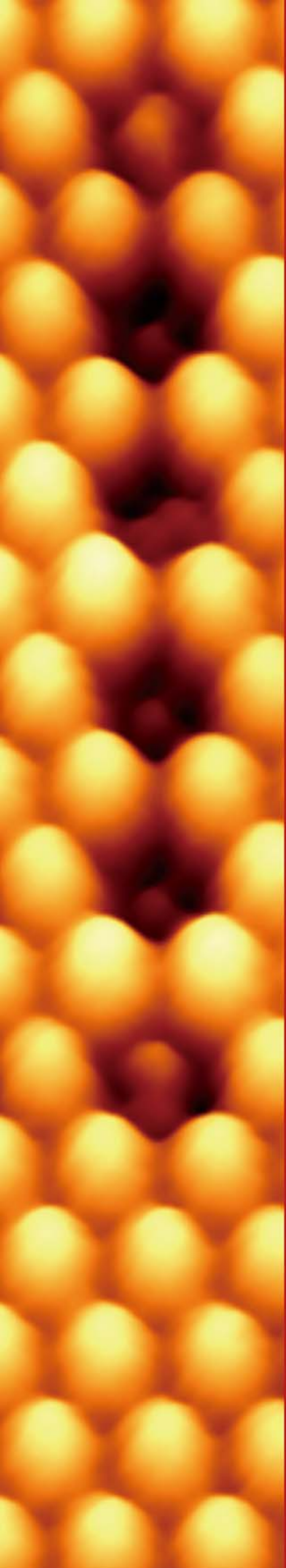
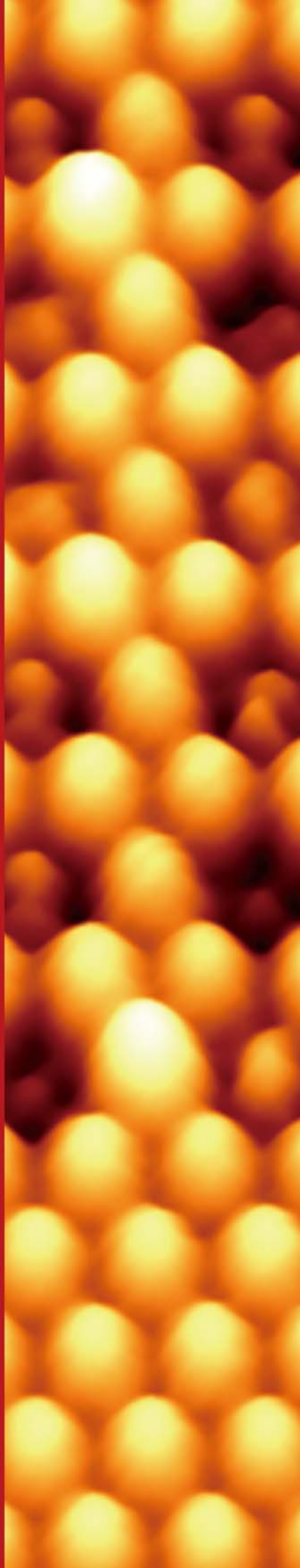


THE 10 YEAR HISTORY OF MANA

2007 – 2017



International Center for
Materials Nanoarchitectonics (MANA)

The 10-Year History of MANA

—So far and hereafter—

In 2017, MANA celebrates the milestone of 10th anniversary. MANA has grown as one of the world's leading nanotechnology research centers in this decade. This booklet reviews the history of MANA over 10 years. Please have a look at what we have acieved and accomplished "to create a better tomorrow."

CONTENTS

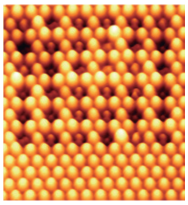
MANA's Vision

Toward a better global future: Pioneering a new paradigm in materials development on the basis of "Nanoarchitectonics"

MANA's Mission

- Develop groundbreaking 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 to achieve innovative research
- Construct a worldwide network of nanotechnology research centers

COVER PICTURE



MANA realized a single molecule size digital (0 or 1) memory bit using a C_{60} molecular film, which is possible to write and erase, and created a storage medium of ultra large capacity (190 b / in^2). The cover picture is the image of C60 film observed by scanning tunneling microscope (STM). Dark C_{60} molecules in the upper part mean the 1 state of 0 or 1. The reason why it is observed darkly is that, the C_{60} molecule forms a dimer or a trimer when it combines with the C_{60} molecule at the lower layer by application of local voltage. It is difficult to control which of a dimer and a trimer is formed because of statistical fluctuation. However, in either case, it is surely the state of 1 of 0 or 1. This picture is a good example of the most important concept of nanoarchitectonics, "reliability that contains ambiguity."

A Message from the Director

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. Commemorating this, we are publishing *The 10 Year History of MANA* as a record of our "footprint" during these ten years. Please also see *Research at MANA – 42 Selected Research Results*, which we have compiled together with this booklet.

If humankind is to continue on a path of sustainable development in the years to come, we must realize a variety of innovative technologies in every field, including the environment, energy, resources, information and communications, medical diagnosis and treatment, and infrastructure, among others. However, many of these innovative technologies cannot be realized unless we develop appropriate new materials. Nanotechnology has made astonishing progress in more than 30 years and has become a pillar of modern materials discovery and development. However, MANA believes that conceptual innovation is necessary in order to extract the maximum value (potentiality) from nanotechnology. We are pursuing this innovation on the basis of the new concept of "Nanoarchitectonics." The concept of "Nanoarchitectonics" (see page 10-11) has been refined continuously by MANA's researchers and has now grown into a concept that is accepted around the world. As we follow this concept, MANA strives to lead the world in new materials development. I humbly request your warm support as we continue our earnest efforts.

Masakazu Aono
Director

History of MANA

Since 2007, MANA has been trying to be an international nano-tech research platform. This timeline of MANA's history will show you its 10 years of footprint and how the concept "Nanoarchitectonics" grew up in the decade. We will keep developing and advancing the "Nanoarchitectonics" to lead the nanotechnology research for the better future.

2007

Masakazu Aono, Director in 2007

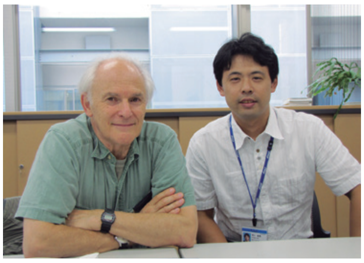
- NIMS with the project called "International Center for Materials Nanoarchitectonics (MANA)" has been selected to participate as one of five institutions in the World Premier International (WPI) Research Center Initiative, a program sponsored by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)
- The Launching Ceremony of MANA
- Independent Scientist system started
- *The Guidebook for Foreign Researchers* was published

2008

- Launch of the new MANA Website in English
- The 1st MANA Seminar entitled "Nanotechnology, a Key to Sustainability" was given by Dr. Heinrich Rohrer (Nobel Laureate in Physics 1986 and MANA Advisor)
- The 1st MANA International Symposium
- The 1st MANA Evaluation Committee Meeting
- ICYS-MANA Program started
- The 1st MANA Site Visit by the WPI Program Committee
- The 1st Follow-up Meeting by the WPI Follow-Up Committee
- Prof. Sir Harold W. Kroto (MANA Advisor) visited MANA
- Celebration of the 1st Anniversary of MANA
- Short-Term Research Invitation Program started
- *MANA Progress Report* was published
- MANA opened satellite laboratories in
  - — University of California, Los Angeles (UCLA)
  - — Georgia Institute of Technology (GIT)
  - — CNRS
  - — University of Cambridge
  - — University of Tsukuba
  - — Tokyo University of Science
  - — Hokkaido University
- Organizational Reform of MANA

2009

The late Prof. Harold W. Kroto with a young researcher



- The 2nd MANA International Symposium
- The 2nd Follow-up Meeting by the WPI Follow-Up Committee
- A delegation from U.S. Department of Energy (DOE) and U.S. Department of Defense (DOD) visited MANA
- Prof. Svante Lindqvist, Nobel Museum Director and Chair of the Royal Institute of Technology, Stockholm, visited MANA
- Prof. Sir Harold W. Kroto visited MANA for one-on-one meetings with young scientists
- Prof. Toshio Kuroki, the WPI Program Director, visited MANA Satellite at UCLA
- The Inaugural issue of MANA's *CONVERGENCE* was published
- Research results from MANA were transmitted via Media Stream

2007 2008 2009 2010

2010

Fujita Takahiro, Former Administrative Director

WPI-MANA building

- The 3rd MANA Site Visit by the WPI Program Committee
- The 3rd MANA International Symposium
- The 2nd MANA Evaluation Committee Meeting
- The 3rd Follow-up Meeting by the WPI Follow-Up Committee
- The 1st MANA Science Café "Melting Pot Club" on "What is nanotechnology?"
- Ms. Kumiko Hayashi, Parliamentary Secretary for Education, Culture, Sports, Science and Technology (MEXT), visited MANA
- Mr. Lim Chuan Poh, Chairman, Agency for Science, Technology and Research (A*STAR), Singapore, visited MANA
- MANA Director-General Masakazu Aono was selected as a winner of the "Feynman Prize in Nanotechnology" given by Foresight Institute, USA
- The Outreach Team was set up
- Construction work of the new MANA Research Building has started
- Prof. James Gimzewski (MANA PI) was featured in NHK's satellite TV Program

2011

- The 1st MANA Grand Challenge Meeting in Miura Peninsula, Kanagawa
- Mr. Yoichiro Genba, Minister of State for Science and Technology Policy, visited MANA
- Launch of the new MANA Website in Japanese
- Dr. H. E. Virachai Virameteekul, Minister of Science and Technology, Thailand, visited MANA
- The 4th MANA International Symposium
- MANA hosted “Prof. Rohrer’s Science Class” for junior high-school students
- Great East Japan Earthquake
- The 4th MANA Site Visit by the WPI Program Committee
- MANA hosted “Prof. Kroto’s Science Class 2011” for preliminary school students and their parents
- The 4th Follow-up Meeting by the WPI Follow-Up Committee
- Mr. Masaharu Nakagawa, Minister of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), visited MANA
- MANA opened a satellite laboratory in University of Montreal, CANADA
- The science picture book *Nima’s Adventure* was published
- Comic explaining Japanese life for foreign residents, *The Challenging Daily Life* was published
- The 200th Commemorative MANA Seminar
- MANA Research Highlights was started transmitting via Online News
- MANA was featured in special issue of STAM

2011 2012 2013 2014 2015 2016

2012

- MANA was featured in a special issue of the journal Advanced Materials
- The 5th MANA International Symposium
- The 3rd MANA Evaluation Committee Meeting
- The 2nd MANA Grand Challenge Meeting in Nasu, Tochigi
- The MANA Second-term Kickoff Meeting at NIMS
- The Commemorative Ceremony for the Completion of the new NanoGREEN/WPI-MANA Building
- The 5th MANA Site Visit by the WPI Program Committee
- Prof. Chung-Yuan Mou, Deputy Minister of the National Science Council, Taiwan, visited MANA
- The MANA 5th Anniversary Memorial Symposium
- The 5th Follow-up Meeting by the WPI Follow-Up Committee
- The 3rd MANA Grand Challenge Meeting (for young researchers) at Miura Peninsula, Kanagawa
- The 2nd WPI Joint Symposium: Inspiring Insights into Pioneering Scientific Research
- The MANA Second-term started

2013

- The 6th MANA International Symposium
- MANA Advisor, Dr. Heinrich Rohrer (Nobel Laureate in Physics 1986) passed away
- MANA participated in the “Summer Science Camp” for high school students
- The 6th MANA Site Visit by the WPI Program Committee
- The 6th Follow-up Meeting by the WPI Follow-Up Committee
- MANA represented by MANA’s Smart Biomaterials Group participated in the event “Science Agora 2013”

The late Prof. Heinrich Rohrer at MANA International Symposium

MANA administrative staff in 2014

Visitation of G7 Science and Technology Ministers

2014

- The 7th MANA International Symposium
- 7th MANA Site Visit by the WPI Program Committee
- 7th Follow-up Meeting by the WPI Follow-Up Committee

FON’14

2015

- The 4th MANA Grand Challenge Meeting in Nasu, Tochigi
- The 8th MANA International Symposium
- The 4th MANA Evaluation Committee Meeting
- The 8th MANA Site Visit by WPI Program Committee
- The 8th Follow-up Meeting by the WPI Follow-Up Committee
- The 5th MANA Grand Challenge Meeting (together with the Institute for Solid State Physics (ISSP) of the University of Tokyo) in Nasu, Tochigi

2016

- The 6th MANA Grand Challenge Meeting (together with Tokyo University of Science) in two parts at Tokyo University of Science (on Jan 8) and at MANA (on Jan 15)
- The 9th MANA International Symposium
- Nano-Theory Field was established
- MANA Advisor, Sir Harold Walter Kroto (Nobel Laureate in Chemistry 1996) passed away
- G7 Science and Technology Ministers visited MANA

The 10-Year History of MANA

Messages for the Future

Kazuhito Hashimoto
President
National Institute for Materials Science (NIMS)

When the Japanese government launched the World Premier International Research Center Initiative (WPI) in 2007, the National Institute for Materials Science (NIMS) was the only Independent Administrative Agency which was selected to participate. NIMS established the International Center for Materials Nanoarchitectonics (MANA) under the WPI program, and since that time, we have provided comprehensive support for MANA's activities as its host institution.

Over the past 10 years, MANA, under the leadership of Director-General Masakazu Aono, has grappled with a variety of challenging research themes in order to construct the new technological system called "nanoarchitectonics." Thanks to the support of all our friends and colleagues, MANA has now grown to the point where it functions as a "hub" that connects nanotechnology research centers around the world. In the process, it has earned an outstanding reputation not only for its excellent research achievements, but also for the internationalization of its organization and the development of young researchers' capacities. In particular, during an excursion (hands-on tour) by the science and technology ministers of the seven advanced countries (G7) held in Tsukuba City in May 2016, the ministers from the countries and related persons observed activities at MANA at the request of the participating countries, and this experience made a deep impression on the representatives of all those countries.

After fiscal year 2017, when direct support from the WPI program ends, MANA will continue active research and development as one of the 7 research centers in NIMS. We intend to put special efforts into promoting bottom-up type basic research and strengthening the MANA research environment, which features a high degree of freedom and internationalization. By incorporating the unique culture of MANA in the operation of the host institution, NIMS, we hope to realize even greater internationalization and activation in NIMS as well, and to promote the further development of NIMS as an organization that contributes to society through the development of materials.

Toshio Kuroki
WPI Program Director

MANA – A tugboat for materials science

The first time I visited MANA was on April 16, 2008. I remember quite well meeting the President of NIMS, Prof. Teruo Kishi, and the Director-General of MANA, Prof. Masakazu Aono, for the first time, and receiving an explanation of the MANA's research policy over a 7 hour period. Ten years have passed since that day, and the growth of MANA during that time has been astonishing. According to the Thomson Reuters Web of Science, "top 1%" papers reached 4.1% during the period 2007-2015, and 6 researchers from MANA were selected as Thomson Reuters Highly Cited Researchers 2016. During a site visit, I was shown the Powerpoint presentation "MANA – A tugboat for NIMS" by Prof. Aono. NIMS is in the forefront of materials science in Japan, and MANA is its driving force. I hope that both will continue to progress in the future, taking advantage of the synergistic effect of the two organizations.

One more impression of MANA is the vigorous research being done there by young researchers from around the world. This was possible thanks to the experience of the International Center for Young Scientists (ICYS), which was a project carried out by NIMS before MANA was launched. Although that are many young researchers from other countries at all the WPI Centers, it would be fair to say that MANA is the model among the 9 WPI Centers. Some years ago, the number of foreign post-docs in this program was quite large, so during site visit, I proposed that they should also hire Japanese post-doc researchers. MANA responded immediately and created a post-doc system for Japanese researchers called YAMATO.

Finally, as Program Director, I would like to express my appreciation to the "troika" leadership group of Director-General Aono, Yoshio Bando, Chief Operation Officer of MANA, and Daisuke Fujita, the former Administrative Director of MANA, and his successor, Tomonobu Nakayama, the present Administrative Director, who have provided the driving force for research at MANA as a tugboat during the past 10 years. I would also like to thank Program Officer Gunzi Saito, AIMR Program Officer Yoshihito Osada, and the working group, beginning with Prof. Klaus von Klitzing and Prof. David L. Allara, who have unfailingly participated in every site visit during the last 10 year and have offered many incisive opinions.

In the future, I hope that MANA will continue to promote research as a member of the WPI Academy.

Gunzi Saito
WPI Program Officer

MANA has made great progress toward achieving its goals during the last ten years. When MANA was selected for the WPI Program, I asked this new research center to develop exceptional "supermen" researchers. MANA responded by assembling a group of world-class researchers from other countries, which was followed by outstanding young researchers from overseas. Seeing their work motivates Japanese researchers to make their own best efforts, and as a result, they have grown to the point where they are also producing extremely good results. In this way, MANA has come to function as a global hub of nanotechnology research.

MANA's organization-building capabilities were also extremely good. In management and operation, MANA could cope with a variety of jobs thanks to the "troika system" of the Director-General, COO and Administrative Director. This has worked effectively in creating a friendly research environment for non-Japanese researchers, and it has also made a substantial contribution to organizational reform in the host organization, NIMS.

I was truly impressed with the high quality of MANA's human resources development. Prof. Kishi, the President of NIMS when MANA was founded, the former President Prof. Ushioda and MANA's Director-General Aono and COO Bando, with their flexible thinking and ability to respond to new challenges, have encouraged young researchers, and this has effectively helped many scientists to achieve astonishing growth.

"Nanoarchitectonics" is a wonderful word, but there are still many issues for deepening this concept from the viewpoint of material science. I hope that MANA will actively pioneer new fields and encourage even greater development of "nanoarchitectonics."

Leaders, collective management and outstanding researchers.

Teruo Kishi
Former President
National Institute for Materials Science (NIMS)

First, I wish to thank all the researchers at MANA for their hard work in the WPI-MANA activities during these last 10 years. I would like to say a sincere "thank you" for the high-level results of the individual researchers in the field of nanotechnology, and for the achievements realized through the fusion of those results. I also understand that these wonderful achievements are of course the result of the efforts of each researcher and the supporting administrative staff, together with the outstanding leadership of Director-General (CEO) Aono and the collective management by Chief Operations Officer (COO) Bando, Chief Administrative Officer (CAO) Fujita and Senior Administrative Officer Kobayashi.

I recall the Evaluation Committee that we employed 10 years ago. All of the examination of documents and interviews were conducted in English. This was quite a struggle for Director-General Aono and myself. However, Director-General Aono pressed ahead with the Nano-Material, Nano-Systems, Nano-Bio and Nano-Green fields, and on the other hand, proposed the creation of a "melting pot environment" of different fields, different cultures and different nationalities, leading to adoption.

Finally, I wish to express my special appreciation to those concerned in NIMS, all our international advisors, Prof. Kuroki and Prof. Saito for their encouragement. I hope that the spirit of these activities and the research system will live on forever in NIMS.

Anthony K. Cheetham
Professor
Cambridge University

A decade has passed since MANA was launched in 2007 as part of Japan's landmark WPI Program, and it is hard to remember what NIMS was like before that time. In fact, it was a very young organization, having been created only 6 years earlier from the merging of two well-established centers - the National Research Institute for Metals and the National Institute for Research in Inorganic Materials. The successful bid for a WPI Center was helped in part by the success of the International Center for Young Scientists (ICYS), and NIMS was the only WPI, of the 6 that we created initially, that was not based on a university campus. This bold initiative transformed NIMS from a rather classical materials institute into a leading center for nanoscience, and enabled it to establish world-class programs in, among others, nano devices, nanomaterials, and (later) nanobio systems. I was privileged to become the chairman of the External Evaluation Committee, a job that was made easy by the outstanding leadership of Aono-san, Bando-san and others. It has been a pleasure to work with you all, and my only regret is that the ministry - short-sightedly to my mind - decided not to renew the program for a second time. The legacy of MANA will nevertheless continue, especially through its dedicated building on the Namiki site, and the whole of NIMS can be grateful for the transformation that was made possible by the creation of MANA.

Nanoarchitectonics

New Paradigm of Nanotechnology

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 microfabrication 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.

Key Points

POINT 1

"Unreliability-tolerant reliability"

In the world of microtechnology, structures can be constructed according to a design drawing or "blue print." 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.

POINT 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 in important.

POINT 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.

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."

MANA's Three "Grand Challenges"

MANA designated three challenging research themes as "Grand Challenges" in order to promote mutual cooperation among researchers in different fields and to revitalize MANA's overall research. These challenging themes are not easily achieved, but researchers from different fields within MANA are in cooperation and making steady progress towards making these dreams a reality.

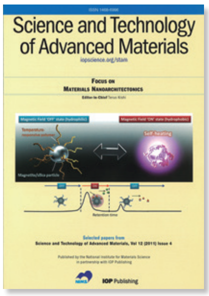
Grand Challenge 1
Nanoarchitectonic artificial brain

Grand Challenge 2
Room-temperature superconductivity

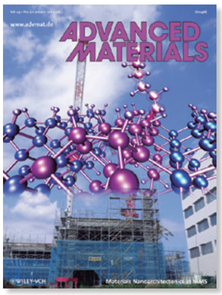
Grand Challenge 3
Practical artificial photosynthesis

The concept of nanoarchitectonics spreading worldwide

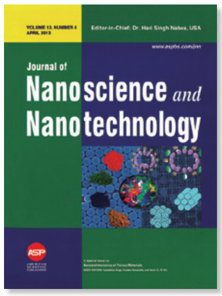
Nanoarchitectonics has seen worldwide acceptance in the last 10 years.
Born at MANA, Nanoarchitectonics has been featured in numerous academic journals, general books, and many more publications.



Science and Technology of Advance Materials
"Focus on Materials Nanoarchitectonics"
August, 2011

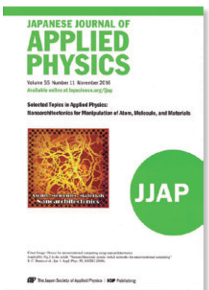


Advanced Materials
"Materials Nanoarchitectonics at NIMS"
January, 2012

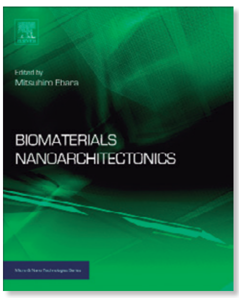


Journal of Nanoscience and Nanotechnology
"Nanoarchitectonics of Porous Materials"
April, 2013

Langmuir
"Interfacial Nanoarchitectonics Special Issue"
June, 2013

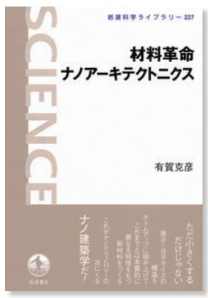


Japanese Journal of Applied Physics
"Nanoarchitectonics for Manipulation of Atom, Molecule, and Materials"
November, 2016



Biomaterials Nanoarchitectonics
Edited by Mitsuhiro Ebara
February, 2016

Supra-Materials Nanoarchitectonics
Edited by Masakazu Aono and Katsuhiko Ariga
October, 2016



Materials Revolution Nanoarchitectonics
Katsuhiko Ariga
June, 2014

Organization

Advisors

Committee Members

Director
Masakazu Aono

Administrative Director
Tomonobu Nakayama

Chief Operation Officer
Yoshio Bando

Duputy Director
Takayoshi Sasaki

Administrative Section

- Planning Team
- General Affairs Team
- Technical Support Team
- Outreach Team

MANA Foundry

Research Section

Nano-Materials
- Soft Chemistry Group
- Functional Nanosheets Group
- Mesoscale Materials Chemistry Group
- Nanotubes Group
- Supermolecules Group
- Frontier Molecules Group
- Semiconductor Device Materials Group

Nano-System
- 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
- Photocatalytic Materials Group
- Photonics Nano-Engineering Group
- Thermal Energy Materials Group
- Nanostructured Semiconducting Materials Group

Nano-Life
- Tissue Regeneration Materials Group
- Medical Soft Matter Group
- Nanomechanical Sensors Group
- Mechanobiology Group

Nano-Theory
- Material Properties Theory Group
- First-Principles Simulation Group

Managing Researchers

Independent Scientists

ICYS-MANA Researchers

MANA's strong operating system

Under the strong leadership of the Director, the administrative section is supervised by the Administrative Director, with the research section supervised by the Chief Operation Officer. This management system at MANA is known as the "Troika system."

This innovative system keeps operation efficient and maintains a solid foundation to support MANA's creative research activities.

Position	Number		Non-Japanese	Female
Principal Investigators (PIs)	20	26	3	1
Satellite Principal Investigators (Satellite PIs)	6		5	1
Group Leaders	9	169	0	0
Associate Principal Investigators (APIs)	2		1	0
Faculty Members	68		9	7
Independent Scientists	7		2	2
ICYS-MANA Researchers	9		6	0
Postdoctoral Researchers	53		47	16
Junior Researchers	21		17	8
Administrative and Technical Staff		29	1	17
Total	224		91	52

(2017. January)

Advisors

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

C. N. R. Rao
Honorary President, Jawaharlal Nehru Center for Advanced Scientific Research

T. Kishi
Former President, National Institute for Materials Science

J.-M. Lehn
Professor, University of Strasbourg
Nobel Laureate in Chemistry (1987)

H. Fukuyama
Director General, Research Institute for Science and Technology, Tokyo University of Science

T. Akaike
Director, Foundation for Advancement of International Science

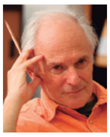
International Cooperation Advisors

International cooperation advisors, including prominent researchers, provide MANA with advice on joint research with overseas research institutes and formulation of a global nano-tech network.

Sir M. E. Welland
Professor, University of Cambridge

L. Schlapbach
Former CEO, Swiss Federal Laboratories for Materials Testing and Research

Former Advisors



Sir Harold Kroto
Nobel Laureate in Chemistry (1996)

Heinrich Rohrer
Nobel Laureate in Physics (1986)

Galen Stucky
Essam Khashoggi Chair in Materials Chemistry, University of California, Santa Barbara

Evaluation Committee Members

Evaluation Committee members provide MANA with critical comments and expert recommendations on the operations and research strategies of MANA projects.

A. K. Cheetham
Professor, University of Cambridge
Chair of the Evaluation Committee

T. Aida
Professor, The University of Tokyo

M. Endo
Professor, Shinshu University

H. Hahn
Professor, Karlsruhe Institute of Technology

Y. Nishi
Professor, Stanford University

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

J. P. Spatz
Director, Max Planck Institute for Intelligent Systems

Former Evaluation Committee Members

Manfred Ruehle
Professor, Max Planck Institute for Metals Reserach

L. Schlapbach
Former CEO, Swiss Federal Laboratories for Materials Testing and Research

K. Tanaka
Honorary Researcher, National Institute of Advanced Industrial and Technology

K. Hashimoto
President, National Institute for Materials Science

MANA Principal Investigators（PIs）

Prominent Researchers who lead Nanoarchitectonics

※ Field Coordinator

Nano-Materials

The Nano-Materials field expands the horizons of nanotechnology. Many prominent researchers belong to the Nano-Materials field.

Takayoshi Sasaki※
Deputy Director
Soft Chemistry Group

Katsuhiko Ariga
Supermolecules Group

Yoshio Bando
Chief Operation Officer

Toyohiro Chikyo
Semiconductor Device Materials Group

Dmitri Golberg
Nanotubes Group

Minoru Osada
Functional Nanosheets Group

Yusuke Yamauchi
Mesoscale Materials Chemistry Group

Zhong Lin Wang
Satellite PI
Georgia Institute of Technology

Nano-System

The Nano-System field emphasizes the fusion research of different fields, and makes innovations in artificial intelligence, energy, environment, and the medical spectrum.

Masakazu Aono※
Director

Xiao Hu
Nano-System Theoretical Physics Group

Yoshihiko Takano
Nano Frontier Superconducting Materials Group

Kazuya Terabe
Nanoionic Devices Group

Kazuhito Tsukagoshi
Thin Film Electronics Group

James K. Gimzewski
Satellite PI
University of California, Los Angeles

Christian Joachim
Satellite PI
Centre national de la recherche scientifique

Nano-Power

For a sustainable-energy society, high-efficiency conversion and the transportation and use of energy are a necessity. World-class PIs, who manipulate the interface of nanoarchitectonics, bring these to fruition.

Jinhua Ye※
Photocatalytic Materials Group

Kohei Uosaki
Director-General, Center for Green Research on Energy and Environmental Materials, NIMS

Takao Mori
Thermal Energy Materials Group

Kazunori Takada
Deputy Director-General, Center for Green Research on Energy and Environmental Materials, NIMS

Yoshitaka Tateyama
Group Leader, Interface Computational Science Group, Center for Green Research on Energy and Environmental Materials, NIMS

Nano-Life

Excellent PIs gather from around the world to contribute to the health and longevity of society. The Nano-Life field brings innovations to biomaterial technology.

Guoping Chen※
Tissue Regeneration
Materials Group

Yukio Nagasaki
Satellite PI
Tsukuba University

Francoise M. Winnik
Satellite PI
University of Montreal

Nano-Theory

Specialists in theoretical fields such as quantum mechanics, statistical mechanics, and large-scale first-principles calculations gather to understand and predict nano-space phenomena.

Taizo Sasaki※
Material Properties
Theory Group

Tsuyoshi Miyazaki
First-Principles
Simulation Group

David Bowler
Satellite PI
University College London

Former Principal Investigators

Many PIs have done brilliant research at MANA during the development of their career.
Though no longer affiliated with MANA, they maintain relationships with MANA as mentors and advisers.

The late
Kenji Kitamura
Former
Nano-Materials PI
(2007-2011)

Kazuhiro Hono
NIMS Fellow/Director, Research Center for Magnetic and Spintronic Materials
Former Nano-Materials PI
(2007-2011)

Naoki Ohashi
Managing Director, NIMS Saint-Gobain Center of Excellence for Advanced Materials
Former Nano-Materials PI
(2007-2011)

Daisuke Fujita
Executive Vice President, NIMS
Former Nano-System PI
(2007-2011)

Tsuyoshi Hasegawa
Professor, Waseda University
(2007-2015)

Omar Yaghi
Professor, University of California, Berkeley
Former Nano-Power PI
(2007-2016)

Kazuo Kadowaki
Professor, Tsukuba University
Former Nano-Materials Satellite PI
(2007-2013)

Hideaki Takayanagi
Professor, Tokyo University of Science
Former Nano-System Satellite PI
(2007-2015)

Mark E. Welland
Professor, University of Cambridge
Former Nano-System Satellite PI
(2007-2012)

Eiji Muromachi
Senior Vice President, NIMS
Former Nano-Materials PI
(2007-2010)

Yoshio Sakka
Senior Scientist with Special Missions Research Center for Functional Materials, NIMS
Former Nano-Materials PI
(2007-2011)

Tomonobu Nakayama
Administrative Director, MANA
Former Nano-System PI
(2008-2014)

Enrico Traversa
Professor, King Abdullah University of Science and Technology
Former Nano-Green PI
(2009-2012)

Liyuan Han
Managing Researcher, Center for Green Research on Energy and Environmental Materials, NIMS
Former Nano-Green PI
(2008-2011)

Yuji Miyahara
Professor, Tokyo Medical and Dental University
Former Nano-Bio PI
(2008-2010)

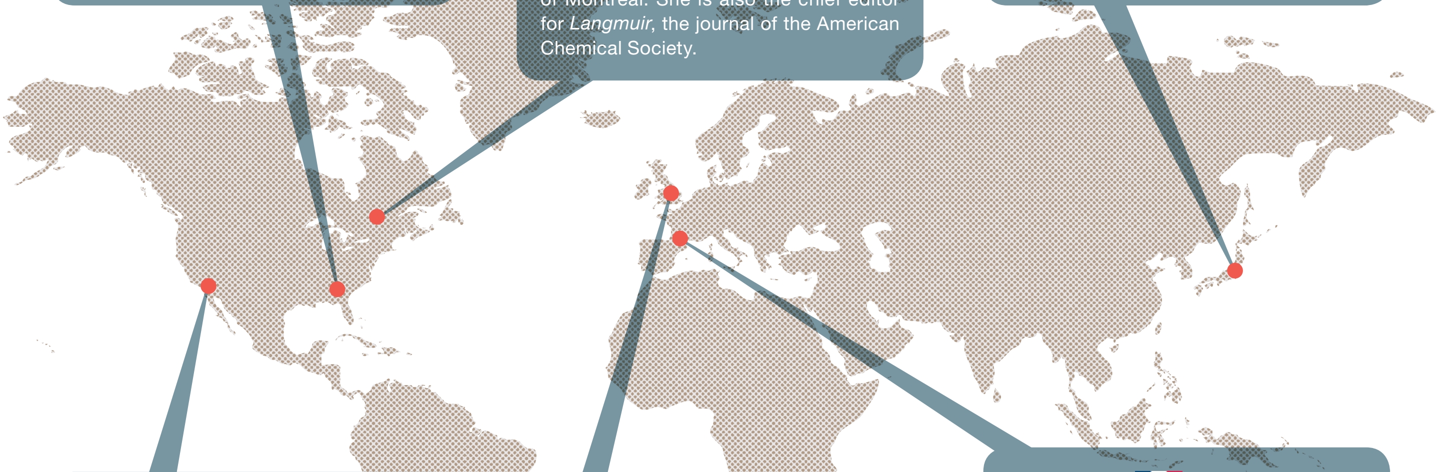
Christoph Gerbe
Professor, University of Basel
Former Nano-System PI
(2008)

Keiichi Tomishige
Professor, Tohoku University
Former Nano-Green PI
(2008-2010)

Takao Aoyagi
Professor, Nihon University
Former Nano-Bio PI
(2010-2015)

Satellite Laboratories

Front bases of MANA's international nanotechnology network



Georgia Institute of Technology

Zhong Lin Wang

The Georgia Institute of Technology is the world's top engineering institute where advanced research in numerous fields is conducted. Prof. Zhong Lin Wang is also one of the world's top researchers, who has over 44,000 citations. He is known for outstanding research on nanobelts and nanowires. As a MANA Satellite PI, he has been working on researching nanogenerators using zinc oxide nanowires.

University of Montreal

François Winnik

The University of Montreal is known for being a university exploring advanced fields such as nanobiology. Prof. Francoise Winnik spent ten years as a researcher at Canada's Xerox Research Center on new materials for printing application technology. After that, she has been working on functional nano particles and nano interfaces research at McMaster University and the University of Montreal. She is also the chief editor for *Langmuir*, the journal of the American Chemical Society.

University of Tsukuba

Yukio Nagasaki

University of Tsukuba is one of Japan's largest national universities, located in the science city of Tsukuba. Prof. Yukio Nagasaki has been working on developing functional materials, especially bio-functional materials, including biosensors, cell culture system, biological information visualization systems, and drug delivery systems via precision synthesis technology of high polymers.

University of California, Los Angeles

James K. Gimzewski

The University of California, Los Angeles is home to the California NanoSystem Institute (CNSI), the world's leading nanotechnology research center. After working at the IBM Research Laboratory in Zurich, Prof. James K. Gimzewski has been conducting fusion research of nanotechnology and biology at UCLA. The research on the atomic switch at MANA is applied to his unique research on realizing an artificial brain.

University College London (UCL)

David Bowler

University College London (UCL) is one of the universities that make up the University of London, and is the world's top research institute with an international research environment. MANA launched the Nano-Theory field to research large-scale calculations with supercomputers. Prof. David Bowler belongs to the field as a specialist of large-scale calculations such as the Order N Density Functional Theory.

Centre national de la recherche scientifique (CNRS)

Christian Joachim

Centre National de la Recherche Scientifique (CNRS), one of Europe's highest scientific research institutes, covers a wide range of fields from mathematics to humanities. Prof. Christian Joachim is the leading expert who has elucidated the electronic state of functional molecules by first-principles calculation. He is working on research to realize monomolecular devices. He is also the founder of "Nano-car Race," the competition by cars made of a single molecule.

MANA introduced the "Satellite Laboratory" system to implement the internationalization of our research environment. MANA invited prominent researchers as Satellite PIs, and established satellite laboratories at each research institute. These laboratories are not just for collaborative research, but they also provide young researchers at MANA an international research training ground, with satellite PIs working as their mentors.

As of 2017, MANA has 6 satellite laboratories around the world, and the proportion of satellite PIs has reached about a quarter of the total number of PIs of MANA.

Through the international network built with satellite laboratories, MANA increases its international presence as a hub gathering knowledge, information, and human resources on nanotechnology.

Former Satellite Laboratories

Hokkaido University

Kohei Uosaki
High efficiency energy conversion
(2008 – 2010)

University of Tsukuba

Kazuo Kadowaki
Superconducting quantum materials
(2008 – 2013)

Tokyo University of Science

Hideaki Takayanagi
Superconductors, quantum information physics
(2007 – 2015)

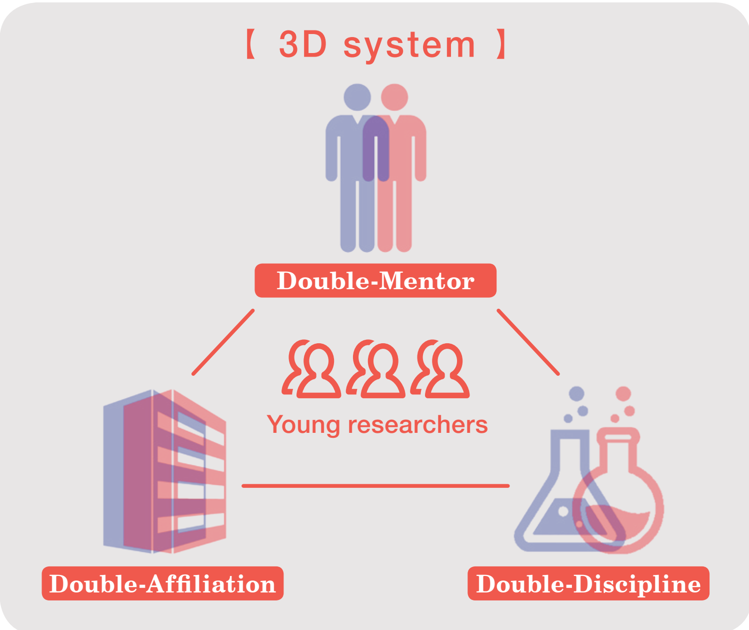
University of Cambridge

Sir. Mark E. Welland
Biological materials
(2007 – 2012)

3D system

To foster international researchers

MANA focuses on cultivating young researchers. MANA's "3D System" is a unique training system for young researchers. The system, which is named after "Double-mentor," "Double-affiliation" and "Double-Discipline," encourages them to acquire the originality, independence, and interdisciplinarity for their research. The experience gained as a researcher at MANA, helps them to advance their careers. This has helped MANA build a vast nanotechnology network, circulating knowledge around the world. The "3D system" is highly valued as a very effective training system for young researchers' career development.



Double-Mentor

MANA encourages young researchers to have two mentors, both in Japan and abroad. A multilateral perspective on their own research is needed for great achievements. Mentors guide them as excellent leaders, as well as partners in collaborative researches.

Double-Affiliation

MANA has a rich nanotechnology network all over the world. Young researchers at MANA can belong to multiple institutes to widen their knowledge and experience. Experience with multiple institutes provides them with the know-how of collaborative research.

Double-Discipline

Researchers trying to get into one specify research field tend to have a narrowed view for their research. In order not to miss the possibilities that can be obtained by changing their viewpoints, MANA recommends young researchers engage in two research fields.

Career development of young researchers

Japan	98	Taiwan	4	Belgium	2	Qatar	1
China	64	Germany	4	Ireland	2	Turkey	1
India	27	France	4	Sweden	2	Czech	1
U.S.A.	18	Singapore	4	Canada	1	Denmark	1
U.K.	11	Poland	3	Russia	1	Slovenia	1
Korea	10	Switzerland	3	Vietnam	1		
Australia	6	Saudi Arabia	2	Iran	1		

Global career up destinations

Young researchers with experience at MANA are active in research institutes around the world. With MANA serving as a hub, the international network of nanotechnology expands year by year.

Nanotechnology Students' Summer School

MANA participates in the annual Nanotechnology Students' Summer School. Excellent students in nanotechnology doctoral courses from all over the world participate in this summer school and learn how fusion research can be done through collaborative research workshops that go beyond different fields and cultures.

Independent Scientists

Independent Scientists System

One of MANA's unique research systems is the Independent Scientists system. This is a system to train young researchers by giving them all discretion about their research activity and nurture leading researchers who can play an active part at the world level.

World-leading researchers are required to create research environments themselves as well as achieve excellent research results. Research activities can not be accomplished through research alone - for example, it is also an important task to approach companies and organizations about providing research funds. Also, participating in symposiums held in various countries to build a network with advanced researchers for a collaborative research are important activities to explore new possibilities. Efforts to nurture young researchers capable of competing in the world are part of the "Independent Scientists" system. Only young researchers with brilliant achievements can be selected as Independent Scientists.

The "Independence" of Independent Scientists

– 1 – Independent authority over research

Independent researchers are given literally "independent" discretion over their research. There are few research institutions that give young researchers this much authority. With this system, they can easily take action related to their research theme and accelerate their research.

– 2 – Independent research budget

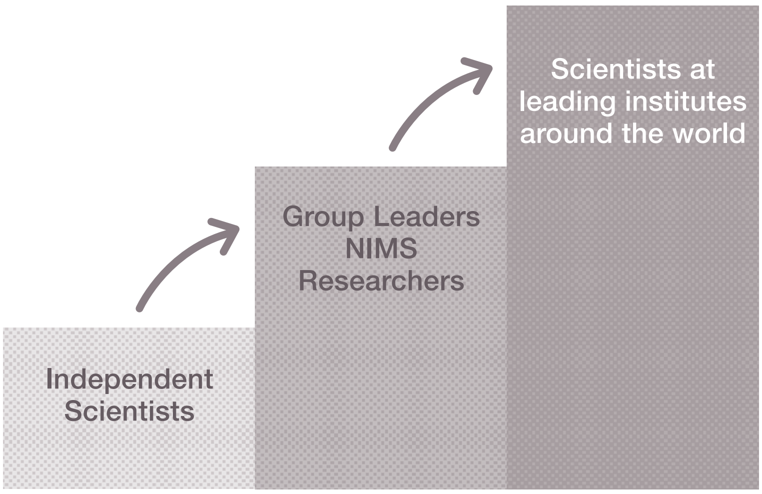
Independent researchers have also been given a research budget from MANA, but the amount is not large. They approach companies and organizations and acquire a budget that they can freely utilize. It is not easy to get a research budget, but MANA's network with many researchers and research institutions is of great assistance.

– 3 – Independent action

Since Independent Scientists' activity is not limited, they can even conduct their research abroad for as long as they want. In order to become an active researcher, it is essential to expand their scope as a scientist. Engaging diverse cultures and different fields by meeting top researchers and getting to know them personally develops their rich research spirit.

Taking the next steps after Independent Scientists

To be an Independent Scientist, a good financial sense, a management skill, rich humanity, a sense as a researcher, and a high degree of internationality are needed. They can build their career with their high ability and network as a researcher after being Independent Scientists. Publishing high quality research papers on the famous scientific magazines and journals makes them to be invited to major research institutes. Some of them are hooked up as MANA's Group Leaders, Principal Investigators, and NIMS researchers as well.



ICYS-MANA

Aiming for an international center for young researchers

Aiming to build an international research environment and a unique training system for young researchers, the International Center for Young Scientists (ICYS) was launched by the Ministry of Education, Culture, Sports, Science and Technology 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 is to get excellent young researchers together from different research fields and countries, and to maximize their creativity by hosting research activites in a “melting pot environment.” The ICYS program received high marks and even after the conclusion of the program in 2007, NIMS inherited the ICYS system. Currently, the ICYS exists via two divisions: ICYS-Sengen and ICYS-Namiki. Researchers who belong to ICYS-Namiki take part in MANA as ICYS-MANA researchers.

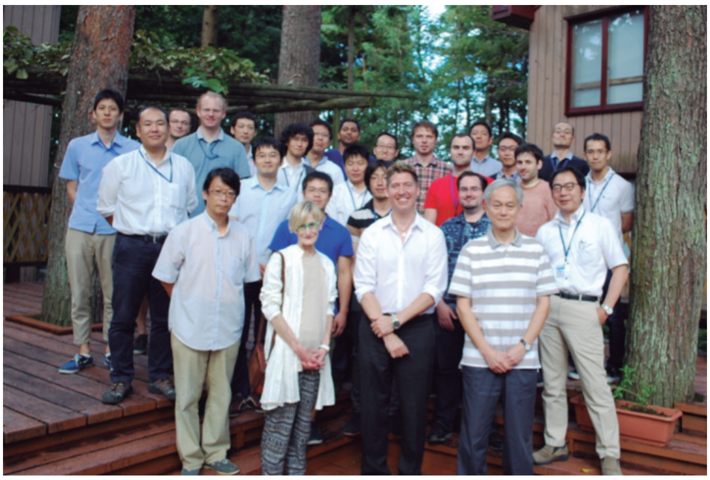
Through open recruitment, only specially-selected excellent young researchers can become ICYS-MANA researchers. So far, 47 applicants have passed the selection process since 2007. After the completion of the program, 12 researchers developed their career as NIMS Tenured Researchers and 35 became young leaders at research institutes in Japan and around the world.

Recruitment

Announcements are placed in leading magazines such as Nature, and open recruitment information is sent out via the NIMS website.

Research Environment

Discretionary research funds are allocated to each ICYS-MANA researcher, and there are prepared environments to provide comfort in their research activities. They can use the world's leading research facilities owned by MANA/NIMS under the support of the Technical Support Team (TST) in English. They also receive total support from the administrative office, which is composed only of English speakers.



ICYS Workshop

We organize the ICYS workshop every year, in which all ICYS researchers, external research experts, and mentors participate. Through active discussions with various viewpoints in each researcher's presentation, young researchers can find new possibilities for progress in their research.

Research Environment

Research Buildings

MANA's research buildings, which consist of the WPI-MANA Building and the MANA Building, are where MANA's researchers intermingle with people from universities, institutes, and companies. Both buildings are designed to foster an innovative research environment. The WPI-MANA Building, completed in 2012, is not only an excellent research building, but also an earth-conscious Zero Energy Building (ZEB). Features include a photocatalytic glass watering system, solar panels and sun louvers, conditioned room temperature, humidity and brightness, all making use of natural energy and designed for comfort as well as energy-efficiency. It is the very first building in Japan with a microgrid system using a multiple power-source network of solar photovoltaics, emergency generators, and storage batteries. The amount of peak shaving reaches 90kW at the facilities' maximum usage. The WPI-MANA Building has been ranked "S" by CASBEE, who evaluate buildings based on environmental performance.

MANA Building

WPI-MANA Building

Melting Pot Environment: Catalyst for Interdisciplinary Research

MANA focuses on providing a "Melting Pot Environment" where many researchers from different research fields, cultures, and nationalities gather. This approach fosters a creative research environment by removing various barriers among researchers. MANA's research buildings feature cafeterias and interaction spaces on each floor for researchers to communicate with each other. Even in their research office and laboratory, there are no walls to hinder their communication. This free communication and exchange of opinions cultivates creative ideas of interdisciplinary research at MANA.

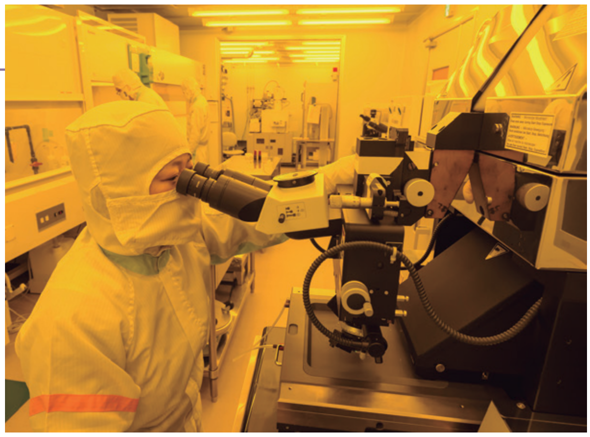
International science city Tsukuba

MANA/NIMS is located in Tsukuba, Japan's largest science city, in Ibaraki Prefecture. Tsukuba has more than 300 national research and company institutes, and is an international city with many foreign researchers. The rich intellectual climate enhances MANA's challenging state-of-the-art nanotechnology research, as well as research collaborations among institutes.

World-class research facilities

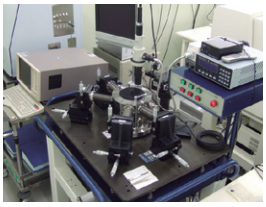
Ample facilities, the accelerator of research achievement

MANA has the world-class facilities which nanotechnology research requires. Researchers at MANA can utilize the “MANA Foundry” where researchers can request micro/nanofabrication with various materials. They can also use facilities owned by the host institute NIMS, including the High Magnetic Field Station, which can generate the world's highest magnetic field. These top-level facilities at MANA/NIMS accelerate the work of our researchers.

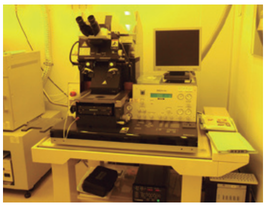

Class 1,000 cleanroom-facility

The MANA Foundry

The “MANA Foundry” is a micro/nanofabrication facility owned by MANA. The facility consists of eight areas: photo lithography, wet process, etching, film deposition, nano measurement, nano analysis, heat treatment, and dicing & wiring. The MANA Foundry provides consistent processes from test piece preparation to structural observation and functional verification of nano-dots, nano-wires, nano-sheets made of various materials including organic, inorganic, metal, insulator, magnetic, superconductor and composite materials.


Quadruple-prober


Angle Resolved X-ray Photoelectron Spectroscopy (XPS)


Contact Mask Aligner

Facilities owned by NIMS

Researchers at MANA can use the world-class research facilities owned by the host institute NIMS. The excellent line-up of research facilities includes the Transmission Electron Microscopy Station, High Magnetic Field Station, Material Analysis Station, and Synchrotron X-ray Station at SPring-8, which are all available for use.

They can also utilize the enormous information database of materials provided by NIMS.


Ultra-high Magnetic field NMR which achieved world's highest magnetic field (1020MHz)


The beamline (BL15XU) at SPring-8


Atomic-resolution analytical electron microsope (Titan)

Technical Support Team (TST)

Specialists who support state-of-the–art research

To allow researchers to focus on their research, MANA has its Technical Support Team (TST). The team works on maintenance of equipment and laboratories, chemical reagent support, safety measures, technical evaluations for installing new equipment, and much more. The team consists of staff capable of full English correspondence to support foreign researchers, which is a must-have for MANA as technical specialists support cutting-edge research.

Research Environment

Support for foreign researchers

Approximately half of researchers enrolled in MANA are foreign nationals. MANA provides a variety of support for foreign researchers so that they can concentrate on research activities comfortably in Japan.

MANA's administrative office is composed only of staff who can speak English, and all necessary procedures can be done in English. Experienced secretaries offer support, including procedures for purchasing reagents and research equipment, adjusting to living in Japan, and arranging air travel for business trips. In addition, we provide opportunities to deepen their understanding of Japan through Japanese language and culture classes.

Administrative office

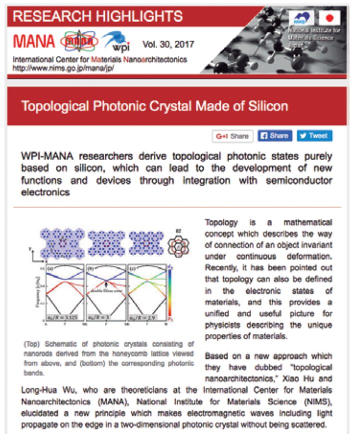
Japanese culture class

Outreach activities

In order to propagate MANA's research results to the world, MANA also focuses on outreach activities, including publication of the PR magazine "CONVERGENCE", distribution of its English news online as "Research Highlights", participation in various scientific events, publication of science books, open house, and much more.

In order to convey the great possibilities of nanotechnology, special science events geared toward the general public are held. Such events include the Science Class by Nobel laureates, the late Dr. Heinrich Rohrer, and the late Dr. Harold Kroto, as well as MANA's original hero show "Smart Polymer Rangers" held for kids at educational science events.

Science class by Dr. Heinrich Rohler



RESEARCH HIGHLIGHTS
MANA wpi Vol. 30, 2017
International Center for Materials Nanoarchitectonics
http://www.nims.go.jp/mana/jp/

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

Topology is a mathematical concept which describes the way of connection of an object invariant under continuous deformation. Recently, it has been pointed out that topology can also be defined in the electronic states of materials, and this provides a unified and useful picture for physicists describing the unique properties of materials.

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

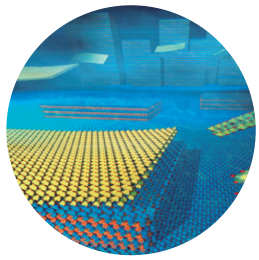
Based on a new approach which they have dubbed "topological nanoarchitectonics," Xiao Hu and Long-Hua Wu, who are theoreticians at the International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS), elucidated a new principle which makes electromagnetic waves including light propagate on the edge in a two-dimensional photonic crystal without being scattered.

MANA Research Highlights

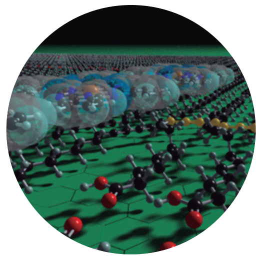
MANA's

Research Topics

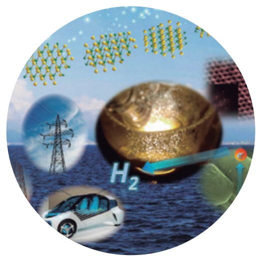
— Nano-Materials



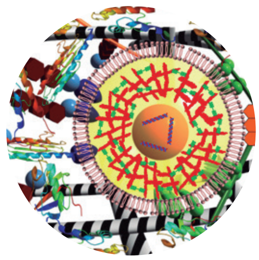
— Nano-System



— Nano-Power



— Nano-Life

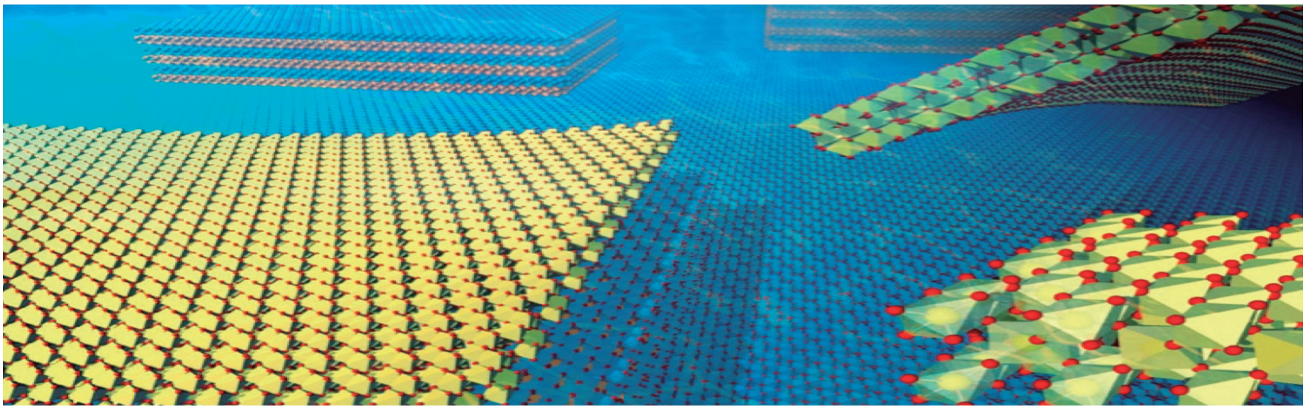


— Nano-Theory

Please see "Research at MANA: 42 Selected Research Results 2007-2017" for the details of the following research topics.

01 *Research Field :* Nano-Materials

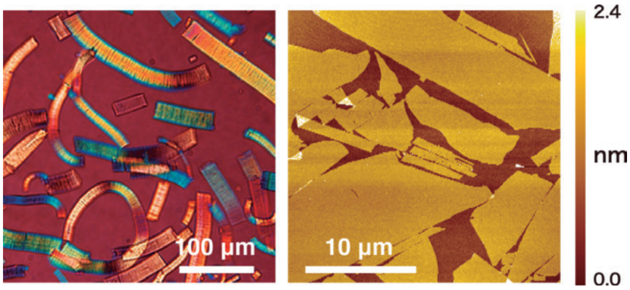
Creating new materials and eliciting novel functions by sophisticated control of compositions and structures at the nano level



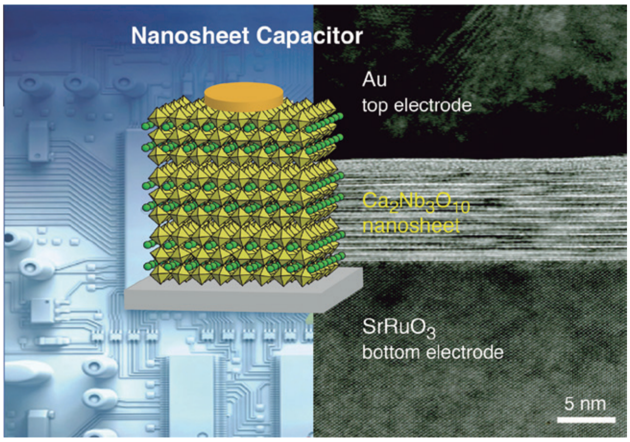
Nanosheet architectonics based on synthesis of new 2D nanosheets

Two-dimensional (2D) nanosheets with atomic or molecular thickness are emerging as important new materials "beyond graphene" owing to their fascinating physical properties. MANA synthesizes 2D oxide and hydroxide nanosheets by inducing enormous swelling of the starting layered materials, can be applied in "material nanoarchitectonics" to develop hierarchical materials with unique, advanced functionalities. Especially, MANA found that platy microcrystals of layered metal oxides undergo more than 100-fold accordion-like expansion in aqueous amine solutions, induced via even permeation of the solution into the interlayer gallery to prop it open. Interestingly, the degree of swelling is not dependent on amine agents, while the stability of the swollen crystals is. We controlled their delamination to produce unilamellar oxide nanosheets in high yield. Through the processes in which swollen crystals are disintegrated into molecularly thin elementary layers, we produced a range of colloidal suspensions of monodisperse 2D nanosheets, which are useful building modules to fabricate functional materials and nanodevices.

Particularly, MANA discovered 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 (εr = 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. Furthermore, we utilized high-k oxide nanosheets as building blocks in LEGO-like assembly and successfully developed various functional nanodevices such as nanosheet field-effect transistors, all-nanosheet capacitors, artificial ferroelectrics, multiferroics, etc. Our work is a proof-of-concept effort, showing that high-performance nanodevices can be made from "nanosheet architectonics."



(Left) Crystals displaying huge hydration swelling
(Right) Delaminated titanium oxide nanosheets



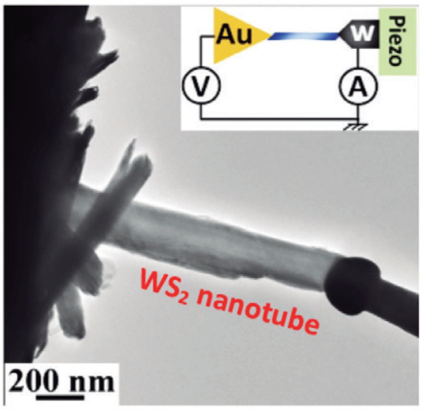
Schematic illustration of nanosheet-based capacitor

Pioneering development of *in situ* transmission electron microscopy techniques

Nanomaterials are in the forefront of Materials Science over the last decades. Their intriguing mechanical, electrical, thermoelectric, electrochemical, magnetic, piezoelectric, ferroelectric, and photovoltaic properties continuously excite scientists and engineers. However, the nanomaterial property studies have been performed using instruments and methods having no direct access to the material internal structure, but rather to only its surface. This has significantly limited the relevance of the collected data since all peculiar inner structural features of a nanomaterial before, during and after testing have been largely hidden.

Keeping in mind the pre-existing drawbacks, MANA developed the state-of-the-art *in situ* analytical methods of nanomaterial property measurements inside a high-resolution transmission electron microscope (TEM) for the first time. These were designed and implemented for mechanical, electrical, thermal, optical, optoelectronic, and cathodoluminescence characterizations of various nanoscale nitrides, oxides, sulfides, selenides, phosphides, and carbides. In the result, high spatial (down to 170 pm), energy, and temporal resolution capabilities, only achievable in the modern high-resolution TEMs, were merged with new possibilities for delicate nanomanipulations (with a precision better than 1 nm) and electromechanical, thermal, and optical probing of diverse nanostructures using piezo-driven stages and optical fibers inserted into a TEM column. With our high-resolution TEM, for example, Young's modulus, tensile strength, and fracture toughness of carbon, boron nitride, and tungsten disulfide nanotubes and nanosheets, and silicon, zinc oxide, sulfide, and gallium nitride nanowires were directly and unambiguously measured for the first time

Clear atomic structure–functional property relationships were established, which is the "Holy Grail" of the material "nanoarchitectonics" concept and the entire material science field.



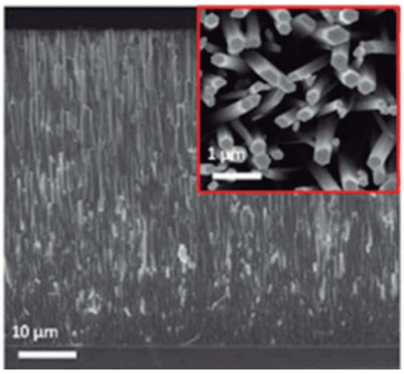
Low-magnification TEM view of the assembled in situ setup featuring an individual tungsten disulfide nanotube stretched and electrically tested between the two metal electrodes

Piezotronics and piezophototronics: novel nanomaterials and nanodevices

MANA has pioneered in exploring the effect of piezopotential on the transport behavior of charge carriers in electronic and optoelectronic nanodevices, aiming at using nanotechnology to achieve sustainable self-sufficient micro/nano-systems in future electronics. Piezoelectricity is the effect of electrical potential build-up inside material under strain, which has been known for centuries. Natural materials with the largest piezoelectric coefficients usually have perovskite structures, which have been widely utilized in electromechanical sensors, actuators, and energy harvesters. However, since these materials are usually insulators, they are not very useful when coupled with electronic devices. Then our study involves coupling the piezoelectric property of wurtzite materials, which are semiconducting materials including ZnO, GaN, InN, and CdS, to the study of electronics and optoelectronics to enable the control of carrier transport through strains/forces.

As a result, 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. A full understanding of the theory of piezotronics to enable novel applications requires investigation of the feasibility of novel materials/structures, for example, p-type piezoelectric semiconductors, n–p homojunctions, etc.

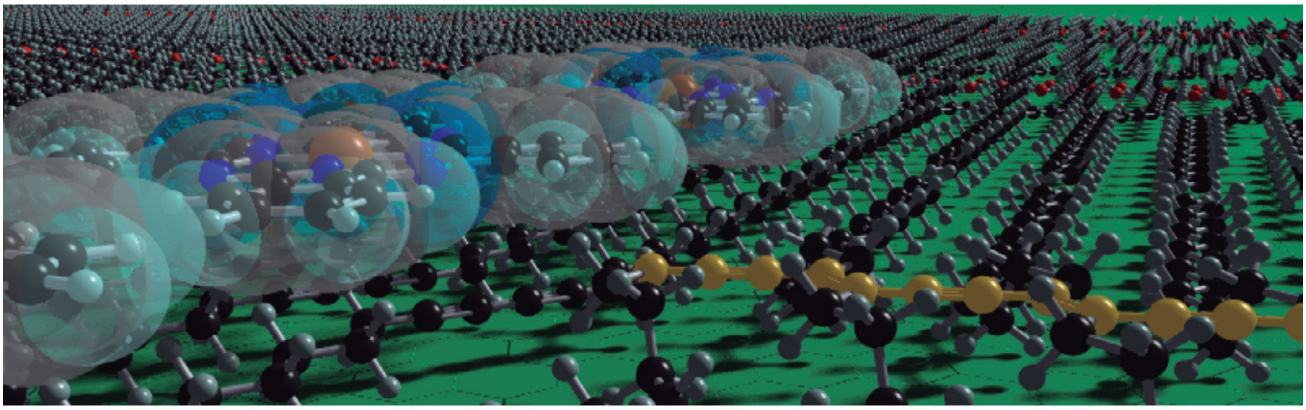
For ZnO nanomaterials, MANA first successfully demonstrated the growth of ultralong p-type ZnO nanowires up to 60 μm in length using a low-temperature solution growth method. We performed the first reported investigation of the piezotronic effect in p-type ZnO and further demonstrated the sensing and energy harvesting applications of p-type piezotronic devices. Furthermore, we developed several novel materials/structures such as ZnO p–n homojunctions, and heterojunctions. The research results indicate potential applications in strain/force-triggered electronic devices, sensors, and logic units.



p-Type ZnO nanowires grown

02 *Research Field :* Nano-System

New Nano-Systems are Changing the World: From Artificial Intelligence to Energy and the Environment, Diagnosis and Medicine



High-performance gapless atomic switch and related novel devices

An "atomic switch" is a switching device that operates through the transference of metallic atoms/ions and a redox process, which occur when a voltage is applied. The initial atomic switch, which was invented by MANA Director-General Masakazu Aono, et al., has a structure in which a gap of approximately 1 nm exists between a metal needle and surface, which function as electrodes. The device requires an extremely small amount of power to start up.

MANA developed a gapless-type atomic switch following the invention of a gap-type atomic switch, in order to create next-generation nanodevices which are essential to upgrade information and communication technology. Especially, our gapless-type atomic switch is utilized to innovate the field-programmable gate array (FPGA), one of the most advanced IC chips. The novel FPGA is vastly improved in functionality and production cost, which is about 1/4 in chip size and 1/3 in power consumption, and is unaffected by interference from strong electric noises or cosmic rays when used in a robot or an artificial satellite. FPGAs incorporating numerous gapless atomic switches are near commercialization.

In addition, the gapless-type atomic switch allowed the development of multiple-valued nonvolatile memory using quantized conductance. We observed quantized conductance by controlling an atomic point contact between a metal filament and an electrode in our gapless-type atomic switch with a simple metal–insulator–metal layered structure. Furthermore, MANA created an all-solid-state electric double-layer transistor (EDLT) based on a nanoionic device and modulated superconducting critical temperature (Tc) with the EDLT. This operation utilizing local ion migration control is derived also from the atomic switch principle.

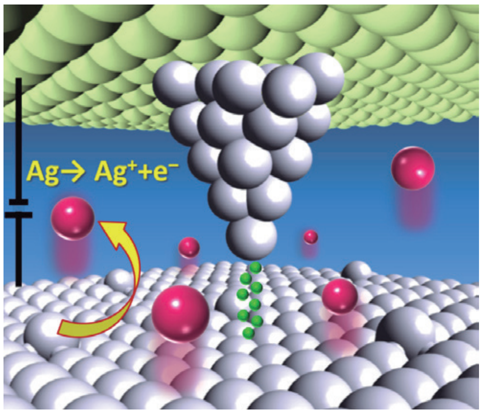


Fig. 1 Schematic illustration of a gapless-type atomic switch.A conductive path of Ag atoms is formed in a solid electrolyte between electrodes.

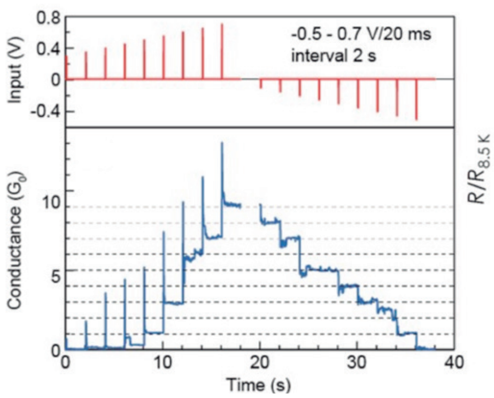


Fig. 2 Increase and decrease in quantized conductance by applying positive and negative pulse bias.

Exploring new frontiers of materials science in terms of topology

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 this regard, MANA is developing a new approach coined "topological nanoarchitectonics." Topology is a mathematical concept describing the way of connection of an object invariant under continuous deformation. Recently, it was discovered that electronic states of materials carry nontrivial topology, which ensures stable quantum properties desired for important implications.

One example of our approach is the quest for zero-energy Majorana bound states (MBS) in topological superconductors, which satisfy non-Abelian statistics and can be exploited for robust quantum computation. Majorana fermion is special because it is equivalent to its own antiparticle, which was proposed to explain the charge-neutral neutrino. While Majorana fermion remains illusive as an elementary particle even after 80 years of research, in the past decade it was clarified theoretically that quasiparticles in topological superconductors behave similarly to Majorana fermions. A world-wide race is underway to confirm their existence experimentally.

We focused on the heterostructure of a s-wave superconductor $NbSe_2$ and a three-dimensional topological insulator Bi_2Te_3 as shown schematically in Fig. 1. Solving Bogoliubov-de Gennes equation, we found two MBS with exactly zero energy inside the superconducting vortex. We clarified that, because of the unique spin dependence in quasiparticle wavefunctions in the present topological superconducting state, the ratio between spectra in spin-up and -down channels should exhibit a checkerboard-type pattern as shown in Fig. 2. With a spin-polarized STM tip, one can resolve experimentally the zero-energy MBS. Hopefully MBS will be captured in the near future as isolated quantum states, and exploited for robust quantum computation.

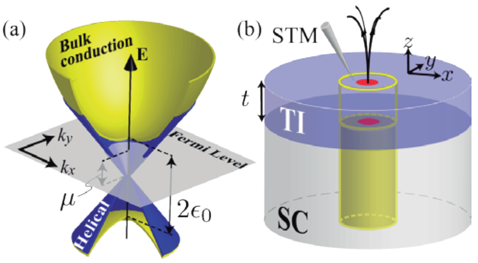


Fig. 1: (a) Schematic of the dispersion relation of three-dimensional topological insulator (TI), and (b) the heterostructure of TI-superconductor. The red dots in (b) represent MBS.

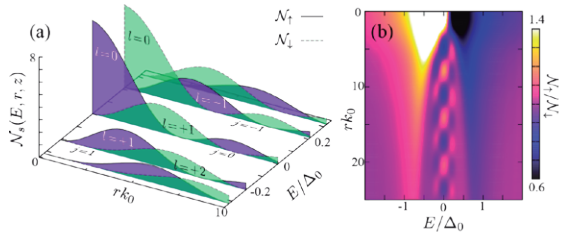


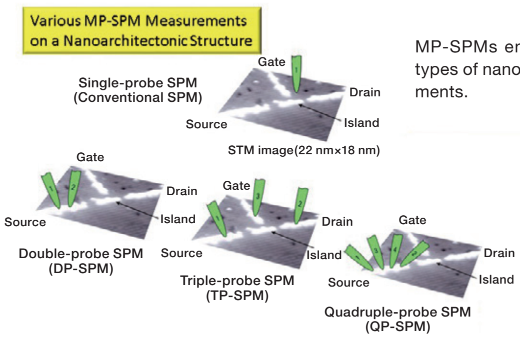
Fig. 2: (a) Wavefunctions of low-energy quasiparticle excitations, and (b) checkerboard-type pattern in the ralative spectrum of spin-up and –down channels.

Multiple-probe scanning probe microscopes for material nanoarchitectonics

The novel properties of individual nanostructures and nanosystems, the outgrowth of material nanoarchitectonics, must be characterized by using innovative instruments and methodologies. For this purpose, MANA developed novel multiple-probe scanning probe microscopes (MP-SPMs) including a multiple-probe scanning tunneling microscope (MP-STM) and multiple-probe atomic force microscope (MP-AFM). High-resolution imaging of an object to be measured, precisely controlled and reproducible point-contact formation, and accurate interprobe distance estimation are all indispensable advantages of MP-SPMs compared with other characterization methods.

MP-SPMs equipped with two to four individually driven probes are used for imaging nanostructures of interest and for performing multiprobe electrical measurements by direct contact between the same probes and a single nanostructure or a nanoarchitectonic system. For example, a single-walled carbon nanotube (SWCNT) on SiO_2 was imaged by two probes of our MP-STM, and the length of the electron meanfree-path of the SWCNT was directly measured to be about 500 nm at room temperature.

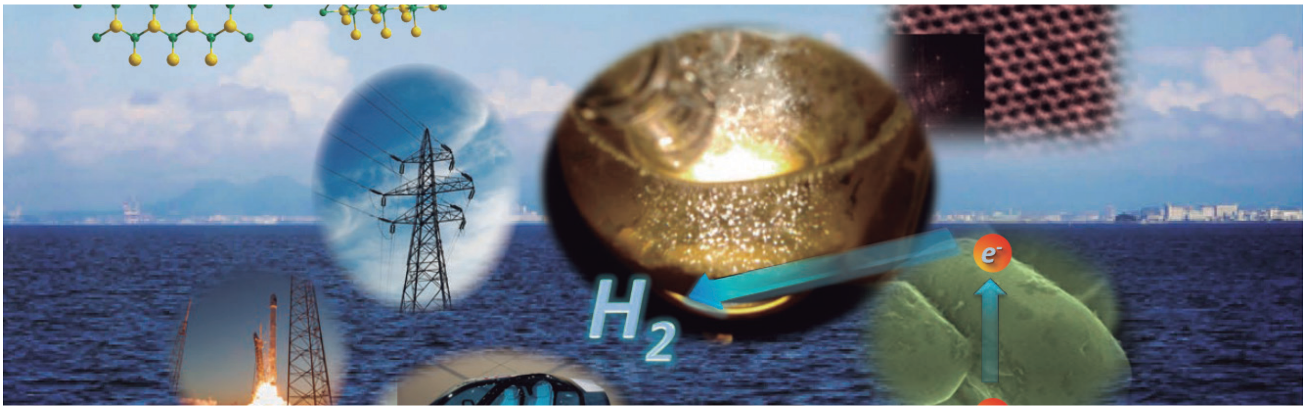
Furthermore, we have recently implemented a noncontact potential mapping function (Kelvin probe force microscopy [KFM]) in our MP-AFM. In general, quadruple-probe measurements prevent the effects of contact resistance when an area sufficiently larger than the interprobe distance is dealt with. Our MP-AFM can not only perform quadruple-probe measurements at the nanometer scale but also realize contact-free electrical measurements using two AFM probes for flowing a current through a target object and one KFM probe to map the potential variation over the object. This feature is extremely important when characterizing nanoarchitectonic systems because such systems should exhibit structural and functional variation over the entire system. This means that we established a new class of nanoscale measurements to perform unique, indispensable nanomeasurements.



MP-SPMs enabling various types of nanoscale measurements.

03 *Research Field :* Nano-Power

High Efficiency Materials and Energy Conversion System for a Sustainable Society



Artificial photosynthesis: nature-inspired nanoarchitectonics for efficient solar–chemical conversion

MANA has been challenging artificial photosynthesis, which offers potential solutions for global warming and energy shortage issues. Especially, for example, new material Ag_3PO_4 with the world's highest quantum efficiency, approaching that of natural photosynthesis, in photocatalytic water oxidation has been synthesized by a unique material-designing guideline.

As nature-inspired nanoarchitectonics, we have developed a unique strategy for constructing a promising 3D artificial photosynthetic system (APS) for efficient CO_2 photoreduction into hydrocarbon fuels. A natural leaf is a synergy of complex architectures and functional components to produce an amazing bio-machinery for photosynthesis. By using leaves of cherry tree as the template, we have successfully fabricated perovskite titanates (e.g. $SrTiO_3$, $CaTiO_3$), which preserves the morphological features of leaf at multi-scaled levels. It was found that leaf-architectured $SrTiO_3$ exhibits about a 3.5~4 fold improvement in activities than the referenced $SrTiO_3$ synthesized without templates, which can be attributed to the synergistic effect of efficient mass flow/light harvesting network relying on the morphological replacement of the 3D architecture of the concept prototype-leaf.

MANA also successfully developed a prototype basic artificial photosynthetic unit by mimicking the nanoscale level structure of natural photosynthesis, which occurs in the nanolayered thylakoids stacks where photosynthetic pigments, functional proteins, electron carriers, and cofactors are precisely arranged. By interfacing a triple junction, with polymeric g-C_3N_4 as an active water-splitting and CO_2 reduction photocatalyst, Au nanoparticles as a co-catalyst, and zeolitic imidazolate frameworks (ZIF-9) as an electron mediator as well as CO_2 activator, we have realized an efficient conversion of solar energy into hydrocarbon fuels and hydrogen. Sophisticated control of the surface/interface structure to mimic the structural and functional elements in nature enables to make a big step toward achieving high-efficiency artificial photosynthesis.

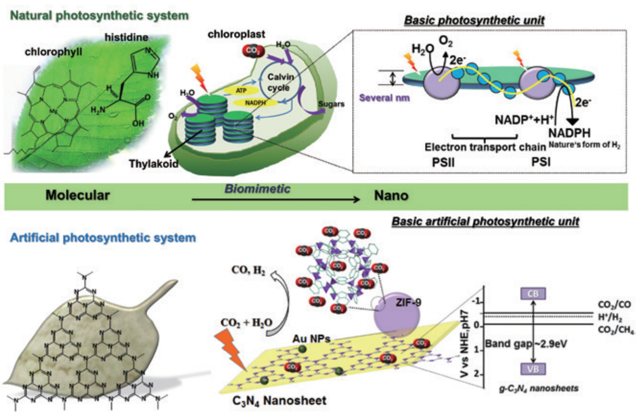


Fig. Schematic illustration and comparison of natural photosynthetic system and artificial photosynthetic system. (a) A natural leaf with abundant nonmetallic elements at the most fundamental (molecular) level. (b) A simplified scheme of the light-driven reactions of photosynthesis in a chloroplast. (c) Basic photosynthetic unit. (d) Molecular structure of polymeric g-C_3N_4. (e) Artificial photosynthesis on the basic artificial photosynthetic unit.

Novel thermoelectric materials toward wide-scale power generation from waste heat

Close to two-thirds of all fossil fuels consumed is lost in the form of waste heat. Thermoelectrics represent conversion of part of this huge amount of energy in the form of useful solid-state conversion, but are still not widely applied because of insufficient material performance and various material and other factors. MANA reported several striking results that are breakthroughs in resolving some critical issues.

MANA achieved novel nanostructuring by utilizing phase diagrams to create surprisingly controlled, effective porosity in a material. This led to effective phonon-selective scattering and a >100% increase in the thermoelectric figure of merit ZT in the champion skutterudite material. High ZT is achieved without using rare earths and without depending on conventional "rattling" phenomena. This means that our novel method keeps material costs and risks low, and improves oxidation resistance beneficial to scaling up production.

As a novel principle, MANA also discovered enhanced thermoelectric properties in magnetic semiconductors like chalcopyrite. Electron–magnon (quasiparticles related to the oscillation of the magnetic moment in magnetic materials) interaction and large effective masses are indicated to enhance the Seebeck coefficient, which contributes to increase in the thermoelectric figure of merit ZT. We propose that magnetism can be a new effective tuning mechanism for thermoelectrics, superior to conventional band engineering that is difficult in actual application.

Furthermore, novel nitrides isoelectronic to well-studied thermoelectric oxides were investigated, and superior properties and interesting anisotropy were revealed, yielding a promising group of new materials. Novel borides like yttrium aluminoboride and Zr-doped beta-boron were also developed with excellent p, n control characteristics and are being considered for high-temperature topping cycles to enhance the output of power plants.

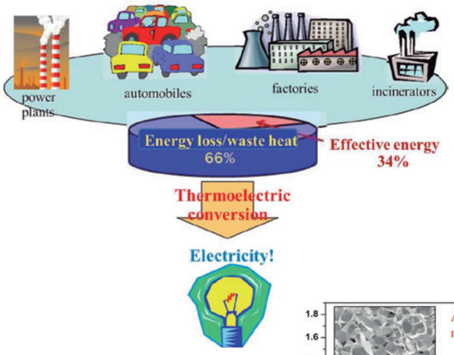


Fig. 1. Image of primary energy consumed by mankind and benefit of thermoelectrics. Only one-third of energy is effectively utilized, with the majority of loss being waste heat.

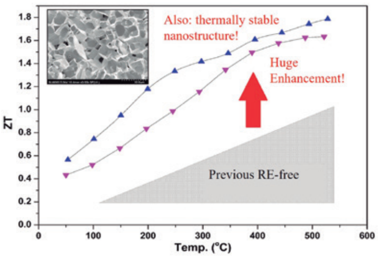


Fig. 2. Figure of merit *ZT* of nano-microporous structured skutterudite. The inset shows the microstructure (nanopores which make up the majority of pores are not directly visible in the picture).

Interface science for new energy technologies via supercomputer simulations

For next-generation batteries, solar cells, and catalysts, understanding and designing the "interfaces between electrodes and electrolytes" are indispensable because electron transfer as well as ion transport at the interfaces govern the performance and reliability of energy storage and conversion. However, the atomic and electronic processes at the buried interfaces are still open questions because of the difficulties in in-situ experimental observations as well as accurate calculations.

Quantum mechanics-based first-principles calculation techniques, which are computationally quite demanding, are necessary to examine the chemical reaction on the surfaces. In this regard, MANA successfully developed highly efficient first-principles sampling codes based on density functional theory for large-scale supercomputers like the K computer, a flagship supercomputer in Japan, and address the crucial issues about the interfaces in batteries, solar cells, and catalysts, in collaboration with leading experimentalists and industries.

Concerning battery issues, we demonstrated a new mechanism of the reductive decomposition of typical organic electrolytes and a novel mechanism called "near-shore aggregation" for the subsequent formation of solid electrolyte interphase (SEI) film on the electrode interface. We also clarified the origins of improved redox stability and fast ion transport in superconcentrated electrolytes, which have attracted considerable interest recently. Probable interfacial structures and the expected functions for dye-sensitized solar cells and perovskite solar cells were also demonstrated. These findings on complicated rare events allow the establishment of a new field, microscopic interface science. Besides, our computational research may play a decisive role in the transition of energy management in society.

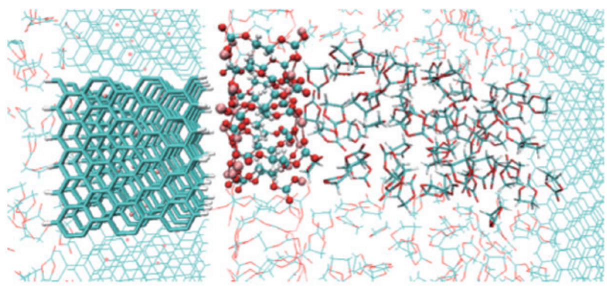
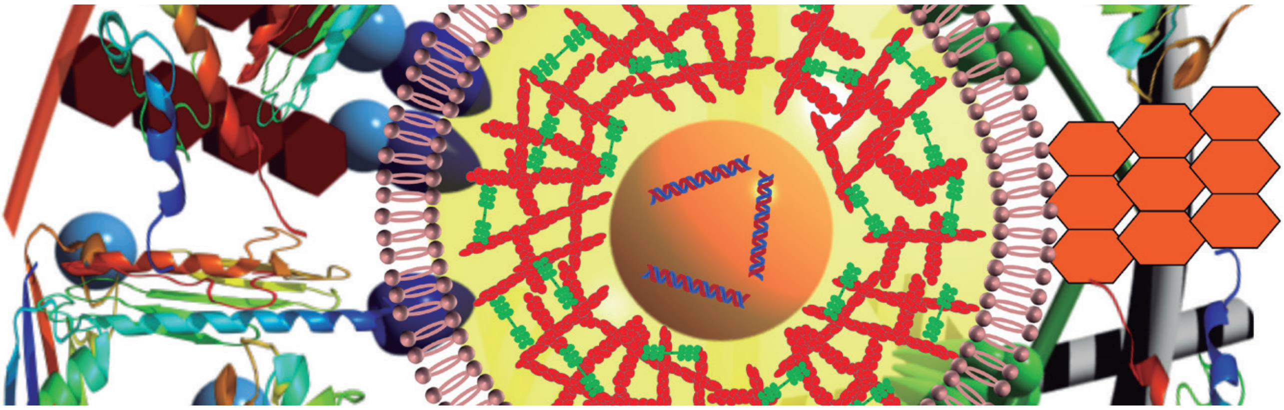


Fig. Calculated probable "Solid Electrolyte Interphase (SEI)" film model in Li-ion battery (LIB).

04 *Research Field :* Nano-Life

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



— MANA's Research Topics —

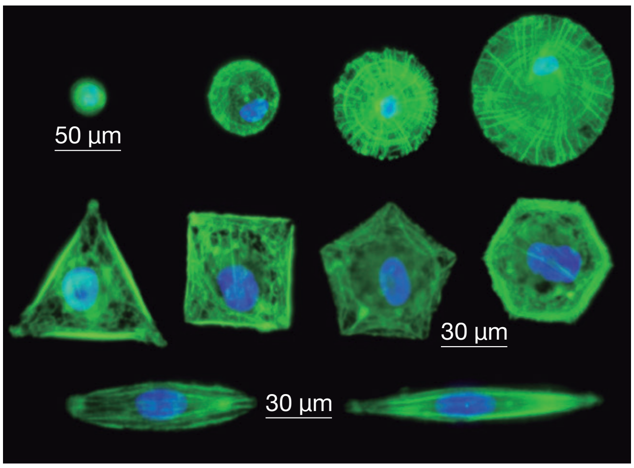
Nano- and microstructured biomaterials for regenerative medicine

By combining cells, biomaterial scaffolds, and bioactive molecules, tissue regeneration has been shown to be a promising therapeutic approach in treating disease and injury. Especially, biomaterial scaffolds, which are the materials where cells adhere, give physiochemical and biological cues to control cell functions for functional tissue regeneration. Ideally, biomaterial scaffolds should provide the same nano- and microenvironments for seeded cells as those of extracellular matrices (ECMs) existing *in vivo*.

MANA successfully developed a few types of highly functional biomaterials that mimic the nanostructured microenvironments surrounding cells *in vivo*, which showed specific control of cell functions and promoted tissue regeneration.

For example, stepwise tissue development matrices that mimic the *in vivo* nanostructured developmental ECMs were prepared by decellularizing serially differentiated mesenchymal stem cells (MSCs). Furthermore, biomimetic porous scaffolds were prepared by 3D culture of cells in a selectively removable polymer template. Autologous ECM scaffolds prepared by this method showed minimal host tissue responses during implantation. These biomimetic nanostructured matrices and scaffolds are useful for tissue regeneration and basic biological research.

A novel method using pre-prepared ice particulates as living porogen materials was developed to control precisely the pore structures of biomaterial scaffolds. Micropatterned porous scaffolds can be used for regeneration of cartilage, skin, capillary, and muscle tissues. We also developed various types of micropatterns by photolithography controlling cell size, shape, and aspect ratio in order to investigate their effects on stem cell functions. Stemness, nanomechanical properties, cell/nanomaterial interactions, and cell differentiation were investigated using the ingeniously designed micropatterns. The micropatterned cells showed different behaviors, indicating that the cell morphology regulated by micropatterns played critical roles in stem cell fate determination.



Stem cell morphology controlled by micropatterns with various geometries.

Novel antioxidative nanomedicine for Alzheimer's disease

Aging increases the risk of neurodegenerative diseases such as Alzheimer's disease (AD), which mostly affect quality of life in the elderly. Oxidative stress caused by overproduction of reactive oxygen species (ROS) is a well-known direct cause of aging. With advancing age, the production of ROS dramatically increases, and endogenous antioxidants fail to scavenge all ROS completely, followed by production of oxidative components.

An increase in oxidative stress in the brain is reported to be involved in aging-related neural dysfunction and/or learning and memory deficiency. Although the promising low-molecular-weight (LMW) antioxidant vitamin E was reported to show slight or no efficacy such as slowing of functional decline in clinical trials in AD, complete recovery was not observed. Since the LMW antioxidants internalize easily in healthy cells and disturb important redox reactions such as the electron transport chain, their effective dosage cannot be administered.

To prevent such adverse effects of antioxidants, MANA designed a novel polymer antioxidant as shown schematically in the Fig. The amphiphilic character of the polymer antioxidant forms core-shell-type nanoparticles (RNPs), which prevents internalization in healthy cells and markedly decreases undesired adverse effects. We investigated whether scavenging of ROS in the brain by orally administered RNPs facilitates the recovery of cognition in 17-week-old senescence-accelerated-prone mice. After treatment for 1 month, levels of the oxidative stress in the brains of the mice were remarkably reduced compared with those in mice treated with 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. This means that our antioxidative nanomedicine is promising for new dementia therapeutics including AD.

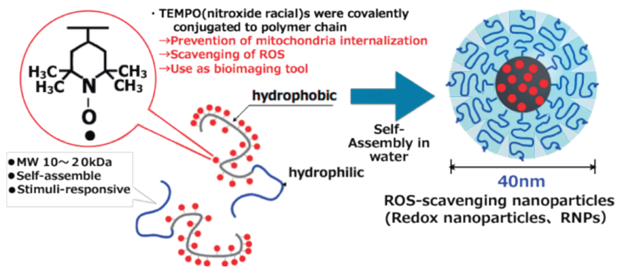


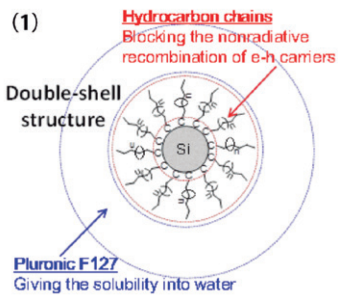
Fig. Design of the antioxidative nanomedicine

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

Semiconductor quantum dots (QDs) are brightly luminescent nanoparticles (NPs) that have found numerous applications in bioanalysis and bioimaging. Water-borne photostable semiconductor QDs of tunable emission wavelength and high PL-QYs are commonly used as imaging agents *in vitro* and in small animal studies. However, QDs emitting between 700 and 950 nm, the so-called first biological optical window, contain toxic elements, such as lead and mercury, a cause for concern within the scientific community. Silicon nanocrystals (ncSi) have emerged as potential alternatives to semiconductor QDs in view of their outstanding photophysical characteristics, high photostability, and very low toxicity.

MANA has reported new octadecyl-terminated silicon nanocrystals (ncSi-OD) based biomarkers adapted for two-photon fluorescence cellular imaging in the near-infrared (NIR) range. They have narrow photoluminescence (PL) spectra free of emission tails and are continuously tunable over the NIR biological window. As shown schematically in Fig. (a), the water-borne NPs consist of a core-double-shell structure where the core consists of individual ncSi covalently bound to hydrocarbon chains (ncSi-OD), coated with an amphiphilic shell made of a Food and Drug Administration-approved amphiphilic polymer that provides water dispersibility. Their PL quantum yields (QYs) exceed 30% and their PL lifetimes are 300 μsec or longer.

The NPs retained their colloidal stability and emission characteristics for extended periods under physiological conditions in the presence of serum albumin, the major blood protein. *In vitro* two-photon fluorescence imaging with NIR excitation confirmed that the double-shelled NPs were internalized by NIH3T3 cells and did not penetrate the cell nucleus. The first demonstration of functional NIR-emitting water-dispersible ncSi-based NPs will open up many interesting possibilities in bioimaging and theragnostics in the near future.



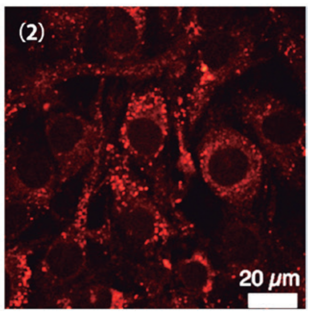
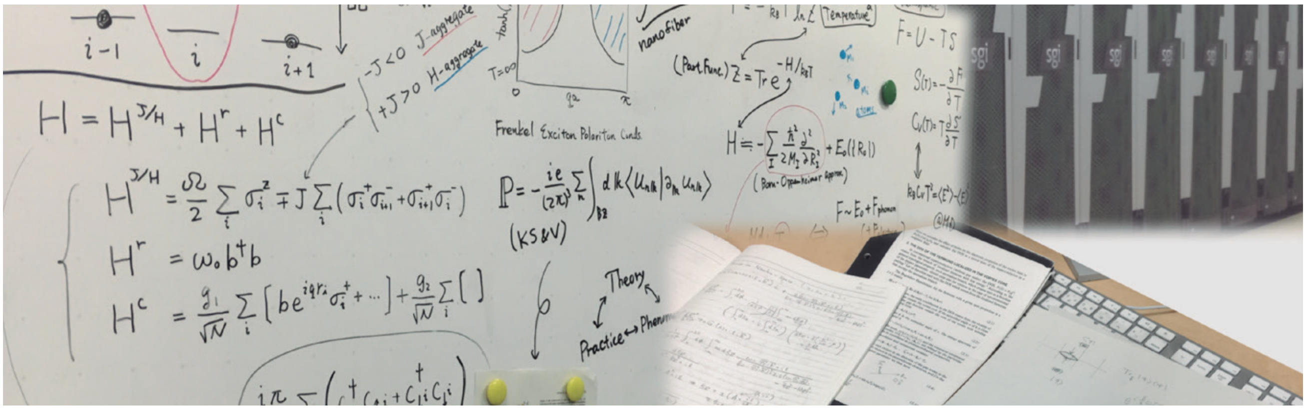


Fig. 1. Double-shelled structure of water-borne ncSi-based NPs
Fig. 2. Micrograph of NIH3T3 cells observed by confocal fluorescence microscopy.

05 *Research Field :* Nano-Theory

Understanding phenomena in the nanospace region, predicting new phenomena and creating novel nanostructured materials



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

The control and growth of semiconductor microstructures and nanostructures have driven the modern electronics industry. As device sizes shrink, an atomistic description of the structure of surfaces and interfaces in semiconductor nanostructures is becoming increasingly valuable.

First-principles calculations based on density functional theory (DFT) are a powerful tool that can provide reliable information on the atomic positions and electronic structures of materials independently from experiments. However, since the cost of DFT calculations is expensive and increases rapidly with the cube of the number of atoms N, it is almost impossible to treat systems containing more than a few thousand atoms by using standard DFT implementations. Thus, it was very difficult to model practical nanoscale devices by DFT methods.

To overcome this problem, in collaboration with UCL, MANA developed a linear-scaling DFT code, CONQUEST, for which the computational cost is only proportional to N. With CONQUEST, we can perform robust, accurate electronic structure calculations, including structural relaxations and molecular dynamics, on very large systems containing more than one million atoms.

Using CONQUEST, MANA conducted collaborative theory-experimental research on Ge/Si core-shell nanowires, which are a promising material for next-generation vertical transistors. Experimentally, we can control the radius of the core and thickness of the shell of the nanowires with high crystallinity. The properties of the core-shell nanowires are expected to depend strongly on the size, interface between Si and Ge, impurity distribution, and other structural factors. With CONQUEST, we succeeded in calculating the strain distribution in the nanowires and electronic structure near the Fermi level. Based on those calculated results, we synthesized Ge/Si core-shell nanowires and found conclusive evidence of hole gas accumulation in the core-shell nanowires experimentally.

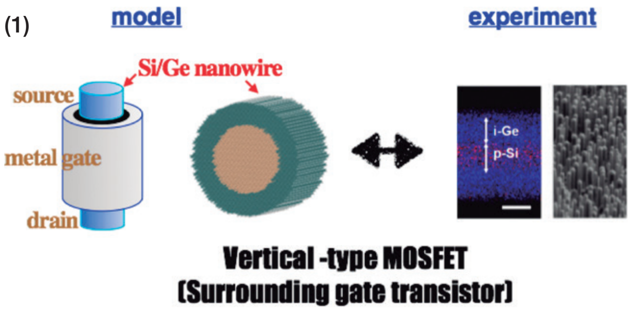


Fig. 1 Atomic models of Si/Ge core-shell nanowire (model), along with TEM and SEM images (experiment).

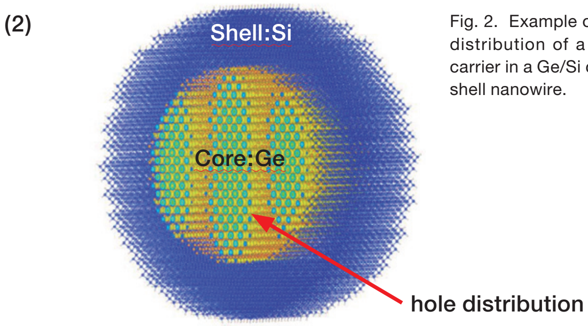


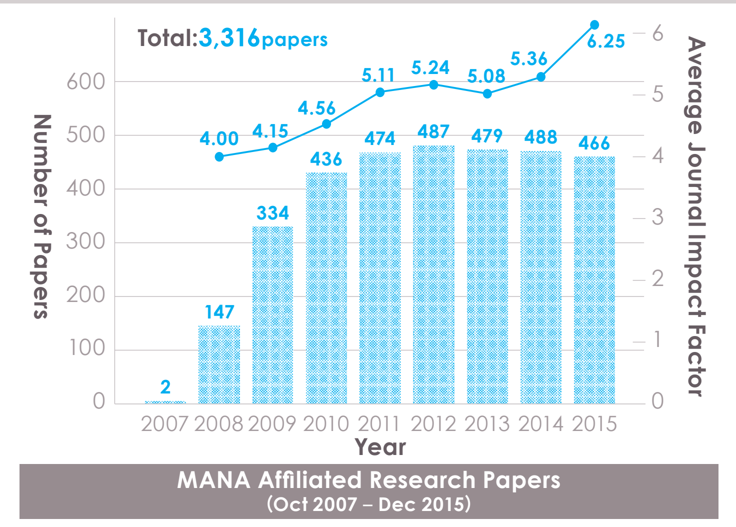
Fig. 2. Example of the distribution of a hole carrier in a Ge/Si core-shell nanowire.

Facts & Figures

Here, we will introduce MANA's activity records from 2007 to 2017.

Number of papers

In 2015, MANA researchers published a total of 466 papers. The average impact factor※ of the journals in which these papers were published was 6.25 in 2015, which reflects the high quality of research results at MANA.



TOP 1% papers
Highly Cited Researchers

Among all 3,316 papers published by MANA by 2015, 118 papers are highly cited papers (Top 1% papers), which is defined based on the database of Thomson Reuters. In 2014 and 2015, 5 Researchers; Katsuhiko Ariga, Yoshio Bando, Dmitri Golberg, Zhong Lin Wang, and Omar Yaghi, and in 2016, 6 researchers; Katsuhiko Ariga, Yoshio Bando, Dmitri Golberg, Yusuke Yamauchi, and Zhong Lin Wang were elected as "Highly Cited Researchers", the authors of highly cited papers.

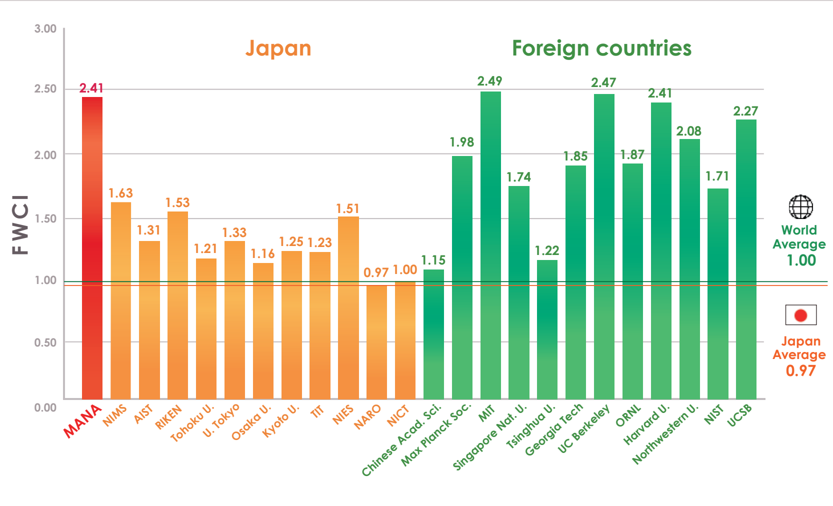
Patents

The total number of patents acquired by MANA reached 581 in 2015. This shows the breadth of potential in nanomaterials, and MANA's proactive approach to the development of new technology, spanning from basic research to applied research.

※Impact factor: The degree of influence is measured and numerically expressed based on the frequency of citation of published articles in scholarly journals.

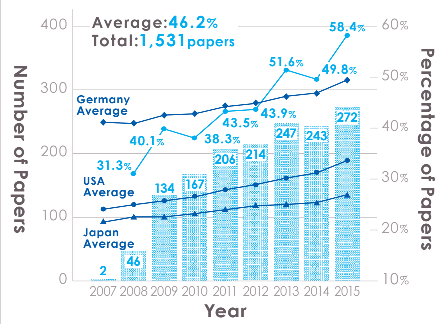
FWCI (Field-Weighted Citation Impact)

FWCI (Field-Weighted Citation Impact) is a new index created by Elsevier B. V., which shows how the number of citations of a group compares with the world average for similar publications, normalized for the research field across the world. MANA's FWCI of 2.42 is extremely high and reached a level of performance comparable to top-ranked universities in the world.



Internationally co-authored papers

The number of international co-authored papers released by MANA has been increasing each year. More than half of the total number of papers since 2013 have been internationally co-authored. The proportion of internationally co-authored papers in 2015 reached 58.4%.



Internationally co-authored papers from MANA
(Oct 2007 – Dec 2015)

Joint Graduate School Program

In the program, NIMS researchers managing independent specialties or affiliated with existing specialties in graduate schools which have concluded cooperation agreements with NIMS, advise doctoral course students as teachers. As of now, 115 students are engaged in research to get the degrees at MANA under the program.

- Doctoral Program in Materials Science and Engineering, University of Tsukuba (established in April 2004)
- Functional Materials Chemistry Unit, Hokkaido University (established in May 2008, reorganized in April 2010)
- Frontier Biomaterials Science, Hokkaido University (established in September 2008)
- Advanced Functional Materials and Physics, Hokkaido University (established in May 2009)
- Major in Nanoscience and Nanoengineering, Waseda University (established in December 2008)
- Course of Advanced Nanotechnology and Engineering, Kyushu University (established in April 2009)

Cooperative Graduate School/ International Cooperative Graduate Program

Under the program, NIMS researchers are entrusted to serve as Visiting Professors of graduate schools which have cooperative agreement with NIMS, and advise graduate students until they receive their academic degrees through advanced research in NIMS. NIMS has concluded cooperative agreements with 33 graduate schools in Japan and 19 international leading universities. To date, 107 students have received guidance at MANA.

Cooperative Graduate Schools

- **Tsukuba University** Doctoral Program
- **Tokyo University of Science**
  Graduate School of Science, Graduate School of Science and Technology, and Graduate School of Industrial Science and Technology
- **Chiba Institute of Technology**
- **Tokyo Institute of Technology**
  Interdisciplinary Graduate School of Science and Engineering, Interdisciplinary Graduate School of Science and Engineering
- **Kyushu University**
  Interdisciplinary Graduate School of Engineering Science
- **Aoyama Gakuin University**
  Graduate School of Science and Engineering
- **Waseda University**
  Faculty of Science and Engineering
- **Kanazawa Institute of Technology**
  Graduate School of Engineering
- **Okayama University**
  Graduate School of Natural Science and Technology
- **Shibaura Institute of Technology**
  Graduate School of Engineering and Science
- **Hokkaido University**
  Graduate School of Information Science and Technology, Faculty of Engineering
- **Yokohama National University**
  Graduate School of Engineering, Faculty of Engineering
- **Kagoshima University**
  Graduate School of Science and Engineering
- **Doshisha University** Graduate School of Science and Engineering
- **Tohoku University**
  Graduate School of Science, Institute of Multidisciplinary Research for Advanced Materials
- **Yokohama City University**
- **Tokyo Denki University**
- **Toyohashi University of Technology**
- **Kitami Institute of Technology**
- **Osaka Prefecture University**
  Graduate School of Engineering
- **Nagaoka University of Technology**
- **Kanazawa University**
- **Tokyo University of Agriculture Technology**
  Faculty of Engineering
- **Nagoya Institute of Technology**
  Graduate School of Engineering
- **Saitama Institute of Technology**
  Graduate School of Engineering
- **Ritsumeikan University**
  Graduate School of Science and Engineering
- **Toho University** Graduate School of Science
- **University of Yamanashi**
- **Meiji University** Graduate School of Science and Technology
- **Saitama University** Graduate School of Science and Engineering
- **Ochanomizu University**
- **Chiba University** Graduate School of Engineering
- **Chuo University** Graduate School of Science and Engineering

International Cooperative Graduate Programs

- **Flinders University** (Australia)
- **Xian Jiaotong University** (China)
- **Charles University** (Czech Republic)
- **University of Pardubice** (Czech Republic)
- **Budapest University Technology Economics** (Hungary)
- **Anna University** (India)
- **Jawaharlal Nehru Center** (India)
- **Yonsei University** (Korea)
- **Universiti Teknologi Malaysia** (Malaysia)
- **Warsaw University of Technology** (Poland)
- **Moscow State University** (Russia)
- **National Taiwan University** (Taiwan)

MoUs

MANA has made MoUs (Memorandum of Understanding) with universities and research institutes. The international nanotechnology network around MANA has been formed through collaborative research and circulation of human resources.

2008

- **Kent State University, Department of Chemistry, USA** (January 10, 2008 – January 10, 2013)
- **Rensselaer Polytechnic Institute, Chemistry and Biological Engineering, USA** (February 28, 2008 – February 28, 2013)
- **University of California, Los Angeles (UCLA), USA** (March 24, 2008 – March 24, 2013)
- **Georgia Institute of Technology (GIT), Center for Nanostructure Characterization, USA** (March 6, 2008 – March 6, 2013)
- **CNRS, Centre d'élaboration de matériaux et d'études structurales (CEMES), France** (March 30, 2008 – March 30, 2013)
- **University of Cambridge, Nanoscience Centre, UK** (June 20, 2008 – June 20, 2013)
- **Indian Institute of Chemical Technology (IICT), India** (July 3, 2008 – July 3, 2013)
- **University of Basel, Institute of Physics, National Center of Competence for Nanoscale Science, Switzerland** (July 20, 2008 – July 20, 2013)
- **Yonsei University, Seoul, Korea** (September 1, 2008 – September 1, 2013)
- **Indian Institute of Science, Education and Research, India** (December 19, 2008 – December 19, 2013)

2009

- **University of Karlsruhe, Institute for Inorganic Chemistry, Supramolecular Chemistry Group, Germany** (January 29, 2009 – January 29, 2014)
- **Fudan University, Department of Chemistry, New Energy and Materials Laboratory (NEML), China** (March 16, 2009 – March 16, 2014)
- **Indian Institute of Technology Madras, National Centre for Catalysis Research (NCCR), India** (April 5, 2009 – April 5, 2014)
- **University of Cologne, Institute of Inorganic Chemistry, Inorganic and Materials Chemistry, Germany** (May 28, 2009 – May 28, 2014)
- **École Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering, Switzerland** (July 20, 2009 – July 20, 2014)
- **University of Rome Tor Vergata, Center for Nanoscience & Nanotechnology & Innovative Instrumentation (NAST), Italy** (July 30, 2009 – July 30, 2014)
- **University of Heidelberg, Kirchhoff Institute of Physics, Germany** (August 31, 2009 –August 31, 2014)
- **Loughborough University, UK** (October 28, 2009 –October 28, 2014)

2010

- **Lawrence Berkeley National Laboratory (LBNL), USA** (February 9, 2010 – February 9, 2015)
- **University of Valenciennes, France** (May 20, 2010 – May 20, 2015)
- **Friedrich-Alexander University, Erlangen-Nürnberg, Germany** (June 21, 2010 – June 21, 2015)
- **Fudan University, Department of Materials Science, China** (July 23, 2010 – July 23, 2015)
- **EWHA Womans University Seoul, Department of Chemistry and Nanoscience, Korea** (August 27, 2010 – August 27, 2015)
- **Karlsruhe Institute of Technology, Germany** (September 16, 2010 – September 16, 2015)
- **Univesité de la Méditerranée, Marseille, France** (September 20, 2010 – September 20, 2015)
- **Anhui Key Laboratory of Nanomaterials and Nanostructures, China** (October 6, 2010 – October 6, 2015)
- **Multidisciplinary Center for Development of Ceramic Materials, Brazil** (October 26, 2010 – October 26, 2015)

2011

- **Vietnam National University Ho Chi Minh City, Vietnam** (January 24, 2011 – January 24, 2016)
- **King Saud University, Saudi Arabia** (January 25, 2011 – January 25, 2016)
- **LMPG, Grenoble, France** (February 1, 2011 – February 1, 2016)
- **Université de Montréal (UdeM), Canada** (July 4, 2011 –)
- **Flinders University, Australia** (July 19, 2011 -)

2011

- **University of Melbourne, Australia** (September 21, 2011 -)
- **Shanghai Institute of Ceramics, China** (December 1, 2011-)

2012

- **Tsinghua University, China** (January 28, 2012 -)
- **Hanoi University of Science and Technology (HUST), Vietnam** (February 7, 2012 -)
- **University of Sao Paolo, Brazil** (April 25, 2012 -)
- **University College London (UCL), UK** (October 8, 2012 -)

2013

- **Kyungpook National University, Korea** (January 18, 2013 – September 27, 2014)
- **Centre Interdisciplinaire de Nanoscience de Marseille (CINaM-CNRS), France** (May 2, 2013 -)
- **National Center for Nanoscience and Technology (NCNST), Beijing, China** (June 24, 2013 -)
- **Huazhong University of Science and Technology (HUST), China** (July 29, 2013 -)
- **Georgia Institute of Technology (GIT), Center for Nanostructure Characterization, USA (Renewal)** (November 25, 2013 -)
- **CNRS, Centre d'élaboration de matériaux et d'études structurales (CEMES), France (Renewal)** (December 10, 2013 -)

2014

- **St. Petersburg State Electrotechnical University (LETI), Russia** (February 28, 2014 -)
- **University of Bristol, Bristol Centre for Nanoscience and Quantum Information (NSQI), UK** (May 7, 2014 -)
- **University of California Los Angeles (UCLA), The California NanoSystems Institute (CNSI), USA (Renewal)** (September 8, 2014 -)
- **Donostia International Physics Center (DIPC), San Sebastian, Spain** (September 9, 2014 -)
- **Kyungpook National University, Korea (Replacement of MOU signed on 2013 Jan 18)** (September 27, 2014 -)
- **University of Eastern Finland, Finland** (December 31, 2014 -)

2015

- **Indian Institute of Science (IISc), Bangalore, India** (January 13, 2015 -)
- **University of Toronto, Canada** (January 21, 2015 -)
- **Chongqing University of Science & Technology (CQUST), China** (May 15, 2015 -)
- **Paul Drude Institute for Solid State Electronics (PDI), Germany** (May 29, 2015 -)
- **National Cheng Kung University (CKU), Taiwan** (May 20, 2015 -)
- **University of Washington (UW), USA** (September 15, 2015 -)
- **University of Science and Technology of Hanoi (USTH), Vietnam** (September 24, 2015 -)
- **University of Wollongong (UOW), Australia** (September 29, 2015 -)

2016

- **University of Chemistry and Technology (UCT), Czech Republic** (January 18, 2016 -)
- **University of Sydney, Australia** (February 16, 2016 -)
- **University of Messina, Department of Chemical, Biological, Pharmaceutical and Environmental Science, Italy** (June 30, 2016 -)
- **MacDiarmid Institute for Advanced Materials and Nanotechnology, New Zealand** (August 18, 2016 -)
- **Vidyasirimedhi Institute of Science & Technology (VISTEC), Thailand** (September 15, 2016 -)
- **Korea Institute of Science and Technology (KIST), Korea** (September 21, 2016 -)
- **Saigon High Tech Park (SHTP Labs), Vietnam** (October 17, 2016 -)
- **Queensland University of Technology (QUT), Australia** (November 25, 2016 -)

Awards

2008

- **02.07** **Alexei A. Belik, Independent Scientist and Pavuluri Srinivasu, ICYS-MANA Researcher** "Encouragement of Research in Materials Science Award" (The Materials Research Society of Japan)
- **05.07** **Ajayan Vinu, Independent Scientist** "The Asian Excellent Youngresearcher Lectureship Award 2008" (The Chemical Society of Japan)
- **06.01** **Yoshio Bando, COO** "The American Ceramic Society Fellow" (The American Ceramic Society)
- **07.09** **Kenji Kitamura, PI** "Inoue Harushige Prize" (Japan Science and Technology Agency)
- **07.16** **Takayoshi Sasaki, PI and Minoru Osada, MANA Scientist** "2008 Tsukuba Prize" (The Science and Technology Promotion Foundation of Ibaraki)
- **09.18** **Kohei Uosaki, PI** "ISE Fellow" (Interantional Society of Electrochemistry)
- **09.25** **Masayoshi Higuchi, Independent Scientist** "SPSJ Hitachi Chemical Award" (The Society of Polymer Science, Japan)

2009

- **03.28** **Ajayan Vinu, Independent Scientist** "CSJ Award for Young Chemists" (The Chemical Society of Japan)
- **04.14** **Minoru Osada, MANA Scientist** "Young Scientists' Prize" (Minister of Education, Culture, Sports, Science and Technology)
- **05.08** **Kazuhiro Hono, PI** "2009 Honda Frontier Award" (The Honda Memorial Foundation)
- **05.19** **James K. Gimzewski, Satellite PI** "Fellow of the Royal Society" (The Royal Society)
- **09.25** **Jun Nakanishi, Independent Scientist** "The Japan Society for Analytical Chemistry Award for Younger Researchers" (The Japan Society for Analytical Chemistry)
- **09.29** **Kohsaku Kawakami, MANA Scientist** "JSCTA Award for Young Scientists" (The Japan Society of Calorimetry and Thermal Analysis)
- **10.05** **Kohei Uosaki, PI** "ECS Fellow Award" (The Electrochemical Society)
- **10.26** **Naoki Ohashi, PI** "Richard M. Fulrath Award" (The American Ceramics Society)
- **12.02** **Ajayan Vinu, Independent Scientist** "ICSB Award of Excellence" (Indian Society of Chemists and Biologists)

2010

- **02.04** **Yusuke Yamauchi, Independent Scientist** "Inoue Research Aid for Young Scientists" (Inoue Foundation for Science)
- **03.03** **Masayoshi Higuchi, Independent Scientist** "Marubun Academy Award" (Marubun Research Promotion Foundation)
- **03.21** **Masanori Kohno, MANA Scientist** "Young Scientist Award" (The Physical Society of Japan)
- **03.27** **Kohei Uosaki, PI** "The Chemical Society of Japan Award" (The Chemical Society of Japan)
- **04.01** **Yusuke Yamauchi, Independent Scientist** "The Ceramic Society of Japan Award" (The Ceramic Society of Japan)
- **04.13** **Katsunori Wakabayashi, Independent Scientist** "Young Scientists' Prize" (Ministry of Education, Culture, Sports, Science and Technology)
- **05.25** **Yoshihiro Tsujimoto, ICYS-MANA Researcher** "Research Progress Award" (Japan Society of Powder and Powder Metallurgy)
- **11.11** **Ajayan Vinu, Independent Scientist** "Friedrich Wilhelm Bessel Research Award 2010" (Alexander von Humboldt Foundation)
- **11.11** **Ajayan Vinu, Independent Scientist** "Catalysis Society of India Award 2010" (Catalysis Society of India)
- **12.21** **Kohei Uosaki, PI** "The Japanese Photochemistry Association Lectureship Award 2010" (The Japanese Photochemistry Association)
- **12.21** **Masakazu Aono, Director** "2010 Feynman Prize in Nanotechnology" (Foresight Institute)

2011

- **01.17** **Katsuhiko Ariga, PI** "Nice-Step Scientist (NISTEP) Award" (National Institute of Science and Technology Policy)
- **02.06** **Katsuhiko Ariga, PI** "ISCB Award for Excellence 2011" (Indian Society of Chemists and Biologists)
- **02.18** **Masayoshi Higuchi, Independent Scientist** "Gottfried Wagener Prize 2010" (German Innovation Award)

2012

- **01.23** **Françoise M. Winnik, Satellite PI** "Macromolecular Science and Engineering Award" (The Chemical Institute of Canada)
- **02.08** **Takayoshi Sasaki, PI** "29th CSJ Academic Prize" (The Chemical Society of Japan)
- **02.14** **Yoshio Bando, COO and Dmitri Golberg, PI** "3rd Thomson Reuters Research Front Award" (Thomson Reuters)
- **04.14** **Satoshi Tominaka, Independent Scientist** "Funai Research Incentive Award" (Funai Foundation for Information Technology)
- **07.25** **Yusuke Yamauchi, Independent Scientist** "Tsukuba Encouragement Prize" (The Science and Technology Promotion Foundation of Ibaraki)
- **10.09** **Zhong Lin Wang, Satellite PI** "Edward Orton, Jr. Memorial Lecture" (The American Ceramic Society)
- **12.17** **Kazuhito Tsukagoshi, PI** "JSPS Prize" (Japan Society for the Promotion of Science)

2013

- **04.02** **Yusuke Yamauchi, Independent Scientist** "PCCP Prize" (The Royal Society of Chemistry)
- **04.05** **Katsuhiko Ariga, PI** "Fellow of the Royal Society of Chemistry" (The Royal Society of Chemistry)
- **04.16** **Takayoshi Sasaki, PI** "Science and Technology Prize for Research in the MEXT Commendations for Science and Technology" (Ministry of Education, Culture, Sports, Science and Technology)

2013

- **04.16** **Alexei A. Belik, Independent Scientist** "Young Scientist's Prize in the MEXT Commendations for Science and Technology" (Ministry of Education, Culture, Sports, Science and Technology)
- **04.16** **Yusuke Yamauchi, Independent Scientist** "Young Scientist's Prize in the MEXT Commendations for Science and Technology" (Ministry of Education, Culture, Sports, Science and Technology)
- **05.29** **Francoise M. Winnik, Satellite PI** "International Award" (The Society of Polymer Science Japan)
- **09.03** **Genki Yoshikawa, Independent Scientist** "Tsukuba Encouragement Prize" (The Science and Technology Promotion Foundation of Ibaraki)
- **11.07** **Masakazu Aono, Director-General** "Nanoscience Prize" (ACSIN-12)
- **12.20** **Yusuke Yamauchi, Independent Scientist** "CSJ Award for Young Chemists" (The Chemical Society of Japan)

2014

- **03.27** **Takako Konoike, Independent Scientist** "Young Scientist Award" (The Physical Society of Japan)
- **03.29** **Lok Kumar Shrestha, MANA Scientist** "Distinguished Lectureship Award" (The Chemical Society of Japan)
- **04.11** **Lok Kumar Shrestha, MANA Scientists and Jonathan Hill, MANA Scientists** "The Award for Excellence at the Beauty in Science Technology Panel exhibition" (Japan Science and Technology Agency)
- **05.12** **Dmitri Golberg, PI** "JSM Seto Prize" (The Japanese Society of Microscopy)
- **05.26** **Kohei Uosaki, PI** "The Surface Science Society of Japan Prize" (The Surface Science Society of Japan)
- **06.18** **Katsuhiko Ariga, PI** "Highly Cited Researchers" (Thomson Reuters)
- **06.18** **Yoshio Bando, COO** "Highly Cited Researchers" (Thomson Reuters)
- **06.18** **Dmitri Golberg, PI** "Highly Cited Researchers" (Thomson Reuters)
- **06.18** **Zhong Lin Wang, Satellite PI** "Highly Cited Researchers" (Thomson Reuters)
- **06.18** **Omar Yaghi, Satellite PI** "Highly Cited Researchers" (Thomson Reuters)
- **09.17** **Kazuhito Tsujagoshi, PI and Katsuyoshi Komatsu, MANA Research Associate** "Paper Award 2014" (Japan Society for Applied Physics)

2015

- **01.28** **Genki Yoshikawa, Independent Scientist** "Project Prize" (nano tech 2015)
- **01.30** **Guoping Chen, PI** "Fellow of the Royal Society of Chemistry" (Royal Society of Chemistry)
- **03.09** **Satoshi Ishii, MANA Scientist** "Konica Minolta Imaging Science Encouragement Award" (Konica Minolta Science and Technology Foundation)
- **03.18** **Jin Kawakita, MANA Scientist** "The Japan Institute of Metals and Materials Meritorious Award" (The Japan Institute of Metals and Materials)
- **03.31** **Mitsuhiro Ebara, MANA Scientist** "Silver Award" (The Tanaka Precious Metals)
- **06.30** **Yoshitaka Tateyama, Group Leader** "Gottfried Wagener Prize" (German Innovation Award)
- **07.04** **Satoshi Ishii, MANA Scientist** "Ando Incentive Prize for the Study of Electronics" (The Foundation of ANDO Laboratory)
- **07.30** **Katsuhiko Ariga, PI** "Contribution Award" (Japan Society of Coordination Chemistry)
- **10.14** **Katsuhiko Ariga, PI** "Highly Cited Researchers" (Thomson Reuters)
- **10.14** **Yoshio Bando, COO** "Highly Cited Researchers" (Thomson Reuters)
- **10.14** **Dmitri Golberg, PI** "Highly Cited Researchers" (Thomson Reuters)
- **10.14** **Zhong Lin Wang, Satellite PI** "Highly Cited Researchers" (Thomson Reuters)
- **10.14** **Omar Yaghi, Satellite PI** "Highly Cited Researchers" (Thomson Reuters)
- **11.09** **Françoise M. Winnik, Satellite PI** "Urgel Archambault Prize" (Association francophone pour le savoir)
- **11.10** **Yukio Nagasaki, Satellite PI** "Nagai Award" (The Japan Society of Drug Delivery System)
- **11.11** **Mitsuhiro Ebara, MANA Scientist** "Scientific Incentive Award" (Japanese Society for Biomaterials)
- **12.02** **Mahito Yamamoto, MANA Research Associate** "Young Scientist Presentation Award" (The Japan Society of Applied Physics)

2016

- **01.04** **Christian Joachim, Satellite PI** "Europe's Rising Stars" (French Ministry of Higher Education and Research)
- **02.19** **Takao Mori, Group Leader** "Research Project Award (Green Nanotechnology Award)" (nano tech 2016)
- **02.19** **Uosaki Kohei, MANA PI** "CSJ Fellow" (The Chemical Society of Japan)
- **08.24** **Katsuhiko Ariga, PI** "Honorary Member of MRSI" (Materials Research Society of India)
- **09.01** **Takeo Minari, Independent Scientist** "KIDS Gold Award" (The Korea Information Display Society)
- **09.12** **Françoise M. Winnik, Satellite PI** "Fellow of the Royal Society of Canada" (The Royal Society of Canada)
- **09.29** **Yohio Bando, COO** "Fellow of the Royal Society of Chemistry" (The Royal Society of Chemistry)
- **09.29** **Jinhua Ye, PI** "Fellow of the Royal Society of Chemistry" (The Royal Society of Chemistry)
- **10.28** **Satoshi Ishii, Researcher** "R&D Encouragement Award" (NF Foundation)
- **11.28** **Katsuhiko Ariga, PI** "Highly Cited Researchers" (Thomson Reuters)
- **11.28** **Yoshio Bando, COO** "Highly Cited Researchers" (Thomson Reuters)
- **11.28** **Dmitri Golberg, PI** "Highly Cited Researchers" (Thomson Reuters)
- **11.28** **Yusuke Yamauchi, PI** "Highly Cited Researchers" (Thomson Reuters)
- **11.28** **Jinhua Ye, PI** "Highly Cited Researchers" (Thomson Reuters)
- **11.28** **Zhong Lin Wang, Satellite PI** "Highly Cited Researchers" (Thomson Reuters)
- **12.08** **Yusuke Yamauchi, PI** "Nice-Step Scientist (NISTEP) Award" (National Institute of Science and Technology Policy)

Conference & Symposium

2008

- Feb 22 — The 1st MANA Seminar entitled “Nanotechnology, a Key to Sustainability” was given by Dr. Heinrich Rohrer (Nobel Laureate in Physics 1986 and MANA Advisor)
- Mar 10-13 — The 1st MANA International Symposium
- Jul 28-Aug 1 — The 5th NIMS-IRC-UCLA Nanotechnology Summer School

2009

- Feb 25-27 — The 2nd MANA International Symposium
- Jun 15-17 — The 8th Japan-France Workshop on Nanomaterials
- Jul 3 — The 1st MANA-NSC Joint Workshop on Fusion of Nanotechnology and Bioscience at University of Cambridge, UK
- Jul 27-31 — The 6th MANA-NSC-CNSI Nanotechnology Students’ Summer School at UCLA, USA
- Sep 20-22 — XJTU-NIMS/MANA Workshop on Materials Science 2009 at Xi’an Jiaotong University, China
- Oct 10-12 — Tsukuba-Shinchu Bilateral Symposium on “Advanced Materials Science and Technology” at National Tsing Hua University, Taiwan
- Oct 13 — MANA-URTV Joint Workshop on Nanostructured Materials for Sustainable evelopment at University Rome Tor Vergata, Italy
- Oct 13-14 — The 1st MANA-CEMES Joint Workshop on Fusion of Theory and Experiment at the MANA Satellite in CNRS Toulouse, France
- Nov 10 — Nanjing University-Anhui Normal University-Hokkaido University-MANA Joint symposium at Nanjing University, China
- Dec 10 — The Osaka University-MANA/NIMS Joint Symposium on “Advanced Structural and Functional Materials Design” at Osaka University

2010

- Jan 14 — The 1st NIMS/MANA-Waseda University Joint Symposium on “Advanced Materials Designed at Nano- and Meso-scales toward Practical Chemical Wisdom” at Waseda University
- Mar 3-5 — The 3rd MANA International Symposium
- 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), in Gora, Hakone, Japan
- Jun 14-15 — The joint IBM and NIMS/MANA symposium on “Characterization and manipulation at the atomic scale”
- Aug 27 — The 1st NIMS-EWHA workshop on “Advanced Functional Materials” (NEWAM-10)
- Oct 28 — The 1st MANA Science Café “Melting Pot Club” on “What is nanotechnology?”
- Nov 24-26 — The 9th Japan-French International Workshop on nanomaterials in Toulouse, France
- Dec 1 — The 2nd NIMS/MANA-Waseda University Joint Symposium

2011

- Jan 19 — The satellite workshop “Dirac Electron Systems 2011” of the workshop “Graphene Workshop in Tsukuba 2011”
- Jan 27-28 — The 1st MANA Grand Challenge Meeting in Miura Peninsula, Kanagawa
- Feb 28 — The workshop on “Advanced Functional Nanomaterials” in Chennai, India
- Mar 2-4 — The 4th MANA International Symposium
- Mar 5 — Prof. Heinrich Rohrer’s Science Class 2011
- Sep 5-8 — The 7th Japan-UK-USA Nanotechnology Students’ Summer School at the MANA Satellite at University of Cambridge, UK
- Sep 17 — Prof. Kroto’s Science Class 2011
- Oct 7 — The Osaka University-MANA/NIMS Joint Symposium on “Advanced Structural and Functional Materials Design” at Osaka University
- Oct 31 — The NIMS/MANA-Flinders University Joint Symposium on “Nanoscience and Nanotechnology”
- Nov 1 — The 3rd NIMS/MANA-Waseda University Joint Symposium at Waseda University
- Dec 17-18 — MANA exhibited a booth at “Science Festa in Kyoto 2011”

2012

- Feb 16-20 — MANA participated in the WPI Joint Exhibition at the 2012 AAAS Annual Meeting in Vancouver, Canada
- Feb 29-Mar 2 — The 5th MANA International Symposium
- Apr 26-27 — The 2nd MANA Grand Challenge Meeting in Nasu, Tochigi
- May 10 — The Australia/MANA joint workshop on “Nanoarchitectonics for Innovative Materials & Systems”
- Jul 19 — The 1st UdeM-MANA Workshop on “Nano-Life” in Montreal, Canada

2012

- Aug 27-31 — The 8th MANA-Cambridge/UCL-UCLA Nanotechnology Summer School
- Oct 1 — The PCCP-MANA Symposium on “Nanotechnology, Materials and Physical Chemistry”
- Oct 3 — The MANA 5th Anniversary Memorial Symposium
- Nov 7 — The NSQI-MANA Joint Symposium
- Nov 12-13 — The 3rd MANA Grand Challenge Meeting (for young researchers) at Miura Peninsula, Kanagawa
- Nov 24 — The 2nd WPI Joint Symposium: Inspiring Insights into Pioneering Scientific Research

2013

- Jan 29-30 — The 2nd Canada-Japan Nanotechnology Workshop at Tokyo Big Sight.
- Feb 14-18 — MANA participated in the WPI Joint Exhibition at the 2013 AAAS Annual Meeting in Boston, USA
- Feb 27-Mar 1 — The 6th MANA International Symposium
- Mar 11 — The 4th NIMS/MANA-Waseda University International Joint Symposium
- Mar 18 — The Osaka University-NIMS/MANA Joint Symposium on “Advanced Structural and Functional Materials Design”
- Mar 19 — The International Symposium MASA 2013 on “Material Architectonics for Sustainable Action”
- Jun 28-29 — The International Workshop on “Thermoelectric Research & Thermal Management Technology”
- Aug 6-8 — MANA participated in the “Summer Science Camp” for high school students
- Aug 19-20 — 6th MANA Site Visit by the WPI Program Committee
- Oct 9-11 — The Swiss-Japanese Nanoscience Workshop on “Materials Phenomena at Small Scale”
- Nov 9-10 — MANA represented by MANA’s Smart Biomaterials Group participated in the event “Science Agora 2013” at Odaiba, Tokyo

2014

- Jan 29-31 — The first edition of the TNT Japan (Trends in Nanotechnology) conference t Tokyo Big Sight with a “MANA Day” on January 30
- Mar 3-4 — The MANA/ICYS Reunion Workshop
- Mar 5-7 — The 7th MANA International Symposium
- Mar 11-12 — The Japan-Taiwan Joint Workshop on “Nanospace Materials” at Fukuoka Institute of Technology
- Mar 24 — The 5th NIMS/MANA-Waseda University Joint Symposium
- Mar 24-25 — The International Symposium on Smart Biomaterials
- Apr 1-2 — The International Workshop Topology in the New Frontiers of Materials Science
- Jun 22-26 — The 12th International Workshop on Beam Injection Assessment of Microstructures in Semiconductors (BIAMS 12)
- Jul 18 — The International Symposium on Material Architectonics for Sustainable Action (MASA 2014)
- Nov 26-28 — The 2nd International Symposium on the Functionality of Organized Nanostructures (FON’14) at the National Museum of Emerging Science and Innovation in Odaiba, Tokyo

2015

- Feb 25-26 — The 4th MANA Grand Challenge Meeting in Nasu, Tochigi
- Mar 11-13 — The 8th MANA International Symposium
- Jun 29-Jul 3 — The 9th Nanotechnology Summer School with students from Japan, Canada, US, Australia, and France
- Jul 29 — The 6th NIMS/MANA-Waseda University Joint Symposium at Waseda University
- Jul 29-30 — The International Symposium on Nanoarchitectonics for Mechanobiology
- Oct 15-16 — The MANA-RSC Symposium: Materials for Energy Generation and Storage
- Oct 16 — 8th Follow-up Meeting by the WPI Follow-Up Committee
- Nov 27-28 — The 5th MANA Grand Challenge Meeting (together with the Institute for Solid State Physics (ISSP) of the University of Tokyo) in Nasu, Tochigi

2016

- Jan 8, 15 — The 6th MANA Grand Challenge Meeting with Tokyo University of Science
- Mar 9-11 — The 9th MANA International Symposium
- Jul 27-28 — The 2nd International Symposium on Nanoarchitectonics for Mechanobiology
- Dec 17-18 — The 2nd Japan-Taiwan Joint Workshop on Nanospace Materials

MANA members

(name, present post, enrollment period in MANA)

Masakazu Aono	Director/PI	2007-
Yoshio Bando	COO/PI	2007-
Takahiro Fujita	Administrative Director	2007-2014
Takayoshi Sasaki	Deputy Director	2015-
Tomonobu Nakayama	Administrative Director	2015-

NANO-Materials

Soft Chemistry Group

Takayoshi Sasaki	Deputy Director/PI	2007-
Renzhi MA	Associate PI	2008-
Yasuo Ebina	Principal Researcher	2008-
Nobuyuki Sakai	Senior Researcher	2013-

Functional Nanosheets Group

Minoru Osada	PI	2007-
Takashi Aizawa	Chief Researcher	2016-
Takaaki Taniguchi	Senior Researcher	2015-

Mesoscale Materials Chemistry Group

Yusuke Yamauchi	PI	2007-
Joel Henzie	Seinor Researcher	2012-
Yusuke Ide	Senior Researcher	2012-
Satoshi Tominaka	Senior Researcher	2010-

Nanotubes Group

Dmitri Golberg	PI	2007-
Masanori Mitome	Chief Researcher	2007-
Ryutaro Souda	Chief Researcher	2008-
Naoyuki Kawamoto	Senior Researcher	2009-

Supermolecules Group

Katsuhiko Ariga	PI	2007-
Jonathan P. Hill	Chief Researcher	2007-
Waka Nakanishi	Senior Researcher	2013-
Lok Kumar Shrestha	Senior Researcher	2010-

Frontier Molecules Group

Takashi Nakanishi	Group Leader	2014-
Kentaro Tashiro	Principal Researcher	2008-
Shinsuke Ishihara	Senior Researcher	2012-

Semiconductor Device Materials Group

Toyohiro Chikyo	PI	2007/2011-
Takashi Sekiguchi	Managing Researcher	2011-
Jin Kawakita	Chief Researcher	2009-
Michiko Yoshitake	Chief Researcher	2011-
Shinjiro Yagyu	Principal Researcher	2011-
Yoshiyuki Yamashita	Principal Researcher	2011-
Jun Chen	Senior Researcher	2008-
Takahiro Nagata	Senior Researcher	2011-

NANO-System

Nano Functionality Integration Group

Tomonobu Nakayama	Administrative Dirctor/ Group Leader	2008-
Hideo Arakawa	Principal Researcher	2009-
Shigeki Kawai	Principal Researcher	2016-
Yoshitaka Shingaya	Senior Researcher	2008-

Thin Film Electronics Group

Kazuhito Tsukagoshi	PI	2008-
Seiichi Kato	Senior Researcher	2016-

Nano-System Theoretical Physics Group

Xiao Hu	PI	2007-
Toshikaze Kariyado	Researcher	2016-
Takuto Kawakami	NIMS Special Researcher	2013-

Nano Frontier Superconducting Materials Group

Yoshihiko Takano	PI	2016-
Hiroyuki Takeya	Chief Researcher	2016-

Nanoionic Devices Group

Kazuya Terabe	PI	2008-
Yuji Okawa	Chief Researcher	2008-
Makoto Sakurai	Principal Researcher	2007-
Tohru Tsuruoka	Principal Researcher	2007-
Takashi Tsuchiya	Senior Researcher	2016-
Song-Ju Kim	NIMS Special Researcher	2013-

NANO-System

Surface Quantum Materials Group

Takashi Uchihashi	Group Leader	2008-
Katsumi Nagaoka	Senior Researcher	2008-
Takahide Yamaguchi	Senior Researcher	2016-

Quantum Device Engineering Group

Yutaka Wakayama	Group Leader	2011-
Shu Nakaharai	Principal Researcher	2013-
Ryoma Hayakawa	Senior Researcher	2010-
Satoshi Moriyama	Senior Researcher	2007-

NANO-Power

Photocatalytic Materials Group

Jinhua Ye	PI	2007-
Mitsutake Oshikiri	Principal Researcher	2016-
Tetsuya Kako	Senior Researcher	2016-

Photonic Nano-Engineering Group

Tadaaki Nagao	Group Leader	2007-
Satoshi Ishii	Researcher	2014-

Thermal Energy Materials Group

Takao Mori	PI	2008-
Yuichi Michiue	Chief Researcher	2016-
Naohito Tsujii	Principal Researcher	2016-
Isao Ohkubo	Senior Researcher	2012-
Norifusa Satoh	Senior Researcher	2009-2010/2016-
Daiming Tang	Researcher	2012-
Rudder Wu	Researcher	2015-

Nanostructured Semiconducting Materials Group

Naoki Fukata	Group Leader	2007-
Wipakorn Jevasuwan	Researcher	2014-

Researchers who have a concurrent post.

Kohei Uosaki Director, Center for Green Research on Energy and Environmental Materials	PI	2008-
Kazunori Takada Deputy Director, Center for Green Research on Energy and Environmental Materials	PI	2008-
Yoshitaka Tateyama Group Leader, Interface Computational Science Group, Center for Green Research on Energy and Environmental Materials	PI	2007-

NANO-Life

Tissue Regeneration Materials Group

Guoping Chen	PI	2008-
Naoki Kawazoe	Principal Researcher	2008-

Medical Soft Matter Group

Kohsaku Kawakami	Group Leader	2008-
Chiho Kataoka	Senior Researcher	2008-
Yoko Shirai	Principal Engineer	2008-

Nanomechanical Sensors Group

Genki Yoshikawa	Group Leader	2009-
Kota Shiba	Researcher	2014-

Mechanobiology Group

Jun Nakanishi	Group Leader	2007-
Mitsuhiro Ebara	Associate PI	2010-
Chiaki Yoshikawa	Senior Researcher	2007-

Managing Researcher

Hisatoshi Kobayashi	Managing Researcher	2011-

NANO-Theory

Material Properties Theory Group

Taizo Sasaki	PI	2016-
Takahisa Ohno	Senior Scientist with Special Missions	2007/2016-
Masao Arai	Chief Researcher	2016-
Wataru Hayami	Principal Researcher	2016-
Kazuaki Kobayashi	Principal Researcher	2016-
Masanori Kohno	Principal Researcher	2007-
Masamichi Nishino	Principal Researcher	2016-

NANO-Theory

Material Properties Theory Group

Yoshihiko Nonomura	Principal Researcher	2016-
Igor V Solovyev	Principal Researcher	2016-
Shigeru Suehara	Principal Researcher	2016-
Akihiro Tanaka	Principal Researcher	2007-2008/2016-
Junichi Inoue	Senior Researcher	2016-
Junya Shimizu	Principal Engineer	2009-

First- Principles Simulation Group

Tsuyoshi Miyazaki	PI	2016-
Ayako Nakata	Senior Researcher	2016-
Jun Nara	Senior Researcher	2016-
Ryo Tamura	Researcher	2016-

Satellite PIs

Zhong Lin Wang	PI	2007-
James K. Gimzewski	PI	2007-
Christian Joachim	PI	2007-
Yukio Nagasaki	PI	2007-
Francoise M. Winnik	PI	2011-
David Bowler	PI	2013-

Independent Scientists

Ryuichi Arafune	Independent Scientist	2010-
Takako Konoike	Independent Scientist	2014-
Jan Labuta	Independent Scientist	2016-
Takeo Minari	Independent Scientist	2009-
Liwen Sang	Independent Scientist	2012-
Naoto Shirahata	Independent Scientist	2007/2011-
Naoto Umezawa	Independent Scientist	2016-

ICYS-MANA Researchers

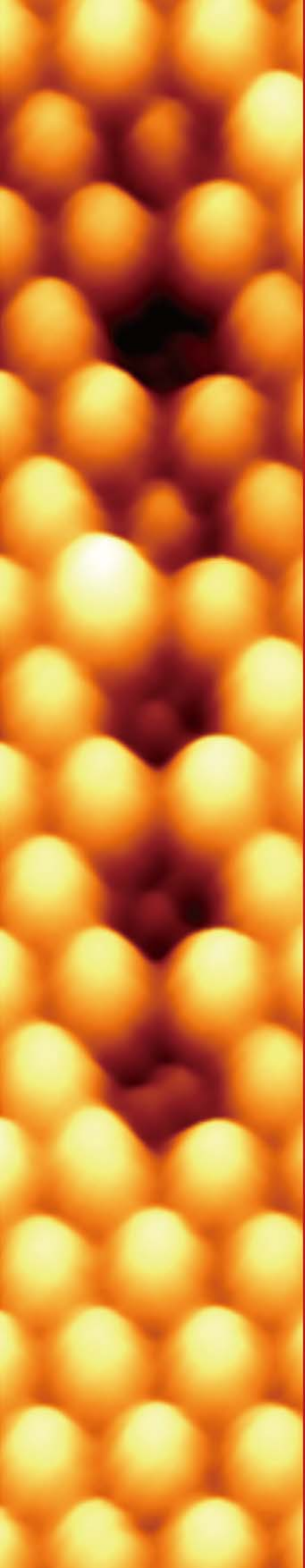
Ovidiu Cretu	ICYS-MANA Researcher	2016-
Alexandre J-Y. Fiori	ICYS-MANA Researcher	2015-
Gaku Imamura	ICYS-MANA Researcher	2016-
Thanh Cuong Nguyen	ICYS-MANA Researcher	2015-
Curtis James O'kelly	ICYS-MANA Researcher	2016-
Gaulthier Rydzek	ICYS-MANA Researcher	2014-
Koichiro Uto	ICYS-MANA Researcher	2016-
Xuebin Wang	ICYS-MANA Researcher	2014-
Shunsuke Yoshizawa	ICYS-MANA Researcher	2015-

MANA Foundry

Toshihide Nabatame	General Manager	2009-
Akihiko Ohi	Senior Engineer	2009-
Naoki Ikeda	Senior Engineer	2016-

Former members (name, last post, enrollment period in MANA)

Eiji Muromachi	PI	2007-2010
Yoshio Sakka	PI	2007-2011
Takahiro Fujita	Administrative Director	2007-2014
Kenji Kitamura	PI	2007-2011
Kazuhiro Hono	PI	2007-2011
Naoki Ohashi	PI	2007-2011
Daisuke Fujita	PI	2007-2011
Tsuyoshi Hasegawa	PI	2007-2015
Omar Yaghi	PI	2007-2016
Kazuo Kadowaki	PI	2007-2013
Hideaki Takayanagi	PI	2007-2015
Mark E. Welland	PI	2007-2012
Enrico Traversa	PI	2009-2012
Liyuan Han	PI	2008-2011
Yuji Miyahara	PI	2008-2010
Christoph Gerber	PI	2008
Keiichi Tomishige	PI	2008-2010
Takao Aoyagi	PI	2010-2015
Yasuo Koide	Chief Scientist	2007
Nobutaka Hanagata	Group Leader	2007/2011-2016
Tsukasa Kiyoshi	Chief Scientist	2007
Tadashi Shimizu	Chief Scientist	2007
Kazutaka Mitsuishi	Chief Scientist	2007
Hideki Yoshikawa	Chief Scientist	2007
Hideaki Kitazawa	Chief Scientist	2007
Takashi Taniguchi	Chief Scientist	2007
Chengchun Tang	MANA Scientist	2007-2010
Hiroya Sakurai	MANA Scientist	2007
Noriyuki Hirota	MANA Scientist	2007
Isao Sakaguchi	MANA Scientist	2007
Yutaka Adachi	MANA Scientist	2007
Yoichi Kubota	MANA Scientist	2007
Keisuke Sagisaka	MANA Scientist	2007
Tadashi Ozawa	MANA Scientist	2008-2015
Tsuyoshi Ohnishi	MANA Scientist	2008-2016
Chunyi Zhi	MANA Scientist	2008-2012
Osamu Kubo	MANA Scientist	2008-2012
Emiliana Fabbri	MANA Scientist	2008-2012
Ashraful Islam	MANA Scientist	2008-2011
Tetsushi Taguchi	MANA Scientist	2008-2016
Martin Pumera	MANA Scientist	2008-2009
Masanori Kikuchi	Group Leader	2008-2016
Yasushi Suetsugu	MANA Scientist	2008-2016
Akiko Yamamoto	Group Leader	2008-2016
Norio Maruyama	MANA Scientist	2008-2013
Sachiko Hiromoto	MANA Scientist	2008-2016
Akiyoshi Taniguchi	Group Leader	2008-2016
Tomohiko Yamazaki	MANA Scientist	2008-2016
Junko Okuda	MANA Scientist	2008-2010
Hidenori Noguchi	MANA Scientist	2009-2016
Masatoshi Yanagida	MANA Scientist	2009-2011
Tamaki Naganuma	MANA Scientist	2010-2016
Forte Giancarlo	MANA Scientist	2010-2013
Ji Qingmin	MANA Scientist	2011-2015
Masahiro Goto	MANA Scientist	2011-2016
Takayuki Nakane	MANA Scientist	2011-2016
Yoshihisa Kaizuka	MANA Scientist	2011-2016
Hiori Kino	MANA Scientist	2012-2016
Ikutaro Hamada	MANA Scientist	2013-2016
Piotr Kujawa	MANA Scientist	2013-2014
Ken Sakaushi	MANA Scientist	2015-2016
Masayoshi Higuchi	Independent Scientist	2007-2011
Shunsuke Tsuda	Independent Scientist	2007-2011
Alexei A. Belik	Independent Scientist	2007-2016
Ajayan Vinu	Independent Scientist	2007-2011
Daniele Pergolesi	Independent Scientist	2008-2012
Lionel Vayssier	Independent Scientist	2008-2012
Katsunori Wakabayashi	Independent Scientist	2009-2015
Eriko Watanabe	Independent Scientist	2009-2010
Cesar Pay Gomez	ICYS-MANA Researcher	2008-2009
Xiaosheng Fang	ICYS-MANA Researcher	2008-2011
Liu Canhua	ICYS-MANA Researcher	2008-2010
Lee Michael Vernon	ICYS-MANA Researcher	2008-2010
Ujjal Gautam	ICYS-MANA Researcher	2008-2011
Masataka Imura	ICYS-MANA Researcher	2008-2011
Tatsuo Shibata	ICYS-MANA Researcher	2008-2011
Yasuhiro Shirai	ICYS-MANA Researcher	2008-2010
Pavuluri Srinivasu	ICYS-MANA Researcher	2008-2011
Robert Scipioni	ICYS-MANA Researcher	2008
Richard Charvet	ICYS-MANA Researcher	2008
Somobrata Acharya	ICYS-MANA Researcher	2008
Samuel Ordnez Sanchez	ICYS-MANA Researcher	2008-2010
Jesse Williams	ICYS-MANA Researcher	2009-2011
Yuanjian Zhang	ICYS-MANA Researcher	2009-2012
Fatin Hajjaj	ICYS-MANA Researcher	2010-2013
Jung-Sub Wi	ICYS-MANA Researcher	2010-2012
Yoshihiro Tsujimoto	ICYS-MANA Researcher	2010-2012
Tianyou Zhai	ICYS-MANA Researcher	2010-2013
Hisanori Ueki	ICYS-MANA Researcher	2010-2011
Christopher Patrick Royall	ICYS-MANA Researcher	2011
Ken Watanabe	ICYS-MANA Researcher	2011-2013
Xianlong Wei	ICYS-MANA Researcher	2011-2012
Hicham Hamoudi	ICYS-MANA Researcher	2012-2015
Songlin Li	ICYS-MANA Researcher	2011-2014
Ming Hu	ICYS-MANA Researcher	2012-2013
Sudipta Dutta	ICYS-MANA Researcher	2013-2015
Yohei Kotsuchibashi	ICYS-MANA Researcher	2013-2016
Fengxia Geng	ICYS-MANA Researcher	2013-2014
Xi Wang	ICYS-MANA Researcher	2013-2016
Huynh Thien Ngo	ICYS-MANA Researcher	2013-2016
Hamish Hei-man Yeung	ICYS-MANA Researcher	2014-2016
Karolin Jiptner	ICYS-MANA Researcher	2015



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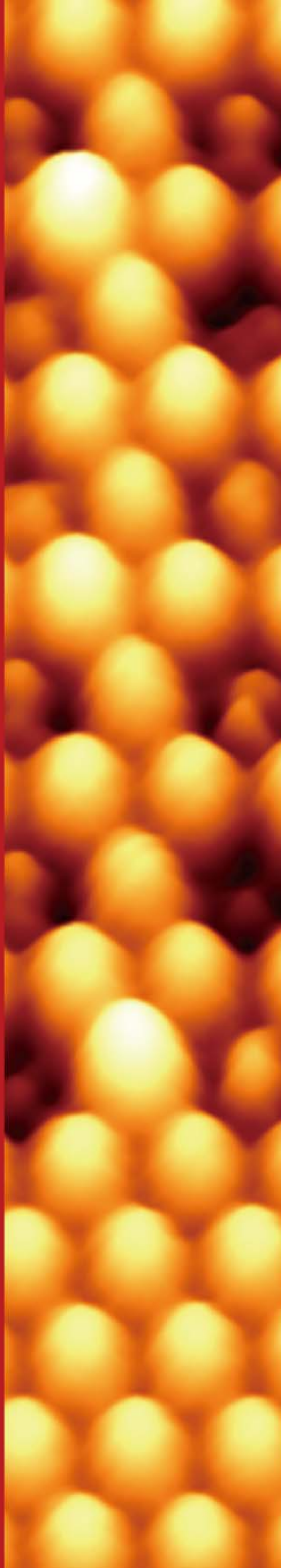
Materials Science



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