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MESSAGE

President's Message

Living Up to Expectations for Scientific and Technological Innovation

FEATURE

Can Geothermal Energy and Ground Source Heat Utilization Provide the Answer to Our Energy Crisis?

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UPDATE FROM THE CUTTING EDGE (January–March 2014)

In Brief

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President's Message

Living Up to Expectations for Scientific and Technological Innovation

Ryoji CHUBACHI

President
National Institute of Advanced Industrial Science and Technology (AIST)

The Japanese people's hopes for science and technology

As we stand at the threshold of a new fiscal year, I am reminded once again of the strong hopes that the people of Japan are placing on scientific and technological innovation. They are the hope that Japan can overcome the issues it is facing over the medium to long term such as the problems of a decreasing and fast-aging population and the necessity of reconstructing deteriorating social infrastructure. They are the hope that scientific and technological innovation can become an engine for economic growth that leads Japan's industry in a world where major shifts in the structure of global society are taking place due to the expansion of the information society and globalization as well as the rapid growth of emerging countries. And they are also the hope that Japan can contribute solutions to global issues that threaten global sustainability such as those related to population, resources and energy, climate change and the environment, water and food, and so on.

The role of AIST

As a representative public research institute in Japan, AIST has two roles to play in this situation: to enhance the level of science and technology, and to use science and technology to increase social and economic value. For this purpose, it is highly important for AIST to not only germinate first-class innovations that stand out in the world, but also to contribute to the solution of the medium- to long-term issues, including the creation of a new energy system that Japan is tackling as a national policy. and becoming the frontrunner in the world in building a society in which people can enjoy long and healthy lives.

On the other hand, the activation of local economies and small to medium-sized companies is also crucial to Japan's growth. In cooperation with public research organizations established by local governments, universities, etc., AIST will make efforts to provide detailed support to help strengthen the technical capabilities of small to medium-sized companies and support venture companies that aim to create new businesses. AIST is fortunate to be endowed with an investment function beginning this fiscal year and we are planning to make best use of this new system.

Working toward the Fourth Term

Since this is the final fiscal year of AIST's Third Mid-term Plan, we are hoping to make this a year of change and embark on the path to our fourth term. At the end of the last fiscal year, AIST was chosen as a candidate organization for a designated national research and development organization (provisional name). Organizations with this designation are expected to "give birth to the world's top-level results that can become the foundation for scientific and technological innovation through global competition based on the national strategies." From such a standpoint, we must make this the year of a major concrete step toward the "re-establishment of AIST."

Increasing people's familiarity with AIST

The first thing we need to do is to change AIST so that people can easily see who we are from the outside. We have been working toward this goal since last year, but, for example, even the names of our research units are still not easy for outsiders to grasp and there are cases where the name of the research unit and the contents of its research are mismatched. We must admit that we still lack understanding of the perspectives of customers and stakeholders, and this might be one reason why AIST sometimes seems to be not easy to approach and is still a relatively unknown institute.

If we can weave phrases and R&D objectives into our organization that reflect the needs of today's industrial sector and society, perhaps then we will be more easily understood from the outside.

Becoming a core player in the government's new industrial science and technology policy

Japan's new industrial science and technology policy places a strong requirement on AIST to reinforce its efforts to serve as a bridge that successfully connects the fruits of science and technology with business.

If we are to play a central role in supporting small to medium-sized businesses and venture enterprises, for example, we should not only collaborate with the companies concerned, but also transform the network with businesses and public research organizations to encourage the development of unique and diversified local strengths.

The management of intellectual property also needs to be changed. For companies to be able to effectively utilize AIST's technologies, the sequence of a cycle that encompasses the development of an invention, the establishment of intellectual property rights, licensing, and inventor compensation must also be harmonized with the systems of society and the industrial sector. Moreover, because the investment function that AIST has been endowed with takes the form of contributions in kind, such as research facilities, patents, and so on, we believe that a change in intellectual property management is crucial for these to be of help in the establishment and development of venture enterprises.

Increasing mobility of human resources

Greater human resource mobility is indispensable for Japan to become an ideal country for scientific and technological innovation, and we at AIST are also considering changes that need to be made. Specifically, I am referring to a transformation of the personnel management system. The current personnel management system has been passed down from the time when we were public servants and can no longer handle today's mobile job market. I am planning to change the system so as to promote flexible and smooth personnel exchanges between companies, universities, and other organizations and when inviting overseas personnel. As a start, we have already begun discussions with several research organizations and universities regarding an appointment system that would allow us to promote mutual personnel exchanges within Japan.

Key projects in FY 2014

Lastly, I would like to mention the key projects for this fiscal year that AIST will be strongly focusing on while promoting the changes mentioned above.

One such project is the full-scale launching of R&D on hydrogen carriers, next-generation photovoltaic power generation, ground source heat and geothermal energy, etc. with the cooperation of companies and universities in Japan and research institutions overseas at the Fukushima Renewable Energy Institute, which opened in April 2014 in Koriyama, Fukushima Prefecture. We will also be launching the following two projects as part of the STrategic AIST integrated R&D (STAR) program. The Leading Engine program for Accelerating Drug discovery (LEAD) is a program aimed at developing a drug discovery process that can cut drug development times and costs for anticancer and other drugs by half through collaboration with RIKEN and pharmaceutical companies. The Initiative for Most Power-efficient Ultra-Large-Scale data Exploration (IMPULSE) is a program that aims to develop the low-energy and high-performance data processing technologies that will be required by data centers by 2030. In addition to these projects, with the aim of supporting local small to medium-sized companies, we will be starting a new business in collaboration with the Council of Promotion for Industrial Technology Collaboration, which is a network of public research organizations in each prefecture, to disseminate technologies in the fields of robotics, 3D printers, and renewable energy throughout Japan.

We at AIST are determined to continue our efforts this fiscal year so as to live up to the expectations of the industrial sector and society overall.

We deeply appreciate your kind support and cooperation.

Can Geothermal Energy and Ground Source Heat Utilization Provide the Answer to Our Energy Crisis?

Using the Earth's Heat Skillfully

How are geothermal energy and ground source heat utilized?

Geothermal energy, the heat that emanates from deep within the center of the Earth, where temperatures reach approximately 6,000 °C, and the heat generated by the decay of radioactive elements within the Earth's crust, can be used as an energy resource. In Japan, this geothermal resource is utilized most extensively for so-called "hot spring" spas. Apart from bathing, geothermal hot water is also used to dry timber, melt snow, heat greenhouses, and to facilitate fish farming. In addition to using the heat of geothermal hot water directly, it can also be used to drive turbines that generate electric power. In geothermal power generation, hot water mixed with steam is drawn up from below the ground, after which the steam is separated from the mixture and used to drive turbines. Relatively high-temperature geothermal resources (at least 150 °C) are used for this purpose.

In contrast, ground source heat utilization takes advantage of the low-temperature thermal energy at relatively shallow depths below the ground, which allows it to be used as a constant temperature heat source throughout the four seasons. For example, systems in which a fluid is circulated through pipes laid below the ground to exchange heat with the Earth can be used to heat or cool buildings. Harnessing the heat of the Earth below the ground in this manner enables the use of geothermal resources, even in areas where hot water does not gush out from the ground.

New technologies for utilizing geothermal and ground source heat energy

Binary cycle power generation is a technique for harnessing geothermal energy that has become established in recent years. In this method, a substance that becomes a gas at 100 °C or below is heated using geothermal energy, and the pressure of the steam is then used to drive a turbine that generates power. This method enables power to be generated using relatively low-temperature geothermal resources that could not previously be harnessed for power generation.

In addition, heat pump technology is becoming more advanced. This technology utilizes the heat exchanged between a heat conveying substance (heating medium) and the ground and the heat of vaporization and condensation of the substance to extract a quantity of energy that is greater than the mechanical energy used to decompress and compress the heating medium. The use of heat pumps allows heating and cooling in areas where it is difficult to use ground heat sources with previous technology. Thus, the use of geothermal heat sources is becoming widespread.

Technology development at AIST

The amount of geothermal resource energy utilized is currently no more than a very small fraction of the total thermal energy that is released from the Earth into outer space. This situation is similar to that of photovoltaic power generation which produces electrical energy through the conversion of a tiny part of all the sunlight that pours over the Earth. Thus, geothermal energy is classified as a renewable form of energy because, even if harvested extensively, such resources will never be exhausted.

However, geothermal energy cannot be utilized everywhere in Japan. In addition to heat from the Earth, hot springs and geothermal power generation sites require the presence of groundwater that works as a medium to carry the heat to the surface, as well as underground structures to store the water. AIST is working to expand the use of geothermal energy by publishing "geothermal potential maps" that show where large reserves of geothermal energy are located.

The impact of large-scale developments, such as those of geothermal power plants on hot springs, is an ongoing cause for concern. In view of this, our technological developments have focused on development methods that do not adversely impact such hot springs, in addition to methods for monitoring the microseismic disturbances that are generated when hot water is pumped out of the ground.

At the same time, it should also be noted that when ground source heat (GSH) is used, the quantity of heat that can be extracted from the underground water

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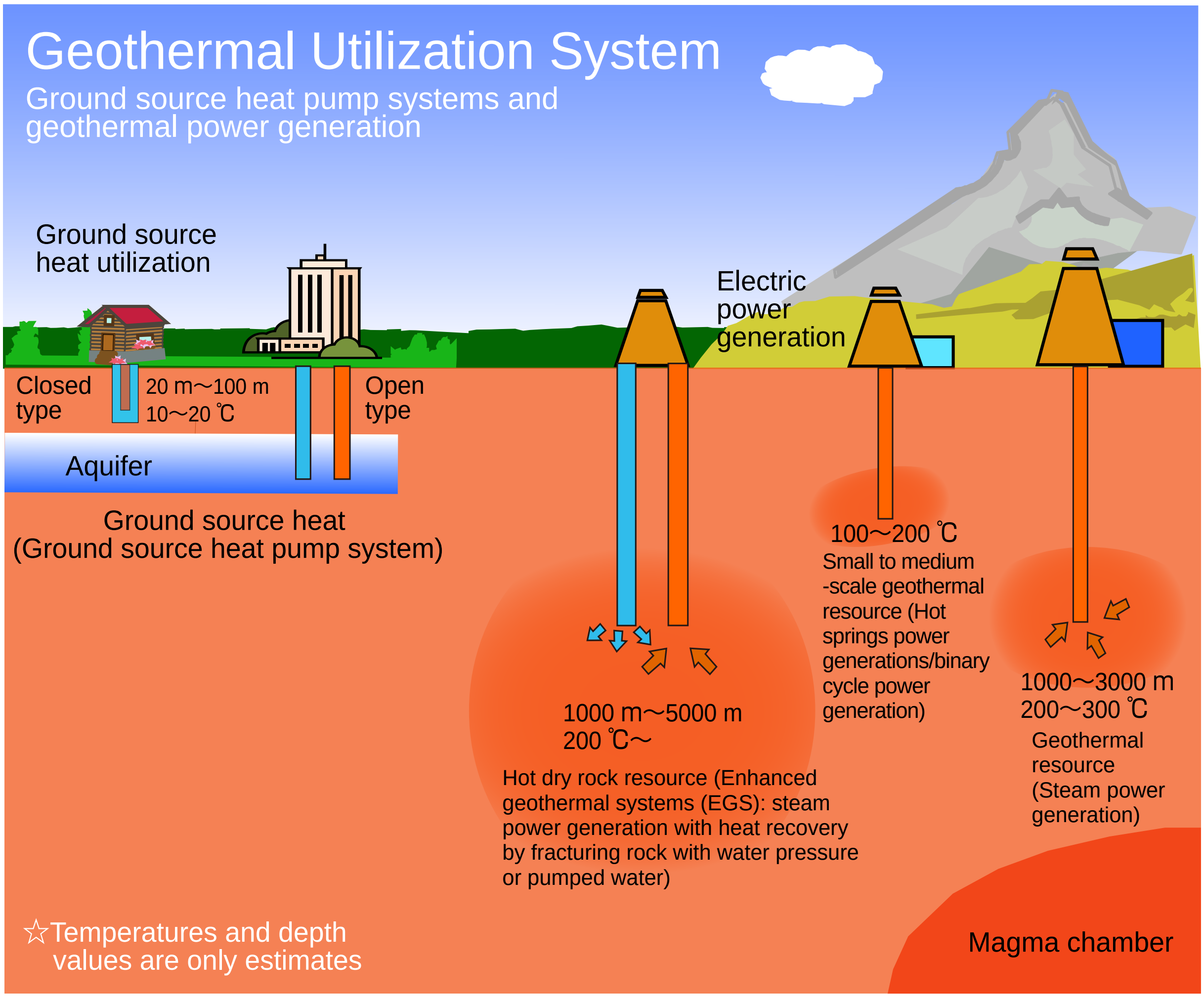

Ground source heat pump systems skillfully use the 10 to 20 °C constant-temperature environment at 20 to 100 m below ground, which is also known as "temperature-differential energy."

flow varies from place to place depending on geology and ground water condition. AIST has also created a map of potential GSH, and has worked to expand their use. GSH utilizing systems are already being adopted in significant quantities in Korea and China, and studies to assess their viability have commenced in various Southeast Asian countries.

Fukushima Renewable Energy Institute

AIST has constructed the Fukushima Renewable Energy Institute in the city of Koriyama in Fukushima Prefecture (opened in April 2014). This research institute is also designed to pursue research and development in geothermal energy and GSH technology.

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Toshiyuki TOSHA

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Keiichi SAKAGUCHI

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Map of Geothermal Resources Assessment

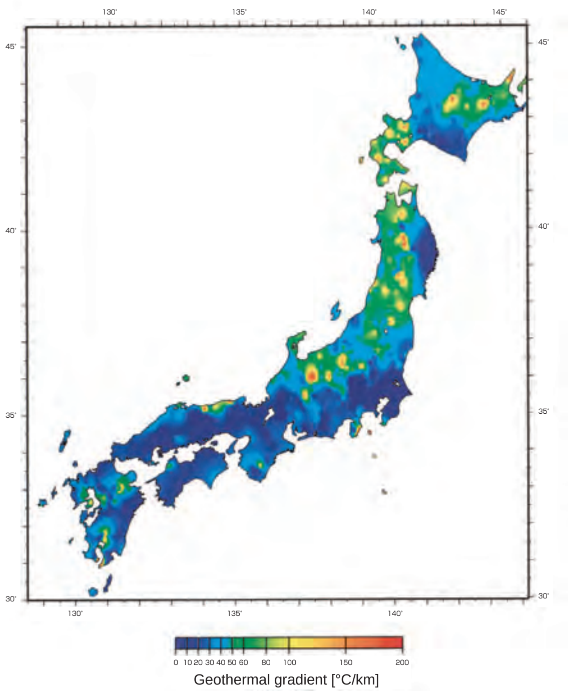

Fig. 1 Geothermal gradient map of the Japan archipelago based on borehole temperature data[1]

Use of the geothermal resource map

Japan is richly blessed with geothermal resources, but this does not mean that geothermal energy can be used to generate power everywhere in the country. To use geothermal heat for power generation, high-temperature steam or hot water that is at least 200 °C is needed. This is only possible in volcanic areas. The areas where warm water (hot springs) of a few dozens degrees Celsius is available are far greater, and this warm water is normally utilized directly for bathing and other purposes.

The most basic information needed when national or local governments formulate geothermal energy-related policies, or when companies or local communities contemplate geothermal energy developments, is maps showing the location and quantity of the resources, along with their approximate temperatures – in other words, geothermal resource maps.

Creating geothermal resource maps takes ingenuity

In the case of photovoltaic power generation, the amount of power that can be generated at a particular location can be calculated approximately by measuring the solar insolation and daylight hours. With geothermal resources, however, the quantity of underground resources cannot be estimated simply by taking measurements at ground level. For this reason, many different types of maps have been devised in attempts to show the distribution and characteristics of geothermal resources (e.g., temperature, hot water properties).

Figure 1 is a map that shows the distribution of temperature gradients below the ground based on temperature data from holes bored into the ground. Areas where temperature gradients are high are likely to have better-quality geothermal resources. Figure 2 is a map that shows the distribution of total geothermal reserves (quantity of thermal energy stored in geothermal reservoirs), which is calculated based on below-ground temperature distributions obtained from hot springs and borehole temperature data, together with the distribution of geothermal reservoirs that store steam

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or hot water based on gravitational measurements.

Assessment of Japan's geothermal resources

Using the "Geothermal Potential Map in Japan"[2] published by AIST, it is possible to evaluate geothermal resources. It is estimated that if all the geothermal reservoirs of 150 °C or above throughout Japan were developed without restrictions (such as those in national parks), approximately 23 GW of electric power could be generated over a 30-year period.[3]

At AIST we are currently engaged in research aimed at creating an improved geothermal resource map.

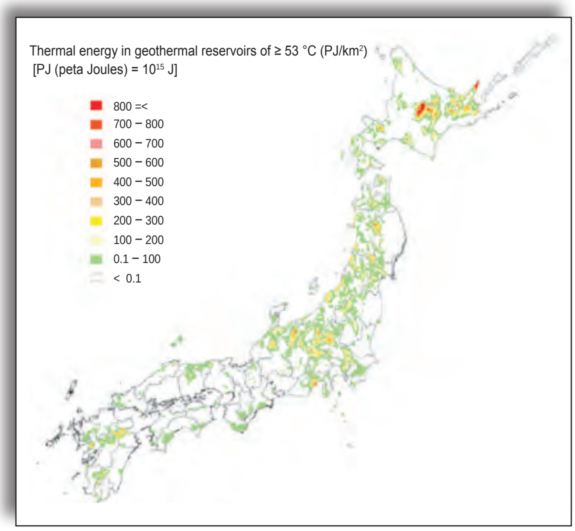

Fig. 2 Distribution of thermal energy in geothermal reservoirs of ≥ 53 °C[2]

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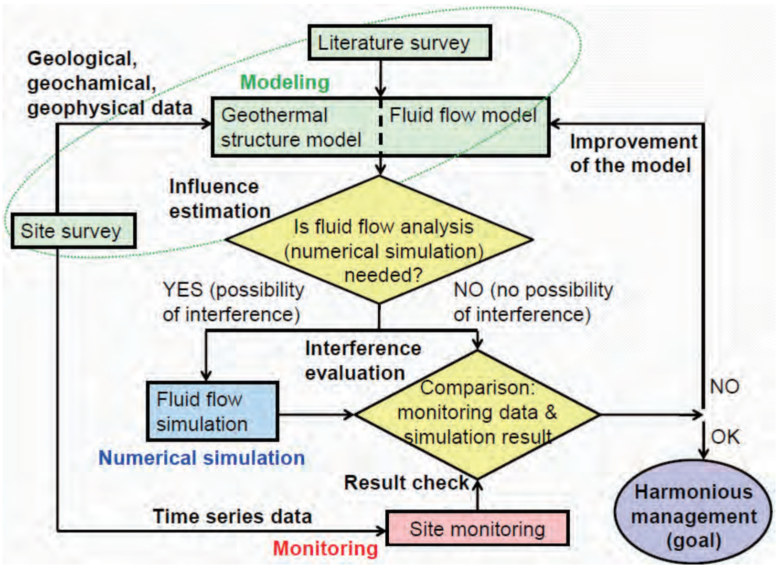
Geothermal Energy Development in Harmony with Hot Springs

We want to use both hot springs and geothermal energy sustainably

When developing a new geothermal energy resource, it is essential to obtain the understanding of the local community – in other words, gain public acceptance (PA). Obviously, a development project should not adversely impact any of the hot springs in the surrounding area. And, indeed, there have been cases in which geothermal energy development projects have been delayed or stopped due to objections from hot spring owners, who fear that such projects could damage their natural hot springs.



Flow chart of the harmonious reservoir management system (without adverse impact on hot springs)

However, any development scheme that would adversely impact its surrounding hot springs or natural geothermal features would also reduce the temperature and /or pressure of the geothermal reservoir itself before any signs of damage became apparent at nearby hot springs, thus making it impossible to generate geothermal power sustainably. Obviously, geothermal energy developers would not entertain such development plans.

In any case, development plans must include a preliminary assessment that verifies that there will be no adverse impact on hot springs.

The essential concepts addressed here are as follows:

- If there is a solid impermeable layer between the geothermal reservoir to be developed and the hot springs aquifer, there is no problem.
- If there is a balance between the amount of heat and water extracted for the hot springs and geothermal project, relative to the amount of natural heat and water supply, there is no problem.

However, it remains a fact that, no matter how much preliminary study work is done, some degree of uncertainty will always remain in the case of underground surveys. To prepare for the possibility of unexpected impacts after the development has been implemented, the area surrounding the geothermal development site must be monitored. If continuous monitoring is performed, any changes to the hot springs can be detected promptly, which will make it possible to take countermeasures before serious problems develop.

At the Institute for Geo-Resources and Environment (GREEN) we conducted a project for the Ministry of the Environment (MOE) from FY2010 to 2012, entitled “Development of an Advanced Geothermal Reservoir Management System for Harmonious Utilization with Hot Spring Resources.” In this study, we created a comprehensive geothermal reservoir management system for geothermal power generation that ensures no adverse impact on hot springs.

This project was accomplished by modeling the geothermal-hot springs system, conducting a simulation to predict impacts and monitoring issues, all based on the above concepts. In addition, it was proposed that the promotion of power generation using existing hot springs could be effective in PA activities. From FY2010 to 2012, GREEN also participated in another study for MOE as part of the same initiative, “Development and Demonstration of a Hot Springs Power Generation System” (led by Geothermal Energy Research & Development Co., Ltd.).

Geothermal surveys are like health checkups for hot springs

From the viewpoint of hot spring owners, does a geothermal energy development offer any benefits?

The answer is yes. When a development is contemplated, all nearby hot water systems are surveyed, including those of hot springs operations. Thus, for the hot springs owners, this represents an excellent opportunity to find out the exact state of the underground hot spring resources being relied upon. In other words, it is like receiving a free health checkup for the hot springs.

In addition, if the surrounding hot springs continue to be monitored after the geothermal energy development project is completed, this means there will be continuing regular checkups. That means if any abnormalities were to occur, even for reasons other than the geothermal energy development, they could be detected promptly. This is certainly a plus for hot springs operators, without any downside.

Balancing the pros and cons

Virtually all development types, including geothermal energy, have some impact on the surrounding environment. However, with skillful use of technology and applied inventiveness, it is possible to minimize such impacts to an effectively negligible level. In addition, even if developments carry a small level of risk, if this is more than offset by advantages, the project has value.

If we consider the added benefits of having a reliable power supply in the event of a natural disaster, and the positive impact on the global environment due to having an effective source of clean power to combat global warming, geothermal energy developments are undoubtedly very significant. Likewise, even if there is some unresolved risk of negative impacts on the hot springs, hot spring operators can obtain timely and accurate assessments of the condition of their resources. And, if any abnormality is detected, they can quickly determine the cause and take corrective action. These are important benefits. In this way, the developers and hot spring operators will enter into a mutually beneficial relationship.

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Can Geothermal Energy and Ground Source Heat Utilization Provide the Answer to Our Energy Crisis?

The State of Hot Springs Binary Cycle Power Generation

What is binary cycle power generation?

A binary cycle power generation system using high-temperature hot springs is attracting significant attention. In this method, the hot water or steam from the hot springs passes through a heat exchanger to evaporate a low boiling point medium, which then drives a turbine (see figure).

Various kinds of fluids are used as the medium in binary cycle power plants, including hydrofluorocarbon (HFC), hydrocarbons, and water-ammonia mixtures. Internationally, 1,000 kW-scale generators that use a hydrocarbon heating medium by Ormat are the mainstream, and a system of this type was introduced at the Hatchobaru Geothermal Power Plant in Oita Prefecture. However, the newly developing hot spring power generation systems in Japan mainly use a HFC medium. Unlike other systems, HFC binary cycle power plants with outputs up to 300 kW do not require special licensed boiler/turbine engineers, which results in lower operating costs.

A geological approach

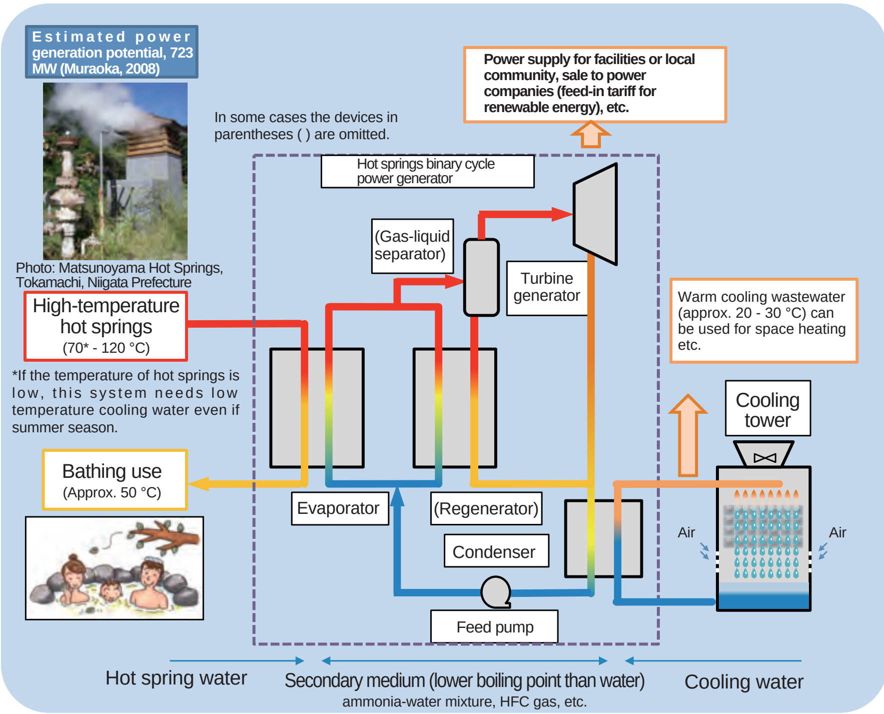
Since FY2007, GREEN has been engaging in research into hot springs binary cycle power plants in collaboration with Geothermal Energy Research & Development (GERD) Co., Ltd. In this work we are taking a geological approach to the problem.

First, based on about 4,500 hot spring source data points collected by Kimbara (2005).[1] we estimated that the total electric power generation potential of high-temperature hot springs in Japan was approximately 720,000 kW (Osato & Muraoka, 2008).[2] Additionally, to estimate the capacity of usable hot springs and their stability, we have been conducting modeling of hot springs areas based on geological and geochemical surveys. Furthermore, we are also studying past data on hot springs production and chemical composition, and have engaged in monitoring the surrounding hot springs.

Next, there is the problem of scale adhesion on heat exchangers due to the presence of silica and calcium carbonate in hot spring water. Here, we estimate the potential for scale adhesion from the chemical composition of the hot spring water and study methods to prevent scaling.

The potential of the Kalina cycle

In our joint research with Geothermal Energy Research & Development Co., Ltd. we are conducting verification trials of a Kalina cycle power plant using a mixture of water and ammonia at Matsunoyama Hot Springs in Niigata Prefecture. The advantage of this method is that the power generation efficiency is higher than that of systems that use an HFC medium, and also that this medium is not a greenhouse gas. However, since



Schematic diagram of a hot springs binary cycle power plant (by Geothermal Energy Research & Development Co., Ltd.)

ammonia gas is toxic, this kind of system currently requires the special licensed boiler/turbine engineer when in operation.

But if it can be demonstrated that a power plant can be operated safely for long periods, regulations might be relaxed, thereby lowering costs, and further promoting the diffusion of this technology. One example of a Kalina cycle system is the 3,450 kW plant at the Kashima Steel Works of the Nippon Steel & Sumitomo Metal Corporation in Ibaraki Prefecture, which uses waste heat from a blast furnace. Since its introduction in 1999, the power plant has operated stably without any problems. During our trial at the Matsunoyama Hot Springs, we investigate whether the 50-kW system designed for hot springs power generation is capable of operating with a similar level of safety and reliability, and also whether hot spring water production is stable.

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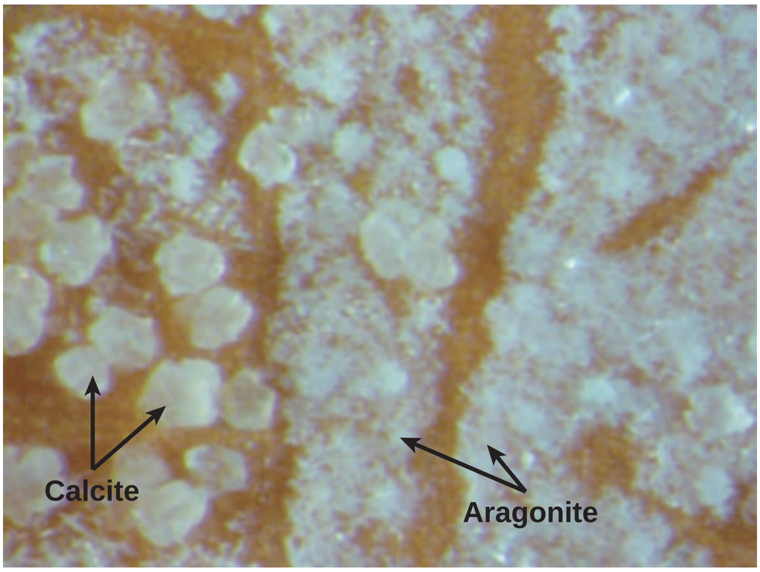
Geothermal Scale

What is scale?

In the baths of hot springs districts, where the vapor rising from the hot water drifts all around, there is an abundance of hot spring water containing a wide variety of chemical substances. Oftentimes, these build up over the years to form attractive natural sinter. These sinter deposits, which are composed of suspended particles and sediments produced by physical and chemical changes in the hot spring water, colorize the baths – with the red of iron, the white of calcium carbonate, and the yellow of sulfur, for example.

However, from the viewpoint of maintaining and managing hot springs resorts, these sinter deposits are an annoying presence, and if they form



Two kinds of calcium carbonate minerals grown on the surface of a material soaked in hot spring water (coarse grained: calcite, fine grained: aragonite) inside wells or piping, they can reduce the production and supply capacity of the hot spring water, and even block wells or pipes. In the context of hot springs and geothermal energy, these deposits are known as "scale." In hot springs, some of the scale substances that commonly cause problems are hydrated iron oxide ($Fe_2O_3.nH_2O$) and calcium carbonate ($CaCO_3$); in geothermal systems, the main problem substances are calcium carbonate and hydrated silica ($SiO_2.nH_2O$), whose principal component is silicon dioxide.

Current state of countermeasures

When hot spring water gushes up from the ground, the dissolved iron content is oxidized, resulting in the formation of hydrated iron oxide. Then, when a dehydration reaction occurs, the substance hardens. To counter this, the offending substance can be filtered out while in suspension, or it can be washed off using a chemical agent after it forms as sediment. When hot spring water is drawn up inside a well, or when it flows within pipes, its pressure drops. This results in the degassing of dissolved carbon dioxide (CO_2) and precipitation of calcium carbonate.

To counteract this process, various ideas have been explored and many experiments have been conducted. Examples include maintenance and management techniques (dilution with water, setup of a sedimentation tank, precipitate dredging, and replacement of blocked piping), electromagnetic treatment (electrolysis, magnetic field irradiation), and chemical treatment (chemical additives). Geothermal water at high temperature tends to contain large amounts of dissolved silica, so the temperature drop that occurs after production causes precipitation of silica minerals in piping and turbines. Countermeasures, including the set up of a sedimentation tank and pH adjustment and suppression of polymerization using chemicals, have been trialed.

Basic research

While the multi-staged utilization of hot springs and geothermal energy is encouraged and expected, it seems that current scale production countermeasures have not given sufficient consideration to the chemical properties of hot spring water, or to their patterns of usage. Accordingly, it is necessary to expand the range of possible solutions to deal with scale-related problems, and to improve their cost-effectiveness. To this end, we are exploring various basic research avenues, such as scale formation mechanisms, inhibition based on the surface properties of various materials, effectiveness of electromagnetic inhibition, and methods of utilizing recovered scale.

With respect to calcium carbonate, for example, we are examining ways to inhibit precipitation when feeding water from a macro perspective by injecting the degassed $C0_2$ into the hot spring water. From a micro perspective, we are looking at the kinds of scale formed by soaking materials in hot spring water, as well as methods to investigate their growth rates (see figure) and investigating methods for studying the effects of dissolved components on the formation of crystalline nuclei. A wide range of physical and chemical characteristics are involved in this kind of basic research, so there is a need for cross-disciplinary collaboration and promotion with other fields, such as materials science.

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Geothermal Energy Development and Microearthquakes

Introduction

In geothermal areas, the underground regions where high-temperature steam and/or hot water are located are known as geothermal reservoirs. In most cases, these geothermal reservoirs are formed in high-temperature locations that possess multiple fractures, such as the walls of calderas and faults. Since the interiors of the water and/or steam filled fractures in such reservoirs are sometimes unstable, seismic activity can be observed at some geothermal reservoirs. In addition, since, during the development of engineered geothermal systems (EGS), it is a common technique to improve permeability by injecting fluid in order to pressurize fractures with low permeability, it is normal for very small earthquakes (which humans cannot feel) to occur when such cracks are pressurized.

Using microearthquakes to monitor geothermal reservoirs

In order to develop and utilize geothermal energy, it is necessary to measure the characteristics of individual fractures in high-temperature, high-pressure environments several kilometers underground. However, the technology that makes it possible to do this is still in the emergence stage. In light of this, research has been conducted to develop a method of examining the locations where microearthquakes occur, and the movement of the quake epicenters. This is now a standard technique in the field of EGS. In addition to providing a way to estimate the distribution of fracture systems, this method also makes it possible to perform monitoring of improvement in permeability when pressurizing fractures. Researchers at AIST and other Japanese institutions have developed very advanced technology in this field, and by applying this for monitoring in different countries, are helping to promote geothermal energy development.

Perceptible earthquakes in geothermal areas

Although extremely rare, perceptible earthquakes can occur due to events in geothermal reservoirs. In the field of EGS, in particular, the risk of such earthquakes at times of high-pressure fluid injection is considered to be one of the possible environmental impacts of geothermal energy development. However, there are very few cases in which decent data related to perceptible earthquakes in geothermal areas are collected for various kinds of analysis. Furthermore, such earthquakes are highly locality-dependent.

In view of this, there is currently insufficient scientific understanding about the cause-and-effect relationship with other geological phenomena, and any development activities that took place underground before and after the occurrence of a perceptible earthquake. At AIST, we are approaching research in this area in a variety of ways, with the aim of assessing the risk of earthquakes in geothermal zones, and of developing geothermal energy development methods that lower this risk.

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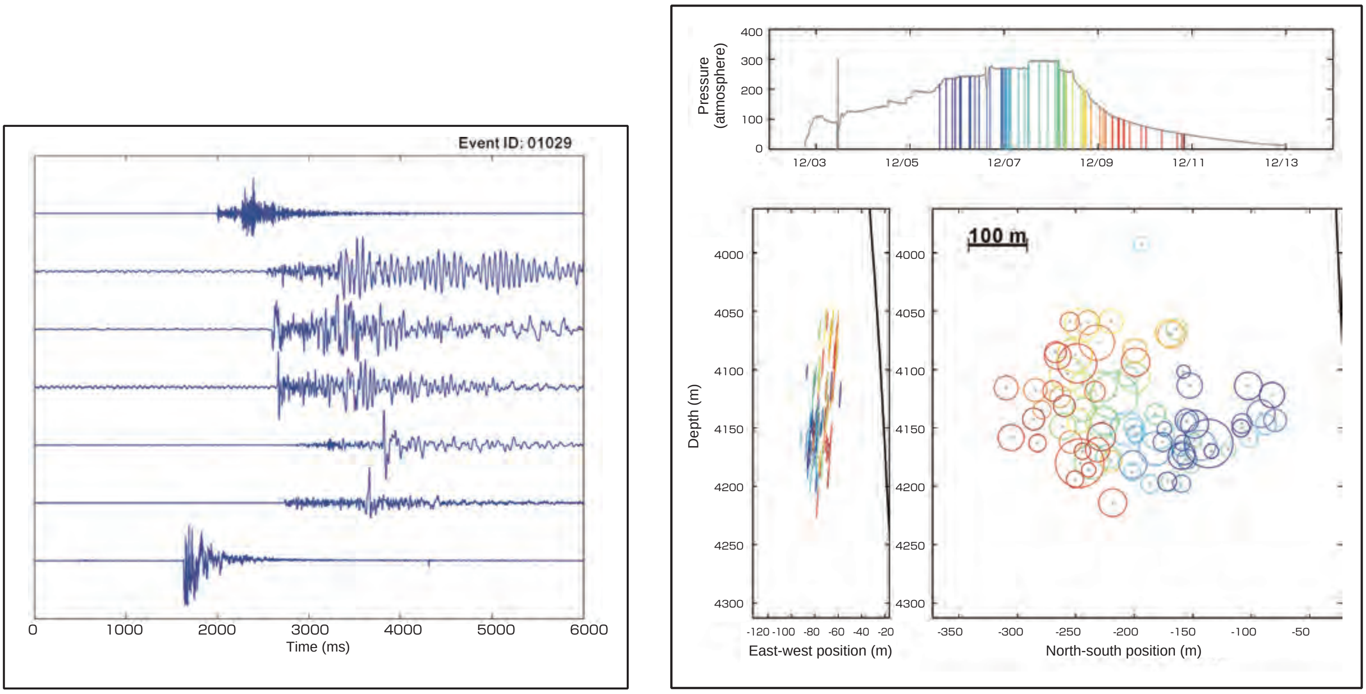

Waveform of microearthquakes (left) and epicenter time-space distribution (right), observed at an EGS project in Basel, Switzerland
The shift of the epicenter as the penetration region expands due to the feed water injection can be seen.

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Creating Maps of Ground Source Heat Utilization Potential

Map of ground source heat utilization potential

Systems that make use of the heat of the Earth are a significant form of energy-saving technology. This technology uses the thermal energy stored below the ground at relatively shallow depths (approx. 50 to 100 m) for heating and cooling, melting snow, and other purposes. The application of such systems is spreading at a rapid rate in North America, Europe, and (more recently) in China. In Japan, however, this technology is only just starting to take off.

To help promote its diffusion, it is important to lower the cost of adoption and increase system efficiency. And for this, we need to compile information about the geology and groundwater conditions related to the use of ground source heat and assess the potential of ground source heat use in the area. The Groundwater Research Group at GREEN is working to develop a method of assessing this potential through a combination of field surveys and numerical analysis.

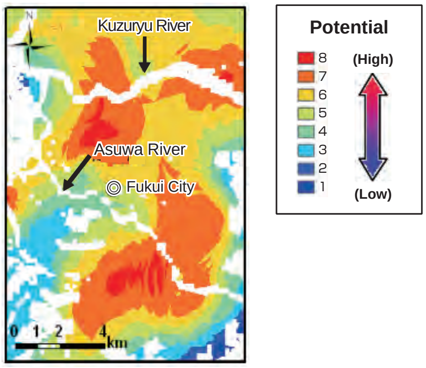
Developing a potential assessment method

In a joint research effort with Kyushu University and Fukui Prefecture, we conducted field surveys on groundwater flow and underground temperature distribution in the Fukui Plain. Then, based on the collected findings, we constructed three-dimensional (3D) models of groundwater flow and heat transport. After building our models, we employed a geographic information system (GIS) to create a map that can be used when selecting the most appropriate areas for ground heat source system uses.

The created map classifies the plains according to eight levels of potential. According to the map, the northern and southern part around the Kuzuryu River, as well as the eastern and southern part around the Asuwa River, all have high potential levels.[1] Next, we attempted to evaluate the ground source heat utilization potential more quantitatively by constructing a local heat exchange well model based on the groundwater flow field and the temperature field points where heat exchange wells have been installed. This allowed us to calculate the total quantity of heat exchanged at multiple points within the plains.[2] Building further on this work, we intend to run actual temperature response tests and conduct trial operations at heat exchange wells in the field, in order to increase the precision of our models.

Further development

There have been many engineering-oriented studies on ground source heat utilization systems in Japan that focused on the advancement of ground source heat pumps and heat exchange wells. In contrast, hardly any research has been done on the ground itself – the part of the system that provides the energy. As part of its geology work, AIST is continuing the implementation of a Japan-wide geology and groundwater survey that has been running for more than 120 years (since the era of its predecessor, the Geological Survey of Japan) and is accumulating data from this. Our aim is to utilize these data to create a map of the potential ground source heat utilization resources for the major regions of Japan.



Created map of ground source heat utilization potential (from [1])

Recently, we have also been engaged in research on methods to assess potential based on the assumption that groundwater is pumped directly out of the ground for use as the heat source of a heat pump system (open system). These potential maps will make it possible to determine the optimum system designs and operation patterns for specific areas of the country, thereby contributing to the diffusion of ground source heat utilization systems in Japan.

References

[1] Y. Uchida *et al*.: *J. Geoth. Res. Soc. Jpn*., 32 (4), 220-239 (2010).

[2] M. Yoshioka *et al*.: *J. Geoth. Res. Soc. Jpn*., 32 (4), 241-251 (2010).

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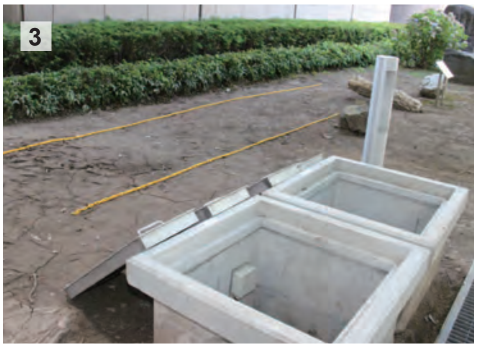
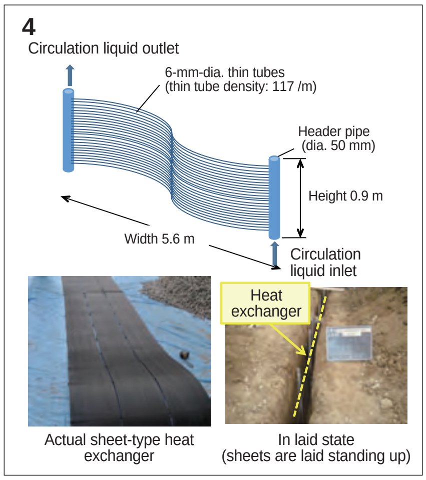
Ground Source Heat Utilization System of the Geological Museum

Geological Museum at AIST

The Geological Museum supports the recording, management, and utilization of geological specimens, of rocks and stones, minerals, fossils, etc. resulting from the research work of the Geoinformation Center, AIST, and conveys the research findings in the geosciences to museum visitors in an easy-to-understand way. The museum was established in the city of Tsukuba in Ibaraki Prefecture in 1980. In Exhibition Room 3 on Level 2 of the Geological Museum, models and panels relating to ground source heat utilization systems are displayed, and the principles of such systems and details of AIST's research in this field are presented.

In May 2013, work started on a ground source heat utilization system of the Geological Museum, and in July of the same year it was completed. The system is designed so that all museum visitors can inspect the system and experience the efficiency of the heating and cooling system, which is powered by ground source heat.





1. Video room of Geological Museum featuring a ground source heat system for cooling and heating
2. The state of system operation can be viewed on a monitor in the same room
3. State-of-the-art sheet-type heat exchanger (laid 1 to 2 m below the yellow chains) at the side of the building. The heat exchanger piping can also be seen.
4. Schematic diagram of sheet-type heat exchanger

Aims of the ground source heat utilization system of the Geological Museum

In systems that burn fossil fuels for space heating and hot water supply, temperatures can reach 500 to 1,500 °C, even though only low temperatures are actually needed (approx. 47 °C for the hot water for space heating, and approx. 60 °C for the water used for hot water supply). Thus, a large amount of energy is exhausted as waste heat. In contrast, in a system that uses the heat stored in the ground – a natural form of energy – the heat source is inherently of low temperature, which means there is relatively little difference in temperature between the source and the medium used for space heating or hot water supply. Thus, by using a heat pump, these small temperature differences can be utilized to build systems that have very low energy losses. In our trial operation of the ground source heat pump system at AIST's Geological Museum, we are working on the following three points:

1. We adopted this system for the Video Room on Level 1 of the Geological Museum and are now trialing it. At the same time, we want museum visitors to understand that the utilization of ground source heat enables substantial savings in electricity for heating and cooling.
2. Comparing a standard system (closed type) with a state-of-the-art system helps to stimulate creation of industries through new technology.
   a) Comparison with a direct expansion/closed type system
   b) Comparison with a horizontally laid ground source heat exchanger
3. The heat exchanger wells set up outdoors and the heat pump and fan coils indoors are all visible. We also devised a way to allow museum visitors to easily understand the workings of the ground source heat pump system,

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which normally operates like a "black box," for example, by setting up an electronic display that shows the status of all kinds of operation parameters in an easy-to-understand way.

Looking ahead, we plan to help to promote this system more widely, by enabling increasing numbers of people to experience an actual ground source heat utilization system through events such as AIST open houses and "open labs," and through special exhibitions at the Geological Museum.

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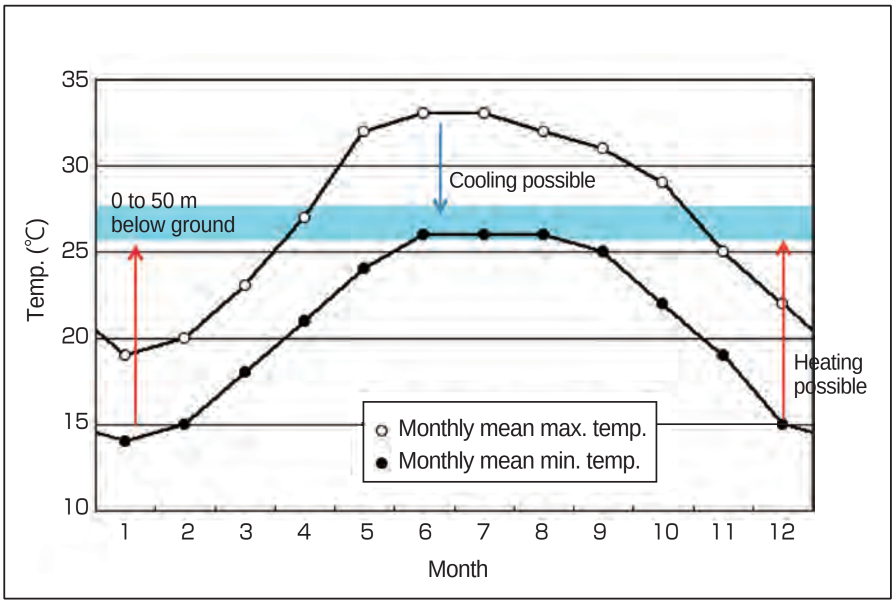
Ground Source Heat Utilization in East Asia and Southeast Asia

Energy situation in East and Southeast Asia

The implementation of ground source heat utilization systems has, thus far, been concentrated largely in Europe, the U.S., and other developed countries. In the coming years, the demand for energy in Asia is expected to grow enormously, so interest in this technology is growing significantly there due to its energy-saving potential. In fact, as a result of a nationwide commitment to adopting and diffusing ground source heat utilization systems, China is now the second ranked country in the world after the U.S. in terms of number of installations.



Viability of ground source heat utilization according to temperature and distribution of underground temperature in the area around Hanoi, Vietnam[1]

Ground source heat utilization systems exploit the temperature difference between the ground surface and underground, so they can be used in ordinary places – not just in "geothermal areas." In addition, they can be used not only for heating, but also for cooling. For these reasons, this technology is being increasingly seen as suitable for use in almost any location. This is why there is a growing expectation that ground source heat utilization will be applied in the urban districts of East and Southeast Asia, where demand for electricity is expected to rise explosively in the years ahead.

On the other hand, in the countries of Southeast Asia, all of which are located in the tropical zone, the air temperatures and underground temperatures are typically higher than those of Japan, and the temperature difference is minimal. This makes it difficult to use ground source heat utilization systems for cooling purposes, and is a challenge that needs to be tackled in the future.

Research in East and Southeast Asia

AIST's Groundwater Research Group is actively participating in and supporting projects implemented by the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP). Since FY2009, the second phase of a groundwater project has been implemented, and the CCOP is set to publish hydrological environment maps that compile hydrological data from the Chao Phraya River plain in Thailand and the Red River delta in Vietnam. Since these maps include data on groundwater levels and quality, as well as underground temperatures, they can be utilized as basic data for geothermal research in the Southeast Asian region.

Upon evaluating the possibility of ground source heat utilization for cooling and using underground temperature distribution and air temperature data, it was found that, in the case of Thailand, underground temperatures are lower than maximum air temperatures throughout the year in the areas of Phitsanulok and Nakhorn Sawan. Furthermore, in the Kanchanaburi area, the underground temperature is lower for part of the year. Thus, ground source heat can be used for cooling in these locations, at least in some seasons. Around Hanoi city in Vietnam, there is some demand for space heating as well as cooling, and the data on underground temperature distribution and air temperature data for this region indicates that ground source heat can be utilized for both.[1]

Upcoming research

The potential or viability of ground source heat cooling systems was evaluated from underground temperature distribution and air temperature data. The design and optimization of ground source heat pump systems for a particular area requires a detailed numerical model that reflects field-based geological data and the hydrological environment. In FY2013, a joint research project was launched by AIST, Chulalongkorn University in Thailand and Akita University in Japan, that focused on ground source heat utilization in Thailand. We are now aiming at the development of ground source heat pump systems that are appropriate for the East and Southeast Asian regions. Using this ground source heat utilization research in Thailand as a springboard, we also expect to gradually extend our research to other countries in the region.

References

[1] K. Yasukawa *et al*.: *Bull. Geol. Surv. Jpn*., 60 (9/10), 459-467 (2009).

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Activities at the Fukushima Renewable Energy Institute

What is the Fukushima Renewable Energy Institute?

Following the unprecedented earthquake of March 11, 2011, on July 29 of the same year, the Japanese government announced its “Basic Policy for Recovery from the Great East Japan Earthquake,” declaring the country’s wholehearted commitment to strive for recovery from the devastating natural disaster. This basic policy contained a proposal to establish relevant sections of government-managed research institutes in Fukushima Prefecture, which was devastated by the nuclear power plant disaster, for the creation of a research and development center on renewable energy. In response to this government decision, AIST made a plan to establish a research and development (R&D) institute named the “Fukushima Renewable Energy Institute,” in Koriyama City, Fukushima Prefecture.

Renewable Energy Research Center

The “Renewable Energy Research Center” which focuses on R&D of solar and wind power generation, energy storage and transport, and system integration technology, as well as geothermal and shallow geothermal energies, was also established under the research institute. The two main R&D themes in the area of geothermal and hydrogeology are as follows.

1. Technology for the effective and sustainable use of geothermal power generation
2. Potential assessment of ground-source heat pump (GSHP) system and system optimization technology

This initiative aims at building a solid renewable energy industry in the

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region to help in the disaster recovery by pursuing these research challenges in collaboration with universities, public research institutions, and companies in Fukushima and other Tohoku region prefectures that were hit by the disaster. It also aims at conducting leading-edge research on renewable energy in partnership with Japanese and overseas research organizations. The buildings of the institute were completed in January 2014, and the research center started operating in April 2014.

Technology for the effective and sustainable use of geothermal power generation

It has been suggested that the reason that little progress has been made in promoting the adoption of geothermal power generation is that, in addition to some technological problems, there are serious social issues that need to be overcome. The research center plans to tackle both of these challenges from an objective and neutral standpoint. On the technology side, we plan to develop advanced geothermal monitoring technology for use in ensuring sustainable operation of geothermal power plants, and for monitoring the impact on nearby hot springs. On the social side, we will be pursuing research aimed at establishing social acceptance by promoting greater understanding of geothermal power generation and alleviating apprehensions regarding its use.

Potential assessment of GSHP system and system optimization technology

When GSHP systems are used in Japan, the efficiency of heat exchange under the ground largely depends on the groundwater flow. The research center will be conducting groundwater surveys to create potential maps for the GSHP system for the plains and basins of the Tohoku district, identifying appropriate locations for application of GSHP systems, and formulating design guidelines for borehole heat exchangers. Furthermore, there are plans to drill pit wells on the site of the research institute for use when conducting experiments, and to facilitate comprehensive R&D on the development and operation of GSHP systems. This will be done through partnerships with universities, the Fukushima Prefecture Hi-tech Plaza, and local companies.

Deputy Director
(until September 2013)
Institute for Geo-Resources and Environment
Toshiyuki TOSHA

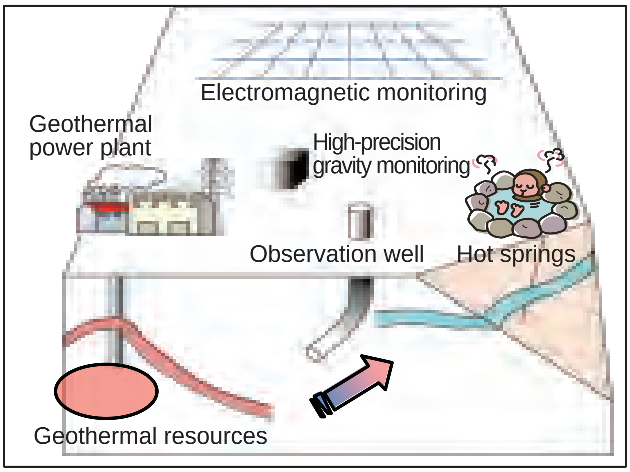

Fig. 1 Schematic diagram of geothermal monitoring technology development

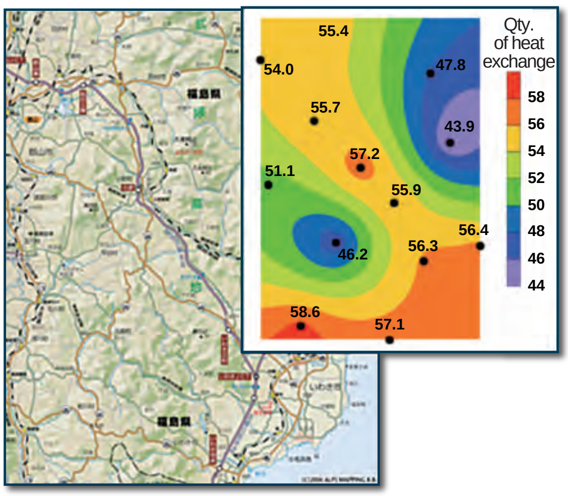

Fig. 2 Image of a potential map for ground-source heat pump system
Creation of a potential map corresponding to a topographical map

The abstracts of the recent research information appearing in Vol.14 No.1-3 of "AIST TODAY" are introduced here, classified by research areas.
For inquiry about the full article, please contact the author via e-mail.

Environment and Energy

Efficient production of high-performance surfactants from non-edible biomass

Production cost reduction of biomass-based chemicals, avoiding competition with food production

We have succeeded in producing highly functional biosurfactants directly from non-edible biomass, mahua oil, by a fermentation process using yeast, and also in establishing the technology for their inexpensive mass supply by optimizing the fermentation conditions and the method of product separation. These biosurfactants, which not only have excellent detergency at low concentrations but also exhibit high biodegradability, are expected to be used in toiletry products such as environmentally friendly detergents and shampoos.

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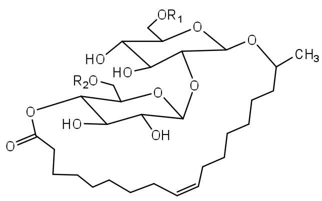

(R_1 and R_2 = H or Ac)

Structure of biosurfactants

	CMC (M)	γ_{CMC} (mN/m)
Biosurfactants	1.4×10^{-5}	32.3
Synthetic surfactant (LAS)	1.6×10^{-3}	34.0

Surface activities of the biosurfactants
The critical micelle concentration (CMC) is the standard for assessing the performance of surface-active agents. γ_{CMC} is the surface tension value at CMC.

Environment and Energy

Low Vf and highly reliable 16 kV ultrahigh voltage SiC flip-type n-channel implantation and epitaxial IGBT

Effective use of electricity, promotion of saving energy

Flip-type n-channel implantation and epitaxial (IE)-IGBT on 4H-SiC carbon face with an epitaxial p^{++} collector layer was investigated. In this study, we employed the epitaxial p^{++} layer as a substrate and the IEMOSFET as a MOSFET structure with an original wet gate oxidation method, to realize high channel mobility. We were able to achieve an ultrahigh blocking voltage of more than 16 kV, extremely low forward voltage drop of 5 V at 100 A/cm^2 and small threshold voltage shift (< 0.1 V). These characteristics are useful for Smart Grid and HVDC systems, the use of which would realize a low carbon emission society.

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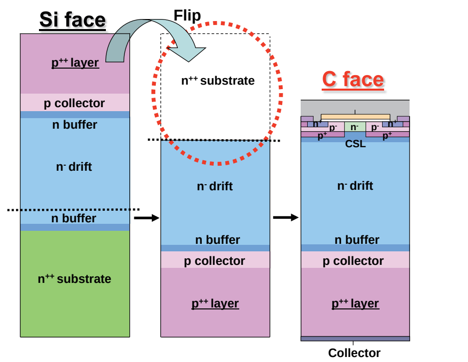
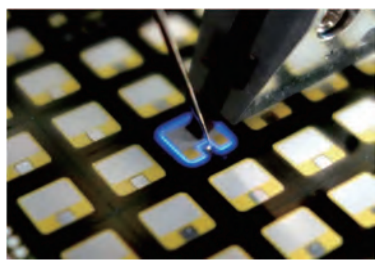


Fabrication process flow of filp-type IE-IGBT on 4H-SiC (000-1) carbon face



Recombination radiation of IE-IGBT steady on-state

Database of sensory characteristics of older persons and persons with disabilities

Graphical presentation of the data according to search criteria entered

We have constructed the "Database of Sensory Characteristics of Older Persons and Persons with Disabilities," which displays the sensory characteristics of vision, hearing, and touch, according to search criteria such as age and types of disability. The data were measured at AIST for target groups with a total number of more than 3,000 people. Since these data on characteristics have been adopted as Japanese Industrial Standards (JISs), the database serves as a tool for displaying JIS contents graphically that were described using equations and tables. By referring to the database, product designers can make products more accessible for various types of people including older persons and persons with disabilities. Japanese and English versions of the database have been released to the public on the Web (http://scdb.db.aist.go.jp/?lng=en) from August 19, 2013. The data can be accessed and used free of charge as long as they comply with the conditions of use.

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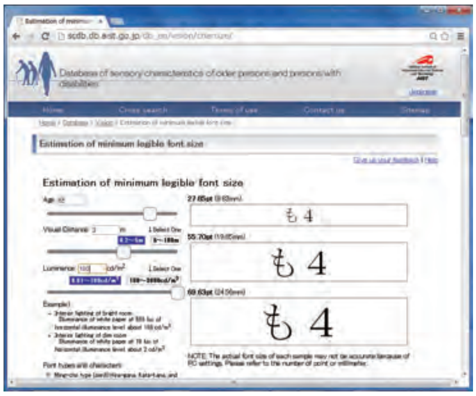

An example of database display: Estimation of minimum legible font size

Novel statistical methods for discovery from big data

Wide applicability in all experimental life sciences

More than three transcription factors often work together to enable cells to respond to various signals. The detection of combinatorial regulation by multiple transcription factors, however, is not only computationally nontrivial but also extremely unlikely because of multiple testing corrections. The exponential growth in the number of tests forces us to set a strict limit on the maximum arity. We developed a novel statistical test called LAMP (limitless-arity multiple testing procedure). LAMP counts the exact number of testable combinations and calibrates the Bonferroni factor to the smallest possible value. LAMP lists significant combinations without any limit, while the family-wise error rate is kept under the threshold. In the human breast cancer transcriptome, LAMP discovered statistically significant combinations of as many as eight binding motifs.

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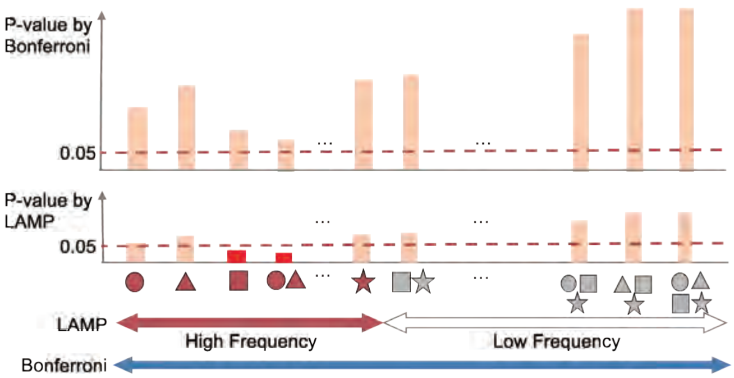

Comparison between LAMP and the existing method
Combinatorial factors shown in red are regarded as discovery.

Lifetime elongation of cells by fish antifreeze protein

Insulinoma cells can live for 5 days at 4 °C

We have developed a cell-preservation solution containing a macromolecule named antifreeze protein (AFP), which uniquely interacts with the membrane of a cell to prolong its lifetime. Even after 5-day hypothermic exposure at 4 °C, the survival rate of approximately 60 % was obtained for rat insulinoma cells (RIN-5F) stocked in a solution containing a flounder-derived type I AFP (AFPI). The 5-day preserved cells retained the ability to secrete insulin. In contrast, the survival rate of RIN-5F cells became zero in a solution without AFP after 3-day hypothermic preservation. We also developed a simple method of purifying massive amounts of the fish AFP, which utilizes the muscle homogenates of the mid-latitude fish as the source material. These results enable us to practically use the fish AFP for the short-term quality storage of the insulinoma cells collected from a donor without freezing. This will lead to an improvement of the success rate of diabetes mellitus treatment.

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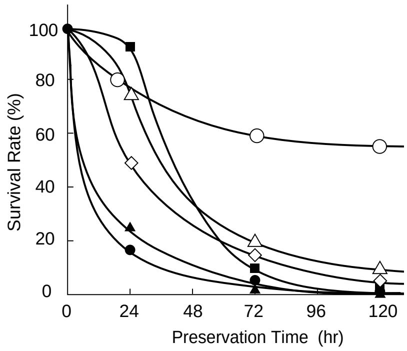
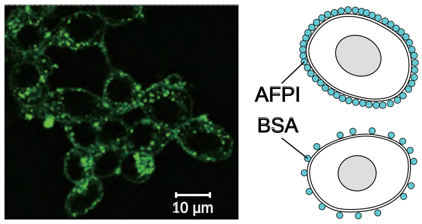


Time-dependence of the survival rate of rat insulinoma (RIN-5F) cells
The cells were dissolved in Euro-Collins solution (●) as well as that containing AFPI (○), AFPII (△), AFGP (◇), treharose (■), and bovine serum albumin (▲).



Photomicroscope observation of insulinoma (RIN-5F) cells
left: Confocal laser microscope image of the cells, whose membranes are brightened with fluorescent AFPI
right: AFPI can adsorb onto the whole membrane, while bovine serum albumin cannot.

Software development kit ‘SCCToolKit’ for medical applications

For quick transition of IT seeds to clinical applications

SCCToolKit is a software development kit to help build medical IT applications such as image processing of endoscope. Small Computings for Clinicals (SCC) is an activity to promote innovative technology and ideas into clinical research for proof of concept.

Main features of SCCToolKit are 1) support of HDTV video capture device, 2) fast image processing, 3) design guideline prohibiting use of keyboard and mouse. Typical applications of SCCToolKit include image fusion of echography and endoscope, and self-learning systems for surgical operations.

We verified that endoscopic applications built on a PC with SCCToolKit could perform as fast as commercial systems built upon custom hardware. We will collaborate with small businesses to assist their entry into medical application market.

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AIST TODAY Vol.14 No.3 p.16 (2014)

Typical system configuration using SCCToolKit

Highly-efficient voltage control of magnetic anisotropy

Development of a fundamental technology for voltage-driven spintronic devices

We have developed a highly-efficient voltage control of magnetic anisotropy in an ultrathin 3*d* transition ferromagnetic metal layer. In spintronics, current-induced magnetic field or spin-polarized current have been used to manipulate the magnetization. However, these current-based manipulations have a fundamental problem of Ohmic dissipation, which causes the high power consumption of devices. Voltage control of magnetic anisotropy in an ultrathin ferromagnetic metal layer is currently of high interest as the ultimate technology for the ultralow-power spin manipulation. In this study, three times larger effect of magnetic anisotropy energy change was achieved in a newly developed MgO double barrier structure compared with a conventional single barrier structure. Our findings will lead to the realization of voltage-driven spintronic devices with ultralow stand-by and operating power.

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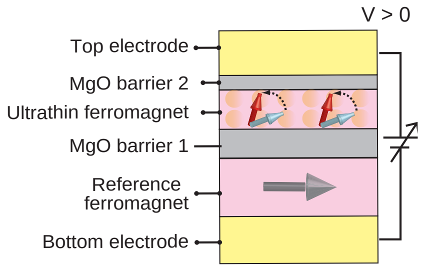
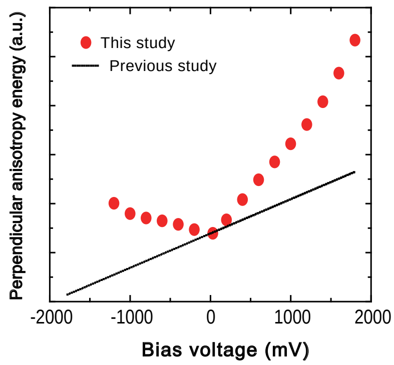


Schematic of the voltage-driven spintronic device with double barrier structure
Arrows represent magnetization directions.



Experimetal results of the voltage-induced perpendicular magnetic anisotropy change

Simulation technology for microdroplet shapes on substrates

Rapid, precise, and easy simulation of microdroplet shapes on hydrophilic/hydrophobic patterned surfaces

We have developed efficient software, named "HyDro," for simulating equilibrium shapes of microdroplets placed on flat substrates that have fine, discontinuous, and arbitrarily shaped hydrophilic/hydrophobic patterned surfaces. HyDro uses a hybrid energy-minimization technique that combines a direct search method to determine the droplet shape around solid/liquid contact lines with a gradient descent method for the other parts of the droplet surface. The software provides high-convergence at a low computational cost with sufficient mesh resolution. We demonstrated that the simulation using HyDro can accurately reproduce observed equilibrium microdroplet shapes on hydrophilic/hydrophobic patterned surfaces deposited by an inkjet printing technique. HyDro provides a useful tool for the optimal design of printed electronic devices. It is also possible to evaluate the surface-energy distribution within the hydrophilic region based on the comparison between observation and simulation. The program can be executed on a commercial personal computer, and is now available for free via a web page.

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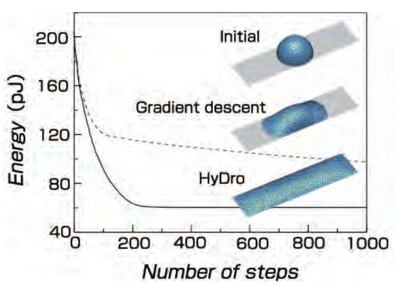
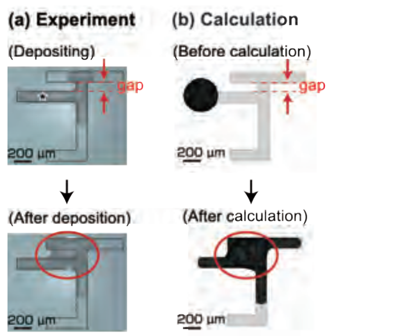


Solution convergence of HyDro and a conventional method for simulating the microdroplet shape placed on a hydrophilic/hydrophobic patterned surface



Observed microdroplet on a wiring pattern deposited by an inkjet printing technique (left) and a simulated result (right)

Drastic improvement in thermal stability of transparent oil-repellent coating

Surface treatment without the use of fluorinated organic compounds

A thermally stable/durable, transparent water/oil repellent coating composed of polymethylsilsesquioxane (PMSQ) was successfully fabricated through a simple sol-gel reaction of methyltriethoxysilane. SEM and AFM confirmed that the resulting coating was smooth (R_{rms} < 0.3 nm). This PMSQ surface showed statically hydrophobic (θ_S= ca. 85°) and oleophilic (θ_S= ca. 35°) properties, but unusually had excellent dynamic dewettability. Small volumes of probe liquids such as water and *n*-hexadecane can be easily set in motion to move across the surface when the substrate tilt angle is ~10° at room temperature. Thanks to thermally stable Si-CH_3 bonds, this excellent water/oil repellency remained even after the thermal treatment up to 350 °C for 24 h in air, which exceeds decomposition temperature of conventional perfluorinated surfaces.

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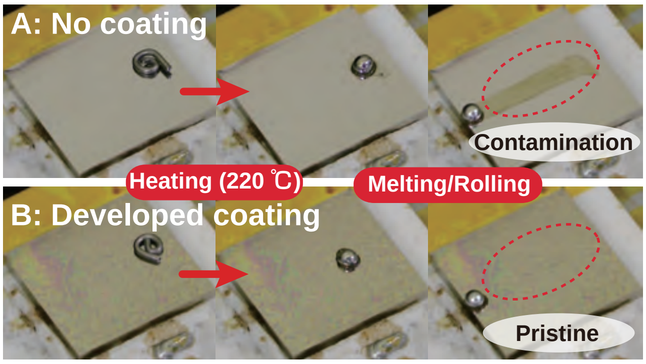

Appearances of rosin core solder on stainless steel plates at 220 °C (plate tilt angle: 5°)
(A) Uncoated stainless steel plate, (B) coated stainless steel plate

Die molded rubber with nanometer-level precision

Arbitrary shapes can be formed on rubber surfaces through the addition of carbon nanotubes

We have developed a technique to allow die molding of a rubber surface with the precision of a few hundred nanometers by adding single walled carbon nanotubes (SWNTs) into the rubber matrix. The die molding processing is superior in productivity and suitable for continuous manufacture and mass production. With the current technology, high precision (nanometer-level) die molding of a rubber surface is difficult. However, we found that a SWNT network structure is formed when long SWNTs are mixed with rubber, and this rubber exhibits high precision surface formability while maintaining its elasticity. Since the network structure of SWNTs is flexible and stretchable like fabric, the elasticity of rubber can be retained even with the addition of SWNTs. Furthermore, the addition of SWNTs allows the rubber to hold arbitrary surface shapes due to reduced mechanical creep properties. This technique is expected to be applied to the development of high functionality rubbers with specifically designed properties, such as wettability, optical, and adhesion, through surface engineering.

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Nanotube Research Center

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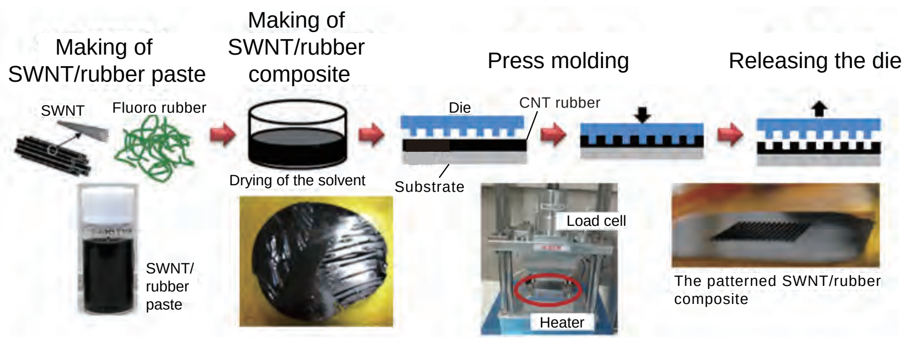
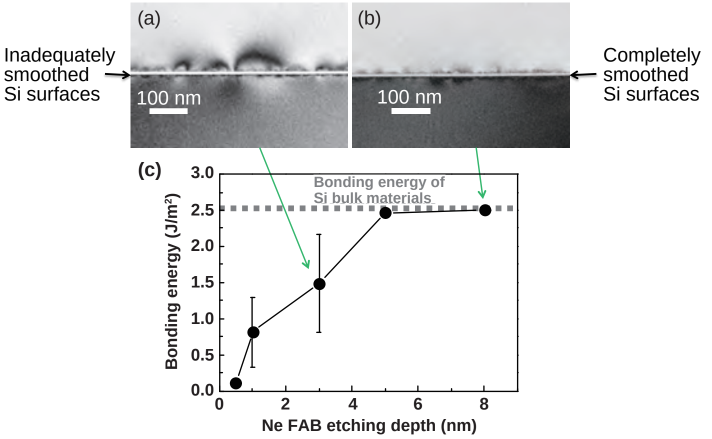


Flow of the manufacturing processes of the SWNT/rubber composite and die molding processing

Surface smoothing process for room temperature wafer bonding

Reduction of local strain at the bonded interface

We found improvement of the bonding strength by surface smoothing effect of the Ne fast atom beam (FAB). Silicon surface roughness decreases from 0.40 to 0.17 nm rms by applying a Ne FAB of 30 nm etching depth. We applied smoothed Si surfaces to surface-activated room-temperature bonding. Without Ne FAB smoothing, bonding between rough Si surfaces cannot be achieved, whereas the bonding energies increase with etching depth up to 5 nm. With Ne FAB smoothing of etching depths over 5 nm, a bonding energy equivalent to that of the bulk materials was finally attained. Local strain at the bonded interface between the rough surfaces was dramatically decreased with the Ne FAB smoothing.



(a)-(b) TEM images of the bonding interface between Si surfaces
(c) Dependence of the bonding energy on the etching depth of the Ne FAB irradiation after Xe FAB roughening

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Unraveling a key of high-performance of diamond devices

An important role of atomic-scale structure at diamond surfaces

We have developed a theoretical model that predicts field-emission efficiency of chemically modified diamond surfaces. It was well known that the field-emission efficiency of a hydrogen (H) terminated surface with negative electron affinity (NEA) is higher than that of a clean surface with positive electron affinity (PEA). Thus the polarity of the affinity was believed to govern the emission efficiency, but this is NOT always the case for chemically modified diamond surfaces. We have performed first-principles simulation to monitor electron dynamics under an applied field and compared the emission efficiencies of several chemically-modified diamond surfaces. Co-termination with H atoms and hydroxyl groups (OH) achieves the NEA of the diamond surface, however, our simulation shows lower emission efficiency of this surface compared to the clean surface. It was found that, in addition to the affinity, the detailed profile of potential for electrons along the way from diamond bulk to vacuum through the surface plays a crucial role in determining the performance.

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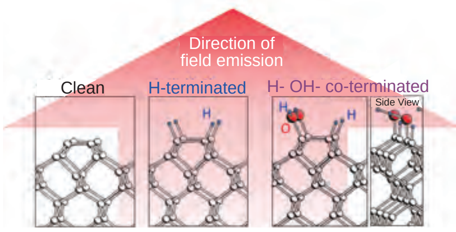
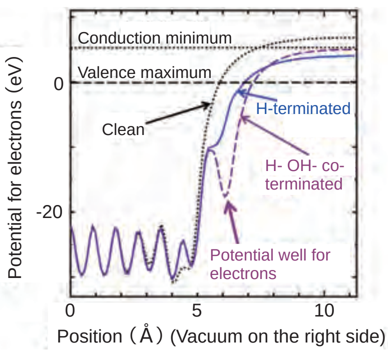
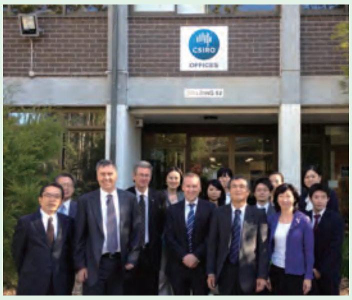


Surface structures of chemically modified diamond surface considered in the simulation



Potential profile for electrons on several surfaces

Workshop with Australia's CSIRO on Innovation Promotion



Dr. Seto (front row, far left), Dr. Roy (next to Dr. Seto), Dr. Miyazaki (3rd from right)

A joint workshop on innovation promotion was held between AIST and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) at CSIRO's North Ryde site, Sydney on November 4, 2013. The delegation from AIST led by Dr. Masahiro Seto (Vice-President) and Dr. Yoshinori Miyazaki (Director, International Affairs Division) included 6 administrative staff members from the Innovation Promotion Headquarters and the Public Relations Department. Participants from CSIRO included Dr. Craig Roy (Deputy Chief Executive) and personnel from the Flagship and Public Relations Departments. As examples of research promotion by the respective institutions, CSIRO introduced its flagship program, while AIST gave an introduction of its Open Lab and the activities of its Innovation Coordinators. There was much discussion and exchange of opinions throughout the workshop. AIST and CSIRO are important international partners in the Asia-Pacific region. Further pursuit of cooperative relationship was affirmed during the workshop.

From November 5 to 12, young administrative staff members visited three CSIRO research centers in Sydney, Brisbane and Canberra respectively, and exchanged opinions on industry-academia-government collaboration, practical use of intellectual property, public relations, etc. Such interchange among administrative staff members was a new approach for AIST. Ways of management for research promotion were presented by the responsible persons from each institution and the issues faced by each institute were discussed.

Through this interchange, the common issues relative to research management were shared by the administrative members of the two institutes, whose organizational structure and size are comparable to one another. We will continue to collaborate not only in the various research fields, but also in actively exchanging information on research management.

AIST Innovation Workshop in Indonesia


President Chubachi making the opening speech

The AIST Innovation Workshop in Indonesia was held in Jakarta, Indonesia on December 20, 2013. There were around 200 participants in total, including 20 AIST researchers led by Dr. Ryoji Chubachi (President), Dr. Masahiro Seto (Vice-President), and Dr. Eikichi Tsukuda (Vice-President), as well as representatives from locally based Japanese companies, and persons representing Indonesian research institutes and companies.

Beginning with the AIST Innovation Workshop in Thailand held the previous year, AIST intends to conduct similar workshops abroad in order to strengthen collaborative relations with the world's leading public research institutes, and further, to include companies in such collaborative relations. The theme for this second Innovation Workshop was renewable energy.

Following the opening remarks by Dr. Chubachi, and greetings by Dr. Marzan A. Iskandar, Chairman of the Agency for the Assessment and Application of Technology (BPPT), Dr. Lukman Hakim, Chairman of Lembaga Ilmu Pengetahuan Indonesia (LIPI), and Dr. R. Sukhyar, Head of The Geological Agency of Ministry for Energy and Mineral Resources, Indonesia (GAI), keynote lectures on innovation promotion were given by AIST and BPPT. These were succeeded by case-study presentations by researchers from AIST, Indonesia, and locally based Japanese companies on photovoltaic power generation, geothermal utilization, wind energy, and biofuels; areas in which there have been much collaborative research activities between the two countries. Throughout the workshop, there was much discussion and exchange of opinions.

Collaborative work for improving the productivity of natural rubber, measurement science, geothermal utility, etc. has been conducted thus far among AIST, BPPT, LIPI, and GAI. Taking this workshop as an opportunity, further strengthening of collaborative relations and the creation of collaborative partnerships in new areas of research may be expected.

AIST also participated in the "Indonesia Japan Expo 2013" held in the adjoining venue. There were 60,000 persons who attended the Expo, in which the scientific activities of AIST and collaboration with Indonesian organizations were exhibited.

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