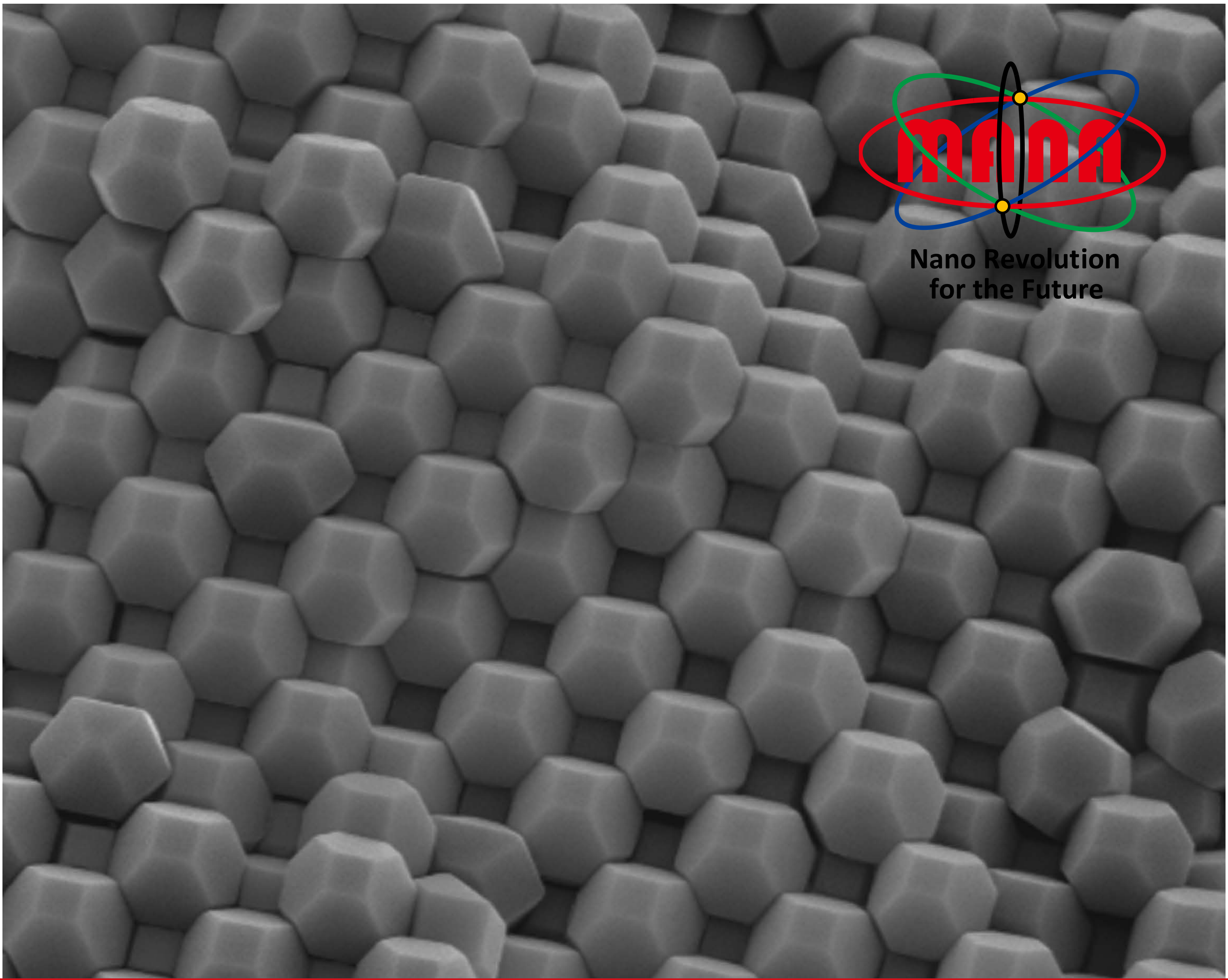
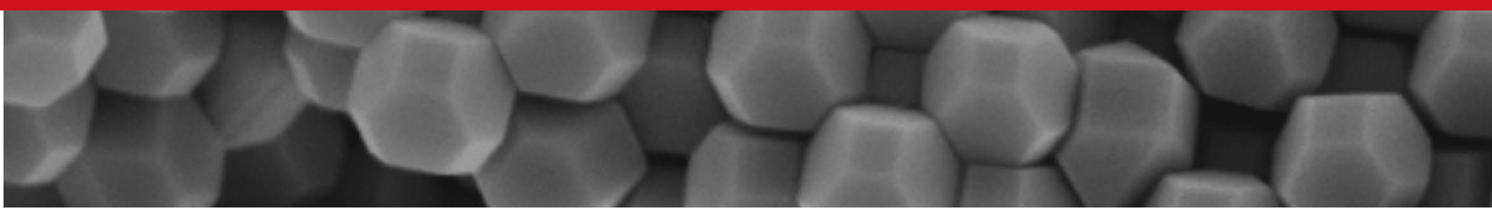


Nano Revolution
for the Future

MANA

INTERNATIONAL CENTER FOR MATERIALS NANOARCHITECTONICS



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 : A Kelvin Structure of Ag Nanoparticles

Ag nanoparticles shaped like truncated octahedra self-organize into a beautiful 3D nanoarchitecture known as the Kelvin structure.

A Message from the Director

The new MANA's mission

Takayoshi Sasaki

The International Center for Materials Nanoarchitectonics (MANA) has been established at NIMS in 2007 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). Thanks to the great effort and support of many people over 10 years, we are proud that MANA has grown into a representative international research center in the fields of nanotechnology and material science, both in name and reality. It is needless to say that for the sustainable development of human society, innovative technologies that are based on discovery and creation of appropriate materials play a crucial role to solve various problems. In recent years, nanotechnology has made astonishing progress and became a modern pillar of materials discovery and development. MANA is pursuing innovation on the basis of our concept of "nanoarchitectonics," where new materials and functions are created by rationally integrating and joining nanoscale parts. "Nanoarchitectonics" has now grown into a concept that is accepted around the world.

As the 10 year WPI funding has ended, MANA is strongly required to grow and develop further, and to continue world leading research activities as an international hub institute for nanotechnology research. We are well aware of it and will continue to deepen and pursue our "nanoarchitectonics." In connection with it, we are striving for new horizons such as heterojunction of dissimilar materials, close cooperation between theory and experiment, and challenge of large scale and complex systems. All of these are considered to be key research for our "nanoarchitectonics" to demonstrate its real value. We look forward to your continued support for further development of MANA.

Takayoshi Sasaki

Organization

Director

Takayoshi Sasaki

Deputy Director/ Administrative Director

Tomonobu Nakayama

- General Affair Team
- Planning and Outreach Team

Advisors

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

Executive Advisors

M. Aono
Former Director, International Center for Materials Nanoarchitectonics

Y. Bando
Former COO, International Center for Materials Nanoarchitectonics

Advisors

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

A. K. Cheetham
Professor, University of Cambridge

Nano-Materials Field

- Thermal Energy Materials Group
- Soft Chemistry Group
- Functional Nanosheets Group
- Mesoscale Materials Chemistry Group
- Nanotubes Group
- Supermolecules Group
- Semiconductor Device Materials Group
- Photocatalytic Materials Group
- Nanostructured Semiconducting Materials Group
- Frontier Molecules Group

Nano-Systems Field

- Nanoionic Devices Group
- Nano Functionality Integration Group
- Thin Film Electronics Group
- Nano-System Theoretical Physics Group
- Nano Frontier Superconducting Materials Group
- Photonics Nano-Engineering Group
- Quantum Device Engineering Group
- Surface Quantum Phase Materials Group
- Nanomechanical Sensors Group
- Mechanobiology Group
- Medical Soft Matter Group

Nano-Theory Field

- Material Properties Theory Group
- First-Principles Simulation Group

Satellite PIs

Independent Scientists

ICYS Researchers

Managing Researchers

Personnel composition

	Number	Non-Japanese	Female
PIs	21	7	2
Group Leaders	7	0	0
Associate PIs	3	1	0
Faculty Scientists	73	10	9
Postdoctoral Researchers	60	43	11
Junior Researchers	50	36	12
Administrative and Technical Staff	83	4	54
Total	297	101	88

(as of October 2017)

About WPI

World Premier International Research Center Initiative

Aiming to be highly visible research centers

In recent years, a competitive search for the most talented minds has been advancing rapidly around the world. This trend in human resources is known as "brain circulation."

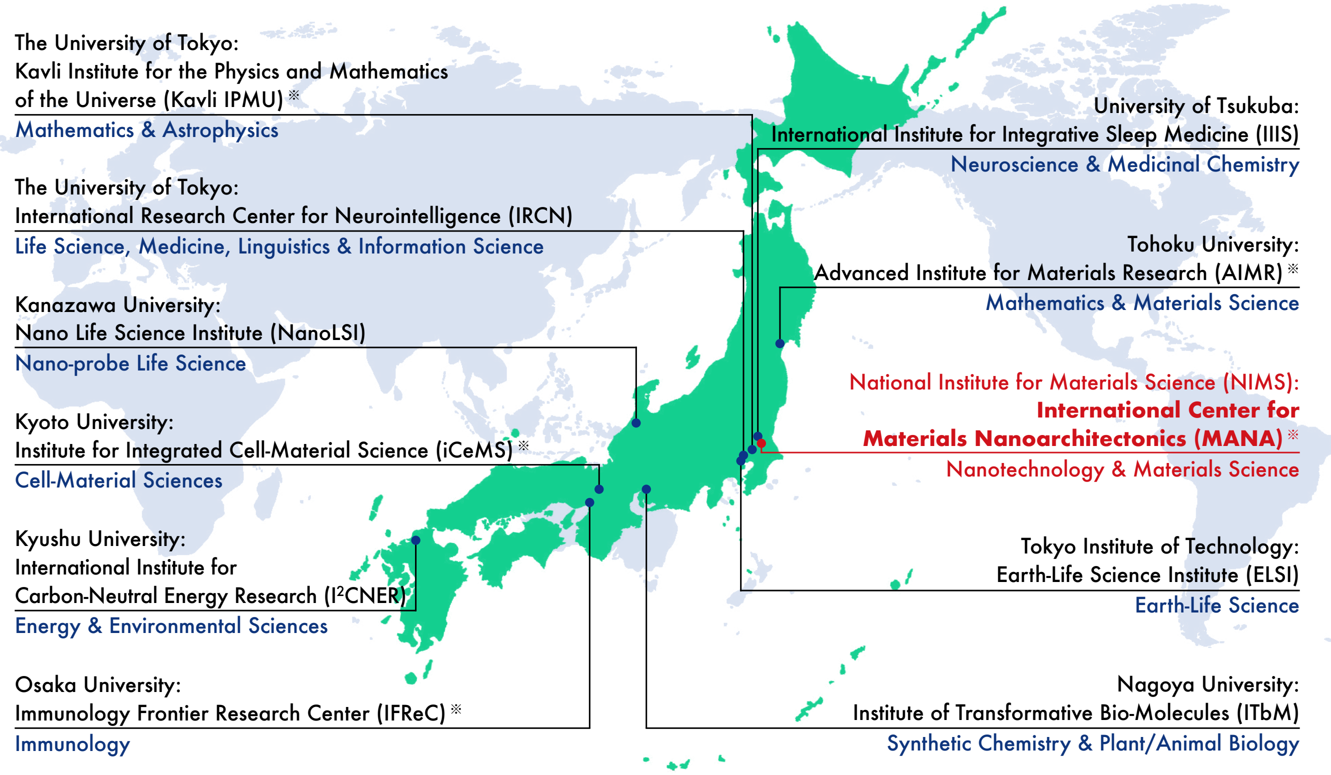
Japan, too, needs to create a place at the forefront where researchers from around the world can gather as part of this global movement of human resources. In 2007, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) established the World Premier International Research Center Initiative (WPI) Program to promote Japan's presence as a powerhouse of science and technology.

To date, eleven research centers have been selected as WPI centers by meeting these four requirements: the world's highest level of research standards, creation of interdisciplinary research fields, implementation of an international research environment, and openness to reform in the research organization. In 2017, five of nine WPI centers were certified to have achieved world premier status, and identified as WPI Academy centers after the 10-year subsidy.

WPI centers serve as models of research institutes in Japan, and are expected to bring innovations in science and technology.

World Premier International Research Center Initiative

WPI research centers, the highest peaks where the world's top researchers gather.



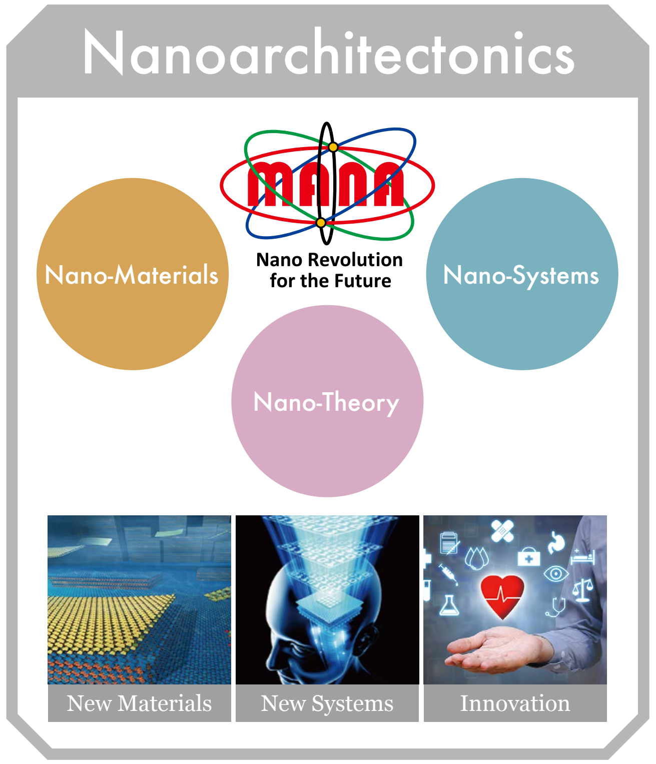
(※ WPI Academy member)

Our Research Concept

What is Nanoarchitectonics?

The New Paradigm of Nanotechnology

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



Grand Challenges

- Nano Perceptive System
- Nanoarchitectonic artificial brain
- Room-temperature superconductivity
- Practical artificial photosynthesis

Four key points of nanoarchitectonics

1 "Unreliability-tolerant reliability"

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

2 "From nano-functionality to nanosystem-functionality"

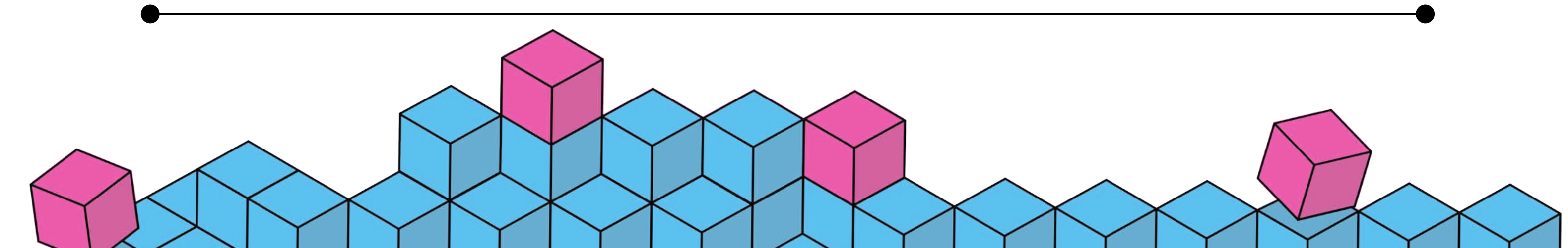
Nanoscale structures (nanoparts) frequently display interesting new properties, but there are limits to their functionalities, either as individual units or as simple aggregates. Thus, creating completely new functionalities by effectively utilizing interactions among nanoparts of the same type or different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

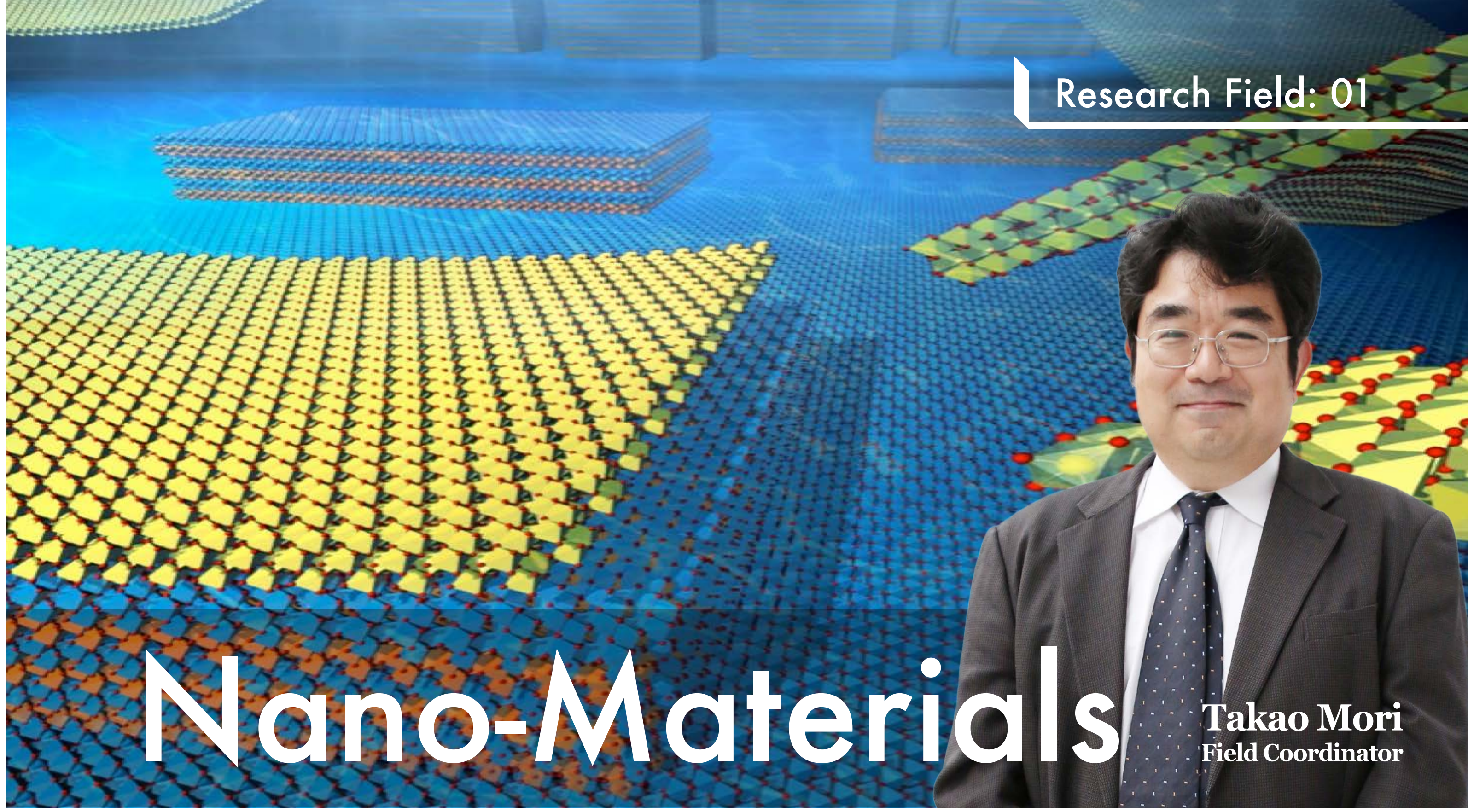
3 "More is different"

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

4 "Truth can be described with plain words"

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





Nano-Materials

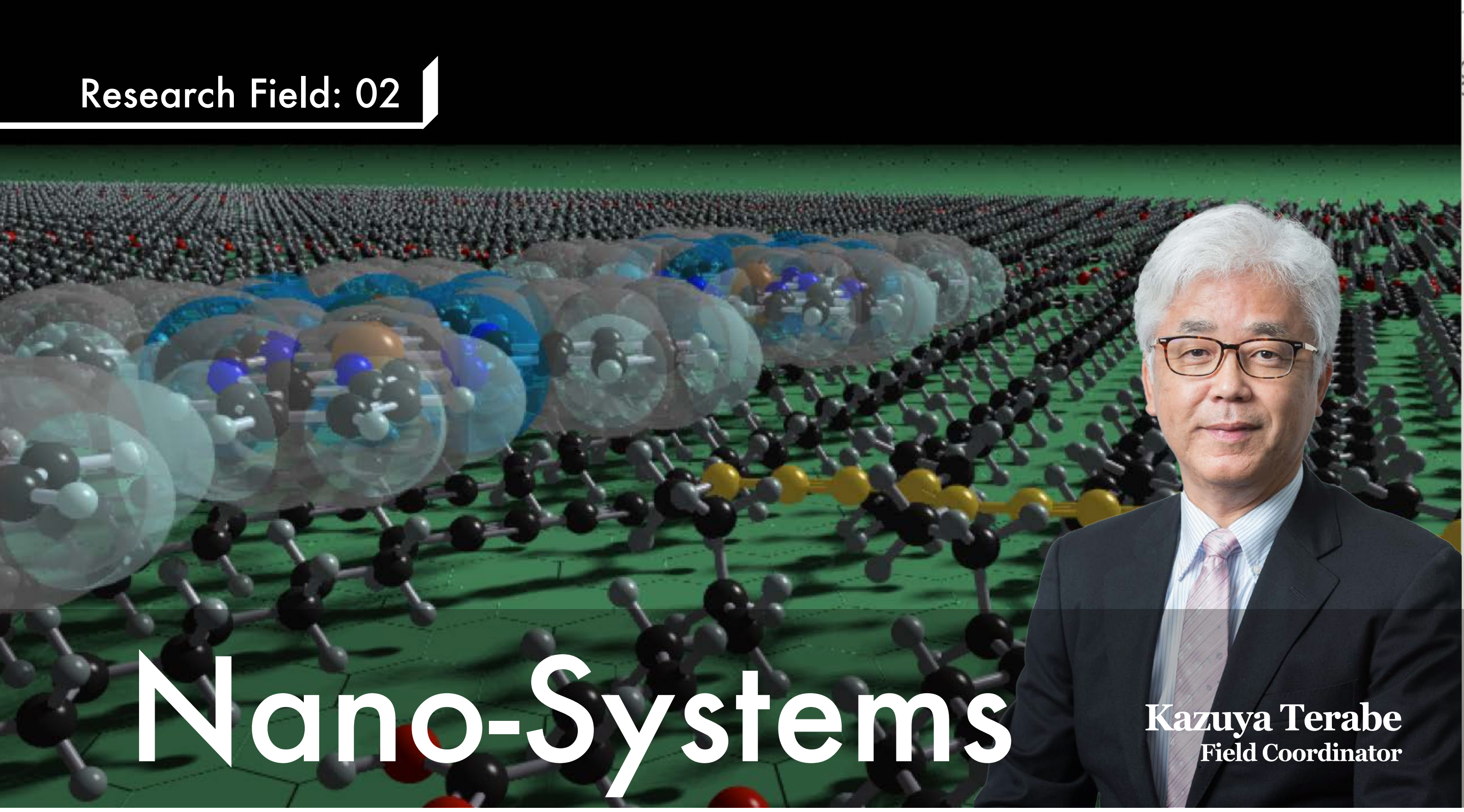
Takao Mori, Field Coordinator

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

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

Research Groups

- Thermal Energy Materials Group
- Soft Chemistry Group
- Functional Nanosheets Group
- Mesoscale Materials Chemistry Group
- Nanotubes Group
- Supermolecules Group
- Semiconductor Device Materials Group
- Photocatalytic Materials Group
- Nanostructured Semiconducting Materials Group
- Frontier Molecules Group



Research Field: 02

Nano-Systems

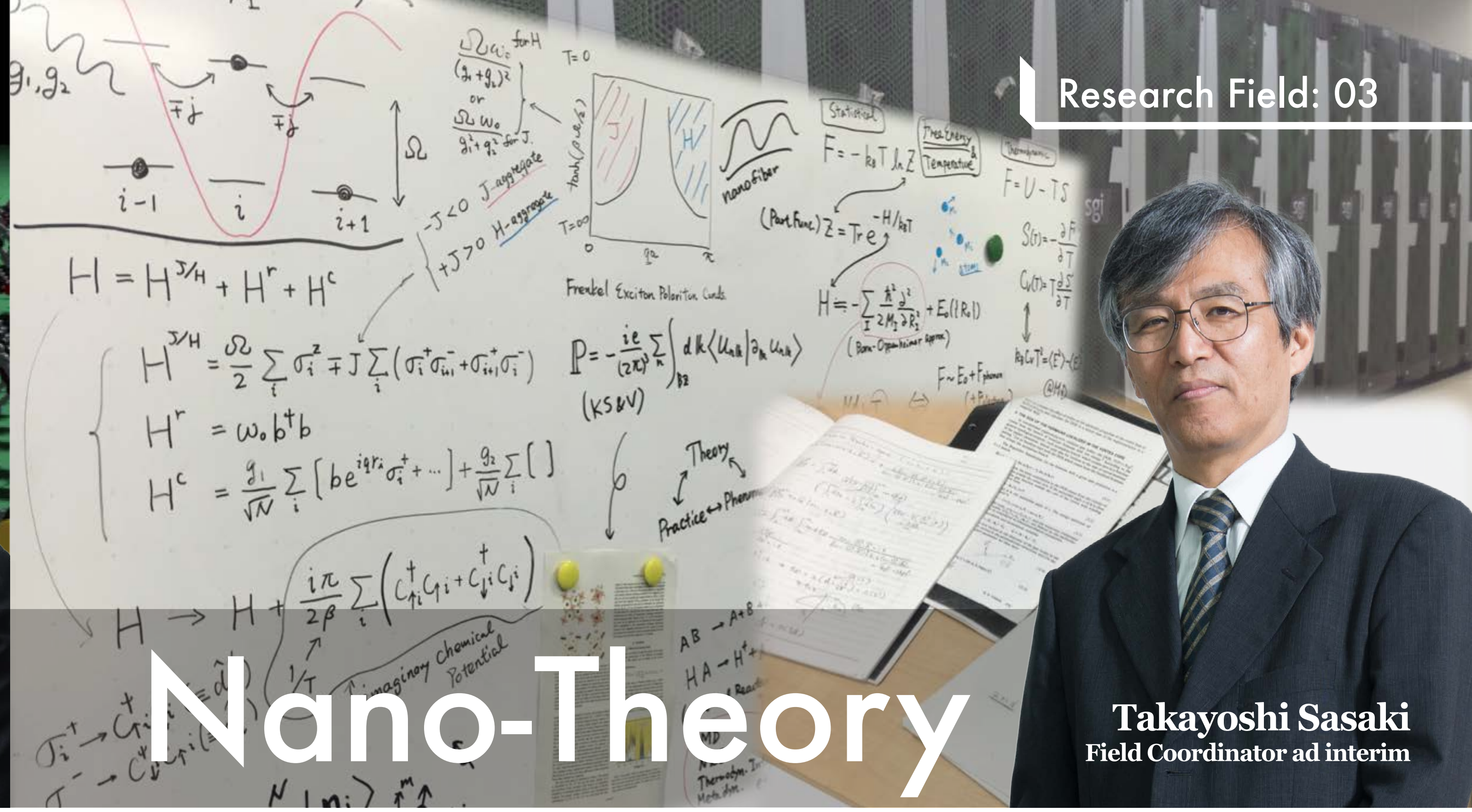
Kazuya Terabe
Field Coordinator

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

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

Research Groups

- Nanoionic Devices Group
- Nano Functionality Integration Group
- Thin Film Electronics Group
- Nano-System Theoretical Physics Group
- Nano Frontier Superconducting Materials Group
- Photonics Nano-Engineering Group
- Quantum Device Engineering Group
- Surface Quantum Phase Materials Group
- Nanomechanical Sensors Group
- Mechanobiology Group
- Medical Soft Matter Group



Research Field: 03

Nano-Theory

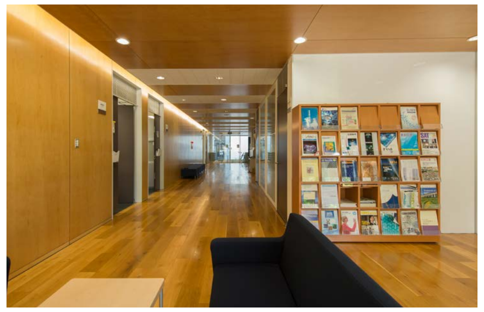
Takayoshi Sasaki
Field Coordinator ad interim

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

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

Research Groups

- Material Properties Theory Group
- First-Principles Simulation Group



Theoretical Research Building

Globalization

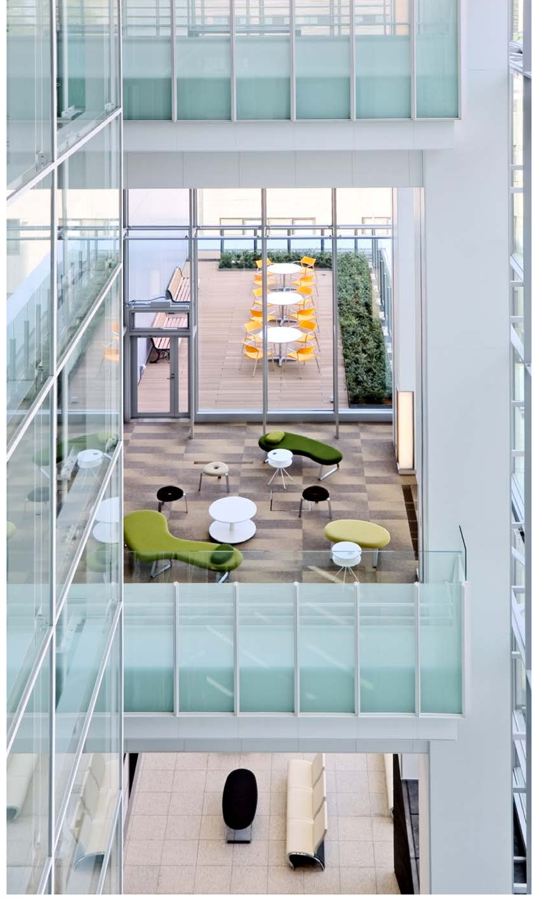
Satellite Laboratories:

Front Base of International Nanotechnology Network

MANA introduced the "Satellite Laboratories" 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 5 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 institute gathering knowledge, information, and human resources on nanotechnology.



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 ideas of interdisciplinary research at MANA.

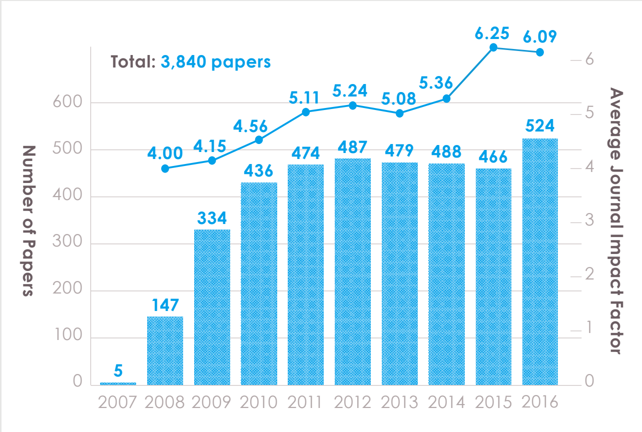
Approximately half of researchers enrolled in MANA are foreign nationals. MANA provides a variety of support for them. MANA's administrative office is composed only of staff who can speak English, and all necessary procedures can be done in English. MANA provides opportunities to deepen their understanding of Japan through Japanese language and culture classes.

MANA in Numbers

Number of Papers and The Average Impact Factor 6.09

From 2007 to 2016, MANA researchers published 3,840 papers in total. In 2016, MANA researchers published a total of 524 papers. The average impact factor ※ of the journals in which these papers were published was 6.09 in 2016, which reflects the high quality of research results at MANA.

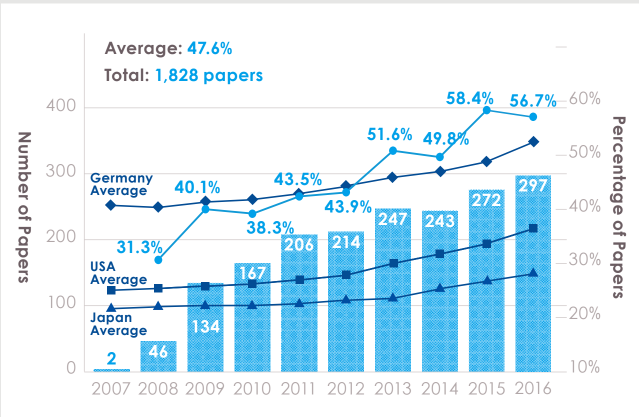
※ Impact Factor: The degree of influence is measured and numerically expressed based on the frequency of citation of published articles in scholary journals.



MANA Affiliated Research Papers (Oct 2007 – Dec 2016)

56.7 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 2016 reached 56.7%.



Internationally co-authored papers from MANA (Oct 2007 – Dec 2016)

142 Top 1% Papers

Highly Cited Researchers

Among the 3,840 papers published by MANA in 2007-2016, 142 papers are Highly Cited Papers (top 1% papers) based on Web of Science database. ISI Highly Cited Researchers are authors of many Highly Cited Papers in a certain research field. In 2014 and 2015, 5 researchers from MANA belonged to this elite group: Katsuhiko Ariga, Yoshio Bando, Dmitri Golberg, Zhong Lin Wang and Omar Yaghi. In 2016, 6 Highly Cited Researchers worked for MANA: Katsuhiko Ariga, Yoshio Bando, Dmitri Golberg, Zhong Lin Wang, Yusuke Yamauchi and Jinhua Ye.

Patents 642

The total number of patents acquired by MANA reached 642 in 2016. 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.

How to join MANA

Students

Joint Graduate School Program

The NIMS Joint Graduate School Program is designed for materials science majors pursuing degrees within the latest research activities, under the supervision of NIMS researchers. As of now, University of Tsukuba, Hokkaido University, Waseda University and Kyushu University are listed as designated universities for the program. Furthermore, NIMS offers a "NIMS Graduate Research Assistantship" to excellent students in the program.

Cooperative Graduated Program

In this program, doctorial students from globally renowned graduate schools are accepted as NIMS visiting scientist (trainee) and undergo training by NIMS researchers on research. NIMS has concluded agreement with 33 universities in Japan and 18 universities abroad.

NIMS Internship Program

The NIMS Internship Program gives students in universities, graduate schools and technical colleges in Japan and other countries oppotunities to experience research at NIMS for up to 90 days. Especially at MANA, a globally open research center, the possibility of obtaining wide-reaching human networks is an important merit for students. NIMS also offer financial support to students who are recognized as particularly outstanding.

Please visit NIMS website for details.
http://www.nims.go.jp/eng/hr-development/

Companies

NIMS, the host institute of MANA, are engaged in activities to bridge NIMS's technology to the industry with the aim of realizing our philosophy, "material becomes material when it is used." We set up a "place of information circulation" that matches needs and seeds, a "joint research place" that develops NIMS's technology with the industry toward practical application through patent licensing, technical consulting, collaborative research, etc.

- Technical Consulting
- Licensing
- Collaborative Research
- Commissioned Research
- Sample Evaluation

Researchers

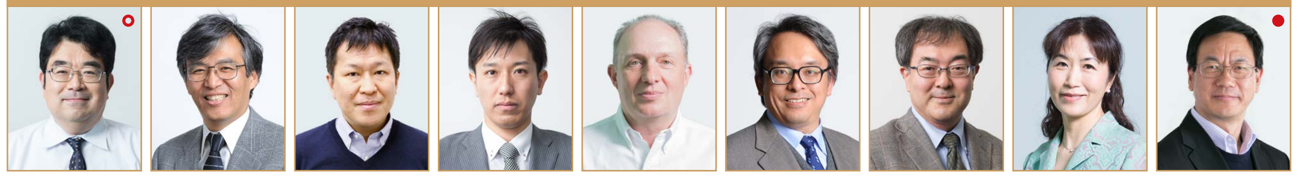
MANA wants researchers who conduct fundamental research with high originality under the concept of "nanoarchitectonics." We update the recruitment information through MANA website: MANA Postdoctoral Fellows, Independent Scientists, ICYS Researchers and various research posts.

Please visit MANA website for details.
http://www.nims.go.jp/mana/recruit/

MANA Member List

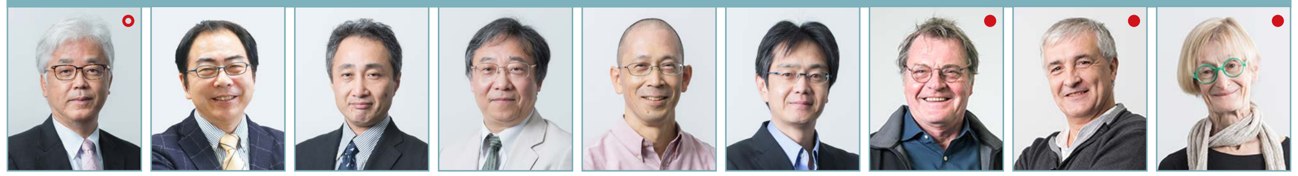
Principal Investigators (PIs)

Nano-Materials



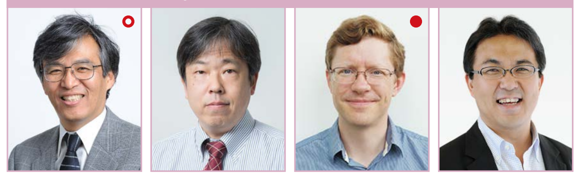
T. Mori ○, T. Sasaki, M. Osada, Y. Yamauchi, D. Golberg, K. Ariga, T. Chikyo, J. Ye, Z. L. Wang ●

Nano-Systems



K. Terabe ○, T. Nakayama, K. Tsukagoshi, X. Hu, Y. Takano, T. Nagao, J. K. Gimzewski ●, C. Joachim ●, F. M. Winnik ●

Nano-Theory



T. Sasaki ○ (ad interim), T. Miyazaki, D. Bowler ●, Y. Tateyama

○ Field Coordinator
● Satellite PI

Research Groups

Nano-Materials

Thermal Energy Materials Group

T. Mori	Group Leader
Y. Michiue	Chief Researcher
N. Tsujii	Principal Researcher
I. Okubo	Senior Researcher
N. Satoh	Senior Researcher
R. Wu	Senior Researcher
D. Tang	Researcher

Soft Chemistry Group

T. Sasaki	Group Leader
R. Ma	Associate PI
N. Shirahata	Associate PI
Y. Ebina	Principal Researcher
N. Sakai	Senior Researcher

Mesoscale Materials Chemistry Group

Y. Yamauchi	Group Leader
J. Henzie	Senior Researcher
Y. Ide	Senior Researcher
S. Tominaka	Senior Researcher

Nanotubes Group

D. Golberg	Group Leader
M. Mitome	Chief Researcher
R. Souda	Chief Researcher
N. Kawamoto	Senior Researcher

Supermolecules Group

K. Ariga	Group Leader
J. Hill	Chief Researcher
L. K. Shrestha	Senior Researcher
W. Nakanishi	Senior Researcher

Functional Nanosheets Group

M. Osada	Group Leader
T. Aizawa	Chief Researcher
T. Taniguchi	Senior Researcher

Photocatalytic Materials Group

J. Ye	Group Leader
M. Oshikiri	Principal Researcher
T. Kako	Senior Researcher

Nanostructured Semiconducting Materials Group

N. Fukata	Group Leader
W. Jevasuwan	Researcher
R. Matsumura	Researcher

Frontier Molecules Group

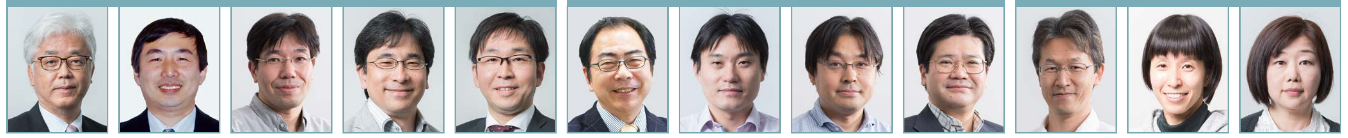
T. Nakanishi	Group Leader
K. Tashiro	Principal Researcher
S. Ishihara	Senior Researcher

Semiconductor Device Materials Group

T. Chikyo	Group Leader
T. Sekiguchi	Managing Researcher
J. Kawakita	Chief Researcher
M. Yoshitake	Chief Researcher
S. Yagyu	Principal Researcher
Y. Yamashita	Principal Researcher
J. Chen	Senior Researcher
T. Nagata	Senior Researcher
A. Ohi	Senior Engineer

Nano-Systems

Nanoionic Devices Group



K. Terabe	Group Leader
Y. Okawa	Chief Researcher
M. Sakurai	Principal Researcher
T. Tsuruoka	Principal Researcher
T. Tsuchiya	Senior Researcher

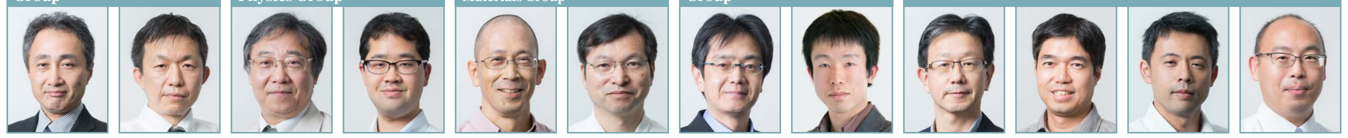
Nano Functionality Integration Group

T. Nakayama	Group Leader
S. Kawai	Principal Researcher
Y. Shingaya	Senior Researcher
H. Arakawa	Principal Engineer

Medical Soft Matter Group

K. Kawakami	Group Leader
C. Kataoka	Senior Researcher
Y. Shirai	Principal Engineer

Thin Film Electronics Group



K. Tsukagoshi	Group Leader
S. Kato	Senior Researcher

Nano-System Theoretical Physics Group

X. Hu	Group Leader
T. Kariyado	Researcher

Nano Frontier Superconducting Materials Group

Y. Takano	Group Leader
H. Takeya	Chief Researcher

Photonic Nano-Engineering Group

T. Nagao	Group Leader
S. Ishii	Senior Researcher

Quantum Device Engineering Group

Y. Wakayama	Group Leader
S. Nakaharai	Principal Researcher
R. Hayakawa	Senior Researcher
S. Moriyama	Senior Researcher

Surface Quantum Phase Materials Group

T. Uchihashi	Group Leader
R. Arafune	Senior Researcher
K. Nagaoka	Senior Researcher
T. Yamaguchi	Senior Researcher

Nanomechanical Sensors Group

G. Yoshikawa	Group Leader
K. Shiba	Researcher

Mechanobiology Group

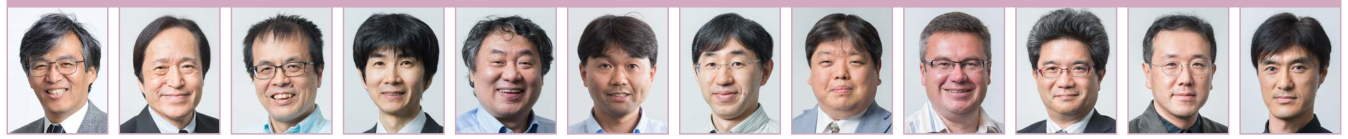
J. Nakanishi	Group Leader
M. Ebara	Associate PI
C. Yoshikawa	Senior Researcher
T. Ueki	Senior Researcher

Managing Researcher

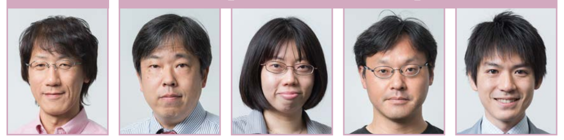
H. Kobayashi	Managing Researcher

Nano-Theory

Materials Properties Theory Group



T. Sasaki	Group Leader ad interim
T. Ohno	Senior Scientist with Special Missions
M. Arai	Chief Researcher
W. Hayami	Principal Researcher
K. Kobayashi	Principal Researcher
M. Kohno	Principal Researcher
M. Nishino	Principal Researcher
Y. Nonomura	Principal Researcher
I. Solovyev	Principal Researcher
S. Suehara	Principal Researcher
A. Tanaka	Principal Researcher
J. Inoue	Senior Researcher

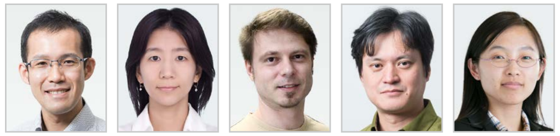


J. Shimizu	Principal Engineer

First-Principles Simulation Group

T. Miyazaki	Group Leader
A. Nakata	Senior Researcher
J. Nara	Senior Researcher
R. Tamura	Researcher

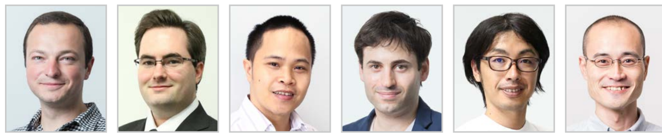
Independent Scientists



G. Imamura	Independent Scientist
T. Konoike	Independent Scientist
J. Labuta	Independent Scientist
T. Minari	Independent Scientist
L. Sang	Independent Scientist

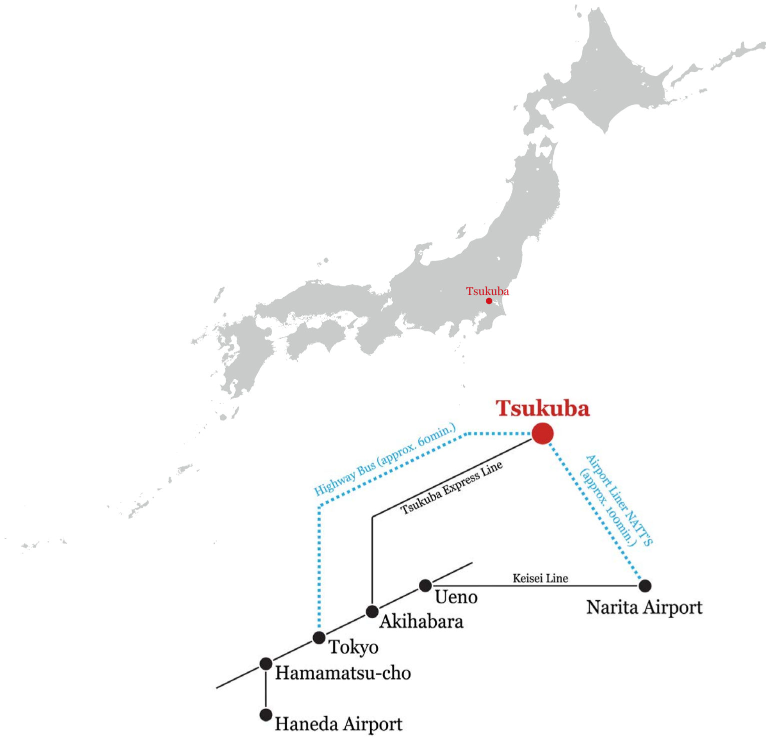
Nano Revolution for the Future

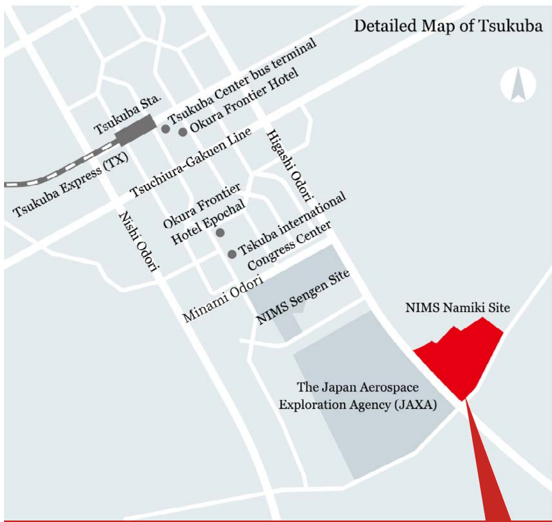
ICYS Researchers (Former ICYS-MANA Researchers)



O. Cretu	ICYS Researcher
A. Fiori	ICYS Researcher
T. C. Nguyen	ICYS Researcher
G. Rydzek	ICYS Researcher
K. Uto	ICYS Researcher
S. Yoshizawa	ICYS Researcher

(October 1, 2017)





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