aono (MANA Director-General). Prof. Takayoshi Sasaki (MANA Deputy Director) and Prof. Makoto Ogawa (VISTEC).

Table 5-1: MANA MOUs with 62 different institutions from 21 countries. The number of MANA MOUs valid on March 31, 2017, is shown in parenthesis.

Region	Number of MOUs
Europa	23 (10)
Asia	22 (10)
North America	8 (4)
Oceania	6 (4)
South America	2 (1)
Middle East	1 (0)
Total	62 (29)

5.3 Partnership with Foreign and Domestic Universities

Since MANA is a part of a public research center and not a university, we strive to collaborate with foreign and domestic universities. In FY2016, MANA continued to hold workshops and symposia with the aim of promoting research exchange and boosting MANA's name recognition in order to scout for talent.

- **List of selected Workshops and Joint Symposia held in FY2016**

Jul 27-28, 2016

The 2nd International Symposium on Nanoarchitectonics for Mechanobiology

Mechanobiology is a scientific field that studies the principle in sensing and generation of physical force in life. Recent studies in this field shed light on the significance of force, comparable to chemical and biochemical cues, in the regulation of biological processes. However, one unique feature in the mechanical regulation, distinct from chemical/biochemical one, is that it can directly react with the multi-layered architectures of living systems, ranging from nano-scale proteins, subcellular organelles, cells, tissues, organs to whole bodies. After the first the 1st International Symposium on Nanoarchitectonics for Mechanobiology held in July 2015, the second symposium was held at MANA in July 2016 (Fig. 5-5).

Fig. 5-5: Participants (left) and Excellent Poster Presentation Award Ceremony (right) of the International Symposium on Nanoarchitectonics for Mechanobiology.

Aug 5, 2016

International NCKU/MANA Workshop on 2D Materials

On August 5, 2016, the International NCKU/MANA Workshop on 2D Materials was held at MANA. This workshop has been organized as a kickoff meeting of the Joint Research Program between NIMS and Ministry of Science and Technology (MOST), Taiwan. Within the framework of this program, several groups at MANA and at National Cheng Kung University (NCKU), Taiwan will work together focusing on graphene-like 2D materials including metal oxide and carbide nanosheets. Needless to say, the research activity in so-called "beyond graphene" has intensified globally year-by year since a range of fascinating functionalities are being discovered in such molecularly thin 2D systems based on diverse compositions and structures.

Dec 17-18, 2016

The 2nd Japan-Taiwan Joint Workshop on Nanospace Materials

On December 17-18, 2016, the 2nd Japan-Taiwan Joint Workshop on Nanospace Materials was held at MANA. Focusing on the research field of Nanospace Materials, this workshop aimed at further development of the scientific and technological exchange between Japan and Taiwan, inviting top-level scientists from both countries to present the latest research topics for two days. This workshop has been co-sponsored by Department of Innovation Research, Japan Science and Technology Agency (JST), and The World Premier International Research Center Initiative (WPI).

Jan 20, 2017

Tsukuba Bio Medical Engineering Forum 2017

On January 20, 2017, the Tsukuba Bio Medical Engineering Forum 2017 on "Nanotechnology based Life Innovation" was held at NIMS. This Forum with 347 participants was chaired by Dr. Guoping Chen (MANA-Life Field Coordinator and Principal Investigator) and aimed to stimulate collaboration between Engineering and Medical doctors (Fig. 5-6).

Mar 28, 2017

International Symposium on Atomic Switch: Invention, Practical Use and Future Prospects

On March 28, 2017, the International Symposium on “Atomic Switch: Invention, Practical Use and Future Prospects” is scheduled to be held at MANA. The “atomic switch”, which was invented in 2001 and has been investigated at MANA/NIMS for about 10 years with the support of JST and MEXT and in collaboration with NEC, has come into practical use as the “NEC AtomSW-FPGA”, which will soon be used in robots and space satellites for example. This is because the atomic switch is not only compact and has low power-consumption, but also because it is scarcely influenced by electromagnetic noise and radiation (including cosmic rays). To celebrate the practical use of the atomic switch, which is a novel nanoelectronics device originating in Japan, we hold a memorial symposium as follows. At the symposium, we will also present information about how the atomic switch has begun to be used for brain-type information processing and for completely novel functional nanodevices.


Fig. 5-6: Oral presentation (left), poster session (middle) and company exhibition (right) at the Tsukuba Bio Medical Engineering Forum 2017.

● Programs for Attracting Junior Researchers to MANA

NIMS Graduate Schools

NIMS operates the NIMS Graduate Schools having concluded agreements with selected Japanese universities, and graduate students are taught advanced research by NIMS researchers on the frontlines of their fields. In Fiscal Year 2016, 14 scientists at MANA are teaching in the NIMS Graduate Schools (Table 5-2). Students in the NIMS Graduate Schools who possess especially outstanding skills are appointed as junior researchers and are paid a salary for their contribution to NIMS research. In FY2016, there are 36 junior researchers working at MANA, of which 29 are foreigners and 10 are females. In September 2009, the graduate school at University of Tsukuba established a Master’s curriculum in which students can take all of their required credits in English. The objective is to attract outstanding foreign students from the Master’s program to the NIMS Graduate Schools.

Table 5-2: Number of MANA members at the NIMS Graduate Schools in FY2016.

School	No. of Faculties	No. of Students
University of Tsukuba	9	22
Hokkaido University	2	6
Waseda University	2	6
Kyushu University	1	2

International Cooperative Graduate Program

Within the International Cooperative Graduate Program overseas doctorial students from renowned universities around the globe spend several months to one year at NIMS researching under the supervision of NIMS researchers. By March 2017, MANA brought in 68 students within this program from 15 different universities (Fig. 5-7): Flinders University (Australia), Tsinghua University and Xian Jiatong University (China), Charles University and the University of Pardubice (Czech Republic), Budapest University of Technology and Economics (Hungary), Anna University and Jawaharlal Nehru Centre for Advanced Scientific Research (India), Yonsei University (Korea), Universiti Teknologi Malaysia (Malaysia), Norwegian University of Science and Technology (Norway), Warsaw University of Technology (Poland), Lomonosov Moscow State University (Russia), National Taiwan University (Taiwan) and University of Washington (USA).

Fig. 5-7: The 15 universities from where MANA has accepted doctorial students within the International Cooperative Graduate Program.

Internship Program

NIMS established an internship system to proactively accept students from universities throughout Japan and the world which have not concluded agreements with NIMS and provide them with opportunities to partake in materials and nanotechnology research. By March 2017, MANA has accepted 473 interns, of which 370 have been foreigners. MANA has welcomed 35 US students from the NSF's National Nanotechnology Infrastructure Network (NNIN) Research Experience for Undergraduates (REU) Program.

5.4 Global Career Advancement

MANA is always aware of its role as a platform for successful career advancement for young researchers. MANA's policy is not merely to gather young researchers from throughout the world and cultivate them into excellent researchers. Rather, MANA seeks to endow these researchers with a thorough understanding of Japan such that they can advance their careers in countries throughout the world. As of December 2016, 273 MANA's young researchers have "graduated" MANA. 5.1% of them were selected for permanent research positions at NIMS, 38% became faculty members (professors and others) of universities both inside and outside Japan, 40% work as Researchers at universities or research institutes (outside NIMS) and 11% have moved to private companies. 36% of those who made research at MANA have secured positions in Japan, and the remaining 64% found jobs overseas, primarily in Asia (Fig. 5-8).

Examples of career advancement of MANA Alumni:

- Assistant Professor, Temple University, USA
- Professor, ETZ Zurich, Switzerland
- Research Group Leader, Max Planck Institute for Intelligent Systems, Germany
- Associate Professor, Uppsala University, Sweden
- Associate Professor, University of Bristol, UK
- Assistant Professor, University of Nora Gorica, Slovenia
- Assistant Professor, King Faisal University, Saudi Arabia
- Professor, Fudan University, China
- Professor, Nanjing University of Science and Technology, China
- Professor, Korea Institute of Energy Research, Korea
- Lecturer, Nanyang Technological University, Singapore
- Professor, University of South Australia, Australia

Fig. 5-8: Destinations of the 273 MANA postdoc alumni between October 2007 and December 2016.

6. Enhancement of National and International Recognition

6.1 MANA International Symposium 2017

The International Center for Materials Nanoarchitectonics (MANA) has held the MANA International Symposium every year to discuss the current status and the future perspective of materials science and technology based on state-of-the-art nanotechnology, inviting many distinguished scientists including Nobel laureates from around the world (Figs. 6-1 and 6-2). On the 10th anniversary of MANA, the 10th MANA International Symposium will specially highlight various aspects of architectonics by organizing a special session "Day of Nanoarchitectonics". Also, we will discuss "Nano Revolution for the Future" at five oral sessions: 1) Nano-Materials, 2) Nano-System, 3) Nano-Power, 4) Nano-Life, 5) Nano-Theory, and at poster sessions. We hope many scientists who are interested in materials science and technology will join this symposium and obtain fresh inspiration from the talks and discussions. MANA was founded in October 2007 with the support of the World Premier International Research Center Initiative (WPI Program) of Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). MANA's host institution, National Institute for Materials Science (NIMS), is the only non-university organization out of nine successful programs to host a WPI center.

2017 **2016**

Fig. 6-1: Left: The 10th MANA International Symposium will be held on February 28 - March 3, 2017. Middle and Right: 411 participants from 24 countries attended the 9th MANA International Symposium 2016.

Fig. 6-2: The first 8 MANA International Symposia held between 2015 and 2008.

6.2 MANA Website

The official English MANA website (www.nims.go.jp/mana/) was launched in February 2008 and is continuously being improved. It provides an overview of MANA, introduces researchers, research projects and output, and informs about events and recent news. In February 2011, the new Japanese MANA website (www.nims.go.jp/mana/jp/index.html) was launched. To further improve the content, both English and Japanese MANA websites have been renewed in FY2013 and again in FY2014. Since January 2015, a responsive web design of the MANA website is being used, which enables easy browsing with a wide range of devices including smartphones.

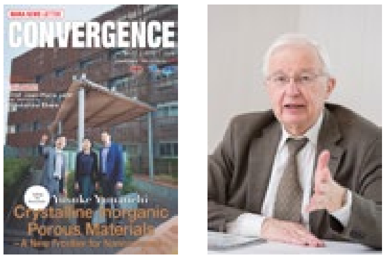
6.3 MANA Newsletter

Since its founding, MANA has published the newsletter CONVERGENCE three times annually in Japanese and English, for a total of 24 issues until end of 2016. Every issue features updates on the center's activities as well as interviews with famous, Nobel-class researchers (Fig. 6-3). This newsletter, which is intended for researchers throughout the world, is currently distributed to 1,650 domestic addresses and 1,800 international addresses.

MANA Newsletter CONVERGENCE

No. 22 February 2016	No. 23 June 2016	No. 24 October 2016

Prof. Leo ESAKI



Prof. Jean-Marie LEHN

Prof. Takuzo AIDA

Fig. 6-3: Issues of the MANA newsletter CONVERGENCE published in 2016.

6.4 Outreach Activities

As a result of MANA's outreach activities, the nanoarchitectonics concept has begun to spread. For example, the E-MRS Fall meeting held in September 2014 featured a "nanoarchitectonics" session. MANA has also actively pursued outreach oriented toward the general public. To nurture interest in science among young students, MANA has held events such as the MANA Science Cafe, joint symposiums, summer camps, and "science school" events for elementary and junior high school students featuring Nobel Prize winners (Prof. H. Rohrer, Prof. H. Kroto, etc.). MANA also creates online videos that explain its research achievements in an easy-to-understand way. MANA has also released general introductory books on its research, such as *Nanoarchitectonics: A Revolution in Materials Science* (2014) and *The Nanotech Handbook for Future Scientists* (2015). Moreover, due to the success of this outreach work, "nanoarchitectonics" will be now listed in the famous and authoritative *Kojien* Japanese dictionary, and is becoming increasingly widely known.

Since 2014, MANA has organized "Tsukuba Action Project (T-ACT): Science Communication Training," which is based on a collaboration between the University of Tsukuba and MANA. Graduate and undergraduate students participate in MANA outreach activities, including interviews with scientists and communication at scientific events. In 2016, MANA continued to participate in domestic and international outreach events (Figs. 6-4 and 6-5).

- **NIMS Open House 2016**

On April 24, 2016, MANA participated at "NIMS Open House 2016" with an exhibition and science workshop for children. At the MANA booth, children-friendly "Smart Polymer Rangers" demonstrated science experiments about "smart polymers as a future material for disease diagnosis and treatment" (Fig. 6-4).

- **European Materials Research Society (E-MRS) 2016 Spring Meeting**

On May 2-6, 2016, the European Materials Research Society (E-MRS) 2016 Spring Meeting has been held in Lille, France. Four WPI Research Centers (MANA, AIMR of Tohoku University, iCeMS of Kyoto University and I^2CNER of Kyushu University) participated with a joint booth. In addition, the Japanese group held a symposium entitled "Function-assembly of nano-materials towards electronics, energy and biological applications" (Fig. 6-4).

- **Lecture at Maebashi Girls' Senior High School**

On July 20, 2016, MANA Associate PI Mitsuhiro Ebara gave a lecture (Fig. 6-4) on "Future Medical Science with Smart Polymers" at Maebashi Girls' Senior High School, which has been assigned as a Super Science High School (SSH) by the Ministry of Education, Culture, Sports, Science & Technology in Japan (MEXT). The lecture was held as part of the SSH activities. In order to foster human resources in science and technology fields, SSHs work on special class lessons, collaborative studies with universities and/or research institutions, and distinctive studies of the local area. About 60 students attended the lecture and had impressive experiences touching medical instruments in use and having experiments with smart polymers.



Fig. 6-4: Left: Smart polymer ranger at NIMS Open House 2016. Middle: Administrative Director Tomonobu Nakayama at the E-MRS meeting. Right: Lecture of Associate PI Mitsuhiro Ebara for Junior High School students.

- **Super Science High Schools (SSH) Student Research Conference 2016**

On August 10-11, 2016, a Super Science High Schools (SSH) Student Research Conference was held at the Kobe Convention Center. MANA participated at the WPI booth with a MANA poster and explanation.

- **Innovation Campus in Tsukuba 2016**

On August 18, 2016, MANA Associate PI Mitsuhiro Ebara gave a lecture for high school students at “Innovation Campus in Tsukuba 2016”. This lecture meeting for high school students, is held in Tsukuba city every summer. It aims to provide students with opportunities to learn about science and innovation through lectures by scientists and business experts. Dr. Ebara lectured on future medicine with biomaterials. At the MANA booth the interesting properties of smart polymers were introduced to the students (Fig. 6-5). Children-friendly “Smart Polymer Rangers” helped to organize a science quiz.

- **Citizen’s meeting of Mino city (Gifu prefecture)**

On October 29, 2016, MANA Associate PI Mitsuhiro Ebara was invited to participate at the united Parents-Teachers Association (PTA) Research Conference at Mino city, Gifu prefecture. Dr. Ebara talked on his research on “smart polymers as a future material for disease diagnosis and treatment” and about his attitude to science.

- **University of Tsukuba Festival**

On November 5-6, 2016, MANA was present at the science corner at University of Tsukuba Festival. MANA advertised the NIMS Graduate School Program and demonstrated the membrane-type surface stress sensor (MSS) of Group Leader Genki Yoshikawa.

- **Tsukuba Science Festival 2016**

On November 12-13, 2016, MANA participated with an own booth and a science show of the Smart polymer rangers (Fig. 6-5) at the Tsukuba Science Festival 2016, an annual event organized by Tsukuba city and Tsukuba Educational Committee. The MANA booth had a panel display presenting MANA’s cutting-edge research achievements and a demonstration of “smart polymers” that could contribute to future medical treatments.



Fig. 6-5: Left: MANA booth at the Innovation Campus in Tsukuba. Middle: Smart Polymer Rangers at the Tsukuba Science Festival. Right: Director-General Masakazu Aono at the 10 years of WPI Memorial Lecture.

- **Science Festa at Ibaraki Airport**

On November 23, 2016," Science Festa at Ibaraki Airport" was held at Ibaraki Airport. MANA presented a booth with poster exhibitions of MANA's latest research achievements and a science show of the Smart polymer rangers.

- **10 years of WPI Memorial Lecture**

On December 17, 2016, the 10 years of WPI Memorial Lecture on "Towards the future of Science in Japan" was held in Tokyo. This event was organized by MEXT and JSPS. MANA Director-General Masakazu Aono talked about "Contributions of new materials to the society" (Fig. 6-5).

6.5 Media Coverage

MANA continues to be featured in Japanese newspaper articles and in Japanese television.

Between October 2007 and December 2016, in the first 9 years and 3 months of the MANA project, 523 press releases about MANA appeared in Japanese newspapers (Fig. 6-6). This corresponds to an average number of press releases of 56.5 per year. To encourage foreign researchers to issue press releases, NIMS has setup a support system.

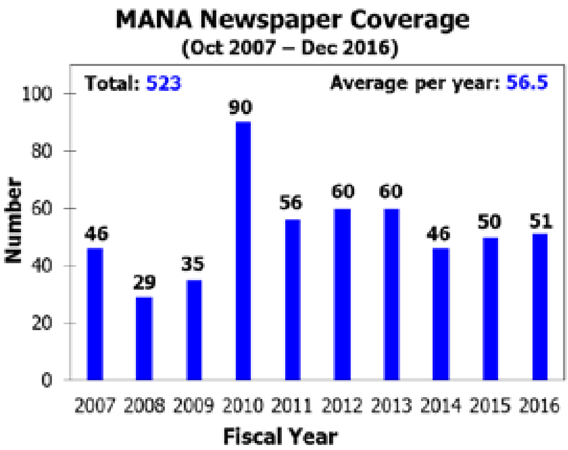


Fig. 6-6: Number of press releases from MANA published in Japanese newspapers between October 2007 and December 2016.

In FY2016, again several researchers from MANA have been featured in Japanese television as summarized in Table 6-1 and shown in Fig. 6-7. The documentary on TBS, *Origin of Future* (Mirai no Kigen) introduced 3 young researchers from MANA: MANA Scientist Kota Shiba about "Aero-Thermo- Dynamic Mass Analysis (AMA)", Group Leader Genki Yoshikawa about the "100 times more sensitive olfactory sensor" and MANA Scientist Shinsuke Ishihara about "Portable toxic gas detector". On December 1, 2016, Associate PI Mitsuhiro Ebara appeared 4 times in the NHK Ibaraki news about "Smart polymers as a biomaterial for cancer treatment and dialysis". The NHK documentary Science ZERO introduced MANA Scientist Waka Nakanishi about the "Nanocar race".

Table 6-1: Research of MANA featured in Japanese television in FY 2016.

Date	TV program	Researcher from MANA	Research topic
2016 Sep 23	TBS, documentary *Origin of Future*	**Kota Shiba** (MANA Scientist)	Aero-Thermo-Dynamic Mass Analysis (AMA)
2016 Sep 30	TBS, documentary *Origin of Future*	**Genki Yoshikawa** (Group Leader)	100 times more sensitive olfactory sensor
2016 Dec 1	NHK Ibaraki, news (4 times)	**Mitsuhiro Ebara** (Associate PI)	Smart polymers as a biomaterial for cancer treatment and dialysis
2016 Dec 11	NHK, documentary *Science ZERO*	**Waka Nakanishi** (MANA Scientist)	Nanocar race
2017 Feb 5	TBS, documentary *Origin of Future*	**Shinsuke Ishihara** (MANA Scientist)	Portable toxic gas detector

Fig. 6-7: Research of MANA has been featured in Japanese television. Kota Shiba (top left), Genki Yoshikawa (top right) and Shinsuke Ishihara (bottom right) appeared in the TBS documentary *Origin of Future* (Mirai no Kigen). Waka Nakanishi (bottom left) appeared in the NHK documentary *Science ZERO*.

6.6 Visitors to MANA

There are several kinds of short-time visitors to MANA.

(a) Researchers visiting MANA for scientific discussion, to give a seminar or to attend a workshop or symposium
(b) Researchers or students invited to MANA for short-time research activities
(c) MANA visit of Satellite Principal Investigators, MANA Advisors and Evaluation Committee members
(d) General Visitors (excluding categories (a), (b), (c))

Table 6-2: Number of short-time visitors to MANA. (*: Apr – Dec 2016.)

Fiscal Year	Total of Visitors (a), (b), (c), (d)	General Visitors (d)
FY2016 *	631 *	161 *
FY2015	796	159
FY2014	757	218
FY2013	715	146
FY2012	565	284
FY2011	248	108
FY2010	315	147

In FY2011 (April 2011 – March 2012), the number of visitors to MANA decreased in the wake of the nuclear power plant incident after the Great East Japan Earthquake in March 2011. But it seems that this so-called *Japan allergy* has disappeared almost entirely and, as shown in Table 6-2, we observe a strong increase of visitors to MANA since FY2012. The 796 visitors in FY2015 came from all over the world: Europe (120), America (70), Asia (581), including (443) from Japan, and other regions (25). In 2016, the highlight was the MANA visit of G7 and European Union science and technology ministers on May 26 (Fig. 6-8). Other visitors to MANA are shown in Fig. 6-9.

Fig. 6-8: G7 and European Union science and technology ministers have visited MANA in May 2016.

Fig. 6-9: Visitors to MANA in 2016. Left: Students from La Trobe University, Melbourne, Australia and National University of Singapore in January. Middle: Prof. Dmitris Pavlidis, Boston University, USA, in September. Right: Delegates from Queensland University of Technology, Australia, in November.

6.7 MANA Scientific Art Pictures

In November 2011, MANA Director-General Masakazu Aono has started a call to submit scientific art pictures. After a second call in October 2012, and a third call in November 2015, MANA has received over 100 scientific art pictures (Fig. 6-10), which are being used to decorate empty walls in the MANA Building and the new WPI-MANA Building. MANA scientific art pictures are being used often at NIMS and MANA in promotion videos, original goods, brochures, websites, greeting cards and exhibitions.

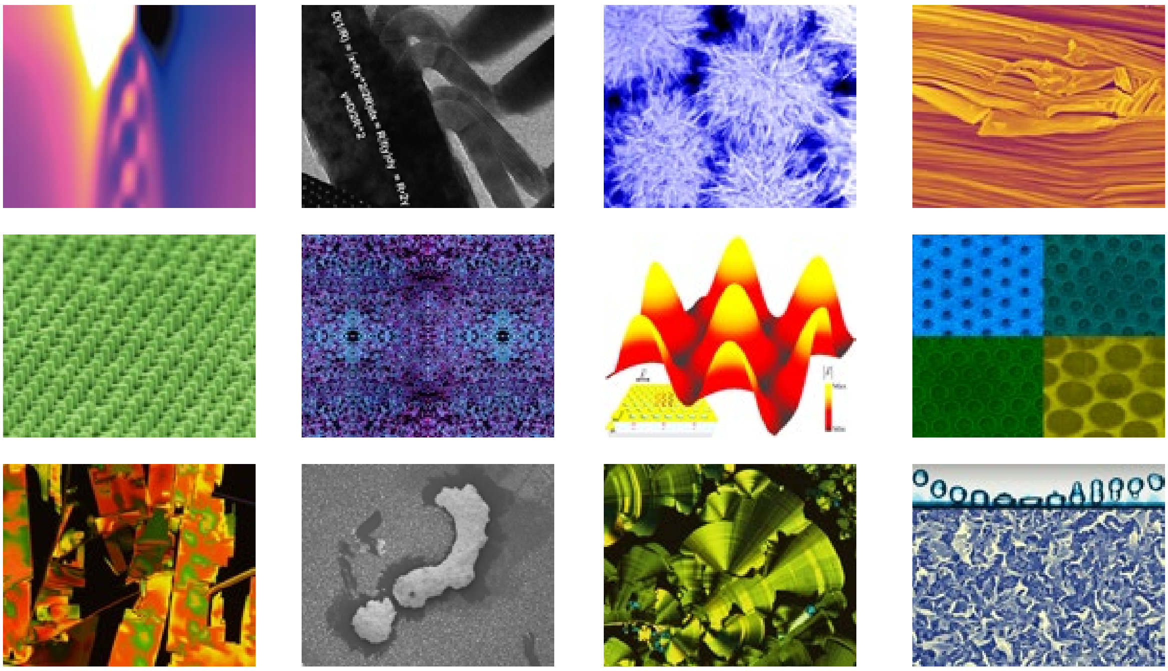


Fig. 6-10: Examples of MANA scientific art pictures from the third call.

6.8 MANA History

The MANA history between September 2007 and March 2017 can be found in Appendix 7.10.

Appendix 7.10: MANA History

Appendix 7.1: MANA Top Management

MANA Top Management (4):

Current as of January 2017

Masakazu AONO
Director-General

Takayoshi SASAKI
Deputy Director

Yoshio BANDO
Chief Operating Officer

Tomonobu NAKAYAMA
Administrative Director

Appendix 7.2: MANA Research Staff

Principal Investigators (26):

Current as of January 1, 2017

Nano-Materials Field (8)

Field Coordinator

Takayoshi SASAKI
NIMS

Katsuhiko ARIGA
NIMS

Yoshio BANDO
NIMS

Toyohiro CHIKYOW
NIMS

Dmitri GOLBERG
NIMS

Minoru OSADA
NIMS

Zhong Lin WANG
Georgia Tech (Satellite)

Yusuke YAMAUCHI
NIMS

Nano-Life Field (3)

Field Coordinator

Guoping CHEN
NIMS

Yukio NAGASAKI
Univ. Tsukuba (Satellite)

Françoise M. WINNIK
Univ. Montreal (Satellite)

Nano-System Field (7)

Field Coordinator

Masakazu AONO
NIMS

James K. GIMZEWSKI
UCLA (Satellite)

Xiao HU
NIMS

Christian JOACHIM
CNRS (Satellite)

Yoshihiko TAKANO
NIMS

Kazuya TERABE
NIMS

Kazuhito TSUKAGOSHI
NIMS

Nano-Theory Field (3)

Field Coordinator

Taizo SASAKI
NIMS

David BOWLER
Univ College London
(Satellite)

Tsuyoshi MIYAZAKI
NIMS

Nano-Power Field (5)

Field Coordinator

Jinhua YE
NIMS

Takao MORI
NIMS

Kazunori TAKADA
NIMS

Yoshitaka TATEYAMA
NIMS

Kohei UOSAKI
NIMS

Research Groups:

Current as of January 1, 2017

Group Leaders 24 (including 15 Principal Investigators), Associate Principal Investigators (2), Managing Researchers (2), Senior Scientist with Special Mission (1), MANA Scientists (65)

Nano-Materials Field (7 Groups)

Soft Chemistry Group (4):

Takayoshi
SASAKI
(Group Leader, PI)

Renzhi
MA
(Associate PI)

Yasuo
EBINA
(MANA Scientist)

Noboyuki
SAKAI
(MANA Scientist)

Functional Nanosheets Group (3):

Minoru
OSADA
(Group Leader, PI)

Takashi
AIZAWA
(MANA Scientist)

Takaaki
TANIGUCHI
(MANA Scientist)

Mesoscale Materials Chemistry Group (4):

Yusuke
YAMAUCHI
(Group Leader, PI)

Joel
HENZIE
(MANA Scientist)

Yusuke
IDE
(MANA Scientist)

Satoshi
TOMINAKA
(MANA Scientist)

Nanotubes Group (4):

Dmitri
GOLBERG
(Group Leader, PI)

Naoyuki
KAWAMOTO
(MANA Scientist)

Masanori
MITOME
(MANA Scientist)

Ryutaro
SOUDA
(MANA Scientist)

Supermolecules Group (4):


Katsuhiko ARIGA (Group Leader, PI)


Jonathan P. HILL (MANA Scientist)


Waka NAKANISHI (MANA Scientist)


Lok Kumar SHRESTHA (MANA Scientist)

Semiconductor Device Materials Group (8):


Toyohiro CHIKYOW (Group Leader, PI)


Takashi SEKIGUCHI (Managing Researcher)


Jun CHEN (MANA Scientist)


Jin KAWAKITA (MANA Scientist)


Takahiro NAGATA (MANA Scientist)


Shinjiro YAGYU (MANA Scientist)


Yoshiyuki YAMASHITA (MANA Scientist)


Michiko YOSHITAKE (MANA Scientist)

Frontier Molecules Group (3):


Takashi NAKANISHI (Group Leader)


Shinsuke ISHIHARA (MANA Scientist)


Kentaro TASHIRO (MANA Scientist)

Nano-System Field (7 Groups)

Nano Functionality Integration Group (4):


Tomonobu NAKAYAMA (Group Leader, Admin. Director)


Hideo ARAKAWA (MANA Scientist)


Shigeki KAWAI (MANA Scientist)


Yoshitaka SHINGAYA (MANA Scientist)

Nanoionic Devices Group (6):


Kazuya TERABE (Group Leader, PI)


Song-Ju KIM (MANA Scientist)


Yuji OKAWA (MANA Scientist)


Makoto SAKURAI (MANA Scientist)


Takashi TSUCHIYA (MANA Scientist)


Tohru TSURUOKA (MANA Scientist)

Thin Film Electronics Group (2):


Kazuhito TSUKAGOSHI (Group Leader, PI)


Seiichi KATO (MANA Scientist)

Quantum Device Engineering Group (4):


Yutaka WAKAYAMA (Group Leader)


Ryoma HAYAKAWA (MANA Scientist)


Satoshi MORIYAMA (MANA Scientist)


Shu NAKAHARAI (MANA Scientist)

Surface Quantum Phase Materials Group (3):


Takashi UCHIHASHI (Group Leader)


Katsumi NAGAOKA (MANA Scientist)


Takahide YAMAGUCHI (MANA Scientist)

Nano System Theoretical Physics Group (3):


Xiao HU (Group Leader, PI)


Toshikaze KARIYADO (MANA Scientist)


Takuto KAWAKAMI (MANA Scientist)

Nano Frontier Superconducting Materials Group (2):


Yoshihiko TAKANO (Group Leader, PI)


Hiroyuki TAKEYA (MANA Scientist)

Nano-Power Field (4 Groups)

Photocatalytic Materials Group (3):

Jinhua
YE
(Group Leader, PI)

Tetsuya
KAKO
(MANA Scientist)

Mitsutake
OSHIKIRI
(MANA Scientist)

Thermal Energy Materials Group (7):

Takao
MORI
(Group Leader, PI)

Yuichi
MICHUE
(MANA Scientist)

Isao
OHKUBO
(MANA Scientist)

Norifusa
SATOH
(MANA Scientist)

Dai-Ming
TANG
(MANA Scientist)

Naohito
TSUJII
(MANA Scientist)

Rudder
WU
(MANA Scientist)

Photonics Nano-Engineering Group (2):

Tadaaki
NAGAO
(Group Leader)

Satoshi
ISHII
(MANA Scientist)

Nanostructured Semiconducting Materials Group (2):

Naoki
FUKATA
(Group Leader)

Wipakorn
JEVASUWAN
(MANA Scientist)

Nano-Life Field (4 Groups)

Tissue Regeneration Materials Group (2):

Guoping
CHEN
(Group Leader, PI)

Naoki
KAWAZOE
(MANA Scientist)

Medical Soft Matter Group (2):

Kohsaku
KAWAKAMI
(Group Leader)

Chiho
KATAOKA
(MANA Scientist)

Nanomechanical Sensors Group (2):

Genki
YOSHIKAWA
(Group Leader)

Kota
SHIBA
(MANA Scientist)

Mechanobiology Group (3):

Jun
NAKANISHI
(Group Leader)

Mitsuhiro
EBARA
(Associate PI)

Chiaki
YOSHIKAWA
(MANA Scientist)

Not affiliated with a group (1):

Hisatoshi
KOBAYASHI
(Managing Researcher)

Nano-Theory Field (2 Groups)

Materials Properties Theory Group (12):

Taizo SASAKI (Group Leader, PI)

Takahisa OHNO (Senior Scientist with Special Mission)

Masao ARAI (MANA Scientist)

Wataru HAYAMI (MANA Scientist)

Junichi INOUE (MANA Scientist)

Kazuaki KOBAYASHI (MANA Scientist)

Masanori KOHNO (MANA Scientist)

Masamichi NISHINO (MANA Scientist)

Sadahiko NONOMURA (MANA Scientist)

Igor SOLOVYEV (MANA Scientist)

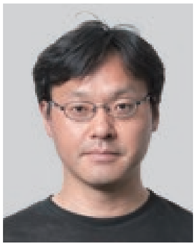
Shigeru SUEHARA (MANA Scientist)

Akihiro TANAKA (MANA Scientist)

First Principles Simulation Group (4):

Tsuyoshi MIYAZAKI (Group Leader, PI)

Ayako NAKATA (MANA Scientist)



Jun NARA (MANA Scientist)

Ryo TAMURA (MANA Scientist)

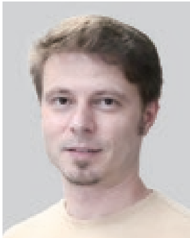
Independent Scientists (7):

Current as of January 1, 2017

Independent Scientists


Ryuichi ARAFUNE


Takako KONOIKE


Jan LABUTA


Takeo MINARI


Liwen SANG


Naoto SHIRAHATA


Naoto UMEZAWA

ICYS-MANA Researchers (9):

Current as of January 1, 2017

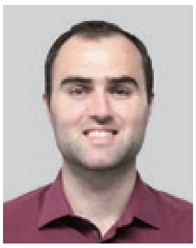
ICYS-MANA Researchers


Ovidiu CRETU


Alexandre FIORI


Gaku IMAMURA


Tanh Cuong NGUYEN


Curtis James O’KELLY


Gaulthier RYDZEK


Koichiro UTO


Xuebin WANG


Shunsuke YOSHIZAWA

MANA Research Associates (39):

Current as of January 1, 2017

Nano-Materials Field (21)


Partha
BAIRI
India


Pranandhy
BOSE
India


Amit
DALUI
India


Dominic
GERLACH
Germany


Avijit
GHOSH
India


Xiangfen
JIANG
China


Jieun
KOO
Korea


Cuiling
LI
China


Fengniu
LU
China


Asahiko
MATSUDA
Japan


Kosuke
MINAMI
Japan


Taizo
MORI
Japan


Malay
PRAMANIK
India


Hongpang
RONG
China


Rahul Raghunath
SALUNKHE
India


Suresh
SANDA
India


Jin
TANG
China


Qunhong
WENG
China


Pan
XIONG
China


Yanming
XUE
China


Ke Xiong
ZHANG
China

Nano-System Field (6)


Chanchal
CHAKRABORTY
India


Kai
CHEN
China


Shrestha Rekha
GOSWAMI
Nepal


Rintaro
HIGUCHI
Japan


Masashi
TANAKA
Japan


Elisseos
VERVENIOTIS
Greece

Nano-Power Field (6)

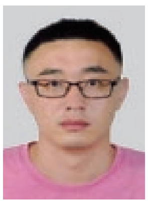

Qansheng
GUO
China


Huimin
LIU
China

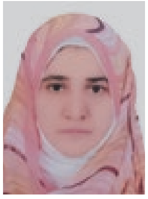

Xianguang
MENG
China

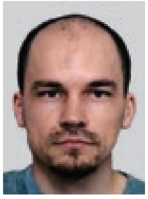

Koichi
OKADA
Japan


Shuo
YANG
China


Huabin
ZHANG
China

Nano-Life Field (6)


Shimaa
ABDELALEEM
Egypt


Gregory
BEAUNE
France


Sourov
CHANDRA
India


Sharmy Saimon
MANO
India

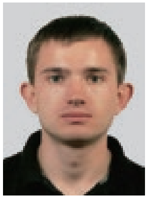

Xinlong
WANG
China

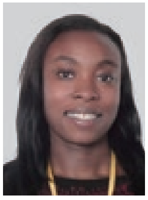

Jianmin
YANG
China

JSPS Fellows (14):

Current as of January 1, 2017

Nano-Materials Field (8)


Mikhailo
CHUNDAK
Ukraine


Geraldine
ECHUE
UK


Yusuf V.
KANETI
Australia


Yunqi
LI
China


Victor
MALGRAS
Canada


B. Zakaria
MOHAMED
Eqypt


Helen
PARKER
UK


Zhongli
WANG
China

Nano-System Field (1)


Yesul
JEONG
Korea

Nano-Power Field (5)


Kun
CHANG
China


Ken
PRADEL
USA


Thiyagu
SUBRAMANI
India


Jean-Baptiste
VANEY
France


Guixia
ZHAO
China

Appendix 7.3: Advisors and International Cooperation Advisors

MANA Advisors (5):

Current as of January 2017

Advisors including Nobel Laureates and prominent researchers provide valuable advice to MANA scientists, drawing on their extensive experience.

C.N.R. Rao
Honorary President
Jawaharlal Nehru Centre for
Advanced Scientific Research
India

Teruo Kishi
Former President,
National Institute for
Materials Science
Japan

Jean-Marie Lehn
Professor,
University of Strasbourg
France
(Nobel Laureate in Chemistry 1987)

Hidetoshi Fukuyama
Director General,
Research Institute for
Science and Technology,
Tokyo University of Science
Japan

Toshihiro Akaike
Director,
Foundation for Advancement
of International Science
Japan

MANA International Cooperation Advisors (2):

Current as of January 2017

International Cooperation Advisors including prominent researchers provide MANA with advice on joint research with overseas research institutes and the formation of a global nanotech network.

Sir Mark E. Welland
Professor,
University of Cambridge
UK

Louis Schlapbach
Former CEO,
Swiss Federal Laboratories for
Materials Testing and Research
Switzerland

Appendix 7.4: Evaluation Committee

Evaluation Committee Members (7):

Current as of January 2017

Evaluation Committee Members provide MANA with their critical comments and expert recommendations on the operation and research strategy of MANA projects.

Chair

Anthony K. Cheetham
Professor,
University of Cambridge
UK

Takuzo Aida
Professor,
The University of Tokyo
Japan

Morinobu Endo
Professor,
Shinshu University
Japan

Horst Hahn
Professor,
Karlsruhe Institute
of Technology
Germany

Yoshio Nishi
Professor,
Stanford University
USA

Rodney S. Ruoff
Professor,
Ulsan National Institute of
Science and Technology
Korea

Joachim P. Spatz
Director,
Max Planck Institute for
Intelligent Systems
Germany

Appendix 7.5: MANA Seminars

List of MANA Seminars (January – December 2016):

1	2016 Jan 5 *Synthesis of Functional Nanoporous Materials for Energy Storage, Energy Saving, and Bio-renewable Energy* **Prof. Kevin C.W. Wu** National Taiwan University, **Taiwan**
2	2016 Jan 12 *Technomimetic nanomachines: Molecular wheels, vehicles, rotors and motors* **Prof. Gwénaël Rapenne** Université Paul Sabatier, CEMES-CNRS, Toulouse, **France**
3	2016 Jan 12 *Molecular catalysis of the electrochemical and photochemical reduction of CO_2 with earth abundant metal complexes in aprotic solvent and in pure water* **Prof. Marc Robert** Université Paris Diderot, **France**
4	2016 Jan 13 *Polyhedral Polymer Gels from "Crystal Cross-Linking" of Metal Organic Frameworks* **Prof. Kazuki Sada** Hokkaido University, **Japan**
5	2016 Jan 22 *Raman Scattering in Semiconductor Nanostructures* **Prof. Andres Cantarero** University of Valencia, **Spain**
6	2016 Jan 25 *From Water and Carbon Dioxide to Solar Fuels using "Rust" and "Dirt"* **Prof. Dunwei Wang** Department of Chemistry, Boston College, **USA**
7	2016 Feb 12 *Hybrid quantum system: Superconducting quantum circuits coupled with other quantum systems* **Prof. Tiefu Li** Tsinghua University, **China**
8	2016 Feb 17 *Bottom-up assembly of highlyoriented porous molecular nanosheets utilizing liquid interfaces* **Dr. Rie Makiura** Osaka Prefecture University, **Japan**
9	2016 Feb 17 *Ionic liquids: From designer solvents to functional polymer materials* **Dr. Yuki Kohno** Tokyo University of Agriculture and Technology, **Japan**
10	2016 Feb 22 *What (anti-)matters with antimatter?* **Prof. Yasunori Yamazaki** Atomic Physics Laboratory, RIKEN, **Japan**
11	2016 Mar 1 *Nanoporous Materials for Gas Storage, Catalysis and Battery Applications* **Prof. Stefan Kaskel** Technical University Dresden, **Germany**
12	2016 Mar 3 *What's so special about metal halide perovskites (HaPs)?* **Dr. David Cahen** Weizmann Institute of Science, **Israel**
13	2016 Mar 15 *Design of bioactive materials for tissue regeneration* **Prof. Jiang Chang** Chinese Academy of Sciences, **China**
14	2016 Mar 15 *New Biomaterials World of Cadherin-Matrix Engineering and Citekine Matrix Engineering for Cell-Recognition and Regulation* **Prof. Toshihiro Akaike** Foundation for Advancement of International Science, **Japan**
15	2016 Mar 16 *Operando synchrotron X-ray scattering studies of solid-liquid and liquid-liquid interfaces* **Prof. Olaf M. Magnussen** Kiel University, **Germany**
16	2016 Mar 18 *Small Functional Rotaxanes* **Dr. Stephen Goldup** University of Southampton, **UK**
17	2016 Mar 18 *Microfluidics assisted materials synthesis for biosensing and imaging applications* **Prof. Amy Shen** Okinawa Institute of Science and Technology, **Japan**
18	2016 Mar 30 *All-Atom Modelling of Charged Metal Oxide-Electrolyte Interfaces* **Prof. Michiel Sprik** University of Cambridge, **UK**
19	2016 Apr 14 *High performance Supercapacitors based on Surface Redox Processes* **Prof. Wataru Sugimoto** Shinshu University, **Japan**
20	2016 Apr 15 *Substrate Variational Method: Opening up a New World for Surface Analysis* **Dr. Bo Da** ICYS-Sengen Researcher, NIMS, **Japan**
21	2016 Apr 15 *Polymeric materials: from interface to the bulk* **Dr. Gaulthier Rydzek** ICYS-MANA Researcher, NIMS, **Japan**
22	2016 Apr 21 *High-Temperature Superconductivity: So far and from now* **Prof. Hidetoshi Fukuyama** Tokyo University of Science, **Japan**
23	2016 May 18 *Materials Chemistry in Two Dimensions* **Prof. Josef Breu** University of Bayreuth, **Germany**
24	2016 May 20 *Electrochemical behavior of reinforcing steel in concrete* **Dr. Kotaro Doi** ICYS-RCSM Researcher, NIMS, **Japan**

25	2016 May 20 *In situ transmission electron microscopy experiments on lowdimensional materials* **Dr. Ovidiu Cretu** ICYS-MANA Researcher, NIMS, **Japan**
26	2016 May 20 *Supramolecular Polymers Based on Host-Guest Molecular Recognition Motifs* **Prof. Feihe Huang** Zhejiang University, **China**
27	2016 Jun 1 *Pencils, Paper and Movie Discs: Curious Minds and Materials Discoveries* **Dr. Jiaxing Huang** Northwestern University, **USA**
28	2016 Jun 3 *Droplet epitaxy quantum dots for ultra-high efficiency solar cells* **Dr. Martin Elborg** ICYS-Sengen Researcher, NIMS, **Japan**
29	2016 Jun 3 *Doping of synthetic diamond, a great challenge* **Dr. Alexandre Fiori** ICYS-MANA Researcher, NIMS, **Japan**
30	2016 Jun 7 *First Principles Based Simulations of Relaxor Ferroelectrics: Domain Dynamics* **Dr. Benjamin Burton** National Institute of Standards and Technology, **USA**
31	2016 Jun 8 *Plasmon enhanced molecular spectroscopy with narrow gaps* **Dr. Rubén Esteban** Donostia International Physics Center (DIPC) and Material Physics Center, **Spain**
32	2016 Jun 17 *Persistent Shockley Surface States of noble metals with graphene or boron-nitride coating layers* **Dr. Thanh Cuong Nguyen** ICYS-MANA Researcher, NIMS, **Japan**
33	2016 Jun 17 *First-principles study of electronic structure of multiband molecular conductors* **Dr. Takao Tsumuraya** ICYS-Namiki Researcher, NIMS, **Japan**
34	2016 Jun 21 *Charge density waves (CDWs) in single-layer, multiplayer, and bulk titanium diselenide - dimensional/confinement effects and the physics of CDWs* **Prof. Tai-Chang Chiang** University of Illinois, **USA**
35	2016 Jun 30 *Proteins at interfaces and surfaces: insight form molecular simulation* **Dr. David L. Cheung** National University of Ireland Galway, **Ireland**
36	2016 Jul 1 *Peptide and Protein Nanomaterials: The Design Challenge* **Prof. Vincent P. Conticello** Emory University, **USA**
37	2016 Jul 1 *Folding π-Conjugated Polymers Inspired by Biopolymers* **Dr. Kazuhiko Nagura** ICYS-Sengen Researcher, NIMS, **Japan**
38	2016 Jul 1 *Interdisciplinary Research on Supramolecular Functional Porphyrinoids and My Personal View on the 1st Missions of ICYS* **Dr. Huynh Thien Ngo** ICYS-MANA Researcher, NIMS, **Japan**
39	2016 Jul 1 *Confessions of an ICYS Researcher* **Dr. Hamish Hei-Man Yeung** ICYS-MANA Researcher, NIMS, **Japan**
40	2016 Jul 6 *Thermodynamic and Kinetic Control over Growth of Supramolecular Stacks* **Dr. Subi Jacob George** Jawaharlal Nehru Centre for Advanced Scientific Research, **India**
41	2016 Jul 8 *Power Spintronics* **Dr. Sadamichi Maekawa** Advanced Science Research Center, Japan Atomic Energy Agency, **Japan**
42	2016 Aug 1 *Generation of a Scaffold Free 3-Dimensional Liver and Cardiac Tissue via a Rapid Cell to Cell Click Assembly Process* **Prof. Muhammad N. Yousaf** York University, **Canada**
43	2016 Aug 18 *Using Light to Fabricate and Analyze Metal Nanostructures* **Dr. Tomas Tamulevičius** Institute of Materials Science of Kaunas University of Technology, **Lithuania**
44	2016 Aug 19 *Affluence from Effluent: A membrane based platform for resource recovery from wastewater* **Prof. William E. Price** University of Wollongong, **Australia**
45	2016 Aug 19 *Microscopic role of carbon on MgB2 wire for critical current density comparable to NbTi* **Prof. Jung Ho Kim** University of Wollongong, **Australia**
46	2016 Aug 26 *Catalysis and Sensing: Click to Proceed* **Dr. John S. Fossey** University of Birmingham, **UK**
47	2016 Aug 29 *Atomic structures and single molecules on hydrogenated semiconductor surfaces* **Dr. Marek Kolmer** Jagiellonian University, **Poland**
48	2016 Sep 5 *Towards a Universal Gate of Majorana Qubit* **Dr. Zhi Wang** Sun Yat-Sen University, **China**
49	2016 Sep 9 *Development of an artificial olfactory system using nanomechanical sensors* **Dr. Gaku Imamura** ICYS-MANA Researcher, NIMS, **Japan**
50	2016 Sep 9 *Nature-adapted next-generation coatings and adhesives* **Dr. Debabrata Payra** ICYS-RSCM Researcher, NIMS, **Japan**

51	2016 Sep 15 *Recent Cosmetic Science "Formulation Technology"* **Dr. Yuji Yamashita** Chiba Institute of Science, **Japan**
52	2016 Oct 4 *Human Derived Biomaterials and Cells for Tissue regeneration* **Prof. Heinz Redl** Director, Ludwig Boltzmann Institute for E & C T Vienna, **Austria**
53	2016 Oct 11 *Cooperative Function in Atomically Precise Nanoscale Assemblies* **Prof. Paul Weiss** University of California, Los Angeles, **USA**
54	2016 Oct 18 *Host-guest chemistry of lowdimensional nanospace materials from immobilization to spatial distribution and diffusion* **Prof. Makoto Ogawa** Vidyasirimedhi Institute of Science and Technology, **Thailand**
55	2016 Oct 26 *The nanocar race* **Prof. Christian Joachim** CEMES-CNRS Toulouse, **France**
56	2016 Nov 1 *Interfacial Coordination Programming of 1D and 2D Materials* **Prof. Hiroshi Nishihara** Department of Chemistry, The University of Tokyo, **Japan**
57	2016 Nov 7 *2D Crystals for Smart Life* **Prof. Kaustav Banerjee** Nanoelectronics Research Lab, University of California, **USA**
58	2016 Nov 7 *Visible light photocatalyzed water oxidations: effects of reagents and light conditions on reaction rate and yields* **Dr. Dominic Walsh** Department of Chemistry, University of Bath, **UK**
59	2016 Nov 10 *Photo-Responsive Surfactant Molecular Assemblies -Micelles, Worm-like Micelles, and Vesicles-* **Prof. Hideki Sakai** Department of Pure and Applied Chemistry, Tokyo University of Science, **Japan**
60	2016 Nov 10 *Molecularly functionalized surfaces and interfaces* **Dr. Adam Stuart Foster** Department of Applied Physics, Aalto University, **Finland**
61	2016 Nov 11 *Chemical and chemoenzymatic synthesis of glycolipids* **Dr. Loïc Lemiègre** Ecole Nationale Supérieure de Chimie de Rennes, **France**
62	2016 Nov 14 *Twenty-Five Years of Carbon Nanotubes and some recent collaborative work at KIT/NIMS on Branched Carbon Nanotubes* **Dr. Sharali Malik** Institute of Nanotechnology, Karlsruhe Institute of Technology, **Germany**
63	2016 Nov 16 *Mixed Transition Metal Sulfides for Electrochemical Energy Conversion and Storage* **Dr. Min Zhou** College of Physical Science and Technology, Yangzhou University, **China**
64	2016 Nov 22 *Chemistry at Structured Interfaces* **Prof. Archita Patnaik** Department of Chemistry, Indian Institute of Technology Madras, Chennai, **India**
65	2016 Nov 24 *Making gels in cells: Intracellular production of synthetic RNA granules by ligand-yielded multivalent enhancers* **Dr. Takanari Inoue** Johns Hopkins University School of Medicine, **USA**
66	2016 Nov 24 *Structural and functional properties of tethered bilayer lipid membranes* **Dr. Ingo Köper** Flinders Centre for Nanoscale Science and Technology, Flinders University, **Australia**
67	2016 Dec 1 *Polypetide modified nanocomposite microcarriers for bone tissue engineering* **Prof. Peibiao Zhang** Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, **China**
68	2016 Dec 1 *Mild Preparation and Biological Application of Hierarchical Structure Hydrogel* **Prof. Qigang Wang** School of Chemical Science and Technology, Tongji University, Shanghai, **China**
69	2016 Dec 1 *Surface Engineering of Biomedical Materials via Bio-Inspired Strategy* **Prof. Jian Ji** Department of Polymer Science and Engineering, Zhejiang University, Hangzhou, **China**
70	2016 Dec 8 *Advances in 2D nanomaterials* **Dr. Adelina Ilie** Department of Physics, University of Bath, **UK**
71	2016 Dec 12 *Novel Metal-Carbon Hybrid Molecules: Endohedral Metallofullerenes* **Prof. Xing Lu** Huazhong University of Science and Technology (HUST), **China**
72	2016 Dec 16 *Intermixing seeded growth of perovskite solar cells and 2D atomic material as electron transport layer* **Dr. Shao-Shian Li** National Taiwan University, **Taiwan**
73	2016 Dec 26 *Design of Cell-recognizable Nanomaterials for Nanomedicine Delivery* **Prof. Toshihiro Akaike** Foundation for Advancement of International Science (FAIS), **Japan**

Appendix 7.6: MANA Research Papers 2016

List of MANA affiliated research papers in English published 2016 in scientific journals (524 papers):

Information current as of January 2017

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490	T. Yokoyama, T.D. Dao, K. Chen, S. Ishii, R.P. Sugavaneshwar, M. Kitajima, T. Nagao, *Spectrally Selective Mid-Infrared Thermal Emission from Molybdenum Plasmonic Metamaterial Operated up to 1000 °C*, Advanced Optical Materials **4**(12), 1987 (2016). doi: 10.1002/adom.201600455 WOS:000392405100011 2-s2.0-84987668314
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492	H. Yoshimitsu, E. Korchagina, A. Kanazawa, S. Kanaoka, F.M. Winnik, S. Aoshima, *Shape-switching self-assembly of new diblock copolymers with UCST-type and LCST-type segments in water*, Polymer Chemistry **7**(11), 2062 (2016). doi: 10.1039/c5py01976a WOS:000372249400007 2-s2.0-84960855640
493	C. Young, R.R. Salunkhe, J. Tang, C.C. Hu, M. Shahabuddin, E. Yanmaz, M.S.A. Hossain, J.H. Kim, Y. Yamauchi, *Zeolitic imidazolate framework (ZIF-8) derived nanoporous carbon: the effect of carbonization temperature on the supercapacitor performance in an aqueous electrolyte*, Physical Chemistry Chemical Physics **18**(42), 29308 (2016). doi: 10.1039/c6cp05555a WOS:000387024300033 2-s2.0-84994019291
494	B.C. Yu, Y. Zhou, P. Li, W.G. Tu, P. Li, L.Q. Tang, J.H. Ye, Z.G. Zou, *Photocatalytic reduction of CO_2 over Ag/TiO_2 nanocomposites prepared with a simple and rapid silver mirror method*, Nanoscale **8**(23), 11870 (2016). doi: 10.1039/c6nr02547a WOS:000378510700013 2-s2.0-84974577842
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503	C. Zhang, X. Wang, Q.F. Liang, X.Z. Liu, Q.H. Weng, J.W. Liu, Y.J. Yang, Z.H. Dai, K.J. Ding, Y. Bando, J. Tang, D. Golberg, *Amorphous Phosphorus/Nitrogen-Doped Graphene Paper for Ultrastable Sodium-Ion Batteries*, Nano Letters **16**(3), 2054 (2016). doi: 10.1021/acs.nanolett.6b00057 WOS:000371946300078 2-s2.0-84960511036
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506	H.B. Zhang, Z.J. Ma, J.J. Duan, H.M. Liu, G.G. Liu, T. Wang, K. Chang, M. Li, L. Shi, X.G. Meng, K.C. Wu, J.H. Ye, *Active Sites Implanted Carbon Cages in Core Shell Architecture: Highly Active and Durable Electrocatalyst for Hydrogen Evolution Reaction*, ACS Nano **10**(1), 684 (2016). doi: 10.1021/acsnano.5b05728 WOS:000369115800072 2-s2.0-84991200039	514	K.X. Zhang, M.Y. Liao, M. Imura, T. Nabatame, A. Ohi, M. Sumiya, Y. Koide, L.W. Sang, *Electrical hysteresis in p-GaN metal-oxide-semiconductor capacitor with atomic-layer-deposited Al_2O_3 as gate dielectric*, Applied Physics Express **9**(12), 121002 (2016). doi: 10.7567/APEX.9.121002 WOS:000388820900001 2-s2.0-84995799475
507	H.B. Zhang, Z.J. Ma, G.G. Liu, L. Shi, J. Tang, H. Pang, K.C. Wu, T. Takei,J. Zhang, Y. Yamauchi, J.H. Ye, *Highly active nonprecious metal hydrogen evolution electrocatalyst: ultrafine molybdenum carbide nanoparticles embedded into a 3D nitrogen-implanted carbon matrix*, NPG Asia Materials **8**, e293 (2016). doi: 10.1038/am.2016.102 WOS:000383414800011 eid: -	515	K. Zhang, M. Liao, M. Sumiya, Y. Koide, L. Sang, *Investigation on the interfacial chemical state and band alignment for the sputtering-deposited CaF_2 /p-GaN heterojunction by angle-resolved X-ray photoelectron spectroscopy*, Journal of Applied Physics **120**(18), 185305 (2016). doi: 10.1063/1.4967394 WOS:000388734700027 2-s2.0-84994810176
508	H.X. Zhang, Y. Okawa, M. KAto, Y. Sasaki, K. Uosaki, *Construction of Pt-Ni nanocomposites from Pt-Ni multinuclear complexes on gold(111) surface and their electrocatalytic activity for methanol oxidation*, Journal of Electroanalytical Chemistry **781**, 41 (2016). doi: 10.1016/j.jelechem.2016.10.060 WOS:000390494200008 2-s2.0-85002374016	516	K. Zhang, M. Sumiya, M. Liao, Y. Koide, L. Sang, *P-Channel InGaN/GaN heterostructure metal-oxide-semiconductor field effect transistor based on polarization-induced two-dimensional hole gas*, Scientific Reports **6**, 23683 (2016). doi: 10.1038/srep23683 WOS:000372921200001 2-s2.0-84962437231
509	H.B. Zhang, T. Wang, J.J. Wang, H.M. Liu, T.D. Dao, M. Li, G.G. Liu, X.G. Meng, K. Chang, L. Shi, T. Nagao, J.H. Ye, *Surface-Plasmon-Enhanced Photodriven CO_2 Reduction Catalyzed by Metal-Organic-Framework-Derived Iron Nanoparticles Encapsulated by Ultrathin Carbon Layers*, Advanced Materials **28**(19), 3703 (2016). doi: 10.1002/adma.201505187 WOS:000376480500010 2-s2.0-84962603082	517	N. Zhang, C. Chen, Z.W. Mei, X.H. Liu, X.L. Qu, Y.X. Li, S.Q. Li, W.H. Qi, Y.J. Zhang, J.H. Ye, V.A.L. Roy, R.Z. Ma, *Monoclinic Tungsten Oxide with {100} Facet Orientation and Tuned Electronic Band Structure for Enhanced Photocatalytic Oxidations*, ACS Applied Materials & Interfaces **8**(16), 10367 (2016). doi: 10.1021/acsami.6b02275 WOS:000375245100035 2-s2.0-84966286505
510	H.B. Zhang, J. Wei, J.C. Dong, G.G. Liu, L. Shi, P.F. An, G.X. Zhao, J.T. Kong, X.J. Wang, X.G. Meng, J. Zhang, J.H. Ye, *Efficient Visible-Light-Driven Carbon Dioxide Reduction by a Single-Atom Implanted Metal-Organic Framework*, Angewandte Chemie - International Edition **55**(46), 14308 (2016). doi: 10.1002/anie.201608597 WOS:000387028000018 2-s2.0-84994017842	518	Q. Zhang, H.Q. Li, L. Gan, Y. Ma, D. Golberg, T.Y. Zhai, *In situ fabrication and investigation of nanostructures and nanodevices with a microscope*, Chemical Society Reviews **45**(9), 2694 (2016). doi: 10.1039/c6cs00161k WOS:000375547100014 2-s2.0-84968754297
511	H.B. Zhang, M.J. Zhang, P. Lin, V. Malgras, J. Tang, S.M. Alshehri, Y. Yamauchi, S.W. Du, J. Zhang, A *Highly Energetic N-Rich Metal-Organic Framework as a New High-Energy-Density Material*, Chemistry - A European Journal **22**(3), 1141 (2016). doi: 10.1002/chem.201503561 WOS:000368906200037 2-s2.0-84954026816	519	W. Zhang, Y.Y. Zhao, V. Malgras, Q.M. Ji, D.M. Jiang, R.J. Qi, K. Ariga, Y. Yamauchi, *Synthesis of Monocrystalline Nanoframes of Prussian Blue Analogues by Controlled Preferential Etching*, Angewandte Chemie - International Edition **55**(29), 8228 (2016). doi: 10.1002/anie.201600661 WOS:000383253300003 2-s2.0-84976876703
512	J. Zhang, S. Hiromoto, T. Yamazaki, J.L. Niu, H. Huang, G.Z. Jia, H.Y. Li, W.J. Ding, G.Y. Yuan, *Effect of macrophages on in vitro corrosion behavior of magnesium alloy*, Journal of Biomedical Materials Research Part A **104**(10), 2476 (2016). doi: 10.1002/jbm.a.35788 WOS:000383861400010 2-s2.0-84983670797	520	G.X. Zhao, G.G. Liu, H. Pang, H.M. Liu, H.B. Zhang, K. Chang, X.G. Meng, X.J. Wang, J.H. Ye, *Improved Photocatalytic H-2 Evolution over G-Carbon Nitride with Enhanced In-Plane Ordering*, Small **12**(44), 6160 (2016). doi: 10.1002/smll.201602136 WOS:000389407000012 2-s2.0-84988851394

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522	M. Zhao, H. Xu, S.X. Ouyang, D.W. Li, X.G. Meng, J.H. Ye, *Effect of band structure on the hot-electron transfer over Au photosensitized brookite TiO_2*, Physical Chemistry Chemical Physics **18**(5), 3409 (2016). doi: 10.1039/c5cp06874f WOS:000369508100004 2-s2.0-84956891197	524	X. Zhou, Q. Zhang, L. Gan, X. Li, H.Q. Li, Y. Zhang, D. Golberg, T.Y. Zhai, *High—Performance Solar-Blind Deep Ultraviolet Photodetector Based on Individual Single-Crystalline Zn_2GeO_4 Nanowire*, Advanced Functional Materials **26**(5), 704 (2016). doi: 10.1002/adfm.201504135 WOS:000369969100006 2-s2.0-84981275684

Appendix 7.7: MANA Journal Cover Sheets

Journal cover sheets related to MANA affiliated papers (October 2007 – December 2016):

	Journal name *Type of cover sheet*	Year	Volume	Issue	doi number (of related paper)
1	Physics Today *Journal Front Cover*	2008	61	12	10.1063/1.3047660
2	Advanced Functional Materials *Journal Front Cover*	2009	19	15	10.1002/adfm.200900295
3	Advanced Functional Materials *Journal Inside Front Cover*	2009	19	12	10.1002/adfm.200801435
4	Advanced Materials *Journal Inside Front Cover*	2009	21	20	10.1002/adma.200802441
5	Advanced Materials *Journal Inside Front Cover*	2009	21	44	10.1002/adma.200901321
6	Journal of Materials Chemistry *Journal Front Cover*	2009	19	3	10.1039/b808320g
7	Journal of Materials Chemistry *Journal Inside Front Cover*	2009	19	25	10.1039/B903791H
8	Journal of Nanoscience and Nanotechnology *Journal Front Cover*	2009	9	1	10.1166/jnn.2009.J076
9	Journal of Porphyrins and Phthalocyanines *Journal Front Cover*	2009	13	1	10.1142/S1088424609000061
10	Physical Chemistry Chemical Physics *Journal Inside Front Cover*	2009	11	29	10.1039/B822802G
11	Soft Matter *Journal Back Cover*	2009	5	19	10.1039/B909397D
12	Solid State Physics (in Japanese) *Journal Front Cover*	2009	44	2	(not available)
13	Advanced Functional Materials *Journal Front Cover*	2010	20	3	10.1002/adfm.200901878
14	Journal of Materials Chemistry *Journal Front Cover*	2010	20	32	10.1039/C0JM01013H
15	Materials Transactions *Journal Front Cover*	2010	51	11	10.2320/matertrans.M2010192

	Journal name *Type of cover sheet*	Year	Volume	Issue	doi number (of related paper)
16	Nanoscale *Journal Inside Front Cover*	2010	2	2	10.1039/B9NR00415G
17	Science and Technology of Advanced Materials *Front Cover of Promotional Copy*	2010	11	5	10.1088/1468-6996/11/5/054506
18	Angewandte Chemie – International Edition *Journal Frontispiece*	2011	50	6	10.1002/anie.201005271
19	Angewandte Chemie – International Edition *Journal Frontispiece*	2011	50	17	10.1002/anie.201007370
20	Chemical Communications *Journal Inside Front Cover*	2011	47	45	10.1039/C1CC15169J
21	Energy & Environmental Science *Journal Inside Back Cover*	2011	4	11	10.1039/C1EE01400E
22	Journal of Materials Chemistry *Journal Front Cover*	2011	21	18	10.1039/C0JM04557H
23	Journal of Materials Chemistry *Journal Inside Front Cover*	2011	21	44	10.1039/C1JM13180J
24	Journal of Nanoscience and Nanotechnology *Journal Front Cover*	2011	11	9	10.1166/jnn.2011.4718
25	Journal of the American Chemical Society *Journal Front Cover*	2011	133	20	10.1021/ja110691t
26	Physical Chemistry Chemical Physics *Journal Back Cover*	2011	13	11	10.1039/C0CP02025G
27	Physical Review Letters *Journal Front Cover*	2011	106	3	10.1103/ PhysRevLett.106.037002
28	Small *Journal Frontispiece*	2011	7	4	10.1002/smll.201001849
29	Small *Journal Frontispiece*	2011	7	10	10.1002/smll.201002350
30	Advanced Functional Materials *Journal Front Cover*	2012	22	13	10.1002/adfm.201103110
31	Advanced Functional Materials *Journal Frontispiece*	2012	22	17	10.1002/adfm.201290101
32	Advanced Materials *Journal Front Cover*	2012	24	2	10.1002/adma.201290004
33	Advanced Materials *Journal Frontispiece*	2012	24	2	10.1002/adma.201102617
34	Advanced Materials *Journal Frontispiece*	2012	24	2	10.1002/adma.201103241
35	Advanced Materials *Journal Frontispiece*	2012	24	2	10.1002/adma.201102958
36	Advanced Materials *Journal Inside Front Cover*	2012	24	2	10.1002/adma.201103053
37	Bulletin of the Chemical Society of Japan *Journal Front Cover*	2012	85	1	10.1246/bcsj.20110162
38	Chemical Communications *Journal Inside Back Cover*	2012	48	33	10.1039/C2CC31118F
39	Chemical Communications *Journal Inside Front Cover*	2012	48	40	10.1039/C2CC30643C
40	Chemistry - A European Journal *Journal Frontispiece*	2012	18	6	10.1002/chem.201102013

	Journal name *Type of cover sheet*	Year	Volume	Issue	doi number (of related paper)
41	Inorganic Chemistry *Journal Front Cover*	2012	51	19	10.1021/ic300557u
42	Journal of Materials Chemistry *Journal Inside Back Cover*	2012	22	14	10.1039/C2JM00044J
43	Journal of Materials Chemistry *Journal Back Cover*	2012	22	21	10.1039/C2JM16629A
44	Nanoscale *Journal Front Cover*	2012	4	8	10.1039/C2NR11835A
45	Nanoscale *Journal Front Cover*	2012	4	10	10.1039/C2NR00010E
46	Oyo Buturi (in Japanese) *Journal Front Cover*	2012	81	12	(not available)
47	Physica Status Solidi: RRL *Journal Front Cover*	2012	6	5	10.1002/pssr.201206082
48	Physical Chemistry Chemical Physics *Journal Back Cover*	2012	14	17	10.1039/C2CP24010F
49	Polymer Journal *Journal Front Cover*	2012	44	6	10.1038/pj.2012.30
50	Advanced Materials *Journal Inside Front Cover*	2013	25	8	10.1002/adma.201204434
51	Angewandte Chemie – International Edition *Journal Back Cover*	2013	52	31	10.1002/anie.201303035
52	Chemical Communications *Journal Inside Front Cover*	2013	49	35	10.1039/c3cc40398j
53	Chemical Communications *Journal Inside Front Cover*	2013	49	36	10.1039/C3CC39273B
54	Chemical Society Reviews *Journal Inside Front Cover*	2013	42	15	10.1039/C2CS35475F
55	Chemistry – An Asian Journal *Journal Frontispiece*	2013	8	8	10.1002/asia.201300247
56	Chemistry – An Asian Journal *Journal Inside Front Cover*	2013	8	12	10.1002/asia.201300940
57	CrystEngComm *Journal Inside Front Cover*	2013	15	45	10.1039/C3CE41150H
58	Journal of Materials Chemistry A *Journal Front Cover*	2013	1	13	10.1039/c2ta00450j
59	Journal of Materials Chemistry B *Journal Inside Front Cover*	2013	1	26	10.1039/C3TB20461H
60	Journal of Materials Chemistry C *Journal Front Cover*	2013	1	11	10.1039/C3TC00930K
61	Journal of Materials Chemistry C *Journal Front Cover*	2013	1	14	10.1039/C3TC00952A
62	Langmuir *Journal Front Cover*	2013	29	24	10.1021/la401652f
63	Langmuir *Journal Front Cover*	2013	29	27	10.1021/la4006423
64	Physical Chemistry Chemical Physics *Journal Back Cover*	2013	15	26	10.1039/c3cp50620g
65	Advanced Materials *Journal Front Cover*	2014	26	26	10.1002/adma.201306055

	Journal name *Type of cover sheet*	Year	Volume	Issue	doi number (of related paper)
66	Advanced Materials *Journal Frontispiece*	2014	26	19	10.1002/adma.201305457
67	Angewandte Chemie - International Edition *Journal Inside Front Cover*	2014	53	43	10.1002/anie.201404953
68	Biomaterials Science *Journal Front Cover*	2014	2	5	10.1039/C3BM60263J
69	Biomaterials Science *Journal Front Cover*	2014	2	6	10.1039/c3bm60212e
70	ChemCatChem *Journal Front Cover*	2014	6	12	10.1002/cctc.201402449
71	ChemElectroChem *Journal Back Cover*	2014	1	4	10.1002/celc.201300240
72	Chemical Communications *Journal Back Cover*	2014	50	49	10.1039/C4CC01336K
73	Chemical Society Reviews *Journal Inside Front Cover*	2014	43	5	10.1039/C3CS60348B
74	Chemistry - A European Journal *Journal Back Cover*	2014	20	36	10.1002/chem.201403308
75	Chemistry Letters *Journal Front Cover*	2014	43	1	10.1246/cl.130987
76	Journal of Materials Chemistry A *Journal Showcase*	2014	2	12	10.1039/C3TA13769D
77	Journal of Materials Chemistry C *Journal Inside Front Cover*	2014	2	3	10.1039/C3TC31787K
78	Journal of Porphyrins and Phthalocyanines *Journal Front Cover*	2014	18	3	10.1142/S1088424613501071
79	Journal of Physical Chemistry C *Journal Front Cover*	2014	118	37	10.1021/jp5036426
80	Journal of the American Chemical Society *Journal Front Cover*	2014	136	29	10.1021/ja502008t
81	Nanotechnology *Journal Front Cover*	2014	25	46	10.1088/0957-4484/25/46/465305
82	New Journal of Chemistry *Journal Front Cover*	2014	38	8	10.1039/C4NJ00016A
83	New Journal of Chemistry *Journal Front Cover*	2014	38	11	10.1039/c4nj00864b
84	Particle & Particle Systems Characterization *Journal Inside Front Cover*	2014	31	7	10.1002/ppsc.201300365
85	Physica Status Solidi C *Journal Front Cover*	2014	11	2	10.1002/pssc.20130010
86	Physical Chemistry Chemical Physics *Journal Back Cover*	2014	16	21	10.1039/C3CP55431G
87	Advanced Functional Materials *Journal Front Cover*	2015	25	37	10.1002/adfm.201502499
88	Advanced Materials *Journal Inside Back Cover*	2015	27	48	10.1002/adma.201570333
89	Advanced Science *Journal Back Cover*	2015	2	8	10.1002/advs.201570032
90	Angewandte Chemie - International Edition *Journal Back Cover*	2015	54	14	10.1002/anie.201410942

	Journal name *Type of cover sheet*	Year	Volume	Issue	doi number (of related paper)
91	Angewandte Chemie - International Edition *Journal Back Cover*	2015	54	38	10.1002/anie.201505232
92	ChemCatChem *Journal Inside Back Cover*	2015	7	5	10.1002/cctc.201402916
93	ChemElectroChem *Journal Inside Front Cover*	2015	2	4	10.1002/celc.201402365
94	Chemical Communications *Journal Back Cover*	2015	51	13	10.1039/C4CC09366F
95	Chemical Communications *Journal Inside Front Cover*	2015	51	96	10.1039/c5cc05408g
96	Chemistry - A European Journal *Journal Front Cover*	2015	21	9	10.1002/chem.201404895
97	Chemistry – An Asian Journal *Journal Inside Back Cover*	2015	10	6	10.1002/asia.201500098
98	ChemSusChem *Journal Inside Front Cover*	2015	8	5	10.1002/cssc.201402996
99	Energy & Environmental Science *Journal Inside Front Cover*	2015	8	6	10.1039/C4EE03746D
100	Inorganic Chemistry *Journal Front Cover*	2015	54	24	1021/acs.inorgchem.5b01183
101	Journal of Materials Chemistry A *Journal Back Cover*	2015	3	6	10.1039/c4ta06027j
102	Journal of Materials Chemistry C *Journal Back Cover*	2015	3	11	10.1039/c4tc02778g
103	Materials Horizons *Journal Back Cover*	2015	2	4	10.1039/C5MH00012B
104	Nanoscale *Journal Front Cover*	2015	7	48	10.1039/c5nr05645d
105	Nanoscale *Journal Inside Back Cover*	2015	7	1	10.1039/c4nr03019b
106	Nanotechnology *Journal Front Cover*	2015	26	34	10.1088/0957-4484/26/34/344004
107	Physica Status Solidi C *Journal Front Cover*	2015	12	8	10.1002/pssc.201400299
108	Physical Review Letters *Journal Front Cover*	2015	115	17	10.1103/PhysRevLett.115.177001
109	Solid State Physics (in Japanese) *Journal Front Cover*	2015	50	2	(not available)
110	Advanced Functional Materials *Journal Back Cover*	2016	26	5	10.1002/adfm.201504135
111	Biomaterials Science *Journal Front Cover*	2016	4	1	10.1039/C5BM00375J
112	Biomaterials Science *Journal Front Cover*	2016	4	6	10.1039/c6bm00100a
113	ChemCatChem *Journal Front Cover*	2016	8	3	10.1002/cctc.201501020
114	Chemical Society Reviews *Journal Front Cover*	2016	45	15	10.1039/c5cs00937e
115	Chemical Society Reviews *Journal Inside Front Cover*	2016	45	1	10.1039/C5CS00517E

	Journal name *Type of cover sheet*	Year	Volume	Issue	doi number (of related paper)
116	Chemistry - A European Journal *Journal Back Cover*	2016	22	4	10.1002/chem.201503490
117	ChemNanoMat *Journal Front Cover*	2016	2	2	10.1002/cnma.201500189
118	CrystEngComm *Journal Front Cover*	2016	18	3	10.1039/C5CE01658D
119	CrystEngComm *Journal Front Cover*	2016	18	36	10.1039/C6CE00986G
120	Ekisho (in Japanese) *Journal Front Cover*	2016	20	3	(not available)
121	Journal of Materials Chemistry B *Journal Front Cover*	2016	4	1	10.1039/C5TB02215K
122	Journal of Physical Chemistry C *Journal Front Cover*	2016	120	4	10.1021/acs.jpcc.5b09364
123	Journal of Physical Chemistry C *Journal Front Cover*	2016	120	29	(not available)
124	Journal of Materials Chemistry C *Journal Back Cover*	2016	4	34	10.1039/c6tc01768a
125	Journal of Vacuum Science and Technology B *Journal Front Cover*	2016	134	1	10.1116/1.4936886
126	Langmuir *Journal Front Cover*	2016	32	5	10.1021/acs.langmuir.5b04302
127	Physical Chemistry Chemical Physics *Journal Back Cover*	2016	18	8	10.1039/C5CP04714E
128	Physical Chemistry Chemical Physics *Journal Back Cover*	2016	18	11	10.1039/c5cp05885f
129	Soft Matter *Journal Back Cover*	2016	12	38	10.1039/C6SM01450J

Appendix 7.8: MANA Patents

All MANA patent applications and MANA patent registrations listed in this Appendix are or were partly or fully owned by NIMS.

1. List of Japanese Patent Applications (January 2015 - December 2016):

Between October 2007 and December 2014, MANA has made 494 Japanese Patent Applications.

No.	Date of Application / *Name of Invention*	Application Number
495	2015 Jan 15 *Resistance-varying element and process for production thereof*	2015-005464
496	2015 Jan 20 *Surgical sealant and method for producing same*	2015-008556
497	2015 Jan 27 *Sensor using receptor layer composed of granular materials*	2015-013271
498	2015 Jan 30 *Sugar responsive gel and medicine administering device*	2015-016395
499	2015 Feb 2 *Bismuth telluride thin film manufacturing method and bismuth telluride thin film*	2015-018256
500	2015 Feb 9 *Immunosuppressive agents that suppress the formation of amyloid fibrils, decomposition agent that dissolves amyloid fibers, prevention of neurodegenerative disease and medicine for treatment and growth of the decease as well as immunosuppressive agent and manufacturing method of decomposition agent*	2015-023490
501	2015 Feb 25 *Topological Photonic crystals*	2015-034902
502	2015 Feb 27 *Sensor covered with receptor layer of base material mixed with granular material*	2015-038190
503	2015 Mar 6 *Capacitor and electrode for dielectric materials involving Bismuth*	2015-044135
504	2015 Mar 6 *Determination of molecular weight and molecular weight measuring equipment*	2015-045316
505	2015 Mar 12 *Tunnel field effect transistor and using method*	2015-050089
506	2015 Mar 16 *Light catalyst composition, improved light catalyst activator and improved method of optical catalyst activity*	2015-052136
507	2015 Mar 17 *Mesoporous metal film and method for producing same*	2015-053162
508	2015 Mar 17 *Mesoporous metal film based molecular sensor, redox catalyst and lithium-ion battery electrodes*	2015-053191
509	2015 Mar 20 *Mesoporous metal film*	2015-057066
510	2015 Mar 23 *Water soluble near-infrared luminescence nano-particles and fluorescent labeling material*	2015-059049
511	2015 Mar 24 *Titanium nitride thin film thermoelectric semiconductor, method for producing same and thermoelectric generator*	2015-060270
512	2015 Mar 31 *Solar cell and production of solar cell*	2015-071854
513	2015 Apr 3 *Sericin-phosphate-copper hybrid structure and method for production thereof and heavy metal ion adsorbent*	2015-076769
514	2015 Apr 27 *Template substrate fabrication method and fabrication equipment*	2015-089930
515	2015 Apr 30 *Electrode wire using metal foil and manufacturing method of organic transistors using same*	2015-092555
516	2015 May 8 *Complex photocatalyst and its manufacturing method*	2015-095761
517	2015 May 11 *Coating agent, material with this coating and method for producing same*	2015-096768
518	2015 May 15 *Surface stress sensor having receptor layer coated with porous material and method for producing same*	2015-100405
519	2015 May 18 *Kekule superlattice structure with huge effective spin-orbit interaction and topological state of honeycomb lattice-type material*	2015-101321
520	2015 May 21 *Hybrid solar cells using nanocrystalline silicon quantum dots fully terminated by molecules*	2015-103575
521	2015 May 26 *Low friction coating and micro machine consisting of boron-doped zinc oxide thin film*	2015-105970
522	2015 Jun 9 *NMR for chiral shift agent, and a method of determining optical purity using the same*	2015-116459
523	2015 Jun 17 *Oxidation-induced self-healing ceramic composition containing a cure activator, method for producing same and the use of high-performance method of oxidation-induced self-healing ceramic composition*	2015-122293
524	2015 Jun 24 *Thin-film transistor of the multi-layer structure, method for producing same and active matrix driving display*	2015-126796
525	2015 Jul 3 *Tissue adhesive, including gelatin derivatives*	2015-134188
526	2015 Jul 8 *Probes for scanning probe microscope and method for producing same*	2015-136715
527	2015 Jul 9 *Immunostimulatory oligonucleotide complex*	2015-138004
528	2015 Jul 24 *Single-electron transistor, a method for manufacturing same and integrated circuit*	2015-146869
529	2015 Aug 26 *Petri dish-type cell culture vessels*	2015-167060

No.	Date of Application *Name of Invention*	Application Number
530	2015 Aug 27 *Cationic glycidyl polymer*	**2015-167548**
531	2015 Sep 3 *Increased primary particle boundary of titanium oxide and method for producing same*	**2015-173456**
532	2015 Sep 8 *Sensor module*	**2015-176709**
533	2015 Sep 10 *Solid electrochemical reaction by magnetic control structure and method and variable magnetic resistance-type electrical device*	**2015-178256**
534	2015 Sep 18 *Zinc-gallium binary oxide composite-type thermoelectric material and method for producing same*	**2015-184586**
535	2015 Sep 18 *Skutterudite thermoelectric strange semiconductor doped with silicon and tellurium, method for producing same and thermoelectric power*	**2015-184746**
536	2015 Oct 6 *Ethylene - vinyl alcohol copolymer and polyvinyl alcohol function method of ethylene - vinyl alcohol copolymer and polyvinyl alcohol*	**2015-198316**
537	2015 Oct 21 *Coating agent, material with this coating and method for producing same*	**2015-206937**
538	2015 Oct 21 *Proton conductor and fuel cell*	**2015-207235**
539	2015 Nov 17 *Adhesion of Bone filler*	**2015-224957**
540	2015 Dec 8 *Specific gas identification sensor using receptor layer with functional particles*	**2015-239115**
541	2015 Dec 18 *Laser oscillators composed of colloidal crystal gels, Laser oscillation device and method for producing same*	**2015-247549**
542	2016 Jan 20 *Method for selecting channels*	**2016-008521**
543	2016 Jan 20 *Apparatus for determination of intention*	**2016-008632**
544	2016 Feb 4 *Core shell composites, fabrication methods of the same, electrode materials, catalysts, electrodes, secondary butteries, and electrical double-layer*	**2016-020182**
545	2016 Feb 23 *Devices of diamond having luminescence and rectification, and fabrication method of the same*	**2016-031787**
546	2016 Mar 3 *Method for analyzing signal and distinguishing sample gases*	**2016-040625**
547	2016 Mar 7 *Vitamin B12 elimination medicines for cure of neural damages*	**2016-043873**
548	2016 Mar 17 *Nano mechanical sensors using polyacrylamine hydrochloric acids as receptors and apparatuses for measuring acetone concentration*	**2016-053812**
549	2016 May 13 *Apparatus for distinguishing drop size and methods for distinguishing drop size*	**2016-097188**
550	2016 May 24 *Porous materials composing of nano particles and fabrication method of the same*	**2016-102976**
551	2016 May 30 *Semiconductor equipment, fabrication methods of semiconductor equipment, inverter circuits, driving equipment, vehicles, and elevators*	**2016-107937**
552	2016 Jun 8 *Method for measuring dew points and apparatuses for measuring dew points*	**2016-114677**
553	2016 Jun 21 *System for investigation, method for investigation and apparatuses for managing material data bases*	**2016-122551**
554	2016 Jun 29 *Fluorescence germanium nano particles and fabrication method of the same*	**2016-129029**
555	2016 Jul 19 *Method for detecting chiral compounds*	**2016-141470**
556	2016 Aug 1 *Magneto-resistant devices and magnetic heads using these magneto-resistance devices and apparatuses for restoring magnetism*	**2016-151330**
557	2016 Aug 9 *Method for controlling electric charges using ion transportation under magnetic fields and uses of the same*	**2016-156389**
558	2016 Aug 9 *Layered metallic oxides having hydration swelling properties, their compounds, their thin films, and fabrication method of the same*	**2016-156967**
559	2016 Aug 17 *Method for internal capsulation of cells and internal capsulated cells*	**2016-160199**
560	2016 Aug 18 *Materials for finding methanol contains*	**2016-160685**
561	2016 Aug 19 *Composite-structured materials with sericin-hydroxyapatite, fabrication methods of the same, materials for adsorption , and materials for water*	**2016-161188**
562	2016 Aug 19 *Capacitor devices with variable capacity and capacitor array*	**2016-161296**
563	2016 Aug 29 *Apparatuses for semiconductors*	**2016-167281**
564	2016 Sep 9 *Composites of organic and inorganic materials and fabrication methods of the same*	**2016-176068**
565	2016 Sep 12 *Method for fabricating composite bodies by segregation of short orientated fibers-cells*	**2016-177481**
566	2016 Sep 12 *Electrode liquids*	**2016-178059**
567	2016 Sep 21 *Organic transistors and method for operation control and equipment of operation control*	**2016-184292**
568	2016 Sep 26 *Medicine for inhibition of cells induced by epithelium mesenchyme transformation*	**2016-186970**
569	2016 Oct 18 *P type thermoelectric semiconductors of copper gallium tellurium system, and thermoelectric device using the same*	**2016-204235**

No.	Date of Application *Name of Invention*	Application Number
570	2016 Oct 27 *Equipment of gas sensor and method for removing gas components*	2016-210632
571	2016 Oct 31 *Thin film transistors and fabrication methods of the same*	2016-213693
572	2016 Nov 8 *Fibers adsorbing creatinine and fabrication methods of fibers adsorbing creatinine*	2016-218324
573	2016 Nov 10 *P type thermoelectric semiconductors, fabrication method of the same, and thermoelectric semiconductors using the same*	2016-219958
574	2016 Nov 24 *Nano particles for thermotherapy for cancer and polymers having absorbing property of biomaterials, composite porous materials of the same, and fabrication methods of the same*	2016-227992
575	2016 Nov 28 *Method for identifying samples by chemical sensors, apparatuses for identifying samples, and method for estimating input parameters*	2016-230468
576	2016 Nov 29 *Method and apparatus for estimating parameter values corresponding to samples*	2016-230793
577	2016 Dec 26 *Fuel cell and electrolysis of water*	2016-251111
578	2016 Dec 27 *Multi-function electric conduction device and use of the same*	2016-252267

2. List of Japanese Patent Registrations (January 2015 – December 2016):

Between October 2007 and December 2014, MANA has made 399 Japanese Patent Registrations.

No.	Date of Registration *Name of Invention*	Registration Number
400	2015 Jan 9 *Organic solvent dispersion in which flaky perovskite oxide particle is blended and method for producing the same, and perovskite oxide thin film using the organic solvent dispersion and method for producing the same*	5672726
401	2015 Jan 23 *Nano crystal grain dispersion solution, electronic device, and its production process*	5682880
402	2015 Feb 6 *Ferroelectric thin film having superlattice structure, manufacturing method thereof, ferroelectric element, and manufacturing method thereof*	5688816
403	2015 Feb 20 *Sugar responsive gel and medicine administering device*	5696961
404	2015 Feb 20 *Synapse operation element*	5696988
405	2015 Feb 20 *Negative-electrode material and lithium secondary battery using same*	5696993
406	2015 Mar 6 *Elastic body material having periodic structure which varies structural color with modulus*	5704007
407	2015 Mar 13 *Axis alignment method and device of energy analyzer*	5711552
408	2015 Mar 20 *Rare earth boron carbide based thermolectric semiconductor doped with transition metal, method of producing the same and thermoelectric power generation element*	5713283
409	2015 Mar 20 *High hardness B4C oriented by ferromagnetic field technique and method for manufacturing the same*	5713284
410	2015 Mar 20 *Metal complex, dye-sensitized oxide semiconductor electrode, and dye-sensitized solar battery*	5713285
411	2015 Mar 27 *Composite cathode material for solid oxide fuel cell operating at medium-low temperature, composite cathode for solid oxide fuel cell, and method for manufacturing electrolyte-composite cathode structure for solid oxide fuel cell*	5717067
412	2015 Apr 3 *Plate single crystal composed of metal oxide, thin film of the metal oxide, production methods for the single crystal and the film and variable-resistance element using the single crystal of the film*	5721100
413	2015 Apr 17 *Analyzer and manufacturing method of analyzer*	5728778
414	2015 Apr 24 *Silicon nanoparticle-silicon nanowire composite material, solar cell, light-emitting device, and manufacturing method*	5733655
415	2015 May 15 *Double-sided coated surface stress sensor*	5743026
416	2015 May 15 *Method of manufacturing anisotropic sliding material and anisotropic sliding material*	5745771
417	2015 May 22 *Field-effect transistor and method of manufacturing the same*	5747245
418	2015 May 22 *Organic/fluorescent metal hybrid polymer and ligand thereof*	5747247
419	2015 May 22 *Tissue adhesive film and method for producing same*	5747264
420	2015 May 29 *Porous carbon film, method of manufacturing the same, and application using the same*	5751582
421	2015 Jun 12 *Organic/metal hybrid polymer which contains metal whose coordination number is 4 and bisphenanthroline derivative, ligand thereof, and method for producing the same*	5757615

No.	Date of Registration *Name of Invention*	Registration Number
422	2015 Jun 12 *Interface layer reduction method, method for forming high dielectric constant gate insulating film, high dielectric constant gate insulating film, high dielectric constant gate oxide film, and transistor having high dielectric constant gate oxide film*	5757628
423	2015 Jun 26 *Highly proton-conductive polymer film, method for producing same, and humidity sensor*	5765692
424	2015 Jun 26 *Amine functionalized mesopore carbon nanocage and method for manufacturing the same*	5765709
425	2015 Jul 3 *Composite porous scaffold*	5769159
426	2015 Jul 3 *Magnetic optical material, magnetic optical element, and manufacturing method of magnetic optical material*	5769238
427	2015 Jul 3 *Process for production of contact structure for organic semiconductor device, and contact structure for organic semiconductor device*	5769254
428	2015 Jul 17 *Adhesive substrate and method for manufacturing the same*	5777052
429	2015 Jul 24 *Zirconium diboride powder and method for synthesizing the same*	5780540
430	2015 Jul 31 *Layered double hydroxide having I3-, and method for producing the same*	5783560
431	2015 Aug 14 *Ultraviolet light detection device and method of manufacturing the same*	5791026
432	2015 Sep 11 *Porous carbon nitride film, method of manufacturing the same, and application using the same*	5804251
433	2015 Sep 18 *Dielectric composition and method for manufacturing the same*	5807861
434	2015 Oct 9 *Chiral shift reagent for NMR and method for determing optical purity using the same*	5817901
435	2015 Oct 9 *Metal catalyst structure and method for producing the same*	5818244
436	2015 Oct 9 *Isopropyl acrylamide derivative having azido group or alkyne group and polymer thereof*	5818245
437	2015 Oct 16 *Patterned porous material and method for manufacturing the same*	5822266
438	2015 Dec 4 *Short fiber scaffold material, method for making short fiber-cell composite agglomerated mass, and short fiber-cell composite agglomerated mass*	5846550
439	2015 Dec 4 *Method for rolling and drawing processing of material made of nickel-free high nitrogen stainless steel, seamless capillary made of nickel-free high nitrogen stainless steel, and method for producing the same*	5846555
440	2015 Dec 4 *Thin-film transistor, method for producing a thin-film transistor, and semiconductor device*	5846563
441	2015 Dec 11 *Mesoporous metal film, and method for producing mesoporous metal film from low-concentration aqueous surfactant solution*	5849369
442	2016 Jan 8 *Actuator using layered double hydroxide, and control method thereof*	5862879
443	2016 Jan 15 *Vertical lamination plasmon metal disc array for capturing light of wide band*	5867810
444	2016 Jan 15 *Method for producing anion-exchanging layered double hydroxide and method for substituting carbonate ion of layered double hydroxide containing carbonate ion*	5867831
445	2016 Jan 15 *Nanofiber having self-heating properties and biologically active substance release properties, production method for same, and nonwoven fabric having self-heating properties and biologically active substance release capabilities*	5867839
446	2016 Jan 22 *Method for manufacturing graphene substrate, and graphene substrate*	5871213
447	2016 Jan 22 *Method for producing nanofiber of synthetic collagen*	5871234
448	2016 Jan 29 *Alumina resistance change memory element and manufacturing method therefor*	5874905
449	2016 Jan 29 *Method for determining number of layers of two-dimensional thin film atomic structure and device for determining number of layers of two-dimensional thin film atomic structure*	5874981
450	2016 Feb 2 *Anode material with high Co tolerance for polymer electrolyte fuel cell*	5877393
451	2016 Feb 12 *Max-phase oriented ceramic and production method therefor*	5881174
452	2016 Feb 19 *High dielectric nanosheet laminate, high dielectric element, and method for manufacturing high dielectric thin film element*	5885150
453	2016 Feb 26 *Reagent for water detection and method for quantitatively measuring concentration of water in aprotic polar solvent*	5888649
454	2016 Mar 4 *Surface stress sensor*	5891465
455	2016 Mar 18 *Device using single crystal tin oxide wire*	5900883
456	2016 Mar 25 *Coated HVJ-E and method for producing coated HVJ-E*	5904434
457	2016 Apr 8 *Water-swelling layered double hydroxide, method for producing same, gel or sol substance, double hydroxide nanosheet, and method for producing same*	5910887
458	2016 Apr 8 *Base material sheet for regenerative medicine*	5911006

No.	Date of Registration *Name of Invention*	Registration Number
459	2016 Apr 15 *Whisker crystal of iron-based superconductor and production method of the same*	**5916009**
460	2016 Apr 22 *Method for forming organic semiconductor thin film, semiconductor element, and organic field effect transistor*	**5920806**
461	2016 Apr 22 *Nanoparticle-containing polymer nanowire and method for producing same*	**5920846**
462	2016 May 13 *Method for producing carbon-containing structure material and carbon-containing structure material*	**5927522**
463	2016 May 13 *Immune stimulating oligonucleotide and curative agent containing the same*	**5930146**
464	2016 May 20 *Device unit for topological quantum calculation using edge Majorana fermion, operation method thereof, device for topological quantum calculation, and operation method thereof*	**5935212**
465	2016 May 27 *Resistance change type memory element using aluminum oxide layer as resistance change layer*	**5939482**
466	2016 Jun 3 *Sugar responsive gel and medicine administering device*	**5943286**
467	2016 Jun 17 *Organic semiconductor single crystal formation method and organic semiconductor device*	**5950251**
468	2016 Jun 17 *Laser oscillation element composed of colloidal crystal gel, laser oscillator and manufacturing method therefor*	**5950252**
469	2016 Jul 8 *Method for producing oxygen by means of light irradiation*	**5963128**
470	2016 Jul 15 *Manufacturing method for graphene substrate, and graphene substrate*	**5967486**
471	2016 Jul 15 *Precipitation method for conductive polymer-metal complex, and conductive polymer-metal complex*	**5967778**
472	2016 Jul 22 *Oxygen reduction electrode catalyst and oxygen electrode*	**5971699**
473	2016 Jul 22 *Probe for fiber and manufacturing method of the same*	**5971789**
474	2016 Aug 5 *Silicon crystal casting furnace*	**5979664**
475	2016 Aug 5 *Manufacturing apparatus and method for organic el element and manufacturing apparatus and method for CVD thin film*	**5979666**
476	2016 Aug 5 *Method for forming metal silicide*	**5979667**
477	2016 Aug 12 *Method for producing thin film consisting of nanosheet monolayer film by spin coat method, and hyperhydrophilized material, substrate for oxide thin film and dielectric material obtained therefrom*	**5984089**
478	2016 Aug 26 *Small diameter Ni_3C nanoparticle and production method of the same, and small diameter Ni_3C nanoparticle inclusion electrode catalyst and production method of the same*	**5991670**
479	2016 Sep 23 *Sputter gun and deposition apparatus using the same*	**6008320**
480	2016 Sep 23 *Shutter device for vapor deposition and deposition apparatus using the same*	**6008321**
481	2016 Oct 14 *Mesoporous metal film*	**6021127**
482	2016 Nov 18 *Optimum ionization potential film deposition apparatus and method therefor*	**6040470**
483	2016 Nov 25 *Fluorite type undoped cerium oxide nanoparticle having high concentration cerium trivalence excellent in atmospheric stability, and manufacture method of the same*	**6044016**
484	2016 Nov 25 *Framework compound, its manufacturing method and fluophor*	**6044023**
485	2016 Nov 25 *Blood purification membrane, method for manufacturing blood purification membrane, and dialysis device*	**6045007**
486	2016 Dec 2 *Tissue adhesive film and manufacturing method thereof*	**6048811**
487	2016 Dec 2 *Fluorescent probe and method for detecting cesium-containing substance*	**6048823**
488	2016 Dec 9 *Channel monitoring method, user equipment and network device*	**6052752**
489	2016 Dec 22 *Rare-earth aluminoboride thermoelectric semiconductor, manufacturing method of the same and thermoelectric generation element using the same*	**6061272**

3. List of International Patent Applications (January 2015 – December 2016):

Between October 2007 and December 2014, MANA has made 219 International Patent Applications.

Note: PCT: Patent Cooperation Treaty EPC: European Patent Convention

No.	Date of Application / Country *Name of Invention*	Application Number
220	2015 Jan 23 **PCT** *Thin-film transistor, oxide semiconductor, and method for producing same*	**PCT/JP2015/051845**
221	2015 Feb 9 **PCT** *Boron nitride particles and production method therefor*	**PCT/JP2015/053488**
222	2015 Feb 9 **PCT** *Spherical boron nitride particles and production method thereof*	**PCT/JP2015/053489**
223	2015 Feb 11 **Taiwan** *Spherical boron nitride particles and production method thereof*	**104104538**
224	2015 Feb 11 **Taiwan** *Boron nitride particles and production method therefor*	**104104539**
225	2015 Feb 26 **PCT** *Semiconductor device comprising a hydrogen diffusion barrier and method of fabricating same*	**PCT/JP2015/001013**
226	2015 Mar 30 **PCT** *Nano-coating material, method for manufacturing same, coating agent, functional material, and method for manufacturing same*	**PCT/JP2015/060000**
227	2015 May 14 **PCT** *Silver diffusion barrier material, silver diffusion barrier and a semiconductor device using the same*	**PCT/JP2015/063860**
228	2015 Jul 21 **PCT** *Sensor having a high-speed and high sensitivity wet and dry response*	**PCT/JP2015/070692**
229	2015 Jul 22 **PCT** *Bioabsorbable member for medical use and method for producing same*	**PCT/JP2015/070888**
230	2015 Aug 10 **PCT** *Electromagnetic wave absorber and emitter material and method for producing the same*	**PCT/JP2015/072687**
231	2015 Aug 31 **PCT** *Sensor having a porous material or granular material as the receptor layer*	**PCT/JP2015/074659**
232	2015 Sep 17 **PCT** *Energy filtered electron detector and scanning electron microscope using the same*	**PCT/JP2015/076404**
233	2015 Nov 16 **PCT** *Method for producing porous particles*	**PCT/JP2015/082087**
234	2016 Jan 13 **PCT** *Resistance change element and method for manufacturing same*	**PCT/JP2016/050853**
235	2016 Feb 25 **PCT** *Sensor including receptor layer coating comprising mixture of base material and particulate material*	**PCT/JP2016/055689**
236	2016 Mar 4 **PCT** *Molecular weight measurement method and molecular weight measurement device*	**PCT/JP2016/056901**
237	2016 Mar 29 **PCT** *Solar cell and method for manufacturing solar cell*	**PCT/JP2016/060029**
238	2016 Apr 20 **PCT** *Manufacturing method and manufacturing device of template substrate*	**PCT/JP2016/062478**
239	2016 May 11 **PCT** *Solar cell combined with molecule-terminated silicon nanoparticles*	**PCT/JP2016/064037**
240	2016 Jun 13 **PCT** *Oxidation-induced self-healing ceramic composition containing healing activator, method for producing same, use of same, and method for enhancing functionality of oxidation-induced self-healing ceramic composition*	**PCT/JP2016/067513**
241	2016 Aug 26 **PCT** *Diamond anvil cell*	**PCT/JP2016/074996**
242	2016 Sep 8 **PCT** *Sensor module*	**PCT/JP2016/076397**
243	2016 Oct 4 **PCT** *Method and agent for functionalizing vinyl alcohol resin*	**PCT/JP2016/079524**
244	2016 Nov 14 **PCT** *Sensor and method for identifying fuel oil where hydrocarbon-group-modified fine particles work as acceptor layer*	**PCT/JP2016/083689**
245	2016 Dec 9 **PCT** *Search system, search method and device for managing physical properties database*	**PCT/JP2016/086739**

4. List of International Patent Registrations (January 2015 – December 2016):

Between October 2007 and December 2014, MANA has made 121 International Patent registrations.

Note: PCT: Patent Cooperation Treaty EPC: European Patent Convention

No.	Date of Registration	Country	*Name of Invention*	Registration Number
122	2015 Apr 8	EPC, France, Germany	*Ferromagnetic tunnel junction structure, and magnetoresistive effect element and spintronics device each comprising same*	2421063
123	2015 Apr 9	Germany	*Gene detection field-effect device and method of analyzing gene polymorphism therewith*	112005000293
124	2015 Apr 21	US	*Method of producing silicon carbide*	9011811
125	2015 Apr 21	US	*Photocatalytic film, method for forming photocatalytic film and photocatalytic film coated product*	9012354
126	2015 Apr 28	Korea	*Dielectric thin film, dielectric thin film element, and thin film capacitor*	1517532
127	2015 May 13	EPC, France, Germany, UK	*Method of controlling degradation time of a biodegradable device*	1997522
128	2015 Jun 16	US	*Luminescent nanosheets*	9057022
129	2015 Jun 17	EPC, Germany	*Device for forming artificial opal membrane and method for forming artificial opal membrane*	2259100
130	2015 Jun 24	China	*Fabrication method and structure of electrode for organic device*	ZL201080053634.3
131	2015 Jul 7	US	*Substrate for surface enhanced Raman spectroscopy analysis and manufacturing method of the same, biosensor using the same, and microfluidic device using the same*	9074938
132	2015 Jul 14	US	*High dielectric nanosheet laminate, high dielectric element and method for producing the same*	9082551
133	2015 Jul 15	EPC, France, Germany	*Colloidal crystal and method and device for manufacturing colloidal crystal gel*	1647843
134	2015 Oct 12	Korea	*Mg-based alloy*	1561147
135	2015 Oct 13	US	*Magnesium-based medical device and manufacturing method thereof*	9155816
136	2015 Oct 21	China	*Polymer fiber, production method for same, and production device*	ZL201180023013.5
137	2015 Nov 16	Korea	*Method of producing silicon carbide*	1570878
138	2015 Nov 18	EPC, Germany, UK	*Mg-based alloy*	2157201
139	2015 Nov 25	China	*All-solid-state lithium battery*	ZL201180017128.3
140	2015 Dec 12	EPC, France, Germany, UK	*Method of controlling average pore diameter of porous material containing apatite/collagen composite fiber*	1743661
141	2016 Jan 6	EPC, Germany	*Sensing device and biosensor*	2518482
142	2016 Jan 12	Canada	*All-solid battery*	2745379
143	2016 Jan 27	EPC, France, Germany	*Iron-containing superconductive substance*	2361879
144	2016 Feb 17	China	*Hydrogen generating material, method for producing same, method for producing hydrogen, and apparatus for producing hydrogen*	ZL201080022074.5
145	2016 Mar 31	Korea	*Ferroelectric thin film having superlattice structure, manufacturing method thereof, ferroelectric element, and manufacturing method thereof*	1609596
146	2016 Apr 26	US	*Dielectric thin film, dielectric thin film element and thin film capacitor*	9324497
147	2016 Apr 29	Korea	*Semiconductor device and manufacturing method therefor*	1618910
148	2016 May 17	US	*Method for producing a recombinant protein using a cell line adapted to a protein-free and lipid-free medium*	9340814
149	2016 Jun 8	EPC, France, Germany, UK	*Luminescent nanosheet, fluorescent device, solar cell and color display using the same, and nanosheet coating*	2308947
150	2016 Jun 29	EPC, France, Germany	*Nanoparticle-containing polymer nanowire and method for producing same*	2792717
151	2016 Jul 13	EPC, Germany	*Phenylboronic acid monomer and phenylboronic acid polymer*	2522679
152	2016 Aug 3	France, Germany	*Use of a composite oxide as a visible light responsive photocatalyst and method for decomposition and removal of harmful chemical material using the same*	1724014
153	2016 Sep 1	Taiwan	*Electrochemical transistor*	I548088

Appendix 7.9: International Cooperation

List of MOU agreements of MANA with overseas institutions signed between October 2007 and March 2017:

No.	Organization, **Country** Signed (Expired, Replaced)	No.	Organization, **Country** Signed (Expired, Replaced)
1	Kent State University, Department of Chemistry, **USA** Signed: 2008 Jan 10 (Expired: 2013 Jan 10)	21	Friedrich-Alexander University, Erlangen-Nürnberg, **Germany** Signed: 2010 Jun 21 (Expired: 2015 Jun 21)
2	Rensselaer Polytechnic Institute, Chemistry and Biological Engineering, **USA** Signed: 2008 Feb 28 (Expired: 2013 Feb 28)	22	Fudan University, Department of Materials Science, **China** Signed: 2010 Jul 23 (Expired: 2015 Jul 23)
3	University of California, Los Angeles (UCLA), **USA** Signed: 2008 Mar 24 (Expired: 2013 Mar 24)	23	EWHA Womans University Seoul, Department of Chemistry and Nanoscience, **Korea** Signed: 2010 Aug 27 (Expired: 2015 Aug 27)
4	Georgia Institute of Technology (GIT), Center for Nanostructure Characterization, **USA** Signed: 2008 May 6 (Expired: 2013 May 6)	24	Karlsruhe Institute of Technology, **Germany** Signed: 2010 Sep 16 (Expired: 2015 Sep 16)
5	CNRS, Centre d'élaboration de matériaux et d'études structurales (CEMES), **France** Signed: 2008 May 30 (Expired: 2013 May 30)	25	Univesité de la Méditerranée, Marseille, **France** Signed: 2010 Sep 20 (Expired: 2015 Sep 20)
6	University of Cambridge, Nanoscience Centre, **UK** Signed: 2008 Jun 20 (Expired: 2013 Jun 20)	26	Anhui Key Laboratory of Nanomaterials and Nanostructures, **China** Signed: 2010 Oct 6 (Expired: 2015 Oct 6)
7	Indian Institute of Chemical Technology (IICT), **India** Signed: 2008 Jul 3 (Expired: 2013 Jul 3)	27	Multidisciplinary Center for Development of Ceramic Materials, **Brazil** Signed: 2010 Oct 26 (Expired: 2015 Oct 26)
8	University of Basel, Institute of Physics, National Center of Competence for Nanoscale Science, **Switzerland** Signed: 2008 Jul 20 (Expired: 2013 Jul 20)	28	Vietnam National University Ho Chi Minh City, **Vietnam** Signed: 2011 Jan 24 (Expired: 2016 Jan 24)
9	Yonsei University, Seoul, **Korea** Signed: 2008 Sep 1 (Expired: 2013 Sep 1)	29	King Saud University, **Saudi Arabia** Signed: 2011 Jan 25 (Expired: 2016 Jan 25)
10	Indian Institute of Science, Education and Research, **India** Signed: 2008 Dec 19 (Expired: 2013 Dec 19)	30	LMPG, Grenoble, **France** Signed: 2011 Feb 1 (Expired: 2016 Feb 1)
11	University of Karlsruhe, Institute for Inorganic Chemistry, Supramolecular Chemistry Group, **Germany** Signed: 2009 Jan 29 (Expired: 2014 Jan 29)	31	Université de Montréal (UdeM), **Canada** Signed: 2011 Jul 4 (Expired: 2016 Jul 4)
12	Fudan University, Department of Chemistry, New Energy and Materials Laboratory (NEML), **China** Signed: 2009 Mar 16 (Expired: 2014 Mar 16)	32	Flinders University, **Australia** Signed: 2011 Jul 19 (Expired: 2016 Jul 19)
13	Indian Institute of Technology Madras, National Centre for Catalysis Research (NCCR), **India** Signed: 2009 Apr 5 (Expired: 2014 Apr 5)	33	University of Melbourne, **Australia** Signed: 2011 Sep 21 (Expired: 2016 Sep 21)
14	University of Cologne, Institute of Inorganic Chemistry, Inorganic and Materials Chemistry, **Germany** Signed: 2009 May 28 (Expired: 2014 May 28)	34	Shanghai Institute of Ceramics, **China** Signed: 2011 Dec 1 (Expired: 2016 Dec 1)
15	École Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering, **Switzerland** Signed: 2009 Jul 20 (Expired: 2014 Jul 20)	35	Tsinghua University, **China** Signed: 2012 Jan 28 (Expired: 2017 Jan 28)
16	University of Rome Tor Vergata, Center for Nanoscience & Nanotechnology & Innovative Instrumentation (NAST), **Italy** Signed: 2009 Jul 30 (Expired: 2014 Jul 30)	36	Hanoi University of Science and Technology (HUST), **Vietnam** Signed: 2012 Feb 7 (Expired: 2017 Feb 7)
17	University of Heidelberg, Kirchhoff Institute of Physics, **Germany** Signed: 2009 Aug 31 (Expired: 2014 Aug 31)	37	University of Sao Paolo, **Brazil** Signed: 2012 Apr 25
18	Loughborough University, **UK** Signed: 2009 Oct 28 (Expired: 2014 Oct 28)	38	University College London (UCL), **UK** Signed: 2012 Oct 8
19	Lawrence Berkeley National Laboratory (LBNL), **USA** Signed: 2010 Feb 9 (Expired: 2015 Feb 9)	39	Kyungpook National University, **Korea** Signed: 2013 Jan 18 (Replaced on 2014 Sep 27)
20	University of Valenciennes, **France** Signed: 2010 May 20 (Expired: 2015 May 20)	40	Centre Interdisciplinaire de Nanoscience de Marseille (CINaM-CNRS), **France** Signed: 2013 May 2
		41	National Center for Nanoscience and Technology (NCNST), Beijing, **China** Signed: 2013 Jun 24
		42	Huazhong University of Science and Technology (HUST), **China** Signed: 2013 Jul 29

No.	Organization, **Country** Signed (Expired, Replaced)	No.	Organization, **Country** Signed (Expired, Replaced)
43	Georgia Institute of Technology (GIT), Center for Nanostructure Characterization, **USA** (Renewal) Signed: 2013 Nov 25	54	Paul Drude Institute for Solid State Electronics (PDI), **Germany** Signed: 2015 May 29
		55	National Cheng Kung University (CKU), **Taiwan** Signed: 2015 May 30
44	CNRS, Centre d'élaboration de matériaux et d'études structurales (CEMES), **France** (Renewal) Signed: 2013 Dec 10	56	University of Washington (UW), **USA** Signed: 2015 Sep 15
45	St. Petersburg State Electrotechnical University (LETI), **Russia** Signed: 2014 Feb 28	57	University of Science and Technology of Hanoi (USTH), **Vietnam** Signed: 2015 Sep 24
46	University of Bristol, Bristol Centre for Nanoscience and Quantum Information (NSQI), **UK** Signed: 2014 Mar 7	58	University of Wollongong (UOW), **Australia** Signed: 2015 Sep 29
47	University of California Los Angeles (UCLA), The California NanoSystems Institute (CNSI), **USA** (Renewal) Signed: 2014 Sep 8	59	University of Chemistry and Technology (UCT), **Czech Republic** Signed: 2016 Jan 18
48	Donostia International Physics Center (DIPC), San Sebastian, **Spain** Signed: 2014 Sep 9	60	University of Sydney, **Australia** Signed: 2016 Feb 16
49	Kyungpook National University, **Korea** (Replacement of MOU signed on 2013 Jan 18) Signed: 2014 Sep 27	61	University of Messina, **Italy** Signed: 2016 Jun 30
50	University of Eastern Finland, **Finland** Signed: 2014 Dec 31	62	MacDiarmid Institute for Advanced Materials and Nanotechnology, **New Zealand** Signed: 2016 Aug 18
51	Indian Institute of Science (IISc), Bangalore, **India** Signed: 2015 Jan 13	63	Vidyasirimedhi Institute of Science and Technology (VISTEC), **Thailand** Signed: 2016 Sep 15
52	University of Toronto, **Canada** Signed: 2015 Jan 21	64	Korea Institute of Science and Technology (KIST), **Korea** Signed: 2016 Sep 21
53	Chongqing University of Science & Technology (CQUST), **China** Signed: 2015 May 15	65	Saigon High Tech Park (SHTP Labs), **Vietnam** Signed: 2016 Oct 17
		66	Queensland University of Technology (QUT), **Australia** Signed: 2016 Nov 25

Appendix 7.10: MANA History

MANA History between October 2007 and March 2017:

Fiscal Year 2007

Date	Event
2007 Sep 12	NIMS with the project called "International Center for Materials Nanoarchitectonics (MANA)" has been selected to participate as one of five institutions in the World Premier International (WPI) Research Center Initiative, a program sponsored by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)
2007 Oct 1	Official Inauguration of MANA
2007 Oct 18	The Launching Ceremony of MANA was held at Okura Frontier Hotel, Tsukuba
2008 Jan 10	MANA signed a Memorandum of Understanding (MOU) with Kent State University, USA
2008 Feb 1	Launch of the new MANA Website in English
2008 Feb 7	The 1st MANA Seminar entitled "Nanotechnology, a Key to Sustainability" was given by Dr. Heinrich Rohrer (Nobel Laureate in Physics 1986 and MANA Advisor)
2008 Feb 28	MANA signed a Memorandum of Understanding (MOU) with Rensselaer Polytechnic Institute, USA
2008 Mar 10-13	The 1st MANA International Symposium was held in Tsukuba
2008 Mar 12	1st MANA Evaluation Committee Meeting
2008 Mar 24	MANA signed a Memorandum of Understanding (MOU) with University of California, Los Angeles (UCLA), USA

Fiscal Year 2008

Date	Event
2008 Apr 1	Start of ICYS-MANA Program
2008 Apr 16	1st MANA Site Visit by the WPI Program Committee
2008 May 6	MANA signed a Memorandum of Understanding (MOU) with Georgia Institute of Technology (GIT), USA
2008 May 7	MANA Independent Scientist Ajayan Vinu received the Asian Excellent Young researcher Lectureship Award 2008 by the Chemical Society of Japan
2008 May 20	1st Follow-up Meeting by the WPI Follow-Up Committee
2008 May 30	MANA signed a Memorandum of Understanding (MOU) with CNRS, France
2008 Jun 2	NIMS Overseas Operation Office opened at the University of Washington, USA
2008 Jun 20	MANA signed a Memorandum of Understanding (MOU) with University of Cambridge, UK
2008 Jul 3	MANA signed a Memorandum of Understanding (MOU) with Indian Institute of Technology (IICT), Hyderabad, India
2008 Jul 9	MANA Principal Investigator Kenji Kitamura received the "Inoue Harushige Prize" given by the Japan Science and Technology Agency
2008 Jul 16	MANA Principal Investigator Takayoshi Sasaki and MANA Scientist Minoru Osada received the "2008 Tsukuba Prize"
2008 Jul 19	Prof. Sir Harry W. Kroto visited MANA
2008 Jul 20	MANA signed a Memorandum of Understanding (MOU) with University of Basel, Switzerland
2008 Jul 28 – Aug 1	The 5th NIMS-IRC-UCLA Nanotechnology Summer School was held at NIMS
2008 Sep 1	MANA signed a Memorandum of Understanding (MOU) with Yonsei University, Seoul, Korea
2008 Sep 11	MANA Principal Investigator Kohei Uosaki was named "International Society of Electrochemistry Fellow"
2008 Sep 25	MANA Independent Scientist Masayoshi Higuchi received the "SPSJ Hitachi Chemical Award" given by the Society of Polymer Science, Japan (SPSJ)
2008 Oct 1	Celebration of 1st Anniversary of MANA. Organizational Reform of MANA
2008 Oct 6	MANA Chief Operating Officer Yoshio Bando was named "American Ceramic Society Fellow"
2008 Nov 27-28	2nd MANA Site Visit by the WPI Program Committee
2008 Dec 11	MANA activities were introduced in the NHK Program "Ohayou Nippon (Good Morning Japan)"
2008 Dec 13	MANA Independent Scientist Alexei Belik and ICYS-MANA Researcher Pavuluri Srinivasu received the "Encouragement of Research in Materials Science Award" given by the Materials Research Society of Japan
2008 Dec 19	MANA signed a Memorandum of Understanding (MOU) with Indian Institute of Science, Education and Research, India
2009 Jan 29	MANA signed a Memorandum of Understanding (MOU) with University of Karlsruhe, Germany
2009 Feb 25-27	The 2nd MANA International Symposium was held in Tsukuba

Date	Event
2009 Mar 16	MANA signed a Memorandum of Understanding (MOU) with Fudan University, China
2009 Mar 17	2nd Follow-up Meeting by the WPI Follow-Up Committee
2009 Mar 28	MANA Independent Scientist Ajayan Vinu received the "CSJ Award for Young Chemists" given by the Chemical Society of Japan

Fiscal Year 2009

Date	Event
2009 Apr 5	MANA signed a Memorandum of Understanding (MOU) with Indian Institute of Technology, Madras, India
2009 Apr 14	MANA Scientist Minoru Osada received the "Young Scientists' Prize" given by the Minister of Education, Culture, Sports, Science and Technology (MEXT)
2009 May 8	MANA Principal Investigator Kazuhiro Hono received the "2009 Honda Frontier Award" given by the Honda Memorial Foundation
2009 May 19	MANA Satellite Principal Investigator James K. Gimzewski was elected as "Fellow of the Royal Society"
2009 May 28	MANA signed a Memorandum of Understanding (MOU) with University of Cologne, Germany
2009 Jun 15-17	The 8th Japan-France Workshop on Nanomaterials held at NIMS
2009 Jul 3	The 1st MANA-NSC Joint Workshop on Fusion of Nanotechnology and Bioscience was held at the MANA Satellite at University of Cambridge, UK
2009 Jul 14	A delegation from U.S. Department of Energy (DOE) and U.S. Department of Defense (DOD) visited MANA
2009 Jul 20	MANA signed a Memorandum of Understanding (MOU) with EPFL, Switzerland
2009 Jul 30	MANA signed a Memorandum of Understanding (MOU) with University of Rome Tor Vergata, Italy
2009 Jul 27-31	The 6th MANA-NSC-CNSI Nanotechnology Students' Summer School was held at the UCLA MANA Satellite, Los Angeles, USA
2009 Aug 31	MANA signed a Memorandum of Understanding (MOU) with University of Heidelberg, Germany
2009 Sep 20-22	XJTU-NIMS/MANA Workshop on Materials Science 2009 was held at Xi'an Jiaotong University, China
2009 Sep 25	MANA Independent Scientist Jun Nakanishi received the "Japan Society for Analytical Chemistry Award for Younger Researchers"
2009 Sep 29	MANA Scientist Kohsaku Kawakami received the "JSCTA Award for Young Scientists" given by the Japan Society of Calorimetry and Thermal Analysis
2009 Oct 2	Prof. Svante Lindqvist, Nobel Museum Director and Chair at the Royal Institute of Technology, Stockholm, visited MANA
2009 Oct 5	MANA Principal Investigator Kohei Uosaki received the "ECS Fellow Award" given by the Electrochemical Society
2009 Oct 9	Prof. Sir Harry W. Kroto visited MANA for one-on-one meetings with young scientists
2009 Oct 10-12	Tsukuba-Shinchu Bilateral Symposium on "Advanced Materials Science and Technology" was held at National Tsing Hua University, Taiwan
2009 Oct 13	MANA-URTV Joint Workshop on Nanostructured Materials for Sustainable Development was held at University Rome Tor Vergata, Italy
2009 Oct 13-14	The 1st MANA-CEMES Joint Workshop on Fusion of Theory and Experiment was held at the MANA Satellite in CNRS Toulouse, France
2009 Oct 26	MANA Principal Investigator Naoki Ohashi received the "Richard M. Fulrath Award" given by the American Ceramics Society
2009 Oct 28	MANA signed a Memorandum of Understanding (MOU) with Loughborough University, UK
2009 Nov 10	Nanjing University-Anhui Normal University-Hokkaido University-MANA Joint Symposium was held at Nanjing University, China
2009 Dec 2	MANA Independent Scientist Ajayan Vinu received the "ICSB Award of Excellence" given by the Indian Scociety of Chemists and Biologists
2009 Dec 10	The Osaka University-MANA/NIMS Joint Symposium on "Advanced Structural and Functional Materials Design" was held at Osaka University
2009 Dec 18	Visit of the MANA Satellite at UCLA by WPI Program Director, Prof. Toshio Kuroki
2010 Jan 7-8	3rd MANA Site Visit by the WPI Program Committee
2010 Jan 14	The 1st NIMS/MANA-Waseda University Joint Symposium on "Advanced Materials Designed at Nano- and Meso-scales toward Practical Chemical Wisdom" was held at Waseda University
2010 Jan 31	MANA Satellite Principal Investigator James Gimzewski was featured in the NHK's satellite TV program "The proposal for the future (mirai-e-no teigen)"
2010 Feb 4	MANA Satellite Principal Investigator James Gimzewski was featured in the NHK's satellite TV program "The proposal for the future (mirai-e-no teigen)"
2010 Feb 4	MANA Independent Scientist Yusuke Yamauchi received "Inoue Research Aid for Young Scientists"
2010 Feb 9	MANA signed a Memorandum of Understanding (MOU) with Lawrence Berkeley National Laboratory (LBNL), USA
2010 Feb 16	MANA Principal Investigator Takayoshi Sasaki ranked as the 18th most-prolific author in the high quality journal "Chemistry of Materials" (Impact Factor 5.046)
2010 Mar 3	MANA Independent Scientist Masayoshi Higuchi received the "Marubun Academy Award"

Date	Event
2010 Mar 3-5	The 3rd MANA International Symposium was held in Tsukuba
2010 Mar 5	2nd MANA Evaluation Committee Meeting
2010 Mar 21	MANA Scientist Masanori Kohno received the “Young Scientist Award” given by the Physical Society of Japan (PSJ)
2010 Mar 24-26	The Workshop on “Materials Nanoarchitectonics for Sustainable Development” as a part of the “Invitation Program for Advanced Research Institutions in Japan” sponsored by the Japan Society for the Promotion of Science (JSPS), was held in Gora, Hakone, Japan
2010 Mar 27	MANA Principal Investigator Kohei Uosaki received the “Chemical Society of Japan Award”

Fiscal Year 2010

Date	Event
2010 Apr 1	MANA Principal Investigator Tsuyoshi Hasegawa and MANA Scientist Kazuya Terabe received the “NIMS President’s Research Achievement Award”
2010 Apr 1	MANA Independent Scientist Yusuke Yamauchi received the “Ceramic Society of Japan Award”
2010 Apr 13	MANA Independent Scientist Katsunori Wakabayashi received the “Young Scientists’ Prize” given by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)
2010 May 20	MANA signed a Memorandum of Understanding (MOU) with University of Valenciennes, France
2010 May 25	ICYS-MANA Researcher Yoshihiro Tsujimoto received the “Research Progress Award” given by the Japan Society of Powder and Powder Metallurgy (JSPM)
2010 Jun 14-15	The joint IBM and NIMS/MANA symposium on “Characterization and manipulation at the atomic scale” was held in Tsukuba
2010 Jun 21	MANA signed a Memorandum of Understanding (MOU) with Friedrich-Alexander University Erlangen-Nürnberg, Germany
2010 Jul 14	3rd Follow-up Meeting by the WPI Follow-Up Committee
2010 Jul 23	MANA signed a Memorandum of Understanding (MOU) with Fudan University, China
2010 Aug 9	Research results of MANA Independent Scientist Ajayan Vinu on “a new fabrication of gold nanoparticles by self-assembly of nanoporous materials” were reported in Nikkei Online
2010 Aug 18	MANA received a high appraisal from the WPI program committee for the activity in Fiscal Year 2009
2010 Aug 25	Three research subjects proposed by MANA researchers were selected for funding from Core Research of Evolutional Science & Technology (CREST) and Precursory Research for Embryonic Science and Technology (PRESTO) by the Japan Science and Technology Agency
2010 Aug 27	MANA signed a Memorandum of Understanding (MOU) with EWHA Womans University Seoul, Korea
2010 Aug 27	The 1st NIMS-EWHA workshop on “ Advanced Functional Materials” (NEWAM-10) was held in Tsukuba
2010 Sep 9	MANA Principal Investigator Kohei Uosaki received the “Japanese Photochemistry Association Lectureship Award 2010”
2010 Sep 16	MANA signed a Memorandum of Understanding (MOU) with Karlsruhe Institute of Technology, Germany
2010 Sep 20	MANA signed a Memorandum of Understanding (MOU) with Université de la Méditerrannée, Marseille, France
2010 Oct 6	MANA signed a Memorandum of Understanding (MOU) with Anhui Key Laboratory of Nanomaterials and Nanostructures, China
2010 Oct 11	Research results of the Traversa Group (MANA) on “Micro-Solid Oxide Fuel Cells” was introduced on Sankei News and Nikkei Online
2010 Oct 22	Research results on the “Development of an Exhaust Gas Catalyst” by MANA Principal Investigator Katsuhiko Ariga and Hideki Abe (NIMS Advanced Electronic Materials Center) were introduced in Nikkei Online
2010 Oct 26	MANA signed a Memorandum of Understanding (MOU) with Multidisciplinary Center for Development of Ceramic Materials, Brazil
2010 Oct 28	The 1st MANA Science Café “Melting Pot Club” on “What is nanotechnology?” was held at Frontier Hotel Okura, Tsukuba
2010 Nov 11	Outreach activities of MANA were featured in the NHK program “Ohayou Nippon (Good Morning Japan)
2010 Nov 11	MANA Independent Scientist Ajayan Vinu has been selected as the recipient of the prestigious “Friedrich Wilhelm Bessel Research Award 2010” given by the Alexander von Humboldt Foundation, and as recipient of the “Catalysis Society of India Award 2010”
2010 Nov 24-26	The 9th Japan-French International Workshop was held in Toulouse, France
2010 Dec 1	The 2nd NIMS/MANA-Waseda University Joint Symposium was held at NIMS
2010 Dec 9	Ms. Kumiko Hayashi, Parliamentary Secretary for Education, Culture, Sports, Science and Technology (MEXT) visited MANA
2010 Dec 15	Mr. Lim Chuan Poh, Chairman, Agency for Science, Technology and Research (A*STAR), Singapore, visited MANA
2010 Dec 21	MANA Director-General Masakazu Aono was selected as a winner of the “2010 Feynman Prize in Nanotechnology” given by Foresight Institute, USA

Date	Event	Date	Event
2011 Jan 1	The researchers MANA Principal Investigator Jinhua Ye and MANA Independent Scientist Yusuke Yamauchi were featured in the NHK Special program “Can Japan Survive?”	2011 Feb 4	Research of MANA Principal Investigator Jinhua Ye was introduced in the NHK Eco Channel
2011 Jan 17	MANA Principal Investigator Katsuhiko Ariga received the “2010 Nice-Step Scientist (NISTEP) Award” by the National Institute of Science and Technology Policy	2011 Feb 6	MANA Principal Investigator Katsuhiko Ariga received the “ISCB Award for Excellence 2011” in the area of Chemical Sciences given by the Indian Society of Chemists and Biologists (ISCB)
2011 Jan 19	The satellite workshop “Dirac Electron Systems 2011” of the workshop “Graphene Workshop in Tsukuba 2011” was held at NIMS Namiki-site	2011 Feb 18	Dr. H.E. Virachai Virameteekul, Minister of Science and Technology, Thailand, visited MANA
2011 Jan 24	MANA signed a Memorandum of Understanding (MOU) with Vietnam National University Ho Chi Minh City, Vietnam	2011 Feb 18	MANA Independent Scientist Masayoshi Higuchi received the “Gottfried Wagener Prize 2010” given by German Innovation Award
2011 Jan 25	MANA signed a Memorandum of Understanding (MOU) with King Saud University, Saudi Arabia	2011 Feb 28	The workshop on “Advanced Functional Nanomaterials” was held in Chennai, India
2011 Jan 27-28	The 1st MANA Grand Challenge Meeting was held in Miura Peninsula, Kanagawa prefecture	2011 Feb 28	Research of MANA Principal Investigator Tsuyoshi Hasegawa was introduced in the NHK English radio program “Japan and World Update”
2011 Jan 29	Mr. Yoichiro Genba, Minister of State for Science and Technology Policy, visited MANA	2011 Mar 2-4	The 4th MANA International Symposium was held in Tsukuba
2011 Feb 1	Launch of the new MANA Website in Japanese	2011 Mar 5	MANA hosted “Prof. Rohrer’s Science Class” for junior high-school students
2011 Feb 1	MANA signed a Memorandum of Understanding (MOU) with LMPG, Grenoble, Fance	2011 Mar 5	Prof. Heinrich Rohrer’s Science Class 2011 was held at NIMS
		2011 Mar 11	MANA was hit by the Great Tohoku-Kanto earthquake

Fiscal Year 2011

Date	Event	Date	Event
2011 Apr 1	Four MANA researchers, MANA Principal Investigator Katsuhiko Ariga, MANA Scientist Emiliana Fabbri, MANA Scientist Daniele Pergolesi and MANA Scientist Tetsushi Taguchi received NIMS President’s Research Awards	2011 Nov 19	MANA Visit of Minister Masaharu Nakagwa (MEXT)
2011 Jun 28-29	4th MANA Site Visit by the WPI Program Committee	2011 Dec 1	MANA signed a Memorandum of Understanding (MOU) with Shanghai Institute of Ceramics, China
2011 Jul 4	MANA signed a Memorandum of Understanding (MOU) with Université de Montréal (UdeM), Canada	2011 Dec 14	MANA was given the grade “A” in the WPI Program Interim Evaluation
2011 Jul 19	MANA signed a Memorandum of Understanding (MOU) with Flinders University, Australia	2011 Dec 17-18	MANA exhibited a booth at “Science Festa in Kyoto 2011”
2011 Sep 5-8	The 7th Japan-UK-USA Nanotechnology Students’ Summer School was held at the MANA Satellite at University of Cambridge, UK	2012 Jan 10	MANA was featured in a special issue of the journal Advanced Materials (IF 10.88) published by John Wiley & Sons, Inc.
2011 Sep 17	MANA hosted “Prof. Kroto’s Science Class 2011” for preliminary school students and their parents	2012 Jan 23	MANA Satellite Principal Investigator Françoise Winnik won the 2012 Macromolecular Science and Engineering Award of the Chemical Institute of Canada (CIC)
2011 Sep 21	MANA signed a Memorandum of Understanding (MOU) with University of Melbourne, Australia	2012 Jan 28	MANA signed a Memorandum of Understanding (MOU) with Tsinghua University, China
2011 Oct 7	The Osaka University-MANA/NIMS Joint Symposium on “Advanced Structural and Functional Materials Design” was held at Osaka University	2012 Feb 7	MANA signed a Memorandum of Understanding (MOU) with Hanoi University of Science and Technology, Vietnam
2011 Oct 19	4th Follow-up Meeting by the WPI Follow-Up Committee	2012 Feb 8	MANA Principal Investigator Takayoshi Sasaki received the “29th CSJ Academic Prize” given by the Chemical Society of Japan (CSJ)
2011 Oct 31	The NIMS/MANA-Flinders University Joint Symposium on “Nanoscience and Nanotechnology” was held at NIMS	2012 Feb 14	MANA Chief Operating Officer Yoshio Bando and MANA Principal Investigator Dmitri Golberg received the “3rd Thomson Reuters Research Front Award”
2011 Nov 1	The 3rd NIMS/MANA-Waseda University Joint Symposium was held at Waseda University	2012 Feb 16-20	MANA participated in the WPI Joint Exhibition at the 2012 AAAS Annual Meeting in Vancouver, Canada

Date	Event	Date	Event
2012 Feb 29 – Mar 2	The 5th MANA International Symposium was held in Tsukuba	2012 Mar 2	3rd MANA Evaluation Committee Meeting

Fiscal Year 2012

Date	Event
2012 Apr 2	MANA Associate Principal Investigator Minoru Osada received the "7th NIMS President's Research Encouragement Awarad"
2012 Apr 14	MANA Independent Scientist Satoshi Tominaka received the "Funai Research Incentive Award" given by the Funai Foundation for Information Technology
2012 Apr 25	MANA signed a Memorandum of Understanding (MOU) with University of Sao Paolo, Brazil
2012 Apr 26-27	The 2nd MANA Grand Challenge Meeting was held in Nasu, Tochigi prefecture
2012 May 7	The MANA Second-term Kickoff Meeting was held at NIMS
2012 May 10	The Australia/MANA joint workshop on "Nanoarchitectonics for Innovative Materials & Systems" was held at NIMS
2012 Jul 5	Commemorative Ceremony for the Completion of the new NanoGREEN/WPI-MANA Building
2012 Jul 19	The 1st UdeM-MANA Workshop on "Nano-Life" was held in Montreal, Canada
2012 Jul 25	MANA Independent Scientist Yusuke Yamauchi received the "Tsukuba Encouragement Prize"
2012 Aug 21-22	5th MANA Site Visit by the WPI Program Committee
2012 Aug 27-31	The 8th MANA-Cambridge/UCL-UCLA Nanotechnology Summer School was held at MANA
2012 Sep 5	Prof. Chung-Yuan Mou, Deputy Minister of the National Science Council, Taiwan, visited MANA
2012 Sep 28	MANA Principal Investigator Omar M. Yaghi was featured in Science, volume 337, in the column "Satellite Labs Extend Science".
2012 Oct 1	The PCCP-MANA Symposium on "Nanotechnology, Materials and Physical Chemistry" was held at NIMS
2012 Oct 3	The MANA 5th Anniversary Memorial Symposium was held at NIMS
2012 Oct 8	MANA signed a Memorandum of Understanding (MOU) with University College London (UCL), UK
2012 Oct 9	MANA Satellite Principal Investigator Zhong Lin Wang was awarded the ACerS Edward Orton, Jr. Memorial Lecture by the American Ceramic Society
2012 Oct 24	5th Follow-up Meeting by the WPI Follow-Up Committee
2012 Nov 7	The NSQI-MANA Joint Symposium was held at NIMS
2012 Nov 12-13	The 3rd MANA Grand Challenge Meeting (for young researchers) was held at Miura Peninsula, Kanagawa prefecture
2012 Nov 24	The 2nd WPI Joint Symposium: Inspiring Insights into Pioneering Scientific Research was held in Tsukuba
2012 Dec 17	MANA Principal Investigator Kazuhito Tsukagoshi received the 9th JSPS Prize from the Japan Society for the Promotion of Science
2013 Jan 18	MANA signed a Memorandum of Understanding (MOU) with Kyungpook National University, Korea
2013 Jan 29-30	The 2nd Canada-Japan Nanotechnology Workshop was held at Tokyo Big Sight.
2013 Feb 14-18	MANA participated in the WPI Joint Exhibition at the 2013 AAAS Annual Meeting in Boston, USA
2013 Feb 27 – Mar 1	The 6th MANA International Symposium was held in Tsukuba
2013 Mar 11	The 4th NIMS/MANA-Waseda University International Joint Symposium was held at NIMS
2013 Mar 18	The Osaka University-NIMS/MANA Joint Symposium on "Advanced Structural and Functional Materials Design" was held at MANA
2013 Mar 19	The International Symposium MASA 2013 on "Material Architectonics for Sustainable Action" was held at MANA

Fiscal Year 2013

Date	Event
2013 Apr 2	MANA Independent Scientist Yusuke Yamauchi received the 7th PCCP Prize 2013
2013 Apr 5	MANA Principal Investigator Katsuhiko Ariga has been admitted as a Fellow of the Royal Society of Chemistry
2013 Apr 16	MEXT Commendations for Science and Technology for FY2013 have been awarded to 3 MANA researchers: Principal Investigator Takayoshi Sasaki (Science and Technology Prize for Research), Independent Scientist Alexei A. Belik (Young Scientist's Prize) and Independent Scientist Yusuke Yamauchi (Young Scientist's Prize)
2013 May 2	MANA signed a Memorandum of Understanding (MOU) with Centre Interdisciplinaire de Nanoscience de Marseille (CINaM-CNRS), France
2013 May 16	MANA Advisor, Dr. Heinrich Rohrer (Nobel Laureate in Physics 1986) passed away
2013 May 29	MANA Satellite Principal Investigator Francoise M. Winnik received the Society of Polymer Science Japan (SPSJ)'s International Award 2013
2013 Jun 24	MANA signed a Memorandum of Understanding (MOU) with National Center for Nanoscience and Technology (NCNST), Beijing, China
2013 Jun 28	Research of MANA Scientist Mitsuhiro Ebara has been featured in Japanese television (Yajiuma TV, TV Asahi)
2013 Jun 28-29	The International Workshop on "Thermoelectric Research & Thermal Management Technology" was held at MANA
2013 Jul 16	Research of MANA Scientist Mitsuhiro Ebara has been featured in the program "Ohayo-Nippon" of Japanese NHK General TV
2013 Jul 29	MANA signed a Memorandum of Understanding (MOU) with Huazhong University of Science and Technology (HUST), China
2013 Aug 6-8	MANA participated in the "Summer Science Camp" for high school students
2013 Aug 19-20	6th MANA Site Visit by the WPI Program Committee
2013 Sep 3	Independent Scientist Genki Yoshikawa from MANA received a Tsukuba Encouragement Prize 2013
2013 Oct 9-11	The Swiss-Japanese Nanoscience Workshop on "Materials Phenomena at Small Scale" was held at MANA
2013 Oct 29	6th Follow-up Meeting by the WPI Follow-Up Committee
2013 Nov 7	MANA Director-General Masakazu Aono won the Nanoscience Prize 2013
2013 Nov 9-10	MANA represented by MANA's Smart Biomaterials Group participated in the event "Science Agora 2013" held at Odaiba, Tokyo
2013 Nov 25	MANA Principal Investigator Katsuhiko Ariga presented a lecture at Takezono Higashi Junior High School in Tsukuba within the "Science Q lectures" sponsored by the Tsukuba-Science City Network
2013 Dec 20	MANA Independent Scientist Yusuke Yamauchi received a Chemical Society of Japan (CSJ) Award for Young Chemists FY2013
2014 Jan 29-31	The first edition of the TNT Japan (Trends in Nanotechnology) conference was held at Tokyo Big Sight with a "MANA Day" on January 30
2014 Jan 29-31	An exhibition of research results obtained by MANA Scientist Mitsuhiro Ebara, was awarded the Project Prize at the 13th nano tech International Nanotechnology Exhibition & Conference (nano tech 2014)
2014 Feb 28	MANA signed a Memorandum of Understanding (MOU) with St. Petersburg State Electrotechnical University (LETI), Russia
2014 Mar 3-4	The MANA/ICYS Reunion Workshop was held at MANA
2014 Mar 5-7	The 7th MANA International Symposium was held in Tsukuba
2014 Mar 7	MANA signed a Memorandum of Understanding (MOU) with University of Bristol, Bristol Centre for Nanoscience and Quantum Information (NSQI), UK
2014 Mar 11-12	The Japan-Taiwan Joint Workshop on "Nanospace Materials" was held at Fukuoka Institute of Technology
2014 Mar 24	The 5th NIMS/MANA-Waseda University Joint Symposium was held at NIMS
2014 Mar 24-25	The International Symposium on Smart Biomaterials was held at MANA
2014 Mar 27	MANA Independent Scientist Takako Konoike was awarded the 8th (2014) Young Scientist Award of the Physical Society of Japan
2014 March 29	MANA Scientist Lok Kumar Shrestha received the Distinguished Lectureship Award of the Chemical Society of Japan (CSJ) Asian International Symposium

Fiscal Year 2014

Date	Event
2014 Apr 1-2	The International Workshop *Topology in the New Frontiers of Materials Science* was held at MANA
2014 Apr 11	A MANA scientific art picture entitled “Rainbow Cube” by two MANA Scientists, Lok Kumar Shrestha and Jonathan Hill, received the Award for Excellence at the 8th “Beauty in Science Technology Panel exhibition” organized by the Japan Science and Technology Agency (JST)
2014 May 12	MANA Principal Investigator Dmitri Golberg was awarded the 59th JSM Seto Prize of the Japanese Society of Microscopy
2014 May 26	MANA Principal Investigator Kohei Uosaki was awarded the 18th Surface Science Society of Japan Prize
2014 Jun 18	Thomson Reuters announced the “ISI Highly cited researchers 2014,” whose number of citations is in the top 1% of a certain research field. This elite group contains 5 Principal Investigators from MANA:: Katsuhiko Ariga, Yoshio Bando, Dmitri Golberg, Zhong-Lin Wang and Prof. Omar Yaghi
2014 Jun 22-26	The 12th International Workshop on Beam Injection Assessment of Microstructures in Semiconductors (BIAMS 12) was held at MANA
2014 Jul 18	The International Symposium on Material Architectonics for Sustainable Action (MASA 2014) was held at MANA
2014 Sep 1-2	7th MANA Site Visit by the WPI Program Committee
2014 Sep 9	MANA signed a Memorandum of Understanding (MOU) with Donostia International Physics Center (DIPC), San Sebastian, Spain
2014 Sep 17	MANA Principal Investigator Kazuhito Tsujagoshi and MANA Research Associate Katsuyoshi Komatsu received the “Paper Award 2014” by the Japan Society for Applied Physics (JSAP)
2014 Oct 24	A talk by MANA Principal Investigator Katsuhiko Ariga where he explained about *Nanoarchitectonics* has been broadcasted in Radio Tsukuba
2014 Nov 19	7th Follow-up Meeting by the WPI Follow-Up Committee
2014 Nov 26-28	The 2nd International Symposium on the Functionality of Organized Nanostructures (FON’14) was held at the National Museum of Emerging Science and Innovation in Odaiba, Tokyo
2014 Dec 31	MANA signed a Memorandum of Understanding (MOU) with University of Eastern Finland, Finland
2015 Jan 13	MANA signed a Memorandum of Understanding (MOU) with Indian Institute of Science (IISc), Bangalore, India
2015 Jan 28-30	An exhibition of research results obtained by MANA Independent Scientist Genki Yoshikawa was awarded the Project Prize at the 14th nano tech International Nanotechnology Exhibition & Conference (nano tech 2015)
2015 Jan 21	MANA signed a Memorandum of Understanding (MOU) with University of Toronto, Canada
2015 Jan 30	MANA Principal Investigator Guoping Chen has been admitted as a Fellow of the Royal Society of Chemistry
2015 Feb 25-26	The 4th MANA Grand Challenge Meeting was held in Nasu, Tochigi prefecture
2015 Mar 9	MANA Scientist Satoshi Ishii received the Konica Minolta Imaging Science Encouragement Award for FY2014
2015 Mar 11-13	The 8th MANA International Symposium was held in Tsukuba
2015 Mar 13	4th MANA Evaluation Committee Meeting
2015 Mar 18	MANA Scientist Jin Kawakita received the Japan Institute of Metals and Materials Meritorious Award
2015 Mar 31	MANA Scientist Mitsuhiro Ebara received the Silver Award of the Tanaka Precious Metals’ 2014 “Precious Metals Research Grants”

Fiscal Year 2015

Date	Event
2015 May 15	MANA signed a Memorandum of Understanding (MOU) with Chongqing University of Science & Technology (CQUST), China
2015 May 29	MANA signed a Memorandum of Understanding (MOU) with Paul Drude Institute for Solid State Electronics (PDI), Germany
2015 May 30	MANA signed a Memorandum of Understanding (MOU) with National Cheng Kung University (CKU), Taiwan
2015 Jun 29 – Jul 3	The 9h Nanotechnology Summer School with students from Japan, Canada, US, Australia, and France was held at MANA
2015 June 30	Group Leader Yoshitaka Tateyama received the “German Innovation Award - Gottfried Wagener 2015”
2015 July 4	MANA Scientist Satoshi Ishii received the Ando Incentive Prize for the Study of Electronics 2015
2015 Jul 29	The 6th NIMS/MANA-Waseda University Joint Symposium was held at Waseda University
2015 Jul 29-30	The 1st International Symposium on Nanoarchitectonics for Mechanobiology was held at MANA
2015 Jul 30	MANA Principal Investigator Katsuhiko Ariga received the Japan Society of Coordination Chemistry Contribution Award
2015 Aug 7, 8	Research of MANA Scientist Mitsuhiro Ebara has been featured in Japanese television news (NHK Ibaraki, NHK)
2015 Sep 15	MANA signed a Memorandum of Understanding (MOU) with University of Washington (UW), USA

Date	Event
2015 Sep 24	MANA signed a Memorandum of Understanding (MOU) with University of Science and Technology of Hanoi (USTH), Vietnam
2015 Sep 25-26	8^{th} MANA Site Visit by WPI Program Director, WPI Program Officer, MEXT and JSPS
2015 Sep 29	MANA signed a Memorandum of Understanding (MOU) with University of Wollongong (UOW), Australia
2015 Sep 29	Research of MANA Independent Scientist Genki Yoshikawa has been featured in Japanese television (Nittere CS news)
2015 Oct 15-16	The MANA-RSC Symposium: Materials for Energy Generation and Storage was held at MANA
2015 Oct 16	8^{th} Follow-up Meeting by the WPI Follow-Up Committee
2015 Oct 17	Research of MANA Independent Scientist Genki Yoshikawa has been featured in Japanese television (NHK news)
2015 Oct 20	Research of MANA Independent Scientist Genki Yoshikawa has been featured in Japanese television documentary "*News no kimo*" (Essential news) on Fuji TV
2015 Nov 9	MANA Satellite Principal Investigator Françoise M. Winnik received the Urgel Archambault Prize 2015
2015 Nov 10	MANA Satellite Principal Investigator Yukio Nagasaki received the 15^{th} Japan DDS society NAGAI Award
2015 Nov 11	MANA scientist Mitsuhiro Ebara received the 37^{th} Japanese Society for Biomaterials Scientific Incentive Award
2015 Nov 27-28	The 5^{th} MANA Grand Challenge Meeting (together with the Institute for Solid State Physics (ISSP) of the University of Tokyo) was held in Nasu, Tochigi prefecture

Date	Event
2015 Dec 2	MANA Research Associate Mahito Yamamoto received the Japan Society of Applied Physics (JSAP) Young Scientist Presentation Award
2015 Dec 16	MANA Satellite PI Christian Joachim won the "Europe's Rising Stars 2015" Award
2016 Jan 8, 15	The 6^{th} MANA Grand Challenge Meeting (together with Tokyo University of Science) was held in two parts at Tokyo University of Science (on Jan 8) and at MANA (on Jan 15)
2016 Jan 10, 27	Research of MANA Independent Scientist Genki Yoshikawa has been featured in Japanese television news (NHK, NHK Ibaraki)
2016 Jan 18	MANA signed a Memorandum of Understanding (MOU) with University of Chemistry and Technology (UCT), Czech Republic
2016 Jan 27-29	Research results obtained by MANA Principal Investigator Takao Mori have been awarded the Research Project Award （Green Nanotechnology Award) at the 15^{th} nano tech International Nanotechnology Exhibition & Conference(nano tech 2016)
2016 Feb 18	Research of MANA Scientist Tetsushi Taguchi has been featured in Japanese television news (NHK Ibaraki)
2016 Feb 19	MANA Principal Investigator Kohei Uosaki received The Chemical Society of Japan (CSJ) Fellow Award
2016 Mar 9-11	The 9^{th} MANA International Symposium was held in Tsukuba
2016 Mar 13	Research of MANA Scientist Mitsuhiro Ebara has been featured in the Japanese television documentary "*Yume no Tobira*" (A door opened to dreams) on TBS

Fiscal Year 2016

Date	Event
2016 April 30	MANA Advisor Sir Harold Walter Kroto (Nobel Laureate in Chemistry, 1996 / Professor, Florida State University) passed away
2016 Jun 30	MANA signed a Memorandum of Understanding (MOU) with University of Messina, Italy
2016 Jul 12	MANA Associate Principal Investigator Mitsuhiro Ebara was certified as Tsukuba Science Education Meister by Mr. Kenichi Ichihara, Tsukuba City Mayor
2016 Jul 21-22	9^{th} MANA Site Visit by the WPI Program Committee
2016 Jul 27-28	The 2^{nd} International Symposium on Nanoarchitectonics for Mechanobiology was held at MANA
2016 Aug 5	The International (National Cheng Kung University, Taiwan) NCKU/MANA Workshop on 2D Materials was held at MANA (NCKU: National Cheng Kung University, Taiwan)
2016 Aug 18	MANA signed a Memorandum of Understanding (MOU) with MacDiarmid Institute for Advanced Materials and Nanotechnology, New Zealand

Date	Event
2016 Aug 23	MANA Independent Scientist Takeo Minari received the Gold Award of Korea Information Display Society (KIDS)
2016 Aug 24	MANA Principal Investigator Katsuhiko Ariga has been selected as an honorary member of Materials Research Society of India (MRSI)
2016 Sep 15	MANA signed a Memorandum of Understanding (MOU) with Vidyasirimedhi Institute of Science and Technology (VISTEC), Thailand
2016 Sep 21	MANA signed a Memorandum of Understanding (MOU) with Korea Institute of Science and Technology (KIST), Korea
2016 Sep 12	MANA Satellite Principal Investigator Françoise M. Winnik has been admitted as Fellow of the Royal Society of Canada (RSC)
2016 Sep 23	Research of MANA Scientist Kota Shiba has been featured in the Japanese television documentary *Origin of Future* (mirai no kigen) on TBS.

Date	Event
2016 Sep 29	MANA Chief Operating Officer Yoshio Bando and MANA Principal Investigator Jinhua Ye have been admitted as Fellow of the Royal Society of Chemistry
2016 Sep 30	Research of Group Leader Genki Yoshikawa has been featured in the Japanese television documentary *Origin of Future* (mirai no kigen) on TBS.
2016 Oct 17	MANA signed a Memorandum of Understanding (MOU) with Saigon High Tech Park (SHTP Labs), Vietnam
2016 Oct 26	9th Follow-up Meeting by the WPI Follow-Up Committee
2016 Oct 28	MANA Scientist Satoshi Ishii received the 5th NF Foundation R&D Encouragement Award
2016 Nov 25	MANA signed a Memorandum of Understanding (MOU) with Queensland University of Technology (QUT), Australia
2016 Dec 1	Research of Associate Principal Investigator Mitsuhiro Ebara has been featured in Japanese television news (NHK Ibaraki, 4 times on that day)
2016 Dec 8	MANA Principal Investigator Yusuke Yamauchi was selected as a one of winners of NISTEP Award 2016

Date	Event
2016 Dec 11	Research of MANA Scientist Waka Nakanishi has been featured in the Japanese television documentary *Science ZERO* on NHK.
2016 Dec 17	MANA Director-General Masakazu Aono talked on "Contributions of new Materials to the society" at the 10 years of WPI Memorial Lecture: Towards the future of Science in Japan
2016 Dec 17-18	The 2nd Japan-Taiwan Joint Workshop on Nanospace Materials was held at MANA
2017 Jan 20	The Tsukuba Bio Medical Engineering Forum 2017, chaired by MANA-Life Field Coordinator Guoping Chen, was held at NIMS
2017 Feb 5	Research of MANA Scientist Shinsuke Ishihara has been featured in the Japanese television documentary *Origin of Future* (mirai no kigen) on TBS.
2017 Feb 28 – Mar 3	The 10th MANA International Symposium is held in Tsukuba
2017 Mar 3	5th MANA Evaluation Committee Meeting
2017 Mar 28	The International Symposium on Atomic Switch: Invention, Practical Use and Future Prospects is held at MANA.

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International Center for Materials Nanoarchitectonics (MANA)
National Institute for Materials Science (NIMS)

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