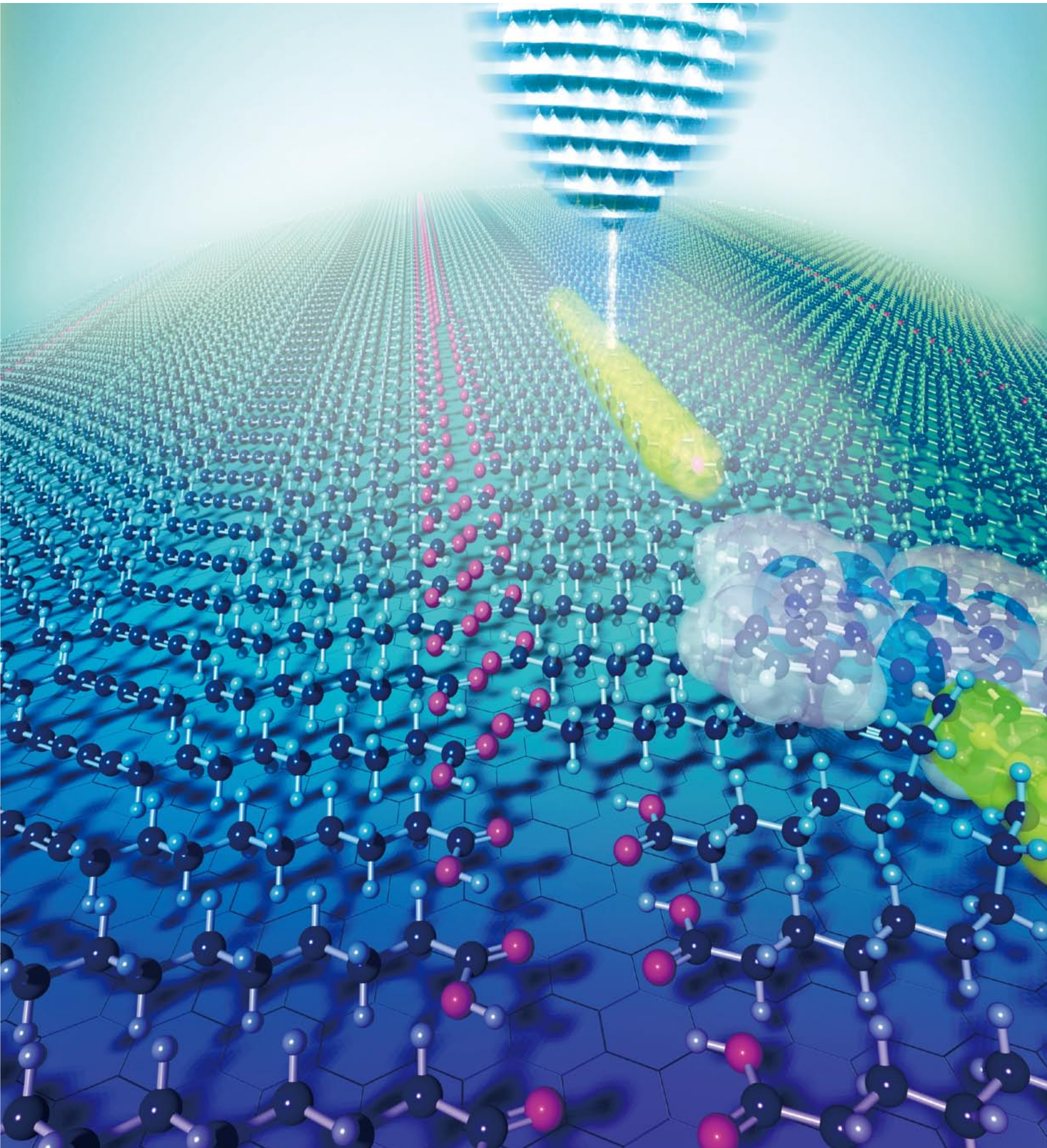
WPI Research Center

International Center for Materials Nanoarchitectonics

MANA



Oriented Towards a Better Global Future: Pioneering a New Paradigm in Materials Development

In 2007, Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) established a program to create new type of research center. The aim was to facilitate advanced research by promoting participation of leading scientists from around the world and by providing an attractive research environment. This was called the World Premier International Research Center (WPI) Initiative. The International Center for Materials Nanoarchitectonics (MANA) is one of the original five centers (a sixth was added in 2010). In order to fulfill its mission as the only WPI center not integrated in a university, MANA has been pursuing a unique path of innovation. Not only have we built a truly international environment with more than half of our researchers coming from overseas, we also are dedicated to the training of young scholars and promotion of interdisciplinary research.

In the 21st century, humanity is facing some unprecedented challenges. The explosive growth of demand in a wide range of areas such as energy, natural resources, foodstuff, water, IT communications, transport, medicine and therapy brings with it a number of problems that stretch the finite resources of our planet. In order to overcome these challenges, technological innovation in a wide range of fields is vital. Such innovation must be brought about by fusing "matter", namely materials, and "mind", that is scientific knowledge on a high plane. MANA was created with the aim of facilitating this type of innovation. A major focus of our activities is the development of materials on the basis of nanotechnology, a discipline that has made tremendous strides over the past quarter century. Going beyond the utilization of various techniques that were previously developed in nanotechnology, we aim for ground-breaking innovation in nanotechnology to explore a new paradigm in materials development. This is what we want to express by the term nanoarchitectonics.

In the three and a half years since its inception, MANA has achieved steady progress. This is reflected in a number of benchmarks and numerous insights gained through research pointing the way towards the future. On behalf of all MANA members who are dedicated to pursuing the aims set forth above, I am looking forward to your continued support for our activities.

MANA Director-General Prof. Masakazu Aono

Mission of MANA

- To promote interdisciplinary research by materials nanoarchitectonics
- To serve as a "Melting Pot" where top-level researchers gather from around the world
- To secure and cultivate outstanding, innovative young scientists
- To construct a network of nanotechnology centers throughout the world

History of MANA

2007 Foundation (October)

2008 Reorganization into 4 research areas

2009 Number of institute members exceeds 200 (52% of researchers from overseas)

2010 Construction of new research building starts

Organization of MANA

Evaluation Committee

Administrative Director
Takahiro Fujita

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

MANA Foundry

Director-General
Masakazu Aono

Advisors

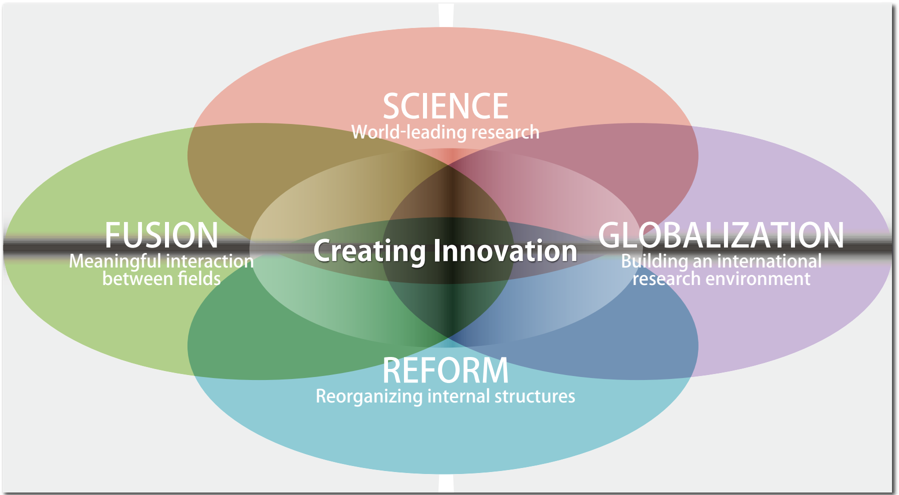
Chief Operating Officer
Yoshio Bando

Research Section
- Nano-Materials
- Nano-System
- Nano-Green
- Nano-Bio
- Independent Scientist
- ICYS-MANA Researcher

Satellites

A Research Center Open to the World

The WPI program of world-class research institutes was established by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2007. It aims to maintain and further Japan's high level of involvement in research also in the 21st century. Dedicated researchers from all over the world will find a vibrant research environment that fosters a high standard of investigation and that is truly open to interaction on an international scale. The six institutes of the WPI program have the following objectives: advance leading-edge research, create interdisciplinary domains, establish an international research environment, and reform the organization of research. Each center is actively engaged in building up an extraordinary roster of researchers and in creating the best environment for them to flourish in.



Host Institution	WPI Research Center	Research Fields
Tohoku University	Advanced Institute for Materials Research (AIMR)	Materials Science
University of Tokyo	Institute for the Physics and Mathematics of the Universe (IPMU)	Astrophysics
Kyoto University	Institute for Integrated Cell-Material Sciences (iCeMS)	Meso-Control & Stem Cells
Osaka University	Immunology Frontier Research Center (IFReC)	Immunology
National Institute for Materials Science	International Center for Materials Nanoarchitectonics (MANA)	Nanotechnology & Materials Science
Kyushu University	International Institute for Carbon-Neutral Energy Research (I^2CNER)	Energy & Environmental Sciences

Sukekatsu Ushioda

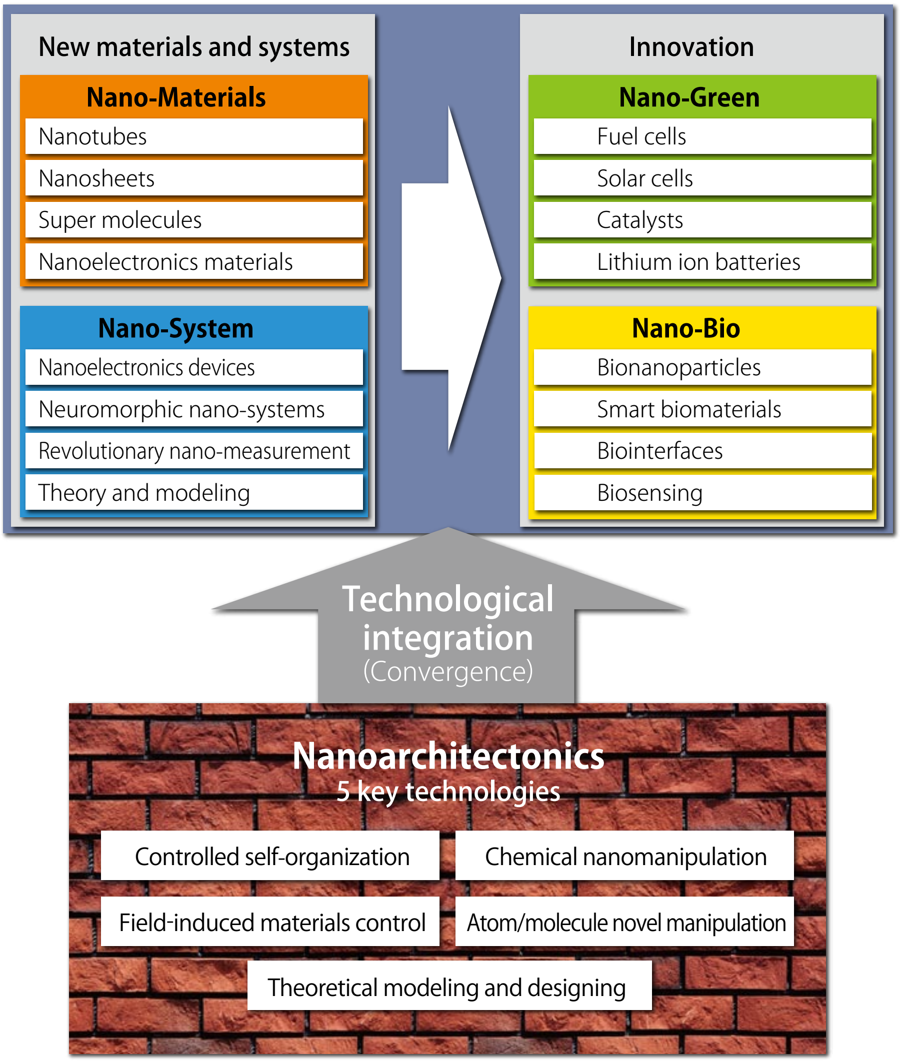
President,
National Institute for Materials Science

The National Institute for Materials Science (NIMS) was the only independent administrative institution selected for a grant by the World Premier International Research Center (WPI) Initiative in 2007 and later in October of that year, established the International Center for Materials Nanoarchitectonics (MANA). The WPI Initiative selects members on the basis

Four Research Fields Supported by Nanoarchitectonics Based on Five Key Technologies

In the past quarter century, nanotechnology has made impressive progress and has become an important pillar of new materials development. But to develop its full potential, nanotechnology needs to continue on the path of innovation. Towards this aim, the conventional analytic view of nanotechnology must yield to a certain synthetic approach. This is conducive to creating new functions that can be exhibited by nanoscale elements in combination through mutual interactions although they are not present in the isolated element. MANA has coined the term nanoarchitectonics to express this innovation of nanotechnology necessary for a paradigm shift in materials development.

MANA pursues nanoarchitectonics by converging five key technologies, namely controlled self-organization, chemical nanomanipulation, field-induced materials control, atom/molecule novel manipulation, and theoretical modeling and designing. These fundamental methods of nanoarchitectonics are harnessed for scientific pursuit organized into four research fields: Nano-Materials, Nano-System, Nano-Green, and Nano-Bio.



of their ability to attract leading researchers from across the globe and bring together a wide range of researchers including young scholars, postdoctoral associates, and graduate students in an environment that should possess a certain level of "global visibility."

Apart from featuring world-class leading-edge research facilities, NIMS also hosts one of the best international research environments in Japan. In its role as host institution, NIMS fully supports the research activities undertaken by MANA and looks forward to seeing MANA develop into a world-class leading research center in the nanotechnology and materials fields, distinguished both by reputation and achievements.

Designing Nanoscale Materials With New Properties and Unprecedented Functions

MANA is promoting research that explores new properties and functions intricately linked to nanoscale size and shape. This exploration covers a wide range of inorganic, metallic, and organic materials.

Many new nanoscale materials are being created by utilizing unique synthetic techniques based on nanoarchitectonics, involving soft-chemical, colloid chemical and supramolecular processes. Highly advanced nanoanalysis techniques based on transmission electron microscopy allow us to study the structure and properties of these materials in detail.

An example of a one-dimensional nanomaterials is the boron nitride (BN) nanotube. A method for high-purity and large-scale production of such nanotubes was developed at MANA. Methods for synthesizing various other types of nanotubes and nanowires of metals, oxides, nitrides, and sulfides (Si, ZnS, ZnO...) were also successfully established.

Regarding two-dimensional nanomaterials, a unique process for delaminating layered compounds has made it possible to create nanosheets with molecule-level thickness. A large number of nanosheets based on oxides and hydroxides have been synthesized, and were found to possess superior electrical, magnetic, thermal, and chemical functionalities.

The obtained nanoscale materials are precisely organized or hybridized with other functional modules via various chemical processes involving self-assembly. New nanostructured materials and nanodevices with sophisticated functionalities are being developed through this so-called soft nanoarchitectonics.

For example, BN nanotubes which have excellent thermal conductivity can be dispersed in polymer to create a material suitable for heat sink substrates. Ultrathin films with a high dielectric constant (High-k films) are also being developed with oxide nanosheets. In this way, research is opening up many new possibilities.

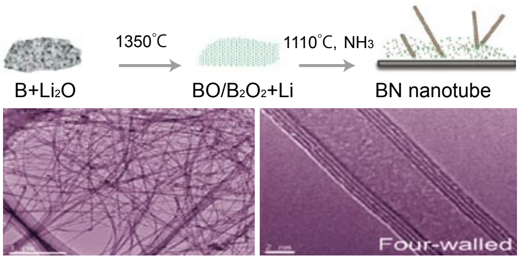
The creation of nanoscale materials and the exploration of their applications have almost unlimited potential. Based on the concept of nanoarchitectonics, MANA is developing novel synthesis techniques to bring forth new materials and new processes that will spur innovation across a range of sectors including electronics, environment protection, and energy technology.

Creating functional nanotubes and nanowires

While working on the creation of new types of inorganic nanotubes and nanowires, diverse synthetic methods such as elemental doping, core-shell structure fabrication, and composite forming are pursued. The combination of these techniques is instrumental in the development of materials with new functionalities.

For example, a method for large-scale synthesis of Boron (B) – Carbon (C) – Nitrogen (N) nanotubes and nanosheets of high purity was developed and applied to the creation of polymeric nanocomposite films through nanophase dispersion in a polymer. Good insulation and excellent thermal conduction properties make this type of films a good candidate for use in heat dissipating substrates.

Another case in point is high-purity semiconductor nanowires made of inorganic materials such as ZnO, ZnS, and Si/Ge. Doping techniques are explored with a view towards the use of such nanowires for ultra-violet light sensors, solar cells, and other applications.

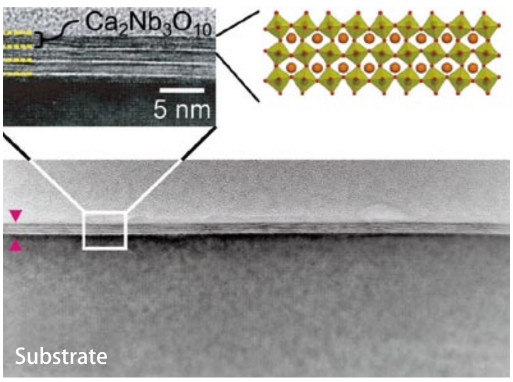


High-purity synthesis of BN nanotubes (top) and their TEM images (bottom)

Developing functional nanosheet films

Solution-based techniques for layer-by-layer assembly of colloidal oxide nanosheets have been developed and novel functionalities have been designed for highly-organized multilayer or superlattice films of various nanosheets.

The illustration below shows a multilayer film of niobium oxide nanosheets (thickness 2nm) with a perovskite-type structure, fabricated by applying the Langmuir-Blodgett method. The obtained film possesses superior dielectric/insulating performance (ε_r = 210-230, J_c < 10^{-8} A cm^{-2} at 1 V), showing promising potential for applications such as capacitors, transistors and so on.



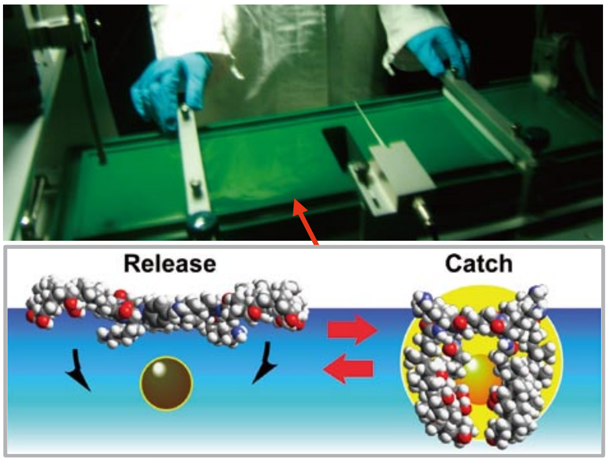
3-layer film of $Ca_2Nb_3O_{10}$ nanosheet (cross-sectional TEM image)

Operating a molecular machine by hands

When molecules of a suitable structure are spread on a liquid surface, a supramolecular film with a thickness of only a single molecule (monolayer) can be created. A molecular machine* can be assembled within monolayers. When the film is compressed or expanded by hands, as shown in the illustration below, the molecular machine will take on an opened or closed conformation, and a target object can be captured or released.

The principle is applicable not only to the surface of a liquid but also to the surface of various other materials. This could, for example, make it possible to remove toxic or polluting substances or release drugs simply by compressing or expanding a material by hand. There is keen interest in the potential applications with this technology.

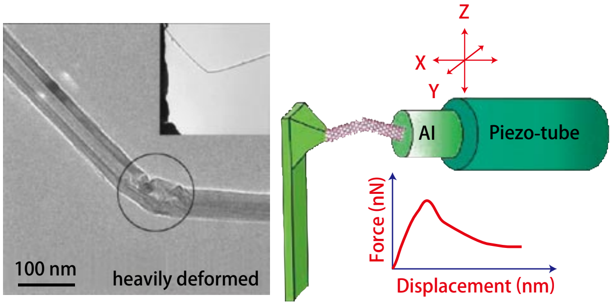
*Molecular machine: Molecules that change their structure in response to external stimulation like machine.



Hand-operation (top) and molecular conformation change dependent on pressure (bottom)

Measuring nanoscale material properties

Advanced electron microscope technology is being employed to explore and clarify the atomic structure as well as properties and functionalities of new nanoscale materials. For this purpose, MANA is utilizing special piezo-driven type sample holders having the functions of a scanning tunneling microscope and an atomic force microscope within a transmission electron microscope. These are used to measure the electrical and mechanical properties of nanotubes and nanowires, for example, BN nanotubes.



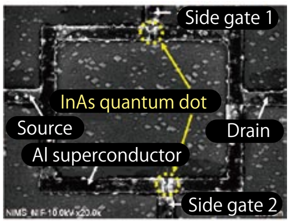
Mechanical properties of a BN nanotube measured inside TEM

Revolutionary Functionality Realized through Mutual Interactions of Nanoscale Functional Units

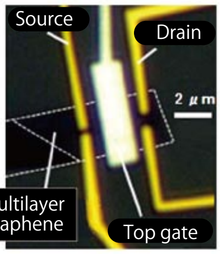
Our research activities encompass not only the discovery and exploration of nanoscale matter and materials with hitherto unknown functions, research also extends to the development of break-through systems that can be created through mutual interactions of such nanoscale units. For this purpose, researchers investigate how nanoscale structures can produce novel linked functionalities.
One of the goals of nanoarchitectonics is the exploration of how such structures can be organized into nano-systems of varying complexity and how this changes their behavior.
In the long run, such nano-systems have tremendous promise for various technical fields, but our research is focused on innovation in three areas, namely advanced information processing and communications, advanced environment sensing, and effective solar light application.
For advanced information processing and communications, the development of new nano-devices that far surpass the limitations of conventional CMOS devices used in today's computers is of course a major goal. But going beyond that, it is necessary to rethink computation algorithms and architecture, and learn from neural networks while aiming for new kinds of information processing nano-systems and quantum information processing nano-systems.
In the field of advanced and highly sensitive environment sensing, the focus is on the detection and identification of the several hundred to several thousand types of molecules present in the gases, liquids, and biological materials that make up the environment. Research is focused on how to achieve this on the single molecule level while at the same time maintaining high spatial resolution measured in nanometers.
With a view to the effective use of sunlight, we are currently developing solar nano antenna collector systems of advanced design.
These research and development activities are based on the concepts and methodology of nanoarchitectonics. The development of new nano-system evaluation methods and the new concepts of theoretical science also are important aspects that guide our work.

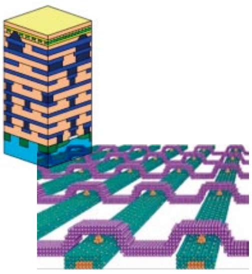
Creating revolutionary nano-system devices

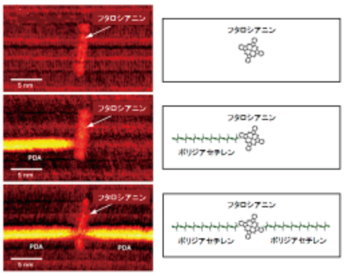
Silicon CMOS devices are the mainstay of current computer technology. But for the future, the development of innovative devices that go far beyond CMOS is absolutely necessary. Otherwise, it will simply not be possible to process the enormous amounts of information that are becoming the norm in the 21st century. Some of the salient keywords are ultrafine (atomic and molecular scale), ultra high speed (including quantum information processing), and low power consumption (including superconducting devices). Nanoarchitectonics is used for basic and applied research into atomic switches, molecular devices, superconducting quantum information devices, graphene devices, as well as solar nano-antenna collector systems that make effective use of sunlight.



Superconducting device

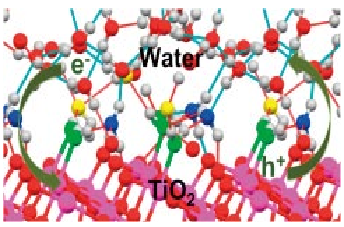
Graphene device



Integration of atomic switches

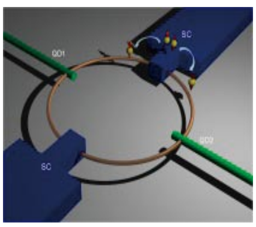

Single-molecule device

Nano-system theory

In nanoarchitectonics, theoretical research and analysis of the new functionalities exhibited by nano-systems, as well as the theoretical exploration of the principles that allow new functions to be formed through such systems are vital aspects of scientific work. Along with first-principle calculation, new calculation methods that are able to incorporate atomic numbers on a much higher scale than before are being applied extensively.

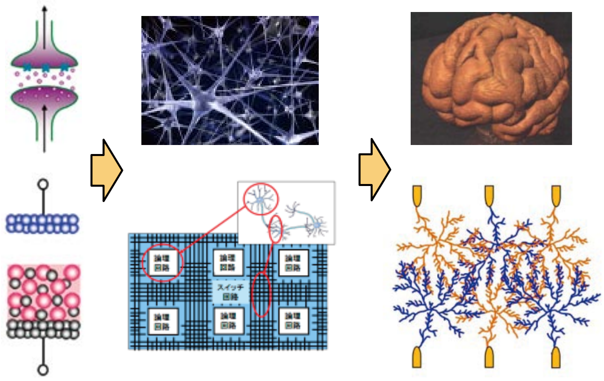


Dynamic processes on the molecule level


Proposed new superconducting device

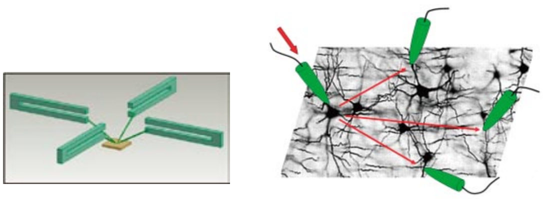
Towards a neural network type nano-system

Modern computers have made enormous progress and have brought about a revolution in the way information is processed. However, after about half a century, von Neumann type computer algorithms that perform calculation according to stored program instructions have reached a plateau, and radical new approaches are called for. Will it be possible to realize computers that perform calculations without programs in a creative manner that emulates the human brain, computers that do not rely on existing device configurations and software instructions, by configuring systems that are made up only of nanoscale materials and components? This is the kind of challenge that is being pursued from the nanoarchitectonics perspective.


Neural network type computing circuit realized directly on the materials level

Developing new nano-system evaluation methods

Just as the age of modern nanotechnology was ushered in by the invention of the scanning tunneling microscope (STM), the future evolvement of nanotechnology is dependent on the ongoing development of new measurement methods. This is particularly important in the field of nanoarchitectonics. Subsequently to introducing the world's first multiple probe scanning tunneling microscope (STM), we have developed an atomic force microscope (AFM) with four probes operated easily. We are also developing a single molecule detection method with a high spatial resolution, a super parallel high-sensitivity molecule detection method, and a new nano-magnetism measurement method subsequently.


Development and application of AFM and STM with multiple probes

Development and application of single molecule sensing method with high spatial resolution

Effective Conversion of Materials and Energy Is Crucial to the Realization of a Sustainable Society

The biggest challenge facing humanity today is the move away from our dependence on energy that is derived from fossil fuels. Renewable energy is the key if we want to realize a sustainable society. Consequently, natural energy sources with the sun as the prime source must be converted with high efficiency into electricity and fuel (namely hydrogen, H_2). Also, because the supply of natural energy as well as the demand will vary depending on the geographical position and time frame, efficient storage and transport of energy are also of high importance. Furthermore, production processes as well as all sorts of devices and equipments must be designed so as to consume fewer resources and less energy.

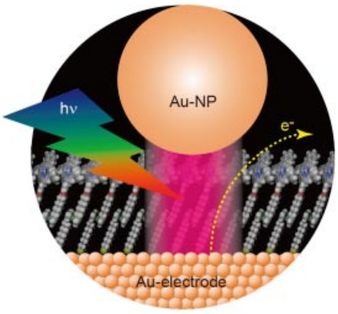
Plants efficiently utilize sunlight to fix carbon dioxide (CO_2) and obtain energy. The key to these processes is the efficient arrangement of molecules that perform various tasks such as transporting electrons and catalyze chemical reactions. To make efficient use of solar energy, we need similar capabilities. When storing, transporting, and retrieving energy through means such as secondary batteries and fuel cells, efficient transport of ions and electrons are required and controlled arrangement of atoms and molecules at interfaces is essential. Furthermore, chemical processes that conserve resources and energy would not be realized without catalyst, which promotes specific reaction with high selectivity and high efficiency. Control of the arrangement of atoms and molecules on the catalyst surface is a vital aspect here.

The scientific underpinning for the realization of a sustainable society therefore lies in the ordered assembly of atoms and molecules based on the rational deign, i.e., surface nanoarchitectonics. Thus, the “Nano-Green” field employs the concepts of surface nanoarchitectonics to directly control the nano structure on the atomic and molecular level. The research aims at illuminating and exploring methods and processes for interconversion between energy and matter with high efficiency.

Capturing the energy of the sun

Based on the concept of nanoarchitectonics, research in this area focuses on two approaches. One involves the use of semiconductor photocatalysts to produce hydrogen by splitting water, or to reductively fix carbon dioxide. The other approach involves semiconductors or metals with a layer of functional molecules on the surface for photoelectric conversion or for reductive fixation of carbon dioxide.

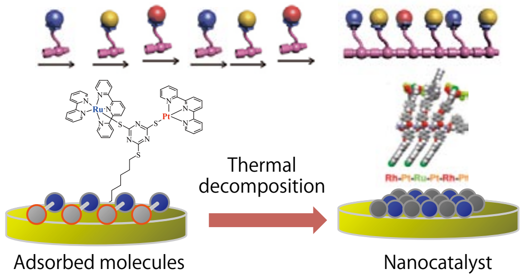
Highly efficient photocatalyst for water oxidation responsive to visible light



Enhancing photoelectric conversion efficiency through the use of nano gap light antenna effect

Programmed arrangement of atoms and molecules to form ultimate catalysts

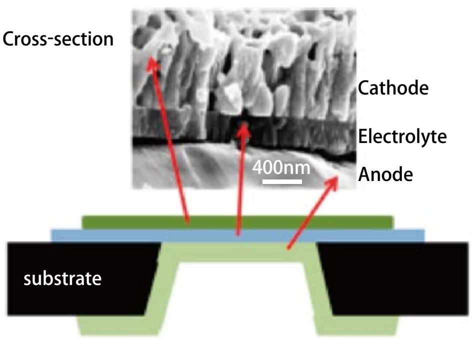
To control and efficiently proceed chemical reactions, catalysts that accelerate each elemental step such as cleavage and formation of chemical bonds are essential. For complex chemical reactions, multi-functional catalysts are required. Ultimate catalysts to realize highest efficiency are being developed by utilizing surface nanoarchitectonics to arrange various atoms in desired positions.

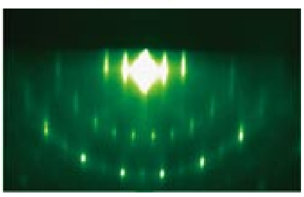


Controlled arrangement of molecules and conversion to highly efficient catalyst

Efficient storage and use of energy

Secondary (rechargeable) batteries are the most widely used energy storage device, but they still leave a lot to be solved in terms of efficiency and safety. One way to solve such problems and drastically improve reliability is to turn the entire battery into a solid through the use of solid ionic conductors. If hydrogen is to be used as energy medium, the development of fuel cells that can convert hydrogen into electricity is essential. In both cases, the key to improve performance lies in increasing the conductivity of the ionic conductor and controlling interfacial structure. Towards this end, new electrolyte materials are being developed based on nanoarchitectonics and interfacial ion transfer mechanism is under investigation.

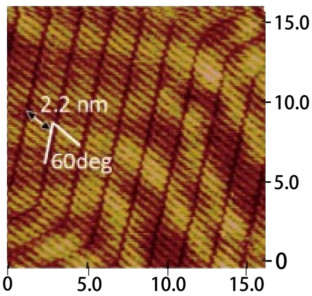


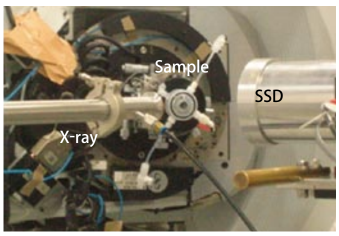


Top: Solid oxide fuel cell
Bottom: Highly oriented electrolyte for lithium ion battery

Determination of Interfacial structure with spatial resolution of 1 billionth of a meter and time resolution of 10 trillionth of a second

In situ, real time determination of the structure of interfaces, particulary solid/liquid interfaces, at high spatial and temporal resolution is essential to achieve the efficient harvesting of solar energy, storage and usage of chemical energy, and catalyst reactions based on surface nanoarchitechtonics. For this purpose, scanning probe microscopy, laser spectroscopy, x-ray scattering/absorption using synchrotron radiation and other advanced measurement techniques are developed to analyze interfacial structures with a spatial resolution to 1 billionth of a meter (1nm) and measure electron transfer dynamics with a time resolution to 10 trillionth of a second (0.1psec).





Top: Laser spectroscopy setup
Middle: STM image of molecule resolution in liquid
Bottom: X-ray absorption spectroscopy setup

Innovative Medical Approaches May Draw on Nanoscale Biomaterial

The smallest building block of the human body is the cell. Aggregations of cells along with the protein that binds them together and other elements of the biological matrix make up the so-called tissue, and multiple such tissues in turn form the organs with their various functions. Under this aspect, the human body can be seen as a hierarchical entity at whose base lies an elaborate and delicate nanostructure. When designing man-made materials, the nanoarchitectonics approach that emulates a similarly complex structure can be a useful strategy. The configuration of diagnosis and treatment systems based on an understanding of the mechanisms of disease is also important.

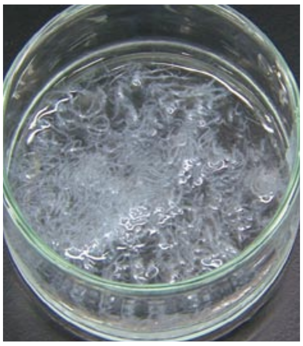
An example of the type of work done in this field is the development of an artificial bone made of oriented open-pore apatite material. In 2009, after approval by Japan's Ministry of Health, Labour, and Welfare, this was commercialized as a product. Developmental research on a drug-eluting stent which effectively avoids restenosis, i.e. the recurring constriction of blood vessels is also ongoing.

In another avenue of research, the direct control of cell functions to create sensor cells has also been attempted successfully. This is an important step that will pave the way for toxicity evaluation of quantum dots, nano particles, and other next-generation nanotech materials. Research into high polymer materials that respond to stimuli is also progressing. This involves materials that significantly change their properties in response to changes in their ambient environment. As the material itself can perform sensing as well as processing and various other functions, these nano-bio materials will allow a significant scaling-down of equipment and devices.

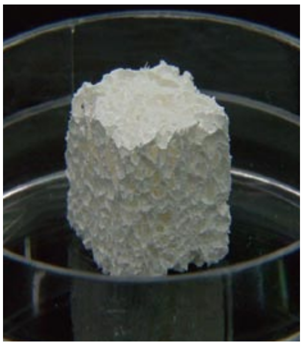
In the nano-bio field, enhancing the natural regenerative power of the human body is an important concept for treating diseases. The aim is to create materials suitable for "materials therapy", i.e. materials that sustainably elicit a regenerative and curative effect from the living tissue. Such materials designed and produced with nanoarchitectonics methods are expected to have an effectiveness that is comparable to conventional medicines. Drawing on the results of past research as inspiration, MANA is intensively working towards the development of such new nano-bio materials.

Artificial bone made of oriented open-pore apatite

Bone has an elaborate hierarchical structure whose major components are hydroxyapatite and collagen. The artificial bone under development has pores that are aligned in a certain direction to facilitate the entry of blood vessels and cells. These pores are formed by using ice as a casting mold, and collagen is added to form an apatite-collagen complex compound. Nanoarchitectonics methods are essential in the development of this type of artificial bone. Researchers are also working towards creating a compound composite of high polymer and collagen. Fiberized high polymer that breaks down in the body could be used in a compound composite with collagen to create a material with an affinity for cells, with the aim of enabling the regeneration of body tissue, an approach that has recently become the focus of attention. Ultimately, the technique should enable the restoration of various tissue and organ functions.



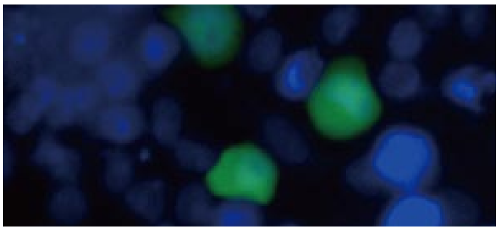
Fiberized hydroxyapatite and collagen compound composite immediately after adjustment



Hydroxyapatite and collagen compound composite made porous

Sensor cells

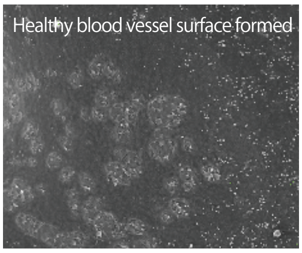
Adapting techniques from molecular biology and cell biology, work on development and application of sensor cells is progressing. It has been found that if a cell can be made to express a fluorescent protein in response to a signal, this method can be used to detect trace amounts of toxic metal ions and anticancer agents. This is expected to be an extremely effective technique for evaluating the toxicity of quantum dots and nanoparticle materials.



Sensor cell emanating light in response to extremely small traces of toxic material

Drug-eluting stent

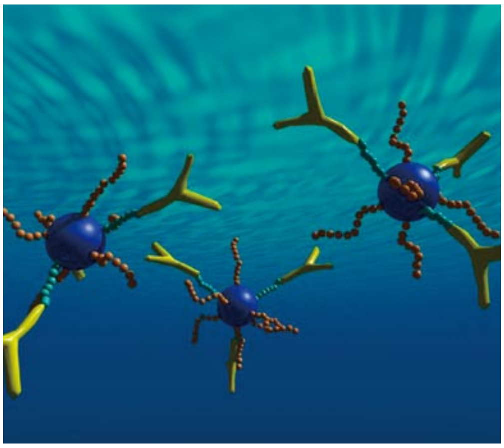
Stents are widely used to expand blood vessels when constriction (stenosis) of a blood vessel occurs due to atherosclerosis. However, recurrence of stenosis (i.e., restenosis) has been a problem with conventional stents. Therefore a stent was developed in which a bio-originated material on the surface elutes a drug that induces endothelial cells to the area, thereby promoting the formation of tissue. As a result, it was found that tissue which is very similar to the surface of a healthy blood vessel can be formed stably.



Interior of blood vessel with drug-eluting stent currently under development. No blood clots are formed, and interior surface is smooth.

Drug delivery system/smart biomaterial research

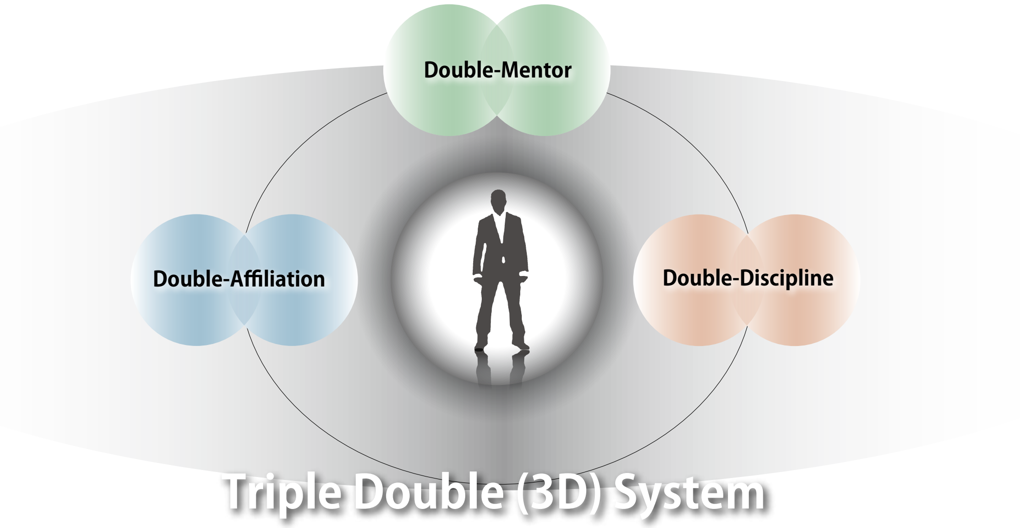
Applying the concepts of nanoarchitectonics, researchers are exploring the possibility of creating particles with controlled shape and size which are designed to exhibit certain functions within an organism. This may enable particles to be sent deep into the lung or to have them enter the bloodstream and travel to an affected area that is being targeted. Research is also being carried out towards smart biomaterial whose functions are controlled from outside the body. Property changes in the material then could be used to control the differentiation of stem cells.



Conceptual image of intelligent particles with controlled nanostructure

Creating a Cosmopolitan Environment that Fosters Interaction Across Different Disciplines and Cultures

When people from diverse backgrounds and with different opinions and viewpoints are able to freely meet and interact, an environment highly conducive to innovation is created. MANA sees itself as a melting pot that offers researchers from a wide range of fields and with diverse cultural and national backgrounds the opportunity to work in such a cosmopolitan environment. Whether in the lab, in the cafeteria, or during events and other activities, there are always opportunities for communication and interaction. We believe that comprehensive research that spans diverse fields will prove beneficial for many positive future developments. With a view to further enhancing the cosmopolitan atmosphere at MANA, we are actively encouraging the participation of scientists from around the globe. Currently, more than half of our researchers come from countries other than Japan.



MANA's unique 3D system for fostering human resources

Young researchers at MANA which is affiliated with NIMS are encouraged to work under the tutelage of one NIMS member and one external non-NIMS member, often based overseas. Young researchers typically have two mentors (Double mentor), are affiliated to two research institutions (Double affiliation) and condact research in two fields (Double discipline). This is called the 3D, or Triple Double System. It aims at fostering young researchers with a truly global perspective and the capability to adopt an interdisciplinary approach.

Many independent scientists work part of the year under their overseas mentor, to hone their skills. Direct contact and interaction with top-level researchers around the world is invaluable for staying abreast of advanced developments at the cutting edge of science. This encourages them to undertake discipline-integrated research and serves to cultivate a global perspective in them.

A young MANA researcher (right, Dr. Fukata) in discussion with Prof. Wang (left), MANA Satellite PI, the Georgia Institute of Technology.

Prof. Kroto (1996 Nobel Laureate in Chemistry) and an ICYS-MANA Researcher (Dr. Fang)

ICYS-MANA Researcher

ICYS-MANA is an evolution of the "International Center for Young Scientists" (ICYS) program originally hosted by NIMS. Gifted and ambitious young researchers from around the world can apply, and those who are selected are given the opportunity to conduct their respective research while having access to an interdisciplinary linkup in a "melting pot" environment. MANA's Principal Investigators serve as mentors for ICYS-MANA Researchers.

Cutting-edge research facilities

MANA researchers have full access to the world's most advanced, high-performance research facilities at NIMS. MANA is home to the MANA Foundry, a collection of top-class equipment that provides the backup for nanoarchitectonics research ranging from nanofabrication to nano-characterization.

In addition to the Foundry, MANA houses various shared facilities and employs experienced technicians to provide maintenance and support.

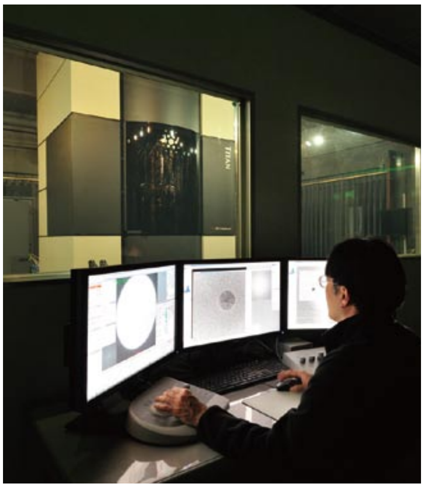
Thorough support for foreign researchers

MANA provides comprehensive assistance to foreign researchers in matters such as registration procedures, finding housing, and emergencies to get them established in Japan. MANA also offers regular Japanese culture and Japanese language classes to foster an understanding of the host country.

There are public accommodation facilities nearby for foreign researchers who work at MANA, making for an ideal environment.

Making all researchers welcome

The official language of MANA is English. MANA employs experienced staff who are fluent in the language, and administrative support systems are in place to ensure that scientists of all nationalities can focus on their research. Seminars and meetings are held in English, and e-mail communication, intranet information, research plans, and administration documentation are all in English as well. Major information pamphlets, the web site, and other publications are to a large extent bilingual.



Monochromated Double-corrected Microscope (300kV)

Technical staff providing research support

MANA Café, a venue for mutual communication and mingling

MANA Foundry: X-ray photoelectron spectroscope (XPS)

Furoshiki (cloth wrapping) class for foreign researchers

Administrative staff providing clerical support

Getting the Message out to Academics, the Community, and the Next Generation

MANA International Symposium

Once per year, MANA hosts a international symposium intended to disseminate research results to a wider audience. In addition to invited presenters from around the globe, all the MANA affiliated researchers also participate in three days of presentations and poster sessions, covering the latest research activities. Each year, over 300 participants engage in active discussions. (The 4th symposium held in early March 2011 had 410 participants from 29 countries.)

MANA International Symposium, March 2011

Keynote lecture by Prof. Klaus von Klitzing (1985 Nobel Laureate in Physics) at the MANA International Symposium 2011

MANA Science Café
— The Melting Pot Club —

This initiative provides an opportunity for citizens to learn about nanoarchitectonics and participate in an exchange of opinions. MANA researchers introduce certain topics, followed by Q & A sessions and discussions in which two-way communication is given high priority.

Science classes for children up to junior high school level
–Special lectures by Nobel laureates–

Let's instill a love of science in the young generation!
Dr. Rohrer and Prof. Kroto who are MANA Advisors have given exciting and entertaining lectures introducing primary and junior high school students to the wonders and the fun of science.

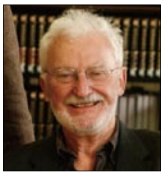
MANA Science Café : Dr. Aono, MANA Director-General (left) and Mr. Itano, Media Producer (right)

Dr. Rohrer (1986 Nobel Laureate in Physics) interacting with junior high school students at the science class

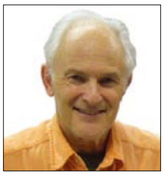
ADVISORS . . . .

Advisors

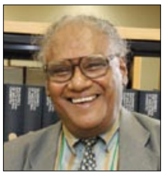
Advisors including Nobel Laureates winners and prominent researchers provide valuable advice to MANA scientists, drawing on their extensive experience.



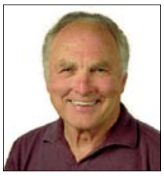
Heinrich Rohrer
Nobel Laureate in Physics (1986)



Sir. Harold W. Kroto
Professor, Florida State University
Nobel Laureate in Chemistry (1996)



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



Galen D. Stucky
Professor, University of California Santa Barbara

Teruo Kishi
Former President,
National Institute for Materials Science

Evaluation Committee Members

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

Anthony K. Cheetham
Professor,
Cambridge University

Takuzo Aida
Professor,
University of Tokyo

Morinobu Endo
Professor,
Shinshu University

Horst Hahn
Professor,
Karlsruhe Institute for Technology

Kazuhito Hashimoto
Professor,
University of Tokyo

Yoshio Nishi
Professor,
Stanford University

Manfred Rühle
Professor,
Max Planck Institute for Metals Research

Rodney S.Ruoff
Professor,
University of Texas

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

Kazunobu Tanaka
Principal Fellow, Center for Research and Development Strategy,
Japan Science and Technology Agency

GLOBAL NANO-TECH NETWORK . . . .

University of Cambridge
Bio-inspired Materials

M.E.Welland

CNRS
Interconnects and Molecular Logic Gates

C.Joachim

University of Tsukuba
Superconducting Quantum Materials

K.Kadowaki

University of Tsukuba
Nano-Biomaterials

Y.Nagasaki

Tokyo University of Science
Superconductivity and Quantum Information Physics

H.Takayanagi

University of California Los Angeles
Neural Network System and Nano-X-Ray System

J.K.Gimzewski

Georgia Institute of Technology
One-dimensional Nanomaterial

Z.L.Wang

University of Montreal
Functional Nanoparticles/ Interfaces

F.M.Winnik

Out of the 25 Principal Investigators (PIs) at MANA, 8 are invited researchers based at outside research institutions at which MANA has established satellite laboratories. These satellites facilitate joint research in fields that could not be covered by NIMS alone. The PIs at the satellites also serve as mentors for young MANA researchers. Functioning as the nodes of a global nano-tech network, the satellites play an important role in the exchange of information.


Chief Operating Officer
Yoshio Bando


Director-General
Masakazu Aono


Administrative Director
Takahiro Fujita

MANA Principal Investigator (PI)

* Field Coordinator ** Satellite Co-Director *** Satellite PI

Principal Investigators are internationally known world top-class scientists who play leading roles in achieving MANA research targets and in fostering younger researchers through mentoring. Principal Investigators are selected from NIMS and other domestic and overseas institutes.

Nano-Materials Field

7 PIs


T.Sasaki*
NIMS


K.Ariga
NIMS


Y.Bando
NIMS


T.Chikyow
NIMS


D.Golberg
NIMS


Kazuo Kadowaki***
Univ.Tsukuba


Z.L.Wang***
Georgia Tech

Nano-System Field

9 PIs


M.Aono*
NIMS


J.K.Gimzewski**
UCLA


T.Hasegawa
NIMS


X.Hu
NIMS


C.Joachim***
CNRS


T.Nakayama
NIMS


H.Takayanagi***
Tokyo Univ.Sci.


K.Tsukagoshi
NIMS


M.Welland**
U.Cambridge

Nano-Green Field

5 PIs


K.Uosaki*
NIMS


K. Takada
NIMS


E.Traversa
NIMS


O.Yaghi
UCLA


J.Ye
NIMS

Nano-Bio Field

4 PIs


T.Aoyagi*
NIMS


G.Chen
NIMS


Y.Nagasaki***
Univ.Tsukuba


F.M.Winnik***
Univ.Montreal

MANA Workforce

Out of 200 researchers at MANA, 109 (55 percent) are foreign nationalities hailing from 21 countries.

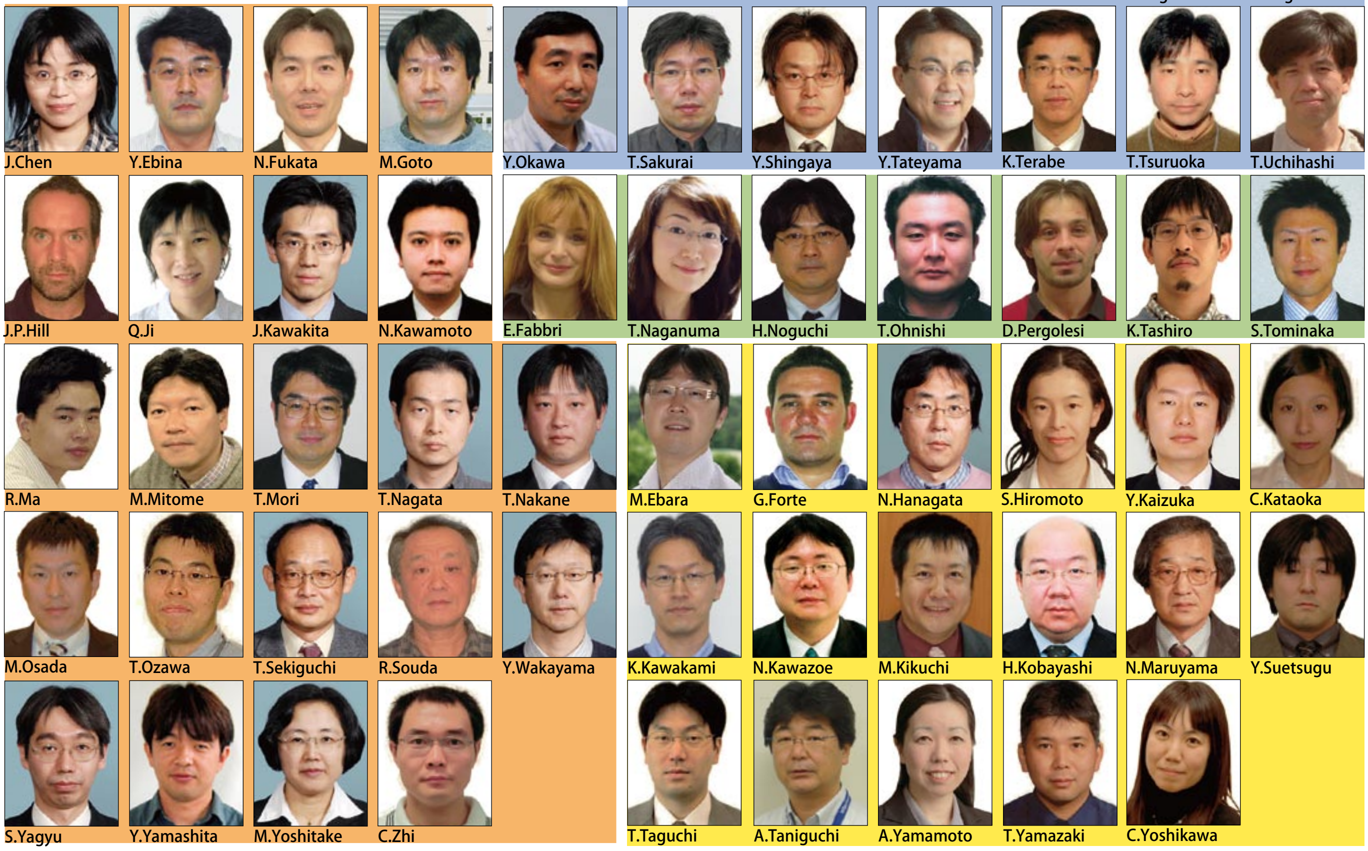
(Current as of November 2011)

Position	Principal Investigator (NIMS)	Principal Investigator (Satellite)	MANA Scientist	Independent Scientist	ICYS-MANA Researcher	MANA Research Associate	Graduate Student	Administrative Staff and Technical Staff	Total
Number	17	8	59	9	13	53	41	26	226
Non-Japanese	5	5	8	2	9	46	34	1	110
Female	1	1	9	0	1	15	16	16	59

MANA Scientist

MANA scientists are researchers from NIMS who conduct MANA research together with Principal Investigators.

H.Arakawa, M.Kohno, S.Kubo, T.Minari, T.Nagao, K.Nagaoka



J.Chen, Y.Ebina, N.Fukata, M.Goto, Y.Okawa, T.Sakurai, Y.Shingaya, Y.Tateyama, K.Terabe, T.Tsuruoka, T.Uchihashi

J.P.Hill, Q.Ji, J.Kawakita, N.Kawamoto, E.Fabbri, T.Naganuma, H.Noguchi, T.Ohnishi, D.Pergolesi, K.Tashiro, S.Tominaka

R.Ma, M.Mitome, T.Mori, T.Nagata, T.Nakane, M.Ebara, G.Forte, N.Hanagata, S.Hiromoto, Y.Kaizuka, C.Kataoka

M.Osada, T.Ozawa, T.Sekiguchi, R.Souda, Y.Wakayama, K.Kawakami, N.Kawazoe, M.Kikuchi, H.Kobayashi, N.Maruyama, Y.Suetsugu

S.Yagyu, Y.Yamashita, M.Yoshitake, C.Zhi, T.Taguchi, A.Taniguchi, A.Yamamoto, T.Yamazaki, C.Yoshikawa

MANA Independent Scientist

MANA Independent Scientists are younger researchers from NIMS who work full-time at MANA and can conduct their own research independently in the 3D system (see page 14).

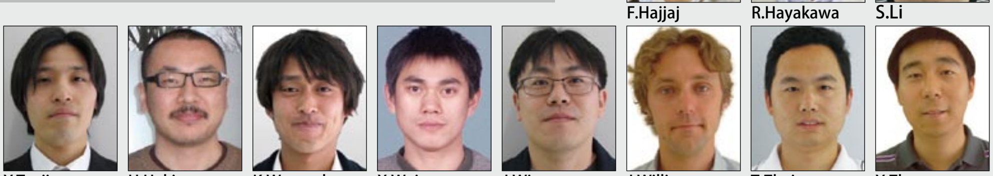
R.Arafune, A.Belik, S.Moriyama, J.Nakanishi

N.Shirahata, L.Vayssieres, K.Wakabayashi, Y.Yamauchi, G.Yoshikawa

ICYS-MANA Researcher (Postdoc)

ICYS-MANA Researchers are postdoctoral fellows selected from all over the world by open recruitment. They conduct their own research independently while receiving advice from mentors and Principal Investigators.

F.Hajjaj, R.Hayakawa, S.Li, C.P.Royall, L.K.Shrestha



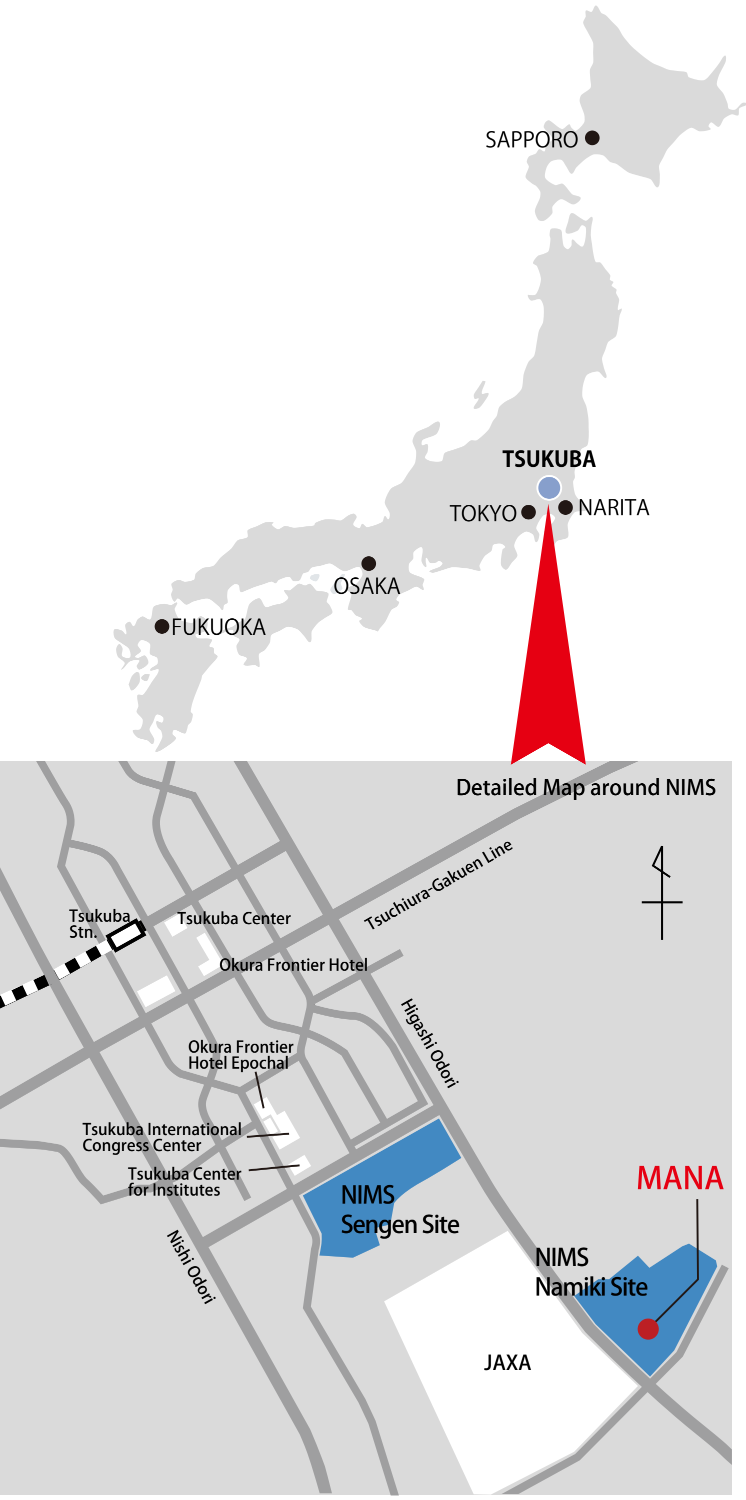
Y.Tsujimoto, H.Ueki, K.Watanabe, X.Wei, J.Wi, J.Williams, T.Zhai, Y.Zhang

MANA Research Associate (Postdoc)

MANA Research Associates are postdoctoral fellows working in a group of Principal Investigators or MANA Independent Scientists.

Graduate Student

Graduate students are doctor-course students at institutions affiliated with NIMS. They participate in research at MANA under the tutelage of Principal Investigators, MANA Scientists, and Independent Scientists.



Access

NIMS Namiki Site

- **By Tsukuba Express Line :** Take the Tsukuba Express from Akihabara Station in Tokyo to Tsukuba Station in Tsukuba City (approx. 50 min.). Then take the bus bound for Arakawaoki Station and get off at the Busshitsu Kenkyujo mae bus stop (10 min.).
- **By highway bus :** Take the highway bus bound for Tsukuba University leaving from bus stop 5 at the Yaesu south exit of JR Tokyo Station and get off at Namiki 1-chome bus stop (approx. 65 min.).
- **By bus from Narita Airport :** Take the Airport Liner NATT' S bound for Tsuchiura Station and get off at Tsukuba Center bus stop (approx. 100 min.) Then take the bus bound for Arakawaoki Station and get off at Busshitsu Kenkyujo mae bus stop (10 min.).

MANA Building

Image of a new MANA building

WPI Research Center
International Center for Materials Nanoarchitectonics (MANA)

National Institute for Materials Science

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E-mail:mana@nims.go.jp
http://www.nims.go.jp/mana/

2011.11