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Full Research in Society, for Society

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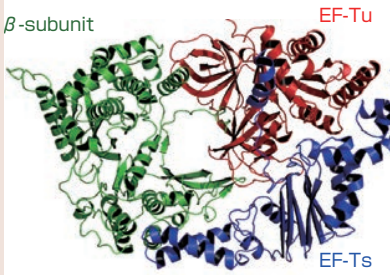


MESSAGE

President's Message

The New Science and Technology Basic Plan and AIST

FEATURE

Research on Environmentally Harmonious Building Materials

–Research on building materials that save energy and provide comfort to living spaces–

Research Hotline

UPDATE FROM THE CUTTING EDGE (January–March 2011)

In Brief

The New Science and Technology Basic Plan and AIST

1. Introduction

Japan's new Science and Technology Basic Plan, which will take effect this year, has been intensively discussed for more than a year. In the report of the Council for Science and Technology Policy, what forms the basis of the plan is the view that science and technology policies and innovation policies should be formulated in an integrated manner so as to transform the results of science and technology into innovation, as well as to improve their level thereby contributing toward strengthening Japan's competitiveness. The target for related investment in research and development was set to at least 4 % of GDP for the private and public sectors combined, with at least 1 % of this to be funded by the government. This figure compares favorably with the level of investment during the term of the previous plans, and is an indication of the determination of the government.

As a member of the Industrial Structure Council of the Ministry of Economy, Trade and Industry, and of the Council for Science and Technology of the Ministry of Education, Culture, Sports, Science and Technology, I participated in the discussions to develop the plan. I was impressed by the intensive discussions concerning competing in the race for global innovation, the necessity of nurturing and utilizing human resources, including engineers and scientists, that can meet the needs of the time, as well as the necessity of making a global contribution with a focus on software rather than hardware, in addition to the importance of industry-academia-government collaboration to promote science and technology innovation policies and revitalize local economies.

2. National goals

What I wish to particularly focus on with regard to the new plan is the following five "national goals" that were discussed. We, the people of Japan, are involved in various policies, including growth strategies, and various tasks related to the implementation of these policies. I would like to say that ultimately, we are all working to achieve the goals set forth in the plan as a common vision. Since the plan has yet to be finalized, the goals are quoted from the Cabinet Office document, "*Basic Science and Technology Policy*":

(1) a nation that can achieve sustainable growth into the future

(2) a nation that can realize a prosperous and high-quality life for its people

(3) a nation that can sustain science and technology, which provides the basis for its existence

(4) a nation that takes leadership on global issues

(5) a nation that continues to create intellectual properties and nurture science and technology as culture

In recent years, concerns have often been expressed over the pessimism pervading Japan due to its decline in the global competitiveness rankings of the International Institute for Management Development (IMD), its sluggish economic growth, and the rapid pace at which other countries are drawing level with it.

Needless to say, Japan has worked hard to catch up with and surpass the developed countries on its road to modernization since the Meiji Era and, as a result, has become globally recognized in the cultural, economic, and industrial spheres. There are many issues on which Japan can contribute to the world with its high level of science and technology achieved over the years, including environmental issues. I would say that Japan is in a position where it can take the initiative to solve the issues specific to this century that the world is facing. It is important that the private and public sectors work together to achieve the national goals. A rise in Japan's global competitiveness ranking will inevitably follow the achievement of these goals.

3. Science and Technology Innovation Policy

The world economy has become globalized with the rapid emergence of countries such as China and India as economic powers. In addition, strong competition has arisen in the arena of global innovation and a phenomenon called the marketization of research and development is appearing in various countries and regions. The global movement of talented people has intensified and the competition for top researchers has become fierce. The purpose of the integrated implementation of the "Science and Technology Innovation Policy" is to respond to the changes in and escalation of global competition and to transform scientific and technological achievements into the creation of new value.

Emphasis is being placed on the development of a strategic structure to promote innovation, enhancement of the industry-academia-government "knowledge" network, and creation of opportunities for industry-academic-government collaboration. With the qualitative changes in competition, addressing the international standardization of technology is becoming increasingly important. This calls for stepped-up nationwide efforts. Support for

international activities in science and technology diplomacy in Asia and other regions will be enhanced. This will make a significant contribution to the promotion of "green innovation" and "life innovation" as pillars of economic growth and the international dissemination of the achievements of these programs.

Reform of research and development organizations is also a matter to be discussed. In the environment of severe global competition, there are an increasing number of issues that are difficult for the private sector or universities to tackle, and that need to be addressed by public research and development organizations. These issues include long-term research and development, research and development for the benefit of the public, and research and development with a high current level of risk. It has been 10 years since Independent administrative institutions were established. In promoting science and technology innovation policies in an integrated manner, enhancing the functions of research and development organizations by improving their governance and management of organization and operations is of great importance.

4. AIST's missions

AIST's current missions are "solution for the 21st century issues" and "reinforcing functions of open innovation hub". We would like to contribute to the achievement of the national goals described earlier through our role in promoting science and technology innovation policies.

In "solution for the 21st century issues", we will take on the challenge of developing fundamental and advanced technologies to promote green innovation and life innovation and to enhance sustainable competitiveness, as set forth in the government's economic growth strategy and the Science and Technology Basic Plan. While having significantly benefited from scientific, technological, and industrial development, human beings are inevitably faced with new issues related to the environment, natural resources, and ethics. We must seek well-balanced development, with consideration given not only to contributing to market growth and improved convenience but also to the issues mentioned above. AIST's research and development leads and supports these efforts.

In "reinforcing functions of open innovation hub", we will promote research and development, assessment, and standardization of technologies through industry-academia-government collaboration utilizing the human resources and organization of AIST. We have been collaborating with universities, public research institutions, and companies on a one-to-one basis or on a consortium basis, setting up collaborative research organizations, and integrating databases together. We will also pursue open and active large-scale collaboration, including participation in technology research associations.

5. Toward creative restoration

The Great East-Japan Earthquake caused serious damage to AIST facilities, particularly AIST Tohoku and AIST Tsukuba. We have been working to resume research activities and have already resumed some research and development activities, while steadily carrying out urgent works including earthquake recovery.

The government will revise the Fourth Science and Technology Basic Plan for a five-year period starting in FY 2011. Revisions to our strategy will probably be made to proactively and quickly incorporate the changes to the plan.

This year marks the 11th year since the establishment of AIST. Expectations for AIST's role in improving the competitiveness of Japanese industry are increasing day by day and year by year. This is evidenced by the rise in the number of visitors and technology research associations realized by industry-academia-government collaboration.

A number of global issues need to be addressed to ensure the sustainability of human society is growing. Global collaboration and competition in innovation are rapidly expanding. This trend is reflected in the increase in the number of research collaboration agreements with overseas research institutions. AIST's activities over the years were well received by the domestic and foreign members of the AIST Advisory Board at its meeting in February, 2011. Over the past 10 years, we have been AIST of Tsukuba or AIST of Japan. We are determined anew to increase our presence as AIST of the world.

In concluding this message, I would like to mention our wonderful mottos: "*Full Research* in Society, for Society" and "Technology to Society". The former is based on the belief that the significance of existence of public research institutions is to aim at the sustainable development of society, while the latter is based on the belief that technology provides the basis for the competitiveness of Japanese industry. At this time of national crisis, we need to contemplate the meaning of these mottos and work hard toward the reconstruction of Japan.

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

Research on Environmentally Harmonious Building Materials
-Research on building materials that save energy and provide comfort to living spaces-

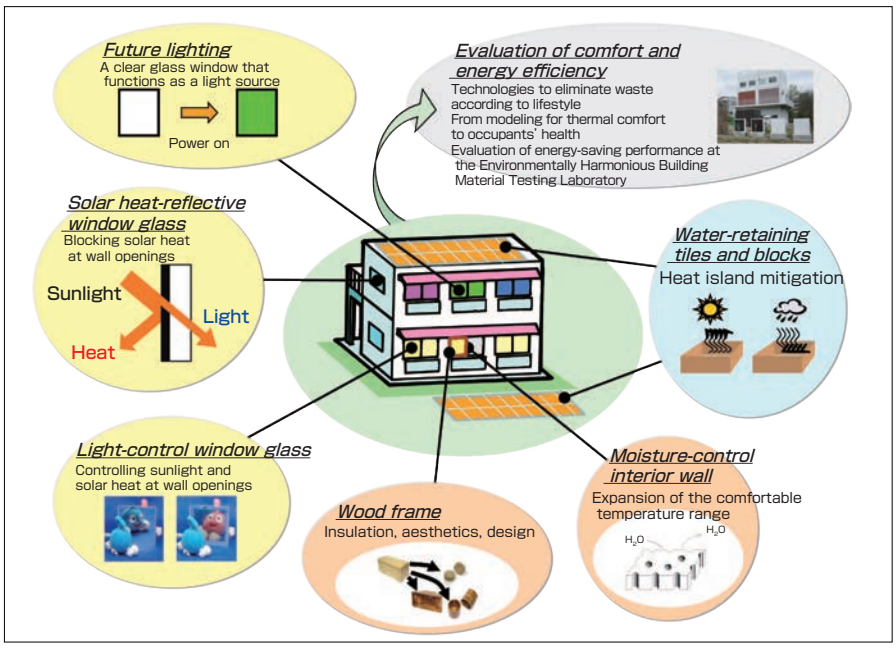
Significance of the Research

Never-ending energy-efficiency improvement

The use of high-performance building materials with good insulation properties is effective in reducing energy use for air conditioning, which accounts for about 25 % of CO_2 emissions from the commercial and residential sectors. Compared with technologies, such as batteries for which a roadmap has been laid out for development through commercialization, the focus in the area of building materials is placed on improvement and widespread use, and the speed of development of energy-saving building materials based on a new concept is slow [1]. The reason for this is that there is no clear roadmap for the development of high-performance building materials for residential and commercial construction due to the long life of homes and buildings. However, energy-efficiency improvement should never end. It is necessary not only to improve the performance of energy-saving building materials, which are increasingly used these days, but also to develop next-generation energy-saving building materials (environmentally harmonious building materials) from a variety of perspectives, such as resource efficiency, energy efficiency, comfort, and environmental harmony.

Importance of comprehensive research and development

The policy "A New Paradigm for the Housing Industry–Toward Further Development of the Housing Industry in an Era of Emphasis on the Housing Stock" announced by the Ministry of Economy, Trade and Industry on April 8, 2008, states that it will be a paradigm for the housing industry to continue to provide valuable living spaces that suit the lifestyles of occupants, including in terms of software, and thereby add value to the lives of the occupants. When we look at research and development of building materials from this perspective, the research needs be comprehensive in that both the development of materials and comfortable living must be achieved.



Research on environmentally harmonious building materials for the creation of comfortable living spaces

Environmentally harmonious building materials

At AIST, the Materials Research Institute for Sustainable Development and several research units are developing environmentally harmonious building materials for the creation of comfortable living spaces (see the figure). In this special feature, the development of a building's indoor and outdoor environments is described from a variety of perspectives, ranging from the microscopic perspective of materials to the macroscopic evaluation of comfort and efficiency.

Research Planning Office of Nanotechnology, Materials and Manufacturing

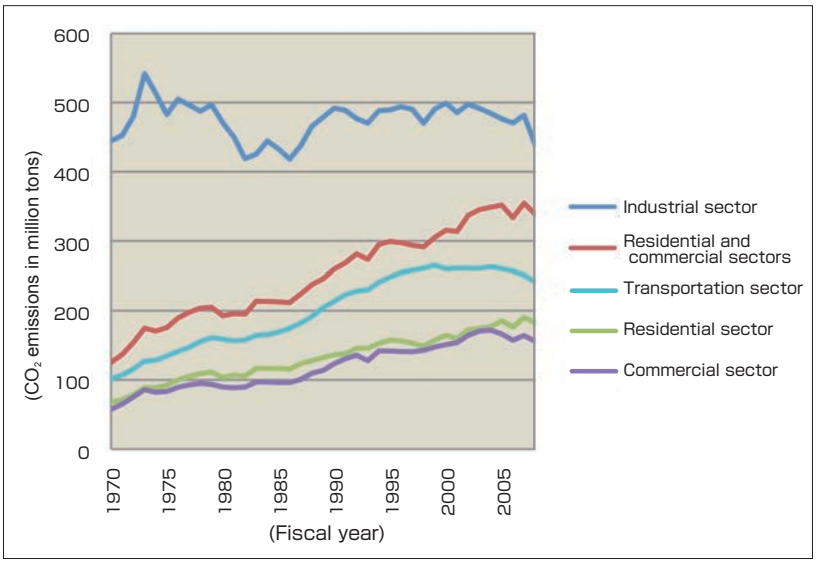
Reference
[1] Institute of Applied Energy: Super-Long-Term Energy Technology Roadmap (2006).

For inquiries about this article : Research Planning Office of Nanotechnology, Materials and Manufacturing E-mail : nanomatman-liaison@m.aist.go.jp

Research on Energy-saving Building Materials to Reduce CO_2 Emissions from the Residential and Commercial Sectors

Use of nanotechnology

A sense of urgency concerning the reduction of CO_2 emissions has become widespread in recent years. Materials technologies, including nanotechnology, have made a significant contribution to the reduction of CO_2 emissions. Materials technologies are used in new insulation materials, heat-storage materials, and moisture-control materials for thermal environments in buildings as well as in materials for solar cells and energy-efficient electrical appliances. For example, a nanometer-scale, multilayer thin film is used for low-emissivity double glass, which is widely used as ecological glass. Porous materials are used in commercially available moisture-control materials. The pore size of such materials is on the order of nanometers. These are examples of the application of nanotechnology to energy-saving materials for living environments. As part of its research in the fields of nanotechnology, materials, and manufacturing, the Materials Research Institute for Sustainable Development is studying the application of sophisticated material design and production technologies to the reduction of CO_2 emissions from the residential and commercial sectors.



CO_2 emissions by sector (fossil fuels + pro-rated to electricity)
(produced from data in reference [1])

Integration of materials and ergonomics

When we look at year-by-year CO_2 emissions in Japan (see the figure), the residential and commercial sectors show a more than 30 % increase over the FY1990 level while the industrial and transportation sectors show a decreasing trend. In particular, the residential sector shows an increase of as much as 34 % over the FY1990 level [1].

Data on energy consumption by type of use reveal that in FY2008, cooling and heating accounted for 26 % of energy use in residential buildings. In commercial buildings, in addition to cooling and heating, lighting accounts for a large proportion of energy use. Air conditioning and lighting require energy-saving measures.

Reducing the energy used for air conditioning and lighting is important. However, research on energy-saving materials that do not compromise occupant comfort requires the integration of materials research and ergonomics research. AIST's research covers a wide range of areas, including development of new energy-efficient materials and research on human comfort. As AIST allows researchers in both areas to work together, it is a research institution suitable for research on materials that offer energy savings without compromising comfort.

Director,
Materials Research Institute for Sustainable Development
Mamoru NAKAMURA

Reference
[1] The Energy Data and Modeling Center (EDMC), the Institute of Energy Economics, Japan: EDMC Handbook of Energy & Economic Statistics in Japan (2010)

Energy-saving Building Materials Being Studied at AIST

Building materials

The term building materials refers to all materials required for building construction and normally excludes equipment. Broadly speaking, they can be divided into structural materials and functional materials. Energy-saving building materials are categorized as functional materials because they function to reduce the energy required to control an indoor thermal environment.

Occupants are usually not aware of structural materials. However, the function of a functional material has effects upon the occupants (for example, in terms of aesthetics and the thermal environment). The quality of a functional material therefore affects the feelings and awareness of the occupants, often making them strongly aware of its presence. It is directly linked to comfort.

Energy-saving building materials

Various types of equipment are used to control an indoor thermal environment within an acceptable range, which requires the use of energy. In the winter, the indoor temperature is controlled at the appropriate level by the balance between the heat generated by fuel or electricity and the heat lost to the cooler outdoor air. Electricity has been increasingly utilized in recent years as an easy-to-use source of energy. In the summer, electricity is used to operate cooling units.

Saving of energy used for thermal environment control is achieved by reducing the use of fuel or electricity for cooling and heating. Therefore, the primary characteristic required for energy-saving building materials is good insulation performance. Increasing the insulation between the indoor air and outdoor air reduces the heating load, resulting in reduced fuel and electricity use. For cooling in the summer, electricity use can be reduced by reducing the heat flow from the warmer outdoor air to the indoor air.

Evaluation and development of energy-saving building materials at AIST

We are conducting research to develop energy-saving building materials with higher performance to be commercialized, evaluate the level of comfort provided by the materials, and develop materials that reduce electricity use while providing comfort using the surrounding environment. This special feature first describes the high performance energy-saving building materials as “smart building materials” and evaluation of the comfort achieved when these materials are used in an actual living space, then gives details on the status of development of next-generation smart building materials that make the most of the environment.

Deputy Director,
Materials Research Institute for
Sustainable Development
Masato TAZAWA

Expectations of Research and Development of Advanced Passive Building Materials to Provide Occupants with Comfort

Professor,
Graduate School of Environmental and
Information Studies, Tokyo City University
Masanori SHUKUYA

A space enclosed by building materials, such as windows, walls, and floors, is called built environment that is the closest to us humans among a variety of environmental-space scales. Assuming that we live for 80 years, we spend more than 70 years in the built environmental space. Therefore, the built environment must be controlled to provide comfort together with health to the occupants. The technologies to achieve this goal are lighting, heating, cooling, and ventilation. The prevailing belief in modern society on these technologies has been that these functions are served solely by mechanical and electrical engineering technologies. However, recent studies have shown that they cannot provide sufficient comfort to the occupants while minimizing the use of fossil fuels. This means that improving the thermal performance, solar optical properties of windows, and absorption and desorption properties of moisture with respect to walls, and other building components is of great importance. In this respect, I have high expectations of the research being conducted by AIST, which has been making efforts in this field.

For inquiries about this article : Materials Research Institute for Sustainable Development http://unit.aist.go.jp/mrisus/cie/

Smart Building Materials

○ Smart Interior Materials

Moisture-control interior materials (moisture-control building materials)

The indoor thermal environment needs to be optimized to create a comfortable living space. With the advancement of science and technology, living environments have been dramatically improved. At the same time, energy use has increased. Energy-efficiency improvements were required as a result of the Oil Crisis of the 1970s, and the airtightness and insulation of buildings were improved. However, if moisture is not controlled, adverse health effects are caused by moisture condensation as well as dust mites and mold growth.

Research in ceramics was conducted at the Agency of Industrial Science and Technology, the predecessor of AIST. In a government-industry collaborative research project named "Basic Research on the Development of Intelligent Moisture-Control Building Materials" carried out from FY1996 to FY1999, research on interior materials with the capability to control indoor moisture was conducted. A material obtained as a result of the research was commercialized as an interior tile (a moisture-control building material) (photo) by a company that had participated in the project. The moisture-control material was highly evaluated as a functional material capable of controlling moisture condensation and mite and mold growth by controlling moisture without using energy. It was used in the "Zero-Emission House" to showcase Japan's environmental technology to the world's media during the Lake Toya Summit in July 2008.

Brown interior tiles (a moisture-control building material) in the entrance hall of AIST Chubu

Next steps

The moisture-control building material was highly regarded for its capability to control moisture condensation and mite and mold growth, and commercialized as a building material to provide comfort. Further improvement in energy-saving performance of such materials is necessary to meet the evolving requirements of society. Therefore a new high-performance material needs to be developed to meet these requirements. We have developed a new moisture-control material (HASClay), which is a composite material of an amorphous hydroxyl aluminum silicate and low crystallinity clay, using a hydrothermal synthesis technology for amorphous clay minerals developed over the years. The material is now in the commercialization phase. Since HASClay can be used in a wide range of relative humidity levels, its primary application will be as an adsorbent for desiccant air conditioning. Its application to next-generation energy-saving comfortable building materials is also promising. HASClay is also capable of absorbing CO_2. We are conducting research and development to apply it to the separation and collection of CO_2.

Materials Research Institute for Sustainable Development
Masaki MAEDA

Institute for Geo-Resources and Environment
Masaya SUZUKI

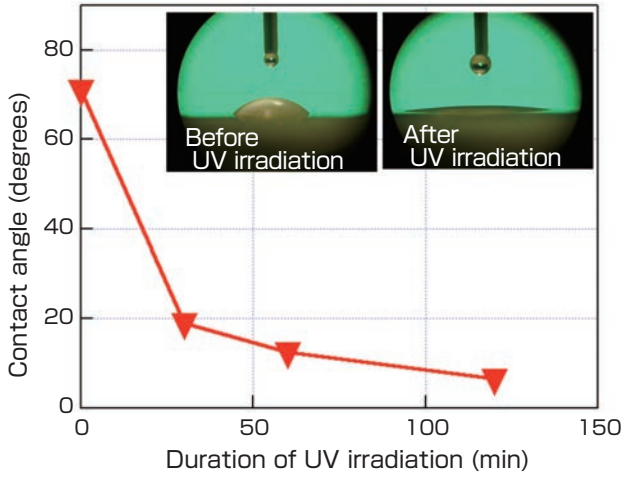
○ Smart Windows

The window – A major opening for daylight and heat

Sunlight streaming in through the windows is vital to our life. According to the 1992 Energy Saving Standards, 71 % of daytime heat flow into houses in the summer is through windows and 48 % of heat outflow from houses in the winter is also through windows. In addition, the Architectural Institute of Japan states that lighting and air conditioning consume more than 50 % of the energy use in office buildings. Accordingly, the window is a major opening for light and heat, and considered as a dominant component to improve energy efficiency of buildings without sacrificing comfort in living. There are already some functional windows, although the windows are expected to have more functions including solar-light control. The Electronics and Photonics Research Institute has been conducting research on functional glasses such as solar-heat reflective glass [1], leading to a so-called "smart window".

Effect of solar-heat reflective glass

Sunlight consists of ultraviolet (UV), visible, and infrared (IR) light. About half of the solar energy is carried by IR light (heat ray). Reflecting IR is therefore effective to reduce cooling load of buildings in the summer. Using sputter coating technology, we fabricated a prototype of solar-heat reflective glass that had a visible light transmittance of more than 80 % and cut the solar energy passing through it by half. A computer simulation was used to calculate the performance of this glass. Compared with standard window glasses, this glass was estimated to decrease the cooling load by 33 % and to increase the heating load by 15 %. Thus the year-round air-conditioning load can be reduced by 21 % overall. The revealed drawback to the heating load will be overcome by double glazing. This is why the double glazed window is recommended for better performance.



Contact angle of the sample to evaluate the hydrophilicity under UV irradiation (365 nm, 2 mW/cm^2)

Multifunctional coatings

Our recent attempt is the incorporation of self-cleaning function into a solar-heat reflective glass. As a material for self-cleaning, we chose anatase type titanium oxide (TiO_2), whose photocatalytic and hydrophilic properties result in self-cleaning. The main difficulty lay in the incompatible process conditions for depositing anatase TiO_2 and fabricating solar-heat reflective films. Dissolving the incompatibility by new materials, we have succeeded in fabricating hydrophilic and heat-reflective glasses. A special multilayer film coated on the glass gave these functions, namely, hydrophilicity, heat-reflection, and transparency in the visible spectrum. The hydrophilicity of the sample glass was evaluated in terms of water contact angle. It decreased with time under UV irradiation at 365 nm with an intensity of 2 mW/cm^2, as shown in the figure. Our coating technic can be applied to plastic substrates to make them more functional.

A nanotechnology-based coating in combination with new materials will be the key to realizing smart windows suitable for the environmental-friendly life. We are advancing our research on materials and process technologies for multifunctional coatings applicable to windowpanes.

Electronics and Photonics Research Institute
Kazuhiko TONOOKA
Naoto KIKUCHI

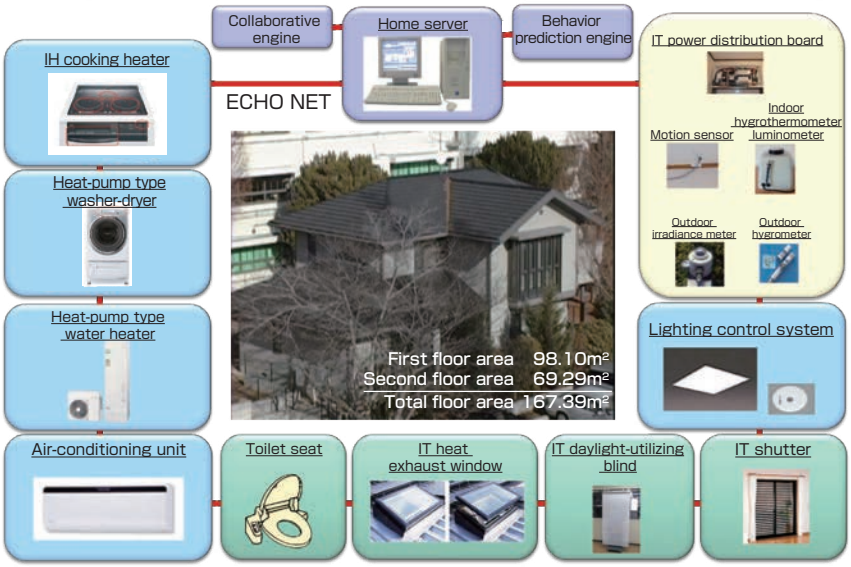
Reference
[1] N. Kikuchi: *AIST TODAY*, 7(12), 24 (2007).

For inquiries about this article : Electronics and Photonics Research Institute http://unit.aist.go.jp/esprit/index.html

Evaluation of Control Systems to Achieve Both Energy Saving and Comfort

Energy saving and comfort

The widespread use of home appliances, which has significantly improved the comfort and convenience of people's lives, has also increased energy use in homes. Energy use per household in FY2008 was about 2.2 times the FY1965 level. This seems to indicate that saving energy at home and improved comfort are incompatible. However, energy savings can be achieved efficiently without compromising comfort by eliminating unnecessary energy use in daily life and studying how comfort is perceived by people.



Scheme for achieving energy efficiency according to the lifestyle of the occupants by judging the occupants' lives from how home appliances are used

Technology to eliminate wasteful energy use in a manner suiting people's lifestyles

We have developed a system, BeHomeS, to comprehensively determine and avoid wastage of energy that the occupants are rarely aware of based on operational data on the use of home appliances [1]. The system can estimate and predict the occupants' living conditions from the data, and realize energy savings in a manner that suits their lifestyles without compromising comfort. For example, the system can: (1) stop the operation of appliances in rooms that are not predicted to be used for an extended period of time and eliminate unnecessary water heating based on the amount of hot water regularly used; (2) achieve energy-saving control of room temperature and lighting to pleasant levels according to the scenes of daily life, such as mealtimes and TV watching times; and (3) achieve energy-saving control without compromising comfort by allowing outdoor air and sunlight in, and shutting them out, and using an air-conditioning unit in a collaborative manner. In a six-month occupancy experiment, about 8.5 % of the total energy use of the house was saved on average.

We will develop the system into an energy-saving technology that can learn the preferences of the occupants in various scenes of daily life and provide better occupant comfort.

From development of a human thermal comfort model to occupant well-being

If the thermal environment is uniform and in a steady state, the sensations of being cold or hot are determined by the heat balance between the heat production and the heat loss, and the number of people who feel uncomfortable increases as the deviation from the neutral sensation (neither hot nor cold) becomes larger. Since many factors need to be considered in modeling humans, we are collecting, analyzing, and classifying data in various scenes of daily life, conducting experiments to reproduce those environments in an artificial climate chamber, and investigating minute effects of the thermal environment factors on the human body. For example, the elderly were shown to have lower sleep efficiency in the summer than in other seasons [2]. In order to study energy-efficient use of air-conditioning units for cooling, we made a comparison between cooling through the night (100 %), cooling for the first half of the night (50 %), cooling for the second half of the night (50 %), and no cooling (0 %). For the same amount of cooling time, cooling for the first half of the night was shown to effectively contribute to occupant well-being in terms of body temperature regulation, sleep efficiency, and decrease of sleepiness after awakening.

We will develop a well-being support technology to maintain people's quality of life.

Deputy Director-General for
Life Science and Biotechnology
Katsunori MATSUOKA
Human Technology Research Institute
Kazuyo TSUZUKI

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[1] New Energy and Industrial Technology Development Organization (NEDO): Development of an Energy-Saving Home Activity Responsive System (BeHomeS), 2007-2009 Research Report (2010).
[2] K. Tsuzuki: Chapter 15: Thermal Environment to Support Pleasant Sleep, *Science of Sleep and Its Application*, CMC Publishing (2007).

Expectations for the Development of New Window Materials

Professor,
Tokyo University of Science
Takashi INOUE

The Intergovernmental Panel on Climate Change (IPCC) has reported that the building sector plays the largest role in combating global warming. Of all building envelope components, such as external walls, windows, and roofs, the windows have a very significant effect on both the environmental load and indoor comfort. Immediately after the first Oil Crisis, buildings with extremely small windows were constructed for the reason that a window is a thermal weakness and therefore small windows are thermally advantageous. However, small windows were not highly evaluated because of their psychological effect on workers in such buildings and other reasons. Subsequently, windows with wavelength-selective glass and automatic control blinds were developed and came into wide use to provide thermal insulation and solar-shading while offering the natural visibility and sense of openness required for windows. However, these windows need to be multiple-glazed and tend to be heavily loaded with sensors, communication devices, controlling systems, and drive devices. Organizations with comprehensive capacity in a wide range of research areas, such as AIST, are the focus of increasing expectations for the development of simple window materials that could provide comfort and energy saving by adapting their performance to changing indoor and outdoor conditions.

Next-generation Building Materials Offering Energy Saving and Comfort

○ Next-generation Window Materials

When we consider energy saving in buildings, the windows and other openings are important in that a large amount of heat goes through them. Particularly in Japan with its large seasonal variations in climate, the cooling and heating load can be significantly reduced if solar heat is well controlled by window glass. Glass that can transmit and block sunlight reversibly to save energy is called switchable glass. Such glass is expected to be the next-generation glass that provides greater energy savings than low-E double glass, which is increasingly being used.

The most typical switchable glass is electrochromic glass that can electrically switch between transparent and light-blocking states. Electrochromic glass using a thin tungsten oxide film as the switchable layer has been studied for more than 40 years. However, such glass requires the process of

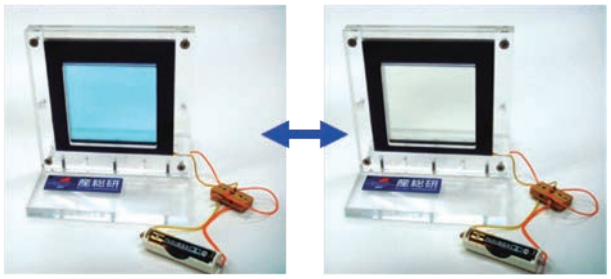

Fig.1 Electrochromic glass using Prussian blue pigment

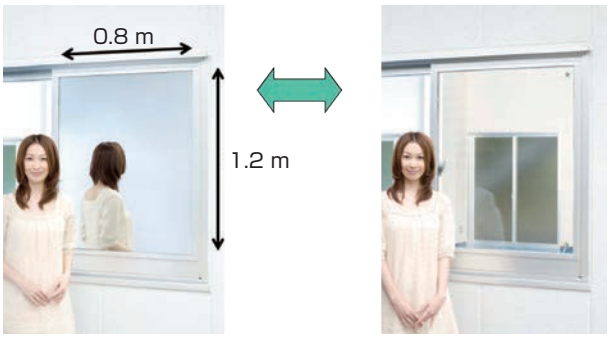

Fig.2 Practical-size switchable mirror glass

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Research on Environmentally Harmonious Building Materials
— Research on building materials that save energy and provide comfort to living spaces —

forming multiple thin layers on glass with a large vacuum deposition system and has the disadvantage of high cost. The Nanosystem Research Institute has developed a new technology to make Prussian blue pigment into nano-ink and produce electrochromic glass by simply applying the ink to the glass surface (Fig. 1) using various wet processes. This technology has the potential to significantly reduce the cost of electrochromic glass.

Conventional electrochromic glasses control light transmission by switching between transparent and colored states. The Materials Research Institute for Sustainable Development has developed switchable mirror glass that can efficiently block sunlight by switching to a mirror state (Fig. 2). The switchable mirror glass has been demonstrated to reduce cooling loads by more than 30 % compared with ordinary transparent glass.

There is another type of switchable glass called thermochromic glass. It is always transparent to visible light and reflective to near-infrared light at high temperatures, and automatically becomes transparent to near-infrared light at low temperatures. In the summer, thermochromic glass reflects the heat of sunlight and prevents a rise in indoor temperature. In the winter, it allows solar heat in. This switching is carried out automatically. The Materials Research Institute for Sustainable Development has developed thermochromic glass using a vanadium oxide thin film and is conducting research to commercialize the glass.

In addition to the glass, the window frame is also important in improving the insulation performance of a window. Wood has a low thermal conductivity about 1/2,000 that of aluminum, though it is inferior in strength, dimensional stability, flame retardancy, and durability. We are working to improve the material properties of wood. We are characterizing the molecular-level microstructure of wood and developing techniques, such as compression, chemical impregnation, heat treatment, and chemical modification, to improve the reliability of wood quality and make wood an environmentally friendly industrial material.

Materials Research Institute for Sustainable Development
Kazuki YOSHIMURA
Kozo KANAYAMA

Nanosystem Research Institute
Toru KAWAMOTO

○ Lighting of the Future

Energy saving in lighting

Lighting accounts for the second-largest amount of residential power consumption after air conditioning, and efforts to improve the energy efficiency of lighting are being accelerated. Figure 1 shows the trend of efforts toward the energy saving of lighting. Currently, efforts are being made to improve the efficiency of existing light sources and use them effectively. Light-emitting diode (LED) lights, have been introduced on the market, expecting higher efficiency. Organic electroluminescent (OEL) lamps are also at the stage of commercialization. In addition to the replacement of existing light sources, there is an increasing need to create a new comfortable lighting environment using a system that takes advantage of new light sources, such as the

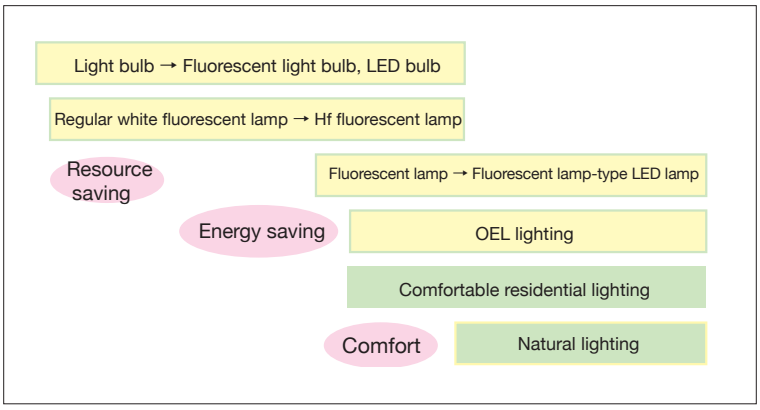


Fig. 1 Trend of the energy efficiency of lights (Older to newer from left to right. Since developments in technology involve many factors, the absolute number of years is not shown; technologies are shown in order relative to each other.)

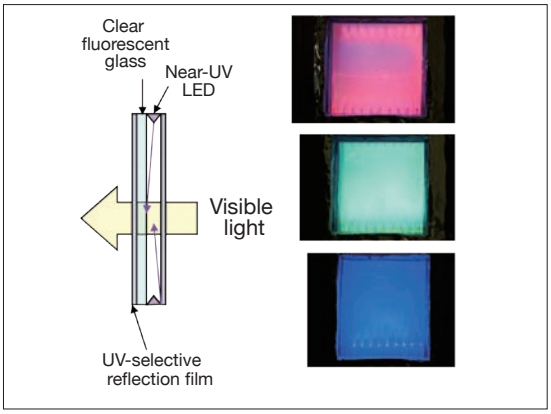


Fig. 2 Example of a light source using a near-UV LED and transparent glass In the photo on the right, the glass is shining red, green and blue using a near-UV LED (375 nm).

directivity, thinness, space savings, and easy and quick output control of LED lights and the flexibility and thinness of OEL lights. Under these circumstances, building components such as walls and windows will inevitably be integrated with electric devices such as lights and displays in the near future. We will also need to develop a method to effectively use sunlight, which has a spectral distribution comfortable for human beings, as a light source in combination with these new light sources.

Transparent light source using glass

In order to achieve the above goal, it is important to functionalize glass using light-emitting devices such as LEDs, without compromising the transparency of glass windows as openings to let sunlight in. As a materials approach, we are attempting to produce a new light source that combines fluorescent transparent glass with an LED. Fluorescent glass can convert the glaring light of an LED light, which is a point light source, to the soft light of a surface light source that the human eye can readily adjust to. A flat light source transparent to visible light can be made by placing a near-UV LED and a fluorescent glass as shown in Fig. 2. The glass that we have produced is a small 3-inch piece. If we can produce larger sizes, which is technically challenging, we can develop windows with a light-emitting capability to correct diurnal and weather-related variations in the intensity of sunlight using LED lights. As wall openings become larger, heat loss increases and the power consumption of air conditioning rises. Therefore, other insulation techniques and thermal design during air conditioning must be considered at the same time

For future lights and displays

Large size and low cost required for building materials are challenging targets for functional materials in developing lights and displays of the future. We will continue our research to develop future lights and displays as well as light-emitting, transparent glass windows.

Research Institute for
Ubiquitous Energy Devices
Tomoko AKAI

○ New Exterior Materials

Ceramic exterior materials

We are developing and demonstrating energy-saving ceramic exterior wall materials, including water-retaining ceramics and exterior wall tiles with controlled sunlight reflectivity. Water-retaining materials absorb water from rain and watering and allow the water to evaporate when the surface temperature rises. These materials cool surfaces by the evaporation of water and help to mitigate the heat island effect. Water-retaining materials have been tested and commercialized for road applications and demonstrated to be effective. They are also expected to be applied to residential building materials. Low cost, high functionality, and high quality are required for residential building materials. We have developed a water-retaining ceramic material that can be used in residential construction, in collaboration with companies with the technical capability to manufacture porous ceramics without sintering as well as public research institutions.

Demonstration of water-retaining ceramic tiles

Development and demonstration of water-retaining ceramics

Indicators for the evaluation of water-retaining ceramics include water-retaining capacity, evaporation rate, water absorption rate, water absorption coefficient (porosity), density, and strength. A porosity of more than 30 vol% and sufficient strength were achieved by optimizing the grain size of the raw material, the material selection, and forming conditions. The relationship between the microstructure and water-evaporation characteristics of the ceramic material was analyzed to control its water-evaporation properties.

Water-retaining ceramics have the inherent disadvantage of being vulnerable to frost damage. We are endeavoring to overcome this vulnerability by eliminating unevenness in forming ceramics. The development and demonstration of water-retaining ceramics are being carried out at the same time to examine problems in commercializing the material and evaluate their capability to mitigate the heat island effect and the energy saving effect (photo).

Materials Research Institute
for Sustainable Development
Toyohiko SUGIYAMA

For inquiries about this article : Materials Research Institute for Sustainable Development http://unit.aist.go.jp/mrisus/cie/

Research on Environmentally Harmonious Building Materials
— Research on building materials that save energy and provide comfort to living spaces —

Development of New Roof and Wall Materials

Professor,
Graduate School of Engineering,
Division of Architecture, Mie University
Yukio ISHIKAWA

The necessity of energy saving in buildings (energy-efficient buildings) to reduce greenhouse gas emissions and fossil energy use has long been argued. An energy-efficient building requires a reduction in cooling and heating load through the building envelope. Performance requirements (heat insulation and shielding) for roof and wall materials have been upgraded to meet building regulations, and various properties of materials have been improved. However, there are limitations on the improvement. Roof and wall materials require further improvement and advanced functionality. There is a need for the development of roof and wall materials with the capability to autonomously adjust their performance (characteristics) over time. More specifically, roof and wall materials are needed that can autonomously adapt to changes in the outside conditions to achieve and maintain optimal performance (detecting, making judgments, adapting, and maintaining). One approach to achieving this is to apply the principle of biomimetics to building materials. Biomimetics is the concept of mimicing the functions of animals and plants, such as environmental adaptation and harmonious coexistence with the environment, and applying to buildings. We are conducting research and development of biomimetic building components, such as perspirable roofs and changing-clothes function of exterior walls, in collaboration with AIST.

Demonstrations of Energy-saving Building Materials

Details of the demonstrations

In order to commercialize an energy-saving building material that has been developed, it is important to evaluate its energy-saving performance, ease of use, and durability in an environment where it is to be used. The Materials Research Institute for Sustainable Development has built a facility called the Environmentally Harmonious Building Material Testing Laboratory at AIST Chubu. At the laboratory and its surrounding test field, we are conducting demonstrations of energy-saving building materials, mainly those being developed by us, including window materials such as a swichable mirror, exterior materials such as solar heat absorption control exterior tiles and water-retaining blocks, and interior materials such as moisture-control materials. Insolation, spectral solar radiation (direct solar radiation, global solar radiation), wind direction and speed, temperature, humidity, and precipitation are continuously measured on the rooftop of the steel-framed, three-story laboratory building. Two identical rooms or structures under the same conditions are prepared for the demonstration of a building material under development. The energy-saving performance was evaluated based on comparison measurements made with and without the use of the material to compare changes in the indoor and outdoor thermal environments and the power consumption of air conditioning to maintain room temperature. Durability of the material is also tested. Demonstrations can provide data and knowledge that cannot be obtained from conventional simulations based on the evaluated material properties using specimens, and can contribute to better simulation in the area of building technology.

Environmentally Harmonious Building Material Testing Laboratory and the annexed facilities

We will also evaluate the energy-saving performance of commercial building materials in collaborative research as long as testing space is available.

Materials Research Institute for Sustainable Development
Koji TAJIRI

Research Hotline

UPDATE FROM THE CUTTING EDGE

Jan.-Mar. 2011

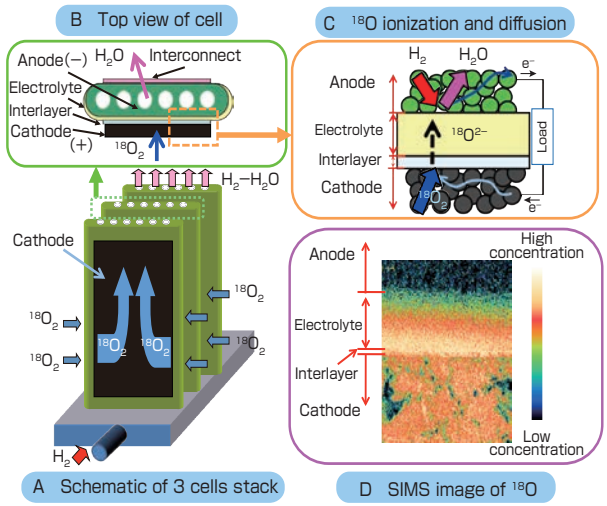
The abstracts of the recent research information appearing in Vol.11 No.1-3 of "AIST TODAY" are introduced here, classified by research areas.
For inquiry about the full article, please contact the author via e-mail.

Environment and Energy

Visualization of oxide ionic flow inside the solid oxide fuel cells (SOFC)

Development of new analytical tools for understanding of SOFC reaction mechanism

We have developed a labeling technique using stable isotope oxygen (^{18}O) for "direct observation" of oxygen/oxide ion movements at the cathode/interlayer/electrolyte interfaces in a practical flatten-tube solid oxide fuel cells. The traces of oxygen motions were labeled during fuel cell reaction (current density of 0.25 A/cm^2 at 650 °C), and the ^{18}O incorporation and diffusion were visualized in a "frozen state" by secondary ion mass spectrometry (SIMS). The active ^{18}O ionization and incorporation sites were found to be in the CeO_2-interlayer between cathode and electrolyte. The higher ^{18}O-concentration in the electrolyte was identified at the bottom of cell (higher current density at bottom).



Schematic diagrams of $^{18}O_2$ incorporation into flatten tube SOFC stack (A), diffusion of ^{18}O inside the single cell (B), diffusion of $^{18}O_2$ and ionic flow of $^{18}O^{2-}$ (C), and SIMS image of ^{18}O at the interfaces (D)

Teruhisa HORITA

Energy Technology Research Institute

t.horita@aist.go.jp

AIST TODAY Vol.11 No.2 p.16 (2011)

Elucidation of complex structure of viral RNA polymerase with host-proteins

Expectations for a new anti-RNA virus drug development

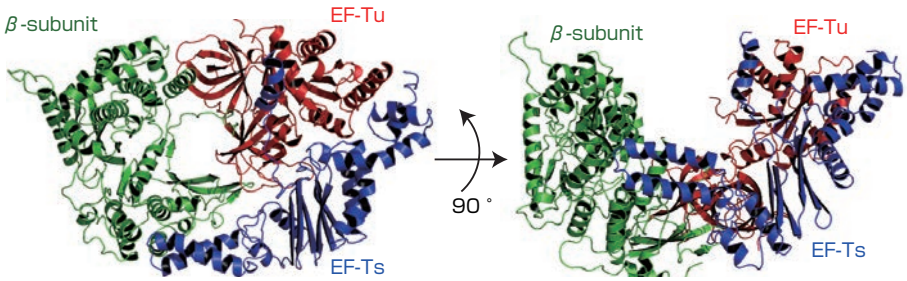
RNA viruses rely on the host-donated factors for replication and transcription of their genomic RNAs. In some RNA viruses, the virus-encoded RNA-dependent RNA polymerase (RdRp) forms a complex with host-donated translational factors. The formation of a complex between the virus-encoded RdRps and the host-donated translational factors is required for RNA replication and transcription of viral genomic RNAs in the host cells. We have determined the complex structure of Qβ virus RdRp and host-donated translational elongation factors. This is the first complex structure of virus RdRp and host-donated proteins. The structure has clarified detailed mechanisms for assembly of an active complex of Qβ virus RdRp with host-donated translational factors, and suggested new functions of host translational factors beyond their established functions in the cell.

Kozo TOMITA

Biomedical Research Institute

kozo-tomita@aist.go.jp

AIST TODAY Vol.11 No.2 p.17 (2011)



Structure of core Qβ replicase. Virus RdRp (β-subunit, green) and host-donated translational elongation factors EF-Tu (red) and EF–Ts (blue)

Ultrawideband ultralow impedance evaluation technology for power distribution network

Design and measurement technology of power distribution network for very low power consumption driving electronic circuits

We have developed an impedance analyzer system with a wide frequency range for evaluating ultralow impedance. The system can evaluate tens of micro-ohms of transfer impedance Z_{21} in the frequency range of 10 Hz to 40 GHz.

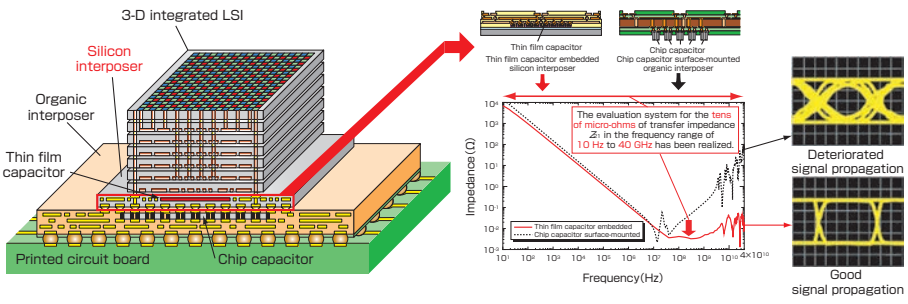
To realize the future very low-power-consumption driving electronic circuit, power supply voltage is required to be lowered. Rapid current change causes instantaneous power supply voltage lowering when high-speed and simultaneous switching of a large number of transistors occurs. This is the high-frequency power supply noise in power distribution network (PND). It is required to reduce the power supply noise up to a high-frequency range by introducing the decoupling capacitors embedded interposers that show low PDN impedance. By developing the ultrawideband ultralow impedance evaluation system, it is expected that the accurate and wideband PDN impedance evaluation of the very low-power-consumption driving electronic circuit can be realized.

Masahiro AOYAGI
m-aoyagi@aist.go.jp

Katsuya KIKUCHI
k-kikuchi@aist.go.jp

Nanoelectronics Research Institute

AIST TODAY Vol.11 No.1 p.16 (2011)



3-D LSI integrated system and relationship between power distribution network impedance of decoupling capacitor embedded interposer and high-speed signal propagation characteristics

Development of monitoring technology for individual solar panels

Smart grid technology to prevent power generation loss by detecting malfunctions of solar panels

We have developed a small and low-cost system to monitor the power generation of each individual solar panel. The data transmitter of the monitoring system is very compact to be built into a junction box of a solar panel.

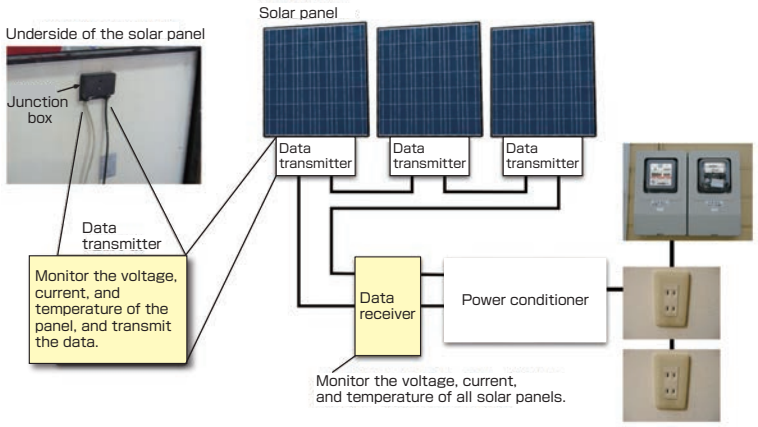
Information of power generation of each panel is sent via already installed direct current lines and is received by a receiver located near a power conditioner. Therefore, malfunctions of solar panels are expected to be found easily. The cost of a built-in transmitting device for each panel would be very low (i.e. less than a few dollars) when it is mass-produced. A consortium starts in 2011 for information exchange on this new monitoring system.

Yuji KASAI

Information Technology Research Institute

y.kasai@aist.go.jp

AIST TODAY Vol.11 No.1 p.17 (2011)



Solar power generation monitoring system

Low-power indoor positioning system that is robust to signal loss, fluctuation, and noise

Analysis of ZigBee wireless packets with stochastic reasoning

We have developed a low-power positioning engine with stochastic reasoning and a navigation system that can run even on mobile phones' MPU. The system is robust to signal loss, fluctuation, and noise by analyzing ZigBee wireless packets by stochastic reasoning, and is light weight enough to work even on powerless MPU installed in mobile phones. In addition to positioning, the system provides a functionality of transferring emergency signals using the sensor network only. Users can enjoy navigation services such as shopping guidance in normal circumstances, and once when emergency signal is received, the system automatically switches to emergency mode and provides routing information to the nearest emergency exit.

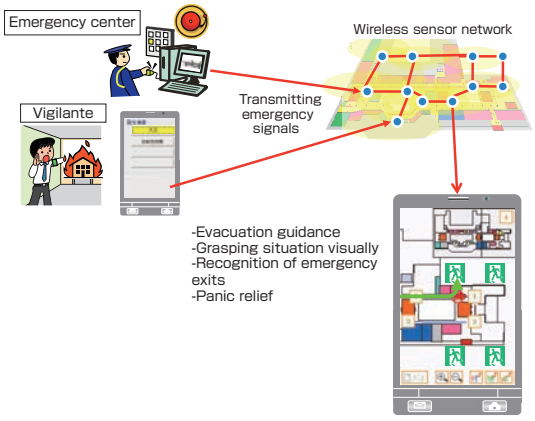
The system is installed at Landmark Plaza in Minato Mirai area, Yokohama City, and its functionality is verified in an actual building.

Koichi KURUMATANI

Information Technology Research Institute

k.kurumatani@aist.go.jp

AIST TODAY Vol.11 No.3 p.20 (2011)



Emergency guidance and navigation

Developing a new photometric standard for light emitting diode (LED)

-Ensuring reliable photometric evaluation of LED-

We are developing a new standard for total spectral radiant flux calibration. The standard is useful for photometric evaluation of light emitting diode (LED) and solid-state lighting (SSL).

LED and SSL show large potential to promote new industries in the future and to reduce the energy consumption of future lighting. However, photometric evaluation of LED or SSL is difficult and it is feared that unreliable evaluations of LED or SSL emerging in the market threaten consumer confidence leading to a delay in market acceptance of LED or SSL.

The difficulty arises from the unique spectral distributions of LED and SSL. The spectral distributions of LED and SSL are quite different from those of the traditional light sources, and the variety of the spectral distributions is much wider than that of the traditional light sources.

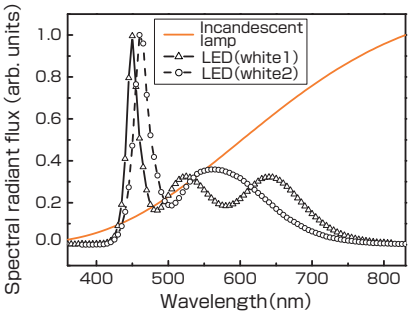
The total luminous flux standard, which is widely used for photometric evaluation of the traditional light sources, is not appropriate to LED or SSL evaluation. The total spectral radiant flux standard is necessary for reliable photometric evaluation of LED and SSL.

Tatsuya ZAMA

Metrology Institute of Japan

zama-t@aist.go.jp

AIST TODAY Vol.11 No.1 p.18 (2011)



Spectral distributions of incandescent lamp and white LEDs
There are many white LEDs whose spectral distributions are different from those shown in the figure.

Nanopore standard: Supporting R&D of innovative materials

Highly-reliable measurement of positron lifetimes and the world's first nanopore reference materials

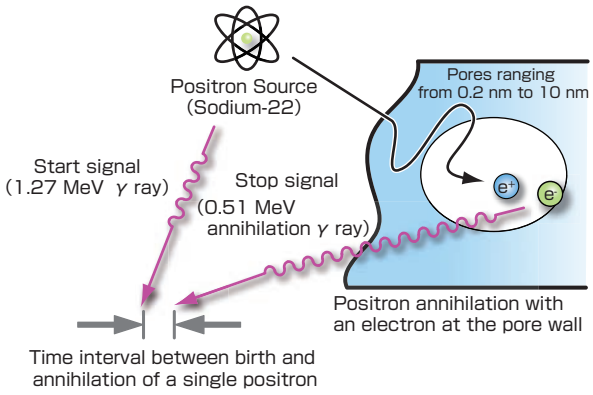
We developed the first nanopore reference materials in the world using synthetic fused silica and polycarbonate for positron hole-size measurements, which are intended for use in controlling the precision as well as in validating the condition of conventional bulk positron lifetime measurements. The first one (fused silica), having a certified value of 1.63 ns for the third lifetime component, had been released in July 2007 as the certified reference material (CRM) of AIST, followed by the second CRM (polycarbonate) with a certified value of 2.10 ns, released in May 2009. The established CRMs are promising in supporting R&Ds of innovative functional materials with engineered nanoporosity, such as inter-layer dielectrics for next generation semiconductors and high-performance separation membranes.

Kenji ITO

Metrology Institute of Japan

k-ito@aist.go.jp

AIST TODAY Vol.11 No.2 p.18 (2011)



Principle of the positron annihilation lifetime measurement.

Evaluation of anechoic chamber for EMI test over 1 GHz

New evaluation method using plane-wave spectral decomposition technique and optical microwave transceiver

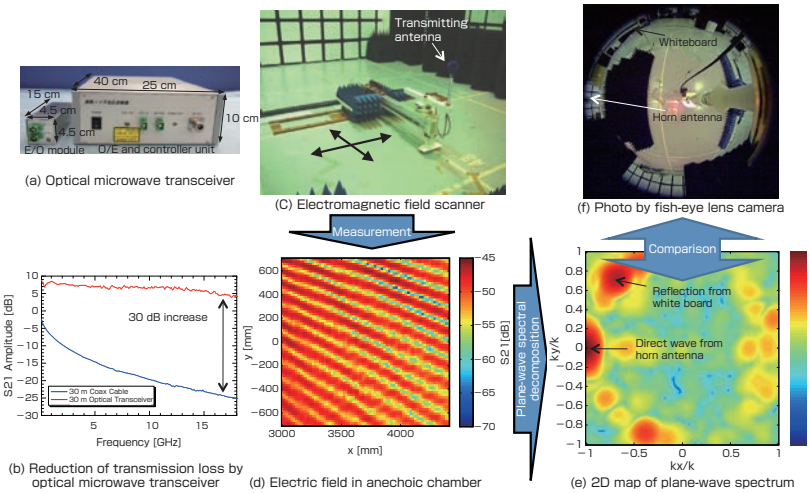
Recently, site evaluation of anechoic chamber for EMI test over 1 GHz has attracted much attention because EU and Japan have started the regulation for the upper frequency limit of EMI from 1 GHz to 6 GHz from October 2010. The evaluation method defined by Comité International Special des Perturbations Radioélectriques (CISPR) is not enough for the detailed analysis of the anechoic chambers for EMI test over 1 GHz because it cannot identify the cause of reflections. To solve the problem, we have developed a new site evaluation method using plane-wave spectral decomposition technique and an optical microwave transceiver. The proposed method enables us to obtain the intensity and the angle of arrival of reflection waves and facilitates improving performance of anechoic chambers in the frequency range from 1 GHz to 18 GHz.

Michitaka AMEYA

Metrology Institute of Japan

m.ameya@aist.go.jp

AIST TODAY Vol.11 No.3 p.21 (2011)



Flowchart of anechoic chamber evaluation using automated electromagnetic field scanner and optical microwave transceiver

Digital super resolution in confocal Raman microscopy

Numerical analysis of confocal volume within a sample

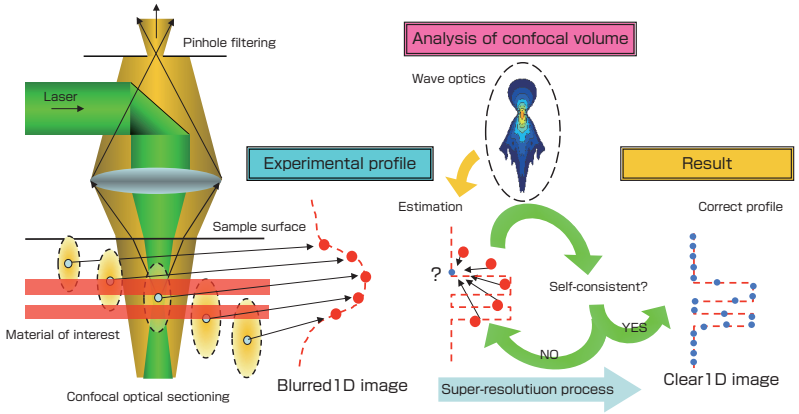
Confocal Raman optical sectioning is a most frequently used technique to obtain non-destructively clear images deep within a thick sample; however, this technique has been known to have the problem that the sample-induced spherical aberration degrades the quality of the images not only laterally but also axially. Here we hence consider the applicability of digital super-resolution reconstruction to this technique. Before the reconstruction we numerically analyzed so-called the “confocal volume” within a sample. The numerical analysis revealed that, with probing deeper inside the sample, efficiently-collected in-focus regions decay due to sample-induced spherical aberration. It is also found that the aberration volume is responsible for the difficulty in the quantitative interpretation of depth analysis.

Yutaka MARUYAMA

Research Institute of Instrumentation Frontier

y.maruyama@aist.go.jp

AIST TODAY Vol.11 No.2 p.19 (2011)



Conceptual scheme of confocal optical sectioning and super-resolution processing
Experimental profiles depend on the extent of confocal volume. The broken circles show the asymmetry in confocal volume.

Opening of borehole data processing system to the public

Promotion of utilization of the borehole data as fundamental information on land

We have developed the processing system of borehole data in collaboration with National Research Institute for Earth Science and Disaster Prevention. The system covers a series of functions necessary for borehole data processing, that is, digitalization, quality verification, version conversion of borehole data format, conversion to a standard mode of soil name, and analysis for geological modeling of borehole data.

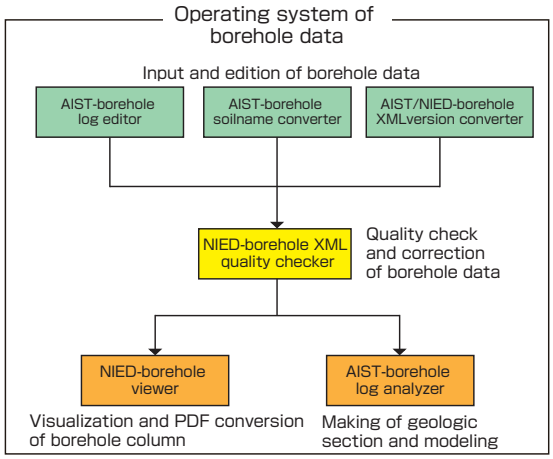
It is expected that profitable use and circulation of the boring data by the local governments and enterprises will be promoted by this opening to the public.

Katsumi KIMURA

Institute of Geology and Geoinformation

k.kimura@aist.go.jp

AIST TODAY Vol.11 No.1 p.19 (2011)



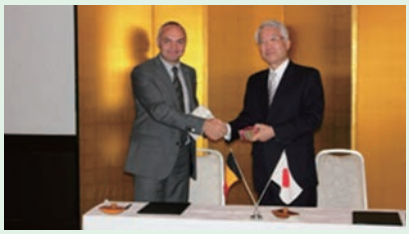
Framework of borehole data processing system

In Brief

MOU Concluded with imec

On November 19, 2010, AIST signed a memorandum of understanding (MOU) on comprehensive research cooperation with imec (Inter-university Microelectronics Centre) International, Belgium in the field of nanotechnology. The signing ceremony was held at Gakushikaikan, and signatures were exchanged between AIST President Tamotsu Nomakuchi and imec President & CEO Luc Van den hove.

AIST, along with the National Institute for Materials Science and the University of Tsukuba and with the cooperation of industry, is working to establish a global nanotechnology research complex, Tsukuba Innovation Arena for nanotechnology (TIA-nano), in Tsukuba where there is a cluster of leading nanotechnology research facilities and experts. To solidify this existing partnership, AIST and imec have signed this MOU to promote their nanotechnology research initiatives through joint research, personnel exchanges, and hosting joint symposiums in nanotechnology, nanoelectronics and other fields, thereby strengthening industrial competitiveness.



imec President & CEO Luc Van den hove (left) and AIST President Nomakuchi (right) at the signing ceremony

Attendants at the signing ceremony

Seventh Biomass-Asia Workshop

Seventh Biomass-Asia Workshop jointly organized by Agency for the Assessment and Application of Technology of Indonesia (BPPT) and AIST was held in Jakarta, Indonesia from November 29 to December 1, 2010. There were presentations from seven countries including Japan, and 250 people (51 from Japan including 15 from AIST) participated.

The last six workshops were supported by the Special Coordination Funds for Promoting Science and Technology of Japan. However, from 2010, the workshop was organized by a new administrative structure centered around the host country. Reports were also given on the Asia Biomass Energy Researchers Invitation Program of the New Energy Foundation of Japan, which has been receiving many researchers including some staying at AIST.

The workshop consisted of greeting speeches, four technical sessions following a keynote address, and panel discussions. There were discussions and presentations on the results of biomass utilization technology focusing on fuel production, and the project of the Economic Research Institute for ASEAN and East Asia (ERIA) regarding international cooperation, human resource development, sustainability assessment, and standardization, and finally, the future direction was indicated in the workshop. On the last day, the participants visited BPPT and private firms, and observed the situation of biodiesel fuel production.

Opening speech by AIST Vice-President Yamazaki

Minister of Research and Higher Education of Norway Visits AIST Tsukuba

On February 8, 2011, Minister Tora Aasland, the Ministry of Research and Higher Education of the Kingdom of Norway visited AIST Tsukuba, and held talks with Senior Vice-President Akira Ono and Vice-President Masakazu Yamazaki.

Minister Aasland visited Japan from February 6 to 9, and came to Tsukuba to visit AIST as well as Japan Aerospace Exploration Agency. At AIST, there were greetings from Senior Vice-President Ono and an overview presentation of AIST by Director Koichi Sakuta of the International Affairs Division; and from the minister, an explanation of the purpose of her visit of deepening research collaboration and promoting exchange of young personnel, and these were followed by lively questions and answers.

Subsequently, there were presentations concerning the fields of "monozukuri" or "manufacturing" and environment and energy, in which collaborative research with Norway is very active. The former was presented by Director Norio Matsuki of the Collaboration Promotion Division, and the latter by Deputy Director Katsuhiko Kadoguchi of the Energy Technology Research Institute. Furthermore, Senior Researcher Takanori Shibata of the Intelligent Systems Research Institute gave a demonstration and explanation of the baby seal robot, Paro, already introduced to Norway. The minister and about 20 attendants looked on with great interest.

There are three research institutes in Norway which have concluded comprehensive memoranda of understanding on research cooperation with AIST, and there is active research collaboration as mentioned above. With this visit, we are expecting to see further development in these areas.

Minister Aasland (second from right)

Cover Photos
Above: Environmentally Harmonious Building Material Testing Laboratory and the annexed facilities (p. 13)
Below: Structure of core Qβ replicase. Virus RdRp (β-subunit, green) and host-donated translational elongation factors EF-Tu (red) and EF–Ts (blue) (p.15)

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Website and 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/