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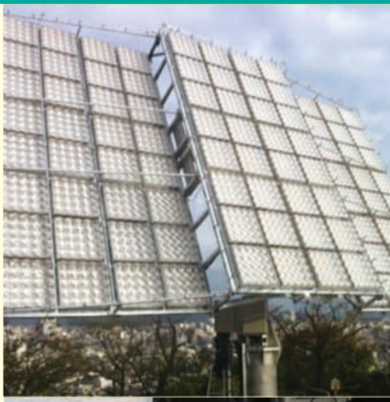

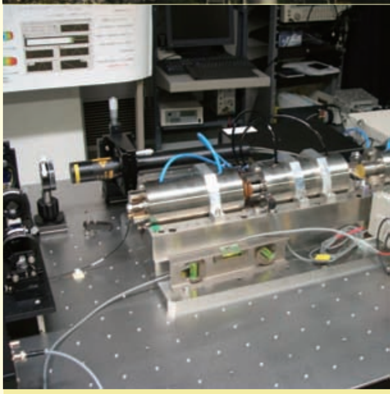

MESSAGE

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UPDATE FROM THE CUTTING EDGE（October−December 2010）

## In Brief

# President's Message
# Thoughts for the New Year-2011

**Tamotsu NOMAKUCHI**

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

## 1. Introduction

A new year has arrived. As I did a year ago, I would like to look back over the past year and share my thoughts for the year to come.

Although the global economy as a whole is recovering from the consequences of the Lehman Shock in 2008, the economies of the industrialized countries including Japan, the United States, and European countries appear to have not regained their former momentum. What concerns me more than these observed economic developments, however, is that global issues such as climate change and natural resources are becoming increasingly serious. In my New Year Greetings for 2011, I would like to mention the R&D and innovation environment surrounding AIST in the Third Term, which was launched at a time of such difficult circumstances.

## 2. Third Term of AIST and the new organizational and operational structure

The Third Term of AIST (covering the five years from April 2010 to March 2015) began in April last year. Today, while benefiting from the advancements made in science and technology and the industrial field, we are faced with new issues involving the environment, natural resources, and ethics. Our research and development activities must be well balanced, with consideration given not only to contributing to market growth and improved convenience but also to addressing these issues. I included “finding solutions to 21st century issues” in our missions in order to express this standpoint. I am aware that we have significant responsibilities for the achievement of “green innovation” and “life innovation” as set forth in the government's economic growth strategy, as well as “the development of unparalleled state-of-the-art technologies”.

Another important mission is “enhancement of the functions as a hub for open innovation”. With the increasing diversity of technologies and the accelerating speed of technological development, the view is widely shared that companies will lose competitiveness if they persist in developing technologies by themselves, and that open innovation, in which companies use external resources to increase the quality and speed of research and development, is a useful approach. Open innovation involving collaboration between industry, government, and academia is now considered to be an appropriate means of promoting, in a well-balanced manner, the research and development mentioned above and of conducting activities to maintain competitiveness, such as international standardization. As a public research institution, AIST is expected by various sectors to play the role of a hub for these activities. Examples of open innovation activities carried out by AIST, such as participation in technology research associations, are described in the September 2010 issue of *AIST TODAY*. Other forms of open innovation activities are also available as appropriate to the target, including forming consortiums, integrating databases and making them available to external users, and forming collaborative research teams.

We reviewed our organizational and operational structure in October last year (as mentioned in the October 2010 issue of *AIST TODAY*). Japanese industry is in an increasingly difficult position in the world. In The Third Term, we need to further enhance our roles of leading the country’s industry in collaboration with universities and supporting industrial infrastructure. Based on this understanding, we have made changes to improve the intellectual productivity and creativity of AIST as a research institution. These changes were made possible by the efforts of many individuals, bringing up ideas such as improving our internal communication, enhancing our capabilities for coordination with external parties, and reducing the distance between research units and supporting divisions. We are expected to produce excellent research results, as well as demonstrate their commercialization potential, develop them into intellectual properties and standards, provide technical consultation, and nurture human resources. Thus, the expectations placed on us are diverse. I believe that we are now capable of working together more effectively to live up to these expectations. Assistance from research supporting divisions is also important for open innovation. I hope that those in the supporting divisions will also develop into key people who can contribute to making AIST a world-class research institute.

AIST's research results are used in the core of the IT system for administrative work. The system flawlessly manages major changes in personnel and workflows.

We discussed and made preparations for the organizational and operational changes over a period of more than a year. The motivation of AIST members to actively participate in the discussions and preparations was admirable.

## 3. Japan’s industrial competitiveness

I participated in the panel discussion at the “Industry, Government and Academia + IEICE Symposium” held in May last year by the Institute of Electronics, Information and Communication Engineers (IEICE), with Vice-President Nishio of Osaka University, and people from industry and the media. The theme of the symposium was “Let's discuss the redevelopment of the ICT industry! – What can industry, government and academia do? What can IEICE do?” The symposium was organized by IEICE, which is deeply concerned about the diminishing presence of Japan's ICT industry in recent years and feels responsible for it. I admire its intention to restore Japan's competitiveness.

However, I rather disagree with the claim of industry and the media that the declining competitiveness of Japanese industry is due to a lack of research and development capabilities or a lack of innovation based on insufficient capabilities. I think that industrial competitiveness involves many factors, including public burdens such as corporate taxes and social security costs; labor costs; the nation's labor supply as a whole; educational levels; laws and regulations; the intellectual properties system; the structure of collaboration among small, medium, and large enterprises; and currency exchange rates.

Japan overcame the turbulent period after the war, continued to grow economically in the 1960s and 1970s, and, in the mid-1980s, became an economic power comparable to the United States and Europe. What was the level of Japan's research and development capabilities during these periods? I think that Japan was criticized for "a free ride on basic research" and its R&D capabilities were not highly recognized. The Japanese were keen to catch up with and surpass the developed countries. Many young people entered university to study science and technology, and strove to achieve world-class levels of research and development. For some time after the end of the war, Japanese products had the reputation of being "cheap and low quality". However, as a result of people's hard work, Japanese products came to dominate the world market with their high productivity and quality. In this process, Japan improved its research and development capabilities, but public burdens and overhead expenses increased and have remained high. Japan has become a high-cost country and is in a situation that supports the assertion that its competitiveness has declined.

How can we shine again? There is no royal road to achieve this. Rather, I believe that we just need to continue improving the factors mentioned above with patience. What is important is to restore the spirit of being "challengers", which has been lost in the space of only several years since the time when we considered ourselves to be the world leaders in industry. More importantly, we need to shine in a manner suitable for Japan as an industrialized country that is different from the way we used to shine. We are in an era when we need to innovate our ways of doing business. We need to change the business model that has focused only on increasing the scale of business and market share by mass-marketing products, to one that can continue to provide solutions over a long period in order to achieve an eco-friendly, safe, secure, and healthy society, including consultations, services, operations, maintenance, and nurturing of human resources. The government and business circles should develop national and corporate policies to realize practical measures, with a clear understanding of the needs described above.

Our research and development activities should contribute to the continuous improvement and maintenance of competitiveness in this new era. I believe that such aspirations are reflected in the Third Term Research Strategy of AIST.

## 4. Diversity

The 10th meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 10), held in October last year in Nagoya, is still fresh in our memories. We understand that diverse living organisms live harmoniously supporting one another on the Earth and that human beings are no exception. However, the reality is that industrial development has resulted in environmental destruction and the anthropogenic movement of species, causing damage to biological habitats and relationships, leading to the extinction of tens of thousands of species each year. In order to prevent this, the Convention on Biological Diversity was established to put biological protection into action, and give consideration to the sustainability of the use of biological resources and the fair and equal sharing of the benefits from the use of biological resources among the countries and regions involved. Biological resources that are most abundant in developing countries are now recognized as playing an important role in innovation. Although this made it difficult for the parties to form a consensus, the Nagoya Protocol was finally concluded. The discussions will continue. We hope that the Protocol will be effective and would like to provide support to make it a reality.

Speaking of diversity, we live diverse lives. Last year, we discussed the career paths of researchers in the process of reviewing our organizational and operational structure. It is desirable that all individuals who join AIST as researchers become leading researchers known throughout the world, but in reality, this is not the case. We have diversified career paths. For example, researchers can broaden their areas of study through participation in interdisciplinary research projects or move to universities or the private sector.

However, when we think about the roles that society expects researchers to fulfill, we find that there are diverse expectations. They are expected to play a role in science and mathematics education from the primary school through university levels, science and technology communication, research coordination, coordination of collaboration with the private sector, consultation on intellectual properties and technologies, domestic and overseas project management, and improvement of research environments. The Council for Science and Technology is suggesting that these functions of people with scientific and technical background should be enchanced. Some of them have been iomproved at AIST so far, and I believe that we can broaden the areas in which we play a major role.

In the Third Term, I would like to make it possible for all those involved in conducting and supporting research to design diverse career paths.

## 5. Celebrating Dr. Junko Nakanishi's winning of the Person of Cultural Merit Award

In November last year, Director Junko Nakanishi of the Research Institute of Science for Safety and Sustainability was chosen as a Person of Cultural Merit. In the preceding year, Director Sumio Iijima of the Nanotube Research Center was awarded the Order of Culture. AIST members thus had the honor of receiving awards twice in a row. Everyone acknowledges that most of Dr. Nakanishi's accomplishments in the field of environmental risk management were made during her years at the University of Tokyo and Yokohama National University. She has also made significant accomplishments as a researcher and leader at AIST. This makes us feel both gratified and honored. In the beginning, the industry in which I worked did not have a positive attitude toward her field of work. Over the course of time, however, her thoroughly impartial scientific discussions made the industry recognize her work and earned her their deep trust. We can say that the research by Dr. Nakanishi and her coworkers has significantly contributed to an enhancement of the “dignity” of the efforts by Japanese industry and society at large to improve the environment and safety in the eyes of the world.

When she told me about the award, I said, “You may get a call from the Nobel Prize Committee someday”. Advances in science and technology have provided many benefits but also posed many risks to humankind. In order for science and technology to progress in an appropriate manner that is useful for humanity, the area of research pioneered by Dr. Nakanishi should receive greater recognition and be further advanced.

## 6. AIST Open Lab

AIST Open Lab provides a good opportunity for people outside our organization to see our “*Full Resaerch*”, from basic to applied research through to practical use. More than 3,500 people from throughout Japan visited AIST Open Lab 2010 held on October 14 and 15. Some 88 % of the visitors were from the private sector, while the remainder were from universities, public research institutions, and administrative bodies. About 15 % of the private-sector visitors were from companies with less than

50 employees, which well characterizes AIST as an organization that makes efforts to collaborate with companies of all sizes. In AIST Open Lab 2010, we tried out some new events, described below, and learned many valuable lessons for the operation of AIST and the forthcoming AIST Open Lab 2011.

First, Intellectual Café: This event provided an opportunity for 24 mid-level researchers from 18 companies, as well as researchers, research collaboration staff, and Vice Presidents of AIST, to engage in deep discussions about R&D from the afternoon into the night on the first day. I joined the social gathering on the evening of the first day. Many of the corporate participants have had long careers in their fields and gave me the impression that they participated in the discussion session with a good understanding of the issues related to improving the R&D activities of their companies. I believe that this event served as an opportunity leading to collaboration among the corporate participants and between them and the AIST researchers. The discussions focused on research subjects. Some participants requested us to add topics, such as industry-government-academia collaboration and exchange of researchers, and continue the event in the future.

Second, Tsukuba Innovation Arena (TIA): A research environment at TIA is being developed by AIST, the University of Tsukuba, and the National Institute for Materials Science. Research environments and facilities for areas such as nanoelectronics, power electronics, carbon nanotubes, and MEMS were opened to visitors. Some technology research association projects and cutting-edge research projects have already begun using TIA. Efforts should be made to make TIA attractive to many more individuals and companies.

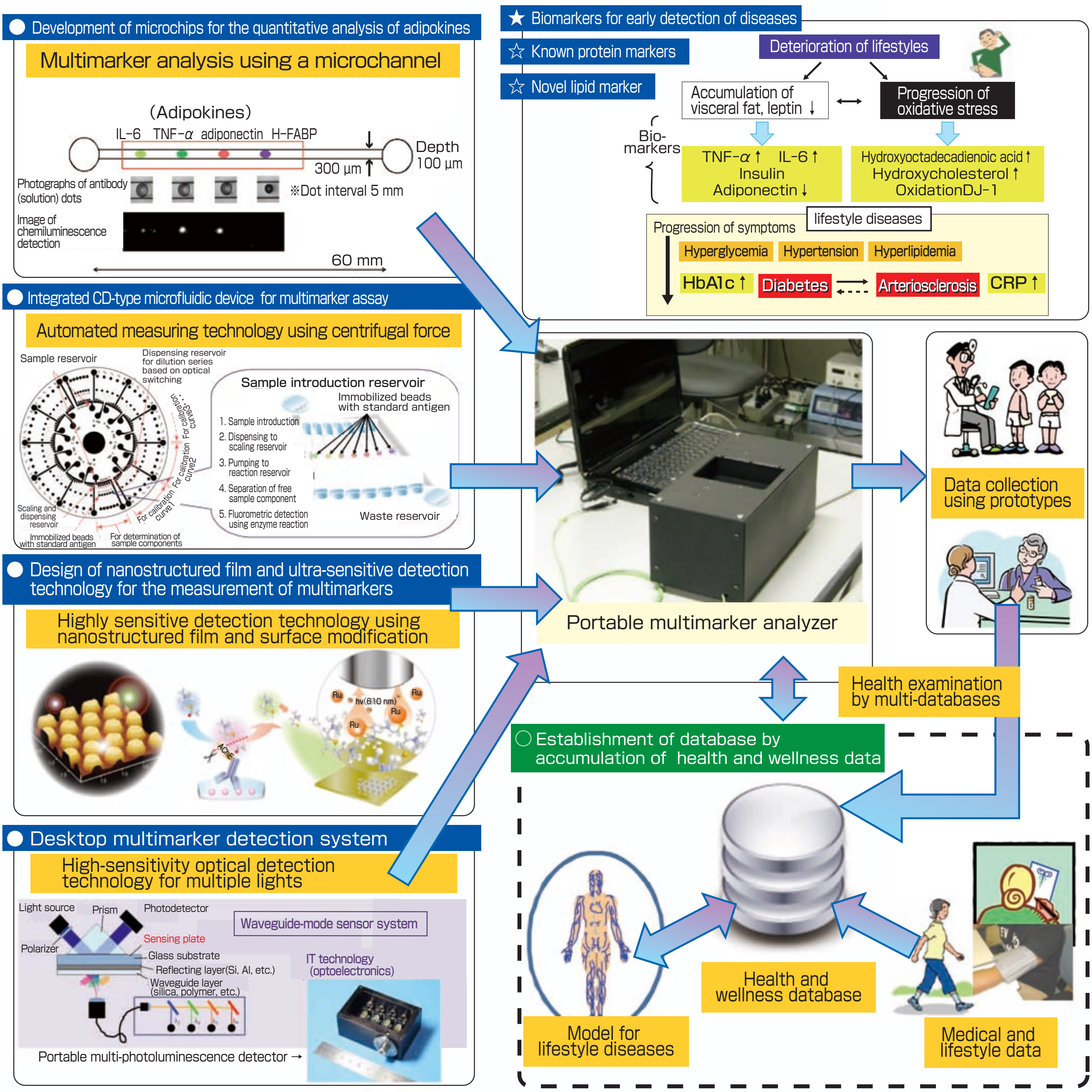
Third, Invitation of Alumni: We sent invitations to many of the alumni of AIST. AIST has produced a large number of talented researchers as well as excellent research results. We organized this event with the expectation that we could build a leading innovation network in Japan by enhancing collaboration between alumni and active researchers. I met some of the alumni who work in corporate laboratories, universities, public research institutes, municipalities, and international organizations. They gave valuable advice on the implementation and management of research activities from their experience both inside and outside AIST. I strongly felt expectations for the full implementation of the Third Term Research Strategy and, in collaboration with companies, the need for a collaborative stance fine-tuned to the capabilities of each company concerned.

I have expressed my thoughts on AIST here. I sincerely hope that this year will be a better year for you and AIST.

# Project for the Development of a Multimarker Analysis System

## Background of and necessity for the project

In addition to issues such as the low birthrate, aging of society, and decrease in the working population, Japan is experiencing a rapid increase in mental illnesses and lifestyle diseases characteristic of modern society. One of the greatest concerns that humanity faces is how to live a long life in a healthy condition. "Healthy" not only means the absence of physical illness, but also living in a daily state of well-being and general happiness. To achieve this, importance is being placed on technological development for health maintenance and the promotion of health-related industries by some including the Council for Science and Technology Policy and the Ministry of Economy, Trade and Industry. In the New Growth Strategy (basic policies) approved by the Cabinet on December 30, 2009, the medical, nursing care, and health-related industries were positioned as drivers




**Development of multimarker analysis system**

Development of a low-cost analysis system that can rapidly make simultaneous quantitative measurements of evidence-based biomarkers

For inquiries about this article：Health Research Institute http://unit.aist.go.jp/hri/en/

of growth. It is necessary to integrate various research fields in order to truly incorporate technologies for analyzing human health conditions and for supporting human life into industrial activities.

### Target of project

The medical cost of lifestyle diseases such as diabetes is 10.4 trillion yen, accounting for 32 % of the nation's medical expenditures (FY2004 data of the Ministry of Health, Labour and Welfare). It has also been reported that the proportionate mortality ratio of lifestyle diseases is 60.9 % (same data as above), pointing to the fact that the prevention and early diagnosis of such diseases are pressing issues. In 2002, for example, there were about 2.28 million diabetic patients, but it was estimated that there were 16.2 million potential cases with the number of the latter thought to be rapidly increasing. However, there is no method to quantitatively diagnose the pre-disease state; that is, the state immediately prior to the appearance of a lifestyle disease. This is because there are few reliable biomarkers supported by sound scientific reasoning to diagnose pre-disease states. The several biomarker candidates available need large analysis devices and long periods of time for analysis, making them unsuitable for practical application.

AIST is promoting a project for the development of a system that can rapidly and simultaneously analyze and evaluate biomarkers to diagnose pre-disease states (multimarkers), by integrating technologies dispersed throughout various research fields within AIST. We also aim to establish a health database integrating noninvasive data such as medical examination information, blood pressure and heart rate measurements, walking gait, and other behaviors. Using this database, we intend to verify the usefulness of multimarkers for diagnosing pre-disease states through complementary analysis of the data obtained by the developed evaluation system. Ultimately, our goal is to disseminate the system in society as a new health management system, in cooperation with private companies.

### Development of project based on AIST technology seeds integration

Our immediate specific goal is to form, in two years, a prototype analysis and evaluation system that will make possible the early diagnosis of lifestyle diseases (especially diabetes) by researchers and clinical examination organizations. To achieve this, we are not only advancing our research by strengthening ties that we have already established with university hospitals and private companies, but also are strongly promoting the integration of technologies developed by individual research units within AIST.

This project is a groundbreaking attempt to develop an early diagnosis system for lifestyle diseases by bringing together the multimarker identification technology of the Life Science and Biotechnology field, the biochip technology of the Nanotechnology, Materials and Manufacturing and Life Science and Biotechnology fields, and the highly sensitive detection technology of the Information Technology and Electronics field. As a verification test, the system will be examined using the health database evaluation system being built up by the Information Technology and Electronics field.

### 【Participating research units】

**Life Science and Biotechnology:**
Health Research Institute, Biomedical Research Institute, Human Technology Research Institute
**Nanotechnology, Materials and Manufacturing:**
Nanosystem Research Institute
**Information Technology and Electronics:**
Photonics Research Institute, Digital Human Research Center, Social Intelligence Technology Research Laboratory

Director, Health Research Institute
**Yasukazu YOSHIDA**

## Expectations for the Health Analysis System

Vice-President,
Director-General for Life Science and Biotechnology
**Noboru YUMOTO**

In Japan, where low birthrate and aging of society are rapidly advancing, building a society of healthy longevity is a critical issue. At AIST, we are developing a health analysis system for early diagnosis and prevention of disease through the integration of various research fields, which is our strong point as a comprehensive research organization. To establish such a system, it is necessary to integrate leading-edge technologies of biotechnology, nanotechnology, materials, manufacturing, and information technology. By advancing this project through close industry-academia-government collaboration, we expect to actualize point-of-care testing (POCT) that allows easy, on-the-spot diagnosis, thereby contributing to the health industry and the overall national welfare.


For inquiries about this article：Life Science and Biotechnology E-mail：life-liaison@m.aist.go.jp

# Integrated CD-type Microfluidic Device

## From hospital-based to home-based medical care

In clinical practice, such as in the hospital setting, various diseases are diagnosed and treated using associated biomarker analyses. Biomarkers are biogenic substances, and enzyme immunoassay (EIA) is widely used for their quantification. Since EIA procedures include complicated handling of solutions, such as dispensing and washing, large-scale automated analyzers are used in hospital laboratories. The aim of our group is to develop systems for clinical analysis that can contribute to daily health management at home. By applying semiconductor microfabrication technologies, we have developed a system that uses a CD-type device in which microfluidic processes are integrated. This integrated CD-type microfluidic system can perform a series of biochemical tests used in hospital laboratories, but on a miniaturized scale, thus requiring extremely small volumes of solutions (on the nanoliter scale).

## Features of the integrated CD-type microfluidic system

During an assay with the integrated CD-type microfluidic system, samples and reagents are applied onto reservoir wells located in the area around the center of the CD-sized disc, and then distributed outward through microflow passages under centrifugal force generated by spinning of the disc. A series of analysis procedures can be performed based on this fluid flow mechanism. The conventional pump-based fluid flow system requires extra sample and reagent volume, in addition to the volume directly required for the reaction itself, for filling pump connection tubes and fluid transfer tubes. On the other hand, the integrated CD-type microfluidic system uses centrifugal force for fluid flow, and requires extremely small volumes of solutions. More importantly, every solution applied on the disc is under the influence of centrifugal force while the disc is spinning, so one motor for disc rotation is sufficient for simultaneous analysis of multiple samples and multiple biomarkers; an individual pumping force for each solution, seen in the conventional system, is not necessary.

For example, we have developed an integrated CD-type microfluidic system that performs EIA for salivary secretory immunoglobulin A (s-IgA), a biomarker indicative of stress status, which enables quantification of s-IgA from a saliva sample as small as 1 μl. Further, in clear contrast to the conventional system, the integrated CD-type microfluidic system uses disposable devices, and thus no complicated washing mechanism is necessary. This is an added advantage in miniaturizing the whole assay system. The assay system will become as compact as a portable CD drive in the future, and will contribute to successful health management in various settings such as individual households, workplaces, and schools. We believe that our integrated CD-type microfluidic technology will play a key role in future home-based medical care.

Health Research Institute
**Hidenori NAGAI**

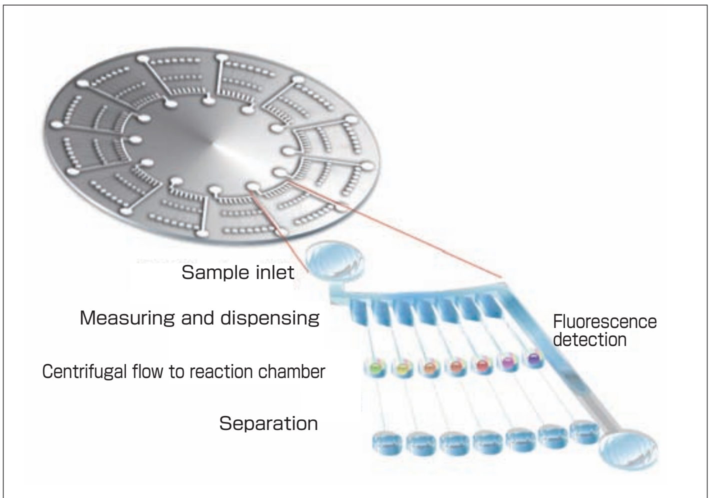



**Fig. 1 Scheme of the integrated CD-type microfluidic system**
A droplet of a sample is applied onto a well located in the area around the center of the disc. The fluid on the disc flows outward under centrifugal force in a stepwise manner, thereby enabling automatic execution of EIA procedures, including measuring, dispensing, enzymatic reaction, separation, and detection.

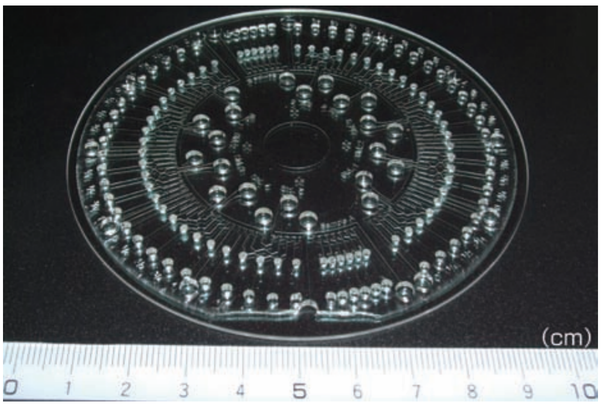



**Fig. 2 Integrated CD-type microfluidic device**

# Measurement of Adipokines and Detection of Biomarkers for Pre-disease States

## Diabetes and adipokines

Lifestyle diseases including type 2 diabetes are increasing due to hyperphagia and a lack of exercise, which lead to excess weight and obesity. The body does not respond properly to insulin secreted by the pancreas in type 2 diabetes, a condition known as insulin resistance. Adipokines, which play an important role in saccharometabolism, are secreted by adipocytes, and they maintain the homeostasis of glycolipid metabolism and the vascular wall. Type 2 diabetes appears as a result of an imbalance of adipokine expression due to the accumulation of adipose tissue through lifestyle disorders (Fig. 1). Arteriosclerosis is often caused by diabetes which increases the risk of heart attack, stroke, retinopathy, kidney failure, and nerve dysfunction. These diseases are obstacles to the patient's quality of life, and the cost of medical treatment for these diseases is huge. At least 7 million people in Japan suffer from diabetes and 13 million people have impaired glucose tolerance, which is thought to be a pre-diabetic state. Since the number of patients is increasing, lifestyle improvements are necessary together with accurate estimations of the risk of diabetes to prevent its onset. For this purpose, we are developing a device that can be used for the comprehensive and continuous examination of expression of several adipokines to analyze the robustness of saccharometabolism.

## Biomarkers for pre-disease states

In obesity, adipocytes secrete adipokines such as TNF-α, IL-6, adiponectin, leptin, and hsCRP. We have selected these adipokines as target markers. Adiponectin improves insulin sensitivity by enhancing glucose uptake into skeletal muscle and inhibiting hepatic glucose production. TNF-α and adiponectin suppress each other in expression at the transcriptional level. TNF-α exacerbates insulin tolerance. On the other hand, adiponectin suppresses insulin tolerance. Leptin, whose production is upregulated in large adipocytes, decreases hunger and stimulates energy expenditure. IL-6 is an inflammatory cytokine, like TNF-α. hsCRP is known as a biomarker for inflammation, and exacerbates arteriosclerosis. We will also examine the production of some oxidative stress markers that are thought to be correlated to the onset of diabetes, such as t-HODE, which was discovered by AIST. We will comprehensively and continuously examine the changes in expression of these biomarkers in people who exhibit impaired glucose tolerance, and estimate the usefulness of these changes as biomarkers for pre-disease states. For the examination of these changes, we are developing a sandwich ELISA (enzyme-linked immunosorbent assay) system on a plastic microchip by combining the advantages of microfluidic channels and inkjet print technology for the immobilization of antibody to reduce the reaction time and reagent consumption of ELISA assays (Fig. 2).

Health Research Institute
**Masatoshi KATAOKA**

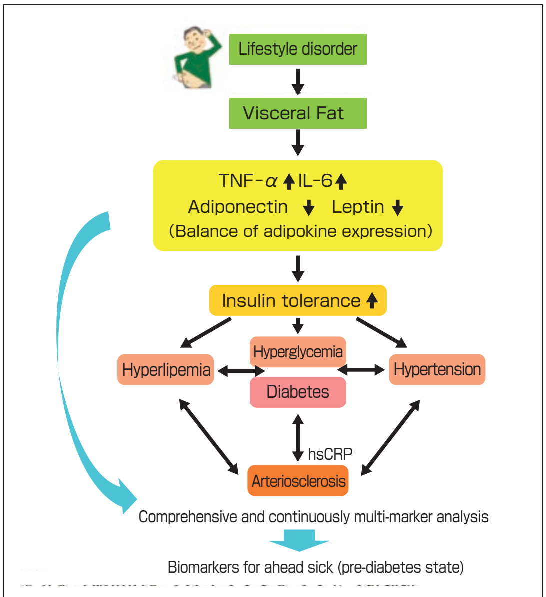



**Fig. 1 Relationship between imbalance of adipokine expression and insulin resistance**
Type 2 diabetes appears as a result of an imbalance of adipokine expression due to the accumulation of adipose tissue through lifestyle disorders.

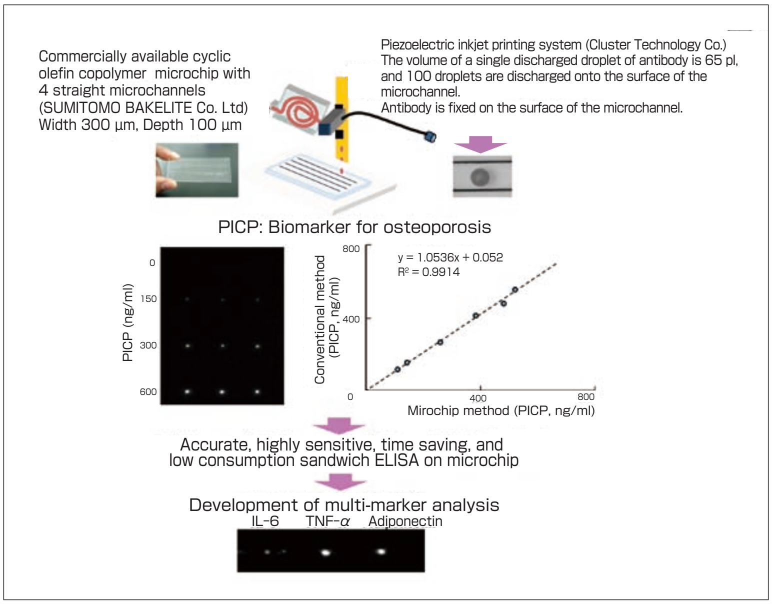



**Fig. 2 Development of sandwich ELISA for microchannel and multi-biomarker analysis**
The sandwich ELISA system utilizes a microchip and inkjet printer for the deposition and fixation of antibodies on a microchannel surface to detect biomarkers in blood.



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# Highly Sensitive Micro-immunodevices with Surface Accumulable Molecules

## Introduction

Various microanalytical devices have been proposed for rapid measurements of proteins and peptides in blood and urine. This is because an enzymatic reaction or immunoreaction occurs effectively in a microchannel due to the extremely large surface-to-volume ratio compared with conventional measurements. However, it is difficult to obtain sufficient sensitivity in the microchannel using the conventional detection method. We have therefore developed a novel detection principle based on a surface reaction which is suitable for microchannels, and applied it to micro-immunodevices.

## Immunoassay with surface accumulable molecule

Thiols are known to be adsorbed on a gold surface, and form a dense self-assembled monolayer. We employed this characteristic for a highly sensitive immunoassay by obtaining the surface preconcentration of thiol molecules (thiocholine) formed by the enzyme (acetylcholinesterase) reaction. Figure 1 shows a schematic of our immunoassay by electrogenerated chemiluminescence determination. Thiocholine is produced from acetylthiocholine by the labeled acetylcholinesterase. The thiocholine molecules are collected and accumulated on the gold surface by gold-thiol binding. Finally, the luminescence intensity is measured when the gold is oxidized with ruthenium complex. Since the luminescence intensity becomes greater as the amount of accumulated thiocholine increases, the analyte concentration can be estimated from the luminescence intensity.

Figure 2 shows portable surface plasmon resonance equipment and a micro-immunodevice with the above thiocholine system. This equipment makes it possible to measure trace peptides around the pg/ml level within 30 min because the reactions (immunoreaction, enzyme reaction and thiocholine accumulation) take place to a sufficient degree in the microchannel.

## Conclusion

We have developed a novel immunoassay method that is suitable for microdevices. Unlike conventional absorption and emission measurements, the sensitivity of our method is independent of the optical length. Therefore, the sensitivity is not decreased by downsizing. Instead, our method makes it possible to perform measurements with high sensitivity in a microchannel because of its high collection efficiency and high linear flow rate.

Biomedical Research Institute
**Ryoji KURITA**

References
[1] R. Kurita *et al.*: *Analytical Chemistry*, 82, 1692-1697 (2010).
[2] R. Kurita *et al.*: *Analytical Chemistry*, 78, 5525-5531 (2006).

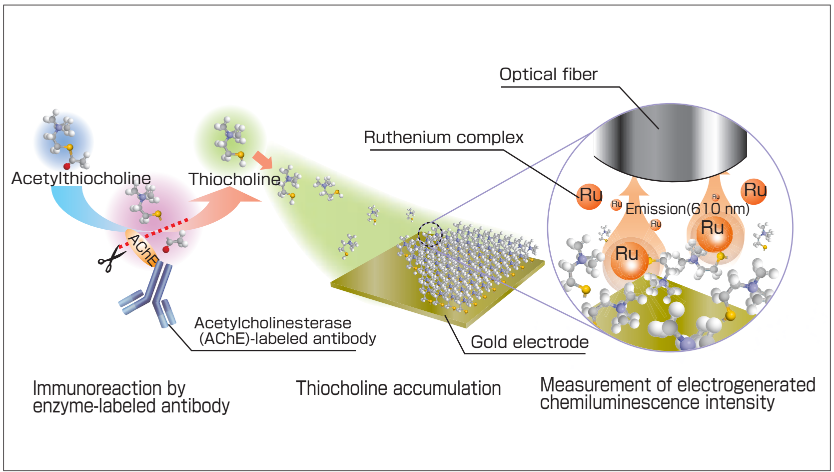


**Fig. 1 Schematic of electrogenerated chemiluminescence-based enzyme-linked immunosorbent assay with surface accumulable molecules**

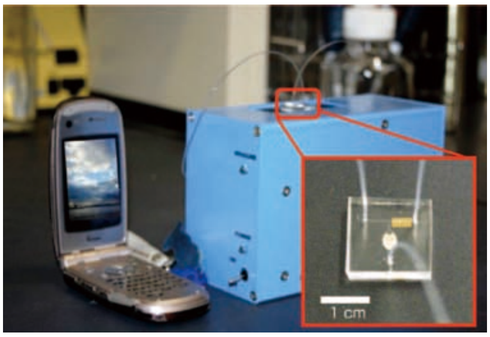


**Fig. 2 Portable surface plasmon resonance equipment and micro-immunodevice (inset)**

# Desktop-type Waveguide-mode Sensor System for Multimarker Measurement

## Research background

Low-concentration microsubstance detection technology is essential to ensure that our lives are safe and secure. Clinical consultations require the identification of substances causing a symptom in order to determine the appropriate treatment. It is also necessary that lifestyle diseases be detected before they develop. As is apparent from the recent pandemics of H1N1 influenza and foot-and-mouth disease, it is important to promptly detect viruses, fungi, and pollutants harmful to humans or livestock on site so as to eliminate them and prevent their spread. The sensor used for such detection must be highly sensitive, precise, easily transportable, easy-to-use, and inexpensive.

## Efforts to realize a highly sensitive but small waveguide-mode sensor

Figure 1 shows the optical arrangement in our waveguide-mode sensor under development[1]. The sensor chip has a single-crystalline Si layer with a thickness of several hundred nanometers and a $SiO_2$ waveguide layer with a thickness of around 400 to 500 nm on a $SiO_2$ glass substrate[2]. The equipment irradiates s-polarized visible light toward the sensor chip placed on the bottom face of the prism, as shown in the figure, and detects changes in the intensity of the reflected light. The properties of the reflected light are sensitive to the permittivity of the waveguide surface. Therefore, the reflected light intensity will change significantly if a substance (e.g., an antibody) that has the tendency to adsorb a specific material is introduced on the chip surface and if the specific material (e.g., an antigen) is actually adsorbed by the substance.

We have successfully improved the detection sensitivity by a digit or more by forming $5 \times 10^9$ vertical holes, each with a diameter of approximately 50 nm, per square centimeter on the $SiO_2$ waveguide layer by means of our unique nanohole creation technology[2]-[4]. The waveguide-mode sensor is also sensitive to colors[5]. Therefore, high-sensitivity detection is achieved by marking specimens with dyes or metallic nanoparticles. When gold nanoparticles with a diameter of 20 nm were used as the marker, we found that the adsorption of one gold nanoparticle per square micrometer of the chip surface was adequate for detection[5].

We have significantly downsized our equipment by using the spectral readout method instead of the angle scanning method that changes $\theta$ in Fig.1. Figure 2 shows a photograph of a prototype of the equipment. We are attempting to downsize the equipment to the size of a pencil case.

## Research outcomes and application to marker measurement

We have successfully detected oil, vitamins, protein, flu viruses, metallic nanoparticles, metallic nano-thin films, and Escherichia using our waveguide-mode sensor. Making use of the expertise that we have gained, we intend to develop a sophisticated marker measurement sensor to prevent lifestyle diseases.

Photonics Research Institute
**Makoto FUJIMAKI**

### References

[1] W. Knoll: *MRS Bulletin*, 16, 29-39 (1991).
[2] M. Fujimaki *et al*.: *Opt. Express*, 16, 6408-6416 (2008).
[3] K. Awazu *et al*.: *Opt. Express*, 15, 2592-2597 (2007).
[4] M. Fujimaki *et al*.: *Microelectron. Eng*., 84, 1685-1689 (2007).
[5] M. Fujimaki *et al*.: *Opt. Express*, 18, 15732-15740 (2010).

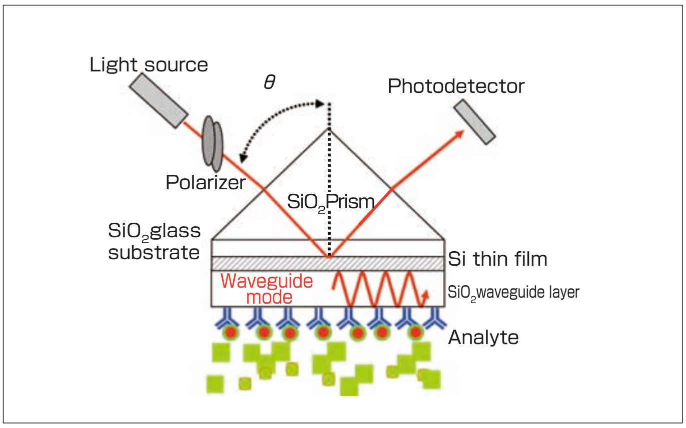


**Fig. 1 Schematic of the optical arrangement in our waveguide-mode sensor**

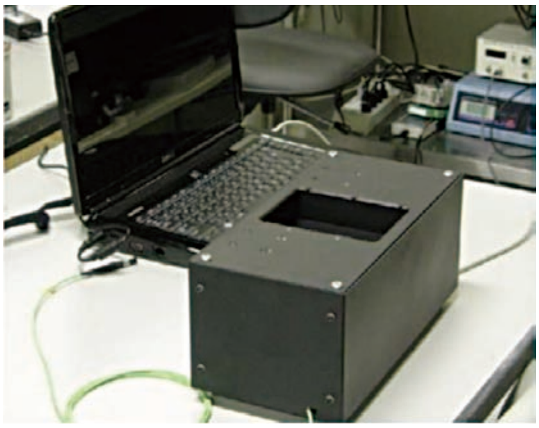

**Fig. 2 Photograph of the prototype sensor**


For inquiries about this article：Photonics Research Institute http://unit.aist.go.jp/photonics/cie/index.html

# Fluorescence Detection System for Multimarkers Based on Long-range Surface Plasmon Resonance

## Biosensing based on surface plasmon resonance

Surface plasmon resonance (SPR) has been widely used for sensing purposes, particularly in bio-related fields. Information acquired through SPR usually comprises changes in film thickness and dielectric constant caused by substances adsorbed on the surface of the sensor substrate. Therefore, the sensitivity of the measurement might be insufficient or imprecise when sensing substances with a small molecular mass. One of the solutions to this problem is the acquisition of information on changes in the fluorescence intensity in addition to changes in the film thickness and dielectric constant. It is known that induced SPR significantly enhances the incident light energy at the surface of the sensor substrate, which leads to fluorescence from the dye on the surface. This suggests that fluorescent labels can be used for high-sensitivity biosensing.

## Fluorescence detection technology based on long-range surface plasmon resonance

Long-range surface plasmon (LRSP) resonance is a specific type of SPR, and the LRSP mode leads to larger electric field enhancement at the surface of the sensor substrate than in the case of normal SPR. Figure 1 shows the structure of an LRSP sensor substrate on which light with a wavelength of 375 nm is incident. The sensor substrate consists of a low-refractive-index dielectric layer ($SiO_2$), a thin metal layer (Al), and an anti-quenching dielectric layer ($SiO_2$). The surface of the anti-quenching dielectric layer was modified with an antigenic protein, transferrin, using a technique for fabricating self-assembled monolayers and the antigen-antibody reaction. Subsequently, anti-transferrin antibodies labeled with three types of Q-dots, each Q-dot having a different fluorescence wavelength, were specifically adsorbed on the transferrin surface of the substrate. Figure 2 shows the fluorescence spectrum of the fabricated surface measured with a fiber spectrometer while the LRSP mode was being induced at the surface of the substrate. The figure clearly reveals fluorescence peaks and a shoulder caused by the existence of antibodies labeled with the three types of Q-dots on the surface of the sensor substrate.

## Future development

After adsorption of the Q-dot-labeled antibodies, the thickness of the organic layer on the surface of the sensor substrate is approximately 20-30 nm. The LRSP mode “amplifies” slight changes on the surface of the sensor substrate through the enhanced electric field. This “amplification” facilitates improvement of the sensitivity of fluorescent measurements, such as those of the fluorescence spectra with a fiber spectrometer and the fluorescent intensities at several specific fluorescent bands with color filters and photodiodes as appropriate according to each band. As an extension of this study, we will develop a system that realizes highly sensitive fluorescent detection of multimarkers related to diseases on a biochip.

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Research collaborator
Optohub Co., Ltd.

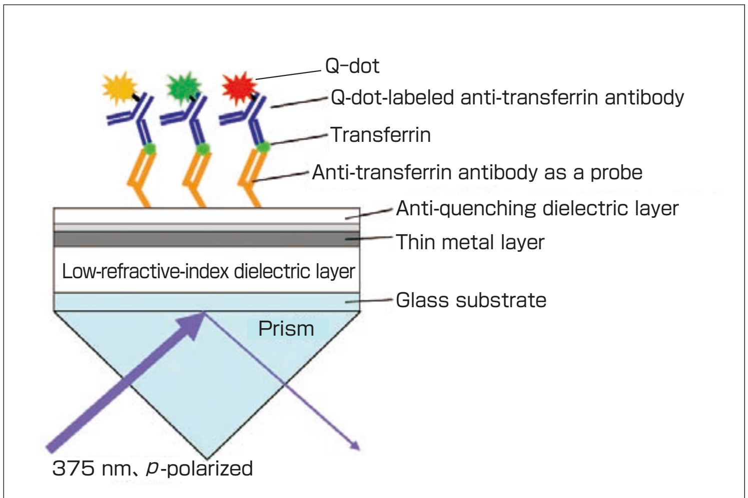


Fig. 1 Structure of the LRSP sensor substrate

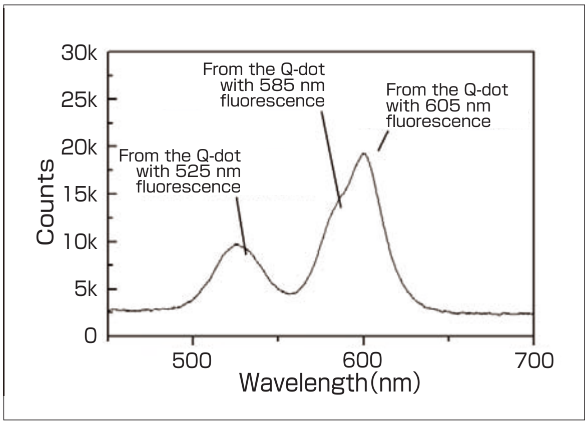


Fig. 2 Fluorescence spectrum under LRSP mode of the surface of the LRSP sensor substrate modified with an anti-transferrin antibody as a probe, after antigen-antibody reactions of anti-transferrin antibodies labeled with three types of Q-dots following transferrin modification

# Development of a Single-channel Multiple Immunoassay Chip Using an Injector-based Antigen Immobilization Technique

## Toward the visualization of health status

In view of the importance of visualizing health status in order to maintain and promote health, we are developing a novel biodevice that enables easy and low-cost diagnosis of changes in health caused by lifestyle, living environment, and, needless to say, disease. We have developed a sandwich ELISA (enzyme-linked immunosorbent assay) chip that allows multiple antigen-antibody reactions in microscopic regions in a channel. Using an injector-based antigen immobilization technique, our single-channel multiple immunoassay chips are fabricated as follows: (1) injection molding of base plates with microgrooves, (2) surface treatment, (3) antigen immobilization, (4) adhesive film covering, and (5) washing of the channels. Although our chips are quite simple, multipoint immobilization of different antibodies enables simultaneous detection of different antigens in one channel without increasing the sample volume.

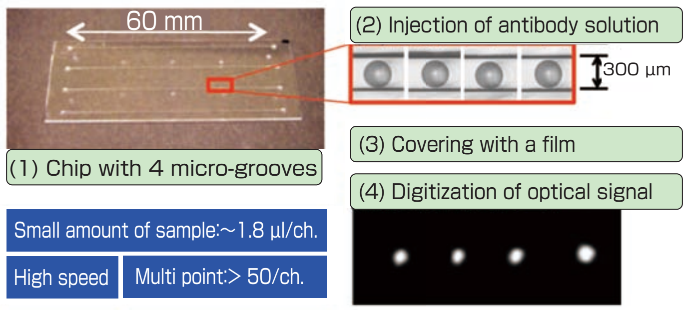


**Fig. Antibody dots were formed on the microgroove surface using an injector, and covered with an adhesive film to make the microchip. In this chip, the concentration of the marker can be measured by the intensity of the light emitted by each dot.**

## Multiple immunoassays using the same volume of blood as that sucked by a mosquito

In the figure, photograph (1) shows a macroscopic image of the chip with four microchannels. An inlet and an outlet port, with a diameter of 1 mm, are located at the ends of each channel. The blood plasma sample required for measurement is approximately 1.8 μl, which is less than the volume of blood sucked by a mosquito. Photograph (2) shows the antibody dots on the bottom surface of the groove. In this case, four antibody dots were formed at intervals of 3 mm in the microchannel (width 300 μm, depth 100 μm). The length of each microchannel is 60 mm, allowing a maximum of 50 antibody dots/channel. The concentrations of antibodies are measured by digitizing the chemiluminescent light of the labeled secondary antibody((4).in the figure). In procollagen type I c-propeptide (P1CP), a biomarker for osteoporosis, and interleukin-6, an inflammatory cytokine, there was no significant difference between the values measured by the chip and those by a conventional ELISA.Both methods have comparable reproducibility.

Since our chip is made of plastic, the chip itself is inexpensive. Further, the injector-based antibody immobilization dramatically reduces the amounts of all reagents, resulting in disposable chips and cost-effective point-of-care testing (POCT). By using similar techniques, we are developing a prediction chip for diabetes and diagnosis chips for other diseases and internal organs. Our goal is a compact POCT device with integrated pump and detector for easy health checks, which will be a key device for the database of biomarkers and health information.


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References

[1] JP Patent Application 2008-165059.
[2] JP Patent Application 2008-334179.
[3] M.Tanaka *et al*.: *J. Laser Micro/Nanoeng*., 5(1), 35-38 (2010).




For inquiries about this article：Health Research Institute http://unit.aist.go.jp/hri/en/

# Molecular Recognition on the Interfaces of Soft Materials ("Soft Interfaces")

### The role of soft interfaces in the detection of target (bio)molecules

Medical tests are required to identify the cause of illness. Sometimes, simple test is carried out for daily health management. Simple, fast and sensitive detection of biomarker proteins, viruses, and target cells related to diseases is desired. Specific affinities between the target molecules and anchor molecules on the detection surface have been used for sensing. Unfortunately, there are a number of significant problems in the detection of such specific biomarkers in bio-samples, including (1) a low concentration of target molecules, (2) large noise from nonspecific binding or adsorption from the sample solution, (3) the difficulty of selecting and obtaining antibodies for the target molecule, and so on.

We have synthesized a new organic material modifing the sensing surfaces and have constructed a functional nanostructured monolayer surface that has demonstrated sufficiently high performance to detect low-concentration target marker molecules in the crude sample.

### Devised arrangement of recognition sites and suppression of nonspecific adsorption

There are specific interactions between carbohydrates and proteins (lectins). However these interactions are quite weak. We have designed a lectin detection surface with carbohydrate-terminated alkanethiol and hydroxyl group (-OH)-terminated short alkanethiol on the substrate in order to improve lectin-carbohydrate binding and suppress nonspecific binding. Lectin-carbohydrate interaction on approximately 10-30 % carbohydrate mixed monolayers were compared with that on a 100 % carbohydrate monomolecular layer modified surface. The amount of lectin adsorption was increased and the interaction became stronger in the case of 10 % carbohydrate mixed monolayer.

We also investigated the resistance to nonspecific protein adsorption. We synthesized and used tri(ethylene glycol)-terminated alkanethiols as a protein-repelling modifier[2]. These new molecules contribute to the affective suppression of noise and the highly effective detection of lectins(Fig.1)[1,3,4].

Our next project is the functionalization of other material surfaces for the construction of sensitive, effective, and simple detection interfaces for target molecules, in addition to present gold substrate. We are also making efforts to develop a new method and concept for the detection of disease marker molecules(Fig.2).

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References
[1] Y. Sato *et al.*: *Chem. Commun.*, 4909-4911 (2008).
[2] M. Tanaka *et al.*: *Tetrahedron Letters*, 50, 4092-4095 (2009).
[3] K. Yoshioka *et al.*: *Anal. Chem.*, 82, 1175 (2010).
[4] Patent Application Publication No. 2009-236848, Sato *et al.*

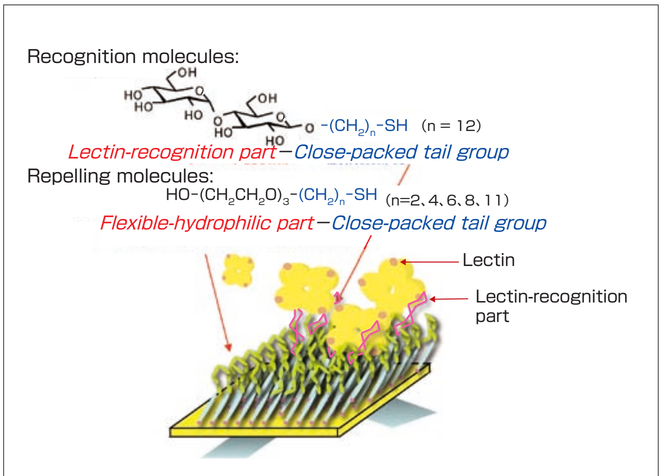


Fig.1 Model structure of lectin detection on the recognition monolayer

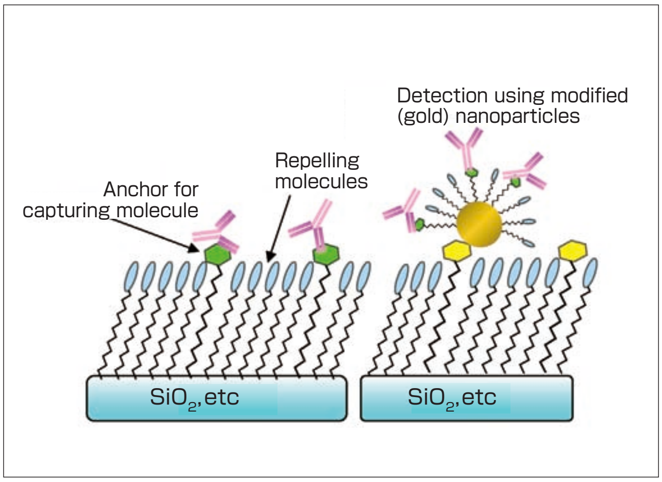


Fig.2 New methods for substrate modification, antibody immobilization, and detection

# Nano-scale Characterization and Controlled Adsorption of Bio-related Substances

## Nano-scale characterization of organic films with immobilized antibodies

We are developing biosensors with specific surface structures that are highly sensitive to virus or marker molecules. We need to suppress unwanted adsorption and detect target materials selectively. As shown in Fig. 1, controlled adsorption, target-antibody reaction, and signal amplification techniques are being investigated. When antibodies are immobilized on a substrate with inappropriate molecular orientations, their activity to capture the antigens will be lost. It is therefore necessary to know the density and orientation of the antibodies on the surface in order to characterize the performance of the sensing chip. Using atomic force microscopy (AFM), one of the nanotechnology characterization methods, the structure and density of small materials adsorbed on a flat substrate can be observed.

Figure 2 (a) shows an AFM image of the sensor surface, N-N'-carbonyldiimidazole (CDI) reacted with an aminosilane monolayer film on a silicon oxide layer formed on a glass substrate. Figure 2 (b) is an AFM image of a CDI surface to which are attached antibodies for the influenza virus. Under the conditions used for the process, spherical objects are observed with a density of 100-200 particles/μm$^2$. Judging from the distributed heights, we believe that the antibodies are adsorbed with various orientations.

## Control of cell adhesion using cross-linked albumin film

Fabrication of micropatterned substrates to control cell adhesion and proliferation is a promising technique for cell-based technologies, including the screening of drug candidate libraries and fundamental investigations of cell-cell communication. Although several successful strategies for creating cellular micropatterns on substrates have been demonstrated, a complex multistep process and requirements for special and expensive equipment or materials limit their prevalence as a general experimental tool. To circumvent these problems, we are conducting research focused on serum albumin which is most abundant protein in blood.

We have established a novel simple fabrication method for a micropatterned surface for cell patterning using serum albumin. As shown in Fig. 3(a), we were able to prepare a water-insoluble, cross-linked albumin film possessing the properties of native albumin, such as resistance to cell adhesion and drug-binding ability[1]. In addition, we found that the cell nonadhesive surface property could be easily changed to allow cell adhesion by exposing the cross-linked albumin film to UV light or cationic polymer solution[2][3]. Cellular micropatterns were created on substrates and inside a microfluidic device by utilizing the convertible cell-adhesion property of the cross-linked albumin film (Fig. 3(b)) [4]. We will apply this method to other bio-related substances to control their behavior of adsorption to material surfaces.

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### References

[1] H. Yamazoe and T.Tanabe: *J. Biomed. Mater. Res. A*, 86, 228 (2008).
[2] H. Yamazoe *et al.*: *Langmuir*, 24, 8402 (2008).
[3] H. Yamazoe and T.Tanabe: *J. Biomed. Mater. Res. A*, 91, 1202 (2009).
[4] H. Yamazoe *et al.*: *Acta Biomater.*, 6, 526 (2010).

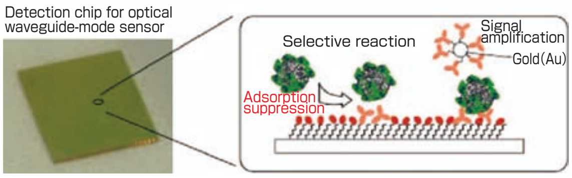


**Fig. 1 Detection chip for the biosensor. Antibodies attached to the surface selectively bind the target material**

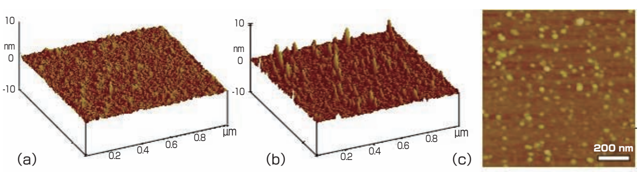


**Fig. 2 (a) AFM image of silicon surface processed with CDI (1 μm square, bird's-eye view) (b) Surface after applying antibodies(Particles with a height of 3-9 nm are observed. ) (c) Gray-scale representation of (b)**

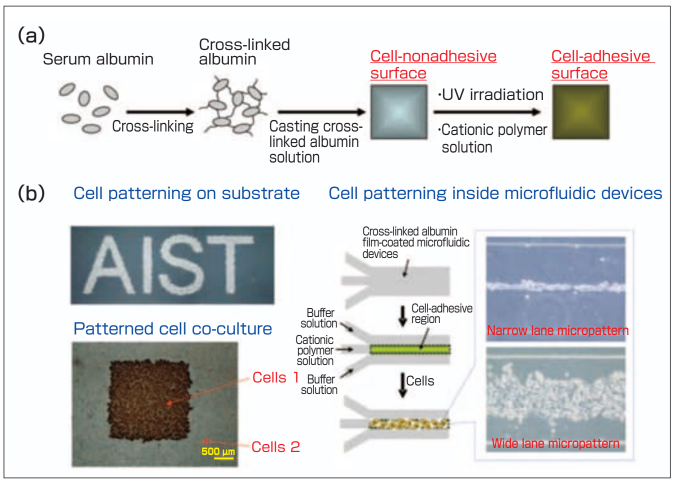


**Fig. 3 (a) Convertible cell-adhesion property of cross-linked albumin film (b) Cell patterning prepared by utilizing cross-linked albumin film**

# Research Hotline

# UPDATE FROM THE CUTTING EDGE

## Oct.-Dec. 2010

**The abstracts of the recent research information appearing in Vol.10 No.10-12 of "AIST TODAY" are introduced here, classified by research areas.
For inquiry about the full article, please contact the author via e-mail.**

Environment and Energy

## Outdoor test facilities for new-type photovoltaic cells and modules

### Development of the evaluation technology for outdoor energy performance for various types of photovoltaic cells and modules

The importance of the technologies of energy ratings and evaluation of lifetime of photovoltaic (PV) modules is increasing as the market of PV modules is rising. Outdoor testing facilities have been installed at two locations: at Saga prefecture especially for commercial thin-film PV modules and at Okayama prefecture for highly efficient III-V compounds PV cells in the form of concentrator PV (CPV) modules. At Saga pref., five different types of PV modules (total of 25 kW) have been connected to the grid in AIST Kyushu, and both outdoor and indoor tests with IV tracer have been carried out. At Okayama pref., the CPV system (total of 30 kW) consists of three different PV cells from three nations. The evaluations of power generation characteristics of the CPV systems and concentrating cells under different climate conditions have been carried out at U.S. and Okayama sites.

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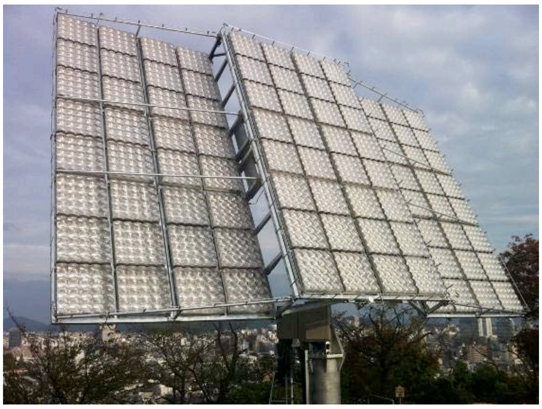

Concentrator photovoltaic system at Kyoyama, Okayama city

# Fabrication of small glass capsules incorporating quantum dots

## Toward practical use as fluorescent reagents for bio-applications utilizing their high brightness and photo-durability

We have developed small glass capsules incorporating multiple CdSe/ZnS quantum dots (QDs) that show bright photoluminescence (PL). The capsule can be used as a fluorescent reagent in a variety of bio-applications. Its brightness and durability could make it useful as a phosphor for electronics as well.

Among QDs, a CdSe/ZnS QD is advantageous in brightness, however, it easily agglomerates. To prevent this, polymer-coated QDs are commercially available. But it is difficult to further increase their brightness. It is advantageous to encapsulate the QDs in glass which is more durable than polymers.

We have worked to develop a QD-dispersed glass capsule with a diameter of less than 100 nm by the Stöber synthesis, a kind of sol-gel method using alkoxide, since the particle of this size is critical for easy endocytosis by cells. Utilizing the properties of alkoxides, we have succeeded in incorporating multiple QDs in a glass capsule. The 50-nm capsule has brightness of about 10 times, light resistance of about 100 times, and cadmium leaching in a buffer solution of less than one-tenth, when compared with those of polymer-coated QDs.

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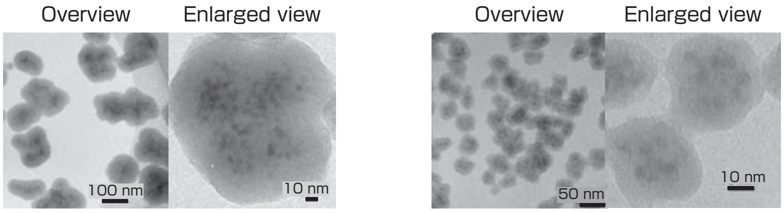


**Transmission electron micrographs of the photoluminescent glass capsules with many dispersed CdSe/ZnS QDs**
Left: Large capsules (95 nm in diameter)  Right: Small capsules (40 nm in diameter)



# A perpendicularly magnetized TMR element enabling the increase of the capacity of Spin-RAMs (MRAMs)

## Design of Spin-RAMs of 5-Gbit or more is feasible

We have developed a high-performance perpendicularly magnetized TMR element that functions as a memory cell for large-capacity Spin-RAMs. In order to develop a large-capacity Spin-RAM with a memory capacity of over 1 Gbit, it is necessary to develop a perpendicularly magnetized TMR element that has not only a magnetoresistance (MR) ratio higher than 50 % to generate a large output signal, but also low resistance-area (RA) product of less than 30 $\Omega\mu m^2$ for impedance matching with peripheral circuits. However, there have been no reports on such perpendicularly magnetized TMR elements. The perpendicularly magnetized TMR element developed at AIST has succeeded in achieving an MR ratio as high as 85 % in a low-RA product region as low as about 4 $\Omega\mu m^2$. This technology enables the circuit design of large-capacity Spin-RAMs of 5 Gbit or more.

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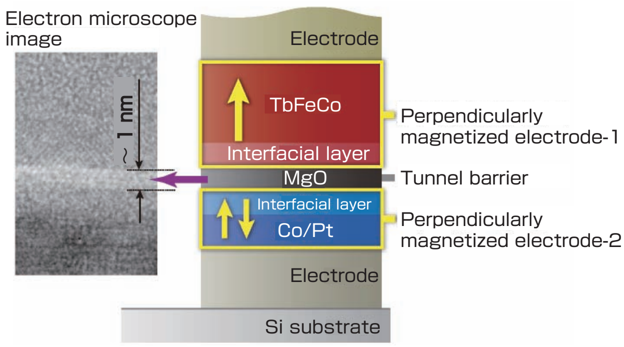


**Electron microscope image of a cross-section of the perpendicularly magnetized TMR element developed (left), and a schematic of the cross-sectional structure (right)**
The development of ultra-thin film planarization technology and a high spin-polarization inducing interfacial layer has led to success in achieving both a very low RA product and a high MR ratio.

# Home environment models for comfortable and independent living of people with disabilities

## Toward a comfortable home environment designed by people with disabilities themselves

We have developed a system design technology that allows people with disabilities to combine various disability aids and use them in an integrated manner. Home environment models to address the needs of individuals with disabilities have also been proposed and demonstrated. In the system, input and output devices that use different control methods are networked by using a common network platform technology for robot modules, "RT (Robot Technology) Middleware". This allows devices to be easily added to or removed from the network and enables cooperation of the devices on the network; thereby, it allows the user to combine devices according to his/her needs. The system is equipped with high-performance interfaces for equipment control, namely a stereovision-based, fast-response gesture interface that can be customized according to the level of mobility of a person with disabilities and a speech-recognition interface that is robust to noise in the home environment and can recognize unclear speech. In addition, active casters for easy movement of home equipment are installed in the home environment to provide physical assistance.

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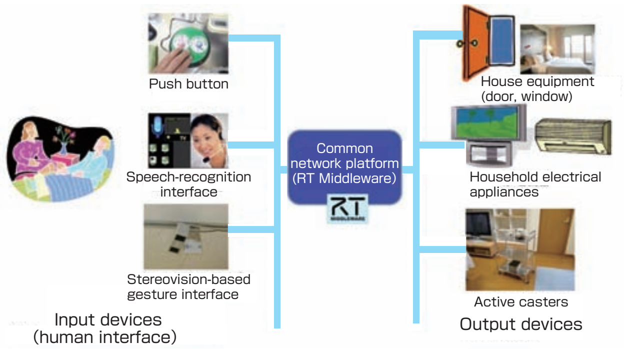


Networking of various disability aids via common network platform (RT Middleware)



# Single-walled carbon nanotubes as capacitor electrodes operable at 4 V

## Leading the way to development of small, light, and high-performance capacitors

We have developed a super capacitor electrode using as-grown single-walled carbon nanotubes (SWCNTs), synthesized by water-assisted chemical vapor deposition. The aligned SWCNT ensembles have better electronic and ionic conductivities compared to activated carbon (AC) due to their cohesion, crystallinity, and absence of filling/binder material. Specifically by fabricating electrodes purely from SWCNTs, with high carbon purity (99.98 %), a higher voltage range of 4 V is achieved compared to only 3 V for AC. Additionally these SWCNT electrodes maintain durability (3.6 % decline over 1000 cycles at 4 V).

Furthermore, due to their high electronic conductivity, the SWCNT electrodes can operate without full coverage by metal current-collectors, thus enabling significant device weight reduction. The performance of a SWCNT device without current-collectors is estimated for an energy density at 17 Wh/kg and for a maximum power density rating at 24 kW/kg.

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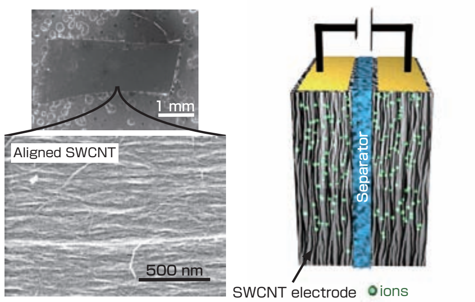
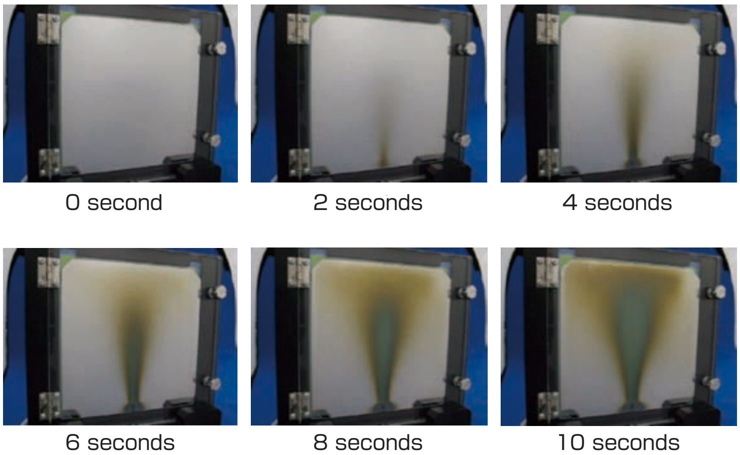



SEM image of SWCNT electrode (left) and cell assembly without metal current-collectors (right)

# Hydrogen sensor using Mg-Ni switchable mirror thin film

## Visualization of hydrogen gas diffusion

We developed a new hydrogen sensor using Mg-Ni switchable mirror thin film. It can be operated without heating with a wide detection range. Also combination use of a switchable mirror thin film and slab wave guide enables to realize a hydrogen sensor with high sensitivity. Using a switchable mirror thin film coated sheet, we can visualize hydrogen diffusion process directly, which is a new way of hydrogen sensing by means of our eyes. This hydrogen visualization sheet will be commercialized shortly.




**Visualization of hydrogen diffusion**
Transitional detection of hydrogen when a pipe is placed upward in the back lower center of a switchable mirror thin film (sheet size:140 mm×130 mm)

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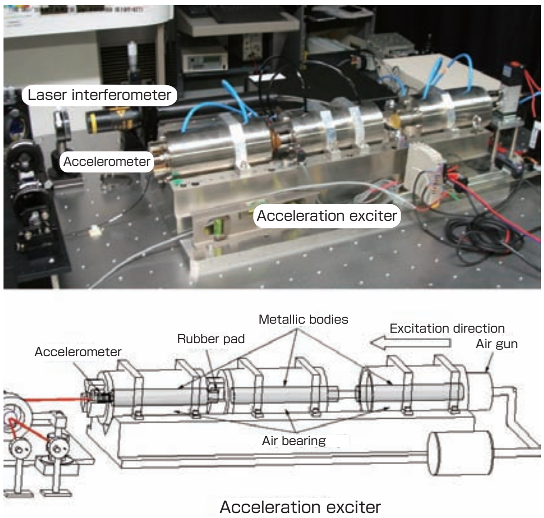
AIST TODAY Vol.10 No.11 p.15 (2010)



# Development of acceleration standard for safety evaluation

## Calibration technique supporting acceleration measurement up to 5,000 $m/s^2$

Shock acceleration measurement is widely used in a variety of applications including air-bag control of automobiles and drop testing of mobile instruments, in which accelerometers are a key device to evaluate human safety or product reliability. However, vibration acceleration available in the calibration service of accelerometers has been limited to several hundreds of $m/s^2$ due to the performance of vibration exciters. Therefore, it is desired to establish a calibration service up to 10,000 $m/s^2$ to cover recent industrial demands. Here we have developed a shock acceleration calibration system to calibrate the sensitivity of accelerometers precisely. The developed calibration system can calibrate accelerometers with the expanded uncertainty ($k$=2) of less than 0.8 % in the range from 200 $m/s^2$ to 5,000 $m/s^2$.




Shock acceleration calibration system (top) and schematic diagram of shock acceleration exciter (bottom)

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# Development of measuring instrument for thermal diffusivity of thin films

## Instrument for easy and fast measurement of thermophysical properties of thin films

A measuring instrument for thermal diffusivity of thin films with thickness of around 1 μm has been developed based on a pulsed light heating thermoreflectance technique. The instrument observes transient temperature change at the surface of the film with 1 ns time resolution. One face of the substrate side of the thin film is heated by pulsed laser with the duration of 2 ns, and the temperature rise at the opposite face is detected by sensing reflectivity change of the film. For the observation of the reflectivity change of the film, a continuous wave laser diode is used instead of a pulsed laser for the conventional thermoreflectance measurements. We measured the thermal diffusivity of a titanium nitride film (680 nm) using the developed instrument, which coincided with the data obtained by the standard instrument of NMIJ, AIST. The developed instrument has several features: desktop size and short data acquisition time about 1 minute.

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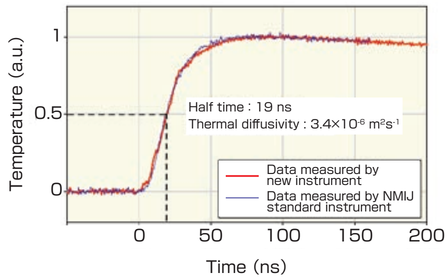
Thermal diffusivity measurement for titanium nitride film (thickness: 680 nm)




Transient temperature change for the titanium nitride thin film (thickness: 680 nm) obtained by the developed instrument along with that measured by the NMIJ standard instrument



# To realize the world top class temperature standard

## The development of highly pure fixed point apparatus and its evaluation

The evaluation of impurity effect on the realization of fixed-point temperatures of the International Temperature Scale of 1990, by which the temperature standard is defined, is essential, since impurity in many cases lowers the fixed-point temperature.

First, the impurity effect was evaluated by a theoretical approach using the impurity information obtained from a chemical analysis of the fixed-point substance. A direct comparison of fixed-point temperatures realized by two different substances was conducted as the second approach. The applicability of these two methods, however, is limited so that the impurity effect cannot be evaluated properly. To this concern, analysis on the changes of temperature and liquid fraction during the realization of the fixed point was performed as the third method. It has been found here that this third method provides a lot of accurate information for estimating the defined temperature, including those provided by the other two methods. Based on the third method, a world top class temperature standard has been realized.

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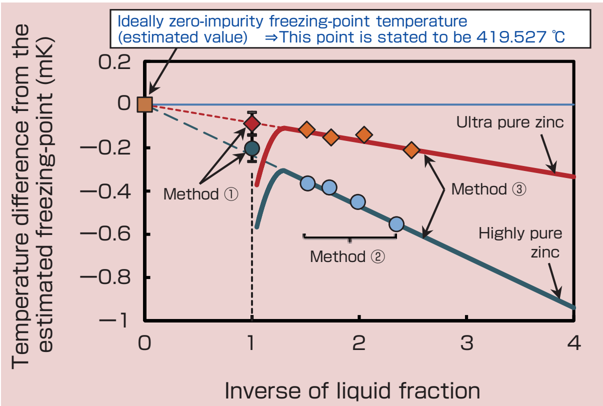


Estimation of zinc freezing point based on three methods

# Application of air-coupled sensor to the laser ultrasonic visualization equipment for flaw inspection of structures

## A contact-free visualization system of ultrasound for flaw inspection

Nondestructive inspection (NDI) is important to ensure the safety of structures such as power plants, vehicles and infrastructures. Ultrasound is one of the NDI techniques majorly used. Our group has already proposed a ultrasound generation laser scanning system for visualizing ultrasound waves propagating on any shape as an animation image, where flaw can be quickly and easily detected. Recently, we have focused on making the system completely contact-free by applying an air-coupled ultrasound transducer as a receiver, instead of a contact piezo-electric receiver. An advantage of the contact-free receiver is that it makes it easy to move the sensing point, and, as a consequence, images from different points of view can be obtained. Reductions of the effects of surface conditions of specimens and contact situations of the receiver are also advantages of the contact-free receiver. Improvements on noise reduction, higher sensitivity, and signal processing are now in progress aiming at more clear and speedy visualization.

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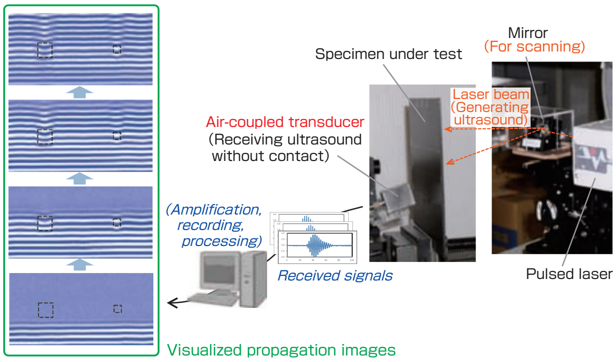



**Outline of non-contact visualization of ultrasound propagation with air-coupled sensor and an example of visualized propagation images**
The visualized images show the propagation of ultrasound on a carbon fiber reinforced plastic with delaminations. Area of visualization is 50×100 mm. Propagation of 320 kHz $A_0$ Lamb wave is visualized with receiving angle 14.6º. Sizes of the delaminations shown with dotted lines are 10 mm sq.(left) and 5 mm sq.(right).

# In Brief

## Cooperation with Mongolia in Geological Survey and Mineral Resource Research

On July 30, 2010, AIST concluded a comprehensive memorandum of understanding (MOU) on cooperation in geological survey and mineral resource research of Mongolia with the Ministry of Mineral Resources and Energy of Mongolia and Japan Oil, Gas and Metals National Corporation (JOGMEC) during Mongolian Minister Dashdorj Zorigt's visit to Japan.

With this conclusion, the three parties aim to strengthen reciprocal cooperative relations in geological survey and mineral resource projects, and will discuss specifics of cooperative projects for developing rare metal resources which are important for high-tech industries. Especially AIST, with its experience of research and technological support concerning mineral resources of Mongolia since the days of the Agency of Industrial Science and Technology, will promote the cooperative project mainly in scientific elucidation and prehension of mineral genesis, properties, and resource potentials of deposits that are the basis of exploration.

AIST President Tamotsu Nomakuchi (left), Minister Dashdorj Zorigt (center), JOGMEC President Hirobumi Kawano (right)

## NSTDA President of Thailand Visits AIST Tsukuba

On August 24, 2010, Dr. Thaweesak Koanantakool, the new president of the National Science and Technology Development Agency (NSTDA) which is an incorporated administrative agency under Thai Ministry of Science and Technology, visited AIST Tsukuba, and had talks with AIST President Tamotsu Nomakuchi. They discussed exchange of researchers, implementation of collaborative research projects, and reconfirmed that the relationship is excellent between the two organizations which have signed an memorandum of understanding on comprehensive research cooperation (MOU). President Thaweesak explained that, in October, NSTDA will announce new priority research plans which will be focused on food, medical care, energy and environment. President Nomakuchi expressed that those plans are related in many ways to research done at AIST, and welcomed the plans as potentially contributing to closer collaboration between the two organizations.

President Thaweesak also visited the Research Center for New Fuels and Vehicle Technology, listened attentively to presentations of biomass fuel research which is a collaborative research project with NSTDA, and asked many questions showing great interest in the project.

AIST President Nomakuchi (left) and NSTDA President Thaweesak (right)

## Workshop with Karlsruhe Institute of Technology of Germany

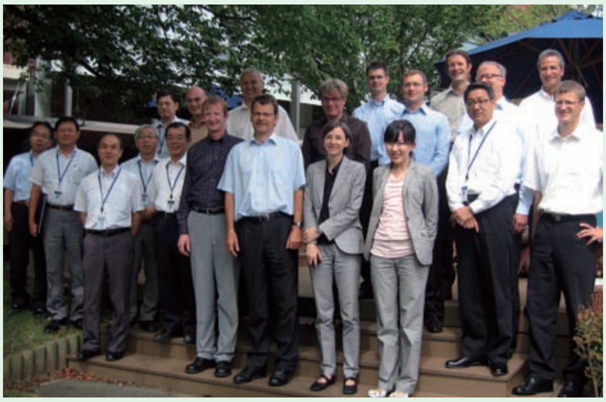
On Sept 14, 2010, a workshop was held at AIST Tsukuba on the main topics of technological transfer and innovation management.

Karlsruhe Institute of Technology (KIT) is a research and educational institute established in 2009 by merging Forschungszentrum Karlsruhe with Universität Karlsruhe, and it is one of 17 member research centres of Helmholtz Association. In April, 2008, before the merger, AIST and Forschungszentrum Karlsruhe concluded a memorandum of understanding on comprehensive research cooperation (MOU). AIST, incidentally, has also concluded an MOU with Forschungszentrum Jülich which is also a member of the Helmholtz Association.

At this workshop, AIST, Helmholtz Association and KIT each gave a brief introduction, alternately gave presentations on technological transfer and innovation management, and discussions were held.

From AIST, the Research and Innovation Promotion Office and the Intellectual Property Department presented the principle of open innovation which AIST promotes, and specific examples of establishing "Tsukuba Innovation Arena (TIA nano)" and technological transfer. There were questions among others concerning ways in which royalty fees are paid to the inventors. In contrast, KIT's technological transfer actively promotes startups of venture companies with research outcomes as the core, using networks including private cooperative organizations. The specific mechanism was highly informative for AIST.

AIST has been collaborating with KIT in research mainly in energy, and it is thought that a good foundation has been established also in management for a cooperative relation such as marketing support in technological transfer.



Participants of the workshop

**Cover Photos**

Above: Concentrator photovoltaic system at Kyoyama, Okayama city (p. 17)

Below: Shock acceleration calibration system (p. 20)

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