ISSN 1346-602X

Full Research in Society, for Society

AIST TODAY

National Institute of Advanced Industrial Science and Technology

International Edition

Winter 2008

No.27

MESSAGE

Confidence in Our Advancement

FEATURE

Focus on the Future Electronics

Next Generation Hardware to Support the Ubiquitous Society

Research Hotline

UPDATE FROM THE CUTTING EDGE（October-December 2007）

In Brief

-Confidence in Our Advancement-

Hiroyuki Yoshikawa
President
National Institute of
Advanced Industrial Science
and Technology

1. Seven years since its foundation

It is almost seven years since the National Institute of Advanced Industrial Science and Technology (AIST) was founded. During this time, there were many things that occurred. Beginning with the integration of 15 research institutes and the drafting of the Medium-Term Plan, there were organization of research and administrative units based on new ideas, defining the functions of regional research centers, setting the headquarters management system, determination of personnel regardless of seniority, budget allocation based on a new formula, and introduction of evaluation. While respecting the long history and tradition of the Agency of Industrial Science and Technology, there were continuous reforms that greatly affected the daily work of every member of the institute.

In our country, the need for reform in many areas was voiced around the end of the high economic growth in the 1990s. There was no exception either in the public domain as politics and administration or in the private companies. It applied to research institutes and universities as well. In the 1990s, I was working at a university, and there was a strong demand for reform from both inside and outside the university, and we worked on it day in and day out. Many reform committees were formed for the first time and the teaching staff was assigned to them regardless of age. I remember that receiving criticism that there were too many committees, a new committee for organizing the committees was formed, and after great discussion, only to eliminate one committee which was ironically the organizing committee itself. The work for reform was so time-consuming that there were even complaints of lack of time for the essential research and education, and a new word, “reform fatigue” was even born.

How was the seven years at AIST? The reforms at

AIST were not easy as they did not stop at organizational changes but were substantial reforms with changes in awareness of responsibility to society and in operational structure. Looking back, not only were there great changes at the time of foundation, but also there followed the constant improvement by re-organizing research units, the switches of unit leaders, the change of management affiliation of each department, the alteration of assessment methods, and the formation of a new research budget distribution system. There was significant development with the research mentioned later. Furthermore, it has managed itself since as an independent administrative institution, a structure that no one had ever experienced before. There was no role model and we had to grope our way through everything. However, the new institute may not be perfect but can be said to have reached a relatively high standard. This achievement is the result of the efforts of all the members of AIST, and perhaps one can add that "reform fatigue" was not felt much during the process.

It can be said that a realization of step by step advancement has been felt during the seven years which brings about a certain conclusion. It is that reform does not mean the rebirth of something new from swiftly casting aside the ills accumulated during a long period of time and totally breaking off from the past. It is a continuous, constant process where new attempts are always made and the effects observed, and renewed attempts are made depending on the results. Furthermore, the attempts are not results of outside coercion or recommendation, but are done from subjective effect observation and self-motivated internal necessity. The integration of AIST in 2001 falls in this category as, although it seemed discontinuous, the move was a result of ideas of young researchers themselves and therefore was continuous. It is easier to understand if all the changes that follow are regarded as part of a constant process of change.

My present conclusion is that the most effective reform is the constant, continuous change brought about by the motivation of the people in charge. It is "reform on location" and it is needed for evolution. If the people in charge cannot do this reform, they are bound to perish. There is nothing more evil than compulsory reform enforced by people who have little "in charge" understanding who have ideological offhand ideas, suffocating the possibilities of efforts by the people in charge. What is forced does not have the liberty to perish, or, in other words, is stripped of the possibility of transferring into something better, has to accept reform without motive, and has to continuously live existing for the purpose of existing.

Luckily, AIST was given the possibility of reform on location and this is one of the reasons why it was able to advance reform that was of drastic change, without reform fatigue. However, the situation given was only one of the necessary conditions for reform. I think that what made reform possible under the circumstances was the realization by the workers at AIST that the basic research on industrial technology had to change according to the changes of society. This realization has become stronger during these seven years and will fuel further development in the future.

2. Unexpected events

Incidentally, last year was not a stable year. Just a year ago, there was the inadequate storage and use of radioactive materials; then the laboratory fire, the inadequate acceptance of patented microorganism deposit, the violation of the building code concerning dangerous substances, and the delay of payment. Prior to these, if the research misconduct and the violation of Cartegena Protocol on Biosafety are considered, there have been numerous serious problems that have occurred during the last couple of years. At one glance, these look as if they were unrelated. However, even if each had occurred by accident, I do not think that it is permissible to consider the problem solved once each is dealt with separately. We have to extract and correct what is behind these problems and have to prevent whatever may happen in the future.

This has something to do with the seven years that have passed since the foundation of AIST as mentioned before. If I may repeat, this was the period in which advancement was realized. Then why did such misconducts occur? Under positive, tension-filled, advancement conditions, they would not occur. One could say that these occurrences probably were exceptional, and happened outside the positive advancement process. Or that these were unexpected and not connected to us and are unrelated to advancement. However, this way of thinking is incorrect.

It is true that through these misconducts we happened to see the contortions that were hidden and that had infiltrated the organization during its long history. However, even if the causes are identified, the fact that the accidents are happening now shows that they are somehow related to the present situation. Evidently we who are striving now need to think of how to prevent such accidents.

First of all, we must realize that it is not necessarily correct to make rules and push for discipline to prevent accidents. To make an accident-prevention manual and to apply it to all activities is one method. However it is not the most appropriate way for researchers. If we are to subjectively find a solution to the problem rather than to follow a given manual or outside pressure, we who are consigned by society to do research at an independent administrative institution supported by the government need to start thinking of what it means to abide by law and to protect the safety of society.

We need to start by basically reconfirming the fact that we are researchers who have the freedom to do research and, at the same time, being free, are taking certain risks. After understanding this, we each need to think of ways to overcome the risks. These risks cannot be avoided if we are to do original research. The risks are as follows:

① **the isolation from society as we engage in free research which is autonomous**

② **the uncertainty of actions done in a new, and not necessarily mature world of research**

③ **the unpredictability of the result of research though done with careful planning**

Original research demands the unpredictable, uncertain and often solitary thinking and experiment. Normally, researchers are proficient and go through the process without special attention or problem. However, one must be aware that this "normality" is not absolute. We researchers know that research is accompanied by the unawares.

Here I would like to jump and talk about my experience. The cause of the tragic criticality accident at the uranium processing plant in 1999 was the deviant behavior from the operating instructions. Poor management became apparent and it led to a criminal investigation. The management had made such an obvious mistake that Accident Investigation Committee of which I chaired had to conclude that it deserved no sympathy[1]. However, I learned an important lesson from the incident. At the plant, the increase of productivity was imperative and the workers were making daily effort to achieve this goal. In that process, the increase of the batch was contrived, and that brought about the criticality. By scrutinizing the goal at hand, they had overlooked a more serious condition. To overlook in such special circumstances of processing nuclear reactor fuel is out of the question and there is no room for sympathy. Generally speaking, however, this is not a special situation and something similar could happen in research and activities related to it. One can easily think that, if a matter is not connected to goal achievement, then it can be suspended for the moment. To suspend it does not cause an immediate problem and as it is going to be dealt with later, it is not an unreasonable act.

We have to think seriously whether it is not unreasonable to place the matter out of one's mind. Assume that while scrutinizing the research project, we place other factors aside. As a result, if we unfortunately deviate from the regulations, it is hard for a third person or the researcher himself to realize this as, with solitary research, most problems, with very few exceptions, are not immediately apparent. However, it is essential not only in research implementation but also in research management that it is done in autonomous, unprecedented conditions and sometimes with unpredicted results. Autonomy cannot be abandoned for the sake of avoiding deviancy.

We can conclude the following. Under our situation, there are certain risks of involuntarily violating the regulations or control limits, and to justify the negligence only by stressing the importance of research is not permissible. The risks seldom immediately cause accidents, and mostly are bypassed without anyone noticing. However, they remain implicit or are accumulated in time, and, are suddenly brought to light by chance, sometimes causing accidents. The reasons given for the cause after the accidents are often as follows; "it was overlooked as a small problem", "it was to be dealt with later and was neglected", "we did not think that it would cause an accident, and "we have always done it this way".

These latent and accumulated factors increase along with the history of an institution. It is overconfident to think that these factors do not exist because the past seven years have been charged. At the beginning, everything seemed transparent and extreme care was taken for all. However, when the advancement is accelerated, some activities become common practice and we stop paying special attention. This is familiarization and it is valid. However, one should be aware that within the process, there exists the danger of disregard, overlook from overwork, assumption, and self-conceit.

The effort to eliminate each of these is necessary, but disregard and overlook are what is apparent on the surface. It is essential to correctly understand the framework of the whole activity behind the risk in order to eliminate the problem at a deep level. Even if scrutinizing a procedure makes one forget other problems, we need to "preserve" the understanding of the total somewhere else.

If one has this preserved within oneself, there is no problem. However, we know by experience that this is difficult and I have stated in the section concerning research misconduct that it is the organization that helps the individual in such circumstances[2]. What is needed is inter-communication amongst researchers and interaction within research units. Furthermore, the conception that the authority of the Superintendents or the Audit Office or those who are responsible in safety-keeping and law abidance is absolute needs to be fostered within our culture or the organization as a whole.

The researchers at AIST are allowed to perform autonomous research consigned by society under the assumption that the results are beneficial to society. In other words, the freedom of researchers is recognized under the condition that they have the ability to avoid certain risks that are harmful to society. Therefore, there is a pact between society and researchers and any deviant act violates this pact, and we need to be strongly aware that it would mean losing our freedom.

3. The next advancement

During the past seven years, we have learned many things. We learned that constant reform on location is important, and are convinced that the elimination of "the unexpected" is possible. With the realization of the seven year advancement in mind, let us think of what to do in terms of research during this year.

Full Research is understood not only within AIST but at universities and other research institutions, and is of high international interest. Through discussions on which fields and projects Full Research should be applied, it has become one of the identities of AIST. The new scientific journal for papers of Type 2 Basic Research which are difficult to express has been launched. It is planned to jump from an internal journal to an international one. It will demonstrate clearly the significance of Full Research by the people in charge, and will open doors to recording it.

There was large development with the innovation hub concept as well. As a result of various attempts to

industrialize achievements of Full Research, Innovation architect has been born, creating a new image of AIST toward industry. With universities, not only are there comprehensive agreements, but the interaction is expanding to a three-dimensional one with AIST research units being placed within university campuses. These are essential qualifications for Network of Excellence and it shows that we are evolving toward it. The AIST Innovation Center for Start-ups has completed its period as a research center under the Special Coordination Funds for Promotion of Science and Technology, however, the experience was great and the effect it had on the management of AIST as a whole was immeasurable, and its further activities are expected as a new center.

The third series of the Research Strategy has been published which has become crucial for the institute, creating its self-awareness, contributing to strategy planning of each researcher, and sending an important message to the outside world. Strategic collaboration with other institutions is also to be followed in the future.

Gender equality is a large objective within the research work site but it is still insufficient, and is unsatisfactory especially in the field of industrial technology. The unique efforts of Gender Equality Office are widely recognized and such future activities are anticipated.

Regional research centers are in the process of becoming national centers of specific fields not only working with local industry but also functioning as international centers of research. Our future assignment is to create an ideal environment through personnel interaction amongst the centers including Tsukuba, contributing both regionally as well as internationally.

The development of human resources is the official mission of AIST. We have started new efforts to further develop the effective environment formed through various training programs and daily research activities. As part of the efforts, there is a plan to build a school-like structure within AIST tentatively called “AIST School”.

These changes have come about through reform of constant change, without following the precedent while fully recognizing the efforts and results of the past. Some changes have been microscopic and others have been in leaps. Whichever the case, they are of continuous advancement, and are not forced but of autonomous activities which are open to society. This is based on the autonomy of the research unit but that is not all, as is evident if one looks back on the discussions at the eighty workshops on Full Research that have been held in the last seven years. Researchers and research administrators of different ages and of different fields got together and discussed the style of research to be done at AIST. The issues gradually evolved and not only were the problems shared but new discoveries were made.

Here, if the “unexpected incidents” are again viewed, one would realize that we already have the basic framework to retain the understanding of the underlying structure of the whole if we scrutinize the research issues. I have stated that what makes the retainment possible is the communication between researchers and the interaction within the research units. The discussions that have continuously been held in the past seven years on what research is to be carried out have

firmly established the formula within AIST. Through discussions on the safety and compliance under the formula, we would like to find the path of liberation from the nightmare of “unexpected agony”.

4. The leap forward of this year

Under the assumption that we will continue to constantly make advancement in all, what will be the leap forward of the year? I am sure that many can be expected as dreams to be realized of each of us, but “service science” can be named as one area that is being shaped within AIST.

The concept of service is nothing new, and as there is a classification of service industry, its definition has become generally known. However, there are reasons why service has suddenly become the center of attention. One is that the ratio of the service industry within industry as a whole has become large mainly in the advanced countries, and its productivity being low, its progress is widely anticipated to have great influence on the economy. The interest in service industry is accelerated especially because the productivity of the manufacturing industry has become more advantageous for the developing countries where the wages are low. More specifically, as a result of sciences such as life science, medicine, neuroscience, information science, behavior science advancing rapidly making clear their outline as science, the expectation for the reasonable improvement of productivity of service industry has increased. It is as if a replay is expected of the progress in productivity of the manufacturing industry brought about by the various technologies based on physics and chemistry. As a result, many academic fields started handling services. As service is complex including many elements, this move should be welcomed. Here I would like to point out the importance of doing research on service industry at AIST which holds research of industrial science as its objective.

The reason is because service science has a high priority in manufacturing industry. In the 1980s I pointed out that these two are not in conflict and that service industry includes manufacturing industry[3], and I have consistently denied the approach that the advanced industrial countries should inevitably shrink the manufacturing industry and should shift to service industry. What is meant here is that the progress of the manufacturing industry supports the advancement of the service industry, and therefore, these two industries need to advance keeping a strong relationship. Therefore, it is incorrect to discuss the improvement of productivity independent from the manufacturing technology, and it is necessary to study harmoniously the research development for the advancement of the manufacturing technology and the productivity improvement of the service industry.

With this reasoning, the setup of service industry research by integrating research of life science, information science, and human science with basic research for manufacturing is underway at AIST. In addition, according to the agreement with the Service Industry Productivity Council, our ties with the industry are established and we can anticipate a large step forward. Of course, cooperation with the universities is essential.

This step forward is not a denial of the past, but shows that AIST which has produced many results from development research of basic technology for manufacturing industry has, consistent with its past, begun research of service science as part of its constant evolution.

References:

[1] “Uranium Processing Plant Criticality Accident Investigation Report”, Atomic Energy Commission, 2000.1
[2] Hiroyuki Yoshikawa, “Thoughts on ‘Pathology of Research’”, AIST TODAY, 2007. April issue, May issue
[3] Hiroyuki Yoshikawa, “Advanced Technology and Mankind”, Sekai, 1988, January issue, Iwanami Shoten

To Improve the Performance of All Kinds of Electronic Devices

Humans aspire for the rich, secure IT society. It can be said that the key to the development of the robot industry and of personal mobile electronic products is the development of higher performance, low energy consumption electronic devices. At AIST the development of next generation devices is being performed in various aspects to support the ubiquitous society.

Devices to support the ubiquitous society are required to be small so that they can be installed anywhere, to have low energy consumption so that they can be used even in large numbers and also to be highly functional to satisfy increasingly high level demands.

At AIST, research strategies are decided and research issues are repeatedly discussed. Currently, silicon CMOS is the main technology used in data processing devices but the continuing pursuit of performance improvements in CMOS devices through miniaturization is, because of physical and engineering difficulties, reaching its limit. Together with miniaturization, the introduction of new materials, new transistor structures and new processes, and further improvement of manufacturing techniques, have become indispensable. At the same time, the measurement and analysis technology that supports these has become extremely important.

Also, having the limits of silicon CMOS technology in sight, many devices with different principles of operation from CMOS have been proposed but at present no specific candidate replacing CMOS has been settled upon. Also, difficulties are being pointed out with memories (DRAM, SRAM, flash *etc.*) the capacity of which has increased remarkably. Proposals and development are aimed toward the practical utilization of new forms of high speed, non-volatile, CMOS compatible memory.

As research and development strategies for next generation data processing devices to support the ubiquitous society, when thinking about the above logic circuits and memory devices, three technologies shown in this pamphlet can be considered to play extremely important roles.

The three technologies introduced here are as follows.

First, with regard to silicon semiconductors, which represent the mainstream in current technology, the

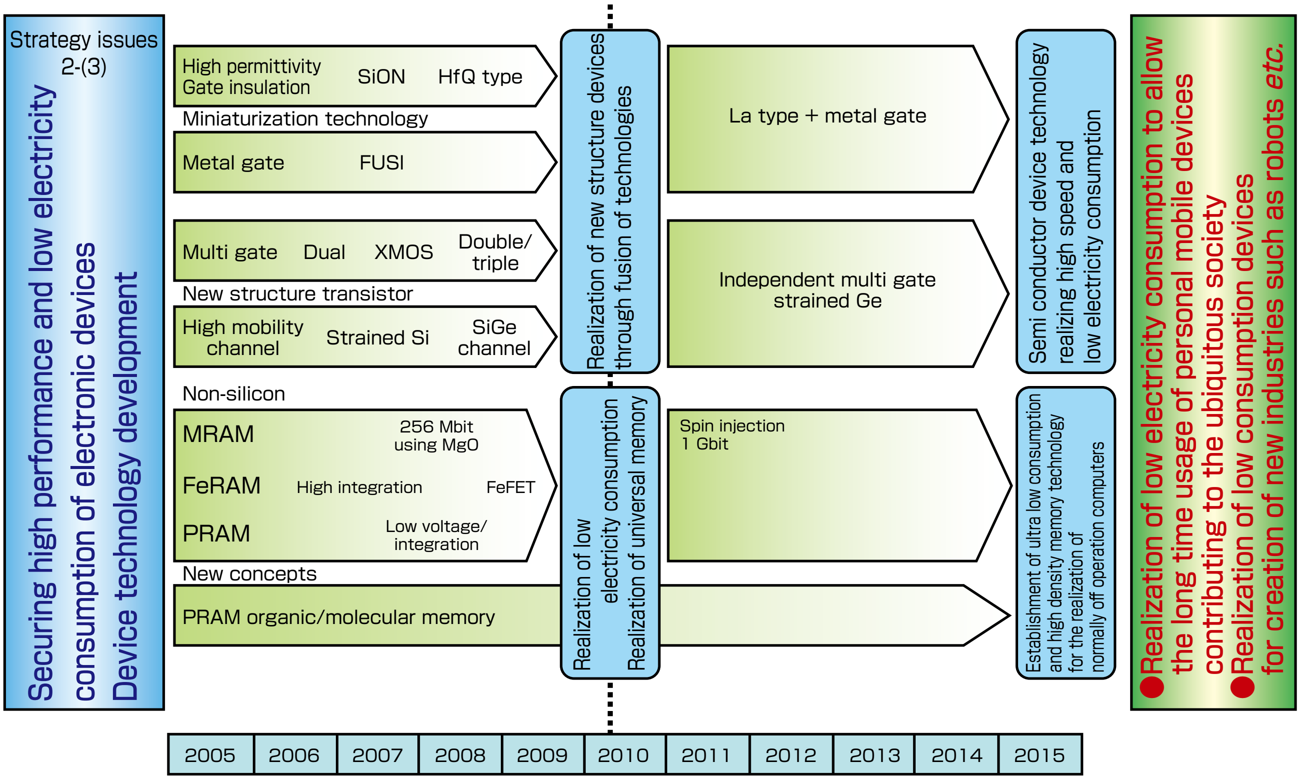


Figure 1 : AIST's device technology roadmap (extract from phase 2 AIST research strategy)

results of size reduction, low electricity consumption and high level functionality research at the Advanced Semiconductor Research Center are presented. Next, research on XMOS transistors, which aim at high speed with the introduction of a new gate structure, is explained. Thirdly research regarding memory which retains data even after the power supply is turned off is presented. The last two researches are mainly pursued in the Nanoelectronics Research Institute.

Figure 1 shows an extract of in the information technology and electronics field, the roadmap relating to electronic devices. The part labeled “Semiconductor device technology to realize high speed & low electricity consumption” in the upper half of the diagram shows the roadmap corresponding to the silicon semiconductor research pursued by the Advanced Semiconductor Research Center together with the Ministry of Economy, Trade and Industry and to the XMOS research being pursued by the Nanoelectronics Research Institute. The section labeled “Establishment of ultra low consumption and high density memory technology for the realization of normally off computers” in the lower half corresponds to the roadmap for non-volatile memory research pursued at the Nanoelectronics Research Institute.

At AIST, there is a super clean room (SCR Bldg.) maintained by the Advanced Semiconductor Research Center together with industrial companies, a clean room at Nano materials Bldg. The device development phase being carried out at these facilities is shown in Figure 2.

At the SCR Bldg, mainly the Advanced Semiconductor Research Center, is doing research to make current silicon semiconductors smaller, faster and lower in electricity consumption. And in Nanomaterials Bldg. research into next generation technology is carried out.

By making the facilities, especially SCR Bldg., open for use by companies and universities, AIST hopes to fulfill the role of “knowledge concentration center” for a semiconductor device technology. We are discussing the issues with related parties. AIST aims to function as a “hub” to bring about innovation in the IT society, constructing a world leading knowledge base system for the nanoelectronics field and setting as its goal contribution to the continuing development of the electronics industry. For example, as a technology system for pursuing the limits of CMOS miniaturization, AIST aims to construct a base system that can be used to predict and analyze device properties, by combining, technology for devices with new materials and new structures, process technology, measurement/analysis technology and *ab initio* simulation. This knowledge base system is to be called the nanoelectronics innovation platform (NIP). Using NIP, demonstrational research based on the creative ideas produced by universities, industry and independent research institutions will be performed and the possibility of further development will be assessed, leading to full scale research and development.

I hope that this pamphlet will be of help to the nation’s semiconductor research.

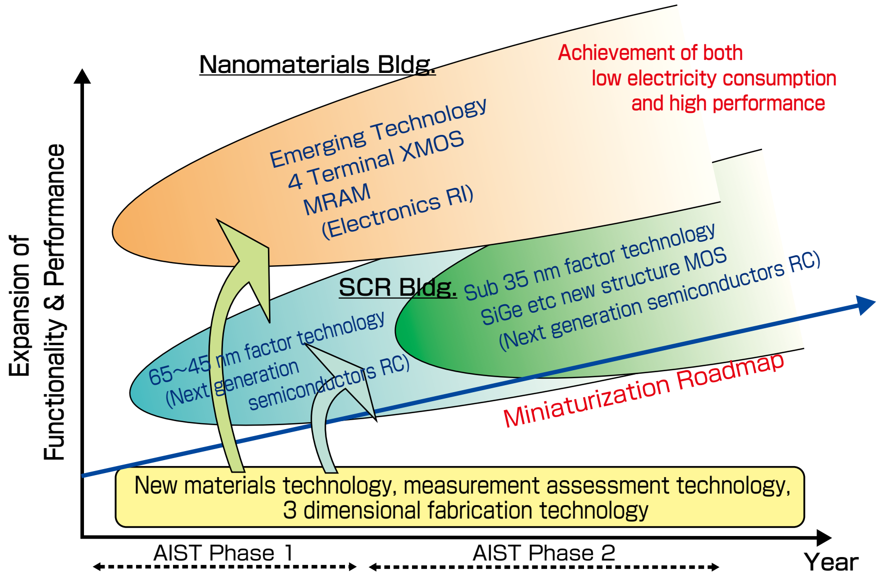


Figure 2 : AIST clean room device development phases (extract from AIST phase 2 research strategy)

Research Coordinator
(Information Technology & Electronics)
Kazuhito Ohmaki

MIRAI Project Builds the IT Society

The role of electronics

With the progress of communications technology, people have become able to use various network services without restrictions on time and place. In order to ensure the convenience and safety of living space in ubiquitous society, the role of electronics systems is becoming more and more important.

The core technology of digital home appliances, cellular phones and automobile electronics *etc.* is that of semiconductor device such as processors and memory (Figure 1). For this reason, the cost and performance of semiconductors determine the added value of many of these products.

The domestic semiconductor market is ¥5 trillion, representing around 1% of the GDP, but it is said that the extent of its knock on influence, including displays, automobiles, industrial machinery and medical equipment *etc.* amounts to ¥200 trillion (40% of the GDP). It can be said that there is a direct connection between the competitiveness of the semiconductor industry in the world market and the international competitiveness of Japan's manufacturing industry.

One chip semiconductor for advanced information processing – the source of industrial competitiveness

Semiconductors that perform wireless communication and image/sound processing and recording *etc.* have from several tens of millions to in excess of several hundreds of millions of transistors integrated on around a 1 cm^2 area of silicon chip.

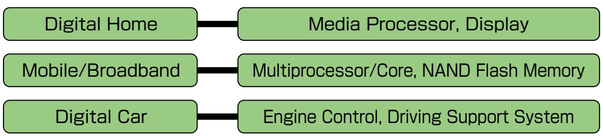
As shown in Figure 2 (left), memory and processors are integrated onto a semiconductor chip, with the functions of the various integrated circuit blocks structured to operate in concert. Figure 2 (right) shows the processing capabilities of media processors for various media such as high definition TVs. Although these are specialized processors, they have around the same level of processing capability as general purpose processors such as Pentium.

Figure 3 shows a cross section of the structure of the MOS transistors used in current integrated circuits (left diagram). Regarding gate length and gate insulator film thickness, the corresponding parts have come to occupy areas of extremely minute dimensions (right diagram). Because of miniaturization, the structure of current transistors results in an increased leak current and the problem now faced is that the drive current, which determines transistor performance, cannot be increased any further. In order to overcome this problem, two main solutions are being considered, as shown in Figure 4.

One solution is to change the transistor structure from a planar structure to a three dimensional one and the other is to add a strain to the Si of the channel, so that the current can flow more easily or to change the material from Si to Ge so that the drive current can be increased. Research and development is proceeding in these areas. In addition, a lot of research is being carried out into replacing conventional SiO_2 used in the gate insulator film with a high permittivity (high-k) material.

In the 60 years since the transistor was invented and the 50 years since the integrated circuit was invented, the performance and data processing capabilities of semiconductors have rapidly improved, revolutionizing and developing the information society. However, improving performance by miniaturization of transistors alone, as has been the case up until now, has become difficult and the introduction of new structures and new materials has become necessary. This is the reason that the history of semiconductor technology has now reached a great turning point.

The reason new semiconductor technology development is being so energetically pursued by the world's semiconductor industry, public research organizations, universities and consortiums *etc.* is that winning through in the coming competition to develop technologies will lead to the strengthening of the basis securing their continued existence, and also enriching the source of national industrial competitiveness.



(Unit:Yen)

	Japanese Market	U.S. Market	World Market
Semiconductor Devices	5 trillion	12 trillion	25 trillion
Displays	2 trillion	—	6 trillion
Automobiles	40 trillion	40 trillion	200 trillion
Electronic Equipment	23 trillion	—	120 trillion

Establishment of sustainable technological supremacy and strengthening of new market creation capabilities through new technology are necessary.
Impact of the semiconductors on GDP is ¥200 trillion (40% of ¥500 trillion GDP).

Figure 1 : Semiconductor devices in the ubiquitous society

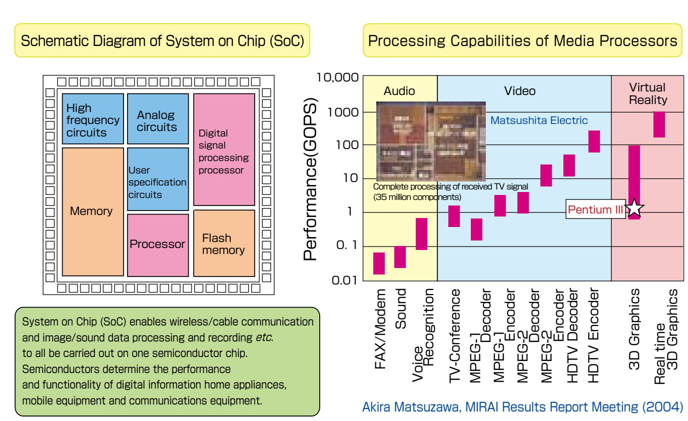


Figure 2 : Semiconductors that perform advanced data processing

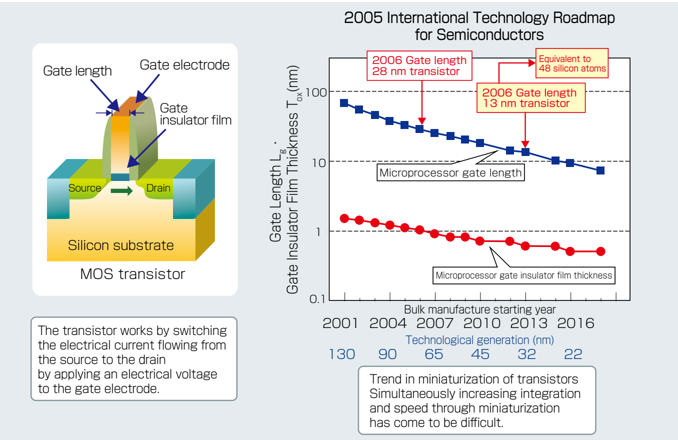


Figure 3 : Miniaturization towards a 10 nanometer gate length MOS transistor

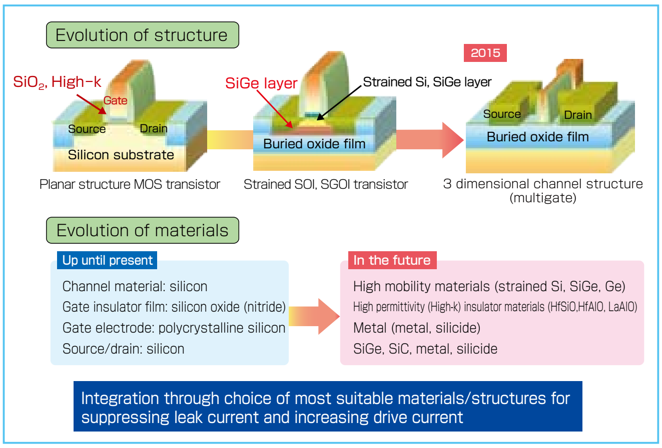


Figure 4 : New materials and structures aimed at improving transistor performance

AIST and semiconductor research

AIST's semiconductor research started soon after World War Ⅱ while in its previous form as the Electrical Laboratory (and later as the Electrotechnical Laboratory) by Michio Hatoyama, Makoto Kikuchi and associates. In the early 1960s integrated circuit research began with Yasuo Tarui at the center. In 1967, Tarui *et al.* performed development of electron beam lithography equipment. In 1976 – 1979, the VLSI Technology Research Association was formed with the purpose of competing with IBM's new computer system "Future System". As a 4-year government subsidized project with a research budget of ¥72 billion (of which ¥30 billion was subsidy), a large scale national semiconductor project was carried out with government and private sector cooperating as one to tackle research and development. The results of this national project afterwards supported the rapid growth of the Japanese semiconductor industry in the 1980s. Also, during this period, the original model for the current double gate MOS, the XMOS, was invented by Yutaka Hayashi *et al.* at the Electrotechnical Laboratory in 1982. The Japanese semiconductor industry, which achieved great success centering on semiconductor memory (DRAM) in the 1980s, has, from the last half of the 1990s onwards due to competitive pressure from various Asian countries, been gradually forced into a hard fight within the world market.

Semiconductor MIRAI Project

Given this situation, in order to restore the competitiveness of the national semiconductor industry, the 7 year "Millennium Research for Advanced Information Technology (MIRAI) Project" of the New Energy and Industrial Technology Development Organization (NEDO) was started in 2001, As a base for the focus of research by industry, academia and government, the Super Clean Room (SCR Bldg.) was completed at AIST Tsukuba at the end of FY 2001. MIRAI Project research and development is currently proceeding, with the participation of AIST and university researchers together with company researchers transferred via ASET (Association of Super-Advanced Electronics Technologies), forming a cooperative research body with the SCR Bldg. as its base of operation. From August 2001, with 120 industry, academic and government researchers and adopting a centralized research system with 5 research themes, phase 1 (2001-2003) and phase 2 (2004-2005) research proceeded (Figure 5). In the 5 years up until the end of phase 2, a total of ¥22.5 billion was expended on research and the technology resulting from the research and development done in this period was transferred to the MIRAI participant corporations, Selete (Semiconductor Leading Edge Technologies, Inc.) *etc.* at the end of FY 2005. Research is currently continuing for technology transfer of certain parts of the results.

Today, the issues that present barriers to semiconductor technology development all require a return to technological basic principles in order that proposals can be made for methods to overcome physical limits and that measures to scientifically prove the validity of these proposals are taken. The basic philosophy of the MIRAI project is to realize technological breakthroughs through the close cooperation between science and technology. Base technologies necessary for this, such as materials, processes, equipment and inspection/measurement methods have been developed within the project.

Three research themes: low-k material interconnect module technology, lithography related measurement technology and circuit system technology (Figure 5), concluded at the end of FY 2005, have reached their targets. Technical

results were transferred to material makers, device makers and consortiums (Selete) *etc.* (see table).

Presently, the results of mask defect inspection technology development are being converted to commercial use by an equipment maker. Results from the development of the critical dimension atomic force microscope, which can measure 3 dimensionally the size and shape of the fine patterns on silicon wafers at high accuracy on the sub-nanometer level, are planned to be commercialized by an equipment maker within a year. Two material makers are aiming to commercialize the newly developed ultra low-k material for use in Cu interconnects, and have taken on responsibility for supplying samples to Selete and device makers.

High-k gate insulator film fabrication technology has been transferred to an equipment maker where it has already been turned into a project. The technology was also transfered to Selete.

In MIRAI project phase 3 (2006-2010), new themes, entrusted by NEDO to Selete, are added and a new organization has been formed with an AIST/ASET joint research body and Selete pursuing 6 research themes (Figure 6). The U-CMOS research and development pursued by AIST/ASET is scheduled for completion within FY 2007 as initially planned. As part of this, the new transistor structure related technology has developed on the results of phase 1 and phase 2. It succeeded in the development of a uniaxial strained fin type transistor (a fusion between a double gate MOS transistor and a strain effect transistor) that realizes high performance CMOS technology (Figure 7). Prototype of this device has been fabricated with the full cooperation of device makers participating in MIRAI Project. Through the know-how accumulation in the research and development process of makers, the technology will be transferred more effectively.

With extreme miniaturization, the ability to measure the distribution of impurities such as donor, acceptor *etc.* in device regions with the atomic scale resolution, and the measurement of localized “stressed” regions in transistors have become indispensable. MIRAI Project has

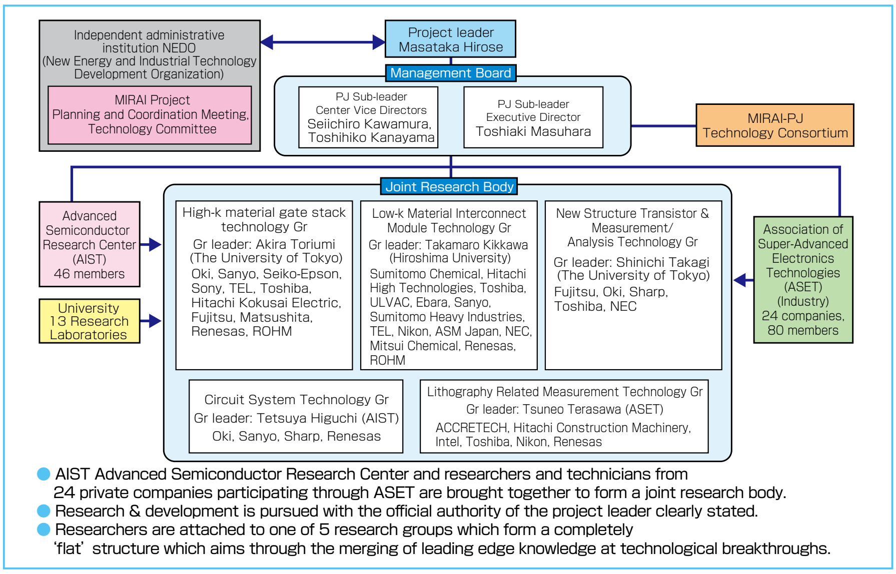


Figure 5 : MIRAI Project Research and Development Structure (2001-2005)

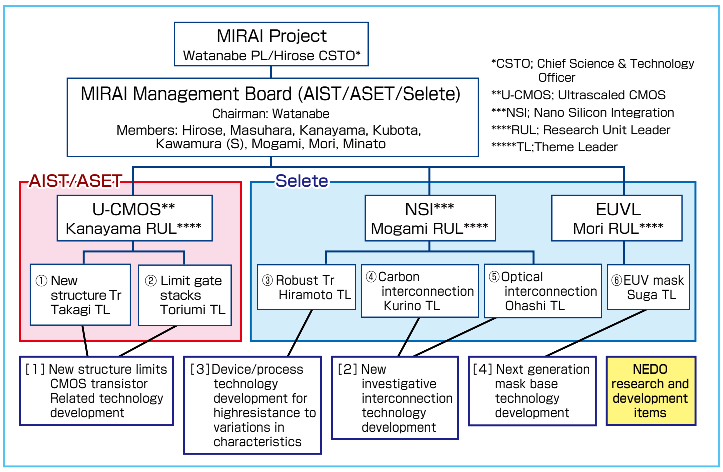


Figure 6 : MIRAI phase 3 management system

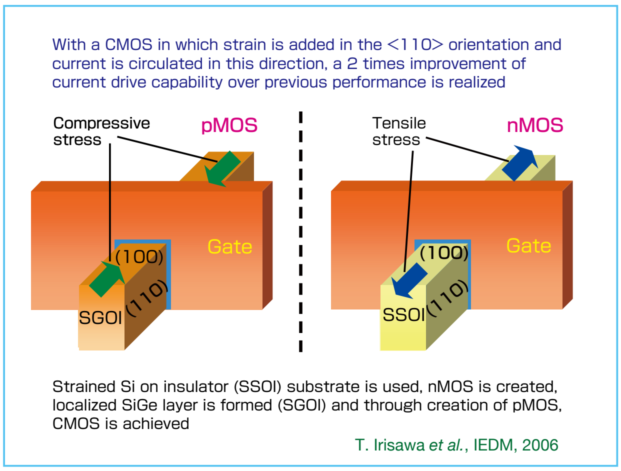


Figure 7: Most effective structure for uniaxial strained multigate CMOS (modulation of sub-band structure)

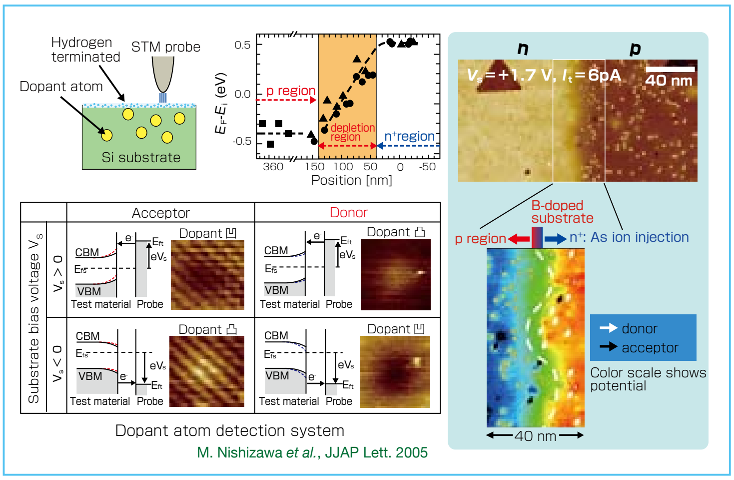


Figure 8 : Detection of individual impurity atoms in a Si crystal and simultaneous potential measurement by STM

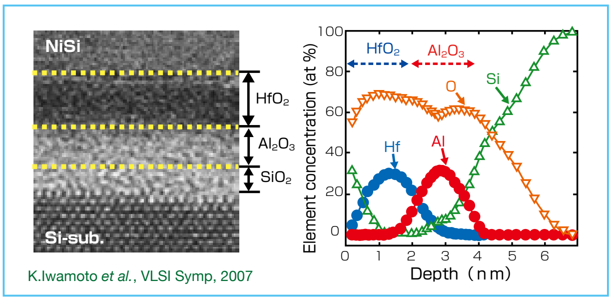


Figure 9 : Cross-sectional transmission electron microscope photograph of high-k gate insulator film consisting of a gate stack comprised of 2 layers: HfO_2/Al_2O_3 (left), and profile of composition of $HfO_2/Al_2O_3/SiO_2$ layers by depth

It was thought that MOS threshold voltage was determined by the characteristics of the upper interface between the NiSi (gate electrode) and HfO_2, but it is now understood that this is determined by the Al_2O_3 and SiO_2 lower interface multi atom layer region. The same conclusion was reached even when the positions of the upper HfO_2 and lower Al_2O_3 layers were swapped over. This discovery, which overturns the popularly held academic view, will change CMOS design methods.

led the way in the development of these technologies (Figure 8). The problem of variations in device characteristics will become increasingly pressing. In order to determine the reasons for the variations, it is necessary to accurately understand the behavior of dopant atoms under heat treatment, behavior of localized strain in transistor active regions and the local fluctuations in gate length, and nanoscale spatial resolution measurement is becoming increasingly important.

Also, with regard to extremely high-k gate stack technology development, a basic principle for designing the metal gate and high-k materials as one body in order to control the transistor threshold voltage has been newly established (Figure 9). This is a new discovery that will force a fundamental re-evaluation of the academic thinking on the subject that has existed up till now. The demonstration of these kinds of new concepts has been made possible because prototype equipment that can control growth of high-k thin films on the atomic scale has been developed in MIRAI Project. It will not be long before a complete system encompassing equipment, materials and device technology appears for the purpose of designing and manufacturing high-k gate stack structures based on high-k MOS transistor threshold voltage basic control principles.

It is expected that these results will be widely developed for application in the semiconductor industry and will create innovation in device technology.

Table : Technology transfer of MIRAI development results to industry

● Research and development adjusted to development application schedules of device makers at the top of the industry

	MIRAI results (new concepts, top in the world)	Destination of 1st transfer (application development, industrial project)	End user
Lithography related measurement	Mask defect inspection factor technology	Toshiba/NuFlare (equipment project)	Mask maker / Device maker
		Selete (joint development)	
	Miniaturized pattern 3 dimensional measurement technology	Hitachi Construction Machinery (equipment project)	
	Wafer pattern defect inspection technology	ACCRETECH (equipment project)	
	EUV mask blanks defect inspection technology	Selete (practical machine development)	
Low-k	Ultra low-k material technology	ULVAC/Mitsui Chemical (material project)	Device maker
	Interconnect formation process technology	Selete (interconnect module development)	
	Plasma polymer low-k material technology	NEC (joint research)	NEC Electronics
High-k	Material deposition technology	Hitachi Kokusai Electric (equipment project)	Device maker
	MOSFET threshold voltage technology	Selete (deposition process development)	
New structure transistors	Strained Si, SiGe wafer technology	Toshiba Ceramics/Komatsu Electronic (joint research)	Device maker
Circuit systems	TCAD parameter automatic extraction technology	Selete (joint research)	Device maker

Advanced Semiconductor Research Center
Masataka Hirose

LSI Technology Aims to Be a New Direction for Development

Obstacles to further miniaturization

Silicon large scale integrated circuits (Si LSI) support the hardware side of the IT society. The remarkable development of LSIs has been achieved through miniaturization of device dimensions (scaling) of MOSFETs (metal-oxide-semiconductor field-effect transistors: single-gate MOSFETs on a Si bulk substrate) of which LSI circuits are composed so far. At present, the semiconductor technology generation (technology node) has already reached the 65 nanometer generation level. It can be said that LSI technology has become a major part of the nanotechnology.

At the same time, we are forced to recognize the strong awareness that extremely large obstacles stand in the way of continuing to reduce the dimensions of devices in order to increase functionality and level of integration as has been done up till now. In other words, we are starting to notice the misgivings that the miniaturization will result in the short channel effect and increase in the leak current, which causes degradation of switching characteristics and prevent the expected improvement in device performance.

XMOS devices breaking through the barrier of miniaturization

As a device structure to solve those intrinsic problems, a double gate MOSFET (initially named XMOSFET, after the Greek letter Ξ (X in the English letter) that resembles the shape of the cross section of the device) with a top-and-bottom gate, was proposed by the Electrotechnical Laboratory (now AIST), in 1984.

The double-gate structure firmly shields the channel from the drain field, and the effect of the drain on the source is kept minimal. Thus the limit on the bulk MOSFET miniaturization can be exceeded. Afterwards, in the late 1990's, the scaling limit of silicon devices began to emerge as a practical problem. Then the effectiveness of the double-gate structure was evaluated and the latest edition (2005) of the ITRS (International Technology Roadmap for Semiconductors) cited the double-gate MOSFET as an ultimate MOS device.

In 2001, AIST took up the XMOS technology as one of the priority themes, and aimed to establish the XMOS device fabrication technology through the development of original processes such as an anisotropic wet etching (Figure 1), a neutral beam etching and an ion bombardment retarded etching *etc.*

Misgivings regarding increase in the leak current (inactive power)

Another serious problem equal to or greater than the miniaturization issue

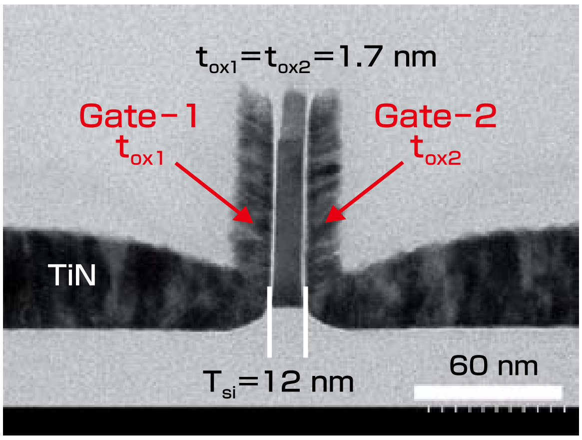


Figure 1 : Prototype 4-terminal double-gate MOSFET (4T-XMOSFET)
Fabricated by using the anisotropic wet etching for the well standing-up fin channel, and the reactive ion etching (RIE) for the gate separation.

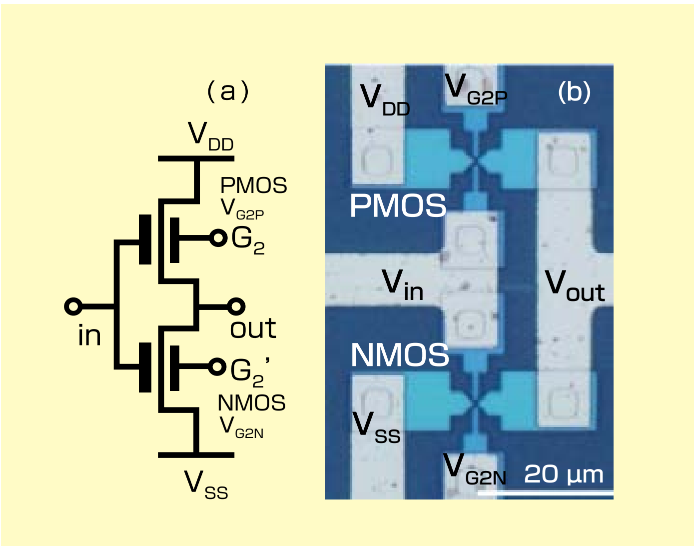


Figure 2 : CMOS inverter that uses 4-terminal double-gate MOSFETs (4T-XMOSFETs)

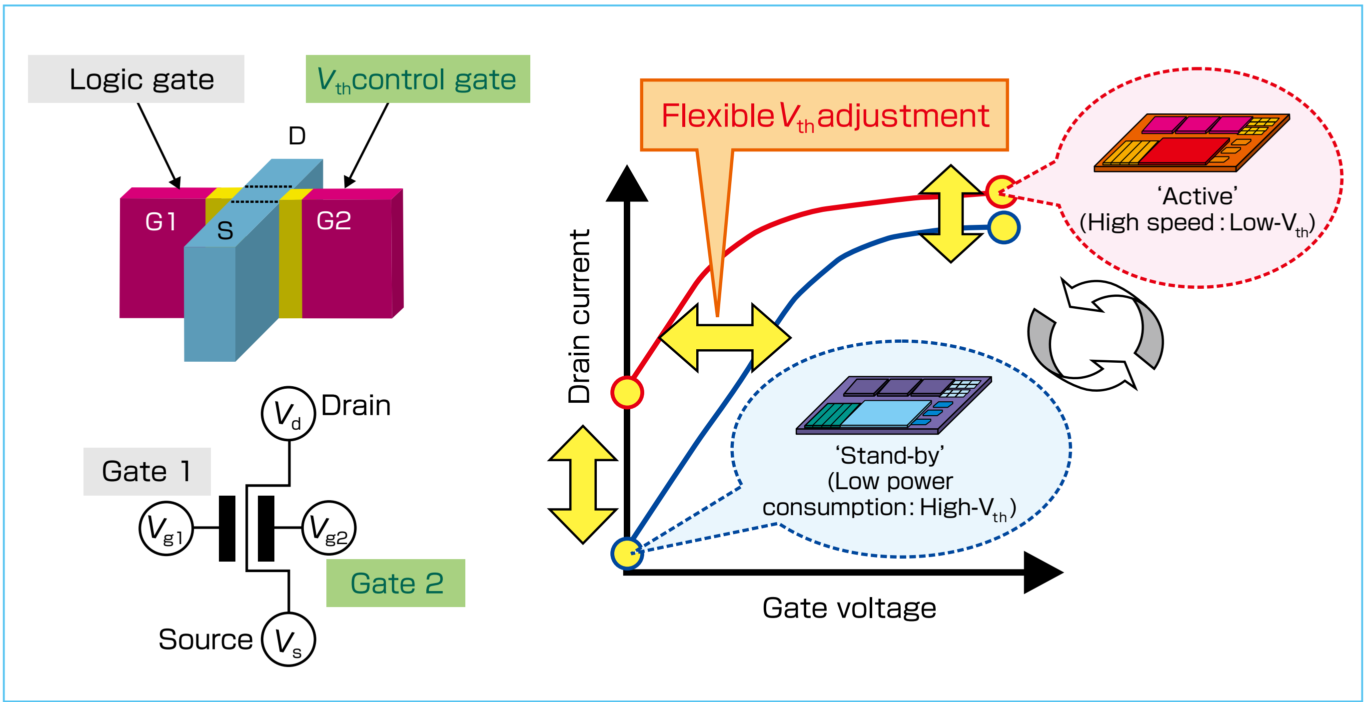


Figure 3 : Unique function of the 4-terminal double-gate MOSFET (4T-XMOSFET) By flexibly controlling V_{th}, both high speed during the active state and low power consumption during the standby state are achieved.

is the increase in the inactive power due to the leak current. The transistor threshold voltage V_{th} is closely related to performance and energy consumption of LSIs. In order to raise speed, namely drivability, it is necessary to choose a low V_{th} value and increase the ON current I_{on}, which also causes the increase in the standby leak current and inactive power.

Conversely, the standby leak current can be reduced by raising V_{th}, but at the same time the ON current is also reduced and the operation speed cannot be raised. This situation is the same for both the bulk MOSFET and double-gate MOSFET with a usual common gate, because the threshold voltages are fixed in both cases.

New LSI "hot & cool chip"

In contrast to the above-mentioned situation, if the double-gate is separated and two gates can be driven independently, one gate can be used to perform switching and the other one can freely control the threshold voltage V_{th}.

Therefore, in the active circuit state, the drivability can be increased by raising the ON current, and during the standby state the OFF current can be decreased and the stand-by inactive power is drastically reduced. Thus an ideal circuit operation is able to be achieved (Figure 2).

If the four-terminal double-gate MOSFET (4T-XMOSFET) as an advanced XMOS device with such a new function is used, it is expected that a ultra low-power consumption LSI having optimum power control, in other words, a "hot & cool chip", can be realized (Figure 3).

It can be said that the ubiquitous electronics (electronic devices that allow us to enjoy the benefits of the IT technology anytime and anywhere) will drive the IT society, where both the advanced data processing function and the low energy consumption are necessary. Therefore, we believe that LSIs composed of the 4T-XMOSFETs will play an active part in near future.

Nanoelectronics Research Institute
Eiichi Suzuki

Nonvolatile Memory that Gives Ultra Low Electricity Consumption

Nonvolatile function and the ubiquitous society

The vast amounts of content data that are transferred across the internet, such as movies and music, are stored on hard disk servers. The mobile music players that are necessary items for enjoyment of music are achieved by using flash memory. In both of these electronic devices data is not lost even if the power is turned off (non volatility). The demand for nonvolatile devices in various areas is increasing.

In order to store the explosively increasing volume of data, further increase in the data storage capacity of hard disks is indispensable. Also, for the movie data, the amounts of data around a thousand times larger than that of music data, the operating speed of flash memory is too slow. The fact that flash memory breaks after usage of several tens of thousands of times confines the possibilities of nonvolatile memory. If high speed, high capacity and nonvolatile memory that can be written and read unlimited number of times (universal memory) could be achieved, computers that can be used at the moment their power is turned on would be possible. If logic devices also come to have nonvolatile functionality, still greater developments can be expected.

With current silicon semiconductor logic circuits, it is necessary for the power to be continuously switched on in order to preserve data. If nonvolatile logic devices could be created which do not lose data even if the power is switched on and off several thousand times per second, then it would be possible to make computers which to human beings look as if they are continuously operating, but in fact have their power switched off for most of the time. This is expected to yield dramatic reductions in power consumption. We have named these “normally off computers” and have made them our long term goal.

Spintronic technology using the ultimate microscopic magnets

Ferromagnetic materials are the most suitable for the achievement of nonvolatile memory. Their speed and their ability to be written and read an unlimited number of times have already been proven by hard disks.

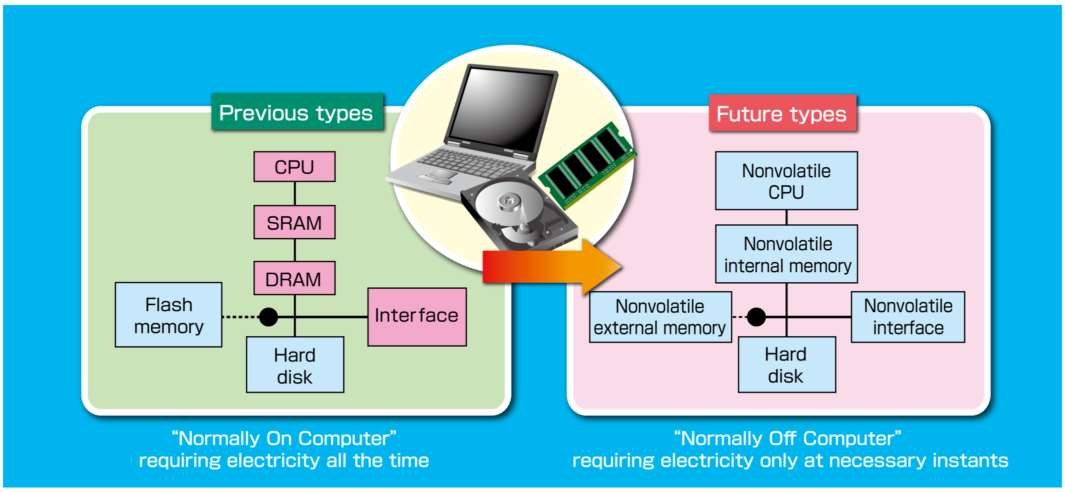
However, for use within electric devices, a conversion between magnetic and electric data is necessary. For a long time, coils have been used for this purpose but their conversion efficiency is low and the limits for improvement have been reached.

The new technology called spintronics solves this problem. Using this technology, conversion between magnetic and electric data can be carried out at high efficiency without the use of coils.

Each electron that carries electric currents has the characteristics of an extremely small magnet (spin). In particular, the electric current which flows out from ferromagnetic materials represents a flow of small magnets with their magnetization direction aligned in the same direction. This spin current can only be observed very closely to the ferromagnetic material (within about 10 nanometers) and so using it has not yet been possible.

However, nanotechnology has made it possible.

Of the consequent results, the most worthy of attention are the tunnel magnetoresistance (TMR) devices. These are devices consisting of a combination of



If nonvolatile devices, which do not lose their data even if the power is turned off, can be developed, then a great reduction in the electricity consumption of electronic data devices is expected.

thin ferromagnetic films and an insulator film of thickness in the nanometer range.

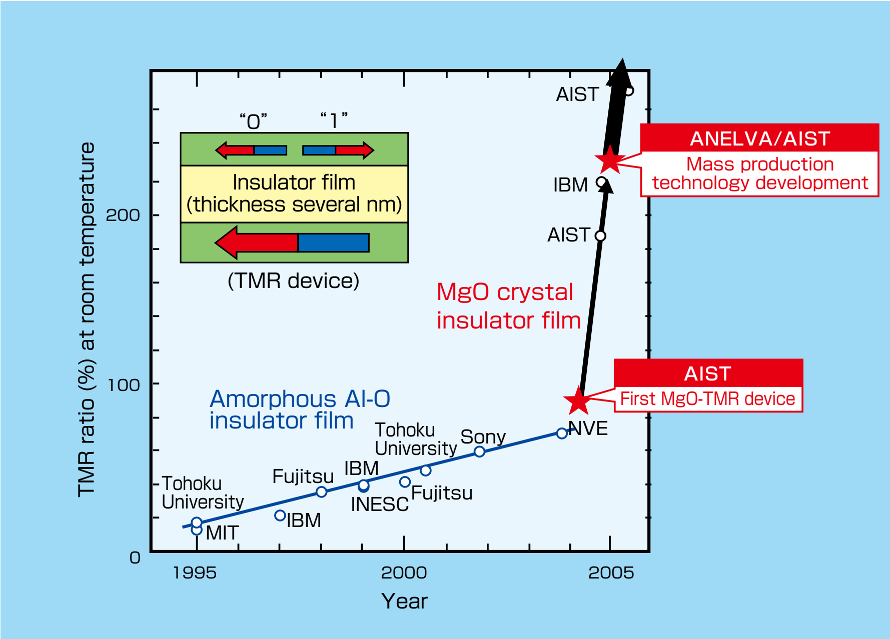
The amount of the spin current passing through the insulator film changes depending on the direction of magnetization of the ferromagnetic films. By using this phenomenon, magnetic data can be read electrically without the use of a coil. Performance is indicated by the resistance change ratio (TMR ratio).

In 2004, we developed a completely new TMR device using MgO crystal as the insulator film and achieved a big leap in performance. Teaming up with a manufacturer, we also succeeded in developing mass production technology. By including MgO-TMR devices in hard disks, a large scale increase in storage capacity can be achieved. This technology has been already included in hard disk drives worldwide.

MgO-TMR devices also represent a powerful card in the development of universal memory. Increasing the capacity of nonvolatile MRAM, which uses ferromagnetic material, was considered to be difficult on 2 points of read signals and write power. With the appearance of MgO-TMR devices the read signal problem has been completely solved.

All that remains is the write power problem. As before, MRAM uses coils for this purpose. We are currently developing a new type of MRAM (Spin RAM) that uses spin current to write magnetic data in place of a coil.

Also, aiming towards nonvolatile logic devices, we are currently developing spin transistors, which utilize the injection of spin from ferromagnets into semiconductors and ferromagnetic semiconductors, which turn the semiconductor itself into a ferromagnet.



History of the performance improvements of tunnel magnetoresistance (TMR) devices which convert magnetic data to electric data
AIST created a new type of TMR device which uses MgO as the insulator film.

Aiming to produce a "normally off computer"

Spintronic technology will lead to the realization of mass storage, universal memory and also a new type of data communications equipment *i. e.* a normally off computer. Following the first appearance of the microprocessor, there was a proposal to help Africa by combining solar cells with small computers, but even after 30 years this is still to be realized.

With the ultra low electricity consumption provided by nonvolatile devices many dreams like this, which are still to be fulfilled, can become reality.

Nanoelectronics Research Institute
Koji Ando

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Research Hotline

UPDATE FROM THE CUTTING EDGE

Oct.-Dec. 2007

The abstracts of the recent research information appearing in Vol.7 No.10-12 of "AIST TODAY" are introduced here, classified by research area.
For inquiry about the full article, please contact the author via e-mail.

Life Science & Technology

Brain-derived neurotrophic factor regulates cholesterol metabolism for synapse development

Brain-Derived Neurotrophic Factor (BDNF) exerts multiple biological functions in the Central Nervous System (CNS). Although BDNF can control transcription and protein synthesis, it still remains open to question whether BDNF regulates lipid biosynthesis. We found that BDNF elicits cholesterol biosynthesis in cultured CNS neurons. Importantly, BDNF elicited cholesterol synthesis in neurons, but not in glial cells. BDNF-induced cholesterol increases were prevented by specific inhibitors of cholesterol synthesis, mevastatin and zaragozic acid, suggesting that BDNF stimulates *de novo* synthesis of cholesterol. An electrophysiological study revealed that BDNF-dependent cholesterol biosynthesis plays an important role for the development of a Readily Releasable Pool (RRP) of synaptic vesicles. Taken together, these results suggest a novel role for BDNF in cholesterol metabolism and synapse development.

Masami Kojima
Research Institute for Cell Engineering
m-kojima@aist.go.jp

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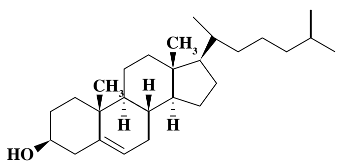

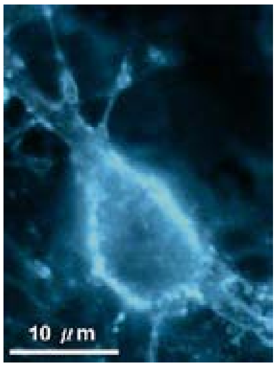

Molecular structure of cholesterol (left) and fluorescence image of cultured neuron labeled by a cholesterol-binding dye Filipin (right)

A possible cognitive risk of using mobile phones during driving

Toward filling the gap between ergonomics and neuroscience

For elucidating a cognitive risk of using mobile phones during driving, we carried out experiments based on a dichotomy of the human visual system: The dorsal subsystem for dealing with 'where' aspect (locations) of visual information and the ventral for 'what' aspect (colors, shapes). Driving in a situation was assumed to use either of the subsystems depending on the aspect of visual information required for the situation. Hearing through a mobile phone in a situation was also assumed to use either of the subsystems for mentally imaging each of the aspects. Subjects in the experiments concurrently carried out visual and auditory tasks; They differentially responded to either location or color in the visual task and their reaction times were measured, while they mentally imaged either location or color in the auditory task. Reaction times were longer when the aspect in the concurrent auditory task was the same as that in the visual task than when different.

Takashi Hamada
Institute for Human Science and Biomedical Engineering
hamada-takashi@aist.go.jp

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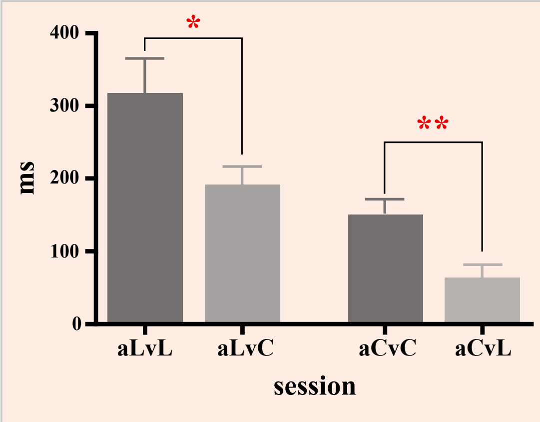

Reaction times (RTs) in the visual tasks were increased due to the concurrent auditory tasks.
The figure shows the increased amount in RTs with respect to the aspects of the visual and auditory tasks.
a: auditory, v: visual, L : location, C: color
*: $p< 0.05$, **: $p< 0.01$.
(p shows the percentage of risk in statistical testing of significant difference)

Autoilluminated fluorescent protein for greater sophistication in cell imaging

GFP fluoresces without exposure to external excitation light

We have developed a technology for exciting Green Fluorescent Proteins (GFP) by using the bioluminescence reaction, and a new imaging technique using this new enhancing technology.

Usually, an external light source was needed to yield the fluorescence of GFP in its various applications. On the other hand, luminous marine organisms such as sea pansy, *Renilla reniformis* can induce GFP fluorescence via luciferin-luciferase reaction. The phenomenon is well-known as bioluminescence resonance energy transfer (BRET). Using the BRET, we have combined GFP variants with *Renilla* luciferase to produce autoilluminated GFPs. If the luciferin called "Coelenterazine" is present, no external light source is required to excite GFPs. Different types of GFPs will emit light of different colors. We have used this technology to develop a new bioluminescence imaging probe that permits the observation of a single cell.

Hideto Hoshino
Research Institute for Cell Engineering
ah-hoshino@aist.go.jp

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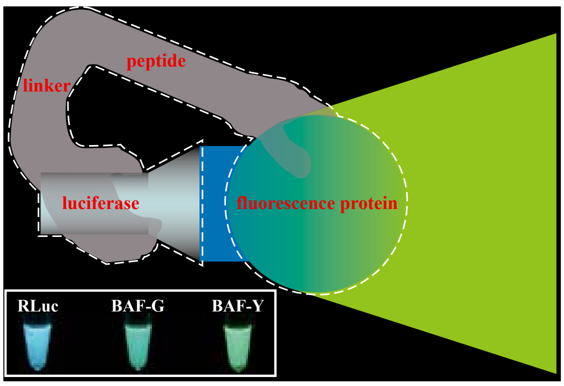

Conceptual diagram of BRET-based Autoilluminated Fluorescent-protein (BAF)
BAF is an artificial protein made by combining fluorescent protein and luciferase with linker peptide (dotted line). Fluorescent protein is made to glow by the luciferin-luciferase reaction (RLuc : blue luminescence of *Renilla reniformis* luciferase (left of photo), BAF-G : green luminescence of the newly developed BRET-based Autoilluminated Fluorescent-protein (center of photo), BAF-Y : yellowish-green luminescence of the newly developed BRET-based Autoilluminated Fluorescent-protein (right of photo).

High-precision measurement system for terahertz frequencies

Development of superconducting heterodyne receiver and its application to gas spectroscopy

We developed a heterodyne receiver based on an SIS (Superconductor-Insulator-Superconductor) mixer followed by an FFT (Fast Fourier Transform) spectrometer, aiming to realize a highly sensitive, broadband, and precise measurement system at terahertz frequencies. The receiver noise level is 10-20 times of the quantum limit in the frequency range of 0.23-0.44 THz, which is as wide as 63 % of the center frequency. We also confirmed that this receiver is applicable to spectroscopy of gas molecules, such as HCN, with the frequency resolution of 60 kHz.

Kenichi Kikuchi
Nanoelectronics Research Institute
kikuchi.kenichi@aist.go.jp

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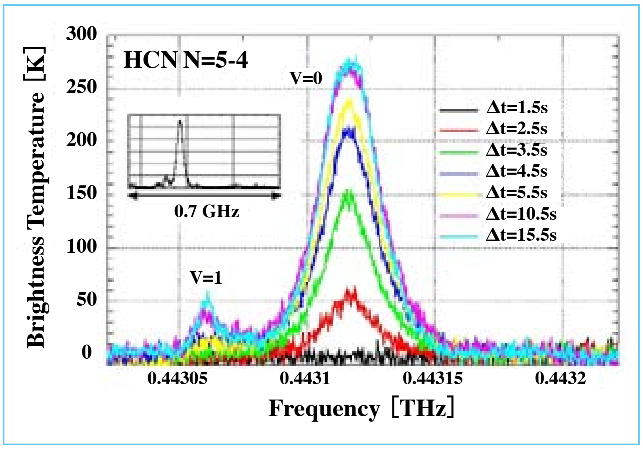

Example of measured spectra. Tarahertz emissions from HCN (N=5-4), produced by electric discharge of CH_3CN, in ground (v=0) and vibration-excitation state (v=1) were observed continuously with 1-second integration. Inset shows the instantaneous bandwidth of the receiver system.

Development of true 3D display using laser plasma in the air

AIST with Burton Inc. and Hamamatsu Photonics has revealed a new “true 3D display using laser plasma in the air” capable of projecting 1000 dots in every second in a 50x50x50cm free space. To achieve this new level of projection, we used the newly developed laser source (repetition rate: 1kHz, average power: 200 W) and improved the 3D scanning system as well as the optical system. This 3D display made it possible to draw animations more smoothly than that released last year. We believe our technology may provide the answer for a real 3D TV in the future.

Satoru Shimada, *et al.*
Photonics Research Institute
photonics-sec@m.aist.go.jp

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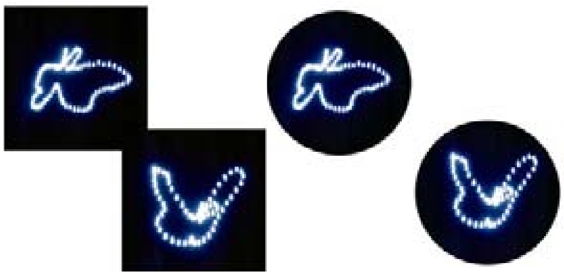
A symbol in the Japanese syllabary, “イ [i]” projected in the air. (size: approximately 40 cm)



Butterflies projected in the air.

Spectrally selective coatings for solar control glass

High heat-reflective and visible transmission for solar rays

We have developed spectrally selective coatings for solar control windows. The coatings prepared on glass can reflect more than 50 percent of solar heat rays while transmitting more than 80 percent of visible light, thereby minimizing disruption of natural lighting and viewing. The coatings can also cut ultra-violet light. These optical properties are realized by interference of light waves reflected or transmitted at interfaces of the coatings. Optical properties of the coatings can be designed according to various demands of application. The coatings have a multilayered structure consisting of titanium-based and silica-based oxides deposited by a sputtering process. The coated glass can reduce heat intake coming through windows, and thus reduces cooling load of the building in summer.

Naoto Kikuchi
Nanoelectronics Research Institute
naoto-kikuchi@aist.go.jp

AIST TODAY Vol.7, No.12 p.24 (2007)

Spectrally selective coating deposited on glass

Multifunctional ionic gelator for a variety of solvents

We have developed a novel "ionic gelator" based on an oligomeric electrolyte as a brand-new class of physical gelator. This gelator was prepared by a simple one-pot condensation reaction of commercially available two chemicals. We observed that the hydrogel was formed from ca. 1 wt% of an aqueous solution not only in a neutral water but also in an acidic solution (pH=1). The gelator is also applicable for organic solvents and ionic liquids by tuning the solubility via the anion exchange. In addition, the ionic gelator was also found to act as an efficient dispersant for single-walled carbon nanotubes (SWNTs) in water. Subsequently, it is easy to prepare "SWNT-hybrid hydrogel" by employing this bifunctional ionic gelator.

Masaru Yoshida
Nanotechnology Research Institute
masaru.yoshida@aist.go.jp

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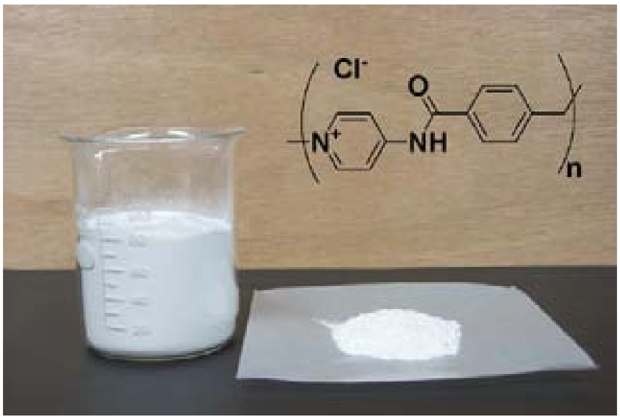

"Ionic gelator" based on an oligomeric electrolyte

A high-sensitive quick-response NO_X sensor

We have developed a planar type NO_X sensor with a dense sensing layer that consists of nano-size grains and a better part of reference electrode buried in an electrolyte by a pulsed laser deposition method. It shows a high NO sensitivity even at low temperature (300-450 °C). Electromotive force (EMF) values were almost linear to the logarithm of NO concentration, and the response was reproducible. The EMF was about -90 mV upon exposure to 1000 ppm of NO at 350 °C. And, the 90 % response time was found to be about 5 seconds. This cell opens up the possibilities for development of an integrated electrochemical device for NO_X gas treatment in combustion exhausts.

Koichi Hamamoto
Advanced Manufacturing Research Institute
k-hamamoto@aist.go.jp

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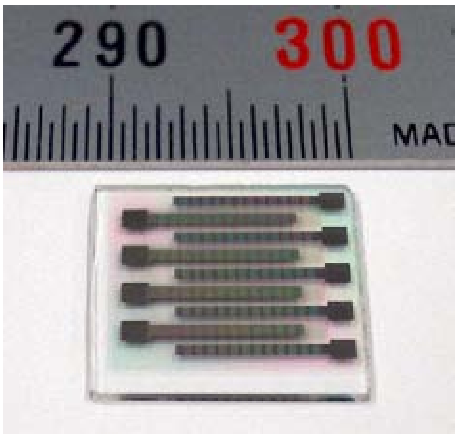

The sensor array with a multilayer sensing electrode.

Electrical switches with colorful patterns by nanoparticles of pigments

Electrical color-switchable glass with Prussian blue nanoparticles was developed using wet processing. We have developed the nanoparticles of Prussian blue and its analogues, which disperse well in organic solvents. Consequently, various conventional coating and printing methods can be used in high-quality micro-fabrication to prepare electronic devices.

We examined electrochromic properties of the nanoparticle thin film fabricated by using a spin-coating on a transparent conducting oxide (TCO) . The blue electrochromism was observed; the color changes between blue and colorless reversibly by applying voltage only with a 1.5 V dry battery. The electrical color-switchable glass with electrolyte sealed between two parallel TCOs was fabricated, exhibiting electrochromism even after 10,000 time operations. Various patterns can be also printed using photolithography.

Tohru Kawamoto
tohru.kawamoto@aist.go.jp
Hisashi Tanaka
hisashi.tanaka@aist.go.jp
Nanotechnology Research Institute

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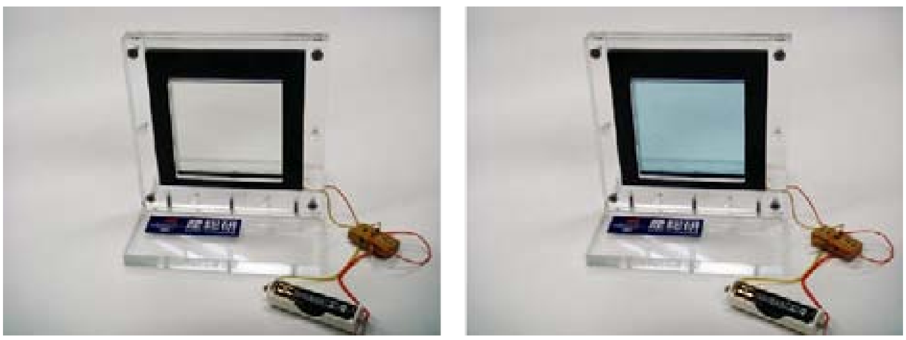
10cm square prototype of electrical color-switchable glass (left : colorless state, right : colored state)

Development of High-sensitivity, high-precision quartz crystal microbalance (QCM) immunosensor system

Suitable for rapid analysis of environmental pollutants, disease markers, and allergens

We have developed a high-sensitivity, high-precision quartz crystal microbalance (QCM) immunosensor system (QCM system) with a flow cell. The stability of the oscillating frequency of QCM in a solution was a serious problem with conventional QCM systems. We successfully improved the stability by more than one order of magnitude by decreasing the phase noise: this resulted in a highly-sensitive, highly precise and rapid measurement of an immunoreaction.

This QCM system allows us to detect the presence of a target substance with high selectivity. A substance (antibody or antigen) that binds specifically to the target substance (antigen or antibody respectively) is immobilized on the gold electrode surface of the QCM-sensor. When the antibody binds to the antigen, there occurs a detectable change in the oscillating frequency of the QCM-sensor device. We expect this QCM-system to be useful in highly sensitive, very precise analyses of substance such as dioxins, endocrine disruptors, pesticide residues, allergens, stress markers, disease markers, and pathogenic microbes.

Shigeru Kurosawa
Research Institute for Environmental Management Technology
shigeru-kurosawa@aist.go.jp

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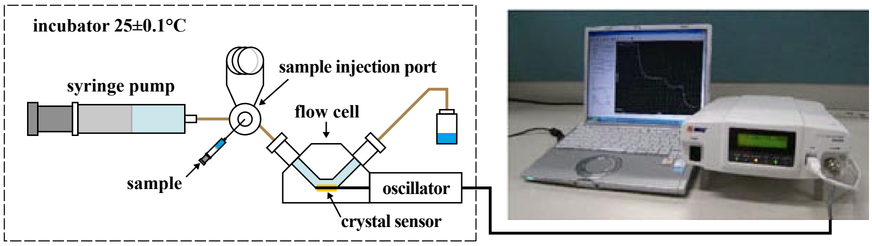


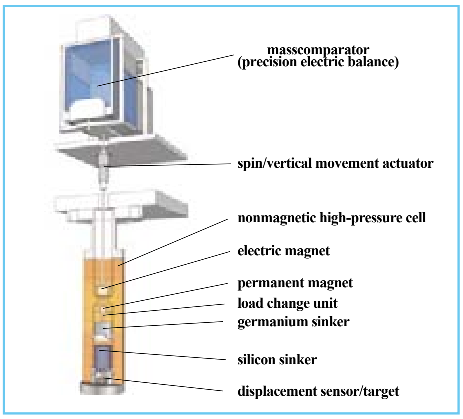
Schematic diagram of the flow-type QCM immunosensor system

Magnetic levitation densimeter for PVT property standard

A magnetic levitation densimeter (MLD) is developed to provide precise pressure-volume-temperature (PVT) property standard data for several novel fluids such as non-fluorinated refrigerants, hydrogen and bio-fuels. On the basis of the solid density artifact in which density is traceable to the primary density standard realized by silicon single-crystal spheres, fluid density can be measured by simple Archimedes principle. By using MLD, one can measure fluid density *via* magnetic coupling which transmit the buoyancy force through the pressure barrier. The bottleneck of this method was the force transmission error of the magnetic coupling to surrounding materials, and it results in an error of about 100 ppm in density measurement. Based on finite element method (FEM) analysis, we have proposed a dual-sinker weight exchanging system. By weighing two density-different sinkers at the same vertical levitation height, fluid density is obtained without any errors related to the magnetism of materials.

Yohei Kayukawa
Metrology Institute of Japan
kayukawa-y@aist.go.jp

TODAY Vol.7, No.10 p.28 (2007)



Dual-sinker magnetic levitation densimeter

President Yoshikawa Attends Thailand NSTDA International Advisory Board, and Exhibition at Thailand National Science and Technology Fair 2007

The International Advisory Board meeting of NSTDA (National Science and Technology Development Agency), the largest national research institute of the Kingdom of Thailand was held in Bangkok on August 2 and 3, 2007, and President Hiroyuki Yoshikawa attended as chairman. There were active discussions on research management, relationship with industries, research assessment, and missions at the meeting.

There are individual research institutes (MTEC, NANOTEC, BIOTEC, NECTEC) under NSTDA. NSTDA signed a comprehensive agreement with AIST in 2004, and active research collaborations are being promoted in areas as energy, environment, and information.

President Yoshikawa and the members of the International Advisory Board of NSTDA (National Science and Technology Development Agency) of Thailand

Moreover, National Science and Technology Fair 2007 which is attended by 1 million people every year was held in Bangkok from August 8 to 19. 2007 marked the 120th year since Japan and Thailand signed a treaty of amity, and Japan opened the Japan booth where 25 universities and independent administrative institutions participated as: AIST, the University of Tokyo, Tokyo Institute of Technology, New Energy and Industrial Technology Organization, National Institute for Materials Science, Japan Agency for Marine-Earth Science and Technology, and RIKEN; and many companies participated as Toyota Motor Corporation, Honda Motor Co. Ltd, and Murata Manufacturing Co.. There were many visitors at the fair site.

AIST participates every year, and exhibited an intelligent wheelchair, a humanoid robot “Choromet”, mental commit robots “Paro”, “Hyper-Mirror”, a power-saving artificial arm, and panels (on GEO Grid, photovoltaic generation, BDF, photocatalysts, biomass, a sugar sensor).

During the fair, Her Royal Highness Princess Sirindhorn tried the intelligent wheelchair while holding Paro, and the scene was broadcasted through televisions and published in newspapers in Thailand, providing an opportunity for AIST research results to be understood by many thai people.

Emeritus Advisor Michio Kuriyagawa Acknowledged as Member of National Academy of Sciences of Argentina

Michio Kuriyagawa, Emeritus Advisor of Institute for Geo-Resources and Environment, aist, was acknowledged as the first Japanese member of National Academy of Exact, Physical and Natural Sciences of Argenitna (National Academy of Sciences of Argentina), and was given a diploma at Buenos Aires on September 10, 2007 by President Alejandro J. Arvia, and gave a commemorative lecture.

National Academy of Sciences of Argentina was founded in 1874 “for the promotion of progression, development and dissemination of sciences”, and having members from home and abroad, it acknowledges as members those who have done distinguished work in science and industry of Argentina. Among its domestic members are 3 Nobel prize laureates, and Albert Einstein who did research in Argentina was one of the overseas members.

Kuriyagawa was in Argentina from May 2001 to March 2005 as a chief advisor of “Industrial Pollution Prevention Project” of JICA (Japan International Cooperation Agency).

While in Argentina, he helped to advance research on environment (training young researchers and acquiring ISO 17025 etc.) at Water Use Technology Center of National Institute of Water, examined many polluted sites within Argentina and offered opinions on strategies. He, for example, did water survey of the city of Rio Gallegos, revealed the polluted conditions, and based on his survey results the city of Rio Gallegos took measures against industrial sewage. Aware of the importance of environmental education in solving environmental problems, he also gave seminars on the subject in various regions in Argentina.

Emeritus Advisor Kuriyagawa receiving diploma from President Alejandro J. Arvia

Kuriyagawa says that this award was possible “thanks to the cooperation of many people involved”, and that he would like to take the opportunities of visits to Argentina to contribute to the National Academy of Sciences of Argentina through scientific education in the environmental fields.

Exhibition at "Japan Fair in Guangzhou" in China

"Japan Fair in Guangzhou" (sponsored by Ministry of Economy, Trade and Industry, Japan External Trade Organization (JETRO) et al.) was held from September 15 to 18, 2007 at Guangzhou International Convention and Exhibition Center.

In April 2007, at the Japan-China heads of state summit talks between the then Prime Minister Shinzo Abe and Chinese Premier Wen Jiabao, it was agreed that Japan would participate as guest of honor in the 4th China International Small and Medium Enterprises Fair, and the Japan Fair was held as a fair within this Exhibition. With over 300,000 visitors, over 450 Japanese companies, universities, and municipalities participated, exhibiting and publicizing for the entry of Japanese products and services to the Chinese market, and for promotion of expansion of local distribution of locally-based Japanese companies. In addition, during the fair, lectures and seminars as "Chinese Intellectual Property Seminar" were held on subjects useful to Chinese businesses.

AIST booth

AIST opened its own booth and sought to increase AIST recognition in China, as well as to explore possibilities of technological transfer to China. Interest was high towards exhibited technologies of AIST with many visitors enthusiastically listening to technological explanation, and possibilities of further collaboration could be seen at the fair.

Report of Workshop with NSTDA and TISTR (thailand) and VAST (Vietnam)

A workshop on research cooperation was held on October 1 and 2, 2007 in Thailand. AIST has signed a comprehensive agreement in 2004 with National Science and Technology Development Agency (NSTDA), Thailand, and Thailand Institute of Scientific and Technological Research (TISTR). With NSTDA, we have especially close relationship as President Sakarindr Bhumiratana of NSTDA is a member of AIST Advisory Board, and President Yoshikawa of AIST serves as chairman of NSTDA International Advisory Board.

At this 5th workshop held in Bangkok, the collaborative research themes were discussed in three sessions according to the research clusters of NSTDA, and future research expansion and project plans were summarized. A session on "R & D management and collaboration" was also arranged where management strategies, innovation strategies, TLO, collaboration among industry, academia and government, and evaluation methods of each institute were presented. There was great interest expressed by the Thai in the AIST cases. We will further exchange views on these subjects at the workshops that will follow.

Thailand-Japan Collaboration Workshop 2007 opening ceremony from right, President Sakarindr of NSTDA, Senior Vice-President Katsura, Governor Nongluck of TISTR

Director Harada(middle, front row)signing MOU on drainage water treatment at 4th Japan-Vietnam workshop with Senior Vice-President Katsura, Vice-President Yamazaki, VAST Deputy Director Son in back row

The 4th VAST-AIST Workshop on Science and Technology Cooperation was also held with Vietnamese Academy of Science and Technology (VAST), a core research institute of Vietnam, in Hanoi on October 4 and 5, 2007. We have also signed a comprehensive agreement with VAST and have alternately held workshops. We discussed research reports and future plans in different session groups as "biomass/new energy", "IT", "environment", "GEO Grid, marine geology for sustainable development and land-sea interaction". There were also discussions between Vietnamese and Japanese participants from industry and universities of the openly proposed newly selected project of 2007 (Ecological Waste Water treatment system for dyeing industries) of New Energy and Industrial Technology Development Organization on implementation specifics. In light of the project, project implementation leader, Dr. Koh Harada, Director of Research Institute for Environmental Management Technology, AIST, Dr. Luu Cam Loc, Director of Institute for of Chemical Technology, VAST and Dr. Nguyen The Dong, Director of Institute of Environmental Technology, VAST, signed MOU. Progress of the project is expected in the future.

Minister of Science and Technology of Sri Lanka Visits AIST Tsukuba

The Minister of Science and Technology of Sri Lanka, Hon. Prof. Tissa Vitarana, visited AIST Tsukuba on October 4 with Prof. Sirimali Fernando, Advisor of the Ministry of Science and Technology, and a Secretary of Sri Lanka Embassy. Minister Tissa Vitarana, a M.D., who majored in virology at Ceylon University, has been in his position since 2004. Sri Lanka planning to build a nanotechnology park, the minister strongly requested to visit AIST Tsukuba as it is one of the major research institutes of nanotechnology in Japan and time was taken within his tight schedule.

Exchanging views

On the day of the visit, Vice-President Naoto Kobayashi gave a greeting speech followed by an AIST briefing by International Affairs Department. During the exchange of views that followed, an interest toward nanotechnology research done at AIST was shown. The minister stated his desire to relay specific wishes concerning possibility of collaboration between corporations of Sri Lanka and AIST.

This visit by Minister Tissa Vitarana is expected to provide an opportunity to form a broader human resource network for the future for AIST as an innovation hub.

Keynote Lecture at the 6th Taiwan National Industrial Development Conference

The 6th Taiwan National Industrial Development Conference hosted by Taiwan Ministry of Economic Affairs (MOEC) (equivalent to the Ministry of Economy, Trade and Industry of Japan) was held at Taipei International Conference Center on November 12, 2007.

Around 300 people from the government, universities, and industries attended, and after H.E. Chen Shui-bian, President of Taiwan, and Chen Ruey-long, the Minister of Economic Affairs, gave their greetings, Masakazu Yamazaki, the Vice-President of AIST, as proxy for President Yoshikawa, gave a keynote lecture titled “AIST management policies for innovation promotion” on AIST organizational reform, research policies, and research management. There was great response to this conference and Yamazaki’s lecture was widely published in the local press.

AIST, having been cooperating in research with Industrial Technology Research Institute of Taiwan (ITRI), a foundation under MOEA, responded to the request for such a lecture. ITRI has brought forth as spin-off companies such international good-standing companies as Taiwan Semiconductor Manufacturing Company, and United Microelectronics Corporation which receives the top and second most manufacturing commissions of semiconductors in the world market.

President Chen Shui-bian and AIST Vice-President Yamazaki at the conference

AIST Web Site

http://www.aist.go.jp/

A variety of information on AIST, such as research results, organization, access map, etc. is available on the AIST web site. The entire contents of the newsletter "AIST Today" is posted in HTML and PDF formats on the day of publication.

Research Information Database (RIO-DB)

http://www.aist.go.jp/RIODB/riohomee.html

Database for Research Result Presentations (RRPDB)

http://www.aist.go.jp/aist_e/database/rrpdb/

In order to encourage the creation of new industries by providing intellectual infrastructure, AIST has incorporated the accumulated research information from its numerous research and development projects and presentations of research results in databases, which is available via the internet as organized, easy-to-use information.

Information on Development of Technology in AIST (IDEA)

http://www.aist.go.jp/aist-idea/

IDEA presents a wide range of intellectual property rights, including patents and others owned by AIST in order to enable use of the research products developed at AIST. (currently only in Japanese)

Companies or others interested in a particular AIST technology are invited to contact AIST Innovations (TLO) of Intellectual Property Dept, AIST.

AIST TODAY
International Edition
No.27 Winter 2008

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Publication Office, Public Relations Department
National Institute of Advanced Industrial Science and Technology (AIST)

AIST Tsukuba Central 2, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, Japan
TEL: +81-29-862-6217 FAX: +81-29-862-6212 Email: prpub@m.aist.go.jp URL: http://www.aist.go.jp/