Emerging MANA Researcher

Genki Yoshikawa

Dr. Genki Yoshikawa talks enthusiastically about his dream of "contributing to world peace by science and technology." For Dr. Yoshikawa, who is engaged in frontline research as a MANA Independent Scientist, the starting point would be his encounter with his former high school teacher, who were "so powerful, passionate, and cool." This encounter also taught Dr. Yoshikawa the importance of the influence of people whom we meet in our formative years. It is also one reason why he has been actively involved in communicating the profundity of science to the next generation since his university days, when he tutored younger school children, to today in his work as a researcher.

The topic of Dr. Yoshikawa's research is the development of a "smell" sensor. Among the five human senses, the sense of smell is the only one that has not been reproduced artificially. While Dr. Yoshikawa was a Visiting Researcher in Switzerland, he learned about the possibility–and difficulty–of sensors, and through repeated discussions with his MANA Advisor, the late Dr. Heinrich Rohrer (recipient of the 1986 Nobel Prize in Physics for development of the scanning tunneling microscope), he solidified the basic theory of a sensor applicable to an artificial sense of smell. After returning to Japan as an ICYS-MANA researcher, he initiated a joint development project with the École Polytechnique Fédérale de Lausanne (EPFL) and succeeded in developing a novel sensor, the membrane-type surface stress sensor (MSS), which satisfies both ultra-small size and ultra-high sensitivity. Dr. Yoshikawa says, "By using this sensor, it may be possible to change people's lives and solve a variety of global problems, including early diagnosis of cancer through breath analyses, simple blood tests, monitoring of environmental pollution, and detection of drugs and explosives." Dr. Yoshikawa believes that "after all, a scientist should grapple with work that he truly loves," and he is now trying to make his dream a reality.

Interviewers: Takaharu Okada, University of Tsukuba graduate student D2, Yasuhiro Nakagawa, M2, and Mizuki Endo, M1*
Writer: Takaharu Okada, University of Tsukuba graduate student D2*

*This article was prepared as part of the "Tsukuba Action Project (T-ACT): Science Communication Program," which is a collaborative project of the University of Tsukuba and MANA.

Profile

MANA Independent Scientist. Ph.D. in science. Received his Ph.D. degree from the Department of Chemistry, Graduate School of Science, University of Tokyo in 2004. Prior to assuming his current position in 2011, he was an Assistant Professor in the Institute for Materials Research, Tohoku University, Visiting Researcher at the University of Basel in Switzerland, MANA Research Associate, and ICYS-MANA Researcher. In 2013, he received the Tsukuba Encouragement Prize (Young Researchers).

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Outreach Team
International Center for Materials Nanoarchitectonics (MANA)
c/o National Institute for Materials Science (NIMS)
1-1 Namiki, Tsukuba, Ibaraki, 305-0044 Japan
Phone : +81-29-860-4710
Facsimile : +81-29-860-4706
Email : mana-pr@ml.nims.go.jp
URL : http://www.nims.go.jp/mana/

"**CONVERGENCE**" is the keyword used to symbolically describe the entire project of MANA, where outstanding researchers from around the world assemble and converge in the "melting pot" research environment to bring together key technologies into nanoarchitechtonics for the creation and innovation of new functional materials.

Cover : Principal Investigator Xiao Hu and MANA Scientist Takuto Kawakami

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International Center for Materials Nanoarchitectonics(MANA)

Asking the Researcher

Topological Nanoarchitectonics

Taking on the Challenge of Realizing Novel Quantum Functionalities

Xiao Hu

Leader's Voice

Nanoscience and Technology in the Past, Present and Future

Don Eigler
Stan Williams
Masa Aono

Topological Nanoarchitectonics
—Taking on the Challenge of Realizing Novel Quantum Functionalities

Xiao Hu

Principal Investigator, MANA
Unit Director, Nano-System Theoretical Physics Unit, Nano-System Field

Realization of novel “nano quantum devices”, which are going to replace the current “semiconductor devices” typically of micrometer scale, is yearned for the development of next-generation technologies. MANA Principal Investigator Xiao Hu, who is engaged in research based on a brand-new approach called “topological nanoarchitectonics,” is continuously challenging himself to discover novel quantum functionalities, paying special attention to collaboration between theory and experiment.

Profile

Dr. Hu completed his Ph.D. in science at the Department of Physics in The University of Tokyo in 1990. He started his career in the Institute for Materials Research, Tohoku University as a research associate and then associate professor. He joined NIMS in 1996 and was appointed as a PI upon inauguration of MANA in 2007. His major is condensed matter physics.

◉ Interviewer : Akio Etori, Science Journalist

Searching for new quantum functionalities

Up to now, high performance of computer has been pursued by miniaturizing individual semiconductor devices. However, thinner wires carrying electrons used for bit calculations exhibit larger electrical resistance and generate a larger amount of heat, which should be cooled by a larger cooling equipment costing more energy. To avoid this deadlock, development of a completely new operating principle has become an urgent issue.

Quantum information technology in which information processing is performed by utilizing quantum states has attracted significant interest as a next-generation science and technology. Quantum computer, which makes use of quantum properties at nanometer scale, is expected to be able to process large amounts of information at ultra-high speed. It is useful for the-state-of-art encryption and quantum simulation for developing novel materials. Even the quantum teleportation would not be a dream.

With this background, Dr. Hu is engaged in research discovering new quantum mechanical properties and their applications. “For physicists around the world, realizing a quantum computer is certainly an ultimate goal. However, before reaching this goal, there are many problems that must be solved. We are now engaged in basic research to overcome these problems. During this process, many discoveries on novel phenomena have been and will be achieved as serendipity.”

Topological nanoarchitectonics

“Topology” originally is a concept of mathematics that describes the invariant property of objects subject to continuous deformation. In physics, it turns out that a unified and useful picture can be derived when the concept of topological invariant is applied to quantum mechanical wave functions of materials.*

Because topology of a material is an intrinsic characteristic determined by the global property, Dr. Hu is carrying on a variety of researches to design robust nano quantum devices making use of topology, which can exhibit functionalities beyond the limitation generally believed before. He coined the terminology of “topological nanoarchitectonics”. Design of a quantum nano device for manipulating Majorana fermions is one example.

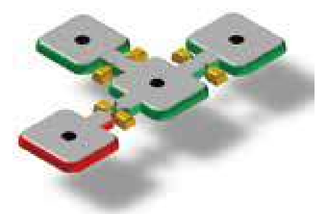
A Majorana fermion is a special type of fermion which is equivalent to its own antiparticle. Their existence as an elementary particle still has not been confirmed. However, in recent years, it has become clear that on the surface of a topological superconductor excited states within the superconducting gap, sometimes called quasiparticles, behave in quite a similar way as Majorana fermions.

As Dr. Hu explains, “One challenge that must be overcome in order to realize a stable quantum computer is the fact that quantum states are easily destroyed for example by electromagnetic field noises from environment. This phenomenon is known as decoherence. Now scientists believe that the problem of decoherence can be resolved by using Majorana fermions, which are stable because they are protected by the topology. This is the main reason why we are focusing on topological superconductivity.”

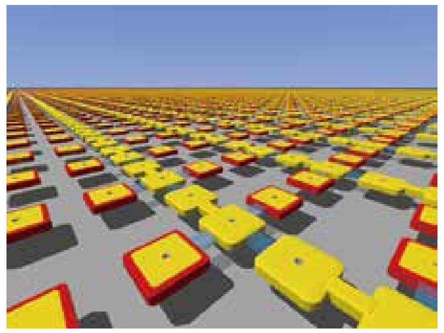
However, because Majorana fermions are electrically neutral, a consequence of equivalence between particle and antiparticle, they are not easy to be derived by electromagnetic field. To solve this problem, Dr. Hu and his colleagues for the first time in the world carried out a detailed quantum mechanical analysis and succeeded in designing a quantum device with which one can manipulate efficiently Majorana quasiparticles merely by turning local gate voltages on and off (Fig. 1) . It was confirmed that positional exchange of Majorana quasiparticles by this device follows non-Abelian

Fig. 1 (a) Schematic diagram of nano quantum devices for manipulating Majorana quasiparticles.

Vortices are pinned at the center of samples as denoted by the black dots. Constricted junctions are created between samples, and gate voltages can be applied there. The connection between samples is controlled by adjusting the gate voltage. When an odd number of vortices exist in one sample or connected samples, Majorana quasiparticles appear at the sample edge. The edge Majorana quasiparticles disappear in case of an even number of vortices. Utilizing this property, the edge Majorana quasiparticles can moved and their positions can be exchanged simply by turning the gate voltages at constriction junctions on and off in a certain sequence.



(b) Schematic diagram of an array of topological quantum bits.



quantum statistics, which can be used for topological quantum calculation. Dr. Hu says, “The goal of achieving robust quantum computer is certainly getting closer.”

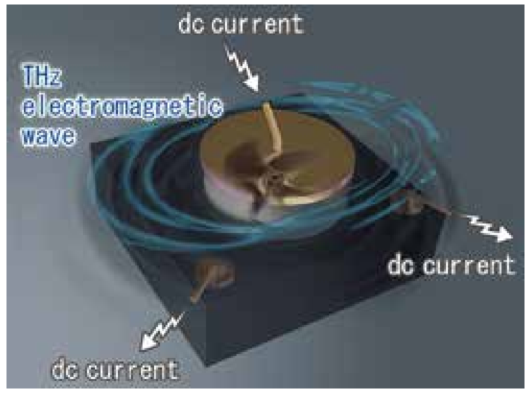
From novel physical phenomena to functionality

Dr. Hu is always making effort to explain complicated physical phenomena in a way that people can understand plainly, and to create functionalities based on these phenomena from which human being can benefit. One example is the discovery of the mechanism for radiation of terahertz electromagnetic wave based on nano superconductivity.

In 2007, it was experimentally observed that nano Josephson junctions built in a single crystal of bismuth-based cuprate high-temperature superconductor (called intrinsic Josephson junctions) emitted coherent terahertz electromagnetic waves. While it was soon noticed as an important breakthrough, no theoretical explanation was available at that time, which is however indispensable for enhancing radiation power for practical uses. Using large-scale computer simulations and theoretical analysis, Dr. Hu and his colleagues discovered a novel quantum state of superconducting phase dynamics. His theory clarified the fact that the intrinsic Josephson junctions function effectively as “nano-windmills”, in which a dc current behaves as the blowing wind, phase kinks

Fig. 2 Schematic diagram of a nano-windmill formed by a stack of intrinsic Josephson junctions in a single crystal of cuprate high-temperature superconductor.

Under a dc voltage bias, a phase kink is developed inside each Josephson junction and works as a rotating windmill (approximately 700 windmills are stacked in the cylindrical mesa of 1 μm tall above the substrate as shown in the figure). This transfers the injected dc energy into terahertz electromagnetic wave radiated into free space from the side surface of the cylindrical mesa.



in nano Josephson junctions are the blades of windmills, and the generation of terahertz electromagnetic wave is similar to the ac current generated by rotation of the windmills (Fig. 2). This theoretical understanding proved the possibility of realization of strong quantum source for terahertz electromagnetic waves based on nano Josephson junctions. A 50-year dream since the discovery of Josephson effects is coming true. Terahertz electromagnetic waves are useful in DNA pathological examination and medicine analysis, and when used for security check at airport, they are not harmful for human body.

Devotion, humor and colleagues

Dr. Hu says that the real pleasure as a theoretical physicist comes when a material or system designed based on physics insight and accurate calculations displays wonderful physical properties through experiments. “There’s nothing better than this pleasure. I love to do research. I’d like to devote my whole life for research.”

However, even Dr. Hu, who feels this way about his work, frequently gets stuck in research. At such times, he feels encouraged to remember the words that he received from his wife, “Inspiration comes of working.”

“In spite of those setbacks, I always try to make my work enjoyable, and not a restless struggle. Research is a series of failures. It’s important to have a sense of humor so that they don’t get the best of you. It’s also important to have a lot of colleagues who can share both the good and the difficult times.”

*Topology

The property that a mag and a donut can be changed into each other by continuous deformation is understood as topological equivalence. Around 1850 Cauchy noticed that the integration of curvature over an object can only take an integer multiple of π , and that objects can be categorized by this integer, the beginning of a branch of mathematics called topology. It became clear in recent years that, when electrons move in periodic potentials created by ions carrying plus charges, their quantum mechanical wave functions in momentum space exhibit properties similar to the curvature of donut. Topology is becoming a new central concept in condensed matter physics and related materials science.

Kazuhito Tsukagoshi
Principal Investigator / Nano-System Field

Creating a Next-Generation Thin Film Transistor

Elemental engineering to realize high definition, energy saving displays.

Importance of energy saving displays

The “informationization” of our daily lives is progressing, and all our activities are now digitalized as information called “big data.” However, in order for people to understand and use this information, it must be converted to information in an auditory or visual form. Since auditory information is frequently uncertain hearsay information, graphical diagrams, photographs, and accurate written communications that can convey large amounts of information instantly are necessary. Moreover, simple information systems like touch panels, which enable not only information acquisition, but also information input, are highly valued. For these reasons, displays are increasingly important, and higher performance is also demanded.

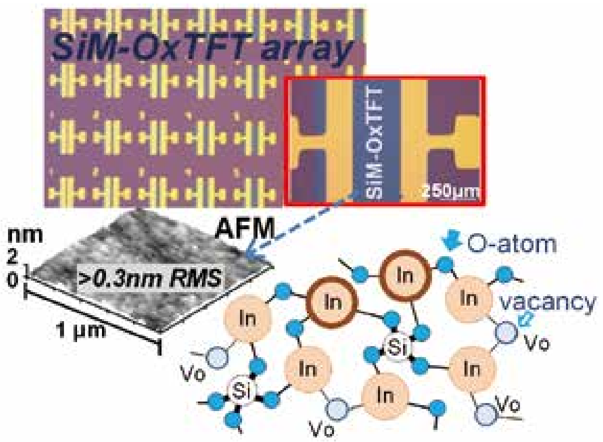
Development of TFT by oxide film with unique element composition

In the current mainstream displays, thin film transistors (TFT) are used in pixel switching. Pixel drive TFTs can be broadly divided into amorphous silicon, which is used in large-scale displays, and polysilicon in medium- and small-size displays. As a new material, use of InGaZnO oxide films has also begun. Nevertheless, there are problems in both the properties and manufacture of each of these materials. In order to realize next-generation displays, our aim is to develop a new oxide film TFT which has high mobility and can reduce unstable elements in the manufacturing process. In particular, because the supply of raw material zinc (Zn) is expected to become unstable within tens years, the development of a Zn-free material is an important issue. To date, in research on the conduction characteristics of amorphous indium oxide (InOx), which has high mobility but large property instability, we investigated the factors in conduction instability by adding a small amount of metal oxide additive to an oxide film (see Figure). Because the conduction charge in amorphous oxide films is supplied from oxygen vacancies, if the conduction charge is increased to satisfy mobility, conductivity will become unstable. We investigated the factors in this instability and discovered a correlation between the stability of electrical properties and the oxygen bond-dissociation energy of dopant elements in thin films. An InOx film doped with silicon has electron field-effect mobility more than 2 orders higher than that of amorphous silicon, while enabling film-forming in the same temperature zone as amorphous silicon. This thin film is also easy to manufacture, as it has high reproducibility, etc.

Toward further energy saving in display

As one problem of displays, energy consumption increases rapidly accompanying higher definition and a larger total number of displays. For example, the power consumption of a high-definition 4K television is more than 100W higher than that of a conventional television, and increased power consumption of the television in a closed room also requires extra air-conditioning energy for cooling. Thus, if a large number of the approximately 120 million television sets in Japan are replaced with 4K products, a large-scale power generating system, with as many as 10 or more new power plants, will be necessary. Moreover, with higher definition 8K televisions, even greater energy saving will be necessary.

Because the mobility in our TFT is higher than the material, and miniaturization can also be possible, this device can greatly improve the pixel aperture ratio simultaneously with realizing high speed pixel operation. With further improvement in its properties, it should be able to contribute to reducing power consumption in the displays which are an indispensable part of our daily lives.



Prototype transistor fabricated using “silicon-doped amorphous indium oxide” thin film with an original element composition. We are engaged in research on controlling the conduction charge supplied from oxygen vacancies in the amorphous oxide thin film so as to avoid over- or under-supply.

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Leader's Voice

Three Pioneers of Nanoscience and Technology Got Together at MANA

Don Eigler and Stan Williams were interviewed by Masa Aono

Nanoscience and Technology in the Past, Present and Future

Aono: Don and Stan, welcome to our research center MANA. I am really happy to have this opportunity to talk with you both here at MANA. In the past quarter century, I really enjoyed the competition and collaboration with you both in my research of nanoscience and technology. I would like to take this occasion to say thank you very much for that.

Today, as the Director of MANA, I will play the role of an interviewer of you both.

Aono: I feel you two are an interesting combination, with Don into basic research and Stan interested in applications as well.

Eigler: When you work for a company, the first rule is the financial success of your corporation. In IBM, nobody did basic research only because they were interested in it; all research had to be strategic research. In that sense, there is no difference between Stan's experience at Hewlett-Packard (HP) and my experience at IBM. My work at IBM was aimed at laying a foundation of knowledge that IBM could identify as being strategic to the company's success in the future.

Aono: Your work on xenon manipulation on a nickel surface was really a breakthrough in nanoscience and technology.

Eigler: I did not intend to do that at the beginning. My goals were to develop a better understanding of how atoms bond with one another and with the surface. When we were carefully operating the low-temperature tunneling microscope, we were able to rearrange the atoms. Then, we attempted to get it under control.

Aono: Stan, you changed from being a surface scientist studying solid surfaces with ion scattering spectroscopy to studying devices such as the memristor. What was your motivation?

Williams: In 1994, the Northridge Earthquake completely destroyed my laboratory at UCLA. Simultaneously, I was offered an opportunity to start up a new fundamental science research group at HP. The concept was to build something from the foundation and create something unique and revolutionary for the company in 10 to 15 years. This would give HP an advantage in the future marketplace. Today, I run a group within HP called Foundational Technologies which focuses on the future, but my activities are concentrated toward bringing those technologies to the marketplace.

Aono: How did you encounter Leon Chua's idea? [The memristor was predicted in 1971 by Leon Chua, an electrical engineer at the University of California, Berkeley.]

Williams: At HP, I spent some time looking at the technological landscape. At that time, Moore's Law had run its course. I started thinking what happens when Moore's Law stops and it is no longer possible to make smaller transistors. I intentionally looked at new types of electronic and photonic devices. I started looking at inorganic materials and working with atomic switches, and that was how I got into memristors. Concurrently, I was also looking at photonics and developed a photonic switch based on a ring resonator.

Aono: Don and Stan, I would like to hear your opinion about the future of nanoscience and technology.

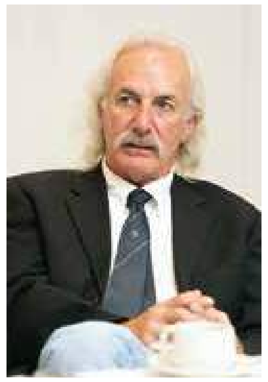
Eigler: Nanoscale science has been going on for a long time. There are many opportunities for learning new things about the properties of materials and the strange behaviors that occur in nanostructures. I do not see nanotechnology having a big impact yet, but 15 to 20 years from now, the impact of controlling things on a nanometer length scale will change the way people do things. However, I do not know if this is a revolution.

Williams: Nanotechnology has been incredibly important, but not for the reasons that most people think. Nanotechnology attracted intelligent young people to come into this field. This influx of intelligent and motivated young people has created an important body of work. Now what we have is a foundation, and it is time to start building on top of that foundation.

Aono: Don, what do you think about the importance of interdisciplinary collaboration?

Eigler: I do not necessarily like the word interdisciplinary because it implies that there are necessary boundaries between the different sciences. One ramification of nanoscience efforts over the last 15-20 years is that many young people are being trained to think, work and communicate across a broad spectrum of the sciences. I regard that ability to combine knowledge and experience from separate fields as being hugely powerful.

Aono: Stan, what do you think about the importance of government science and technology policy?



Don Eigler (Director, The Wetnose Institute for Advanced Pelagic Studies)

Dr. Donald M. Eigler is a physicist who has specialized in the development and use of low temperature scanning tunneling microscopes. His research is aimed at understanding the physics of nanometer-scale structures and exploring the applications of nanometer-scale structures to computing. He is best known for his 1989 demonstration of the ability to manipulate individual atoms with a low-temperature scanning tunneling micro-scope, famously spelling out the letters "IBM" with 35 xenon atoms. He received both his bachelors and doctorate degrees from the University of California, San Diego. He joined IBM as a Research Staff Member in 1986, was named an IBM Fellow in 1993 and left IBM in 2011 to become the director of The Wetnose Institute for Advanced Pelagic Studies.

Stan Williams (HP Senior Fellow)

Dr. R. Stanley Williams, one of the world's leading scientists in nanotechnology, is a Hewlett-Packard Company (HP) Senior Fellow and the Vice President of Foundational Technologies at Hewlett-Packard Laboratories in Palo Alto, California. He received a B.A. degree in Chemical Physics in 1974 from Rice University and his Ph.D. in Physical Chemistry from the University of California, Berkeley in 1978. At HP, he led a group that developed a working solid state version of Leon Chua's memristor. His present research interests are nano-electronics and -photonics, computation and cognition. He has published over 400 original research papers in peer-reviewed journals and has been awarded over 300 patents worldwide.

Masa Aono (MANA Center Director)

Dr. Masakazu Aono is currently the Center Director of MANA and also a NIMS Fellow. After receiving his Ph.D. from the University of Tokyo in 1972, he joined the National Institute for Research in Inorganic Materials (NIRIM) as a Research Staff Member. From 1978 to 80, he worked at the Synchrotron Radiation Center of the University of Wisconsin-Madison, USA, as a Visiting Professor with an IBM group headed by Dr. Dean Eastman. In 1986, he moved to the Institute of Physical and Chemical Research (RIKEN) as a Chief Scientist and organized the Surface and Interface Laboratory. From 1996 to 2005, he was concurrently a Professor of Osaka University. In 2002, he moved to NIMS as the Director of the Nanomaterials Institute and was then appointed to his present position in 2007. He has done various pioneering work in surface science, nanoscience, nanoelectronics and nanoscale measurement, symbolized by the words "impact-collision ion scattering," "atomcraft," "atomic switch," "multiple-probe SPM" and "chemical soldering."

Williams: Most people in government have got a wrong impression about what research is. Creation of new knowledge from academic research is an important byproduct, but the real product is the creation of highly skilled and motivated people who will be making new advances to keep a nation's economy strong. Today, there is too much emphasis on what academic researchers are doing. I am trying to pound those ideas into people in the government, but sadly, we are seeing a situation where decision-makers are ignorant of the system for which they are making the decisions.

Aono: What do you think about the recent young scientists?

Eigler: The most rewarding aspect of my professional life has been being able to create opportunities for young scientists and then to see them grab on to those opportunities. Creating opportunities for young people is an obligation that a scientist has to shoulder to some extent; otherwise, science is going to die. Other human endeavors make our lives wealthier, but new fundamental knowledge drives humanity forward, and this comes through research.

Aono: Don, you could have hired many young scientists, but you have had a small group. Stan, your group is large and you are managing many young scientists very well.

Eigler: I wanted to be a part of a small group so that I could always be close to the science and hopefully get into a laboratory as much as I could. Even then, I was not very successful at that and I have spent less and less time in the laboratory.

Williams: I was brought into HP to create a new culture and introduce more foundational research. I was expected to build up that capability within the company, and it was clear that I would have a large group. However, I never expected it to get as large as it did. After the nanotechnology explosion in the 2000s, I kept finding very interesting young people and found creative ways to hire them. These people then went out and found new people.

Aono: What are your future plans in your research and life?

Eigler: I left IBM 3 years ago because I wanted to do something new. I have been thinking about fundamental physics experiments. For instance, I have spent time on how to do laboratory-scale measurement of the speed of gravity. Part of the reason I choose these things is because they are incredibly difficult, although not impossible.

Williams: I am thinking about cognition as an engineering exercise. My study concludes that people do not understand as much as they think they do about brain function, so I am trying to understand it in more mathematical detail. I am hoping that I can make a much bigger contribution to this understanding with the idea of trying to build an artificial brain. We are still probably centuries away from being able to build something as truly sophisticated as a real brain, but there are computational things that brains can do very efficiently that could make today's computers much more efficient.

Aono: Before this interview, both of you toured our labs at MANA. What is your opinion about MANA and your advice on the future of MANA?

Eigler: Jealousy! I am overwhelmed by the amount of resources that is available in MANA. I see MANA as being an investment that the Japanese people are making in their own future and also in the future of everybody else. Nothing even remotely close to MANA is happening anywhere else in the world.

Williams: I agree with Don. The work that is going on here is at the very top of anything in its class that is being done anywhere. It is a place where people can dream and can aspire to do things that others think are impossible. They have a chance to completely redefine the frontiers of understanding.

Aono: Oh, your words, the words from two pioneers in nanoscience and technology, will be a strong encouragement to all the scientists in MANA. I want to say a very sincere thank you to you both.

Tadaaki Nagao
Group Leader / Nano-System Field

Infrared Radiation and Plasmonics

Infrared radiation and nanomaterials science

Because infrared (IR) radiation is a type of electromagnetic wave that oscillates at approximately the same frequency as the molecular vibration of organic molecules and phonons in crystals, IR radiation is deeply related to material's thermophysical and energy transfer phenomena, and belongs to an extremely important frequency region which is also utilized in medicine and environmental monitoring, the chemical and food industries, and numerous other fields. However, because the wavelength of IR light is on the μm scale, and IR rays themselves are invisible, it has been difficult to do IR imaging in submicron scale and further improving its spatial resolution. For this reason, there is still little activity in nanoscience research using IR light in comparison with research with visible light. Our laboratory investigated the functions of thin nanomaterials that are dramatically smaller than the wavelength of IR light, focused on basic research on phonons and the plasmon wherein a large number of atoms and electrons oscillate dynamically in a collective manner. Based on this research, we believe that material development will become possible by utilizing the IR absorption characteristics and thermal radiation characteristics possessed by various materials. We are currently involved in research on trace detection of environmental pollutants and biomolecules in liquids, noncontact temperature sensors, solar heat absorption/conversion materials, and others.

An infrared molecular sensor

In infrared absorption spectroscopy of aqueous solutions, the large signal of the water itself is an obstacle which makes it difficult to measure trace amounts with high sensitivity. One can avoid this problem by utilizing the strongly-enhanced plasmonic nearfield generated at the nanogaps of Au nanostructures to selectively detect the molecules entered in the nanogaps while suppressing the signal of the bulk water. By forming a gold nanogap structure, in which the targeted protein molecules have a width on the order of 2 or 3 target molecules, and coating molecules called DNA aptamers, which strongly bond with and capture the target molecules in the nanogap structure, selective detection of trace amounts of pathogenic enzymes and other substances mixed in water was possible (Fig. 1).

Wavelength-selective IR absorber

Infrared perfect absorbers, which can absorb 100% of infrared radiation, have the potential for use in various applications such as sensing of organic molecules in liquids and gases, generation of electricity using thermal radiation as an energy source, etc. We developed a simple lithography method using inexpensive base metals and ceramics, in which microspheres are used as a mask material, and developed a technique for fabricating IR perfect absorbers with high accuracy utilizing this method (Fig. 2). Using this fabrication method, we realized sharp wavelength-selective IR absorption and high sensitivity molecular sensing, and we also started to study thermal radiation.

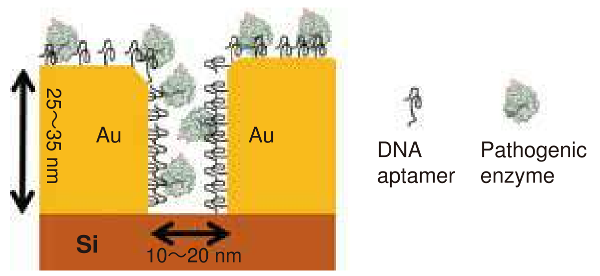


Fig. 1: Schematic diagram of adsorption of DNA aptamer and pathogenic enzyme in nanogap.

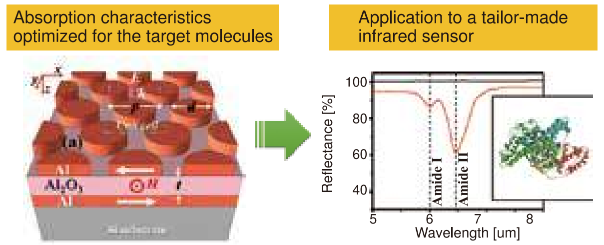


Fig. 2: (a) Schematic diagram of infrared perfect absorber using aluminum. (b) Example of plasmon-enhanced infrared spectroscopy of biomolecules. In observation of the signal from bovine serum albumin on the order of a single molecular layer, a dramatically amplified signal (absorption rate: approx. 30%) could be observed (red line) with the developed IR perfect absorber in comparison with the IR absorption (black line) of a flat aluminum surface.

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Satellites: MANA's Seven Sisters

At MANA's seven Satellites, Principal Investigators (PI) or Associate Principal Investigators (API) are engaged in research on nanoarchitectonics. Researchers at the Satellites and MANA carry out joint research through frequent mutual visits and email communications. The Satellites are an irreplaceable presence for MANA.

■ Star-studded Satellites

The seven PI or API in the MANA Satellite program are all prominent scientists in their respective fields.

MANA's seven Satellites

Organization	Nationality	PI
CNRS	France	C. Joachim
Georgia Institute of Technology	USA	Z. L. Wang
Tokyo University of Science	Japan	H. Takayanagi
UCL	UK	D. Bowler
UCLA	USA	J. K. Gimzewski
University of Montreal	Canada	F. M. Winnik
University of Tsukuba	Japan	Yukio Nagasaki

Prof. James K. Gimzewski of UCLA is a distinguished nanotechnology researcher who received the 1997 Feynman Prize and has been often featured on Japan's NHK television network. He is energetically investigating atomic switches in joint research with MANA researchers, and is also dedicated to training human resources, for example, in holding the Nanotechnology Summer School for graduate students at MANA and undertaking intern training for MANA's administrative staff at UCLA.

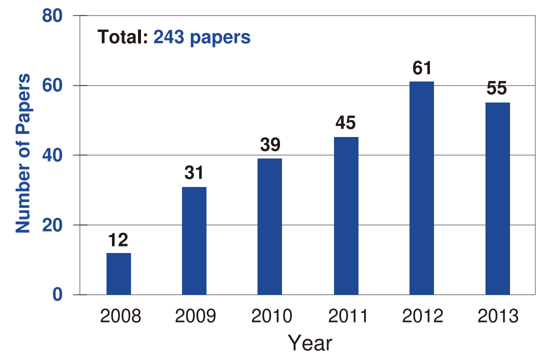
Prof. Françoise M. Winnik of the University of Montreal is a world-renowned scientist in the fields of polymer chemistry, surface chemistry, and nanoscience, and serves as Editor-in-Chief of the publication Langmuir of the American Chemical Society. Prof. Winnik has laboratories at both MANA and the University of Montreal, and has spent a total of 583 days at MANA in the past 4 years. She is actively engaged in fusion-type research using nanoparticle materials and nanotubes developed by MANA researchers.

■ Satellites in Orbit

Researchers at MANA Satellites have published more than 10% of all MANA papers in the past 6 years. Many of these papers appeared in journals with a high impact, including Nature Materials, Nature Nanotechnology, and Advanced Materials, etc. From this viewpoint as well, the Satellites are making an important contribution to MANA's research results.

In short, MANA's Satellites are smoothly in orbit!

MANA Affiliated Research Papers from Satellites



Key to successful international collaboration

Dr. Adam Stieg, (Vice Director, MANA satellite at UCLA)

If there exists a recipe for effective international collaboration it most certainly involves two main ingredients: substantive commitments and immersive cultural exchange. Commonly galvanized by mutual interest and formally sanctioned through bilateral agreements, successful Institutional collaborations are best achieved by parties whose operational models and shared interests both enable and motivate the commitment of tangible resources. Ambitious ventures like the WPI Initiative and California Institutes for Science and Innovation (ISI) program provide such a framework. The artful execution of any good recipe lies in the attention to detail. Since 2007, the MANA Satellite at UCLA played an active role in realizing the vision of nanoarchitectonics through collaborative research and scholarship. A blend of vigorous engagement and perseverance has been crucial, especially when faced with inevitable yet unforeseen challenges. One must always be mindful of culture, not only through the lens of scientific discourse but also from the personal and societal perspectives. Indeed, the value of opportunities for cultural exchange extending beyond meetings and symposia cannot be over-stated. Participants at all levels of research and administration must do more than just visit - they must host and be hosted, they must live and learn together, they must not simply share ideas but generate them as partners. When paired with openness to unconventional ideas, such a recipe can only produce an exciting potential for innovation.

News

"No" to Subsidy Extension

The WPI program committee recently discussed a 5-year extension of subsidies for the five WPI centers launched in 2007 after completion of the original 10-year plans. We were notified of the decision as follows:"MANA has achieved "world premier" status as fully meets the goal of the WPI Program. On top of that, we concluded that Kavli IPMU is the only WPI center that will receive WPI subsidy for five more years by considering all the various factors together."

This conclusion is disappointing for all of us. Nevertheless, we are proud and honored to have created one of the world's most remarkable international research centers in just 7 years. Fortunately, MANA has already become a research division of NIMS, and both the structure and name of MANA will be maintained in a sustainable way. We are truly grateful for your contributions to MANA, and your continued support will be greatly appreciated.

Recent Events

FON' 14

FON'14 (The 2nd International Symposium on the Functionality of Organized Nanostructures) was held at the National Museum of Emerging Science and Innovation in Odaiba, Tokyo from November 26 to 28, 2014. The symposium also commemorated another important milestone in the 25th Anniversary of the start of the "Aono Atomcraft Project," which was carried as an ERATO Project of the Research Development Corporation of Japan, and was held to mourn the loss of Dr. Heinrich Rohrer, who was a recipient of the Nobel Prize in Physics in 1986 and passed away in 2013. The event featured 24 invited lectures and 78 poster presentations, as well as a special session held to remember Dr. Rohrer's passion for science. A total of 217 persons attended during the 3-day period.

"Smart Polymer Rangers" appear at Tsukuba!

MANA participated in the "Tsukuba Science Festival 2014" on November 10 in Tsukuba with an exhibit titled "Smart Polymer Rangers." MANA exhibited "smart polymers" as a future material for disease diagnosis and treatment. This exhibit was based on collaboration between the University of Tsukuba and MANA. University students planned and managed the event in cooperation with MANA researchers.

Awards

Genki Yoshikawa, Independent Scientist, "nano tech 2015Project Prize": "New Sensor Enabling Diagnosis by Breath Analysis and Blood Test with a Cell Phone (2015. 1)

*Please see the back cover as for his research.

Upcoming Events

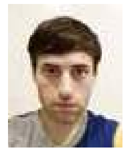
MANA International Symposium 2015

The MANA International Symposium 2015 will be held at the Tsukuba International Congress Center (Epochal Tsukuba) from March 11 (Wed.) to March 13 (Fri.), 2014. This event will feature invitational lectures by distinguished scientists from Japan and other countries, as well as oral and poster presentations on recent research results by MANA researchers. (No charge for participation.)

Website: http://www.nims.go.jp/mana/2015/

New Face

MANA Scientist
Takaaki Taniguchi



ICYS-MANA Researcher
Gaulthier Rydzek

ICYS-MANA Researcher
Alexandre Jean-Yves Fiori