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Science in Society, for Society

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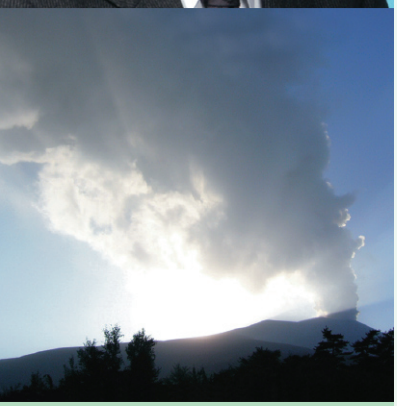
MESSAGE

Toward the Second Research Phase



FEATURE

Volcanic Eruptions and the Blessings from the Earth

Volcanic Research to Reduce Disasters and Make the Most of the Blessings of Volcanoes

Research Hot Line

UPDATE FROM THE CUTTING EDGE (Jan.-Mar. 2005)

In Brief

Toward the Second Research Phase

1 Full Research

Let's look back to the organizational principle underlying AIST. "Organizations are possible only when you have people." Independent researchers gather at their own initiative around unit heads, who are independent thinkers, thereby forming a research unit. Even though the unit has taken shape in an autonomous way, it demonstrates an organizational principle unique to AIST. Specifically, one research unit has three different types of researchers—those engaged in Type-I basic research, those performing Type-II basic research, and those involved in product realization research—and these researchers collaborate coherently and concurrently in their research pursuits. We refer to this organizational principle as Full Research. Backed by this principle, each of our units has demonstrated fluid progress in their research endeavors. That research has shown steady gains not only in formal quantitative accomplishments, but also in quality, whether measured in terms of ingenuity or in contributions to industry.

Suffice it to say that Full Research has taken root at AIST. Of course, depending on the research unit, that may at times be only partially the case. This is particularly true for the Research Center, which faces project deadlines. However, from a long-term perspective, this is not really an exception to the rule because individual units can be understood to be making progress on their own, discrete elements of a larger undertaking in Full Research. Individual units at AIST are each engaged in their own ventures in Full Research. However, in terms of working together toward the achievement of a single research goal as pursued on an institute-wide scale, their efforts taken together form the structure of Full Research at AIST on the whole. The primary goal of that Full Research is to generate technologies essential to a shift by Japanese domestic industry to assume the leading role in the creation of sustainable societies on this planet.

Many topics were covered by the some 50 workshops held to date on themes relating to Full Research. Those workshops were spread across four series: Type-II basic research, the products of Full Research, Type-I basic research for Full Research, and strategies for Full Research. At each of those venues, young researchers, research unit heads, vice-presidents, and many staff from the administrative sector had opportunities to freely present their views and opinions. Given that its activities span such a broad range of research fields, AIST was, as to be expected, initially concerned about the communication problems participants might face. However, as the series of workshops proceeded, the seeds of discourse and dialogue rapidly took root, and from that point forward, researchers in different fields acquired the common language they needed to share in AIST's objectives. This "language" has become an invaluable asset to AIST.

2 Research Coordinators

Currently, AIST has 10 research coordinators who either individually or in pairs handle one of seven different research fields: life science and technology; information technology; environment and energy; nanotechnology, materials, and manufacturing; social infrastructure (geology) and marine science; social infrastructure (standards); and computer science. Research coordinators typically possess a wealth of research experience and solid track records of accomplishment as well as a comprehensive perspective that extends beyond their own field of expertise. As indicated earlier, on an organization-wide basis, individual projects at AIST add up to undertakings in Full Research. Independent research units are one of the fundamental characteristics of AIST. As such, they tend to be an assemblage of research teams driven by disparate goals. It follows that special efforts in coordination are necessary to ensure that all research units are integrated into Full Research toward a single, overriding goal. The greater the level of autonomy that individual research units possess, the more difficult integration of this kind is likely to be. Nonetheless, research coordinators at AIST are successful in carrying through with this exceptionally

Four years have elapsed since the inauguration of the National Institute of Advanced Industrial Science and Technology (AIST). AIST has just completed its first research phase and is preparing to enter the second. We have learned many things in the past four years. The second phase will bring new challenges while allowing us to translate the results of our learning into action. Let's consider what the future holds in store. This outlook is guided by a tenet of the AIST Charter: "Science in Society, for Society."

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

difficult task of structuring Full Research together at AIST without impeding the autonomy of its individual research units in any way.

The work of individual research coordinators entails preparing research strategies, budget allocation plans, and researcher employment plans for the fields under their supervision, through dialogue with the research units affected. The research coordinators' conferences strive for integration aimed at structuring together unit-level research operations into Full Research undertakings at the institute level. At the same time, through research reviews, they provide individual research units with feedback that conveys the goal of Full Research institute-wide. This involves much more than just management and communications. It is a process that continually provides researchers in a given field with guideposts for the pursuit of specialized research. To that end, coordinators develop insights not only into the latest cutting-edge research developments, but also into developments are likely to be made soon; predict the impact those themes may have on research in general and on industry; and put together a scientifically persuasive research roadmap that is based on their insights and predictions. And the resulting accomplishments of this specialized research are utilized at AIST for the formation of innovative theories relevant to the research field. On the whole, these approaches should be evident from AIST's recently completed research strategy.

The coordinators' conferences have also been announcing interesting results, including the fusion of nanotechnology with biotechnology, and the proposal of new industries through collaboration between the fields of measurement and standards technology and other fields. These conference results do not just impact research, but also are generating mechanisms for developing researchers equipped with entirely new specialties. Through the amalgamation of an even broader spectrum of research fields, the seeds for "AIST-industry-academia projects" are being borne.

3 An Innovation Hub

As discussed in the preceding section, research coordination has the benefit of carrying individual research unit coherency and concurrency to an institute-wide level. This benefit, however, can also be expected to extend beyond AIST's confines.

The Science and Technology Basic Law of 1995 as well as the subsequent Science and Technology Basic Plan include provisions that strongly advocate cooperation between industry and academia. This is a global trend, as underscored by the "Science in Society and Science for Society" segment of the Declaration on Science and the Use of Scientific Knowledge issued at the 1999 World Conference on Science (in Budapest). Various events have been held in Japan, including Business-Academia Collaboration Summits. Cooperation between industry and academia has become an important goal, together with the incorporation of Japan's national universities. That is because close cooperation by academia and the business community is understood to be a realistic and effective way of returning public funds invested in basic research under the Science and Technology Basic Law back to society and individual citizens. However, this is not to imply we have a clear understanding of the forms of business-academia cooperation that are best suited to this goal, or how best to realize the cooperation.

According to FY 2002 data, research expenditures, including personnel costs, totaled 16.7 trillion yen that year. Of that total, 3.5 trillion yen was supplied by the government, mostly through funding allocated to universities and public research institutions. The rest, or 13.2 trillion yen, came from the private sector, and almost all of that was utilized by private institutions. These flows of research funds do not intersect. Except for research funding programs that have been set up exclusively to finance extremely short-term undertakings in joint research, there is no incentive for business-academia cooperation in the research domain. Overcoming this impasse will demand the introduction of a public research funding framework that encourages collaboration by the business community and academic sector (similar to the Intelligent Manufacturing System (IMS) international joint research set up by the Ministry of Economy, Trade, and Industry). In addition, though, it will be necessary to devise mechanisms that guarantee that cooperation brings beneficial results. To this end, AIST has begun work on the following structures.

The structures are designed to spread Full Research beyond the confines of AIST. Full Research comprises the coherent and concurrent pursuit of three different types of research—Type-I basic research, Type-II basic research, and product realization research—by a single research unit, thereby leading to the formation of a process in which the achievements of basic research generate social value. An individual research unit needs to comprise at least several dozen researchers for this process to be implemented in complete form. At AIST, this is feasible because each research unit employs 52 (full-time) researchers on average. However, the situation at universities is different. Based on available statistics, Japan has a total of about 54,000 working professors. Including doctoral students, the number of researchers under a university professor's supervision averages about five. This accordingly suggests that to engage in Full Research undertakings, a university would have to create a special provisional organization for the purpose. That organization, moreover, would have to allow its member researchers to collaborate in a coherent and concurrent fashion; functioning purely for liaison purposes would be useless.

Within the university setting, organizations are usually created with an educational focus. For example, university departments are composed of professors with different research interests within a given academic field who join together to offer students a balanced curriculum. Accordingly, the professors who come together to form the faculty of a department have created an organization for the ultimate purpose of providing education; research is led by individual professors and cooperation with other professors in that research is not always possible. For this reason, research led by faculty members within the university setting is usually conducted for the purpose of receiving acclaim from academic societies in the same field. And in most cases, it is limited almost entirely to Type-I basic research. Generally speaking, universities may be described as organizations ideally suited for undertakings in Type-I basic research. In terms of fostering academic progress, this form of organization does not present any inconsistencies. Still, universities run into trouble when they seek social value for research accomplishments in keeping with the mission of a particular academic field. Engineering is a classic example.

When striving to create social value with the fruits of basic research, research papers written in the interest of earning acclaim from academic societies typically fall short. In our experience, this goal usually requires that Type-II basic research or product realization research also be performed. However, if that is not possible within the confines of the university, researchers then have the option of utilizing the intellectual property of their research accomplishments for joint research with private companies, or licensing it, or launching independent ventures of their own. That is certainly something to be encouraged. Nonetheless, the more original and novel the results of Type-I basic research, the more indispensable basic research in other areas—namely, Type-II basic research

or product realization research—will be to the task of assigning those results real value. Furthermore, achieving balance with Type-I basic research will be a difficult undertaking for small groups of researchers. This reality has become an obstacle for many universities even in the U.S., a country known to be a world leader in promoting collaboration between business and academia. If university professors were to pour their resources too heavily into cooperation with industry or into their own private ventures while remaining members of a small-scale university research organization, they could risk compromising their educational obligations or their own highly original Type-I basic research within the university setting. It has been reported that the trend now is toward placing restrictions on such sideline ventures.

As a way to help avert difficulties of this nature, AIST is planning to open up Full Research to the outside. In effect, this will be collaboration between universities and AIST. People engaged in Type-I basic research in a university setting would engage in joint research with researchers pursuing Type-I basic research at AIST. That approach would lead naturally to a fusion with AIST-led Type-II basic research and product realization research. Private industry would then be the next step. From the university perspective, this approach would provide a bridge to collaboration with private business and help lower the costs associated with such collaboration. Although these costs would be essential to drawing corporate expectations and obtaining information for engineering research, they must be kept within reasonable limits. Furthermore, in their effort to lower these costs, if universities prove too eager to satisfy corporate expectations, they may lose sight of their fundamental research goals and compromise the originality and novelty of their research. Conversely, from AIST's perspective, cooperation is possible as long as the university is engaged in Type-I basic research on common themes.

And, needless to say, for the collaborative bridges to be worthwhile from the university perspective, Full Research at AIST must lead appropriately to industrial applications or benefits for society at large. That is the fundamental goal of Full Research and although I will not elaborate here, let me underscore the connections. Through Type-II basic research or product realization research, Full research by individual research units leads to connections with society in the broad sense, that is, through the products of research that each research unit shares with society. However, when collaboration is with private business in the narrower sense, practical approaches range from joint research and consigned research to licensing agreements, personnel transfers, personnel exchange, and the startup of venture companies. To facilitate these forms of collaboration, it is imperative that AIST, as a public institution that conducts mainly publicly funded research, have a transparent relationship with cooperating companies, which, as private institutions, are driven by the profit motive. For example, in joint research undertakings, relationships between research progress and injections of public research funding must be clearly defined. Also, problems will arise in determining the extent of public funding that can be provided for the launch of high-tech startups that will capitalize on the fruits of publicly funded research. These issues are difficult to quantify. However, to frame it in simpler terms, as noted earlier, the greater the originality or novelty of the accomplishments of Type-I basic research, and consequently, the stronger the impact those accomplishments are expected to have on private industry, the less likely collaboration will be. Heavy and sustained injections of public funding will conceivably still be necessary after the results of Type-I basic research have been obtained. In the case of high-tech startups, the accomplishments of basic research will presumably be at too basic a level to translate into anything worthwhile. However, if those accomplishments are considered to have value in facilitating a shift of industrial infrastructure toward sustainable industrial pursuits, sharing them with corporations would conceivably be meaningful as a way for a public institution to support startup ventures. Further, experience with that process would presumably provide knowledge of ways to convert the accomplishments of basic research into actual value. Accomplishments that can be expected to translate easily into successful venture startups need not have support from public institutions.

In this way, universities, AIST, and private industry could establish clear relationships with one another. In fact, AIST has already established cooperative relationships and begun cooperating with several universities on the basis of these concepts. Additionally, it has already entered into collaborative ventures with private corporations based on a variety of models, including comprehensive agreements with large companies, theme-specific agreements with smaller companies, and institute-wide plans for the promotion of high-tech startups. The AIST-industry-academia project I

touched on earlier constitutes a crucial trial undertaking aimed at integrating these approaches into one.

AIST is now in the process of drafting plans for the nationwide creation of suitable schemes for collaboration with universities and private industry through a synthesis of these varied tie-up formats. Given that other public research institutions in addition to AIST are likely to possess comparable research frameworks, these models could conceivably be explored for purposes other than research on industrial technologies. As a device for facilitating the generation of social value from basic scientific research, this would constitute a network model for innovations that evolve into new Japanese inventions—in other words, a network of excellence. AIST is committed to serving as a "hub of innovation" within that network.

4 The Separation of Power

In the previous sections, I stated that we have already embarked on a path toward building a uniquely Japanese network for collaboration with universities and private industry by having our research coordinators extend Full Research to the institute-wide level, and from there, to the national level, while retaining independent research units as our foundation. That is the path AIST has explored and set for itself by applying its strengths in full. However, in the process, AIST has learned about something else: namely, problems associated with the methodologies for research institution management and operation.

Although it has been four years since its inauguration, AIST is still a young organization. Furthermore, given that it is one of the first independent administrative institutions of its kind—an organizational structure with which Japan does not yet have much experience—AIST still has some time to go before it can be described as mature. The management approach for independent administrative institutions involves the assignment of initial goals set by administrative organs to the institution and the achievement of the goals by the institution primarily with public funding, albeit with a certain degree of autonomy in operation. The institution is then evaluated for its performance, and is assigned new goals depending on the outcome of that evaluation. However, many hitherto unknown problems confronted this management approach. We are learning much as we solve those issues.

The management of AIST has focused on research autonomy which is fundamental to research institutions: in other words, the autonomy of its research units. However, responsibility for achieving the mission assigned AIST by national government institutions, that is, the execution of assigned objectives, is guaranteed by giving the president the power to alter or eliminate research units. In fact, over the past four years, many research units have been created, reorganized, or disbanded as AIST has pursued its research strategy. AIST has learned about the methods used for those purposes, and is in the process of codifying them. During this period, each research unit demonstrated major strides in the arena of Full Research. And in the process, AIST gradually put into tangible form the management and operation practices it has adopted for its research units. Those practices cover everything from hiring, personnel management, evaluations, and budget allocations to collaboration with other sectors, information gathering and dissemination, international cooperation, and intellectual property management. To date, AIST has continued with efforts to improve the environment for research by devoting consideration to numerous internal rules and regulations aimed at supporting research efforts. They had to do chiefly with the diversification of hiring methods; the design of career paths; the evaluation of research units and individual researchers, and the use of evaluation findings for management purposes; budget allocation formulas; intellectual property strategy; and procedures for the establishment of new ventures. It can be concluded that those efforts have helped AIST assume its proper "shape" as a research institute that is an independent administrative institution and design itself as a forum for research. Organizational design and operation are matters subject to the optimization- and efficiency-oriented goals that are assigned to independent administrative institutions. This, too, is something that AIST has continued to pursue day in and day out thanks to its officers' strong awareness of AIST as a pioneering independent administrative institution. It is urgent that lessons learned in these areas be shared and quickly utilized. Although I do not have space to discuss each and every one here, I will consider presenting them for institute-wide discussion and debate at the earliest convenience. Here, a general overview will have to suffice.

Here it is my intention to discuss matters relating to the structure and sharing of fundamental operational roles involved in the performance of work, and to the clarification of the powers and responsibilities associated with the sharing of those roles, all of which are common for management and operation practices aimed at supporting research bearing the diverse content described above. Every job incorporates the following elements: the presentation of problems, analysis of the problems, drafting of plans of action, deliberation, enactment, enforcement, evaluation, revisions, and so on. The first requirement is that the structures formed by these elements become an essential loop for functional evolution. Looking back over the past four years and the revisions that were made each year to arrangements that had been established the year before for many research fields, it seems reasonable to conclude that this loop has operated properly. The formula employed

for budget allocations is a classic example, and was something that researchers tended to view as ambiguous. However, conditions have begun to settle down and the organization at last seems to be exiting from the unsteady phase it experienced upon startup. Nonetheless, the loop I mentioned above has not always been visible, and this problem relates to matters I will discuss below.

A second requirement is the clear division of responsibilities and authority, but further study is needed here. In short, one may say the separation of power within the organization has not been clarified sufficiently. Although it may seem awkward to apply the concept of the separation of power, as taken from classic theories of the nation-state, to an institution with clear objectives like AIST, we are of the view that we are now being asked to deal with fundamental organizational theories that require precisely such concepts.

There is a fundamental relationship between formulation and enforcement. As noted earlier, AIST found it necessary over its first four years to draft numerous rules and regulations. These were then put into effect and enforced. In the process, though, there were concerns that the bounds of authority and responsibility dividing formulators, enactors, and enforcers had not been clearly defined. As a consequence, there were cases where work concentrated on certain sections, people knew not where to turn when they faced problems during implementation, and certain departments were at times subjected to undue criticism. Although all of these problems were resolved thanks to the diligent efforts of the responsible personnel, it cannot be denied that efficiency suffered in the meantime.

To better portray the parties concerned here in their traditional form, suffice it to say the Planning Headquarters was responsible for formulation, the Board of Directors (Executive Committee) for enactment, and the various vice-presidents for enforcement. Although the president should bear general responsibility for the institute, the powers and responsibilities of formulation, enactment, and enforcement should clearly revert to the three groupings mentioned above. Furthermore, it should go without saying that clarifying where authority and responsibility lie effectively encourages mutual dialogue by the holders of authority. Another aspect of the separation of power is evaluations and audits, which Montesquieu would have termed as judicial power. Currently within AIST, the independence of these duties is being cultivated.

Idealistic arguments aside, the prime objectives of management and operation are to establish a climate that facilitates the implementation of research which is our ultimate objective and to strive to do this in an efficient way. AIST has endeavored enormously to that end over the past four years. And, it has amassed a track record of accomplishment and learned its lessons sufficiently in the process. By doing its best to systematize and apply these, it is anticipated that AIST will move a step closer toward the attainment of its goals.

5 Concluding Remarks

The recently enacted AIST Charter, "Science in Society, for Society," was prepared by the Drafting Committee which is composed of 10 young researchers headed by Reiko Azumi as Chairperson. This Charter has earned the overwhelming support of all AIST personnel, including senior researchers, and has even emotionally moved many of those who read it. Although that is directly attributable to the excellence of the Charter's content and written style at the hands of the Drafting Committee's young members, it is not the only reason. Indeed, it is my feeling that the Charter stands on the one hand as a declaration toward the future, and on the other, as an emotionally moving statement that succeeds in expressing with brevity the hardships shared by all who have led independent administrative institutions over the past four years. Today, we all stand on the threshold of a future that the second research phase will bring, having together shared in the lessons of those last four years. Further, as expressed in the AIST Charter, we can declare with confidence that AIST will adequately satisfy the commitments it has been assigned in Japan, which is moving forward with a Science and Technology Basic Plan in accordance with provisions of the Science and Technology Basic Law.

Japanese society, including Japanese industry, clearly has an instrumental role to fulfill in creating a sustainable society, now a challenge for all humankind. Elaborating on the scale and quality of this role will demand the creation of "products for society" that are derived from fresh scientific knowledge. And to that end, AIST is determined to move forward, into tomorrow.

Volcanic Research to Reduce Disasters and Make the Most of the Blessings of Volcanoes

Eikichi TSUKUDA Research Coordinator (Geological Survey and Applied Geoscience)
Masahiro AOKI Director of Geological Museum

A Nation of Volcanoes

There are many volcanoes on the Japanese archipelago, where approximately 10% of the world's on-land volcanoes are said to exist. The crust of the earth is covered with more than 10 gigantic rock plates. Slight movements of these plates are thought to cause a variety of disasters, including earthquakes and volcanic activities.

The subduction of the Pacific plate to the east or the Philippine Sea plate to the south under the Eurasian plate on the west side (the continent side) is the basic cause of active volcanic activities around the Japanese archipelago.

Volcanic Research by AIST

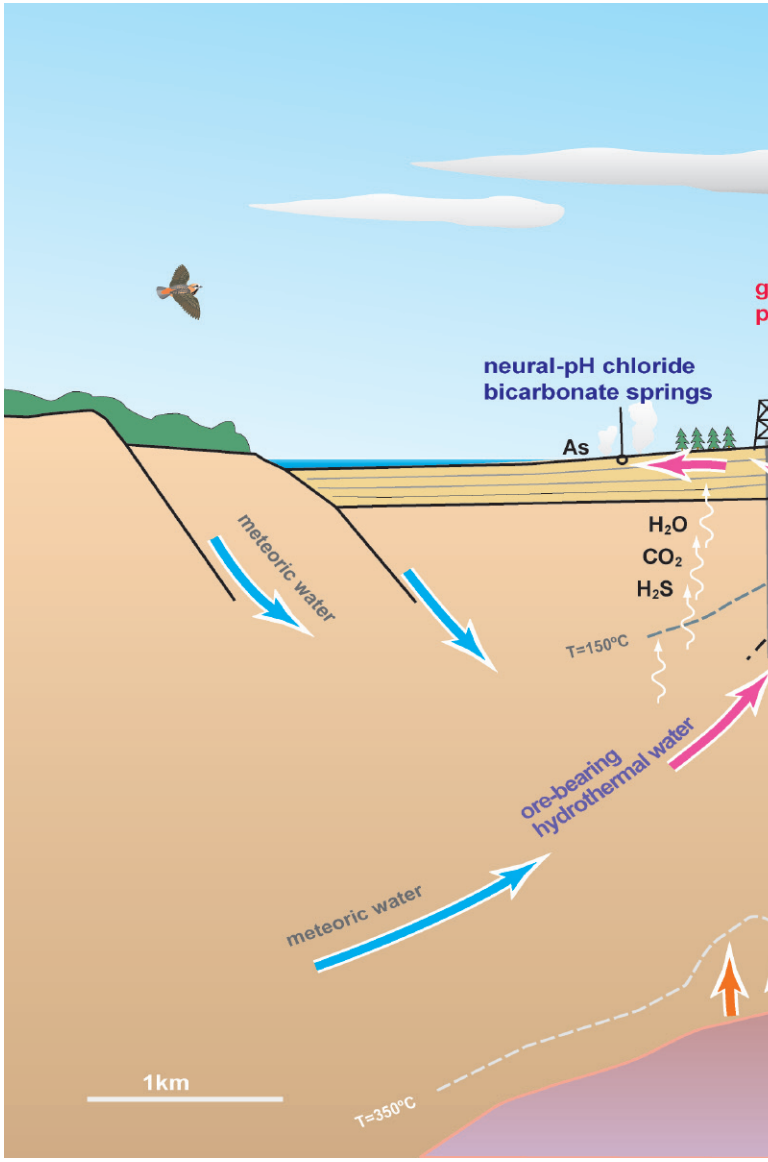
AIST's Geo Information Research branch, Institute of Geology and Geoinformation and Institute for Geo-Resorces and Environment, and Research Center for Deep Geological Environments are using their own approaches to independently conduct broad volcanic research ranging from research aimed at reducing disasters due to volcanic eruptions to research of geothermal heat resources and mineral resources that are the blessings of volcanic activities. Most of the research is aimed at seeking profound scientific understanding and is based on years of consistent surveys and observational studies. We are expected to offer scientific information necessary for disaster prevention measures and exploitation of volcanoes. In this special editiont, we will introduce you to the front line of volcanic research by AIST.

Disaster Prevention Measures Start From Understanding Volcanoes

In Japan, serious disasters sometimes occur due to powerful volcanic activities. Eruptions of Mt. Usu in Hokkaido and of the volcano on the Izu Island of Miyake in 2000 are still fresh in our memory. It is necessary to always understand the way nature works to protect our lives and properties from the threat of nature and to prevent disasters.

Although volcanic activities themselves are natural phenomena, they cause disasters and damage both human life and industrial activities. The first step in developing disaster prevention measures starts from fully understanding volcanoes. It is then necessary for individuals, communities, governing bodies, and nations to take measures from each respective standpoint.

We are conducting research activities to provide the most basic information with the aim of improving reliability.

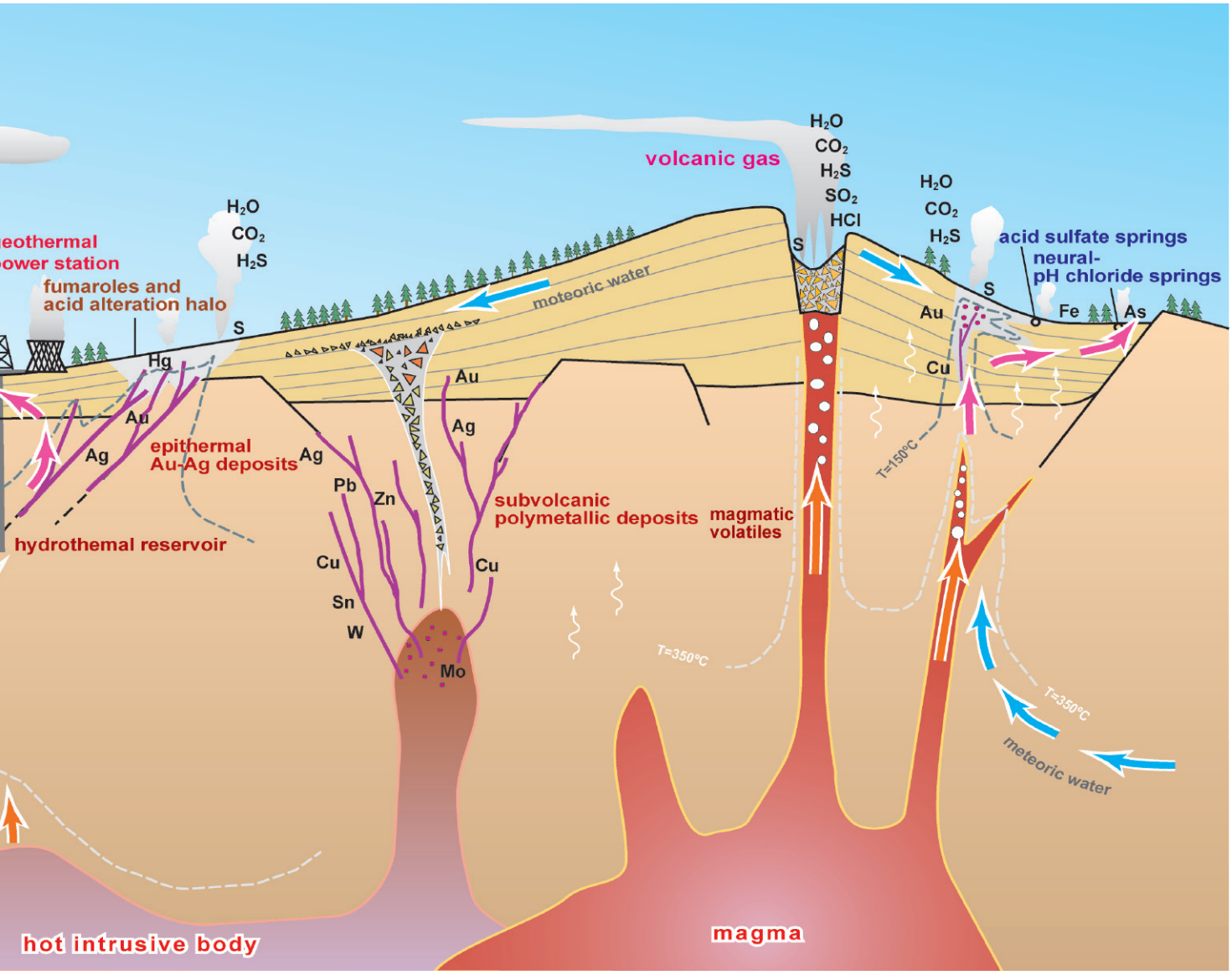


Understand Volcanoes Better

Many people live around volcanoes in Japan and also visit volcanoes for their beautiful natural environment, hot springs, and sightseeing. However, these people do not necessarily understand volcanoes well. We sincerely hope that people will deepen their understanding toward the actual conditions of volcanoes, take measures to minimize damage, and live a rich and peaceful life while enjoying the daily blessings of volcanoes. We are hoping to contribute toward that end through our research.

The AIST series Challenge Volcanic Eruptions (edited by the Geological Survey of Japan) focusing on research

The Mt.Asama eruption 2004
Image by Dr. Kohei Kazahaya, GSJ



to reduce damage from volcanic eruptions is published by Maruzen. It may help you deepen your understanding.

At the Geological Museum in the AIST Tsukuba center, the state of the earth and the mechanisms of its change are introduced in a simple way using plenty of geological specimens, three-dimensional models, and images. Above all, we are trying to introduce a variety of geological phenomena from many viewpoints, such as volcanic eruptions and hot spring phenomena caused by magma rising to the earth's surface. Volcanoes let us feel the "living earth" and they greatly excite our curiosity. While volcanoes bring life threatening eruptions and landslide disasters, they can also enrich our lives with hot springs and geothermal and mineral resources. Coexistence with volcanoes may be an eternal theme for those who live on the Japanese archipelago. Many interesting questions about volcanoes arise, including: Where do active volcanoes exist and what kind of eruptions did they cause in the past, for instance what damage could occur if Mt. Fuji erupts? How are volcanoes and hot springs associated? How can we extract the energy from the geothermal fluid existing under volcanic regions? In what kind of places are clay deposits and metal veins such as gold, silver, copper, and zinc formed? How can we find a vein?

Why not visit the Geological Museum and discover the answers to these fundamental questions?

Pursuing the Eruption: Emergency Survey on Miyake-jima

Institute of Geology and Geoinformation
Hiroshi SHINOHARA

Collection of Detailed Data in order to Learn about Volcanic Activities

There are 108 active volcanoes in Japan, which repeat eruptions. Even large-scale volcanic activities which require the evacuation of local residents occur every five years on average. Modern volcanic observation network has allowed us to almost certainly catch the signs of a large-scale eruption beforehand. However, currently it is difficult to predict the style and the duration of an eruption as well as the shift of volcanic activities beforehand.

Accurately grasping the state of volcanic activities and having a clear picture of the shift in activities is necessary in order to reduce the damage of an eruption. Therefore, the Coordinating Committee for Prediction of Volcanic Eruptions will collect detailed observational data and analyze volcanic activities at the brink of an eruption. AIST is conducting surveys on eruption products, volcanic gases and of ground deformation in cooperation with the Japan Meteorological Agency, Universities, and related research institutes. Cooperation from many researchers in various fields is necessary in order to conduct urgent and concentrated surveys and research when an eruption occurs. Thus, emergency observation task force team may be created temporarily, for example AIST set up the Emergency Countermeasure Headquarters, in which our vice chairman was assigned as the chief, and nearly 40 staff cooperated when the eruption occurred on Miyake-jima.

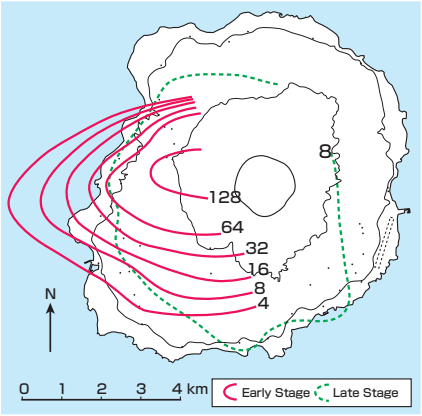


Figure 1 The distribution of volcanic ash released from the Miyake-jima volcano on August 18, 2000 (numbers refer to thickness in mm).

Indispensable Local Surveys

Volcanic activities on Miyake-jima which began in June, 2000 were large-scale ones said to have happened for the first time in 3000 years. All residents were forced to evacuate from the island due to possible eruptions followed by the release of a large amount of volcanic gases.

When an eruption occurs, the most important thing is to determine the characteristics of the eruption based on a local survey and predict subsequent volcanic activities. On Miyake-jima, a collapsed crater of 1.6 kilometers in diameter was formed on the summit of the volcano in July and August with repeated eruptions. During the eruptions, AIST researchers conducted surveys in the island covered with volcanic ash and studied the distribution and the amount as well as the form and the composition

Table Latest major volcanic eruptions and damage

2000 -	Miyake-jima	Collaped crater formation. Large amount of gas emission. Evacuation of all residents.
2000	Mt. Usu	The lava dome.
1990 - 1995	Mt. Unzen	Pyroclastic flows and debris-avalanches 43 death.
1986	Izu-Oshima	Lava flows. Evacuation of all residents.
1983	Miyake-jima	Lava flows. Villages were buried.

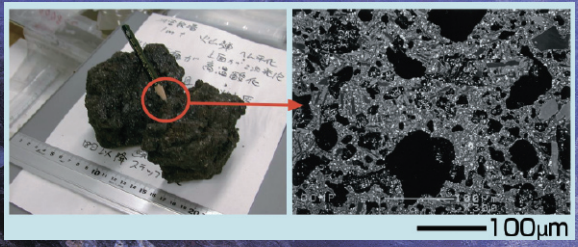


Figure 2 Volcanic bombs ejected from the Miyake-jima volcano on August 18, 2000 and their microscopic images.

Photo 1 The collapsed crater formed on the summit of the Miyake-jima volcano and volcanic gases being actively released.

of eruption products (volcanic ash and volcanic bombs) to determine the characteristics of the magma which caused the eruptions.

On Miyake-jima, large amounts of volcanic gases were continuously released after the formation of the collaped crater, a rare phenomenon globally. Residents of Miyake-jima are still in evacuation because these poisonous volcanic gases continue reach to residential areas.

AIST is continuously monitoring the emission and the composition of volcanic gases as well as other activities in cooperation with the Japan Metrological Agency and Universities, since precise understanding of volcanic activities is the key to judge the risk of an eruption and volcanic gases. An urgent and detailed survey of an eruption is not only necessary to directly reduce damage, but also important as the basic research in volcanology. An eruption is a precious opportunity for research.

Mankind has not experienced many eruptions since the development of modern observation methods. Therefore, volcanic researchers who have experienced actual eruptions are like doctors treating patients with rare diseases and are invaluable within their fields. Researchers at AIST are conducting front-line surveys and research on eruptions, aiming to reduce damage and hazards by developing a better understanding of volcanic processes.

Photo 2 The survey of eruption products on Miyake-jima: taking pictures of the layers of accumulated volcanic ash.

Monitoring of Volcanic Activities Using Satellites

Institute of Geology and Geoinformation
Minoru URAI

The use of satellites enables us to monitor volcanic activities safely, extensively, periodically, and consistently. Satellites are especially effective at volcanoes where observations from the ground are difficult. For example, Mt. Chachadake on Kunashiri Island, one of the most active volcanoes, has a severe natural environment in addition to some political issues, making it the most difficult volcano for ground observation.

Figure 1 is an image of Mt. Chachadake observed by the ASTER sensor developed by the Ministry of Economy, Trade and Industry. We can observe that vegetation near the south and north caters is not recovered yet which was dameged by 1973 Eruption.

Figure 2 is a topographical map created by using the stereo-image function of the ASTER sensor. The topographical map of this region had not been updated since it was issued by the Geographical Survey Institute in 1922. The new topographical map shows the detailed topography of the south crater and the north crater.

Figure 3 shows the distribution of surface temperatures on Mt. Chachadake observed at night; the brighter parts indicate high temperature, and the darker parts indicate low temperature. Even though the surface temperature lowers as the height above sea level increases, brighter points can be found on the summit of Mt. Chachadake. This indicates higher surface temperatures on the summit than in the surrounding areas due to volcanic activities. Meanwhile, no heat abnormalities are found in the south or north crater. The temperature of the sea on the north side of the island is low because of drift ice alongside the coast, while the temperature of the sea on the south-side of the island is higher than the land temperature.

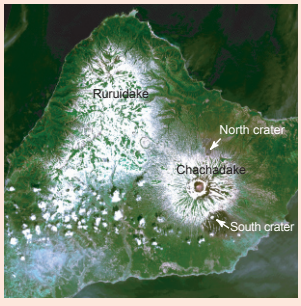


Figure 1 Mt. Chachadake observed by ASTER on May 8, 2002 The range of all images is 30 km × 30 km.

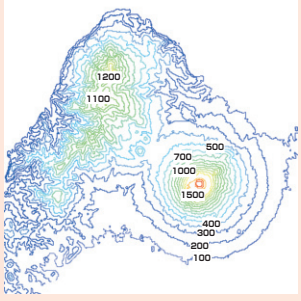


Figure 2 A topographical map of Mt. Chachadake created from the stereo image pairs of ASTER.

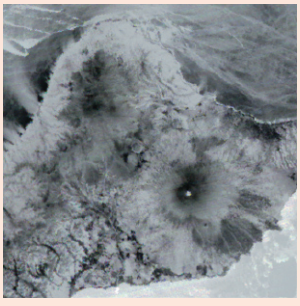


Figure 3 The distribution of surface temperatures on Mt. Chachadake observed by ASTER on March 13, 2001.

Mechanism of the Ascent of Magma to an Eruption

Institute of Geology and Geoinformation
Akira TAKADA

Understanding the mechanism from the ascent of magma to an eruption is indispensable when developing theories based on various observational and surveyed data for predicting a volcano eruption (Figure 1). It is also important when making a program of numerical calculations. The keys to the mechanism are magma movements due to cracking and the vesiculation during the ascent of magma, both of which are dynamic physics and are difficult to analyze theoretically. Although typhoons can be monitored by using satellites, magma cannot be observed directly. There are technologies for observing magma such as geophysical surveys and drillings, equivalent to X-rays and endoscopes; however there are still limits on observational accuracy, depth, temperature conditions, and budget. Thus, we utilize the magic of innovation; we analyze the mechanism by reproducing the magma plumbing system in a laboratory.

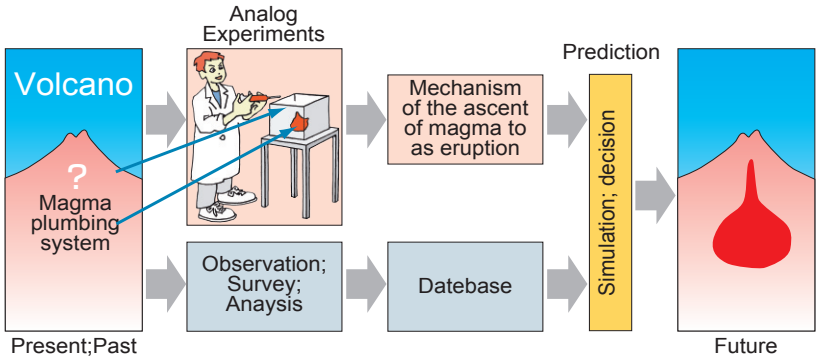


Figure 1 The purpose and positioning of analog experiments.

Vesiculation During the Ascent of Magma

This is an approach that reproduces a magma plumbing system and artificial magma in a laboratory by generating high-temperature and high-pressure conditions equivalent to the earth's interior. The size and amount of bubbles in pumice are indicators representing vesiculating process that controls explosivity of volcanic eruptions. In order to observe the process in our laboratory, we have developed a pressure vessel for gas pressure with decompression speed controller that can reproduce the ascending process of magma for observation[1] (Figure 2 on the left). Magma, produced by re-melting of actually-erupted rocks at 100 MPa (1000 bar) and 900ºC, was enclosed in the vessel and underwent bubble formation. We measured the vesiculating texture of the artificial pumice formed in the experiment. The results showed that the vesiculating process was greatly affected by the ascending speed of magma[2] (Figure 2 on the right).

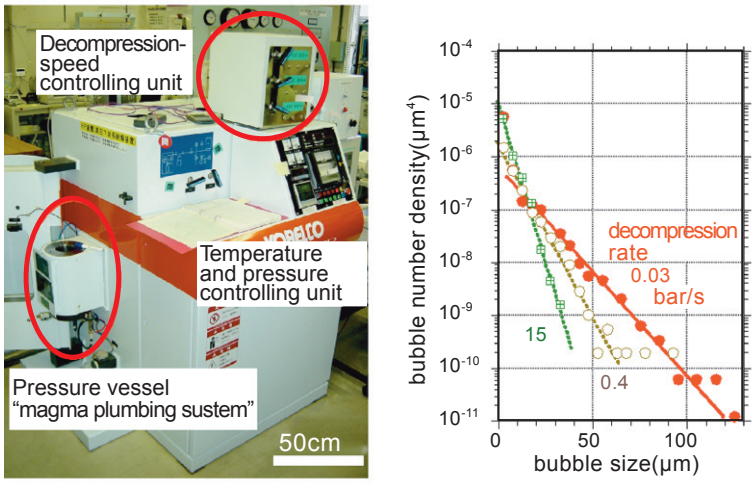


Figure 2 The equipment used for the decompression experiment (left)[1] and the size distribution of the resulting bubbles (Right)[2].

Magma Movements due to Cracking

This is an approach that reproduces an artificial magma plumbing system in a laboratory by using an analog material and reducing the scale. Oil, designed to function as magma, is injected into transparent gelatin as a brittle elastic body that represents the earth, to form a crack. Then its movement is observed. In this system, the physical properties and stresses of gelatin as well as the physical properties and injection rate of oil can be controlled, depending on purpose. Though the theoretical analysis is limited to two dimensions, this experiment enables us to observe the basic shape of a three-dimensional fluid-filled crack and its movements under various stresses. As a result, new ideas such as mechanical

Reference
- [1] A. Tomiya & I. Miyagi: Program and abstracts, Volc. Soc. Japan, 2001 Fall meeting, No.2, 177 (2001)
- [2] A. Tomiya: Eos. Trans. AGU, 84(46), Fall Meet. Suppl., Abstract V51L-01 (2003)
- [3] A. Takada: J. Volcanol. Geotherm. Res.93,93-110 (1999)
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- [5] A. Takada: Chisitsu News, GSJ, 591, 24-27 (2003)

interaction between cracks have emerged[3] (Figure 3). Recently we have reproduced the analog of a fissure eruption under stress.[4] A model of a magma plumbing system due to cracking was created, and it was a common concept to consider that magma moves due to the formation of cracks even at the time of Unzen, Usu, and Miyake-jima eruptions. This concept is applied to explain the difference between a polygenetic volcano and a monogenetic volcano. This experiment is widely used in promotional activities for public and science education.[5]

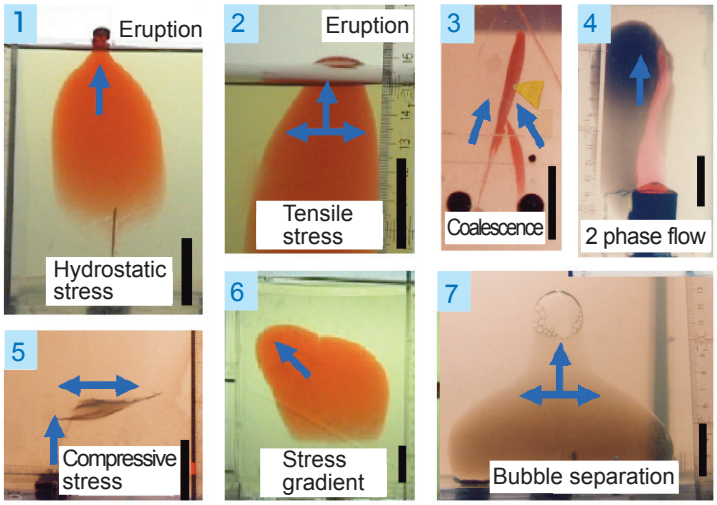

Figure 3 Examples of the analog experiment of cracks. 3 and 5 are the sides of the cracks. The rest are the front of the cracks. The arrow is the flow of the liquid. The black scale is 3 cm.

Scientific Drilling Reached the Magma Path of 1990-95 Eruption of Unzen Volcano

Institute of Geology and Geoinformation
Kozo UTO

Unzen Scientific Drilling Project (USDP) is a six-year term international project started in April 1999, co-sponsored by the Japanese Government (MEXT) and International Continental Scientific Drilling Program (ICDP). More than 20 institutes nationwide and abroad are participating the project, and AIST is serving as one of the principle research centers. The highlight of this project, to penetrate the magma path (conduit) of the Heisei eruption in the middle of the mountain, was successfully completed after reaching the conduit of the Heisei magma in July 2004.

At Unzen volcano, pyroclastic flows caused by the collapse of lava domes occurred frequently during the Heisei eruption between 1991 and 1995, causing serious damage and 44 casualties. The surveys on these eruptions produced much observational data on such as earthquakes, uplifts, and deformations of mountains, which provided us with a detailed model of the ascent and eruption process of magma.

USDP is aiming to understand the growth history, subsurface structure and magma ascending mechanism of Unzen Volcano not only by scientific drillings but also by related geological, geophysical and geochemical studies. In the project, we planned to drill a hole to reach the conduit of the Heisei eruption in order to clarify the ascending and degassing process of magma and understand the mechanism of an eruption. The driling work began in February 2003 from the site on the northside slope of Unzen volcano at the altitude of 850 meters. Work was suspended several times, but we were able to reach the Heisei conduit by making some revisions after drilling approximately 1.3 kilometers horizontally and approximately 900 meters perpendicularly, the total drilling distance was 2000 meters.

There was a conduit zone near the area right under Mt. Fugen at around the sea level, where old and new conduits including the Heisei conduit were concentrated within approximately 500 meters. The temperature in the conduit zone is approximately 200°C, lower than expected before the drilling, which is assumed to have resulted from quick cooling due to hydrothermal activities.

Future extensive research is expected to provide the details of the ascending process of magma.

Photo Unzen Scientific Drilling site on the north-side slope of Unzen
Fifty meter-high rig were set up in an area of approximately 2000 m2, and a road was constructed in the national forest. (Pictures provided by Professor Setsuya Nakada, Univ. Tokyo)

Geological Map of Volcanoes: Research of Recent Eruption History

Institute of Geology and Geoinformation
Hideo HOSHIZUMI
Shun NAKANO

Japanese Volcanic Islands

The Japanese Islands are a region where volcanoes cluster. As seen in Figure 1, active volcanoes, however, do not exist all over Japan but their distribution is partial. The edge of the distribution on the Pacific side is called volcanic front that runs almost parallel to the Kurile, Japan and Izu-Ogasawara Trench, along which the Pacific plate is subducting beneath the continental plate.

There are many volcanoes along the volcanic front, a few of them appear in the west (Japan Sea) side, but none is seen in the east of the trench. Deep earthquake plane occurs at approximately 110 kilometers directly beneath the volcanic front, which indicates that the formation of the volcanoes is closely associated with the subduction of the Pacific plate.

In western Japan, there is a volcanic front that runs from the San-in region through Kyushu and then spreads toward the Tokara Islands. This volcanic front is formed as result of subduction of the Philippine Sea plate.

Active Volcanoes and Volcanic Disasters

Volcanoes which erupted in the past 10,000 years are defined as active volcanoes, and they have the potential to erupt again in the future. There are 108 of such active volcanoes are recognized by the Japan Meteorological Agency (Figure 1). Regardless of their scenic beauty and neighboring hot springs that attract sightseers and climbers, however, most of the recognized volcanoes, once reactivated, may cause serious destruction to themselves and

Quaternary Volcanoes in Japan Database

http://www.aist.go.jp/RIODB/strata/VOL_JP/

Quaternary volcanoes are referred to those active within the last 1.8 (or 1.7) million years, naturally, including the active volcanoes. In this particular time span, the general distribution trend and range of volcanoes are similar to those of the active volcanoes shown in Figure 1. There are more than 300 Quaternary volcanoes recognized in Japan. For example, Gassan in the Tohoku region, Nantaisan in Nikko, and Daisen in the San-in region are famous volcanic mountain though not active. Should a volcano that erupted within the last 10,000 years reactivate we will label it as an active volcano.

Within AIST's research database (RIO-DB), data on Quaternary volcanoes are open to the public. The data cover all the volcanoes that were active during the Quaternary. Data include volcano type (stratovolcano or lava dome), rock type (basalt, andesite, etc.), activity period, names of topographic maps showing locations of volcanoes (longitude and latitude) and related literature. The data also contain eruption records and pictures of the active volcano. Geological maps issued by AIST are to be added to the database in addition to a plenty of pictures for each volcano. At the present, the database is available in Japanese, but in the near future, English version will be published. In general, it is planned to be developed to a more detailed and socially useful database.

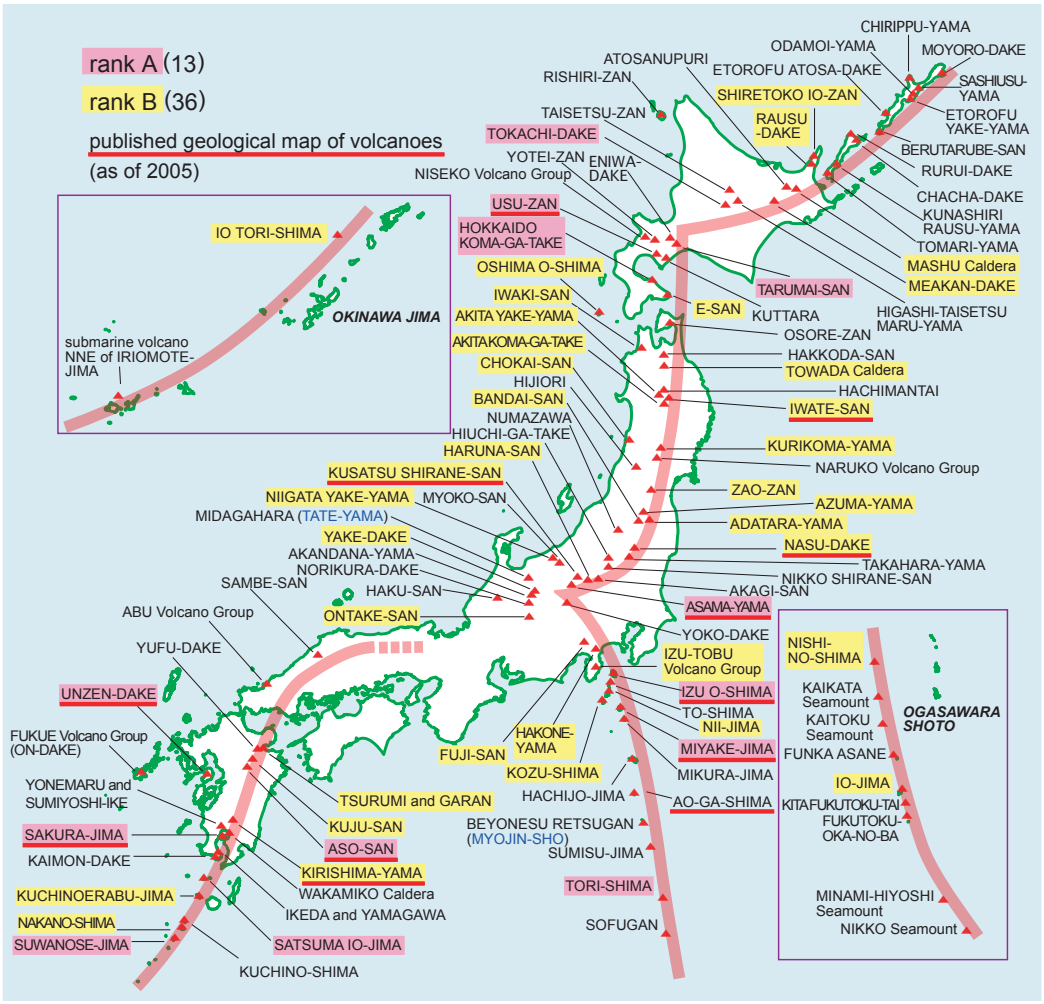

Figure 1 Distribution of active volcanoes in Japan. Active volcanoes are classified into three ranks from A to C with decreasing scale of activity: A- most active includes 13 volcanoes, B- includes 36 and C- includes 36 volcanoes. Submarine volcanoes and those in the Southern Kurile Islands (Kunashiri and Etorofu) are excluded from this classification. Future survey may add more active volcanoes. Thick orange lines are volcanic fronts.

surrounding areas.

AIST has been making geological maps of past eruptions of active volcanoes since the time of our antecedent, the Geological Survey of Japan, and has been providing them as geological maps of volcanoes. Questions such as when, where and how a volcano erupted and affected can be determined based on our intensive study of past distribution of erupted products, eruption time and characteristics using field surveys and laboratory experiments.

Each volcano has its own varying characteristics, patterns, frequencies, and scales of eruption. The geological map of a volcano can be referred to as a resumé of the volcano since the time it was formed by clarifying such differences mentioned above. The geological map of a volcano will help with prediction of shift in the activity when an eruption is imminent or actually begins. The data on patterns and scales of past eruption are used as basic material to establish hazard map (a chart of expected damage due to an eruption) by local administration.

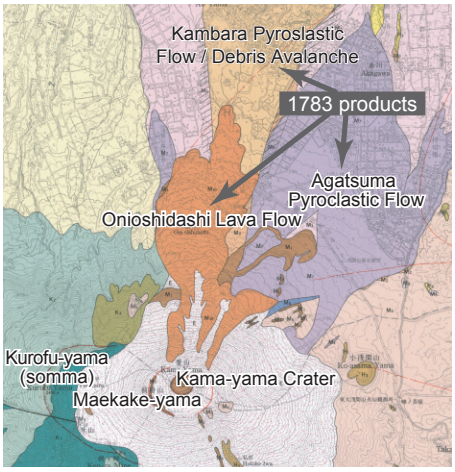

Figure 2 Part of the geological map of Asama volcano (1993 issue). Erupted products are color-coded according to time and type. Active part is in the Kama-yama crater inside the Maekake-yama cone. The latter is surrounded by somma of Kurofu-yama that was formed by a gigantic collapse of the mountain body. For this particular structure Asama volcano is often referred as a triple volcano. In 1783 eruption the volcano released a large amount of pumice fall, followed by pyroclastic flows and ended by the Onioshidashi Lava Flow.

The Blessings of Volcanoes : The Front Line of the Utilization of Geothermal Heat

Institute for Geo-Resources and Environment
Hirofumi MURAOKA

High-Temperature Hydrothermal Convection Systems Generated by Volcanoes

Many volcanoes in the Japanese archipelago are considered to have been formed by lava and pyroclastic flows spewed out repeatedly from magma chambers in the shallow part of the crust formed by the magma rising from the upper mantle and the bottom crust. The calc-alkaline series magma is believed to form a magma chamber in the shallow part, a few kilometers underground, due to its high buoyancy. Many hot springs with a temperature of 90ºC or higher, near boiling point, are found around volcanoes originated from calc-alkaline rocks because the magma chamber in the shallow part heats up groundwater and forms a high-temperature hydrothermal convection system.

Advantages of Geothermal Power Generation

When drilling is conducted on a hydrothermal convection system around a volcano, even hot reservoir water will vaporize and become steam with a temperature of 160-330ºC due to reduced pressure during the ascent in a well and will flush out to the surface by itself. It is possible to generate electricity without consuming fossil fuels if this steam is used to rotate a turbine. This is the mechanism of geothermal power generation.

Geothermal power production is advantageous not only in terms of energy security because it is a purely domestic energy, but also as a countermeasure against global warming because it is a clean energy that generates only a very small amount of carbon dioxide. However the capacity of the geothermal power generation facilities in Japan is approximately 550,000 kW, which places Japan only sixth in the world.

Recently, even nations with few volcanoes are working toward the development of geothermal power production by drilling to great depths and utilizing non-volcanic crustal heat flow. Needless to say, a volcanic nation like Japan has advantages regarding geothermal power production, thus Japan is aiming to improve its systems for more extensive use.

Approach to High-Temperature Magma

Japan is leading the world in the development of geothermal technology. We have already mentioned imagining actually observing a magma chamber in the shallow part of the crust forming a high-temperature hydrothermal convection system. This image was in fact physically proved for the first time in the world by the Deep Geothermal Resources Survey in Kakkonda, Shizukuishi-cho, Iwate Prefecture in Japan. In the survey, the 3729 meter-deep well, called WD-1a was drilled in 1995. As shown in Figure 1, the well passes through the hydrothermal convection system and also the Kakkonda Granite, a solidified magma chamber, the heat source of a hydrothermal convection system. The complex can be referred to as a newly-solidified magma chamber because the temperature at the boundary of granitic rock was 370ºC and the temperature at the bottom of the well dug to the depth of 3729 meters was more than 500ºC, as shown in Figure 2. These records lead the world in terms of scientific achievement in geothermal drillings and thus have caught the world's attention.

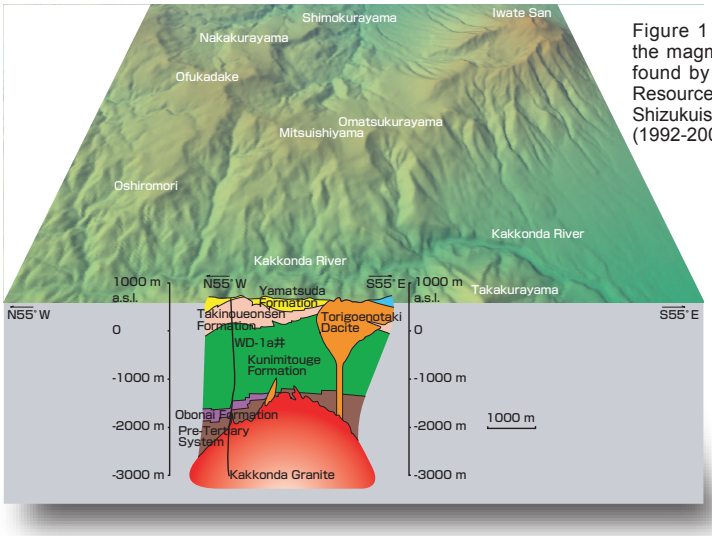

Figure 1 A sectional image of the magma chamber (solidified) found by the Deep Geothermal Resources Survey in Kakkonda, Shizukuishi-cho, Iwate Prefecture (1992-2000)

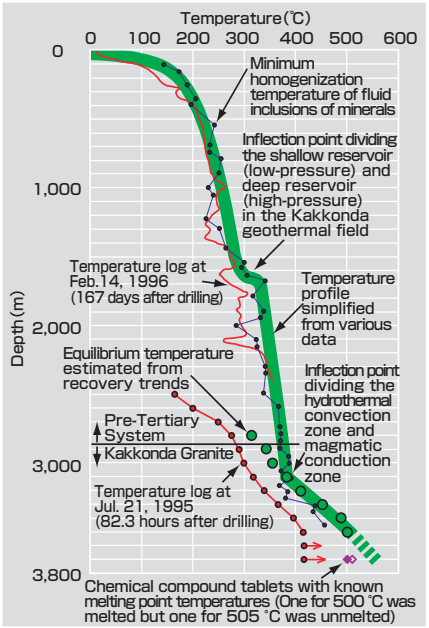

Figure 2 The distribution of the temperatures around Kakkonda granitic rock and explanations

Volcanoes as Tourism Resources : Marvelous Views and Hot Springs

Institute for Geo-Resources and Environment
Keiichi SAKAGUCHI

Pleasures Provided by Volcanoes

Volcanoes provide us various pleasures (see Figure). First of all, they provide us amazing landscapes with high-rise peaks such as Mt. Fuji and crater lakes filled with blue water such as Lake Towada. The attraction of volcanoes can be appreciated from the fact that they exist in 18 of Japan's 28 national parks.

Volcanoes also provide us pleasures of climbing and skiing. Quaternary volcanoes account for nearly half of Hisaya Fukada's 100 Well-Known Mountains in Japan. Many popular ski parks including Zao and Myoko utilize the slopes of volcanoes. Furthermore, volcanoes provide us plenty of spring water at the foot of mountains. Much of the spring water found around volcanoes such as Mt. Yotei, Mt. Fuji, and Mt. Aso is included in the Selected 100 Exquisite and Wall-conserved Waters.

Hot Springs in Volcanic Regions

The greatest blessing of volcanoes for the Japanese people is the hot springs they provide. There are 3,100 hot springs in Japan, where annually 140 million people in total visit and stay (from data presented by the Ministry of Environment in fiscal 2002). Recently, hot spring development in non-volcanic regions such as in plains is very popular. Although hot springs in volcanic regions do not account for a very high proportion in terms of their numbers, there are many attractive hot springs in volcanic regions including many high-temperature hot springs and those with wide-ranging chemical characteristics. In volcanic regions, interactions between water and rocks under high temperature as well as a mixing of gases and fluids from magma and groundwater occur because of a hot magma chamber existing underground. Hot water produced by such processes is spread by a hydrothermal convection current to the outskirts to form hot springs with various characteristics.

Figure Pleasures provided by volcanoes

Can Electricity be Generated from Hot Springs?

Bad Brumau in Austria is a spa resort known for its unique buildings. It is also known as an eco-resort. A hotel there conducts geothermal power generation using hot spring water of 110ºC and recycles the hot water used in the power generation for hot-water supply systems by heat exchange (see photo). Even though hot water of 110ºC is not suited for conventional geothermal power generation, they have adapted a binary cycle power generation technique that vaporizes the low-boiling point medium by heat exchange to rotate a turbine with the steam generated.

Austria has no volcanoes. Bad Brumau is a hot spring found during a prospective survey for oil conducted in the 1970s, and obtains hot water from a bored well 2000 meters deep. High-temperature hot water can be obtained more easily at hot springs in volcanic regions.

Many foreign countries have already adapted binary cycle power generation facilities of various scales. A survey on potential binary cycle power generation using hot springs has just started in Japan. Future development is anticipated.

Photo Geothermal power generation facilities (Left) and the unique hotel buildings (below) at Bad Brumau (Austria)

Mineral Resources Produced by Volcanic Activities

Institute for Geo-Resources and Environment
Yasushi WATANABE

Solving the Puzzle of the Formation of Metal Deposits

Volcanic activities and the accumulation and deposition of metal elements are closely related as seen in the gold deposition on the summit of Osorezan in Aomori Prefecture because the magma that forms a volcano contains metal elements. However, surprisingly little is known about the processes required for the metal elements in magma to form a deposit. Deposits are not often found near volcanoes remaining in the original form because the metal deposits are formed at depths of hundreds to thousands of meters beneath the surface. Instead, many deposits have been exploited near volcanoes which have lost their original form due to erosion. Not all volcanoes have metal deposits; in fact volcanoes with a deposit are extremely rare.

Mt. Muine, the highest peak in Sapporo city in Hokkaido, (see Photo) was formed by the eruption of andesite lavas approximately three million years ago. Silver, indium, zinc, lead, and copper are being mined at the Toyoha deposit in the north. Even now, the temperature of the host rocks of the underground tunnels at the Toyoha deposit is as high as 100ºC or higher, which indicates that not much time has passed since the metalliterous veins were formed. Therefore, this is a good example to study how metalliterous veins are formed.

Our Model of the Magma-Hydrothermal System

We designed a model of the magma-hydrothermal system as mentioned below based on the surveys and investigations on ground surfaces and the undergroud (see Figure). After the eruption of lavas at Mt. Muine volcano, magma and hydrothermal fluid accumulated at a greater depth, two kilometers below the mountaintop. The hydrothermal fluid separated into hot volcanic gases and brine. Volcanic gases abundant in SO_2 ascended and reacted with the andesite around the volcanic craters to form advanced argillic rocks made of alunite and cristabalite.

Meanwhile, the brine, dissolving large amounts of base metal elements including silver, zinc, and lead, flowed toward the outside, separately from the volcanic gases due to its high density. The brine ascended the fault belt and mixed with meteric water that penetrated from the surface after flowing approximately three kilometers northward. It then precipitated into quartz and metal-sulfide minerals such as pyrite and sphalerite as veins. At the same time, it caused propylitic and sericitic alteration around the veins, turning them mostly into chlorite and illite. Then, after forming the veins, the remaining hot water ascended the faults and formed an argillic alteration zone mainly consisting of kaolinite. The zone is in Yunosawa, to the east of the deposit.

Photo Overlooking Mt. Muine from the east

These results provide us with indicators in our search for metal veins around volcanoes. Massive intrusion of magma immediately after the formation of a volcano is necessary for the formation of a metal deposit, and whether hydrothermal alteration zoes are developed or not is the key to the distinction. Furthermore, it is important to understand which part of a hydrothermal system developed by the magmatic intrusion you are observing by examining the combination and chemical composition of minerals in hydrothermally altered rocks in detail, and in which part you can expect the accumulation of metal elements by analyzing the geological structures.

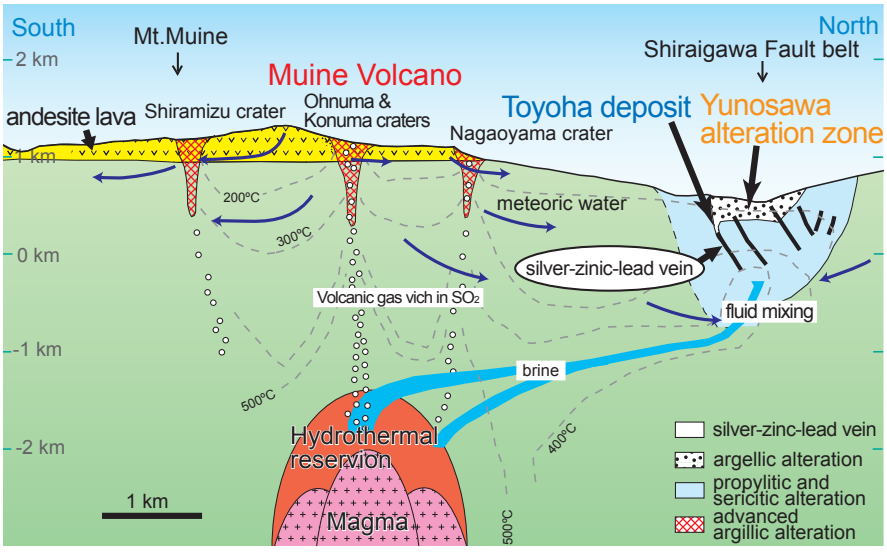

Figure Section images of the Muine-Toyoha magmatic hydrothermal system

Seafloor Hydrothermal Systems

Institute of Geology and Geoinformation
Kokichi IIZASA

Sulfide Deposits Formed by Seafloor Volcanic Activities

Seafloor hydrothermal activities, in which hot water vigorously spouts out from chimney-like holes (chimneys) formed in the ocean bed, are one of the most active geological phenomena on the earth. Shifts within the earth are observed through the movements of heat and substances such as heavy metals caused by seabed volcanic activities followed by hot fluid circulation (see Photo). This hot fluid circulation supplies copper, lead, zinc, iron, gold, and silver as sulfides to the surface of the seabed. Also, an ecosystem peculiar to hydrothermal fields is formed there.

AIST is conducting basic surveys and research on seabed hydrothermal systems in active ocean areas including ones around Japan and ones in the central oceanic ridge. We are collecting data using manned submersibles, unmanned vehicle, and benthic multi coring system and are working to determine the mechanism of the movements and accumulations of substances and to produce a model of the deposit formation mechanism.

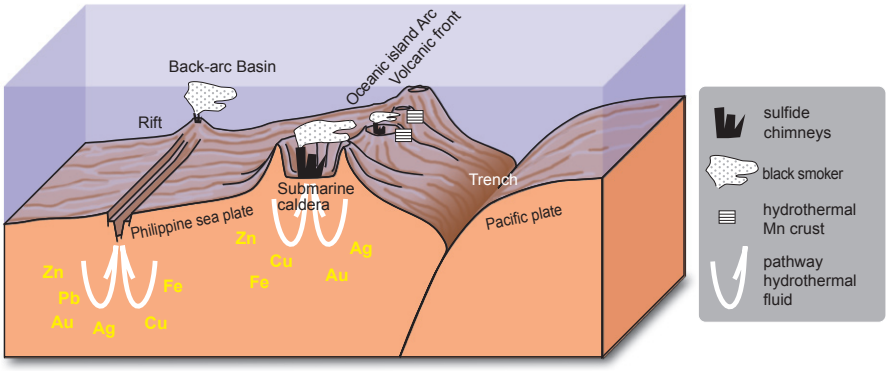

Figure 1 Distribution of potential sulfide deposits in sea areas around Japan, and schematic illastration of mineval formation processes

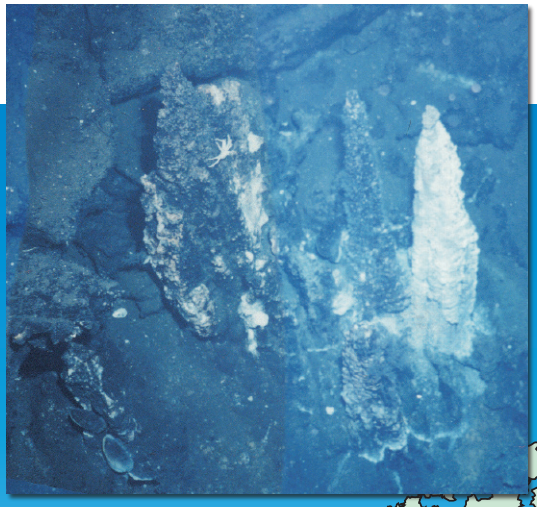

Photo Approximately 1 meter-high sulfide chimneys and sulfide debris (The Sunrise deposit on the Myojin knoll)(By Iizasa by JAMSTEC Shinkai 2000)

The Izu and Ogasawara Arc, equal to the Honshu Arc in size, is located in the area of sea south of Tokyo. In this seabed, there are many active seabed volcanoes on the west side of the Trench as well as islands in the southern and northern directions. The line of volcanoes along the trench is called a volcanic front. On the west side of this volcanic front, long and narrow depression, called a back-arc rift, lies from the north to the south. Many submarine calderas existing in the volcanic front and back-arc rift have concave topography where active hydrothermal activities are taking place. At submarine calderas with active hydrothermal activities, sea water sinks into the depth through cracks. Then the penetrated water is heated by the heat of the magma chamber and rises again to the surface of the seafloor as a hot fluid solution containing heavy metals and produces a potential sulfide deposit abundant in heavy metals, called a kuroko-type deposit (Figure 1). The same phenomenon as seen in the Izu and Ogasawara Arc is also taking place in the Ryukyu Arc.

The Distribution of Metal Deposits in Seas around Japanese Islands

In the exclusive economic zones around Japan, many potential metal deposits formed by the processes mentioned above (marked ★ in Figure 2) containing an abundance of gold, silver, copper, lead, and zinc, exist in volcanic fronts and back-arc rifts.

Research Hot Line

UPDATE FROM THE CUTTING EDGE

Jan.-mar. 2005

The abstracts of the recent research information appeared on the Vol.5 No.1–No.3 of "AIST TODAY" are introduced and classified by research area. For inquiry about the full article, please contact the author directly.

Life Science & Technology

Innovative Display to Present Multiple Images of Various Formats

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AIST Today
Vol.5 , No.1 (2005)14

We succeeded in a trial display system of "Virtual Projectors and a Screen" (VPS). On it, the images of different formats, TV, digital camera, PC, etc., can be displayed as one federation. It's simple to use. Required devices can be put into VPS. The images of them can be moved freely to anywhere by a remote controller. If unnecessary, it has to be pulled out. As one example of VPS useful use, on endoscopic surgery, the required information of endoscopes, tomograms, sphygmomanometers, etc. at the moment of the surgery step is displayed on VPS at a suitable position, at the same time on demand.

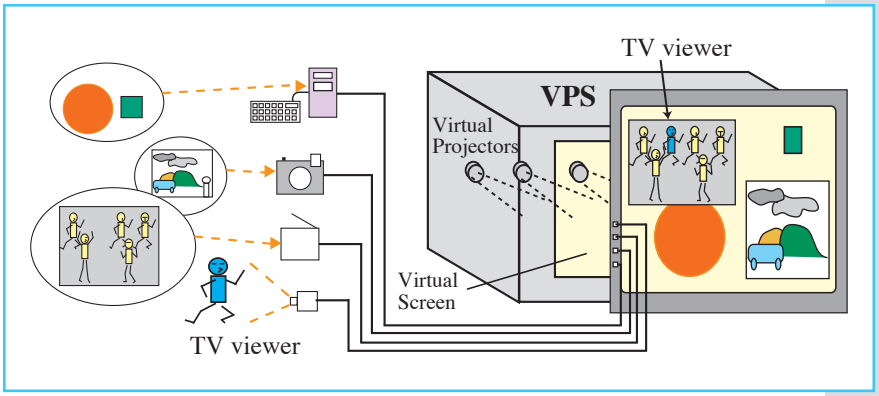

Fig. A TV viewer can dance with TV star on a VPS screen !

A new view on the mechanism for generating evoked fields

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AIST Today
Vol.5 , No.1 (2005)15

I analyzed not-averaged neuromagnetic responses to repetitive sounds. It was found that ongoing oscillations around 6 Hz are relevant for generating the auditory evoked fields. Namely, phases of the oscillation were locked, their magnitudes were increased and magnetic fields were often reduced to an equivalent current dipole in the auditory cortex at around the timings of N100m, but the phases were unlocked and the fields were seldom reduced to a dipole at the other timings. These lines of evidence suggest there exist several oscillators within the cortex whose phases are locked at around the timings of N100m, but otherwise unlocked.

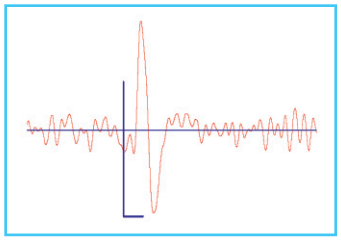

Fig.1 Auditory evoked field. Vertical bar: onset and 100 fT/cm. Horizontal bar: 100 ms.

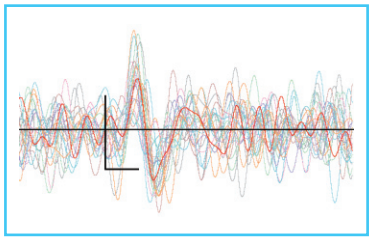

Fig.2 Raw data after passed the band-pass filter in 20 consecutive trials. Scales are the same as in Fig.1.

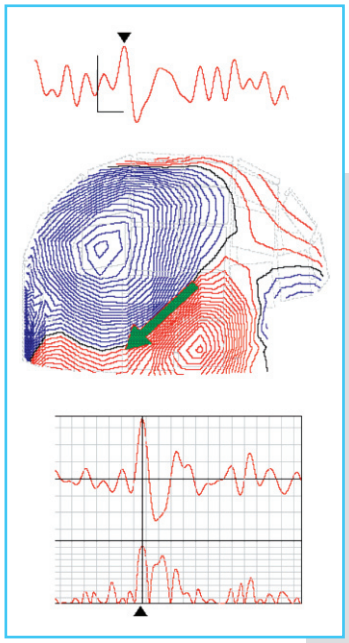

Fig.3
(a): One of the traces in Fig.2.
(b): Magnetic field above the right cortex at the timing shown by a triangle in (a), and the estimated dipole.
(c): Magnitude (20 nAm step) and goodness-of-fit (10 % step) of the estimated dipole vs. time (50 ms step).

Development of multi-component MO method beyond Born-Oppenheimer approximation

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AIST Today
Vol.5, No1 (2005) p18

In order to explore the nature of hydrogen-bonding with isotope effect, we have developed the multi-component molecular orbital (MC_MO) method, which takes into account the quantum effect of proton and deuteron, beyond Born-Oppenheimer approximation. In the case of H_2, HD, and D_2 molecules, we have clearly demonstrated that the difference of charge distributions between proton and deuteron reflects the electronic structure and bond distance (see Figure 1). This MC_MO method is a powerful tool to study the geometrical and kinetic isotope effects for various chemical phenomena, such as the hydrogen-absorbing metallic nanoparticle, C-H...O type hydrogen-bonding, and hydrogen (proton) abstraction reaction.

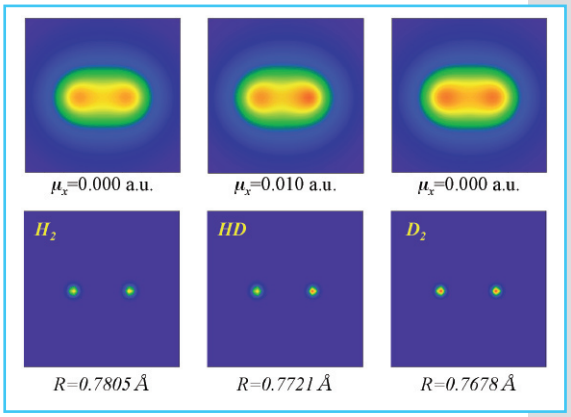

Fig. Charge distributions of nuclei (lower panel) and electrons (upper panel) of H_2, HD, and D_2 molecules. The internulear distances and dipole moments are shown as R and μx, respectively.

Development of Single-CD Linux" KNOPPIX / IPv6" with International Accreditation IPv6 Ready Logo Acquired

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AIST Today
Vol.5 , No.1 (2005)17

The National Institute of Advanced Industrial Science and Technology (AIST) has developed a next generation internet infrastructure, IPv6 Linux "KNOPPIX / IPv6" which can be booted with a single CD (compact disk), in collaboration with the Alpha Systems, CO., Ltd. (Alpha Sys.) and the WIDE Project.

The "KNOPPIX / IPv6" was produced on the basis of "KNOPPIX Japanese Edition" which had been maintained by the AIST for Linux distribution and incorporated by Alpha Sys. with the IPv6 protocol stack which had been developed by the WIDE Project.

The "KNOPPIX / IPv6" has two functions: host to build up an IPv6 system in any PC with a single CD, and rooter to link up PC network. The operation of these functions has been verified, and the International Accreditation Organization IPv6 Ready Logo Committee issued the international linkup certificate IPv6 Ready Logo for Linux distribution first in the world, as of August 29, 2004.

The international recognition of IPv6 compatible function of "KNOPPIX / IPv6", makes it possible for users to utilize it securely, and to create products customized on the basis of "KNOPPIX / IPv6" owing to the mutual certification for other IPv6 devices. Since the "KNOPPIX / IPv6" consists of free software, it is possible to add original IPv6 compatible applications so long as the license agreement is observed.

Fig. Label design of "KNOPPIX / IPv6".

Red color materials containing gold nanoparticles

Harmless and highly light-resistant color materials were developed

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AIST Today
Vol.5 , No.1 (2005)18

Red color materials containing gold nanoparticles and natural polymers such as gelatin and agar were obtained by the treatment of the polymers with a chloroauric acid solution and a reductant solution successively. Dissolution of the materials in hot water gave red-colored gold hydrosols containing gold nanoparticles. These materials would serve as harmless and highly light-resistant red color materials for foods.

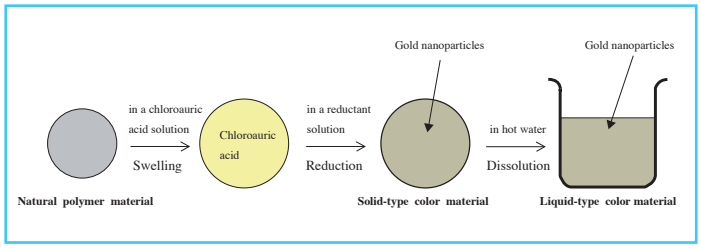

Fig. 1 Preparation of red color materials.

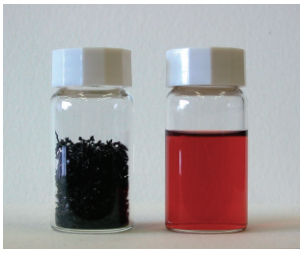

Fig. 2 Solid- and liquid-type color materials using gelatin.

Dye Aggregation Driven by Intermolecular Hydrogen Bonds

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AIST Today
Vol.5 , No.1 (2005)19

Some alkylated merocyanine dyes form "J-aggregates" that are self-organized functional supermolecules in their monolayers prepared upon aqueous subphases containing metallic cations such as Mg^{2+}. "What drives the J-aggregation?" was an open question because the molecules' static dipoles may prefer another type of aggregate. Recently, it has been found that one of those dyes forms a J-aggregate upon pure water and a detailed infrared absorption study of this new J-aggregate has answered to that question. That is, the large dielectric constant of water enables intermolecular hydrogen bonds (or metal chelation) to drive the J-aggregation against the interaction between the dipoles.

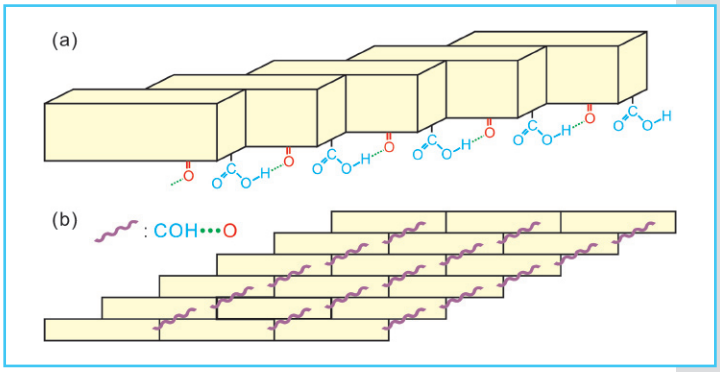

Fig. Merocyanine dye molecules are connected by intermolecular hydrogen bonds (a) and then stacked side-by-side by electrostatic force (b), giving rise to formation of ribbon-shaped J-aggregates.

New Method of Synthesizing Organic Hydrogen Storage Materials for Fuel Cells

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AIST Today
Vol.5 , No.1 (2005) 20

We have developed technology for synthesizing decalin, a promising material of hydrogen storage for fuel cell through the combination of supercritical carbon dioxide with a supported metal catalyst. This process has merits of low temperature, high selectivity, high efficiency, easy recovery of decalin, and capability of recycling carbon dioxide solvent. It is expected to contribute to the implementation of hydrogen storage materials synthesis system to reduce the environmental burden.

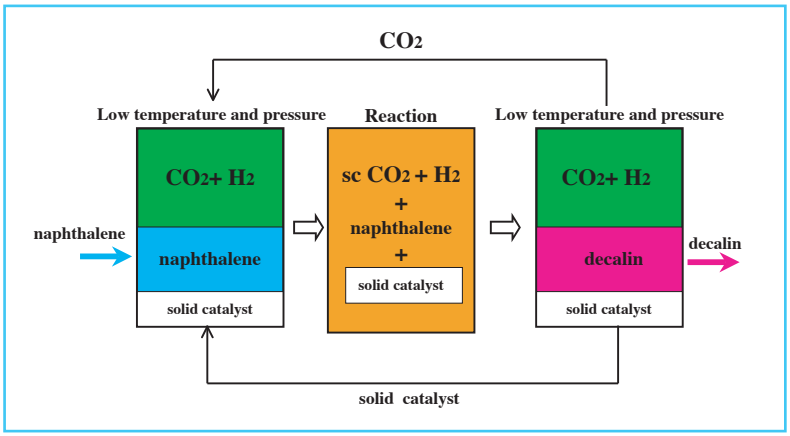

Fig. Multi-phase catalytic reaction system with supercritical carbon dioxide.

The production of a sheath around a stacked-cup carbon nanofiber

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AIST Today
Vol.5 , No.1 (2005) 21

Carbonaceous materials have the ability to withstand elevated temperatures and structural characteristics that often exhibit changes, especially at graphitization temperatures. Stacked-cup carbon nanofibers (GSI Creos Corp., 24PS-AR50) were heat treated at ca. 3000 ℃ for 10 minutes in a high-purity argon stream using a graphite-resistance furnace. The heat treatment has induced a nanoscale structural change resulting in a composite texture, i.e. multi-graphene sheets rolled into concentric cylinders sheathe the stacking morphology of truncated conical graphene layers. The edge sites of graphitic layers of stacked-cup carbon nanofibers are considered to stabilize through the structural change when releasing hydrogen at elevated temperature.

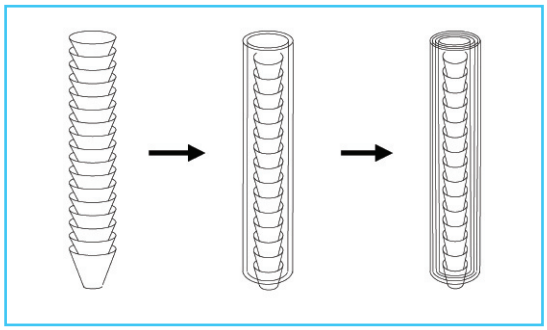

Fig. Schematic illustration of the structural conversion from stacked-cup to an MWNT-stacked-cup composite texture.

Novel synthesis of the electroluminescent materials using microwave irradiation

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AIST Today
Vol.5 , No.1 (2005) 22

Transition metal complexes, especially iridium(III) complexes with 2-arylpyridine ligands such as *fac*-[Ir(ppy)$_3$] (ppyH = 2-phenylpyridine) have attracted much attention as phosphors for organic light-emitting diodes (OLED). We report on a novel synthesis method for the production of facial tris-ortho-metalated iridium(III) complexes *fac*-[Ir(L)$_3$] (L = 2-arylpyridine) by the reaction of $IrCl_3 \cdot nH_2O$ with a large excess of the corresponding 2-arylpyridine under microwave irradiation. The method does not require "dehalogening reagent" such as $AgCF_3SO_3$, and fac tris-ortho-metalated Iridium(III) complexes were obtained rapidly, selectively and efficiently compared to the procedure with standard oil-bath heating.

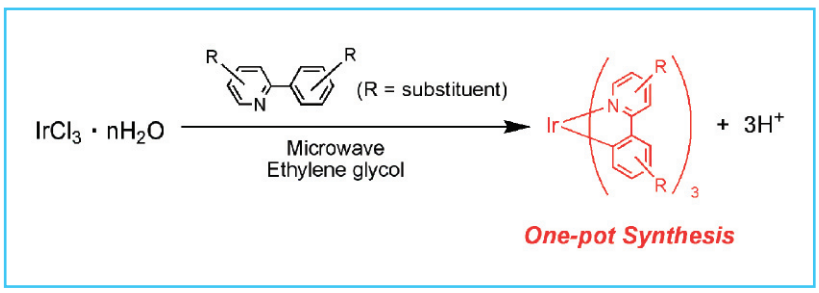

Fig. New synthetic route of phosphorescent material for OLED.

Super CO tolerant anode catalysts for fuel cells – A new generation electro-catalysts based on organic metal complexes

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AIST Today
Vol.5 , No.1 (2005) 23

Abstract: In the stationary fuel cell, fuel gas such as city gas is first reformed into hydrogen, and then fed into the cell to generate electric power. Thereby byproduct impurity CO forms in the reformed gas, and when this exceeds a few ppm, the fuel cell performance degrades drastically. While it has been known that Pt-Ru alloy catalyst is resistant to CO, it is expensive and still fails to protect the electrode when the concentration of CO becomes higher than 25 ppm. From this motivation, new catalysts are developed based on organic metal complex as a co-catalyst for platinum, with much better performance than that of the conventional catalyst. The catalyst is prepared by mixing platinum precursor with organic metal complex, incorporating the mixture over carbon particles and baking in inert gas. This provides adequately stable catalyst. The catalyst is tolerant to CO at the concentration higher than 100 ppm. Such a high resistance to CO is world first achievement, and the practical application of this catalyst will mitigate strict requirements of fuel reformer for reducing CO and bring forth a spin-off effect of saving cost of the reformer itself.

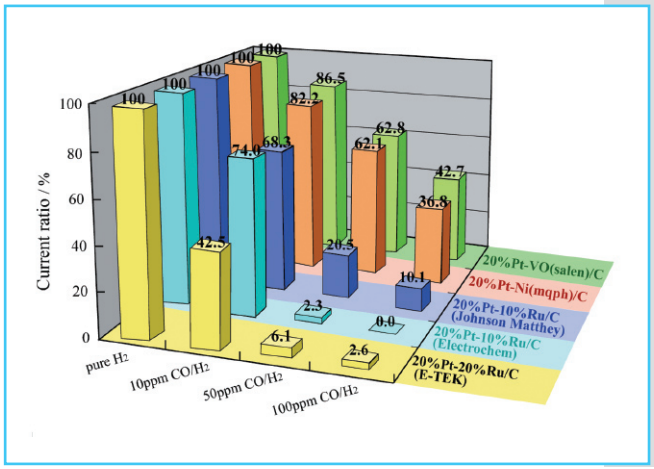

Fig. Performance of new catalysts for the anode of fuel cells in comparison with that of Pt-Ru.

Detoxification of Dioxins under Mild Conditions

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AIST Today
Vol.5 , No.1 (2005) 24

Dioxins, which include polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and coplanar polychlorinated biphenyls (co-PCBs), are chlorinated organic compounds with high toxicity. In this study, detoxification of dioxins was carried out in a solution of NaOH in 2-propanol in the presence of an alumina-supported palladium catalyst (Pd/Al_2O_3). When dioxins were extracted from fly ash, which had been collected in a commercial solid-waste incinerator, and were treated by using this system at 82 ℃ for 3 h, the concentrations of dioxin homologues decreased nearly to the experimentally detectable limits. The toxicity reduction was calculated to be > 99.96 %. We studied the reaction mechanism and revealed that chlorine atoms of dioxins were replaced stepwise by a hydrogen atom of 2-propanol and consequently dioxins were transformed to chlorine-free compounds.

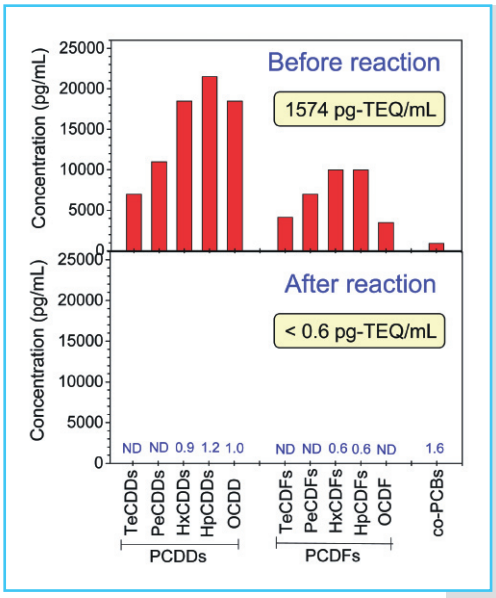

Fig. Detoxification of dioxins extracted from fly ash.
Reaction conditions; 2-propanol (20 mL), NaOH (80 mg), Pd/Al_2O_3 (200 mg), 82°C, 3 h.

Development of fiber-optic structural health monitoring system

We have developed a novel fiber-optic structural health monitoring system using fiber Bragg grating (FBG) sensors. This system enables not only to measure strain at fast speed over several kHz but also to detect acoustic emission and ultrasonic wave. Compared with conventional structural health monitoring system, this system has great advantage that sensory network can be quite simplified from the multifunctionality and multiplexibility of FBGs. The figure shows response signal of FBG sensor and conventional piezoelectric sensor in an ultrasonic damage detection test. As shown in the figure, FBG sensors have better damage detectability than conventional piezoelectric sensors.

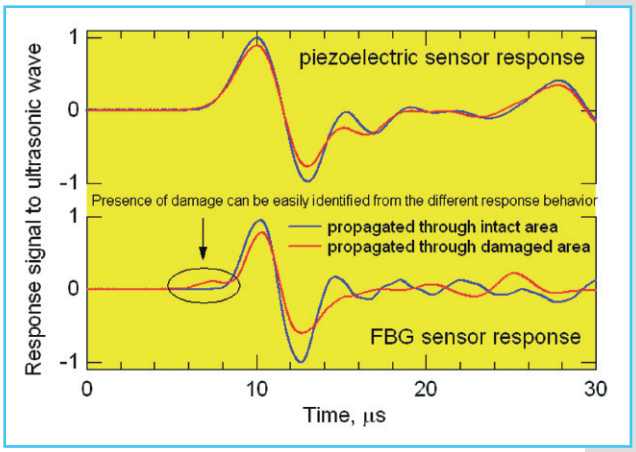

Fig. Example of ultrasonic damage detection test.

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AIST Today
Vol.5 , No.1 (2005) 25

Supersensitive two-photon absorption material

Seeking for materials efficiently absorbing two photons simultaneously

It has been believed that a molecule absorbs one photon on its photoexcitation. This is true for most cases. However, under strong irradiation of light like a pulsed laser beam, two photons are absorbed at the same time by a single molecules—this is two-photon absorption (TPA). Generally organic dyes show very weak TPA. We developed dyes exhibiting very strong TPA. The dyes consist of diacethylene derivatives and is stable compared to other TPA dyes. The dyes also show drastic increase of the TPA sensitivity for visible ray because of the mechanism called resonance enhancement (near double resonance). These supersensitive TPA dyes have high potential for the application such as high-density optical storage, 3D-microfabricaion, and photodynamic therapy.

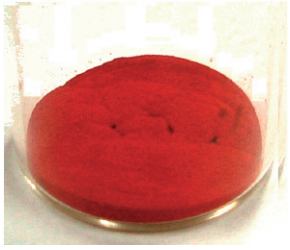

Fig.1 High-sensitive two-photon absorptive compound and its morecular structure.

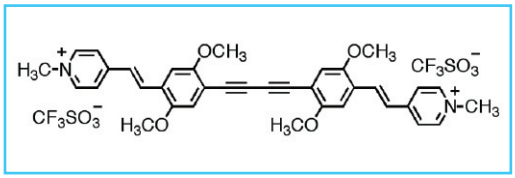

Fig.2 Two-photon absorption spectrum of the diacetylene compound.

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AIST Today
Vol.5 , No.2 (2005) 20

n-Type Organic Thin Film Transistor Prepared by Solution Process

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AIST Today
Vol.5 , No.12 (2005) 21

The PRI-AIST has succeeded in synthesizing a new fullerene derivative, C60-fused pyrrolidine-meta-C12 phenyl (C60MC12), by incorporating alkyl chain to fullerene (C60). C60MC12 is soluble in organic solvent, and found to constitute a good quality crystalline thin film by simple spin coating where fullerene heads self-aggregate to form layered structure.

An organic TFT has been prepared by using newly synthesized fullerene derivative C60MC12 for organic semiconductor layer, and characterized. The electron mobility is as high as 0.067 cm^2/Vs, which is the highest value for n-type organic semiconductor prepared through coating process (figure).

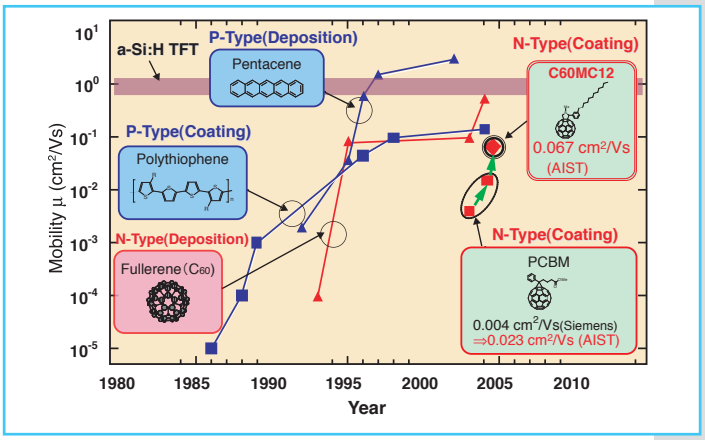

Fig. Mobility of holes and electrons in p-type and n-type organic semiconductors, respectively.

Nano-Sized Calcium Phosphate Crystals Obtained by Bio-Inspired Methods

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AIST Today
Vol.5 , No.2 (2005) 22

Living matters produce various materials in their bodies without consuming thermal energy. The natural bodies can be considered as material manufacturing plants with high-efficiency. In the biological synthesis of inorganic solids, an organism creates a proper organic matrix, and the crystals precipitate onto the matrix due to chemical interactions of an inorganic/organic hetero-interface. We attempted to apply this mechanism in material synthesis to produce nano-sized calcium phosphate crystals. Phase separated microenvironments of organic molecules were employed as microreactors for the nano crystals formation. Organic functional group bounded water mediated calcium phosphate crystal nucleation, and the nano-sized crystals were obtained.

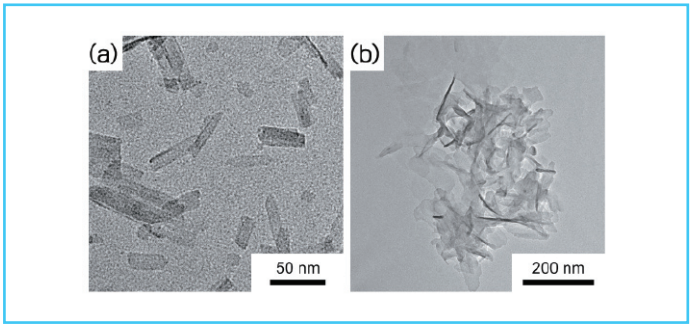

Fig. TEM images of the obtained nano-sized calcium phosphate crystals.

Electrically conductive DLC coatings by plasma based ion implantation

Electrically conductive DLC(diamond-like carbon) coating technique has been developed by plasma based ion implantation with bipolar pulses. Energetic electrons and ions, which were induced by positive and negative pulses, respectively, were bombarded/deposited alternately on a substrate in hydrocarbon plasma. As a result, the resistivity of the DLC film decreased with the negative pulse voltage, and reached to 1 mΩcm at -20kV. Hardness of the film was 5.4GPa. TEM observation showed that the electrically conductive DLC films are composed of cluster of graphite-like aggregates. The technique can be applied for a metal separator in fuel batteries, where high conductivity and high electrochemical stability are needed.

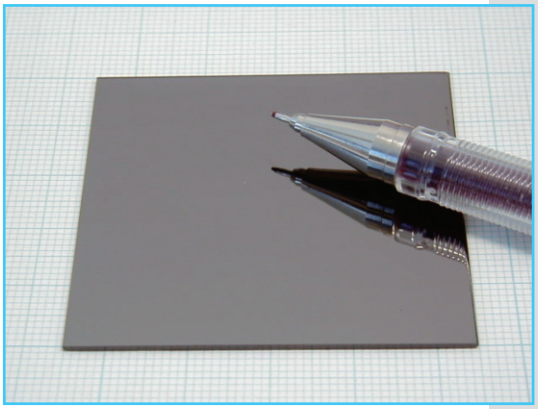

Fig. Electrically conductive DLC film coated on a stainless steel substrate.

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AIST Today
Vol.5 , No.2 (2005) 23

A new growth technique for high-quality III-nitride semiconductors

We propose a new technique for the growth of high-quality III-nitride semiconductors with ultra-flat surface morphologies and low dislocation density. The key-point of the technique is the use of vicinal sapphire (0001) substrates for the growth. We use plasma-assisted molecular beam epitaxy to grow the films. As a result, ultra-flat surface with mono-layer steps is achieved using a 0.5° vicinal substrates. Furthermore, the dislocation density in the GaN film grown on a 2.0° vicinal substrate is greatly reduced to the order of $10^8/cm^2$, which is more than one order lower than that grown on a usual just-oriented substrate. The technique provides a new chance for the high performance of III-nitrides-based optical and electronics devices.

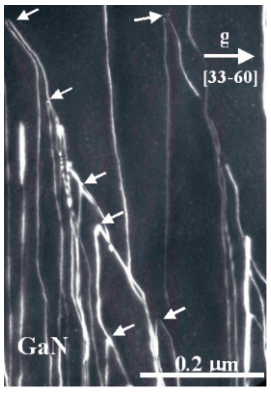

Fig. Dark-field TEM image of a GaN film grown on a 2 degree-off sapphire(0001) substrate. The threading dislocations are indicated by white lines,and the dislocation loops are shown by arrows.

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AIST Today
Vol.5 , No.2 (2005) 24

4H–SiC Lateral RESURF MOSFETs

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AIST Today
Vol.5 , No.2 (2005) 25

We have developed lateral RESURF MOSFETs on 4H-SiC substrates, which has a great potential for SiC power ICs. The 4H-SiC MOS devices, however, had a serious problem that the on-resistance was too high due to its low channel mobility. We have overcome this problem by using 4H-SiC (000-1) C-face substrates. Blocking voltage V_{bd} of 450 V and specific on-resistance R_{ons} of 49 mΩcm^2 were obtained for the lateral RESURF MOSFET on a 4H-SiC C-face. The R_{ons} for the C-face was improved to one thirtieth of the Si-face at the almost same V_{bd}.

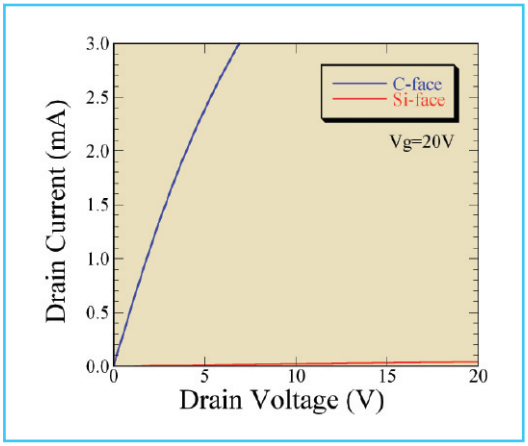

Fig. Drain characteristics of the RESURF MOSFET fabricated on the 4H-SiC Si-face and C-face.

Technology developed by AIST used to neutralize bombs containing poisonous chemicals found in Kanda Port, Fukuoka

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AIST Today
Vol.5 , No.2 (2005) 26

AIST has proven that PCB and other hazardous substances can be neutralized with a high degree of disintegration under the high-temperature and ultrahigh-pressure environment created by an explosion.

Based on the results of these research projects, AIST has successfully developed an unprecedented new technology, for using an explosion to neutralize abandoned chemical weapons (ACWs) produced during World War Two.

This technology was applied in the autumn of 2004 for the destruction of 57 ACWs found in Kanda Port, Fukuoka. The disposal of the ACWs took about one month and was successfully completed without any mishaps or detrimental effect to the surrounding environment. AIST is committed to continuing its research and development to find a swift resolution to this negative legacy.

Photo. Sealed detonation chamber used to dispose of munitions.

Novel Fe–Mn oxide positive electrode for rechargeable lithium battery

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AIST Today
Vol.5,No2 (2005) 27

Novel Fe-Mn oxide positive electrode materials with high capacity (150mAh/g) and superior high temperature (60 ℃) cycle performance has been developed through the combination of material design fully utilizing Fe ion with novel synthetic route for getting homogeneous and fine particles (<100nm). The material belongs a $LiFeO_2$-Li_2MnO_3 solid solution and could be expressed as $Li_{1+x}(Fe_{0.5-y}Mn_{0.5-y}Ni_{2y})_{1-x}O_2$ ($0<x<1/3$, $y=0$ or 0.1). The synthetic route consists of three steps; coprecipitation, hydrothermal and post heat-treatment processes for complete mixing of two or three transition metal ions. As iron resource is available abundantly, it will open the way to the development of low cost lithium ion battery.

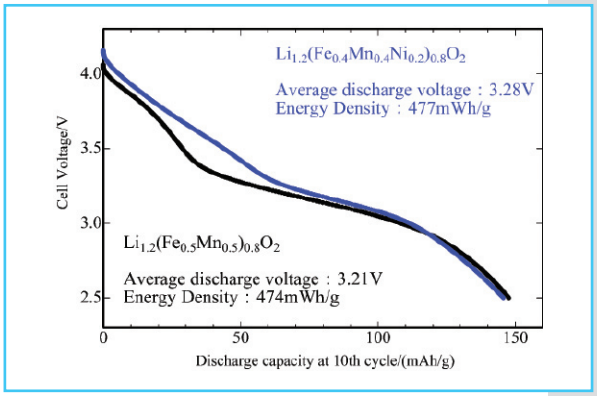

Fig. Discharge curves of two newly developed positive electrode materials against carbon negative electrode after 10 cycles following charging up to 4.3 V at 60 °C.

Decomposition of environmentally persistent perfluorocarboxylic acids by a heteropolyacid photocatalyst

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AIST Today
Vol.5 , No.2 (2005) 28

Perfluorocarboxylic acids have been widely used in industrial applications such as surfactants. The use of these compounds has steadily increased, and some of them have detected in the environment. Hence, it is desirable to develop an artificial method for decomposing these compounds to environmentally harmless species under mild conditions as a measure against stationary sources.

We developed the effective decomposition method for perfluorocarboxylic acids such as perfluorooctanoic acid (PFOA), using a homogeneous system consisting of the heteropolyacid photocatalyst, water, and oxygen. Most of the PFOAs are transformed into F^- and CO_2.

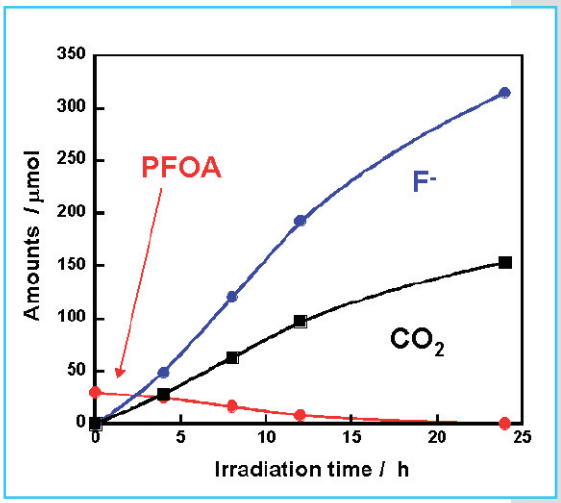

Fig. Irradiation time dependence of the PFOA decomposition. [Reprinted with permission from Environ. Sci. Technol. 2004, 38, 6118. Copyright 2004 American Chemical Society]

Production of Hydrogen Out of Woodchip

Demonstration of Continued Bench Scale Production with Carbon Dioxide Absorbed by Calcium

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AIST Today
Vol.5, No1 (2005) p29

The Biomass Technology Research Laboratory (BTRL) of the National Institute of Advanced Industrial Science and Technology (AIST), an independent administrative institution, succeeded in a demonstration experiment of CO_2 absorption gasification from biomass in collaboration with the Center for Coal Utilization, Japan (CCUJ), a juridical foundation. Using a 10 kg/day throughput continuous production plant, clean fuel gas without including CO_2 was produced: hydrogen 83 %, methane 15 % and output 0.5 Nm^3/h. The successful production in continuous mode will open the way to the biomass utilization at a commercial level.

- While there have been successful cases of clean fuel gas production in batch mode on a laboratory scale, step-up to continuous production has not been readily implemented.
- Continuous production of clean gas without CO_2 is the first feat in the world, and upgrading of gas quality to hydrogen concentration 80 % or higher is also leading the world.

The future efforts will be focused on stable operation, long-term operation and optimization, to establish the prospect for commercial production.

Photo. A picture of bench scale gas production plant.

Development of a new goniophotometer for accurate absolute calibration of total luminous flux

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AIST Today
Vol.5, No1 (2005) p30

The luminous flux is the quantity to represent the optical power that is perceived as light by the human eye, and its scale, lumen is one of the most important photometric quantities. Accurate luminous flux calibration is crucial in many scientific and industrial fields, for example, for quality systems in manufacturing light sources or for reliable evaluation of newly developing light sources such as LEDs and OLEDs. A new goniophotometer system for absolute calibration of total luminous flux has been developed at AIST. The new goniophotometer has the long photometric distance (2.7 m) to minimize the uncertainty due to the lamp alignment. The goniophotometer is calibrated against the illuminance responsivity scale directly traceable to the AIST high-accuracy cryogenic radiometer. The new calibration facility based on the AIST goniophotometer has also been developed. AIST is now offering new calibration services for the total luminous flux of lamps according to Japan Calibration Service System (JCSS).

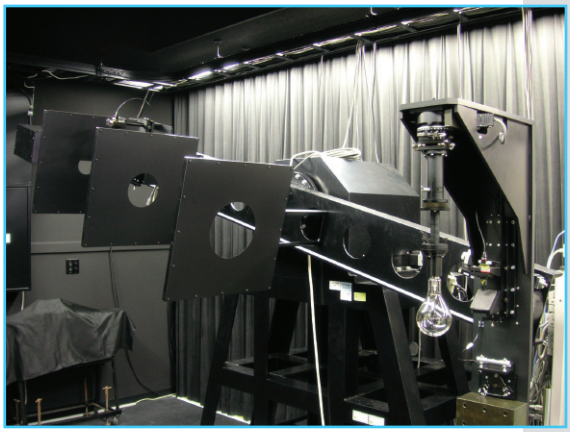

Fig. Photograph of the new AIST goniophotometer

Elucidation of proton diffusion mechanisms by solid-state NMR

Proton diffusion measurements in inorganic solid acid salts (potential solid electrolytes in fuel cells) containing no water

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AIST Today
Vol.5,No2 (2005) 31

Fast proton-conductive materials containing no water are promising in application to solid electrolytes in fuel cells. Some inorganic solid acid salts show high proton conductivity. We have studied proton dynamics in $CsHSO_4$ by means of ^1H solid-state NMR. The proton mean residence times are determined, which can well explain the macroscopic electric conductivity, as shown in Fig. 1. Proton transfer between two neighboring SO_4 tetrahedra takes place much more easily than the reorientation of the SO_4 tetrahedra in both the room-temperature phase and the high-temperature phase. Thus, the SO_4 reorientation limits the rate of the proton transport.

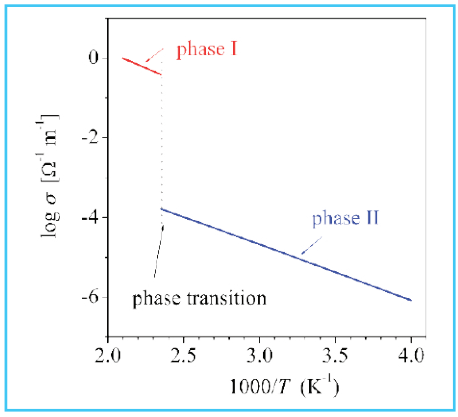

Fig. Proton conductivity estimated from NMR results.

High Accuracy Automatic Fitting for Next Generation Transistor Model HiSIM

Cost Reduction for Development of Semiconductor Manufacturing Process through Application of Genetic Algorithm

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AIST Today
Vol.5,No3 (2005) 24

We have developed an automatic fitting method using the GA (Genetic Algorithm) for next generation transistor model HiSIM (Hiroshima University-STARC IGFET Model) to be used for circuit simulation in the development of advanced semiconductor manufacturing process. The fitting experiments were performed using MOSFET devices fabricated with the most advanced process (90 nm rule) provided by STARC. To accomplish the fitting, it took only a few hours using eight PCs, whereas it would typically take several days even for a skilled person. This technology will be commercialized by the Evolvable Systems Research Institute, Inc., a venture enterprise authorized by the AIST.

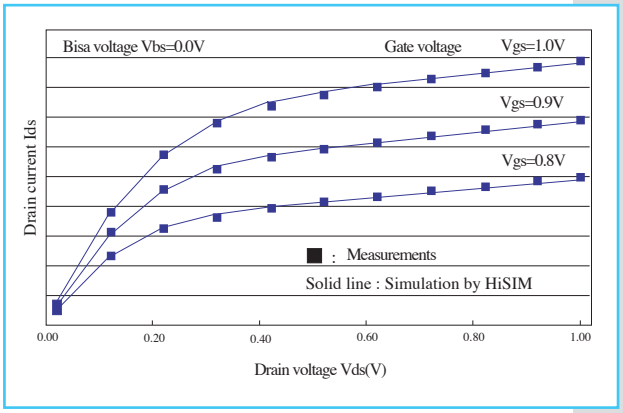

Fig. Fitting results for Ids-Vds characteristics of MOSFET: Lg(Channel length)=0.10um/Wg(Channel width)=2.0um. RMS errors for all devices were within only 2.5%.

Development of High Performance Magnetic Tunnel Junction (MTJ) Devices

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AIST Today
Vol.5 , No.3 (2005) 25

A magnetic tunnel junction (MTJ) device consisting of an ultra-thin insulating layer (called a tunneling barrier) sandwiched by two ferromagnetic electrodes is the key to developing non-volatile memory, MRAM (magnetoresistive random access memory). In the conventional type of MTJ devices, which use amorphous Al-O as the tunneling barrier, the fact that magnetoresistance is only about 70% at room temperature is an obstacle to large capacity MRAM. We developed a new type of MTJ devices using a tunneling barrier of high quality MgO and achieved a huge magnetoresistance ratio of 230% at room temperature. This is the world's highest performance in a MTJ device, at more than 3 times the level in conventional devices (see Fig. 1).

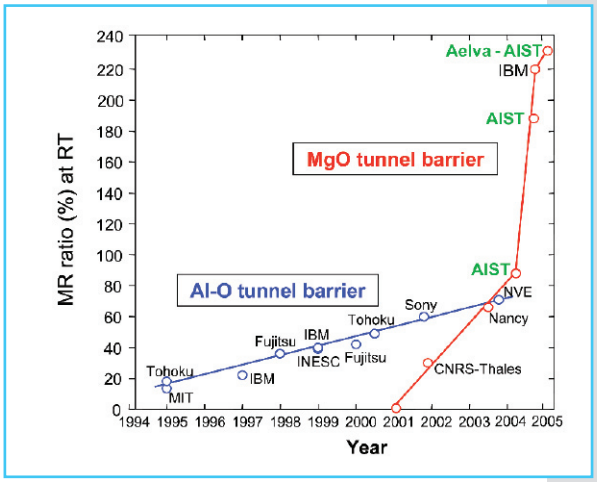

Fig. History of improvement in performance of MTJ devices (magnetoresistance (MR) ratio).

Ceramic Reactor to Purge NOx by Using Power Derived from Exhaust Heat

Utilization of Electrochemical Device for Purging Vehicle Exhaust Gas

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AIST Today
Vol.5, No3 (2005) p26

The AMRI-AIST has been engaged in R&D of technology of electrochemical purging for NOx by using electrochemical reactor based on oxygen ion-conductive ceramics, and succeeded in decomposing NOx in oxygen-rich (3 % or more) gas mixture into N_2 and O_2 with an electrochemical reactor selectively and continuously, using very little electric power. The technology is attracting worldwide attention as zero emission purging, characterized by directly decomposing NOx by electrical means, in comparison to the conventional catalytic method with combined reductive agents. On the other hand, the electrochemical reactor system requires electric power to drive the reactor, in contrast to the catalyst method. As one of means to solve this problem, it has been attempted to provide electric power for driving the electrochemical reactor through power generation based on temperature difference between exhaust heat in waste gas and atmosphere by using thermoelectric conversion ceramics (Fig1).

It has been demonstrated that the thermoelectric conversion as high as 40 mW/cm2 is obtained for a temperature difference of 500 oC with a pair of thermoelectric ceramic devices. Moreover, the characterization of a compound module prepared by combining in series 37 pairs of 2× 2 x 20 mm rectangular solid modules has proved to generate 300 mW power (at 3.5 V) for around 650 ℃ temperature difference (with one end of junction heated to 800 ℃ while air-cooling the other, verifying the availability of the module as power supply for NOx purging electrochemical reactor.

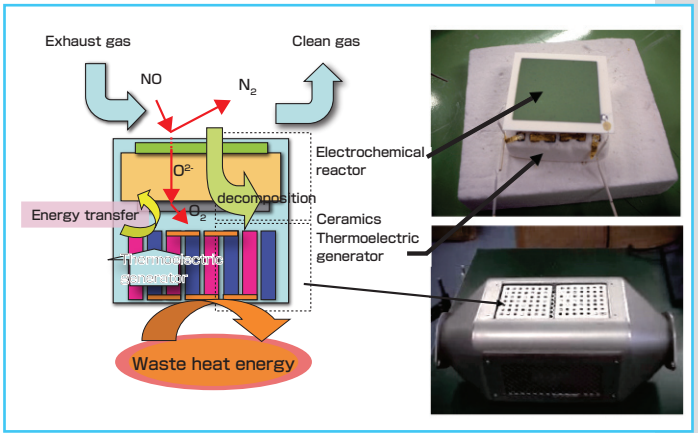

Fig.1 The principle of NO_x decomposition by electrochemical ceramic reactor using waste heat power generation.
Fig.2 NO_x decomposition electrochemical cell connected with oxide thermoelectric generator, and the example of NO_x decomposition reactor.

New Li–Mn–O Cathode Materials with High Voltage and Capacity

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AIST Today
Vol.5,No3 (2005) 27

We have synthesized $Li_{0.44}MnO_2$ with a tunnel structure by ion exchange reaction in molten salt using $Na_{0.44}MnO_2$ as a precursor. ICP-AES analysis indicated the Na/Li ratio in the present $Li_{0.44}MnO_2$ sample was less than 0.003. The electrochemical tests using lithium metal anode showed the good charge-discharge cycles, and its initial discharge capacity of 166 mAh/g between 2.5 and 4.8 V. A plateau region above 4 V was first revealed in the present study. Partial replacement of manganese with titanium upgrades the performance further to initial discharge capacity of 177 mAh/g.

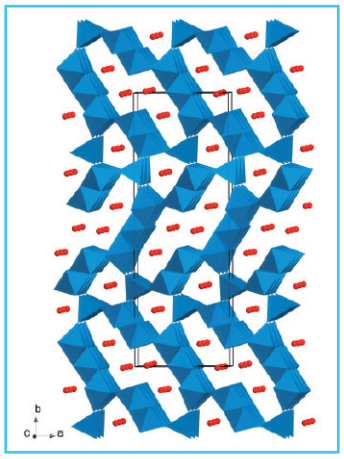

Fig. 1. Crystal structure of $Li_{0.44}MnO_2$.

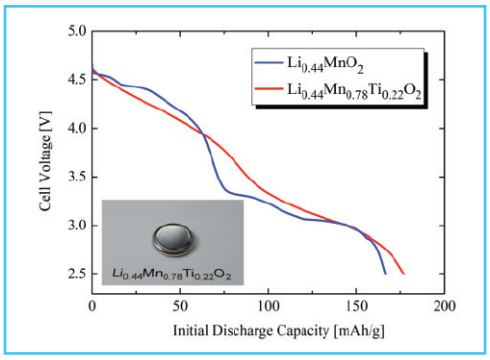

Fig. 2. Initial discharge curves of newly developed lithium manganese oxide cathode materials and its capacity upgraded by substitution with titanium, using lithium metal anode after charging up to 4.8 V. The photograph is prototype coin-type cell.

Novel Ionic Liquids Electrolyte for Li Metal Anode

Ionic Liquids Based on Aliphatic Quaternary Ammonium

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AIST Today
Vol.5,No3 (2005) 28

We have synthesized new ionic liquids based on aliphatic quaternary ammonium and fluorine-contained anion. Especially, N-methyl-N-propylpiperidinium (PP13) bis(trifluoro-methylsulfonyl)imide (TFSI) exhibits wide electrochemical windows comparing with conventional RTILs based on 1-ethyl-3-methylimidazolium (EMI) and TFSI. In the RTIL (PP13-TFSI), lithium metal could be electrochemically deposited on a metal electrode. The most striking feature was that the surface of the deposited lithium was very smooth comparing with a dendritic deposition in an conventional organic electrolyte.

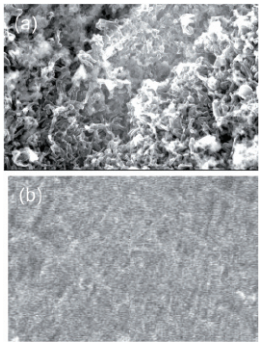

Fig. 1 SEM pictures of electrochemically deposited Li metal.
(a) in an organic solvent (PC), (b) in PP13-TFSI.

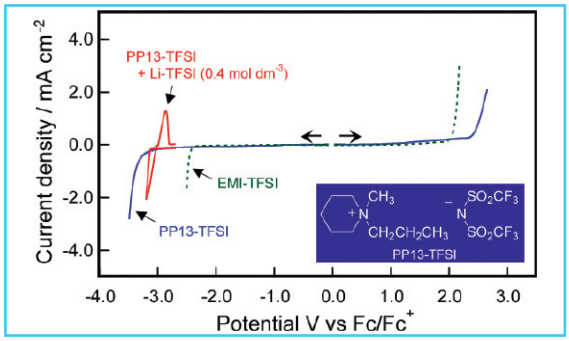

Fig. 2 Various voltammograms taken in RTILs at 298 K. (blue) linear sweep voltammograms (LSV) of PP13-TFSI on glassy carbon electrode (GC); (green) LSV of EMI-TFSI on GC; (red) cyclic voltammogram of PP13-TFSI containing Li-TFSI. Scan rate = 50 mV/s.

Transient uplift after a 17th-century giant earthquake in Hokkaido

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AIST Today
Vol.5 , No.3 (2005) 29

While the geodesic data indicate that the Pacific coast of eastern Hokkaido is sinking for the past hundred years, the geological data shows slow coastal uplift for the past hundred of thousands years. In order to solve this mysterious controversy, the Active Fault Research Center has investigated volcanic ash deposit, tsunami deposit and fossil diatoms in the coastal geological layers, and found a coastal uplift of 1 to 2 m over decades following multi-segment interplate earthquakes occurred in the 17th century. A model computation indicates that the coastal uplift is due to fault movement at a depth below the seismogenic zone of the interplate earthquake.

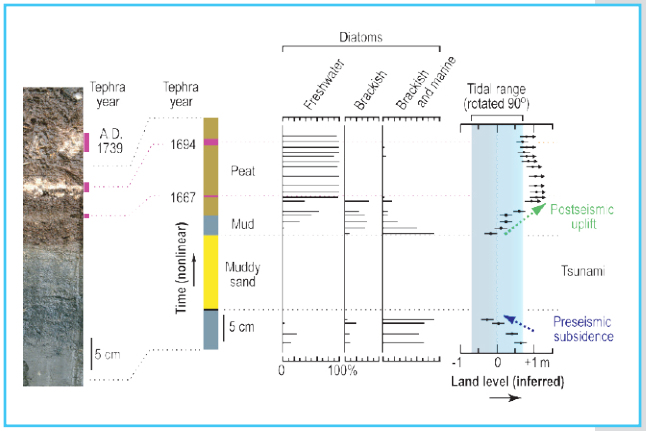

Fig. Changes in the coastal elevation (right) is estimated on the basis of fossil diatoms (center) contained in the coastal deposit (left). Layers of mud and peat deposit are sandwiched between a sand deposit brought by a tsunami from a giant earthquake in the 17th century in the bottom and a volcanic ash in the top. The identification of diatom species suggests a slow rise of the coast.

Density and thickness measurement of a thin-film by the pressure-of-flotation method

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AIST Today
Vol.5, No3 (2005) 30

A new method for density and thickness measurements of a thin-film is proposed by a pressure-of-flotation method (PFM). A density difference is determined by the PFM while a mass difference is measured by an electric balance for the samples before and after thin-film is prepared on a substrate (Fig). Then, the density and thickness of the thin-film on the substrate can be derived. The density and thickness of a molybdenum thin-film prepared on a silicon substrate are evaluated by this method. The estimated standard uncertainties of density and thickness for the molybdenum film are 3.8 % and 4.0 %, respectively.

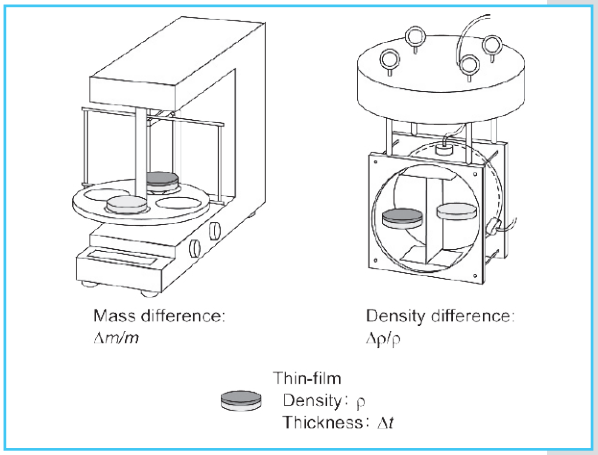

Fig. Density and thickness measurement of a thin-film by density and mass comparisons.

Progress in the Research on the Thermometry in Magnetic Fields

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AIST Today
Vol.5, No3 (2005) p31

Two temperature fixed points, triple point of water (273.16 K) and argon (83.8058 K), were developed to be used in magnetic fields. As their temperature values are not affected by magnetic fields, they serve as ideal tools to study the magnetic field effects on the various temperature sensors. For example, a correction function for a platinum resistance thermometer was proposed with a basis on the results at the triple point of water and its applicability was assessed by argon triple point to have an accuracy of 3%.

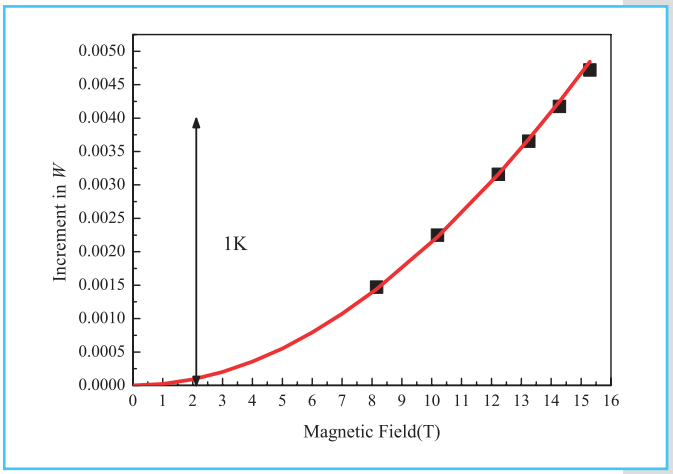

Fig. Assessment of the scaling rule for the magnetic field effect on a platinum resistance thermometer. The experimental results at argon triple point(■) agree with the predicted curve(—)determined by the data at the triple point of water.

Coherent control of molecular orientation by two-color laser fields

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AIST Today
Vol.5,No3 (2005) 32

We demonstrate molecular orientation by using phase-controlled two-color ω +2 ω laser pulses with an intensity of 1.0×10^{12} W/cm^2 and a pulse duration of 130 fs. This method performed well because (1) molecular orientation can be achieved by only optical fields; (2) the direction of orientation is easily switched by changing the sign of the quantum interference; and (3) this method is free from any resonance constraint and thus can be applied to any molecule.

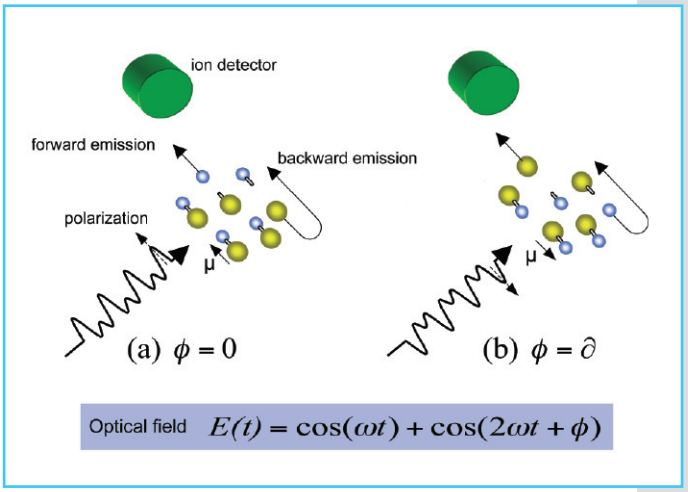

Fig. Method to observe molecular orientation induced by phase-controlled two-color ω +2 ω laser pulses.

The asymmetry of ω +2 ω field can discriminate between parallel and antiparallel configurations of polar molecules. The orientation of molecules can be monitored by the directional asymmetries of the photofragment angular distribution in dissociative ionization.

In-Ambulance Remote Image Acquisition System Based on New Data-Compression Technology

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AIST Today
Vol.5 , No.1 (2005)10

The Advanced Semiconductor Research Center (ASRC) of the National Institute of Advanced Industrial Science and Technology (AIST), an independent administrative institution, has developed in collaboration with the Tsukuba Medical Center Hospital (TMCH) and the Tsukuba City Fire Department (TCFD) under the Urban Area Tripartite (Industrial-Academic-Governmental) Collaboration Promotion Program of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), a system named "In-Ambulance Remote Image Acquisition System" which allows doctors sitting in the emergency ward to monitor images, both moving and still, of medical scenes within an ambulance rushing back to the hospital, through their own camera operation. The system is expected to contribute to upgrading lifesaving performance of the emergency medical service requiring prompt treatment.

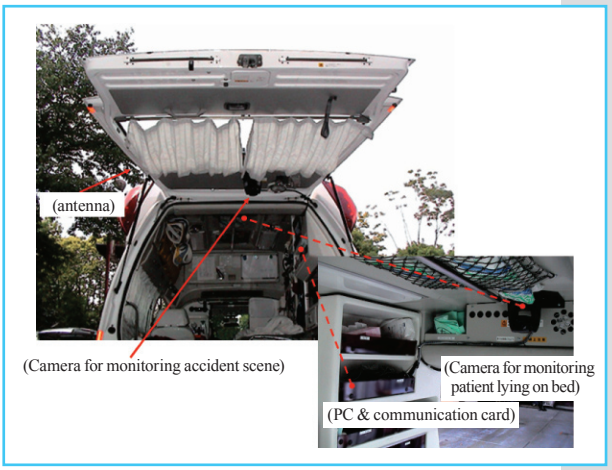

Fig. Overall view of the system installed on an ambulance with cameras and PC.

New Road to Cancer Therapy Opened through Nanotechnology

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AIST Today
Vol.5 , No.2 (2005)14

Quantum dot refers to a particle of a few nanometer size, made of inorganic semiconductor. When irradiated with ultraviolet rays, it gives strong fluorescent emission. It has been regarded as a means for imaging genes and proteins in cells, as well as cancer cells within the body. The SMBL-AIST has developed technique to prepare the quantum dot in a simple way, and that for combining antibody or lectin identifying cancer cells with quantum dot. In this way, technology for distinguishing cancer cells from normal ones has been successfully developed. Moreover, it has been found that cancer cells selectively ingested quantum dots are readily killed by the irradiation with ultraviolet rays. This is the first achievement in the world to clearly show that quantum dots are applicable not only to molecular imaging but also to photodynamic cancer therapy.

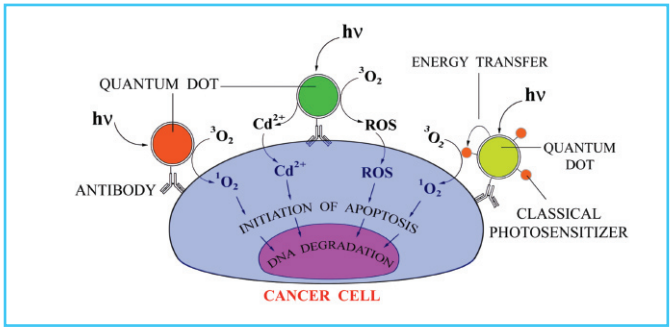

Fig. Potential mechanisms for photosensitizing activity of QDs in viable cancer cells.

The Sumatra Earthquake and Tsunami in the Indian Ocean

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AIST Today
Vol.5, No1 (2005) p18

The December 26, 2004 Sumatra earthquake generated tsunami in the Indian Ocean and caused more than 200,000 casualties. AIST made computer simulation of the tsunami (Figure) in the same day and the animation was posted on the website. It reproduced the observed features of the tsunami; the initial tsunami to the east (e.g., Phuket) began with receding wave while to the west (e.g., Sri Lanka) large wave suddenly reached, and the tsunami was larger in the direction perpendicular to the fault orientation. On the following day (December 27) alone, more than 60,000 accesses from all over the world were recorded.

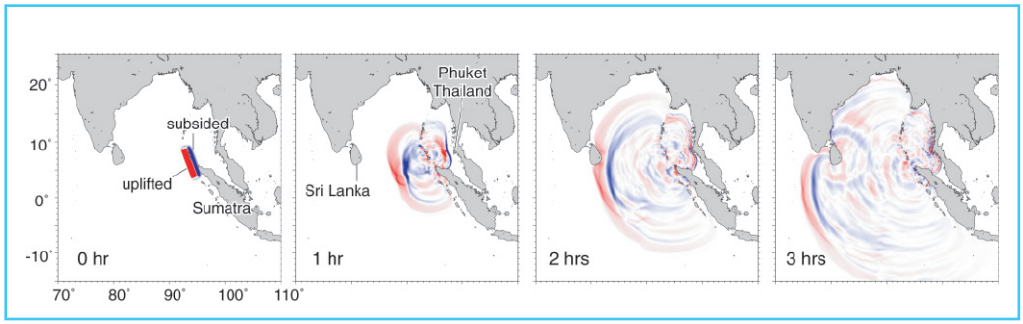

Fig. Computer simulation of the tsunami propagation in the Indian Ocean. Red color means that the water surface is higher than normal, while blue means lower. The darker the color, the larger the amplitude.

World's First Room-Temperature Ice Nanotube Is Discovered

Opening the way to understanding the behavior of water molecules in nanometer-scale environments

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AIST Today
Vol.5,No3 (2005) 18

The Nanotechnology Research Institute of the National Institute of Advanced Industrial Science and Technology and Graduate School of Science in Tokyo Metropolitan University have performed a detailed analysis of the structure of water in a single-walled carbon nanotube (SWCNT) by means of X-ray structural analysis conducted at the Photon Factory of the High Energy Accelerator Research Organization (KEK), an inter-university research institute corporation. The detailed structural analysis found that water within SWCNT forms tubular ice, called ice nanotube (Ice-NT), at lower temperatures. It was found that there was a tendency for the melting point of Ice-NT to vary greatly depending on the diameter of the SWCNT, with the melting point becoming higher as the diameter of the SWCNT becomes narrower, contrary to existing empirical rules. In particular, water in SWCNT with a diameter of 1.17 nm crystallizes at 300 K or lower. In other words, it was proved that Ice-NT could be formed at room temperature. Moreover, it was discovered that, at approximately 45 ℃ , water within SWCNT would vaporize and be ejected, leading to the possibility of a number of applications, including nano-size inkjet printing.

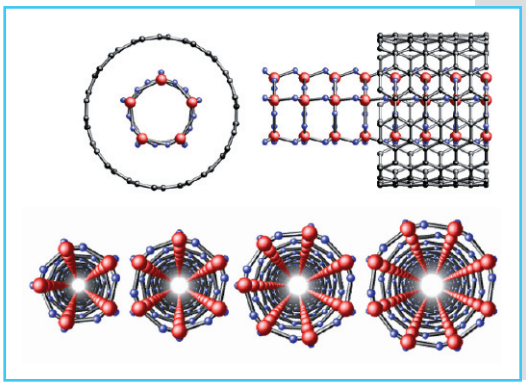

Fig. A schematic diagram of Ice-NT
Top: 5-membered ring Ice-NT formed inside SWCNT. The melting point is 300K.
Bottom: From left to right: 5-membered ring, 6-membered ring, 7-membered ring, 8-membered ring Ice-NT found in this research. Red sphere: oxygen atom; Blue sphere: hydrogen atom; Black: carbon atom.

Further development of profile–profile alignment methods for protein structure prediction

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AIST Today
Vol.5 , No.3 (2005) 22

We had developed our own profile-profile comparison method, FORTE1 to make use of known structural information for protein structure prediction. The FORTE1 system utilizes the correlated coefficient as a similarity measurement between two profile columns to be compared. Our team employed several descendants of our unique profile-profile comparison method (FORTE Method; Patent Pending) – and won the third place, and was invited to give a presentation of our achievements in CASP6, the 2004 Olympic games of protein structure prediction. The techniques developed by us are expected to be applied to infer protein structures and functions for genes whose information will become more available through the genome projects.

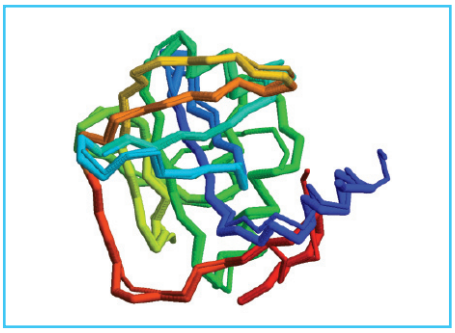


Fig. An example of the prediction result (PDB ID:1WGB) using the FORTE method in CASP6.
A thick line shows our prediction model and a thin line shows the native structure.

Collaboration agreement signed by AIST and Singapore's A*STAR

AIST signed a collaboration agreement with the Agency for Science, Technology and Research (A*STAR), one of Singapore's major research organizations, on Oct. 19, 2004. Both agreed to future programs to exchange personnel and information, hold workshops, and conduct collaborative research.

A*STAR is in charge of twelve research institutes in Singapore covering a large range of topics including bio-technology, information technology, and materials science. A*STAR also plays a major role in supporting Singapore's industrial science and technology, and is authorized to contribute to government policies related to science and technology, and to manage the relevant budget. A*STAR is strategically important for AIST in developing a network of cooperative research partners within Asia.

Mr. Boon Swan Foo, managing director of A*STAR, is a member of the AIST Advisory Board, and AIST's President Hiroyuki Yoshikawa serves as a board member of A*STAR. The signing ceremony for the agreement took place at AIST Tsukuba Center during Mr. Boon's visit to Japan to attend an Advisory Board meeting at AIST.

The 4th AIST Workshop on LCA for APEC Member Economies

An AIST workshop on Life Cycle Assessment (LCA) for APEC member economies entitled "Capacity Building in the Region" was held at the Tsukuba International Congress Center from October 26 to 27, 2004. It was sponsored by the Research Center for Life Cycle Assessment,AIST. The Sixth International Conference on EcoBalance was held at the same time. This is the fourth time the workshop on the status of LCA projects in APEC economies and surrounding regions has been held since 1998.

The participants came from a total of nineteen countries, including a number of European entries. The fifty delegates were able to participate in a number of stimulating discussions during the two-day event.

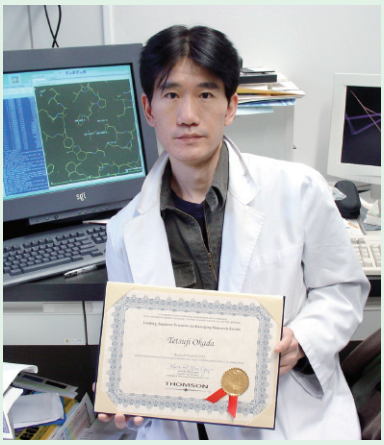
During the conference, AIST representatives reported on the LCA status of various countries, as determined by surveys that were collected by AIST, then discussed the progress that was being made. Delegates then listened to LCA status reports by members of the United Nations Environment Programme, and representatives of Holland, Germany, and other countries. The Chilean representative proposed that APEC countries clarify the definition of "life cycle inventory" and that life cycle concept should be made mandatory. Moreover, it was deemed necessary to involve private organizations in order to attract attention to this important issue.

The members of APEC economies participated in lively discussions to determine effective ways to cooperate on LCA issues in the future.

Tetsuji Okada, Senior Research Scientist at the Biological Information Research Center receives Research Front commendation

On Nov. 2, 2004, a celebratory event was held to commend Japanese researchers who have made a significant contribution to emerging Research Fronts (defined as a set of seminal papers in a specialized or highly focused area of research). Thomson Scientific Corporation developed the idea of the Research Front. A total of 13 Research Fronts and 16 outstanding Japanese researchers were identified by determining the most highly-cited papers and how they related to one another, using Thomson database. Tetsuji Okada of the Molecular Functional Analysis Team at AIST's Biological Information Research Center was identified for his work in structural biology.

Dr. Okada was commended for his work on the structure determination of the prototypical member in the largest membrane protein family of the human genome. He wrote four papers which were cited 1,100 times. His most frequently referenced paper was "Crystal structure of rhodopsin: AG protein-coupled receptor: Science 289 (5480), 739–745."



Research cooperation initiated between AIST and the Vietnamese Academy of Science and Technology

AIST and the Vietnamese Academy of Science and Technology (VAST) signed a research cooperation agreement at joint workshop held in Hanoi from Dec. 15 to 18, 2004.

AIST is working towards becoming a hub for a network of major Asian research organizations while setting up an environment to support overseas development for Japanese industries. To that end, AIST signed a general agreement on research cooperation with VAST, the largest national research organization in Vietnam, and held a joint workshop to advance the progress of cooperation.

The workshop was sponsored by Japan's Ministry of Economy, Trade and Industry (METI), NEDO, JETRO and JICA. There were about one hundred participants and they discussed three major topics. The first topic involved environmentally conscious technologies, such as effluent liquid waste processing by the textile industry and metal plating, including heavy metals, and protection from pollution in aquacultural development areas for shrimp and prawns. The second topic was information technology including geological information processing using natural language and grid technology. The final topic was marine geology, including efforts to produce geological maps of the South China Sea, and the possibility of using satellite data to predict flooding.

At the signing ceremony, Senior Vice-President Kisaburo Kodama signed for AIST and President Dang Vu Minh signed for VAST. The ceremony was followed by speeches by Dr. Dang and other guest speakers, including Mr. Hachiro Okonogi, Japan's Vice-Minister of Economy, Trade and Industry, Dr. Le Dinh Tien, Vietnam's Vice-Minister of Science and Technology, Mr. Norio Hattori, the Japanese Ambassador Plenipotentiary to Vietnam, and Mr. Hiroyuki Fujimura, the Chairman of the Industrial Division of the Tokyo Chamber of Commerce and Industry.

AIST and Thailand's core research organizations sign general agreements on research cooperation following a joint workshop

Recognizing its role as a Japanese research institute within the larger Asian community, AIST is working towards becoming an Asian hub organization that will promote the development of excellent human resources for research in the region. The institute is also developing a strategy to disseminate AIST research throughout Asia to foster sustainable development on a global scale. To that end, AIST signed general agreements on research cooperation on Nov. 25, 2004, in Bangkok with two core Thai national research organizations: the National Science and Technology Development Agency (NSTDA) and the Thailand Institute of Scientific and Technological Research (TISTR). The signing ceremony was part of the Thailand-Japan Collaboration Workshop held on Nov. 24 and 25.

The workshop addressed issues in recycled and distributed energy, such as biomass and photovoltaic energy, and other environmental technologies. It also covered nano-technology and new materials development. Since the Asian region has the most abundant biomass resources in the world, there were discussions on the possibility of using energy in multiple ways to utilize biomass resources effectively. Participants also addressed the idea of centralizing diversified biomaterials marketplaces and reducing CO_2 emissions by increasing biomass production through forest regeneration and tree planting in desert regions.

Attendees included forty researchers, specialists and associated partners from AIST, industry, and academia including on-site staff of the Japan International Cooperation Agency (JICA), the Japan External Trade Organization (JETRO), and the New Energy and Industrial Technology Development Organization (NEDO). In additions, there were sixty Thai researchers and specialists from NSTDA and TISTR, bringing the total attendance to 100.

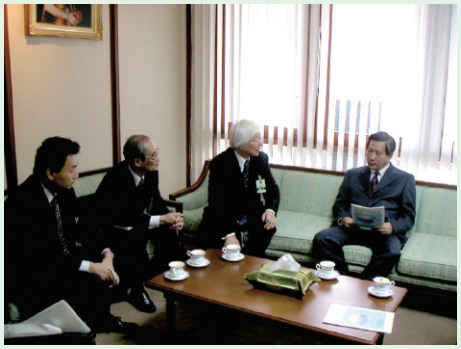
Each research organization introduced itself briefly and presented international and Asian strategies. Participants discussed potential topics for cooperation in research and development, and ways to manage such projects. The workshop was then divided into two sections, one on energy and environment and the other on materials and nano-technology, at which the Japanese and Thai researchers reported on their studies and considered possible future collaboration. Finally, the chairperson of each session proposed topics for possible collaboration: 11 research items in energy and environment fields, and 14 in materials and nano-technology fields.

The ceremony for signing the agreements was held at the end of the workshop. President Sakarindr Bhumiratana signed for NSTDA, Governor Nongluck Pankurddee signed for TISTR, and President Hiroyuki Yoshikawa signed for AIST. NHK, Japan's national broadcaster, reported on the ceremony, interviewed President Yoshikawa, and televised it on a nation-wide news program on the morning of Nov. 26.

During the tight schedule of the workshop, AIST President Yoshikawa, Vice-President Naohiro Soga, and Director-General for International Affairs Takayuki Matsuo met with Thailand Vice-Premier Phinij Jarusombat and Mr. Korn Thapparansi, Minister of Science and Technology. Both Thai representatives warmly welcomed the plan for collaboration between Thai research organizations and AIST, giving their full support to sustainable development as a momentous and collective issue that demanded collaboration throughout the world.

It was determined that a follow-up meeting would be held in March 2005 in Japan to discuss further details. In addition, the Biomass-Asia Workshop 2005 was planned for Japan in January 2005.

Heads of three organizations at the signing ceremony:
From left, Governor Nongluck of TISTR, President Yoshikawa of AIST, and President Sakarindr of NSTDA.



Meeting with Vice-Premier Phinij (right) .

Poster Prizes awarded on two consecutive days during 2004 Fall Meeting of MRS

The Materials Research Society (MRS) is one of the largest societies for research in materials engineering and nano-technology. During the 2004 Fall meeting of MRS, two researchers from AIST's Research Institute for Ubiquitous Energy Devices were awarded Poster Prizes on consecutive days. On Nov. 29, 2004, Dr. Satoshi Ichikawa (center left) received a prize for his paper "Electron Holographic Characterization of Nano-Hetero Interface Effect in Gold Catalysts". On the following day, Dr. Tomoki Akita (right) was recognized for his paper "Analytical TEM Study of the Degradation Phenomena in Proton Exchange Membrane Fuel Cell".

Dr. Ichikawa characterized the atomic and electronic structures at nano-hetero interfaces between gold particles and titanium oxide supports using electron holography in order to elucidate the catalytic mechanism in cooperation with first-principle calculations. Dr. Akita investigated the degradation phenomena of the proton exchange membrane fuel cell (PEMFC) by an analytical transmission electron microscope. This investigation revealed the nano-scale structural changes in the electrocatalyst and the membrane. Only four presentations are awarded the Poster Prize from among several hundreds of poster presentations on each day. The fact that researchers from the same research organization received two separate Poster Prizes proves that the AIST is fostering a high level of achievement. This is a proud accomplishment for any world organization.
http://unit.aist.go.jp/ubiqen/index.html

Biomass Asia Workshop 2005 held in cooperation with the Ministry of Agriculture, Forestry and Fisheries of Japan

AIST held an international workshop called "Biomass Asia Workshop 2005" from Jan. 19 to 21, 2005 in Tokyo and Tsukuba in cooperation with Biomass Nippon at the Ministry of Agriculture, Forestry and Fisheries.

Biomass is drawing public attention these days as a recyclable organic resource. It is necessary to build strong partnerships with Asian countries in the future in order to utilize these resources effectively. This workshop was held to determine the future direction of policies for industry and agriculture and for research and development. Decisions will be based on the exchange of policies, techniques, and opinions among staff members of Japanese industries and government organizations and the government administrative offices and research organizations in other Asian countries.

Biomass Asia Workshop 2005 was the first multi-level meeting that AIST has organized in cooperation with associated Asian government organizations and research organizations on the topic of cooperation in the field of biomass. Through this workshop, AIST will be able to take a leading role in the establishment of networks and partnerships in Asia. These efforts should raise AIST's profile in Asian countries.

This workshop helped to build a network among government and research organizations in Asian countries. It served to outline the current situation and address issues facing each country. Additionally, it helped to create opportunities for the newly developed human resource network and pave the path for future research collaboration.

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