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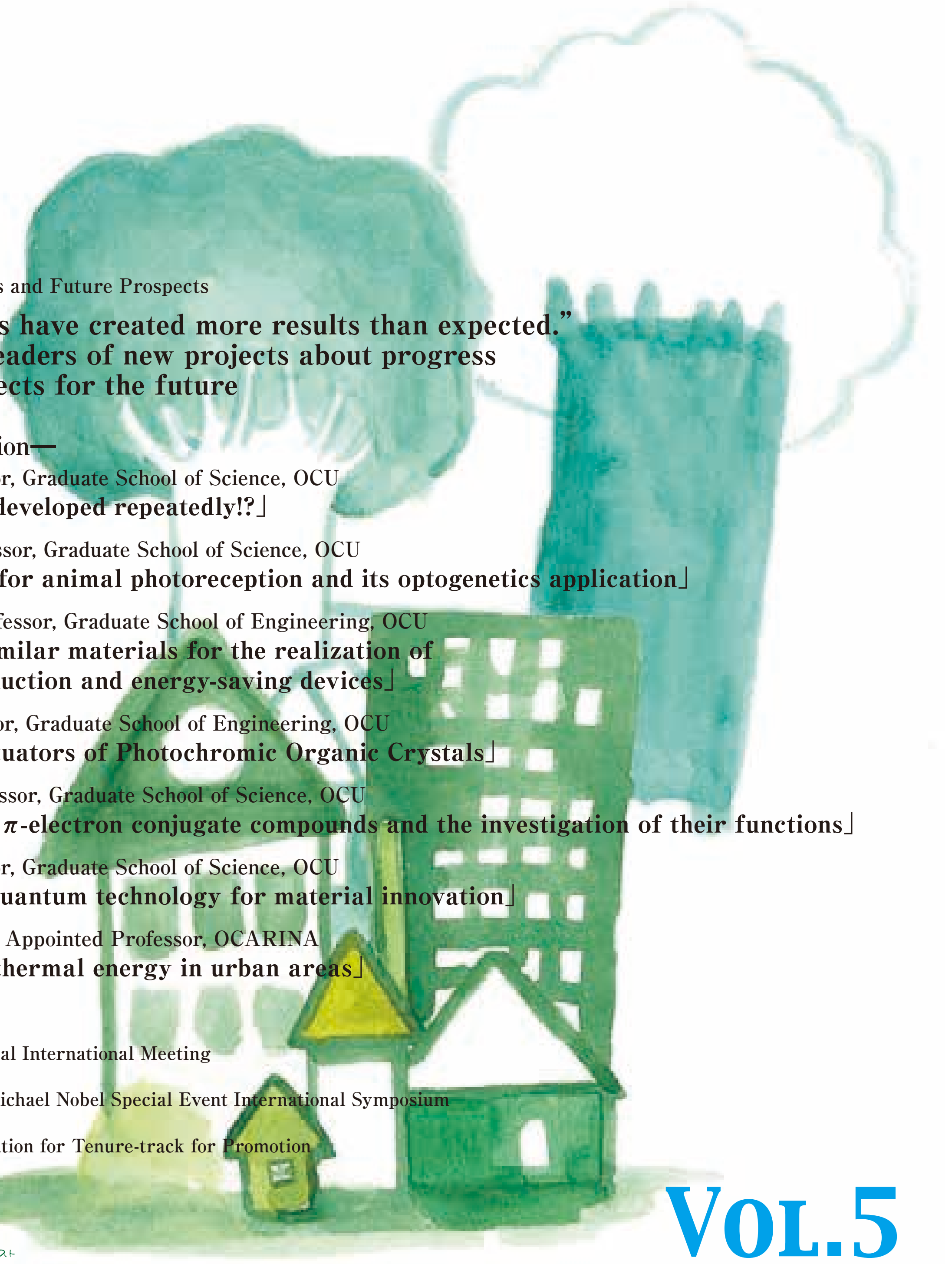
The OCU Advanced Research Institute for Natural Science and Technology



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Research Project Reports and Future Prospects

"The new projects have created more results than expected." Discussion with leaders of new projects about progress report and prospects for the future

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—Activity Report—

The 2014 OCARINA Annual International Meeting

Distinguished Professor Michael Nobel Special Event International Symposium

Academic Forum,Organization for Tenure-track for Promotion

OCARINA Seminars

木下 佑一氏
デザイン・イラスト

VOL.5

■Special Project Research Project Reports and Future Prospects

"The new projects have created more results than expected." Discussion with leaders of new projects about progress report and prospects for the future

In April 2015, new research projects launched. Three leaders of the projects talked about their research results of the year, and future prospects. Free discussions were held, beyond the fields of study, and possibilities for new collaborative research were reconfirmed.

A Wide Variety of Fields of Study – The Advantage of a Comprehensive University Offering Both Humanities and Science Programs

Dr. Oshima/Today, we would like you to report the accomplishments of your research and have free discussions, beyond your fields of study. We hope today' s meeting will promote the development of our institute. Firstly, could you tell us about the content and results of your research within this year?

Dr. Shigekawa/Our team is currently trying to create a solar cell by means of an unconventional method and improve its conversion efficiency. In general, solar cells are made by piling layers of various crystals, but in the case of a semiconductor, this process is very difficult. So, we are trying to forcibly bond the parts that will not combine. This is not a proper way of proceeding in the field of semiconductors, but it is making more progress than expected. In terms of conversion efficiency, the cell is better than a silicon solar cell. We expect that it will achieve efficiency 30% higher than that of silicon-based cells.

The merit of our method is that we can optimize materials individually and integrate them. We study individual materials and the entire system separately while taking both into consideration. Thus, we are able to speed up our research. We think that this bonding technology can be applied not only to solar cells but also to various energy-related devices.

Dr. Nakao/There are three projects in the field of urban energy disaster prevention aiming to find the efficient ways to use urban thermal energy. I am engaged in one of the projects which have been completed this year. It involves the study of "thermal grids", which is a thermal version of smart grids. It is a system that can freely transfer heat between multiple buildings. It manages heat sources for air conditioning (refrigerating machines, heat pumps, etc.) in optimal manner. We studied the structure of the thermal grids, built the optimization system for best flow patterns, and developed a control method for implementation in 2005.

At present, the system is undergoing proof-of-concept trials at the Osaka International Exhibition Center (Intex Osaka). We compared the consumption volume of gas and electricity on days when the system was fully operational in 2015 with days in 2014 when the system was not installed, during the period from July through September. We confirmed that the consumption volume reduced by 70%. The thermal grid system will be published in the White Paper on the Environment. Dr. Kanjo, could you explain the second project?

Dr. Kanjo/Our project aims to decrease the amount of sludge produced during sewage treatment, by producing methane gas through the use of methanogen, and to use the carbon-neutral methane gas as an energy resource. We are trying to make effective use of methane gas for the creation of a low-carbon society.

It is necessary to heat sludge to 40°C~50°C in order to produce methane gas. Previously, 30%~40% of the precious methane gas produced was used as a heat source.

profile

Vice President, OCU/Director, OCARINA

Hiroshi Oshima

Left the doctorate course, Department of Applied Chemistry and Bioengineering, Graduate School of Engineering, OCU in Sep. 1977. After working as the assistant, assistant professor and professor of the Department of Applied Chemistry and Bioengineering, Faculty of Engineering, he became the professor of the Department of Applied Chemistry and Bioengineering, Graduate School of Engineering, OCU in April 2002. In April 2014, he became the Vice President, and Director of the Office for School Reform, Collaborative Research Promotion Section, Gender Equality Promotion Section, and OCARINA. Doctor of engineering

profile

Vice Director, OCARINA

Yoshinori Kanjo

Graduated from the Department of Sanitary Engineering, Faculty of Engineering, Kyoto University in March 1983. Completed the master' s course at the Department of Sanitary Engineering, Graduate School of Engineering, Kyoto University in March 1985, and joined the Faculty of Engineering, OCU in April 1985. Became the professor of the Department of Urban Engineering, Graduate School of Engineering, OCU in 2006 and took up his present post in 2010. Since 2013, he has been acting as the leader of the research project "Technological development and experiments for reducing CO2 emission", consigned by the Ministry of the Environment. He specializes in water treatment engineering. He studies the evaluation and disposal of nutrient salts and trace contaminants, and the recovery of valuable materials. Doctor of engineering

It is waste of energy. Therefore, we talked with Dr. Nakao and decided to heat sludge using a solar water heater. Also, it became possible to collect and use the heat of the sludge after processing.
Furthermore, the temperature of sewage in Osaka does not decrease below 15°C, even in winter. It is higher than the air temperature. We are examining a system for obtaining the thermal energy using a heat exchanger and a heat pump, and using it to heat the sludge processing tank. We are carrying out experiments at the sewage plant in Osaka City. We have found that the consumption of methane gas can be reduced by more than 70%, and the remaining gas can be used efficiently.

Dr. Oshima/70% is a remarkable figure.

Dr. Miyata/I am engaged in advanced-bio project 1. Our biggest accomplishment this year was our proposal that the gliding motility of the pathogenic microorganism, mycoplasma, might be caused by accidental contact between an adhesive protein, which exists in most pathogenic microorganisms, and ATP-synthetase, which exists in all organisms and is necessary for maintaining their membrane potential.
Biologists have long been discussing the movement of organisms as something complicated. However, we have recently found that it may result from a very simple encounter.

Dr. Kamiya/In the field of artificial photosynthesis, we have stepped into the phase of creating an artificial photosynthesis device that works efficiently by integrating researchers' individual studies. Dr. Amao is acting as the leader of the project. We are now required to create a working system while comparing its costs with that of power generation using fossil fuels.
Recently, the term "hydrogen society" has often been used. However, hydrogen generation and carbon dioxide fixation are totally different in their levels of difficulty. At present, we are studying a device that generates hydrogen from water and a device that synthesizes formic acid, which is a carrier of hydrogen.

Further development through the integration of multiple fields of study

Dr. Oshima/I understand you are all enjoying your studies.
Though some of your studies involve physics and others are related to engineering, engineering cannot exist without physics, so you all appear to be interested in each other' s field as well.

Dr. Miyata/I have a question for a professor studying solar panels. Is it possible to use radioactive materials instead of solar light for power generation using panels. Can' t we get energy from a radioisotope little by little and use it, not taking a large amount of energy through boiling high pressure water?

Dr. Shigekawa/The energy density of a radioactive material is higher in comparison than solar light; therefore, a larger panel would be required.
One of the disadvantages of solar power generation is although its power generation efficiency is relatively high, its energy density is low. We aim to create a portable, self-distributed system; however we are facing the problem of conversion efficiency. We must produce power that can manage a certain system in a limited space. In the case of radioisotopes, the energy density must be kept lower from a safety perspective, in order to use them in the same manner as solar panels. Therefore, it would be more difficult.
We also have the problem of disposal. In the study of recyclable energy, we must consider how to dispose of the device.

Dr. Oshima/Dr. Kanjo, does your study of the collimation technique of solar light have anything to do with the fact that the energy density in solar power generation is low?

Dr. Kanjo/Yes. The biggest problem in the use of solar energy is, naturally, that it cannot be used unless it' s sunny. Another problem is the accumulation of dust on the panels' surface. It needs fine weather, but it also needs some rain to prevent the accumulation of dust. The most difficult aspect of harnessing solar energy is weather conditions, which cannot be controlled.

Dr. Shigekawa/I have heard that the use of water-repellent treatment on panel surfaces is advancing. The coating should be applied once in a few years, of course, but it pays regardless of the cost.
Solar power generation should be considered not only in terms of a device, but also as a system including the device.

■Special Project

profile

Vice Director, OCARINA
Nobuo Kamiya

Graduated from the School of Science and completed the doctoral course at the Graduate School of Science, Nagoya University. Doctor of science. Worked as the guest researcher at the High Energy Physics Research Institute, Photon Factory (PF), the researcher and research sub head at RIKEN and the director of the R&D office of RIKEN Harima Center (Spring-8). Became the professor of the Graduate School of Science, OCU in 2005 and took up his present post in 2010. Awarded the Asahi Prize in 2012.

profile

Specially Appointed Professor, OCARINA
Masaki Nakao

Graduated from the Department of Mechanical and Control Engineering, Graduate School of Science and Engineering, Tokyo Institute of Technology in March 1973. Doctor of engineering. Worked for NTT Musashino Research Institute for Electrical Communication, NTT, NTT Facilities, and Sogo Setsubi Consulting, Co. Ltd. Became the professor of the Graduate School of Science, OCU in April 2004 and took up his present post in 2015.

Prof. Nakao/As the use of hybrid energy has been put into practical use, the conversion efficiency of solar cells increases when they are cooled down. However, hybrid energy has not become popular. If such a technology were refined, it would be very useful. Must hydrogen panels, which generate fuels by means of artificial photosynthesis, also be cooled down?

Dr. Kamiya/In contrast to solar cells, artificial photosynthesis involves chemical reactions; therefore, its efficiency is increased by circulating the solution. We need to use a pump to circulate the solution in a device at the initial stage; however, it requires additional costs. We need some device to reduce the energy used to circulate the solution as much as possible. Furthermore, it is impossible to attain an energy conversion efficiency of 100%, and to prevent an increase in the temperature of the solution. We will need your advice for how to deal with the heat when our research reaches that stage.

Dr. Nakao/The temperature is high enough at 45°C for heating and 65°C for hot-water supply. I am very interested in the temperature level after circulation of the solution. Perhaps, the solution should be cooled down so that exhaust heat can be utilized for something. If it leads to the use of heat, for example, if there is a large merit in the use of heat even if pumping is necessary, it will pay. Right? I think we can provide some help in establishing such a system.

Dr. Kamiya/We would appreciate it. I am sure that this aspect will become a big issue. At present, we are at the stage of making the device; however, it is not enough at all. Our aim is to create a system including the device and popularize it.
We will continue our research, taking the use of exhaust heat and total cost into consideration.

Dr. Shigekawa/Another disadvantage of solar power generation is that the device cannot accumulate the generated energy. We need batteries to store the energy. When viewed in this way, organisms are really great. They are systems that generate and accumulate energy. It seems to me that each molecule has a specific function, yet it naturally acquires various functions at an early stage of growth.
Of course, it must have taken billions of years to evolve to such a level. However, I wonder how we are able to understand and fill up the gap between organisms and artificial inorganics.

Dr. Oshima/That's right, organisms are far more advanced systems. What should we aim at in order to make inorganics attain the level of organisms?

Dr. Kamiya/I think in the following way. Basically, one type of protein has only one function. However, numerous types of proteins are combined in cells. When we think about organisms, the most important issue is how the networks of different types of proteins are controlled. I think that organisms appear to be advanced systems because they are able to use different functions by switching the networks of proteins.
In plant leaves, solar energy is accumulated as chemical compounds at one time, and the chemical compounds are burnt for plant's activities at another. Both processes are activated by molecules of ATPase.
If we consider inorganics such as silicon and titanium oxide as materials for artificial photosynthesis, I think their biggest difference from living organisms is their specificity. Titanium oxide used for artificial photosynthesis consists of the crystal structure of the units of TiO_2. Reactions occurring on one part of the crystal surface are sometimes different from those occurring in another part. It means that the specificity of a reaction occurring on the crystal surface is not very high. How to improve the specificity is an important factor in increasing the functional efficiency in inorganics.
I would like to add that living systems are very costly systems. As a whole, they are really wasteful systems.
The efficiency of each type of protein that I study is very high; however, more than 100 types of proteins are involved in photosynthesis. Therefore, many losses are caused, and the thermal energy produced is used for different cells to live. Losses in photosynthesis are not wasteful for organisms. We need to separate them clearly.

Dr. Oshima/Do you mean to create waste in a useful manner?

Dr. Kamiya/Both photosynthesis and artificial photosynthesis produce heat during reactions. The heat is not wasteful. If not all, even a part of it should be used as energy. I think we will surely require the concept of cogeneration in the field of artificial photosynthesis as well in future.

profile

Professor, Graduate School of Engineering, OCU
Naoteru Shigekawa

Graduated from the Department of Physics, Faculty of Science, University of Tokyo in March 1984, and completed the master' s course at the Department of Physics, Graduate School of Science in March 1986. Studied compound-semiconductor heterojunction devices at NTT Atsugi Electrical Communications Laboratories (present NTT Device Technology Laboratories) from April 1986 until Sep. 2011. Took up his present post in Oct. 2011. Doctor of science.

profile

Professor, Graduate School of Science, OCU
Makoto Miyata

Completed a doctorate in science at Department of Biology, Faculty of Science, Osaka Univ. in Mar 1988. Research Associate at Department of Biology, Faculty of Science, Osaka City Univ. Apr 1988-Spt 1995. Visiting Scholar at Harvard University, Mar 2000-Mar 2001. PRESTO JST researcher Oct 2003-Apr 2007. Leader of Grand-in-Aid for Scientific Research on Innovative Areas "Harmonized supramolecular motility machinery and its diversity", from The Ministry of Education, Culture, Sports, Science and Technology (MEXT). July 2012-Mar 2017
Current position since October 2006.

Dr. Miyata/I agree. There are many ways to increase the efficiency of proteins. With regards to efficiency, people' s recognition of life phenomena including motility has changed during the last 20 years. They used to be highly recognized as excellent systems, but they are now regarded as something really inefficient. Organisms are still in the midst of evolution.

Future tasks and dreams, based on accomplishments

Dr. Oshima/I see. All research projects are very impressive. Lastly, could you tell us about your future plans?

Dr. Shigekawa/As for bonding materials, we are getting intriguing results through different combinations of various materials. In the field of solar power generation, as I mentioned earlier, development of batteries is our future task.

Dr. Miyata/In my field of study, it is important to establish high resolution theories and understanding regarding the newly discovered motility mechanisms. Another task is the reconstruction of biological system. If we are unable to reconstruct the system, it means that we do not understand it fully. Some motility systems that have long been studied, such as movement of muscles driven by motor proteins, can be reconstructed but others cannot. That remains a task to be tackled by biologists.
There is one thing that I think is unfortunate for us. In general, people tend to think that higher eucaryotes with more complicated systems have complicated mechanisms. However, the reality is to the contrary: their function at each molecular level is specified completely, so the mechanisms like muscles that was found a long time ago, for example, is easier to be reconstructed.
In that sense, the reconstruction of newly found motility may be more difficult.

Dr. Oshima/With regard to "thermal grids", how far are you planning to extend the range of experiments? The technology that can create energy savings of 70% is remarkable.

Dr. Nakao／The system is designed for buildings with large heat sources such as refrigerators and boilers. We are planning to install a loop piping system that connects multiple buildings and a router in a vacant space, for example in underground parking, which switches the flow of heat between the buildings. Thus, we aim to use heat efficiently and minimize the use of the primary energy.
The system should be useful in areas that contain many buildings with a central heating system. The system can be applied to existing buildings; therefore, it has a huge social impact.
We intend to go on to the study of the next version of thermal grids. When water at different temperatures flows in a pipe, which we call "water packet transfer", it causes a loss in the thermal capacity of the piping and a change in the temperature at the water head. We are envisioning inner insulation piping to solve this problem. If it is realized, it will be a great innovation.
For example, when we wash our face in the morning, it often takes time for hot water to come out. If the insulation property is high and thermal capacity low inside the piping, it should not take much time until hot water comes out. This innovation will greatly contribute to society.
I would like to seek advice from Dr. Shigekawa as to the method of bonding the new material to the inside of piping.
There is also a project that has been completed. In urban areas, there are networks of sewage pipes that run in all directions. In a NEDO project, we developed equipment for boiling water and heating air using the heat of sewage in buildings close to manholes. We would like to spread the results of this research in actual settings.

Dr. Oshima/All research projects are very impressive, and I would like to hear about them in more detail if I have a chance. I think these discussions on various topics have been rewarding, and I believe we were able to see the overall outlook of our organization.

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■Research Introduction

profile
Professor, Graduate School of Science, OCU
Makoto Miyata

Completed a doctorate in science at Department of Biology, Faculty of Science, Osaka Univ. in Mar 1988. Research Associate at Department of Biology, Faculty of Science, Osaka City Univ, Apr 1988-Spt 1995. Visiting Scholar at Harvard University, Mar 2000-Mar 2001. PRESTO JST researcher Oct 2003-Apr 2007. Leader of Grand-in-Aid for Scientific Research on Innovative Areas "Harmonized supramolecular motility machinery and its diversity", from The Ministry of Education, Culture, Sports, Science and Technology (MEXT). July 2012-Mar 2017 Current position since October 2006.

How motility is developed repeatedly!?

Many organisms can move. At first glance, the motility mechanism seems diverse. However, we understand that almost all organisms including human being have the common mechanism of motility when we trace the mechanism. Namely, conventional motor proteins, Myosin, Kinesin, Dynein glide on rail protein based on the hydrolysis energy of ATP. Numerous prominent researches have been conducted about the process of force generation and we got considerable understanding of the mechanism. However, based on the recent progress of genomic analysis and visualizing technology, it is becoming clear that many intrinsically different mechanisms of motility exist. I am in charge of the project, "Harmonized supramolecular motility machinery and its diversity", a Grant-in -Aid for Scientific Research on innovative Areas from Ministry of Education, Culture, Sports, Science and Technology in Japan. In our project, we are trying to clarify the mechanism of motility to atomic level. We think that the understanding of various motility mechanisms lead to the understanding of organisms themselves. Furthermore, it leads to methods to control organisms critical for medicine and industry.

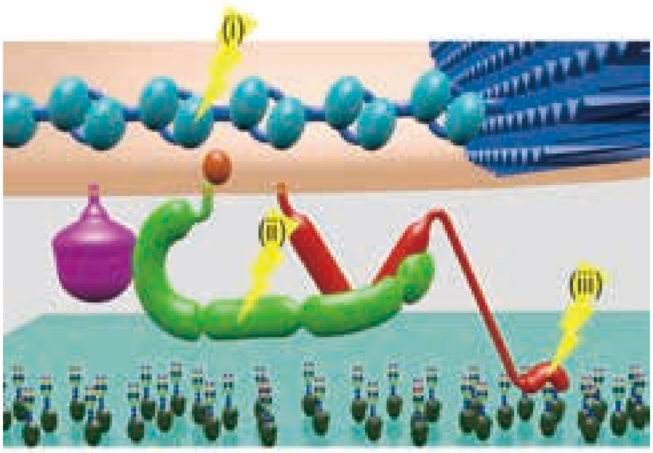
In Osaka City University, we offer the technological development and analysis of "Quick freeze replica electron microscopy method (which is useful but to be lost as it stands)" and the analysis of mass spectrometry, as the generic support for the proposed research area, to the approximately 50 research area- groups throughout Japan. Besides, we study the motility mechanisms of class *Mollicutes* which is a group of pathogenic bacteria, as the role of research team at Osaka City University.

The class *Mollicutes* is a class of bacteria, Low-GC branch of Gram-positive bacteria which evolved in unique ways through parasitic life cycle in higher animals and plants. They threw away their cell wall and tail (in other words, peptidoglycan and flagellum) which are to be the targets of host immune system, and then obtained a soft and light body. Furthermore, they obtained a method of camouflage and three separate unique motility mechanisms in order to escape from immune system thoroughly. We have studied these three motility mechanisms of class *Mollicutes* since 1997 and the research is about to reach its climax before long. We published the proposal that the accidental contact of adhesin, common in most pathogenic microorganisms and ATP synthetase, existing in all organisms and essential for maintenance of the membrane potential might have developed the gliding mechanism of *Mycoplasma mobile*, a freshwater-fish pathogen.

(The below figure is the magnified image of the gliding machinery of *Mycoplasma mobile*. Upper blue structure like a string of beads originated from ATP synthetase. The cell inside is colored light pink. Lower surface is the solid surface like glass. The force is transmitted from (i) to (iii) in this order.

【References】Miyata M and Hamaguchi T (2016), Prospects for the gliding mechanism of *Mycoplasma mobile*. Current Opinion in Microbiology. 29, 15-21. PMID: 26500189. doi:10.1016/j.mib.2015.08.010.

Nakane D, Kenri T, Matsuo L, and Miyata M (2015), Systematic structural analyses of attachment organelle in *Mycoplasma pneumoniae*. PLoS Pathogens. 11, e1005299. PMID: 26633540. doi: 10.1371/journal.ppat.1005299



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Research Introduction

profile
Professor, Graduate School of Science, OCU
Akihisa Terakita
Completed a doctorate course at the Graduate School of Science, OCU in March 1989. Received a professorship at OCU in April 2006 after conducting research as a fellow of the Japan Society for the Promotion of Science, and holding positions as a research scientist at the Science and Technology Agency (RIKEN), assistant (education) at Oita University and assistant (science) and assistant professor at Kyoto University. Became a researcher at the Research Center for Science Systems, the Japan Society for the Promotion of Science in April 2013 (concurrent post).

Molecular basis for animal photoreception and its optogenetics application

Humans obtain more than 80% of external information through vision. Visual photoreception starts with light absorption by the photosensitive proteins, visual pigments, which exist densely in the retina of the eye. In many types of vertebrates, the visual pigment-related protein (rhodopsins) are also found in extraocular tissues and organs, such as the brain and skin, suggesting rhodopsins are involved in functions other than vision (nonvisual functions) such as light-regulation of biological rhythm. In humans, some types of rhodopsins express in the brain. They are attracting attention, although their functions have not been clear. We have studied the molecular basis and functions of extraocular photoreception and nonvisual photoreception. Our previous studies have revealed that several kinds of nonvisual rhodopsins have some properties that support extraocular photoreceptive function in various animals. [1, 2]

Recently, the method of genetically introducing photosensitive proteins into neurons and controlling their activities by light has become widely used. This method is attracting attention as optogenetics. In the conventional methods of optogenetics, a kind of microbial rhodopsin, which is a light-activated ion channel, is introduced into neuron, and the neuronal activities (membrane potential change, "outlet") are controlled by light (see figure). Meanwhile, animal rhodopsins are G protein-coupled receptors, which light-dependently activate G proteins, signal transduction molecules. Animal rhodopsins have the potential to control the activities of various cells in addition to neurons, by controlling the "inlets" of the cells; therefore it is expected to become a new tool in optogenetics. [3] The animal rhodopsin binds to 11-cis retinal, a special isomeric chromophore, which is generated by enzymes in the eye and related organs. Because 11-cis retinal does not abundantly exist outside the eyes, animal rhodopsins used to be regarded as inappropriate for optogenetics.

Some types of "extraocular" rhodopsins, which we have recently identified, have properties adequate for "extraocular" functions: in contrast to vertebrate visual rhodopsins, which can absorb light only once, "extraocular" rhodopsins revert to their original dark state when they receive further light, and therefore maintains its photosensitivity. As an example, due to this property, one of animal rhodopsins, parapinopsin, which localizes to the photosensitive pineal organs in the brain of lower vertebrates, activate G proteins in response to UV light, and stops activation immediately after visible light absorption. [4, 5] Also, another type of animal rhodopsins, invertebrate Opn3, functions by binding to 13-cis retinal chromophore, which exists throughout animal bodies. These types of animal rhodopsins are expected to become effective tools in optogenetics. [6] In addition, some types of rhodopsin with unique properties have been identified in various invertebrates, and are also expected to become optogenetic tools. [7, 8]

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6) Koyanagi M. et al., Proc. Natl. Acad. Sci. USA. 110, 4998-5003 (2013)
7) Koyanagi M. et al., Proc. Natl. Acad. Sci. USA. 105, 15576-15578 (2008)
8) Nagata et al., Science 335, 469-471 (2012)

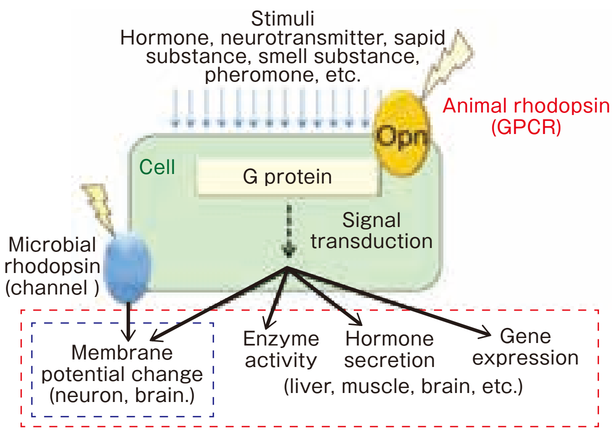

Fig: Outline of the optogenetic control of cells using animal rhodopsins

■Research Introduction

profile
Professor, Graduate School of Engineering, OCU
Naoteru Shigekawa

Graduated from the Department of Physics, Faculty of Science, University of Tokyo in March 1984, and completed the master's course at the Department of Physics, Graduate School of Science in March 1986. Studied compound-semiconductor heterojunction devices at NTT Atsugi Electrical Communications Laboratories (present NTT Device Technology Laboratories) from April 1986 until Sep. 2011. Took up his present post in Oct. 2011. Doctor of science.

Bonding of dissimilar materials for the realization of new energy-production and energy-saving devices

Since April 2015, I have been engaged in "the advanced material project" at OCARINA as an interlocking researcher. Three research groups from the Graduate School of Science and Graduate School of Engineering are implementing this project. I belong to the group "R&D of compound semiconductor tandem solar cells on nano-structure silicon substrates", and I am conducting research with Prof. DaeGwi Kim, Prof. Tatsuru Shirafuji and Dr. Jianbo Liang of the Department of Physical Electronics and Informatics, Graduate School of Engineering. Dr. Kim is studying the new properties of semiconductor nano particles, and Dr. Shirafuji is engaged in the application of atmospheric plasma. I will introduce their research in detail on another occasion, and outline Dr. Liang's and my research here.

Our research focuses on "the junction (bonding) of dissimilar materials for realizing innovative functions from the perspectives of energy production and energy saving". The surface activation method is used for bonding: Ar-atomic beams are irradiated on the surfaces of samples in a vacuum and they are bonded under load. We manufactured hybrid tandem solar cells by bonding Si solar cells and compound semiconductor (GaAs, InGaP, etc.) cells, and obtained favorable properties [1]. Also, we are evaluating the fundamental properties of junctions made of wide-gap semiconductor materials such as SiC and GaN, which are attracting attention in the field of power electronics, and Si or GaAs [2].

Heteroepitaxial growth technologies such as molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) have been used in the junction of different semiconductor materials. Using these technologies, semiconductor lasers, light-emitting diodes (LED) and high-frequency transistors have been manufactured and put into practical use. However, there is a limit in combinations of semiconductors that can be integrated into heterojunctions by growth; it is very difficult—of course it is not impossible—to fabricate heterojunctions from semiconductors with large difference in crystal structures, lattice constants or thermal expansion coefficients. Our approach is based on the simple idea of bonding materials if crystal growth is difficult.

According to a wise man, "God made the bulk; surfaces were invented by the devil." (by Wolfgang Pauli) As all of those familiar with solid-state physics know well, the periodicity in atomic arrangements is lost at the interfaces of dissimilar materials and, therefore, a highly dense interface states exist in the bandgap, which is expected to exert various adverse effects. To create new functions by using the bonding interface may seem to be an ignorant attempt. However, Herbert Kroemer declared, "The interface is the device." It was confirmed that the influence of interface states could be reduced through heat treatment after bonding [3]. We are seeking structures and uses that can maximize the advantages and minimize the disadvantages in bonding of dissimilar semiconductors.

At present, our research mostly targets semiconductors; however, "new functions created by bonding" may have various possibilities that we are not aware of. We welcome your suggestions for expanding the range of our research.

[1]N. Shigekawa, et al. Jpn. J. Appl. Phys. 54, 08KE03 (2015).
[2]J. Liang, et al. Appl. Phys. Lett. 105, 151607 (2014).
[3]M. Morimoto, et al. Jpn. J. Appl. Phys. 54, 030212 (2015).

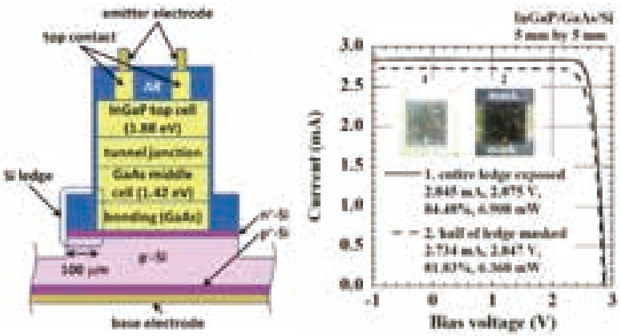

Fig: Schematic cross-section of the InGaP/GaAs/Si triple junction solar cell (left) and its characteristics (right). [1]

■Research Introduction

Light-Driven Actuators Based on Photochromic Organic Crystals

profile
Professor, Graduate School of Engineering, OCU
Seiya Kobatake
He received Ph.D. degree from OCU in 1996. He engaged as postdoctoral researcher and research associate at Kyushu University. He moved to OCU as associate professor in 2004, and was promoted to professor in 2011. He received the CSJ Award for Young Chemists in 2002, the APA Prize for Young Scientist in 2010, and the JPA Award in 2014.

When a molecular structure changes reversibly by some external stimuli, the properties of the materials consisting of the molecule can change reversibly. Such molecules will possess the switching function. A phenomenon that exhibits a reversible color change by photoirradiation is called photochromism. The photogenerated colored state is thermally unstable or stable depending on the photochromic compounds. In many cases, photochromic reactions take place even in solid states as well as in the solution. However, compounds that exhibit photochromism in the crystalline state are very rare.

Color change of photochromic diarylethene crystals is shown in Figure. Due to the different in the molecular structure of diarylethenes, the crystal color changes to yellow, red, blue, and green by irradiation with ultraviolet (UV) light. The colored crystal is thermally stable and returns to the original colorless one by visible light irradiation. This is due to the reversible change in the molecular structure. The photogenerated colored isomer can be directly observed as a disorder structure by single crystal X-ray crystallographic analysis. The cell length is slightly changed by the photochromic reaction. This indicates that the shape of the bulk crystal may be changed by the photochromic reaction.

In 2007, a reversible crystal shape change accompanied with a molecular structure change of a small-sized photochromic single crystal was reported for the first time. [1] The corner angle of the thin crystal changed and the rod-like crystal exhibited bending by the photochromic reaction. Because such a photomechanical phenomenon can change photon energy to mechanical energy without any direct contact and electrical wire, it is expected as a photoactuator for application. However, photoinduced crystal shape changes are limited to contraction, expansion, and bending, and thus creation of the more complicated photomechanical function is required. [2-5]

Photoinduced reversible twisting was found for a diarylethene crystal. [6] There is a right-handed twisting or a left-handed twisting depending on the crystal faces irradiated with UV light. The twisting of the crystal requires both a gradient of photocyclization conversion in the thickness direction and the contraction and expansion of the crystal in the diagonal direction. The crystal can be protected by coating the crystal using thin metal film and thin polymer film. Gold-coated diarylethene crystals exhibited photoreversible bending upon alternating irradiation with UV and visible light. It can be used as an actual electrical circuit ON/OFF photoswitching. [7]

These findings bring about not only a new strategy to design for photomechanical actuators but also a new practical use of photomechanical crystals.

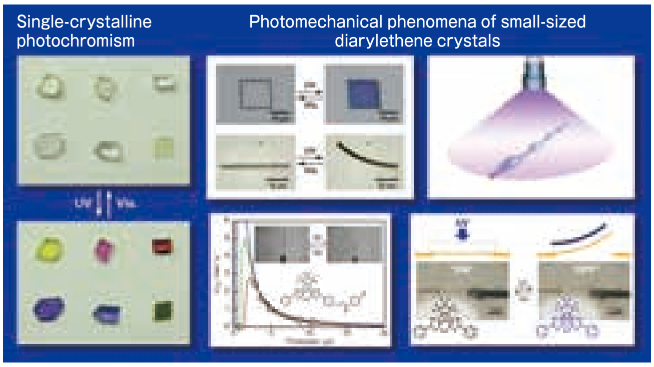

Figure. Examples of studies on photochromism and photomechanical phenomena of diarylethene crystals.

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3) D. Kitagawa, S. Kobatake, *Photochem. Photobiol. Sci.,* 13, 764-769 (2014).
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Research Introduction

profile
Professor, Graduate School of Science, OCU
Masatoshi Kozaki

Graduated from Department of Structural Molecular Science, the Graduate University for Advanced Studies in 1994. Worked as the postdoctoral researcher at the University of Alabama in 1994 and the University of South Carolina in 1995. He became the assistant of the Faculty of Science, OCU in 1997, the lecturer of the Graduate School of Science, OCU in 1999, and the assistant professor of the Graduate School in 2005, and took up his present post in 2015.

Creation of new π-electron conjugate compounds and the investigation of their functions

Development of precise macromolecules and the investigation of their functions

Macromolecules that can express the high-level functions required in vital activities are playing active roles in living organisms. For instance, protein complexes of size 10 nm or larger play a significant role in plants' photosynthesis. Protein is made up of a number of accurately arranged atoms to express its functions. It is possible to synthesize macromolecules of the same size as natural ones; however, synthesized macromolecules are incomparable to their natural counterparts in structural accuracy.Meanwhile, state-of-the-art fine processing technologies have enabled the construction of 10 nm-scale microstructures on the surface of semiconductors. Our research team is engaged in the development of technology that can produce 10 nm-scale molecules at will. We aim to create finely designed macromolecules, provide them with similar functions to those of natural ones, and to produce macromolecules that can be used as a single molecule device through being connected with a metal terminal.

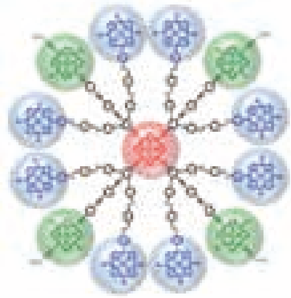
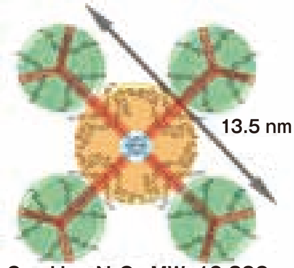


Fig. 1 : A solar light-harvesting antenna

I focus on molecules that belong to the dendrimer group. Dendrimer is a precise macromolecule that has a structure of repetitive branches radiating from the center toward the peripheral area. We designed and established a method of constructing dendrimer molecules that have a characteristic structure of flexible branch chains and rigid straight conjugated chains. At present, we are trying to realize high-level functions by using their flexibility and rigidity. So far, we have succeeded in creating antenna molecules that can efficiently collect solar energy and molecules that can convert light energy to electric energy. [1,2] The rigid structures of these molecules can be used to accurately arrange dye molecules in a three-dimensional space that are required for expressing functions. For example, the antenna molecule shown in Fig. 1 contains three kinds of porphyrin pigments finely arranged. As a result, energy moves from the peripheral parts toward the center with high efficiency. In addition, the rigid structure of conjugated chains functions as a pathway for the efficient transfer of electrons and energy. We aim to develop macromolecules that can express high-level functions comparable to those of natural macromolecules, by accurately arranging a wide range of functional parts in the dendrimer structure.



$C_{1188}H_{1070}N_4O_{56}$MW: 16,299

Fig. 2: A cross-shaped dendrimer assembly

We have developed many functional macromolecules using the dendrimer structure. Meanwhile, the protein mentioned earlier is made up of multiple macro sub-units that express high-level functions. Similarly, I assume that it is possible to express high-level functions that cannot be accomplished through a single molecule, by integrating multiple artificial macromolecules and forming an assembly. For this, we need technology that can integrate and arrange macromolecules freely. Therefore, I tried producing a huge dendritic compound by combining the surface ends of dendrimer's rigid structures. [3] Using this method, it is possible to produce an assembly of macromolecules in the same way as assembling a molecule model by using a dendrimer structure that contains an appropriate number and arrangement of conjugated chains. Bonding the macromolecules was more difficult than expected; however we patiently examined a number of reacting conditions and separating conditions, and succeeded in producing a huge dendrimer assembly with a diagonal length of more than 10 nm. (Fig. 2) We further improved our molecule bonding technology, and succeeded in synthesizing dendrimer octamers with a total length of approximately 50 nm. [4] As shown in Fig. 3, the structure of this molecule extends out at high temperatures and folds in at low temperatures. The rigid conjugated chains present characteristic changes in absorption spectra in accordance with the octamer's high-order structural changes. Therefore, the changes in absorption spectra are used to monitor the octamer's high-order structure. We are now trying to express innovative functions using the characteristic high-order structural changes of dendrimer assemblies.

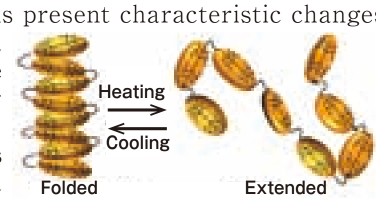


Fig. 3: Dendrimer assembly's high-order structural change

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Research Introduction

Molecular spin quantum technology for material innovation

profile
Professor, Graduate School of Science, OCU
Kazunobu Sato
Completed his doctoral course and obtained his doctorate degree (science) at the Graduate School of Science, OCU in March 1994. Has worked as an assistant professor, lecturer and associate professor in the Faculty of Science and Graduate School of Science, OCU, since April 1994, and received his professorship in April 2006. Became a researcher at OCARINA (concurrent post) in 2015

Quantum computers, which utilize the properties of quantum states, are attracting attention as a next-generation information processing technology. They are expected to improve computing capability greatly. In contrast to the classical (digital) computers, which operate on the binary system of zero and one, quantum computers (QCs) operate on a quantum state, using quantum bits (so-called qubits). The QCs enable us to establish an efficient information processing system with quantum parallelism and quantum search algorithm by using properties peculiar to quantum states, such as superposition and entanglement. Also, high secure communication is assured due to quantum no cloning theorem. The trends toward a new quantum information world have already begun. In addition, a quantum computing process is reversible; not only is one-way computing from A (initial state) to B (final state) possible, but also computing from B to A. This property provides an ideal circuit model for a highly efficient information processing system without information loss during computing processes. It is no exaggeration to say that quantum computers mark the beginning of a smart, sustainable society with efficient energy use.

A research of quantum computers dates back to the time of theoretical consideration by R. P. Feynman and D. Deutsch in 1980's. Subsequently, P. W. Shor's discovery of the quantum algorithm, which computes prime factorization at a high speed, marked a large break through. The development of the quantum algorithm and quantum computing theories has been discussed actively so far. In recent years, in order to realize quantum computations, one of our tasks has been the control of qubits in existing physical systems such as photons, semiconductor quantum dots, superconducting magnetic fluxes and electron/nuclear spins. In order to apply them as information resources, studies have been carried out to increase the number of qubits, develop technologies for controlling qubits, and establish hybrid systems that combine different qubits.

We focus on the quantum properties of unpaired electrons and the nuclear spins in molecules, and aim for the realization and application of quantum information processing/quantum computers, using these properties as qubits. In this project research, we proceed with development of quantum technology for applying the electron/nuclear spin property in molecules to information resource. Experimental approach is based on our knowledge of both pulsed electron spin multiple resonance and molecular spins, which we have experienced for a long time. Our challenge will open a path for molecular quantum technology.

Pulsed magnetic resonance is a type of time-domain spectroscopy which evaluates the magnetic interactions and relaxation processes of spin systems by radio wave or microwave irradiation in a static magnetic field. As shown in NMR, multi-dimensional spectroscopy is a powerful methodology to measure various interactions in detail. It is possible to apply optimized pulses for the precise spin manipulation. When the electron or nuclear spin information in molecules is considered as quantum information, the electron or nuclear spin can be manipulated by means of pulsed magnetic resonance technique. By controlling the irradiation conditions like frequency or strength, it is possible to excite different spins simultaneously or selectively. The pulsed technique, therefore, plays the role of a quantum gate as a processing circuit which can change quantum spin states. We have applied the pulsed electron multiple resonance technique to molecular spin systems, having characterized molecular entanglement between the electron and nuclear spins and verified the 4π periodicity (Spinor property) of electron spin or nuclear spin with a half integer angular momentum. We have also selectively controlled one of coupled electron spin (implementation of two-qubit gate).[1-4] We are currently developing advanced technology based on pulsed microwaves for the precise control of the electron spins. In order to realize quantum control for molecular quantum information processing and quantum computers (molecule quantum cybernetics), we will make molecular optimization for appropriate spin systems towards quantum state control as well as application of quantum chemical approach for highly accurate magnetic parameter calculation. Also, we will establish an innovative pulsed magnetic resonance technology such as coherent microwave multiple resonance technique for molecular spin quantum computers.

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Research Introduction

profile

Specially Appointed Professor, OCARINA

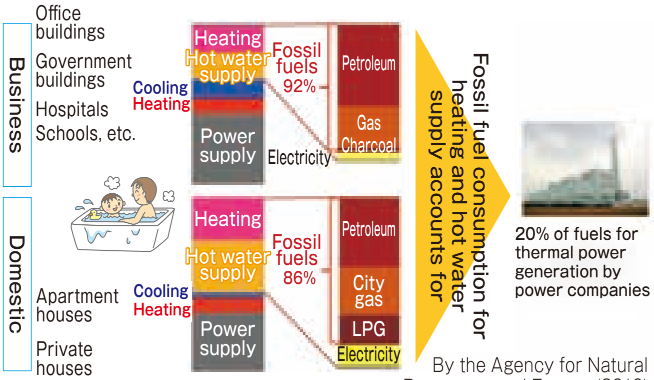
Masaki Nakao

Graduated from the Department of Mechanical and Control Engineering, Graduate School of Science and Engineering, Tokyo Institute of Technology in March 1973. Doctor of engineering. Worked for NTT Musashino Research Institute for Electrical Communication, NTT, NTT Facilities, and Sogo Setsubi Consulting, Co. Ltd. Became the professor of the Graduate School of Science, OCU in April 2004 and took up his present post in 2015.

Effective use of thermal energy in urban areas

Japan still largely depends on fossil fuels for its thermal energy consumption in urban areas. For instance, approximately 90% of the energy consumed for hot water supply and heating in the civilian sector (business and domestic) is produced using fossil fuels. If this energy was used for power generation, it would account for around 20% of the total power generation within Japan. We are burning fossil fuels to obtain temperatures of 45° C for heating and 65° C for hot water supply, which is very wasteful or "Mottainai".

Our urban energy project reviews this "wasteful heat supply" from the perspective of urban engineering, and investigates ways of meeting the need for thermal energy in urban areas with unused energy from within the town or city. The following is an outline of our projects, including those to be completed this year.



By the Agency for Natural Resources and Energy (2010)

Fig. 1: Annual consumption of final energy for business and domestic purposes (2010)

Thermal grids (thermal version smart grids)

The thermal grid system can transfer heat freely in both directions between multiple buildings. We created a double loop piping system, as the system's first model (Fig.2). (Ministry of the Environment project (project leader: Nakao, FY2012~2015)) The system is applied to areas that contain buildings with a heat source used for air conditioning (refrigerator). The loop piping and router, which switches thermal flow, are installed to transfer heat. The thermal energy model is established for buildings to minimize the amount of primary energy consumption. This control system optimizes and greatly reduces energy consumption through the combination of heat resources of the buildings.

The thermal grid consisting of double loop piping and routers is undergoing proof-of-concept trials in the Osaka International Exhibition Center (Intex Osaka, Fig. 3) (Ministry of the Environment project (project leader: Obayashi Corporation, Fig. 4). We are now examining the results in detail, and have confirmed that the system was able to reduce the primary energy consumption amount for air conditioning by a maximum of 70% and on average 50% in the summer of 2015.

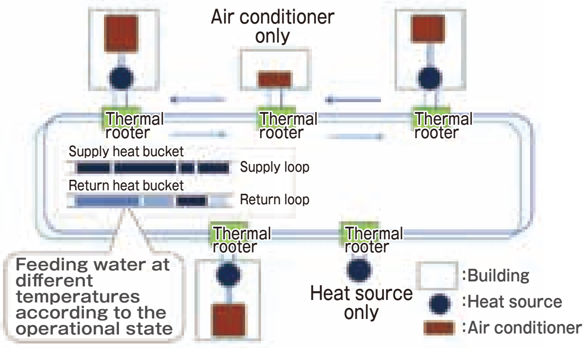


Fig. 2: Configuration of the double-loop thermal grid

We believe the thermal grid system, which can transfer heat freely between multiple buildings, will play a significant role in applying the technologies of hydrogen energy produced by artificial photosynthesis and waste heat energy to urban architectures.

In the future, we will continue the study of packet thermal energy transfer technology, which was launched during the development of the thermal grid system. We will also go on to study a new form of thermal grids and inner insulation piping.

Fig. 3: Trial of the thermal grid at the Osaka International Exhibition Center[1]

A system for the effective use of sewage bio gas

This is a Ministry of the Environment project that aims to reduce the carbon in methane fermentation equipment

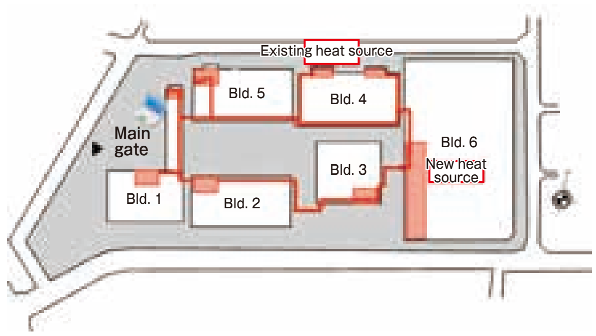


Fig. 4: Application of the thermal grid to six buildings with an independent heat source

at sewage disposal plants. (project leader: Dr. Kanjo, OCU, FY2013~2015) In the methane fermentation process, sewage sludge is put in a processing tank, and the tank is heated to generate bio gas. See Fig. 5 for the energy flow. In the previous system, 45% of generated biogas was used to heat the tank.

In our experimental system (see Fig. 6), the tank is heated by the heat obtained from sludge or water drained from the tank, and solar energy. Thus, the usable amount of generated bio gas can be maximized. We will complete the experiment by the end of the 2015 fiscal year, and use the system in actual facilities.

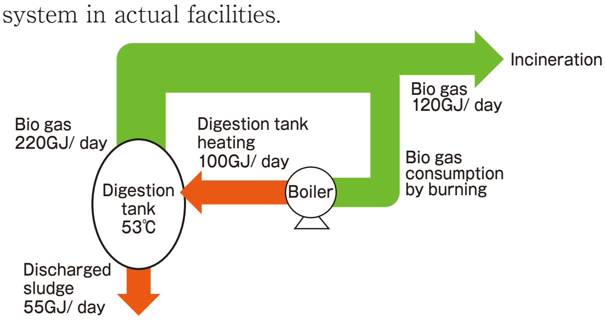


Fig. 5: The conventional digestion tank heating method (figures are for reference)

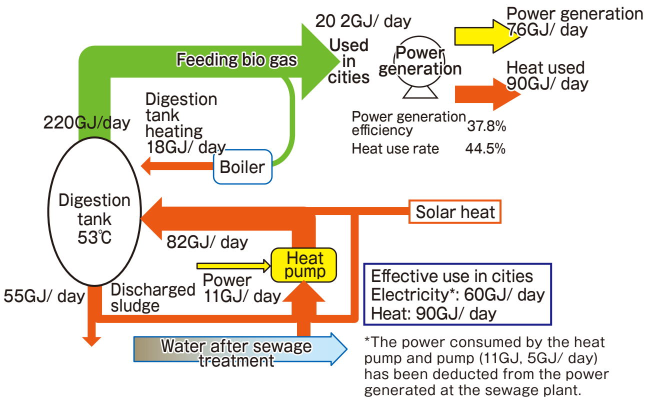


Fig. 6: The digestion tank heating method using discharged sludge, etc.

Aquifer heat storage systems

We started a new project for aquifer heat storage (Fig. 7) in the 2015 fiscal year. (Consigned by the Ministry of the Environment, project leader: Kansai Electric Power Co., Inc.) Japan is lagging behind western countries in the use of aquifer heat storage systems. (Fig. 8)

The reasons for slow spread of these are the decrease in water flow rate due to the deterioration of return wells over time, the difficulty of powering water pumps, the regulation of water pumping in urban areas and low economic efficiency. We will tackle these problems in order to spread aquifer heat storage systems.

We will work on the following tasks in collaboration with our joint researchers (Kansai Electric Power, the General Environmental Technos, NEWJEC, Morikawa Sakusen and Mitsubishi Heavy Industries). We will develop wells with high water pumping and returning efficiencies that can be applied to complicated stratum structures within Japan, and study methods of decreasing the risks of ground subsidence. Also, we will study technology for the use of stored heat in leveling electric power loads between daytime and nighttime, for which fundamental studies have been conducted jointly with Kansai Electric Power. We will also develop an air conditioning control system for low carbonization. From within OCU, Dr. Mitamura of the Graduate School of Science and Dr. Oshima and Dr. Nishioka of the Graduate School of Engineering are also participating in the project. The details of the project are as follows:

1) Develop the heat source for highly efficient wells
   (1) Realization of a completely sealed well structure
   (2) Drilling method for highly efficient wells
      ･Gravel size determination method
      ･Screen shapes and material properties
   (3) Appropriate maintenance through monitoring
2) Decrease the energy consumption of pumps
   Realization of a completely sealed structure with a waterfall prevention function
3) Work for deregulation of water pumping in urban areas
   ･Estimate of ground subsidence due to periodical pumping and returning of water
   ･Decrease in ground subsidence due to the arrangement of multiple pumping wells and returning wells
4) Develop daily heat storage system to control the peak demand of electricity
   ･In addition to seasonal heat storage, adding daytime and nighttime heat storage for leveling power loads

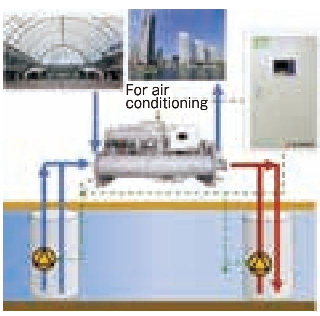


Fig. 7: The aquifer heat storage system

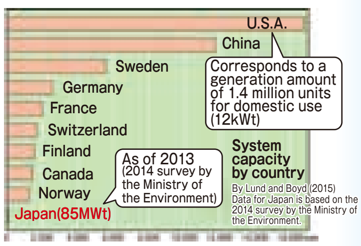


Fig. 8: Aquifer heat storage system capacity by country

References:
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2) Geo-heat promotion association of Japan website (2015)
http://www.geohpaj.org/introduction/index1/disadv

Activity Report

The 2014 OCARINA Annual International Meeting

Guest Speakers

Licheng Sun (Department of Chemistry, KTH Royal Institute of Technology, Stockholm, SE, Professor)
Ryu Abe (Professor, Kyoto University)
Masaya Matsuoka (Professor, Osaka Prefecture University)
Tomoko Yoshida (Associate Professor, Nagoya University)
Shigeru Ikeda (Associate Professor, Research Center for Solar Energy Chemistry, Osaka University)
Rei Narikawa (Lecturer, Shizuoka University)
Masami Nakazawa (Assistant Professor, Osaka Prefecture University)
Yoshinori Tsuji (Assistant Professor, University of Tsukuba)
Eiji Yamashita (COI-T Project leader/ General manager, Fuji Chemical Industries Co., Ltd.)

In-house Speakers

Hideki Hashimoto (Professor/ Project leader, OCARINA)
Shigeyuki Minami (Specially Appointed Professor, OCARINA)
Eriko Nakadai (Specially Appointed Tenure-Track Associate Professor, OCARINA)
Yoshihiro Yamaguchi (Specially Appointed Tenure-Track Associate Professor, OCARINA)
Hajime Masukawa (Specially Appointed Associate Professor, OCARINA)
Seiya Kobatake (Professor, Graduate School of Engineering, Applied Chemistry and Bioengineering)
Naoteru Shigekawa (Professor, Graduate School of Engineering, Physical Electronics and Informatics)
Masaki Nakao (Extraordinary Professor, Graduate School of Engineering, Urban Engineering)
Tasuku Hamaguchi (Specially Appointed Assistant Professor, Graduate School of Science, Biology and Geosciences)
Masakazu Hirotsu (Associate Professor, Graduate School of Science, Molecular Materials Science)
Akihisa Terakita (Professor, Graduate School of Science, Biology and Geosciences)
Kazunobu Sato (Professor, Graduate School of Science, Molecular Materials Science/ Department of Chemistry, Faculty of Science)
Shuichi Suzuki (Lecturer, Graduate School of Science, Molecular Materials Science)

The 2015 OCARINA Annual International Meeting was held in the OCU Media Center on March 4 and 5, 2015. OCARINA has been carrying out research activities under the theme of the development of next-generation energy for urban areas, environmental preservation and ground disaster prevention, and in particular, focusing on the research of photosynthesis and sunlight for next-generation energy production.

OCARINA's activities were summarized during the meeting, and researchers who are engaged in the research of photosynthesis or artificial photosynthesis domestically and internationally made presentations. In addition, new projects for the further development of OCARINA were proposed, and the meeting ended in success.

Distinguished Professor Michael Nobel Special Event International Symposium

Keynote Lecture

Michael Nobel
(Distinguished professor, Osaka City University)

Guest Speakers

Licheng Sun (Professor, School of Chemical Science and Engineering, KTH Royal Institute of Technology)
Keiichi Tomishige (Professor, Graduate School of Engineering, Tohoku University)
Michikazu Hara (Professor, former Chemical Resources Laboratory, Tokyo Institute of Technology)

As part of the distinguished foreign researcher invitation program, OCU held an international symposium commemorating the participation of Dr. Michael Nobel as a distinguished guest professor, cosponsored by the Biomass Conversion Catalysis Study Group, Catalysis Society of Japan, at Tanaka Memorial Hall on Wednesday, October 28, 2015.

Dr. Michael Nobel, a great-grandnephew of Alfred Nobel, the founder of the Nobel Prize, plays an active role in a wide range of research fields. He has held successive posts as the chairman of Nobel Sustainability Trust Foundation, and has received many prizes, such as the Einstein Prize.

The symposium had 112 participants from within and outside of the school. Dr. Nobel gave a lecture entitled "The Innovative Genius of the Nobel Brothers and the Nobel Prizes", in which he talked using gestures about the origin of the dominant characters of the Nobel family, Nobel Prize and the background of Alfred Nobel, while showing valuable documents.

In the latter part of the symposium, an active discussion was conducted with the panelists Prof. Licheng Sun, a leading researcher of artificial photosynthesis from the KTH Royal Institute of Technology and Prof. Tomishige and Prof. Hara from the Biomass Conversion Catalysis Study Group, Catalysis Society of Japan.

From here on, we will set up a "Renewable Energy Laboratory" in the Research Center for Artificial Photosynthesis, and begin collaborative research with Dr. Nobel, strengthening cooperation with foreign universities through his network.

Academic Forum,Organization for Tenure-track for Promotion

The OCU Tenure Track Study Conference was held at the Conference Room (C03+C04) in Knowledge Capital Tower (Tower C 8F), Grand Front Osaka on December 4, 2015.

In the conference, five tenure track researchers who were appointed through an international public advertisement held sessions for their own research fields, inviting outside experts as guest panelists, and conducted discussions regarding advanced research, which aimed to develop the young researchers' work.

Three members of OCARINA; Dr. Eriko Nakadai, specially appointed tenure-track associate professor, Dr. Yoshihiro Yamaguchi, specially appointed tenure-track associate professor and Dr. Taka-Aki Asoh, specially appointed tenure-track lecturer, participated in the conference. The conference started with an opening speech by Prof. Michio Miyano, Vice President of OCU, and active discussions regarding advanced research were conducted among the guest speakers. The conference ended with a closing speech by Prof. Hiroshi Oshima, director of the OCARINA, who encouraged the researchers in anticipation of their future activities. The conference was highly successful.

OCARINA Seminars

OCARINA seminars are held to provide opportunities for researchers at OCARINA to talk with other researchers from Japan and abroad, and give presentations on their research results. In addition to seminars inviting leading scientists from inside and outside of the country, a wide variety of activities such as study tours and PR activities are also held.

22nd	Date	Feb. 20, 2015	Venue	Building 2, 220B
	Guests	Dr. Tilo Mathes (Free University of Amsterdam)		
	Theme	Translating light into biological information: Photoactivation and signal transduction of BLUF photoreceptors		
23rd	Date	May 28, 2015	Place	Nankou-kita, Suminoe-ku, Osaka
	Study Tour	"Aspen Accord Japan 2015, Thermal Grid Seminar and Study Tour"		
24th	Date	Aug. 3, 2015	Venue	Faculty of Science No.6 Lecture Room
	Guests	Dr. Toshifumi Shibata (Nagasaki University Graduate School of Biomedical Sciences, Microbiology and Oral Infection)		
	Theme	Gliding machinery of the gliding bacterium Flavobacterium johnsoniae		
25th	Date	Sep. 30, 2015	Venue	Faculty of Science No.6 Lecture Room
	Guests	Dr. Kazunori Kawasaki (National Institute of Advanced Industrial Science and Technology)		
	Theme	Cell-walls and nano-structures in water analyzed through the quick freezing replica method		
26th	Date	Jan. 12, 2016	Venue	Faculty of Science No.10 Lecture Room
	Guests	Dr. Yoshiaki Kinoshita (Graduate Course in Life Science, Graduate School of Science, Gakushuin University)		
	Theme	Research on the movements of archaeal flagella which differ from the flagella of eukaryote and procaryotae		
27th	Date	Jan. 14, 2016	Venue	Faculty of Science Conference Room B102
	Guests	Dr. Naohiro Oka (Lecturer, Preparation room for the establishment of Faculty of Bioresource and Bioindustry (tentative name), Tokushima University)		
	Theme	Technical development and diversified utilization of the mass cultivation of marine algae on land		
28th	Date	Feb.23, 2016	Venue	Faculty of Science No.6 Lecture Room
	Guests	Dr. Shigeru Ito (Emeritus professor, Nagoya University/ Visiting professor, Nagoya Institute of Technology)		
	Theme	The principle and evolution of the photosynthetic photo-reaction		

See the website for details.

History of the Osaka City University Advanced Research Institute for Natural Science and Tehnology

2008	March	Founding Anniversary International Symposium held
	April	The OCU strategic key research project (2008-2011) started
	December	International Workshop held on the efficient use of sunlight energy
2010	March	1st International symposium held
	March	Enforcement of official regulations(start of activities as an official bureau)
	October	Building 2 renovated for research floors of OCARINA
	November	Opening symposium for building 2 of OCARINA held
	December	2nd International symposium held
2011	March	3rd International symposium, "Kakuno memorial," held
2012	March	Annual meeting and the OCU strategic key research project (2008-2011) debriefing held
	April	The OCU strategic key research project (2012-2014) started
	July	School of Science Building C completed, partial occupation
2013	March	4th International symposium held
	April	2 new full-time staff members appointed
	June	**Research Center of Artificial Photosynthesis opened**
2014	February	Partial occupation for the new School of Science Building
	February	One new full-time tenure track staff member appointed
	March	One new full-time tenure track staff member appointed
	March	5th International symposium held
	April	One new full-time tenure track staff member appointed
	April	The OCU strategic key research project (2014-2015) started
2015	March	6th International Symposium held
	April	One new full-time staff member appointed
	April	New project started

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