ISSN 1346-602X

Full Research in Society, for Society

AIST
National Institute of Advanced Industrial Science and Technology
TODAY
International Edition

Spring
2007

No.24

FEATURE

From Environmental Protection to Environmental Creation

Research Hot Line
UPDATE FROM THE CUTTING EDGE (Jan.-Mar. 2007)

In Brief

From Environmental Protection to Environmental Creation

Offering an optimal solution through prediction and assessment

Research for environmental management is drastically shifting the helm, "from environmental protection to environmental creation." In the past, every time new environmental issues arose, environmental regulations were reviewed and new environmental protection measures were developed in response to the issues. These include, for example, the instrumentation technology for detecting environmental pollutants in industrial effluents/gas emissions, technologies for predicting environmental impacts based upon elucidation of advective diffusion behavior of pollutants, and decontamination technologies, all of which have already become widely used in industry as production management technologies. However, with the heightening of environmental awareness in society, new technologies are emerging as our trump for "environmental creation" aiming at a harmony between man and environment. These technologies are completely different from the after-the-fact approaches that only work for the conventional “environmental protection” and will provide an effective measure of prevention by predicting the rise of new environmental issues beforehand.

Meanwhile, the Ministry of Economy, Trade and Industry is taking action by revising the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances (Chemical Substances Control Law), as well as enforcing the Law Concerning Reporting, etc. of Releases to the Environment of Specific Chemical Substances and Promoting Improvements in Their Management (PRTR Law), the Law Concerning Special Measures against Dioxins, and the Law Concerning the Recovery and Destruction of Fluorocarbons. In addition, movements are under way to initiate full-scale efforts targeting 2010-2020 regarding "optimal management based on risk trade-off," which will meet a global trend as a future-generation technique for chemical substance management. Consequently, urgent demands are arising for consideration for sustainability of technologies and thorough enforcement of risk management.

In light of such social demands, AIST works to develop the following technologies, and has been establishing the seeds thereof: chemical substances risk assessment, life cycle assessment (LCA), global environmental impact assessment, environmental measurement and monitoring which enable the detection of trace amounts of environmental load substances, and environmental cleanup and restoration technologies capable of catering to widely diffused environmental load substances. In the future, we plan to challenge further integration and fusion of these key technologies to achieve an innovative technology for prediction, prevention and action - consisting of a trinity of instrumentation, assessment, and action technologies - and to offer it to society in a timely manner.

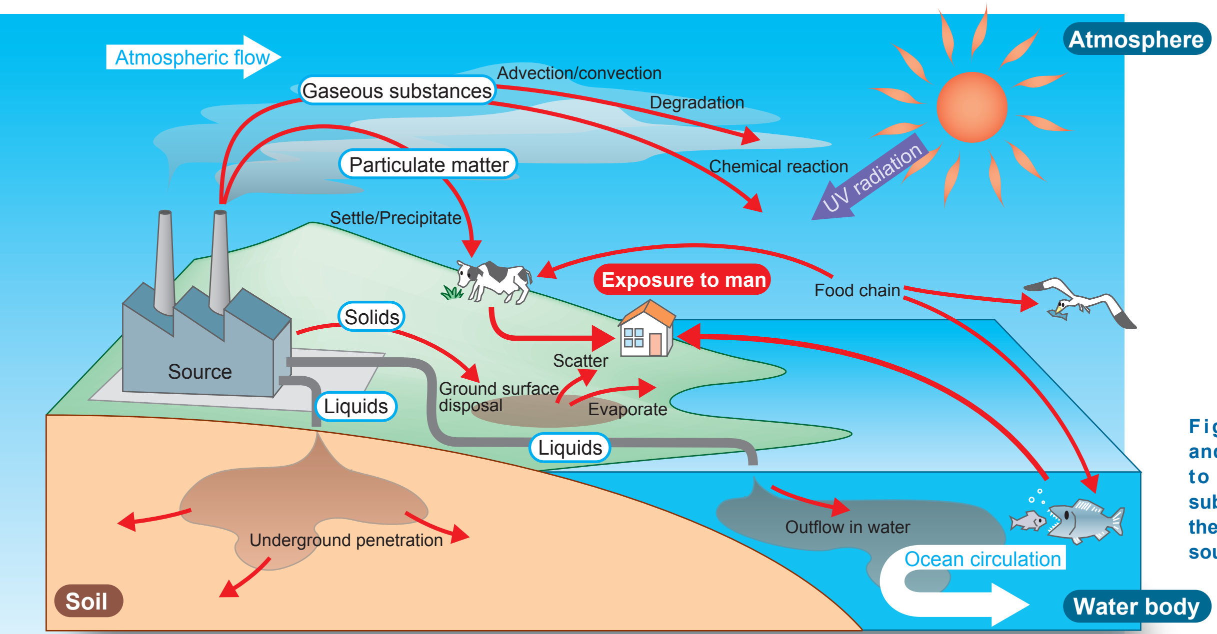


Figure 1: Behavior and route of exposure to man, of chemical substances emitted into the environment from a source

It is the common goal of mankind to realize a sustainable society so that global people may live rich lives extending into the future. In the "Second Period Research Strategy" formulated by AIST in April 2005 as well, "To offer optimal solutions in terms of environment and safety measures through the fusion of prediction, assessment and protection technologies" is set forth as a priority strategic goal characterizing AIST's environmental research. This feature article presents carefully selected researches regarding "assessment techniques leading to prediction" and "optimal solutions leading mankind to a rich future," which constitute the core of the strategic issues to be overcome in achieving our strategic goals.

Masaaki Yamabe
Research Coordinator

Ryuichi Nagaosa
Planning Headquarters

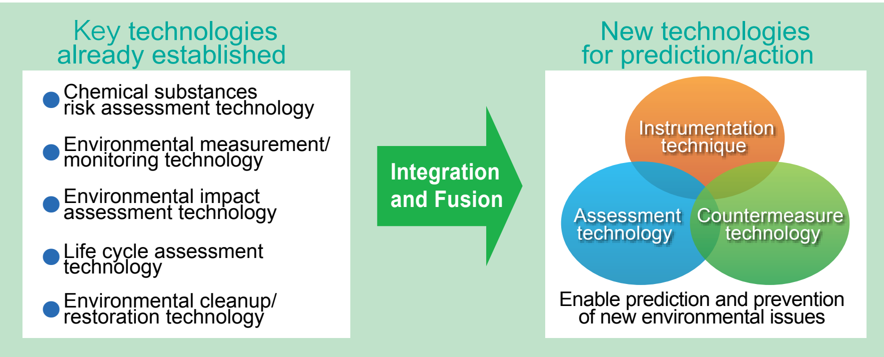


Figure 2: Concept of the environmental management technology which AIST aims for

VOCs control measure using nonthermal plasma

For the removal of volatile organic compounds (VOCs) emitted from stationary sources, we are utilizing a kind of miniaturized thunder, one of the three notoriously fearful things for Japanese such as earthquakes, thunder, and fire. While only electrons are activated in small volumes of nonthermal plasma reactors, the gas temperature itself is kept nearly ambient as Figure shows. Besides oxygen gas, water can be used as an oxidant with this approach, and any kinds of VOCs can be decomposed oxidatively: toluene, dichloromethane, methanol, etc. Our goal is the removal of VOCs from exhaust gases with feasible minima of energy consumptions. For this purpose, several factors have been investigated: reactor type, operating conditions, etc. As the distribution of electron energies is uncontrollable at this moment, hybridization of nonthermal plasma and catalysts is our main theme to improve energy efficiency. For these five years, we have implemented the six joint projects sponsored by private sectors to facilitate collaborative researches with them. We have published thirty-six papers and have received the six paper awards from the overseas and domestic academic societies and publishers.

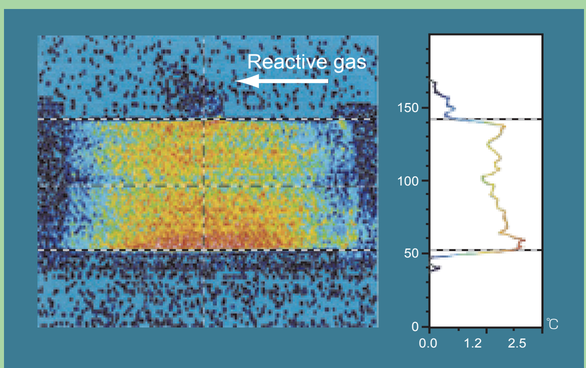


Figure: Temperature distribution of a nonthermal plasma reactor in operation

Shigeru Futamura
Research Institute for
Environmental Management Technology

The Future of Risk Management of Chemical Substances

Toxic substances – such as PCB and lead of long ago, dioxins from garbage incineration facilities and formaldehyde, a causative agent of sick-house syndrome in the 1990s, as well as the recent asbestos – have each independently caused a public sensation, and each time, regulations have been tightened on the relevant substance. However, such ad hoc responses only result in dragging the villain hunt on forever, and will never let us achieve safety or security.

Therefore, we need an approach for reducing the total risk, by prioritizing while keeping sight of the overall picture. To this end, AIST's Research Center for Chemical Risk Management (CRM) has been conducting development and implementation of techniques in "the science of simulating risk." The results of our efforts constitute risk assessment documents of 30 substances currently in progress. It covers most of the substances which are considered to be of high risk at this point, but also leaves us with the following doubts. The first is the question of whether or not our 30 substances are really sufficient when the number of chemical substances is said to be as high as 20-100 thousand. Another is the reservation regarding the potential of a vicious cycle, in which if Substance A is deemed bad, we go on to Substance B, and if B is dangerous, we then substitute Substance C. In order to resolve these issues, CRM has progressed on to the next level, which is multiple risk assessment and management. Below, we present a broad overview of a new risk assessment and management paradigm in a multiple risk society.

From single to multiple

We are not only exposed to numerous toxic substances, but are faced with various risks including disasters and accidents as well. In other words, we are living in a multiple risk society (Figure 1). In order to reduce the risks in society as much as possible, we need to prioritize our risk measures by considerations for cost effectiveness, to decide how much of a limited budget should be allotted to each measure. Thus, we require a technique for efficiently assessing large numbers of substances from little data and for assessing the trade-off relationships between risks. Regarding the former, we examine a method for supplementing the data gaps through statistical methods and judgment of specialists. The latter is what we call risk trade-off analysis.

Owing to the Pollutant Release and Transfer Register (PRTR) system, emissions of substances targeted for PRTR reporting have been reduced significantly, while in their place, substitutions to non-target substances are increasing. However, it cannot be said that substances targeted for reporting are dangerous while substances not targeted for reporting are safe. We need to examine whether or not the risk is really reduced with use of the alternative substance, taking into account changes in the emission volume as well. In so doing, we need to compare the risks of the non-target substance of which little data are available, with the target substance having relatively abundant data. In

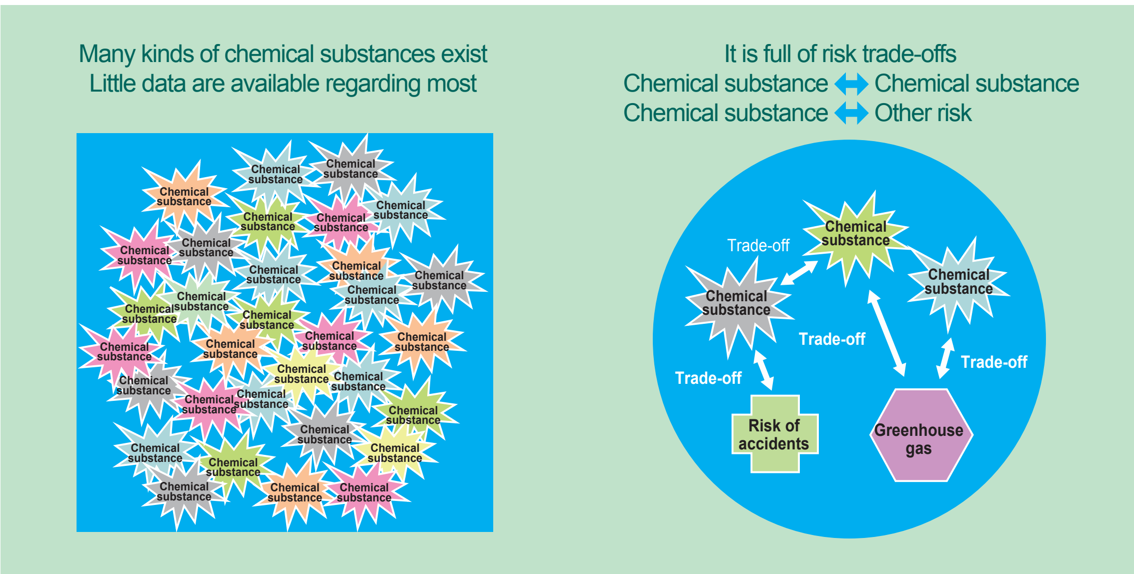


Figure 1: Characteristics of a multiple risk society

addition, we need to make considerations for factors other than risk of chemical substance exposure. For example, treating exhaust gas by combustion by crude oil eliminates emission of the relevant substance but results in emission of CO_2. Alternative substances of low toxicity may possibly increase the danger of explosion or make a chemical change into another toxic substance when in the environment.

From point to distribution

The assumptions employed in risk assessment up to now were designed to fall on the safe side in cases of uncertainty or variation in data. In other words, they protected the high-risk party. This approach is effective in the case, for example, of determining environmental standard values. However, as the degrees of assumption to the safe side differ between substances, it is difficult to compare the relative levels of risk between substances. In multiple risk assessment, we need to treat uncertainties and variation in data as distributions where possible so that inter-substance and inter-event risks may be compared, and so that we may grasp an overall view of risks, and not just the point estimates.

From defensive to offensive

Risk assessment and management up to now have been conducted on a 'defensive' stance, of avoiding violating regulations. However, by performing risk assessment in parallel with the development stage when developing new substances and new technologies in the future, it will become possible to take an initiative in planning the framework of the controls which were conventionally taken passively. This will lead to reduction of waste and uncertainties related to research and development investments. The recent approaches of European Union (EU), including RoHS regulations which prohibit the content of specified toxic substances in electrical and electronics equipment and REACH, the new bill regarding registration, evaluation, approval, and control of chemical substances, may be considered 'offensive' approaches aiming to gain international leadership.

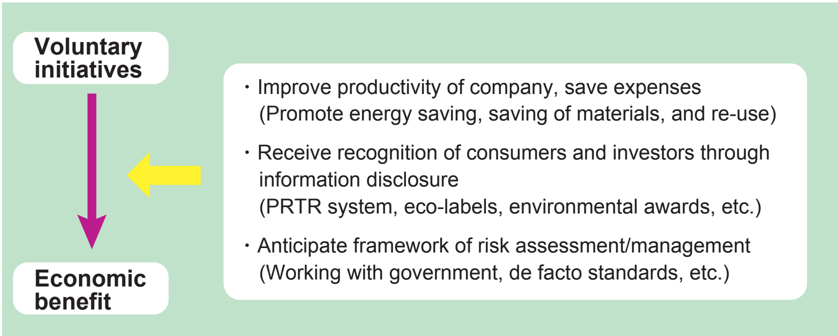


Figure 2: The route by which voluntary initiatives lead to economic benefit

From the aspect of risk management as well, there is a new recent trend shifting from regulatory control to voluntary management. Environmental reports show that corporations are taking action by conducting reductions in emissions cutting widely below regulatory levels and by voluntarily increasing the variety of target substances. The incentives for engaging in voluntary initiatives are believed to be as shown in Figure 2. However, voluntary management in the true sense is not simply to implement emissions reduction measures ahead of regulatory values, but consists of a series of operations, of performing voluntary risk assessment and disclosing in a comprehensible manner the results as well as the grounds of any decisions based upon considerations thereof, to the stakeholders.

From management to governance

Whether or not nanomaterials and biotechnologies are accepted by society is not determined solely by the size of risk involved; the mutual balance between risk and benefit becomes the key. The risk in this case is not limited to health risks, but consists of the large concept which includes impacts to anxieties of the public and ethical aspects as well. In the case of a new technology, evaluation should not be based upon the one attribute of health risk, but upon the collection of many attributes including convenience as well as public perception and preference.

This type of evaluation is called technology assessment, and the form of management based upon it is referred to as governance. In other words, what we require is not a one-sided management from government to corporation, but a form in which various bodies are involved -including citizens, NGO, corporation, and government – as society at large, to control the technology.

Atsuo Kishimoto
Research Center for
Chemical Risk Management

Progress from Product-Oriented LCA to Social LCA

Life cycle assessment (LCA) is the quantitative assessment of the environmental impact of a product over its entire life cycle, from manufacture through use and disposal. Backed by government aid for the establishment of techniques and accumulation of data, use of LCA is spreading in the industrial world. It is employed by many companies, and the results are increasingly disclosed in environmental reports and websites of corporations.

Such methods for evaluating every aspect related to a system are being utilized in various areas. Now, it is no longer applied only to evaluation of products, but increasingly to evaluation of corporate activity, recycling-oriented social systems, and regional measures as well.

Of the various types of LCA, AIST's Research Center for Life Cycle Assessment tentatively refers to the LCA oriented in application to various constituent bodies of society as mentioned above, as 'social LCA.' And the Research Center works to lead the development of such social LCA by developing the necessary techniques, implementing case studies, and preparing an environment for its implementation.

Evaluation of corporate and industrial activity –Using "environmental efficiency"–

"Environmental efficiency" is a ratio of the function (service) provided by the company/product to the environmental load calculated by LCA. The concept is as follows: regarding identical functions in products, the one causing a lower environmental load is preferable, and regarding identical environmental loads, the one offering more comprehensive functions is preferable. Presently, environmental efficiency is utilized in many advanced corporations. However, its definition varies, and may cause confusion on the part of the receiving end (mainly the "consumers"). In addition, as the types of products and services offered differ between manufacturing and service industries, comparisons hold no significance. It is difficult to compare different industries or companies in terms of environmental efficiency. We have therefore proposed a calculation method which unifies on the levels of country, industry, company and product, as shown in Figure 1, and we are working to develop an environmental efficiency index which will allow comparison at each level. It may be used on various levels, for example, to compare GDP and CO_2 emission on a country level, and the added value of a company and environmental load on a corporate level. This index enables formulation of environmental strategies within companies and offers support to consumers in decision-making when purchasing products/services. We are currently implementing case studies through corporate collaboration efforts in which we are working to define and resolve the issues as well as to develop the environmental index which incorporates corporate views.

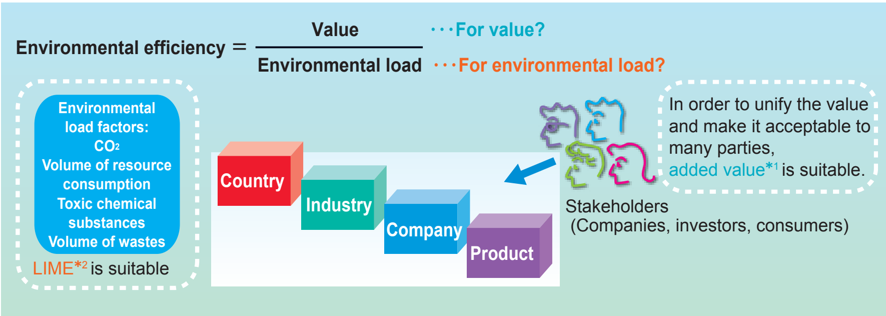


Figure 1: Concept of environmental efficiency
*1 The total of added values is the GDP
*2 Environmental load integrated using the Japanese version of Life-cycle Impact assessment Method based on Endpoint modeling (LIME)

Evaluation of regional measures

We are developing a method which evaluates the environmental impacts by local measures accompanying their implementation from the perspective of life cycle, in order to reduce the environmental loads. We are working in cooperation with local governments to implement regional measures, such as industrial development, biomass utilization and waste treatment.

As shown in Figure 2, the method of

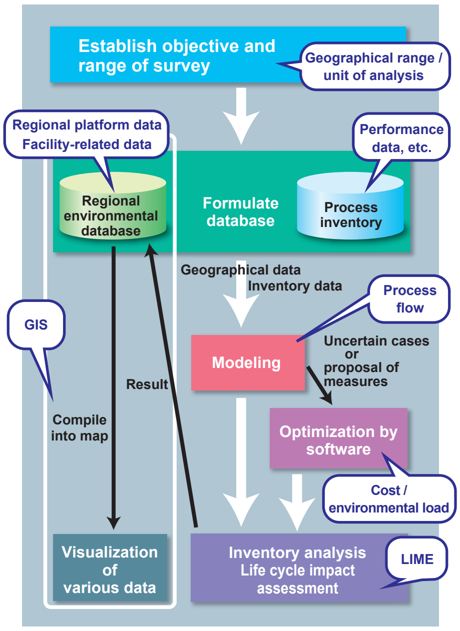


Figure 2: Procedure for applying LCA to regional measures

Table: Estimations for reduction in CO_2 emission in eco-lifestyles

Lifestyle	Eco-life type	Network type	Economizing type	Return-to-tradition type	Service-using type
Lifestyle image	Unchanged inclinations regarding material possessions and consumption, but purchases eco-products	Uses the Internet to avoid movement such as commuting as much as possible and lives regionally dispersed	Not concerned with public appearances, and economizes to spend savings on leisure activities or hobbies	Utilizes the resourcefulness of the traditional lifestyle to control wasteful consumption	Switches to rental and purchasing of services instead of buying and possessing a range of objects
Approval rating	17.0%	19.2%	32.2%	18.6%	3.5%
Reduction effect [A] CO_2 (kg) / Month	−102.3	−55.4	−76.9	−61.8	−27.5
Rebound effect [B] CO_2 (kg) / Month	+29.7	+50.4	+32.9	+21.1	+1.7
Reduction effect [A-B] CO_2 (kg) / Month	−72.6	−5.0	−44.0	−40.7	−25.8

application of LCA to local measures is based upon conventional procedures for ISO-LCA, and it uses an inventory database which organizes the inputs/outputs of each process. It also constructs a regional environmental database on the geographical information system (GIS) in order to include considerations for regional characteristics of population distribution, land use and transportation network. Furthermore, we are developing software linked to the regional database to optimize material cycles and energy use within regions. This method is compiled in a practical guide (to be disclosed in the NEDO website), to be offered for practical utilization.

Presently, we are progressing with new efforts including time-axis considerations and the implementation of environmental efficiency. The method is anticipated for utilization in various scenes as a technique for countermeasures designing against global warming as well as environmental management in local communities.

Approach regarding consumer activities

In order to allow the spread of environment-conscious products and achieve a reduction in environmental load, the products need to be accepted by the consumers and be actually used. An environment conscious lifestyle is also required. Here, the lifestyle must be easily accepted by each consumer, and the actual load reduction effect must be quantified and reflected in product development and policy proposal. The Research Center for LCA has been tackling these issues in terms of "sustainable consumption."

The Table classifies environment-conscious lifestyles into five categories, and shows the approval rating and behavior of each. According to the Table, consumers in favor of the "economizing type" are largest in number, however, these people demonstrate a tendency to use the funds which they saved by economizing to take behavior which increases environmental load, such as going on overseas trips (corresponding to the "rebound effect" in the Table), thereby diminishing the overall reduction effect. Through the perspective of such actual load reduction effects and consumer preferences, we hope to contribute in proposing measures for environmental load reduction.

Towards evaluation of sustainability

The triple bottom line (environment, economy, and society) has been recognized as an element indispensable to sustainable development, and evaluation along this axis is now expected in the assessment of the activities of various bodies of society. Evaluation is possible by various economic indices from an economic aspect, whereas from an environmental aspect, development of LCA is demanded, and from a social aspect (referring generally to the concepts of poverty, education, culture, and safety, thus differing from the "society" mentioned above in the application of LCA to "society"), much discussion and accumulation of evaluations are required to allow quantification of assessment. The Research Center for LCA, finding a handhold in the benefit evaluations of consumers and local citizens, has begun work on evaluation of this social aspect as well. Long-term approaches, as well as the efforts of many not limited to the Research Center for LCA, are required in order to establish assessment techniques aiming for sustainability.

Masayuki Sagisaka
Research Center for
Life Cycle Assessment

Consideration of Global Warming Assessment Indices

Global warming and future technologies

Progression of global warming is believed to cause a serious impact on the future global environment. As global warming proceeds gradually over an extended period of time, it will generate a large burden on the citizens of the future. It is the obligation of modern man towards the people of the future to carry out the countermeasure technologies which are the most effective for global warming. We need to select the technologies which are superior as global warming countermeasures, keeping in mind the amounts of our resources and progresses in science and technology. For this purpose, we need to predict scientifically the global warming caused by a countermeasure technology before proceeding on with it, to accurately determine the suitability of the technology. Scientific global warming assessment can potentially suggest the technical issues indispensable to the future. The accurate assessment technique is the key to protect the future environment.

Scientific global warming prediction

Evaluation methods using GWP (Global Warming Potential) are generally used in global warming assessment. GWP is a numerical expression of the global warming effect of a gas over a certain period of time, based upon the global warming effect of carbon dioxide during the same time period set as "1." For example, the 100-year value of HFC-134a, a fluorocarbon refrigerant, is 1300. This indicates that in a 100-year comparison, HFC-134a (1 kg) will cause a global warming effect of 1300 times that of carbon dioxide (1 kg). In GWP evaluations, when the period of evaluation is extended, the reference value itself consisting of the integrated value of the global warming effect of carbon dioxide also increases. In GWP, as this increasing value is always defined as "1," a "1" of another evaluation period means something different, thus it is difficult to compare evaluation results of differing times. The HFC-134a mentioned above has a GWP over 500 years of about 400 times that of carbon dioxide, greatly reduced from the 1300 times for 100 years. HFC-134a is eliminated rapidly from the atmosphere, and thus does not cause global warming after 100 years, while carbon dioxide exists in the atmosphere for a long time and continues to cause global warming over an extended time period after 100 years. However, as evaluations including time cannot be compared at present, assessments are performed only for 100 years.

In addition, as GWP is the integrated value of global warming from the time of emission of the gas into the atmosphere through the evaluation period, it is not possible to differentiate between those that cause strong global warming only in the initial stages and those that cause lower global warming over extended long periods. It therefore does not allow discussion regarding the time change of the global warming effect.

Despite these issues, the 100-year evaluation value has been used regardless and independently as the "GWP value," to allow the GWP to be used in the Kyoto Protocol for policy evaluation. Furthermore, GWP fundamentally evaluates the direct global warming of compounds emitted into the atmosphere but does not include the indirect global warming caused by degradation products and such.

A new assessment method

In global warming assessment, it is important to predict the warming to be caused in the future by the gas emitted in the present. In addition, the assessment should preferably reflect as many of the conceivable global warming effects as possible. From this perspective, we propose two alternative methods to replace GWP.

TWPG (Total Warming Prediction Graph), prediction of future warming

We have developed TWPG as a new method for expressing global warming, from the need for a scientific and easy-to-understand global warming assessment method capable of visualizing future warming. In this assessment method, the warming caused by 1 kg of gas emitted into the atmosphere at present is expressed in a graph showing the relationship between elapsed time (x-axis) and intensity of global warming (y-axis). Of course, it can be expressed in table form as well. TWPG was developed as a scientifically-backed assessment method, as it adds up not only the intensity of warming due to absorption of infrared radiation by the emitted gas, but also the warming effect of the degradation products generated upon degradation of that gas in the atmosphere and the warming effect due to the tropospheric ozone generated due to atmospheric degradation. It also includes the cooling effect of the troposphere caused by degradation of ozone in the stratosphere regarding chemical compounds which destroy the stratospheric ozone. (Figure 1, left)

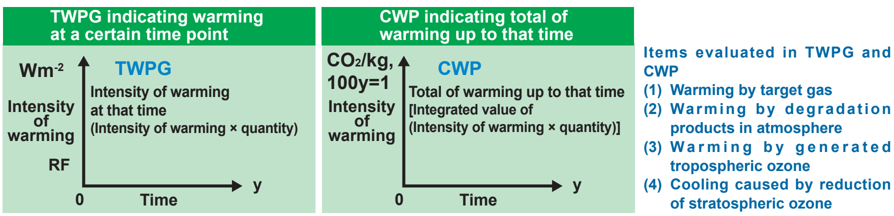


Figure 1: What are TWPG and CWP analyses?

Table: Examples of CWP analysis of gases

Compound	Life in atmosphere (years)	CWP				GWP
		100 years	500 years	1000 years	∞ years	100 years
CO_2	–	1.0	3.2	5.4	60.0	1
CF_4	50000	5700	28386	56490	2466760	5700
NF_3	740	10800	41968	63322	85443	10800
HFC-134a	13.8	1300.8	1303.7	1305.5	1347.2	1300
HFC-245fa	7.9	951.0	953.2	955.3	1005.9	950
HFC,c-$C_5F_7H_3$	3.4	251.2	253.7	256.1	317.5	250
c-C_5F_8	0.98	91	93	96	152	90
HC,n-C_3H_8	0.04	10.9	17.6	24.1	187.9	–
HC,n-C_5H_{12}	0.01	17.0	23.8	30.4	197.1	–
COF_2	–	0.7	2.1	3.6	40.0	–

CWP (Composite Warming Potential), an expression of the integrated amount of warming by time axis

CWP shows the integrated values of TWPG. In this case, the integrated warming of carbon dioxide over 100 years is always set as "1," thus evaluations going beyond 100 years in the same unit are possible. In addition, as it indicates integrations of the four values of warming provided in TWPG, it enables the scientific and objective evaluation of compounds. (Figure 1, right)

Evaluation of gases

TWPG and CWP are based upon evaluation of the warming effect of the gas itself. Here, CWP which is the integrated value of the quantity of warming is shown in the Table. Although evaluations by the conventional GWP were limited to the 100-year value, we can see that by changing the time of evaluation, the situation changes completely.

Example of evaluation by alternative techniques (system evaluation)

Figure 2 shows an example where data from a recent document on a car air-conditioner refrigerant analyzed by LCCP (Life Cycle Climate Performance), a method for comprehensively assessing the warming effect of air-conditioners and freezers, has been converted into TWPG and CWP analysis. From it, we can understand that even in the cold district of Boston, which is at a disadvantage in terms of fluorocarbons, HFC-134a is superior to carbon dioxide as a car air-conditioner refrigerant. HFC-134a is inferior to carbon dioxide refrigerant in the initial stages, however, surpasses carbon dioxide with time. Global warming indices showing such time changes were achieved for the first time through TWPG and CWP analyses. They show superior characteristics as new indices for global warming.

Alleviation of global warming and selection of alternative technologies

Global warming may be regarded as none other than a repercussion of present-day human activity on the global environment of the future generation. Prediction of global warming needs to have sights on the future. To this end, TWPG and CWP analyses enable us to predict the global warming caused by a technology, so that we could select the best technologies. As is obvious from the example of the car air-conditioner, it is not uncommon for the analysis to yield ranking results opposing GWP evaluations in the case of foaming and cleaning agent usages as well, implying the weight of our task of assessing what technologies are truly good for the environment.

The potential of TWPG and CWP analyses

TWPG and CWP analyses show us the technologies necessary from the perspective of global warming. Using the methods of assessment, we may not only evaluate fluorine compounds, but may also gain knowledge regarding the superiority of alternate energies, or regarding which part of a certain usage causes the warming and how much effect can be achieved by improving that part. It goes without saying that the most important factor in maintaining a better global environment for as long as possible is to perform solid assessment and implement active measures conforming to the assessment. We are working to spread TWPG and CWP methods as a means for making this decision.

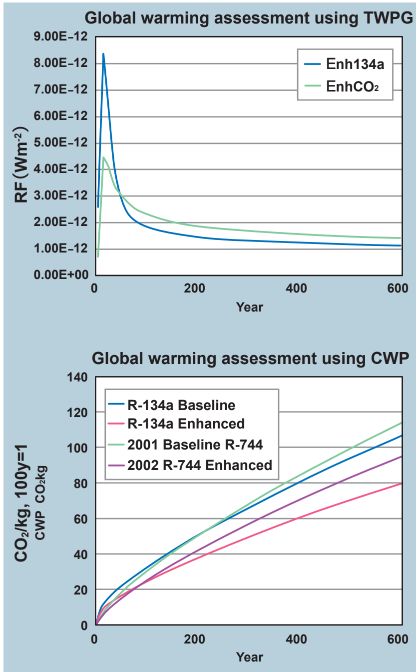


Figure 2: Car air-conditioner analysis in Boston
Calculations based on data from "Stella Papasavva, Bill Hill, New Delhi, India, 2005, p.21"

Akira Sekiya
Research Institute for Innovation in Sustainable Chemistry

Technologies for Earth Observation and Measures to Counter the Problem of Global Warming

Mankind has been emitting massive amounts of carbon dioxide into the atmosphere by consuming fossil fuels such as coal and petroleum, causing widespread concerns including progression of global warming, sharp climate changes, rises in sea levels, changes in the ecosystem, as well as serious impacts to food production.

As the strategy for controlling the accumulation of global warming gases in the atmosphere in order to counter global warming is an issue encompassing the energy utilization and industrial structures of countries worldwide and even extends to review of individual lifestyles, finding a solution for it is not an easy task. It requires the collective wisdom of all mankind.

The role of scientists here is to minimize the uncertainty of the present knowledge through observation and experiment, to perform future prediction with higher accuracy, and to propose countermeasure technologies and validate/evaluate the effects thereof. This is exactly the “fusion of prediction, assessment and protection technologies” that AIST works for in the “Second Period Research Strategy.”

A new “earth observation” system

The first step in countering global warming is to become aware of the present state and predict the future. Observation of the atmospheric carbon dioxide concentration has been implemented continuously since the International Geographical Year conducted in 1957, and presently, is performed at over 100 observation points. In addition, diverse observation systems for capturing global-scale phenomena are being proposed and implemented, including satellites and ground/marine observation systems.

However, suggestions have been made that conventional observation systems are weakly coordinated and that we are entering an era in which earth observation strategies should be shifted from seed-oriented to utilization need-oriented technologies. The enhancing of international cooperation on global earth observation was advocated in the G8 summit of 2003, and as a result, the Earth Observation Summit was held in which the GEOSS (a global earth observation system consisting of multiple systems) 10-year execution plan was approved. The plan aims to implement observation catering to the needs of users, based upon international cooperation. It maintains the existing observation systems, and develops systems and sensors which cover their deficits, to thereby establish an earth observation system which integrates satellite and on-site observations.

In Japan, the Council for Science and Technology Policy has formulated the “Global Earth Observation Promotion Strategy” targeting the next 10 years, and will contribute to construction of GEOSS through a system of collaboration among the Cabinet Office and ministries.

AIST has been implementing observation of the carbon dioxide balance in the forest ecosystem and the ocean. We are presently initiating research to develop new observation systems and sensors to be used at these observation sites, as well as methods for their evaluation and standardization. In addition, as the GEOSS observation concept shown in the Figure is consistent with the view of the GEO Grid System (AIST TODAY July 2006, P20-21) under development at AIST, AIST is expected to play a significant role in this area in the future.

Technologies for measures against global warming

In order to resolve the issue of global warming, we need to not only “become aware of the present state and predict the future” but also to implement strategies to control the warming gas concentration in the atmosphere. However, establishing a society which does not need to rely on fossil fuels is expected to take some time. Until

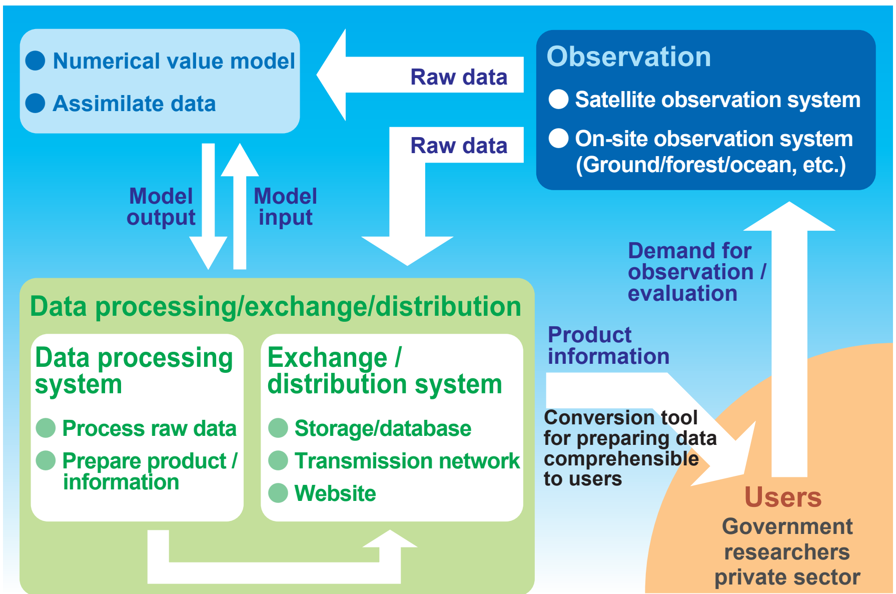


Figure: Concept of international earth observation system of GEOSS

then, while accepting the use of fossil fuels under international agreement, we may need to select a method for rigorously controlling the emission of carbon dioxide into the atmosphere. Such methods include carbon dioxide recovery/storage technologies, for which underground aquifers and deep sea are presently under consideration as sites of storage. It is highly likely that systems resembling GEOSS mentioned above will become necessary for evaluating the adequacy of storage and in selecting suitable sites, as well as in post monitoring.

AIST conducts research which contributes to GEOSS establishment, and promotes research linking countermeasure technologies to it as well.

Koh Harada
Research Institute for
Environmental Management Technology

Environmental measurement for diagnosis and evaluation

Similar to the progression seen in medical care, from examination to diagnosis, treatment and prevention, we are aiming to advance from environmental measurement to diagnosis, remediation and prevention as well. Therefore, not only are we conducting research on environmental measurement technologies, but also on the environmental science to serve as an intellectual platform of diagnosis.

We have newly incorporated the concept of “field” to develop a technology for simultaneous observation of substance and field. Here, “field” refers to the ecosystem into which substances are emitted. By bilateral viewing of the effect of a chemical substance upon the ecosystem and reversely, the “purifying” function of the ecosystem upon that chemical substance, we collect useful data for environmental diagnosis and the industrialization of environmental function. Analogically speaking, in watching a baseball game, we find it interesting only because we watch the ball and the players at the same time. Until now, the chemists have been watching the ball (chemical substance) while the biologists have been watching the players (microorganism in the ecosystem) independently of each other, which leads to the loss of useful information. Therefore, we are developing techniques such as electrophoresis and mass spectrometry, familiar to chemists, which can be applied as new methods of analyzing microorganisms. While existing methods that involve culturing and DNA analysis require extended periods of time, we are targeting measurement on the order of minutes. These new methods of analysis will propagate to areas such as food (salmonella, etc.), hygiene (O-157 bacillus and in-hospital infections), and safety (airport quarantines), in addition to environmental areas such as bioremediation. They are also useful in the search for microorganisms that possess new functions among the 99% of environmental microorganisms said to be as yet unknown, and investigation of their potential application to industry. By substituting “biological system” for “ecosystem” and “biomolecules” for “microorganisms”, respectively, the technology may also develop into a health science consisting of a collaboration between medical and environmental science.

Hiroaki Tao
Research Institute for
Environmental Management Technology

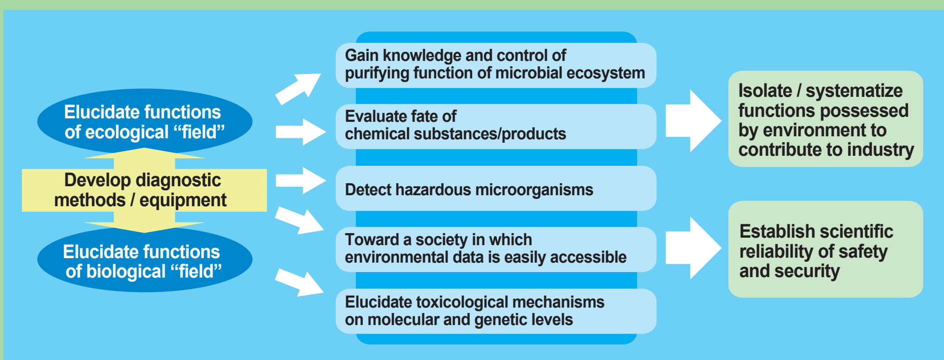


Figure: Towards diagnosis of interaction between “Substance” and “Field”

Research Hot Line

UPDATE FROM THE CUTTING EDGE

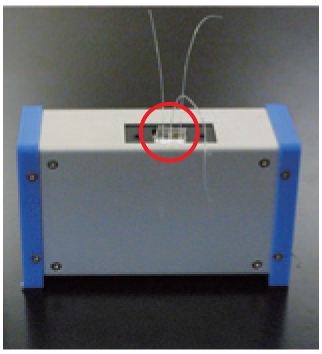
Jan.-Mar. 2007

The abstracts of the recent research information appearing in the Vol.7 No.1–3 of "AIST TODAY" are introduced, classified by research area. For inquiry about the full article, please contact the author via e-mail.

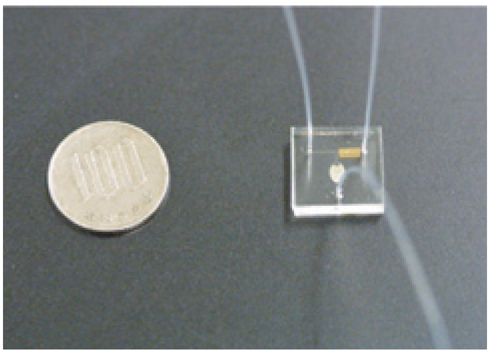
Life Science & Technology

A micro immuno–sensing chip for cardiac marker detection

We have developed a micro immuno-sensing chip designed to determine B-type natriuretic peptide (BNP) using a microfluidic device combined with a portable surface plasmon resonance sensor system. The lower detection limit of 5 pg/mL was achieved by monitoring the surface plasmon resonance angle shift caused by enzymatic product accumulation in the microfluidics, which covers the required detection range for the BNP concentrations found in blood. We were able to measure trace levels of BNP (15 fg) within 30 min by the simultaneous use of a labeled enzymatic reaction and the real-time monitoring of enzymatic product (thiol) accumulation in the microfluidic device.



A portable surface plasmon resonance sensor
(○: micro immuno-sensing chip)



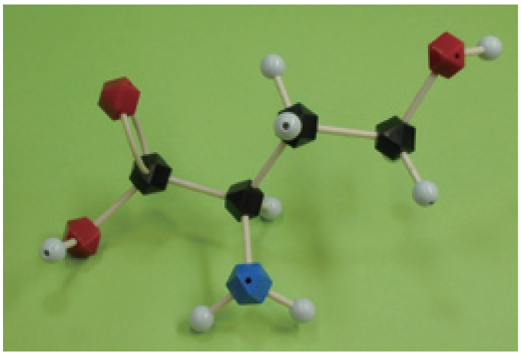
A magnified figure of micro immuno-sensing chip

Ryoji Kurita
Institute for Biological Resources and Functions
r.kurita@aist.go.jp

AIST TODAY Vol.7, No.2
p.20-21 (2007)

Microbial resolution of DL-homoserine for the production of D-homoserine

For the development of a practical process producing **D**-homoserine from **DL**-homoserine, microbial optical resolution was investigated. A bacterial strain 2-3 which can enantioselectively assimilate the **L**-enantiomer from **DL**-homoserine was isolated, and identified as *Arthrobacter nicotinovorans*. The strain 2-3 grew on a medium containing 5% (w/v) of **DL**-homoserine hydrobromide and exhausted **L**-enantiomer from the culture to leave **D**-enantiomer, which was recovered with enantiomeric excess of over 99.9%. The present method is simple and suitable for practical use.



D-Homoserine
Black, carbon atom; blue, nitrogen atom; red, oxygen atom; light bule, hydrogen atom

Kazuya Mochizuki
Institute for Biological Resources and Functions
mochizuki-kazuya@aist.go.jp

AIST TODAY Vol.7, No.3
p.16-17 (2007)

Development of an intelligent electric wheelchair equipped with an omni-directional stereo camera system

We have developed a support technology to enhance the independent mobility of disabled persons, featuring an electric wheelchair fitted with an innovative camera system “Stereo Omni-directional System”. The camera system can capture omni-directional color images and range data in real time, enabling automatic detection and avoidance of hazards in the wheelchair’s traveling environment. Furthermore, the wheelchair enables emergency stop by detecting gestures and abnormal postures of the driver.

An appearance of the intelligent electric wheelchair

Yutaka Satou
Information Technology Research Institute
yu.satou@aist.go.jp

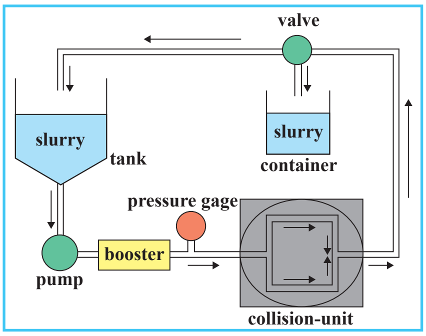
AIST TODAY Vol.7, No.1
p.26-27 (2007)

Fabrication of stable ceramic slurries to produce green high-density bodies

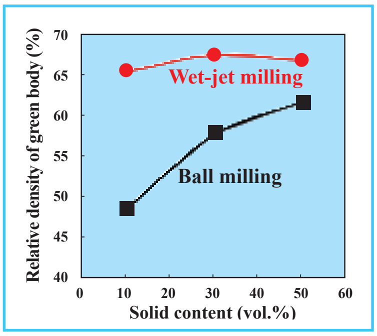
We studied a wet-jet milling process as a novel method to prepare stable ceramic slurries because properties of slurry have an influence on the manufacturing cost, the material characteristics and the reliability of products. The wet-jet milled slurries showed low viscosity and were stable for a long time. The slurry could produce green high-density bodies regardless of the slurry solid content as well as sintered compacts with low shrinkage. Our process can contribute strongly to the reliability improvement in the ceramic material and the components.

Yuji Hotta
Advanced Manufacturing Research Institute
y-hotta@aist.go.jp

AIST TODAY Vol.7, No.3
p.18-19 (2007)



A wet-jet milling process



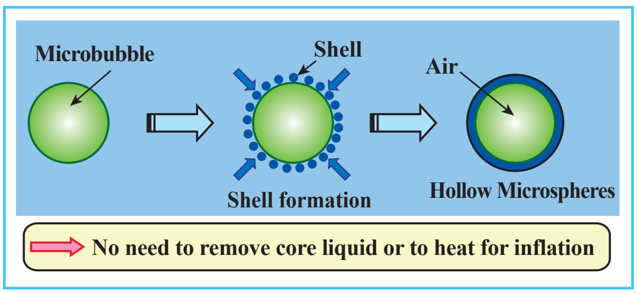
Relative density of green Al_2O_3 bodies as a function of slurry content. The primary particle size of Al_2O_3 particle is 570 nm.

Simple fabrication of hollow microspheres using microbubbles as templates

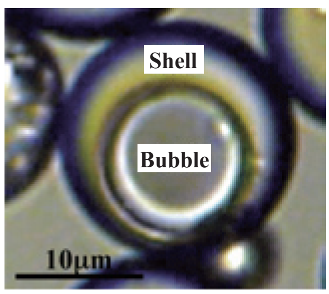
A simple method was developed that uses microbubbles generated in liquid phase as templates to fabricate hollow microcapsules ranging 1 to several 100 μm in diameter covered with a polymer shell. In this method, we adapted a polymerization reaction or a solvent evaporation method that is a phase separation method commonly used to fabricate microspheres including core liquid. Because the microcapsules can be covered with a biodegradable polymer, they are expected to be used as ultrasonic contrast agents in medical applications.

Fumio Takemura
Energy Technology Research Institute
takemura.f@aist.go.jp

AIST TODAY Vol.7, No.1
p.28-29 (2007)



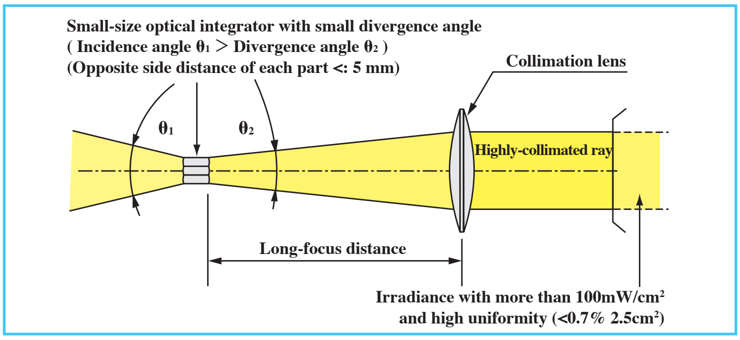
Fabrication process of hollow microspheres using microbubbles as templates



Hollow microcapsules covered with a biodegradable polymer

A highly-collimated solar simulator for photovoltaics calibration

The Research Center for Photovoltaics investigates calibration and evaluation method of photovoltaics (PV). In the field of calibration, we contribute to a sound spread and promotion of PV as the top of traceability through calibration of a reference cell that is a transferred standard of the traceability. The calibration value is utilized as the key comparison reference value of World PV Scale. We have developed a new calibration system for a primary reference cell which was composed of a highly-collimated solar simulator, a wide-band spectroradiometer and a spectral responsivity measurement equipment, etc. The ray parallelism of the simulator is less than 1.2 degree in double angle. Thus we have achieved the direct traceability to the World Radiometric Reference (solar irradiance scale) on indoor calibration by the simulator and an absolute cavity radiometer.



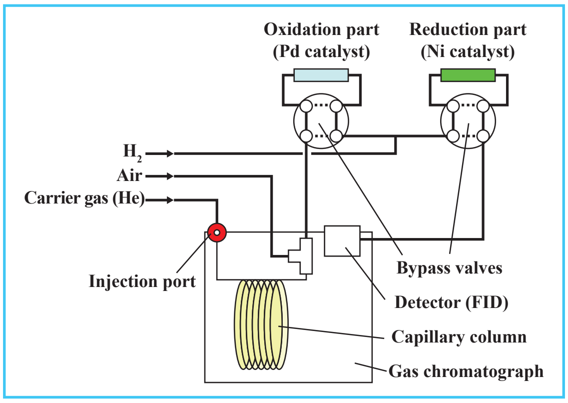
Principle of optical system of highly-collimated solar simulator

Sanekazu Igari
Research Center for Photovoltaics
sanekazu.igari@aist.go.jp

AIST TODAY Vol.7, No.2
p.22-23 (2007)

Development of a precise method for the quantitative analysis of volatile organic compounds

We developed an analytical method attaining SI-traceability for various volatile organic compounds using only one calibration material (reference material). An apparatus was designed and made in which analytes are converted to methane for detection. Test sample gases were prepared by the precise gravimetric method and used for the evaluation of our analytical method. The results showed that the analytes in the sample gases were converted to methane stoichiometrically and the analytical values showed good consistency to the gravimetric values.



Schematic diagram of the designed apparatus

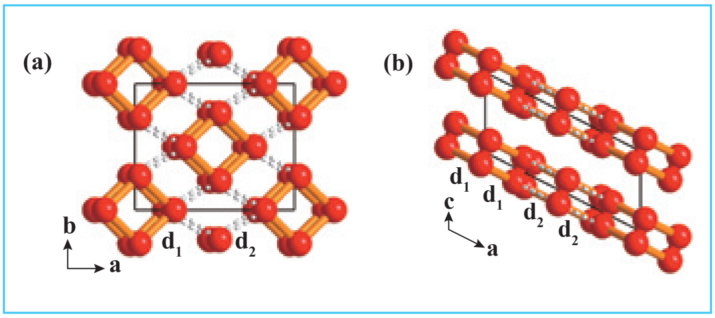
Takuro Watanabe
Metrology Institute of Japan
watanabe-takuro@aist.go.jp

AIST TODAY Vol.7, No.1
p.30-31 (2007)

Crystal structure determination of solid oxygen ε phase

Discovery of an O_8 cluster in a red solid state

A red form of solid oxygen (ε phase), formed under high pressure from 10 GPa to 96 GPa, was found in 1979. Despite many experimental and theoretical studies, the crystal structure of the ε phase has been unknown. We performed powder X-ray diffraction experiments and succeeded in analyzing its crystal structure. A unique O_8 cluster that consisted of 4 oxygen molecules was discovered in the structure.



The crystal structure of oxygen ε phase at 11 GPa. (a) its projected figure to the *ab* plane, (b) its projected figure to the *ac* plane. *a*,*b*, and *c* denote crystallographic axes.The intra-molecular bond length of the oxygen molecule is 0.120 nm. The intra-cluster bond length of O_8 cluster (orange bar line d_1) is 0.234 nm, and the inter-cluster distance (dotted line d_2) is 0.266 nm.

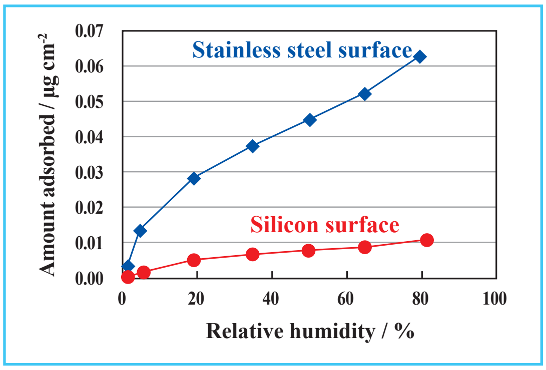
Hiroshi Fujihisa
Research Institute of Instrumentation Frontier

hiroshi.fujihisa@aist.go.jp

AIST TODAY Vol.7, No.1
p.32-33 (2007)

Precise mass measurement of mass standards under vacuum condition

The amount of water molecules adsorbed on solid surfaces was determined in order to carry out precise mass measurement of mass standards under vacuum condition. The experimental data showed that the amount of the adsorption on a stainless steel surface was about 6 times larger than that on a single-crystal silicon surface treated with chemical mechanical polishing. This result can be interpreted as follows: the surface roughness and grain boundaries of the stainless steel surface influence the amount of adsorbed water.



Adsorption isotherm of water vapour

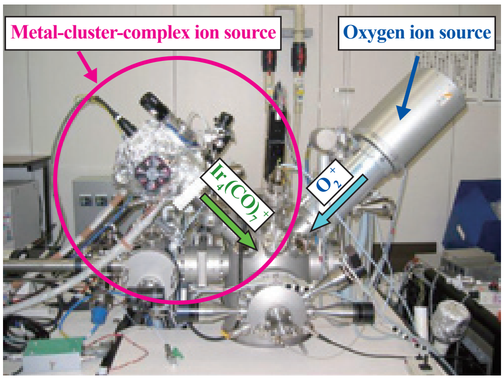
Shigeki Mizushima
Metrology Institute of Japan

s.mizushima@aist.go.jp

AIST TODAY Vol.7, No.2
p.24-25 (2007)

A new ion beam source using a metal cluster complex

We have developed a new ion source using massive molecules called a metal cluster complex. The use of ion beams of metal cluster complexes allows for a layer-by-layer sputtering technique, resulting in accurate measurement of trace amounts of elements in samples. The ion source is compact enough to be installed in commonly-used secondary ion mass spectrometry (SIMS) systems. With the ion source, we have performed SIMS analysis of boron-doped silicon samples, thereby demonstrating that high depth resolution of less than 1nm can be obtained at a beam energy of 5 keV. In addition to inorganic materials, it also allows one to analyze organic materials with higher sensitivity and lower damage. Hence, we expect that the ion source will have great potential in SIMS analysis of various materials such as heterogeneous and biomedical materials.



The metal-cluster-complex ion source is installed in a commercial SIMS system. The ion source is compact and comparable in size to oxygen ion sources.

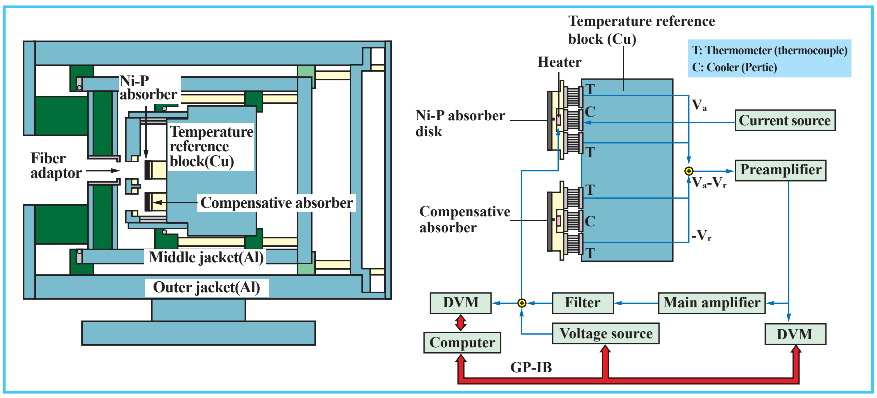
Yukio Fujiwara
Research Institute of Instrumentation Frontier
yukio-fujiwara@aist.go.jp

AIST TODAY Vol.7, No.2
p.26-27 (2007)

Development of optical fiber power standard

High-accuracy measurements of optical fiber power and its international comparison

Rapid expansion of optical communication network strongly demands accurate measurements of optical fiber power. For this reason, we developed an optical fiber calorimeter as Japan's national standard for optical fiber power and started the calibration service of optical power meters using the standard. Combining the calorimeter with a linearity calibration system enabled us to measure the optical fiber power as low as 1 μW accurately. Using these systems, we participated in international comparison of optical fiber power measurements. The results support the reliability of our calibration systems.



Structure of optical fiber calorimeter (left) and block diagram of its main body (right)

Kuniaki Amemiya
Metrology Institute of Japan
k.amemiya@aist.go.jp

AIST TODAY Vol.7, No.3
p.20-21 (2007)

Signing of Comprehensive Agreement of Research Collaboration with The Foundation for Scientific and Industrial Research (SINTEF) at the Norwegian University of Science and Technology (NTNU)and Institute for Energy Technology (IFE), Norway

On January 16, Unni M. Steinsmo, President of Foundation for Scientific and Industrial Research (SINTEF), Norway and Kjell H. Bendiksen, President of Institute for Energy Technology (IFE), Norway visited AIST Tsukuba and had a discussion with Hiroyuki Yoshikawa, President of AIST. They signed comprehensive agreements of research collaboration between AIST and each Norwegian institutes. A comprehensive agreement of research collaboration was already concluded with the Norwegian University of Science and Technology (NTNU) in last September. These agreements with such major research organization in Norway will strengthen our collaboration.

SINTEF has about 1,800 staffs and carries out R & D of industrial technology widely. IFE has about 500 staffs and carries out research on energy technology including atomic energy. Both the organizations have research collaborations not only within the country but are also enthusiastic about foreign collaborations. They acquire research funds by tying up research contracts with industries etc. and actively promoting collabolation in their country.

Research collaboration between AIST and the above research organizations is mainly in the fields of environment and energy. Cooperation for the development of an optimized local energy supply system of electricity / heat / fuel induding renewable energy carried out with SINTEF. AIST collaborates with IFE regarding the development and evaluation of new hydrogen storage materials and the development of a storage system of natural energy using hydrogen. Joint workships are also held.

Along with promoting research collaboration in the fields of environment and energy, we also positively seek possible collaboration in material research such as biotechnology and nanotechnology in the future.

AIST presented the results of Grid Technology at SC06

SC 06 was hosted by ACM and IEEE in Tampa, Florida, U.S.A. from November 11 to 17. Around 7100 participants took part in the grand event.

SC is held every year in U.S.A. and it is an international conference regarding high-performance calculation, network technology, data storage and analysis. Along with large scale exhibitions by major IT companies and research organizations around the world, presentation of research papers were also held.

The Grid Technology Research Center of AIST set up a large booth of 12 meter square and presentations were made by using 18 panel exhibits and demonstrations. They also invited a number of top-class researchers related to research at the center from various countries. They and members of the center gave presentations followed by discussion.

This time there were a number of presentations related to data storage and we noticed a high demand for information from both business & science. The Grid Technology Research Center introduced middleware Gfarm realizing a grid file system and the GEO Grid system which offers high speed and unified interface for large amounts of earth observation data which requires huge storage space.

In addition, programming tool NinfG and GridMPI in grid environment, G-lambda which simultaneously reserves network and calculation resources surpassing management domain, OGSA-WebDB an integrated software for the database, GridASP an utility computing software etc, were introduced. Wide ranged research results of grid technology attracted the attention of about 1,000 participants who visited the AIST booth, and we were able to appeal the existence of AIST in research and development of grid technology.

International Council on Nanotechnology, Asian Workshop

As goods made of nanomaterials started to be sold in the market and movement over healthy environmental influence of nanotechnology becoming active, "ICON Asian Workshop on International Collaboration on Nanotechnology Environmental Health & Safety" (EHS) was held by International Council on Nanotechnology (ICON) with the co-sponsorship of Nanotechnology Business Creation Initiative in Tokyo from November 30 to December 1.

ICON,based in Rice University, U.S.A., measures reduction of risk by accumulating and providing information about EHS of nanotechnology and aims at maximizing social benefits. Therefore, it established collaborative relationships with various concerned parties within and outside U.S.A., and reflected in the workshop attended by researchers, policymakers, company executives, NGOs from U.S.A., Japan, Europe, China, Australia, Taiwan, Republic of Korea and Singapore.

The University of California, Santa Barbara presented a survey report on Nanotech Industry (A Survey of Current Practices in the Nanotechnology Workplace) which was funded by ICON. There were discussions on ICON's operations, R & D of nanotechnology and present condition of EHS issues in various Asian countries in the workshop. Besides, information was exchanged on establishing safe handling methods of nanomaterials.

EHS-related policy, measurement of risk management of nanomaterials carried out by the National Institute for Environmental Studies were presented by Japan. Besides, a concrete action plan on risk management of nanoparticles being carried out as a NEDO project was introduced by Junko Nakanishi, Director of Research Center for Chemical Risk Management, AIST.

In the survey report of ICON and discussion in the workshop, it was clarified that insufficiency of toxic information of nanomaterials became a hindrance while dealing with the issue of EHS of Nanotechnology. Thus, introduction of the Japanese project attracted attention.

Workshop with Chinese Academy of Sciences

CAS-AIST-NEDO Workshop 2006 on Energy and Environment-Related Nanotechnology

Workshop called "CAS-AIST-NEDO Workshop 2006 on Energy and Environment-Related Nanotechnology" was held from December, 11 to 13 in Beijing, China by the co-sponsorship of Chinese Academy of Sciences (CAS), National Institute of Advanced Science and Technology (AIST) and New Energy and Industrial Technology Development Organization (NEDO).

As a definite action plan based on the comprehensive agreement of research collaboration between CAS and AIST in May, 2004 attracted worldwide attention. Hoping for merits of mutual cooperation between China and Japan focusing in the fields of environment and energy, it was followed by another workshop held under the tripartite sponsorship in Guangzhou,China in November, 2005. The topic of the workshop this time was "Nanotechnology concerned with Environment and Energy".

In the two day sessions, the Nanotechnology Research Institute, the Research Institute for Ubiquitous Energy Devices, the Research Center for Chemical Risk Management, the Energy Technology Research Institute of AIST and participant industries of NEDO project represented Japan. China was represented by the Technical Institute of Physics, the Institute of Physics, the Institute of Chemistry, the Research Center for Eco-Environmental Science, Shanghai Institute of Ceramics, Dalian Institute of Chemical Physics and Chemistry and researchers (Graduate School) belonging to CAS. About ten papers were presented by both sides and they discussed on themes of thermo electric conversion, hydrogen energy, fuel cell etc, in energy related session. Environment decontamination by catalyst, influence of nanomaterials to human body and other issues were actively discussed in the environment related session. A laboratory tour was conducted on the third day, and a lot of information was obtained related to the current situation of the conference theme in China.

In addition, there was an introduction including the fellowship system of AIST for the exchange of researchers and about means and funds to promote international research collaboration. There was interest for AIST fellowship from Chinese side, and opinions for promotion of future collaborations was exchanged.

AIST TODAY
International Edition
No.24 Spring 2007

AIST 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/