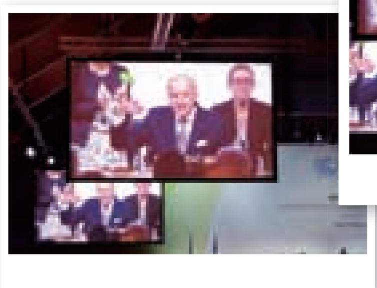
Advanced
Low Carbon
Technology Research
and Development
Program

ALCA

Change the game with technologies!

2016



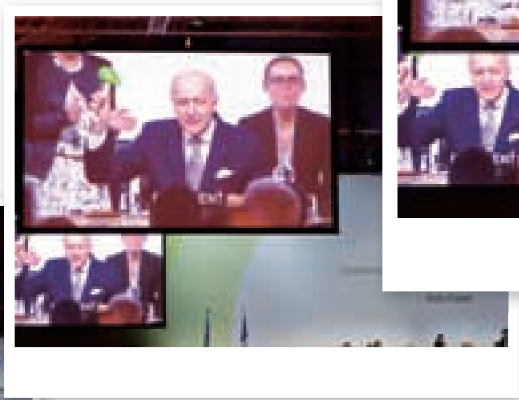


Photo by Dr. Kentaro Tamura at Institute for Global Environmental Strategies (IGES)

ALCA Outline

The opportunity for technological development in environmental energy becoming ripe again

The emission of CO_2 actually accounts for the largest percentage among greenhouse gases (GHG) as a cause of global warming issues. Today, through reducing it, realizing a low carbon society has become a global challenge. In the context of such an international trend, the Japanese government has taken an approach to reduce GHG emission, and the Advanced Low Carbon Technology Research and Development Program (ALCA) was launched in 2010 as a research program toward developing a low carbon technology for the reduction of GHG emission.

In the Paris Agreement, adopted in December 2015 in the 21st session of the Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC), "holding the increase in the global average temperature within 2°C from pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C from pre-industrial levels" has been requested. Specifically, each party is requested to submit its reduction target for after 2020 to the United Nations.

The Japanese government has formally decided a goal, which promised that "GHG will be reduced by 26% (compared with fiscal 2013) in fiscal 2030" in July 2015, prior to holding the COP21. The government decided that the achievement of such a goal should be aspired by innovative energy-saving technology development and also by largely reducing the ratio of the thermal power generation and by increasing the ratios of the renewable energy and nuclear power generation, from the current power supply configuration.

As mentioned above, the tide of enhancing to develop the environmental and energy-related technology has risen globally. It can be said that ALCA, which aims at creating a future low carbon society with game changing technology, is really a research program at the forefront of such a global trend.

Low carbon society by "mitigation option"

There are basically two approaches to solve the global warming issues: the "adaptation option" and "mitigation option". The former is to reduce the global warming effect by adjusting a paradigm for nature and society. In contrast, the latter is to suppress the GHG emission themselves, which is greatly expected by the contribution of science and technology.

ALCA has every intention of building a low carbon society, curbing the emission of CO_2 through energy generation, energy storage, carbon neutral and energy saving, though we can find scientific and technological options in various R&D areas.

Scope of ALCA

It is expected that the scientific and technological outcomes of ALCA will be implemented in the future society by conveying them to the research and development phase which is close to practical use. Therefore, it is necessary for research subjects in ALCA to satisfy the following three requirements.

❶ There is an air of expectancy among the industry.
❷ Sufficient effort has not been made yet in the industry.
❸ It is expected that academia will deal with the problems in the future.

Creation of "game changing technology"

In order to realize a low carbon society, we must look to the creation of game changing technology, which greatly changes the paradigm of science and technology, to break through the existing fossil energy dependent society.

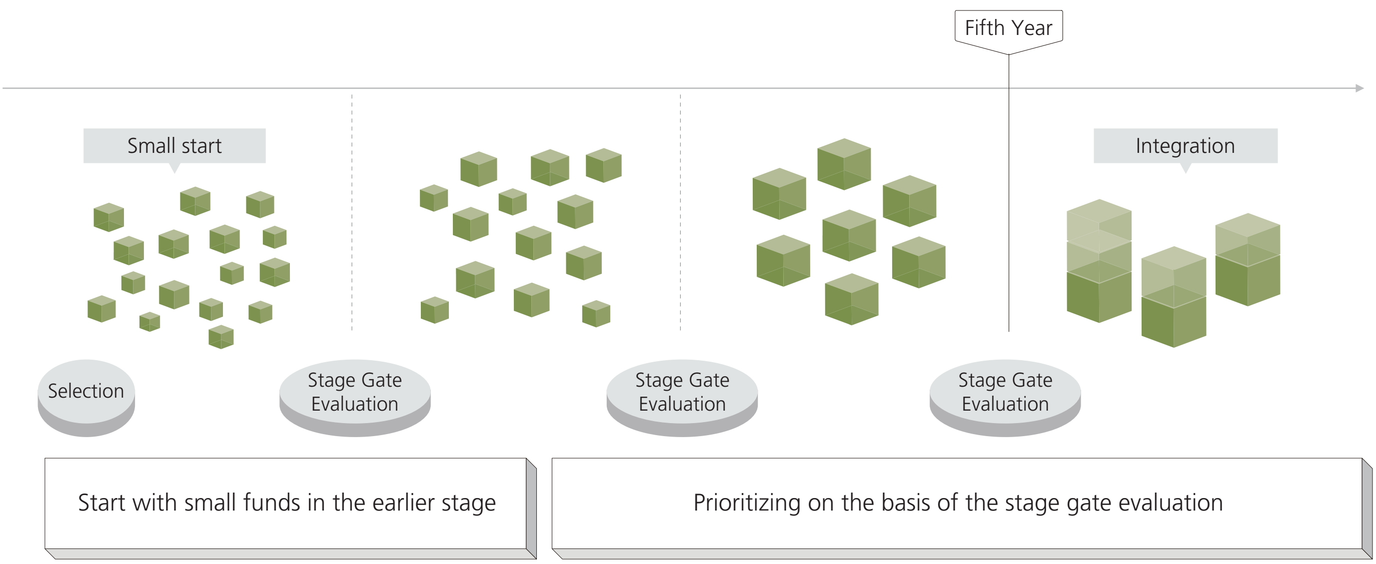
To do so, we are asked to identify research and development which should be addressed at present by back casting from the future low carbon society. In ALCA, which is a society needs pull type, it is encouraged to take inter-discipline efforts without being tripped up the existing mono-disciplines.

Selection and concentration by stage gate evaluation

While ALCA positively adopts game changing problems through peer review process to the proposals, a "stage gate evaluation" is strictly carried out during the research period for making a decision on continuing the research or not. The evaluation is made not only in light of the scientific merit, but also in the light of "potential contribution for a low carbon society", which means the goal of ALCA.

With adopting, many PIs are adopted with relatively small funds (small start), and those which have passed through the stage gate evaluation will be prioritized. In the bottom up proposal type, the PIs who have passed the ALCA stage gates with the initial five fiscal years and which have further passed the stage gate focusing on the latter five fiscal years, will be driven forward in the ALCA research in the latter five fiscal years (enabling technology project) with the expanded research scale.

By the selection and concentration in such a stage gate evaluation, we intend to accelerate the research and development, focusing on the social implementation in 2030. We will adopt new ALCA problems to renew, proceeding with the concentration.



ALCA Tech. Areas

In ALCA we are promoting research and development in two domains: (a) the "top down proposal type technology area (special priority technology area)" focusing on a clear exit from R&D and (b) the "bottom up proposal type technology area" based on freedom of researchers. Each domain adopts problems depending on accumulation of technologies for them and prospect of their practical use, sharing game changing problems on a common basis.

Especially, in the special priority technology area, it is required that the individual elemental technology undertaken as a new science and technology is accumulated to productize (systemize). At the same time, the cooperation with the related programs and projects in other government agencies such as the Ministry of Economy, Trade and Industry (METI) is promoted and we are focusing on bridging the outcome for practical use.

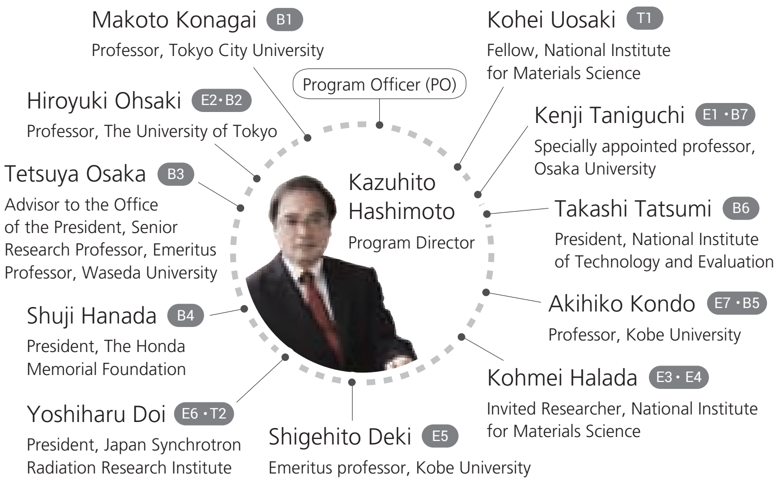
On the other hand, in the bottom up proposal type, each research issue is of the bottom up type since it is based on the free idea from the researcher, and each research issue is also a problem-solving-type fundamental research towards "contribution to the future low carbon society". Also in the adaptation and the stage gate evaluation, it is requested that the issue is "game changing" including "potential contribution to a low carbon society".

Technology area management (Program Officer)

The management requested for the Program Officer (PO) will depend on whether the top down proposal technology area (special priority technology area) or the bottom up proposal technology area.

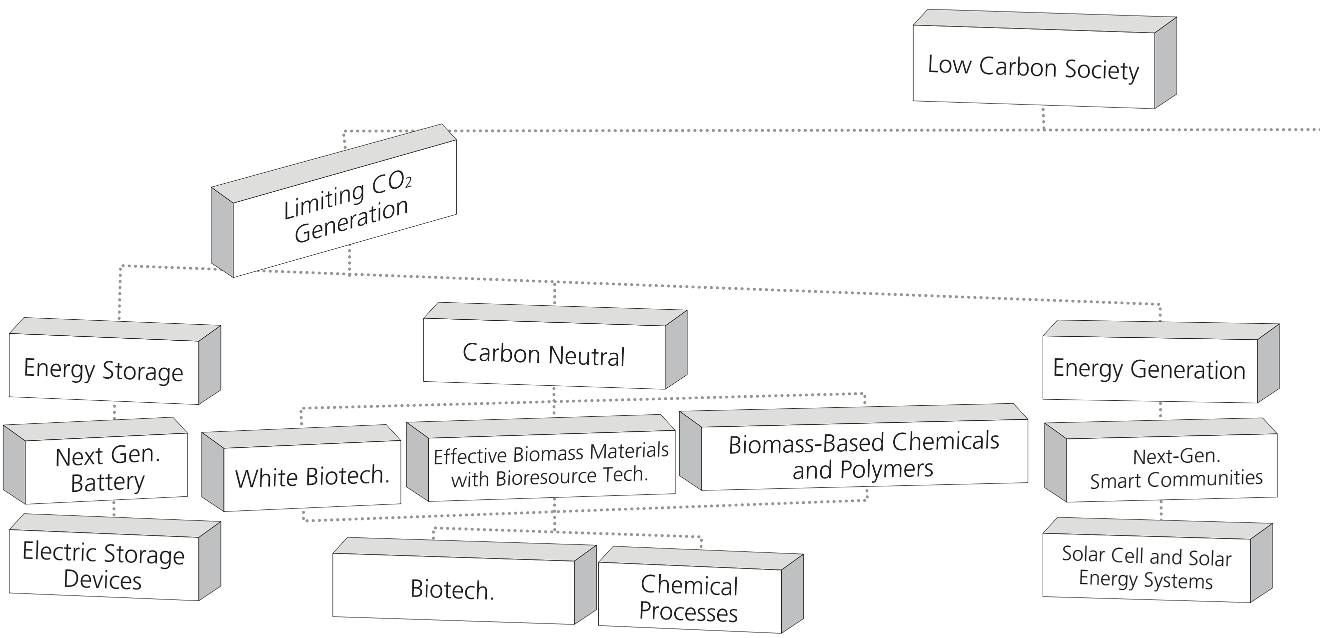
In the former, the essence of the management includes (i) a team formation focusing on productization and (ii) a R&D strategy focusing on developing a product is formulated and an operation is made based thereon. Especially, in (ii), it has been attempted to strongly become aware of the research and development looking ahead to exit through the continuous interactions such as the PO interviews and site visits.

On the other hand, in the latter, the implementation of the research issue is committed to game changing effort based on the originality and the creativity provided by the individual researcher, it is confirmed whether the implementation is met with the object and method of ALCA, and the directionality of the research has been appropriately requested.



ALCA Enabling Tech. Projects since 2015

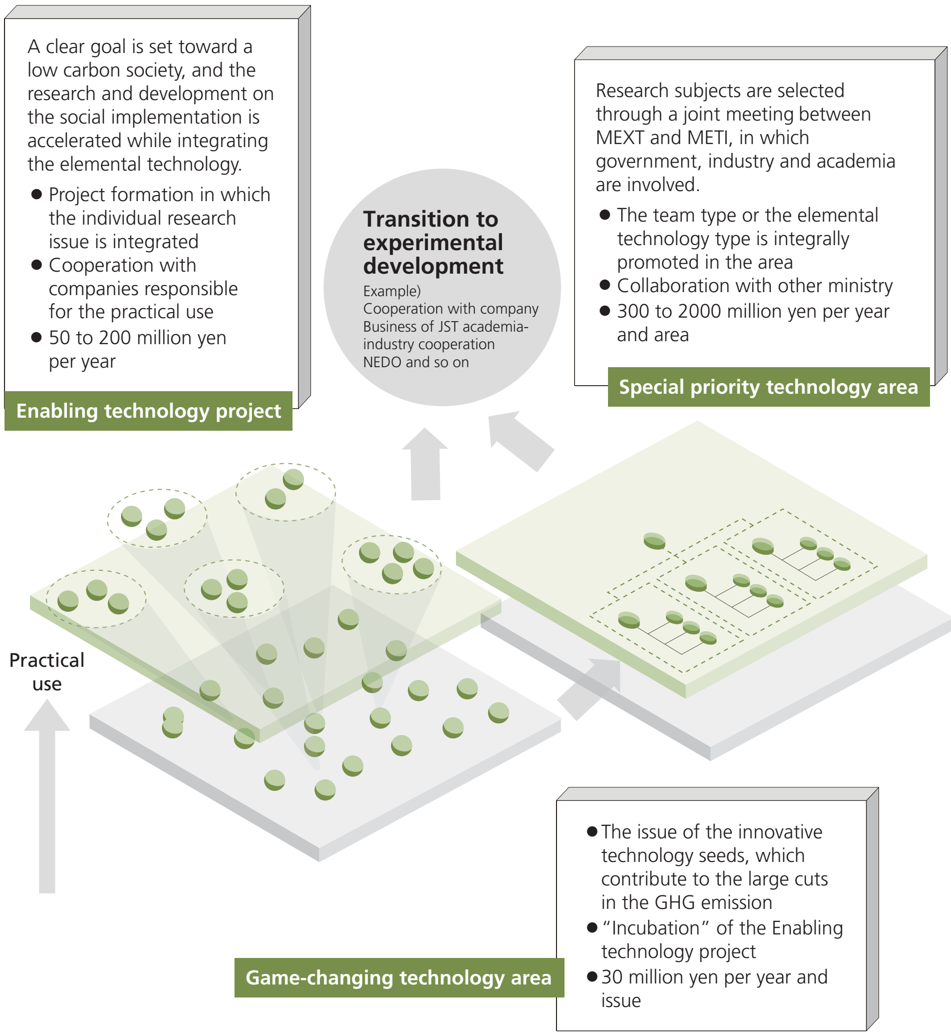
E1	High-Quality and Large-Diameter GaN Wafer	E5	Next-Generation Smart Community
E2	Superconducting Electric Power Equipment using Liquid Hydrogen Cooling	E6	Highly Efficient Production Process for Biomass-Based Chemicals and Polymers
E3	New Heat Resistant Materials for Next-Generation Thermal Power Plants with Less CO_2 Emission	E7	Production of Effective Biomass Materials with Bioresource Technology
E4	Innovative Light-Weight Materials for the Energy-Efficient Society		



Layered Structure of

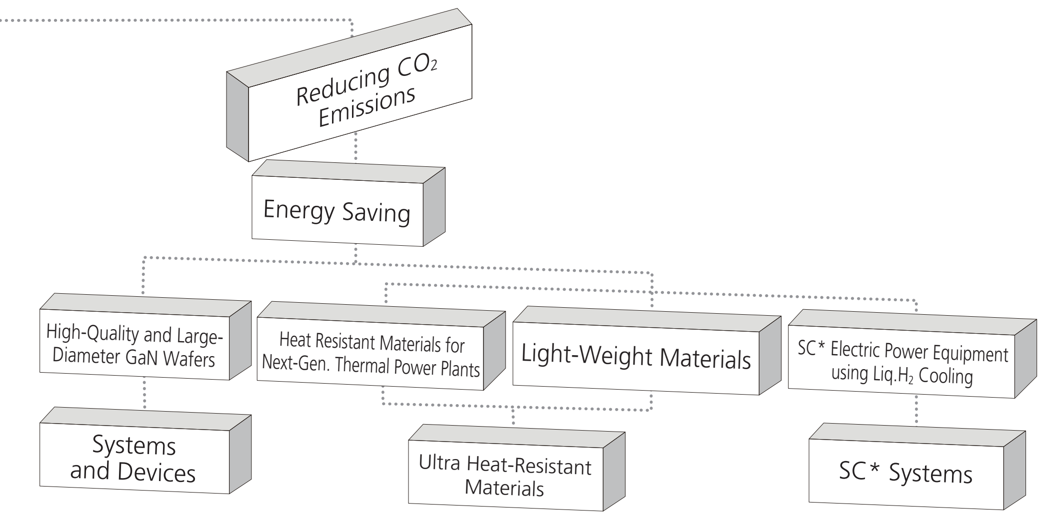
ALCA Enabling Tech. Projects since 2015

After the initial five years, ALCA has accelerated further to improve a framework for promotion, toward the social implementation in 2030. Specifically, in addition to the conventional top down proposal type of the technology area, "the Enabling technology project", which shares a clear goal, has been established.



ALCA Tech. Areas

T1	Next Generation Batteries (special priority technology area)
T2	White Biotechnology (special priority technology area)
B1	Solar Cell and Solar Energy Systems
B2	Superconducting Systems
B3	Electric Storage Devices
B4	Ultra Heat-Resistant Materials and High Quality Recyclable Steel
B5	Biotechnology
B6	Innovative Energy-Saving and Energy-Producing Chemical Processes
B7	Innovative Energy-Saving and Energy-Producing Systems and Devices



*SC: Superconducting

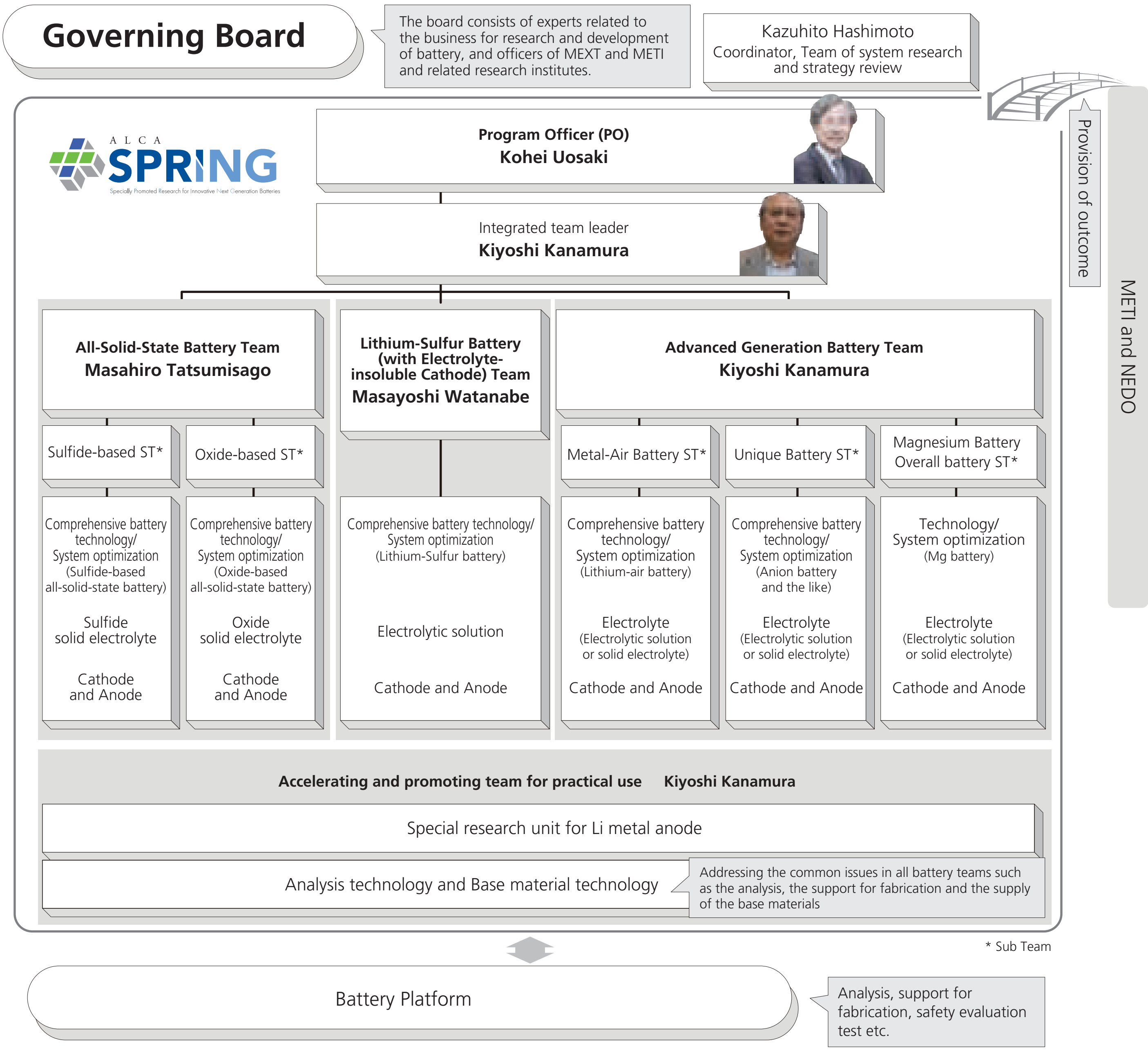
ALCA Technology Areas

Special priority technology area

Next Generation Batteries

Outline of the area

Consolidating the accumulated outcome of battery research and elemental technologies, and incorporating interdisciplinary knowledge, we promote a project research to accelerate the fundamental and basic research for practical use. Specifically, we do the R&D on leading candidates for the next-generation batteries such as an "all-solid state battery", "Lithium-Sulfur battery with electrolyte cathode" and "advanced generation battery" including the multivalent ion battery. In addition, we newly organize accelerating and promoting team for the practical use basically comprising a "special research unit for Li metal anode" and "analysis technology and base material technology". Thus, we take up four team formation, and promote under this system. The optimization group for the comprehensive battery system in each team has the responsibility and exercise leadership for the entire team working together, not only by materials research on such as the active material, the electrolyte and the separator, their mechanisms elucidation or the elemental technology, but also by making the maximum performance as a battery.



Outcome

— Improvement of capacity in the All-Solid-State battery

In the sulfide-based all-solid state battery, the target energy density has already been achieved ahead of the original R&D plan, and the research for practical use has been accelerated further upon cooperating with the Consortium for Lithium Ion Battery Technology and Evaluation Center (LIBTEC).

— Cycle property of Lithium-Sulfur battery

A better cycle property (500 mAh/g after 800 cycles) has been obtained at the long-term cycling test, using the world's first solvated ion liquid.

— Operation of Magnesium battery (advanced generation battery)

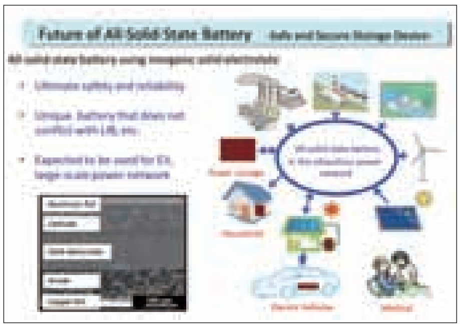
A practically superior electrolytic liquid for Magnesium battery has been developed upon contriving the electrolytic solution.

All-Solid-State Battery Team

Masahiro Tatsumisago
Professor, Graduate School of Engineering, Osaka Prefecture University

We conduct research on All-Solid-State batteries using inorganic solid electrolytes for practical use.

The All-Solid-State battery does not use any flammable electrolytic solution, and accordingly, has been considered to be a highly safe battery that is also free from the risk of electrolyte leakage and is promising for application as an electric vehicle battery. This team is split into two sub-teams, "sulfide-based all-solid-state battery" and "oxide-based all-solid-state battery", and involves fundamental technologies such as interface fabrication, materials processing, battery design and so on. Especially, the sulfide sub-team has led the research towards practical use upon cooperating with LIBTEC.

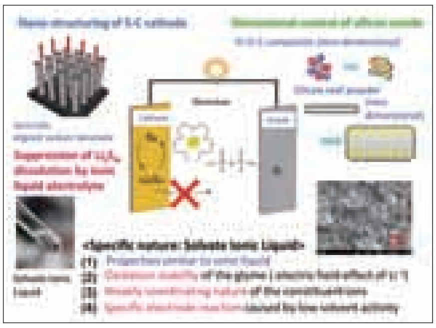


Lithium-Sulfur Battery (with Electrolyte-insoluble Cathode) Team

Masayoshi Watanabe
Professor, Graduation School of Engineering, Yokohama National University

Lithium-Sulfur (Li-S) battery is one of the most promising candidates for beyond lithium-ion batteries because of its high theoretical energy density. The S-based cathode also has the advantages of high natural abundance, low price, and environmental friendliness. By combining with metallic Li or Si anodes, both of which have high theoretical capacity, and ionic liquid electrolytes, high performance Li-S battery will be realized.

We aim at avoiding the dissolution of intermediates from the S-based cathode, which is a fatal disadvantage in this battery, by utilizing an ionic liquid, offering very low solubilization in addition to its non-volatility and non-flammability. The issue of volume change of the cathode and anode materials by discharge and charge will be mitigated by the control of the nano structures. Towards practical use, we extend the research by cooperating with the LIBTEC.

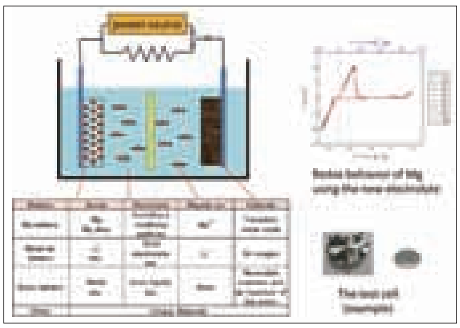


Advanced Generation Battery Team

Kiyoshi Kanamura
Professor, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University

The team explores the various advanced generation battery technologies, such as Mg batteries where two electron transfer is possible by divalent ions, metal-air batteries with high theoretical energy density, and batteries running by migration of negative ions (anions).

We focus on the development of innovative batteries which fulfill the requirement from electrical vehicle applications and enable to utilize sustainable natural energy, through the systematic R&D from fundamental material science to prospect battery materialization, and consequently will bring the novel promising battery technology to the light.

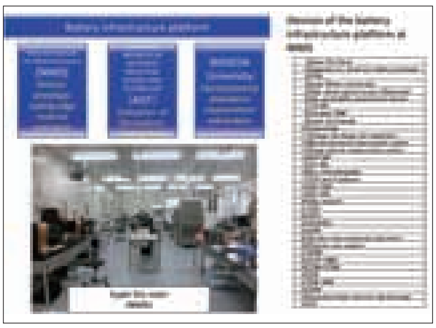


Accelerating and promoting team for practical use

Kiyoshi Kanamura
Professor, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University

Experts are cooperating to address the problems found in each battery system through ALCA-SPRING research.

The special research unit for Li metal anode tackles a safety concern and self-discharge problems of Li metal to realize practical Li-metal secondary batteries. Common issues for battery researches, such as the advanced analysis, battery fabrication, and supply of the base materials, are also all addressed on the basis of the cutting edge facilities and well-organized systems with a support from the battery platform.



Special priority technology area

White Biotechnology

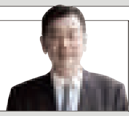
Outline of the area

It is expected that the creation of chemicals from biomass by the white biotechnology will largely contribute to the reduction of CO_2 emission in light of carbon neutral and energy-saving. In order to develop a practical production process of the biomass based chemicals, it is extremely important to establish the fundamental technologies in the based chemical industries such as (i) efficient separation of objective biomass components, (ii) chemical-engineered and biological-engineered conversion into core chemicals, and (iii) synthesis of high performance polymers and utilization thereof. An innovative elemental technology in the throughout process for producing high added-value chemicals from biomass will be developed to establish the biomass-based chemical industry.

Operationally we cooperate not only within the ALCA technology area but also with other JST programs. In addition, in order to effectively promote the cooperation among the projects with "Technical development of producing process of chemicals from inedible plants" in NEDO, a joint meeting comprising JST, NEDO and concerned parties for the project are established.

- The white biotechnology in which the biomass-based chemicals are produced as an ingredient is a clean and sustainable technology for manufacturing chemicals, which can partly replace the petroleum-based product.
- Team type: conducting the consistent synthesizing process
- Elemental technology type: solving the technological bottlenecks for biomass-based polymers
- Specific technology type: promoting R&D for next-generation cellulose nanofiber

Program Officer (PO)
Yoshiharu Doi



- JST Department of Green Innovation, NEDO Department of material and nanotechnology
- JST Program Officer, NEDO project leader, project subleader
- Observers: MEXT, METI and Ministry of Environment

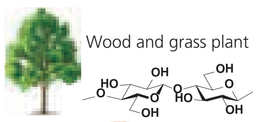
Team type and elemental technology type

Provision of outcome

NEDO: Technical development of producing process of chemicals from inedible plants

Macromolecular polysaccharide

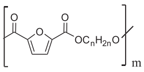
Thermoplastic resin
Creation of high performance macromolecular polysaccharide bioplastic upon utilizing the characteristic of polysaccharide
Tadahisa Iwata



Forming high performance membrane

Sugar

High heat resistance and high tensile polyester
Synthetic process with low environmental load by solid catalyst
Kiyotaka Nakajima

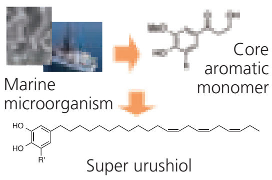


Glycolic acid polymer
Polymer synthesis by microorganism
Ken'ichiro Matsumoto

High functional biosurfactant
Creation of new additive from microorganism
Hiroshi Habe

Lignin

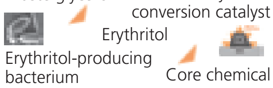
Super-urushiol (Artificial Japanese lacquer)
Creation of aromatic polymer material (Artificial Japanese lacquer) by a catalyst of marine microorganism which degrades lignin
Yukari Ohta



Muconic acid
Production of muconic acid from lignin
Tomonori Sonoki

Waste glycerol and natural rubber

Butanediol
Throughout industrial process fusing microbial conversion and catalytic technology
Takashi Arai



1,3-propanediol
Microbial conversion of waste glycerol
Toshiaki Nakajima-Kambe

High performance rubber
Development of reaction controlling technology
Yuko Ikeda

Specific technology type (cellulose nanofiber)

Interfacial asymmetric organocatalysis
Takuya Kitaoka

Cellulose nanofiber composite plastic foam
Masahiro Ohshima

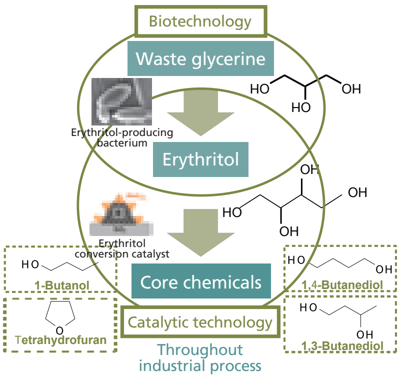
"Shinayaka (Flexible)" material
Takashi Nishino

In the ALCA white biotechnology, attention is focused on the polymer material as a final product. We promote development of synthesis and a material design for high polymer properties such as high thermal resistance, high strength and also the development of a process for effectively producing a monomer chemical. Operationally, this technology area consists of three types of the team type, the elemental technology type and the specific technology type. The research and development on "vertical integration type team research", "elemental technology research for solving the technological bottleneck" and "next-generation cellulose fiber" is mainly conducted for 5 fiscal years in each type.

Basic chemicals prepared by bio and catalytic technology

Takashi Arai
Group leader, R&D Promotion, R&D Headquarters, Daicel Corporation

The waste glycerol is converted into erythritol by the biotechnology, and then erythritol is produced into butanediol and so on by the catalytic technology, independently. The throughout industrial process in which the technologies proven successful for each purpose are fused is established to contribute to the reduction of CO_2 emission.

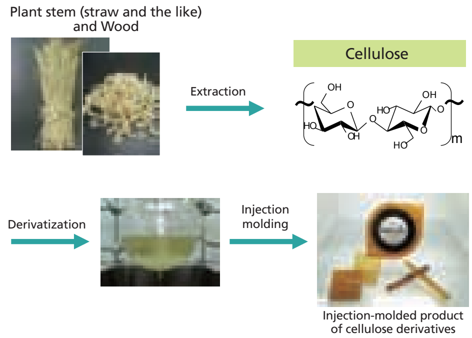


Basic chemicals prepared by bio and catalytic technology

Innovative synthesis of high-performance bioplastics from polysaccharides

Tadahisa Iwata
Professor, Graduate School of Agricultural and Life Sciences, The University of Tokyo

High-performance bioplastics are innovatively synthesized from polysaccharides extracted from nature or produced by enzymatic polymerization with keeping their characteristic structures. New products with high added-value and environmental harmonization are developed.



Catalytic production of di-carboxylic acids and diols from biomass-derived carbohydrates

Kiyotaka Nakajima
Associate professor, Institute for Catalysis, Hokkaido University

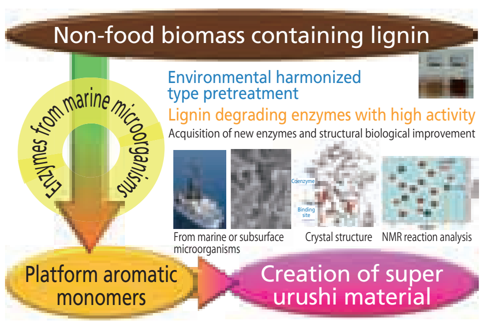
An environmental benign production of dicarboxylic acids and diols from non-edible and biomass-derived carbohydrates has been developed with stable and highly active heterogeneous catalysts. These compounds are readily available as raw materials for useful plastics as replacements of fossil fuel-derived polyesters.

Polyalkylene furanate resin, a next-generation biopolymer as a replacement of conventional aromatic polyester
- High thermal resistance, tensile strength, and gas barrier property
- Easy-processability

Development of bioprocess using marine microbial enzymes for efficient lignin degradation and catalytic generation of super-urushiol from lignin monomers

Yukari Ohta
Deputy group leader, Research and Development Center for Marine Biosciences, Japan Agency for Marine-Earth Science and Technology

The non-food biomass containing lignin is pre-treated with an environmental harmonized type approach. By using the so-obtained product, phenyl propanone aromatic monomers are selectively manufactured by using the set of enzymes of marine microorganisms. Further, the monomers will be functionally developed into a "super urushi material" by chemical catalysts.



Special priority technology area

White Biotechnology

Elemental technology

Development of microbial process for production of glycolate-based polymers from sugars

Ken'ichiro Matsumoto
Associate professor, Graduate School of Engineering, Hokkaido University

By constituting an artificial polymer synthetic system in microorganism, a plastic which is superior in degradability is synthesized from renewable sugar biomass.

Elemental technology

New development of natural rubber by technological innovation of vulcanization

Yuko Ikeda
Professor, Faculty of Molecular Chemistry and Engineering, Kyoto Institute of Technology (Director, Center for Rubber Science, Kyoto Institute of Technology)

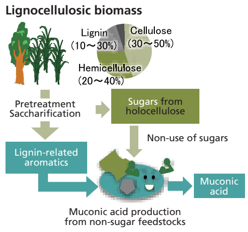
In order to reduce carbon dioxide emission and establish security and a safe society, a technology for controlling the vulcanization for rubbers is consolidated in view of biodiversity and biosecurity of natural rubber.

Elemental technology

Sugar-independent bioproduction of muconic acid

Tomonori Sonoki
Associate professor, Faculty of Agriculture and Life Science, Hirosaki University

We develop a microbial process for effectively producing muconic acid which can be utilized for a wide variety of phenolic polymerization from lignin.

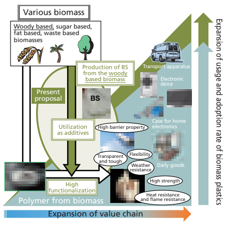


Elemental technology

Development of high functional biosurfactant for mastering the bioplastic

Hiroshi Habe
Group leader,
Environmental Management Research Institute,
National Institute of Advanced Industrial Science and Technology

The biosurfactant is utilized as an additive for plastics towards innovative development for the material sophistication technology such as high-level dispersion of materials.

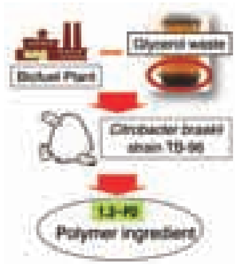


Elemental technology

Microbial conversion into polymer ingredient from biofuel waste based biomass

Toshiaki Nakajima-Kambe
Professor, Faculty of Life and Environmental Sciences, University of Tsukuba

The production of 1,3-propanediol (1,3-PD) which is a polymer ingredient is sought from the waste glycerol obtained through the manufacturing the biodiesel fuel.



Specific technology

Nanocellulose controls molecular chirality in heterogeneous asymmetric organocatalysis.

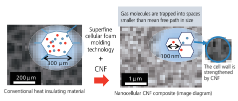
Takuya Kitaoka
Professor, Faculty of Agriculture, Kyushu University

An unexpected combination of wood nanocellulose and organocatalysts provides new insight into asymmetric synthesis with high catalytic efficiency and high stereo-selectivity.

Specific technology

Preparation of cellulose nanofiber composite plastic foam with ultralight and high insulation performances

Masahiro Ohshima
Professor, Graduate School of Engineering, Kyoto University

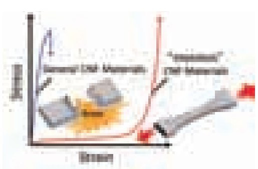


CNF as a multifunctional additive is composited and foamed with a plastic in a way that hundreds of billions of pores a nanometer in size are formed in a material and the weight per unit volume of the material is reduced to a tenth or less of its original weight, thereby foams having high thermal resistant property are created.

Specific technology

Development of "SINAYAKA" cellulose nanofiber composite materials

Takashi Nishino
Professor, Graduate School of Engineering, Kobe University



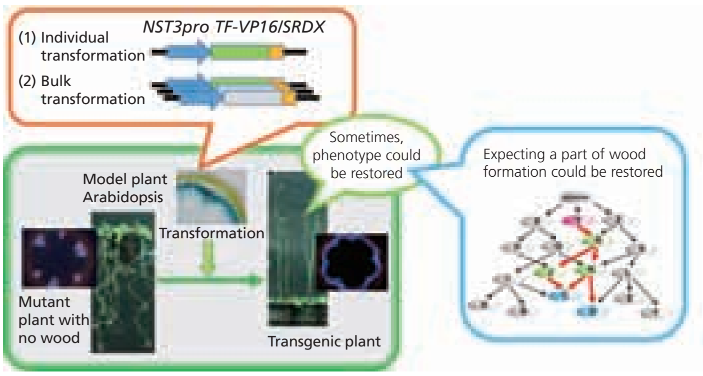
Cellulose nanofibers (CNF) have been employed to strong and hard constructional materials. Herein, we create "Shinayaka" (flexible and strecthy) polymer composites with CNF.

H23

Producing new wood in plant with no wood

Nobutaka Mitsuda
Senior scientist, Bioproduction Research Institute,
National Institute of Advanced Industrial Science and Technology

In order to reduce the emission of carbon dioxide, it is requested to expand the production of second generation bioethanol using inedible plant woody material as an ingredient. The present issue is to develop a plant forming a new woody material which can produce bioethanol at a low cost and in large amounts in comparison with a normal wood material, by additionally expressing various genes in a plant which cannot produce the woody material due to mutation of important genes.



Akihiko Kondo
Professor, Kobe University

Enabling technology project

Production of Effective Biomass Materials with Bioresource Technology

Biomass can be converted into a useful bioresource such as bioethanol, bioplastic, core chemical and others upon CO_2 fixation, and is expected to contribute to reducing GHG emission. While various biomass production research projects are currently promoted both within and outside Japan, there exist many hurdles for the practical use such as stability and reproducibility in the open air and open system, the cost for purifying a target material and so on.

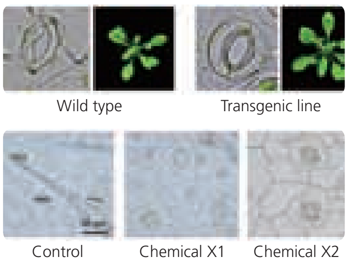
This ALCA project aims for enhancement of the biomass production and the effective utilization of its useful component by gene modification and metabolic control, in order to effectively utilize CO_2 which is fixed by the biological body from the environment. Our project will contribute to the achievement of a low carbon society, conducting R&D based on the output of ALCA research so far with knowledge and technology linkage.

H22

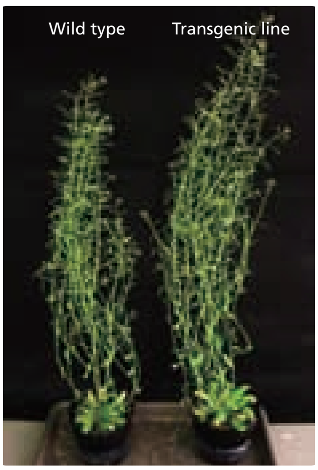
Promotion of photosynthesis and plant productivity by controlling stomatal aperture

Toshinori Kinoshita
Professor, Institute of Transformative Bio-Molecules, Nagoya University

The stoma present on the epidermis of a plant is a sole inlet of carbon dioxide necessary for photosynthesis which is the plant-inherent metabolic reaction. It has been known that the stomatal resistance which is created in incorporating carbon dioxide through the stoma is one of the main rate restricting steps for photosynthesis. In the present research, a molecular mechanism for stomatal opening and closing is elucidated, and creation of a plant body in which the stomatal aperture is artificially controlled and identification of a compound controlling the stomatal aperture are addressed to seek the improvement of the photosynthesis activity (CO_2 uptake) and the plant productivity.



Stomatal opening induced by Chemical X1 and X2

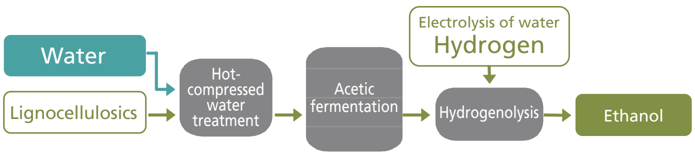


H22

Advanced bioethanol production by acetic acid fermentation from lignocellulosics

Shiro Saka
Professor, Graduate School of Energy Science, Kyoto University

With the aim of establishing a low carbon society, ALCA research has been conducted for a new ethanol production process using acetic acid fermentation. The present process consists of hydrolyzing lignocellulosics by hot-compressed water without catalyst, followed by acetic acid fermentation of the obtained decomposed products, and ethanol production from acetic acid by hydrogenolysis. In this process, ethanol can be manufactured with high efficiency in comparison with conventional yeast alcoholic fermentation.



Enabling technology project

Highly Efficient Production Process for Biomass-based Chemicals and Polymers

Yoshiharu Doi
President,
Japan Synchrotron Radiation Research Institute

To develop a new catalyst and a reacting process for effectively producing biomass-based chemicals and polymer materials from a carbon-neutral resource is an important science and technology issue for establishing a low carbon society. Actually, its research and development is aggressively promoted in various countries in this context. For practical use, there are various issues such as cost reduction of the biomass product, improvement of performance, reduction of the environmental load, and the like, in order to compete with the current petrochemical industry. Especially, it is strongly requested to create a well-designed energy-saved producing process with cost advantage and chemicals and polymer materials with high added-value.

In the present project, we aim at developing game-changing biomass conversion technologies such as highly added-value biomass-based chemicals, high-performance biomass-based polymer, high-efficiency and rapid synthesis catalysts and enzymes, and an environment-conscious process for target products.

On the basis of biomass-related technology which has previously accumulated in the ALCA contributes to the formation of a low carbon society, by stepping up the technology for practical use, and by developing innovative high-efficacy biomass converting process, while cooperating with other projects.

PRESS RELEASE

Success in developing a transparent resin with the best strength in the world

A synthesis of cinnamon-based bioplastic produced with a transgenic microorganism is succeeded and a transparent resin with the highest strength based on this was successfully developed.

Bioplastics are derived from regenerable organic resources (biomasses) such as plants, but they inherently have problems in mechanical strength, like being easy to break. So, its use is limited and is currently used only as disposable material.

Using a newly-developed transgenic microorganism, the research team has succeeded in producing amino cinnamic acid, a kind of cinnamon-based molecule from the biomass ingredient.

The bioplastic developed on this occasion was not only well-transparent equivalent to polycarbonate, a multipurpose transparent resin (87% of transparency: 400 nm in wavelength), but also has high mechanical strength of 407 MPa, which is 6 times higher than polycarbonate. Achieved mechanical strength means to be far more superior to glass mechanical strength (100 to 150 MPa), and is expected to partly replace the glass-based product. Since the heat resistant temperature of the developed bioplastic is about 250°C, it can be expected as an industrial material for a wide variety of uses. They can be expected for use especially in weight-saving transportation equipment such as automobiles and a new material for flexible panels, and it can be considered that the bioplastic can contribute to CO_2 reduction in the atmosphere.

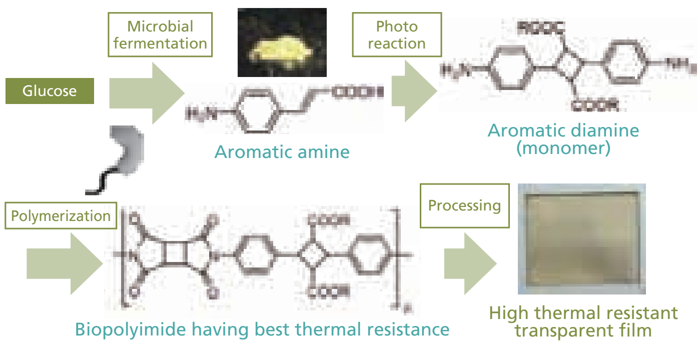
(From press statement of Japan Advanced Institute of Science and Technology)

H22

Generation of super-engineering plastics using microbial biomass

Tatsuo Kaneko
Professor, Graduate School of Advanced Science and Technology, Japan Advanced Institute of Science and Technology

A fermentation system of microorganism, which produces 4-amino-cinnamic acids having the ideal structure as materials of super engineering plastics in large amounts, is established and the super engineering bioplastics which are compatible with the metal substituting materials are developed. Further, a method of recycling with biodegradation for stocking carbon as carbon dioxide in the material system over the long term is developed, and creation of new concept of "carbon minus material", which is a game changer for carbon neutral, is conducted.

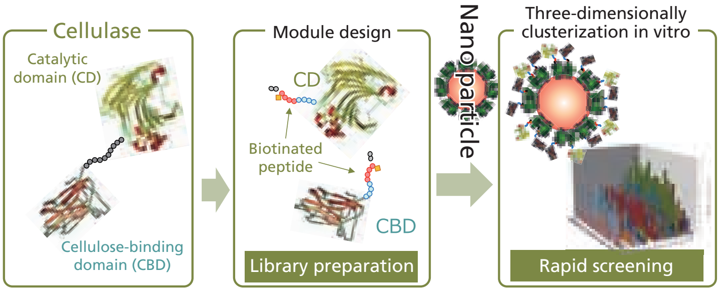


H23

Nanobio design for solid-degrading enzymes: CO_2 bypass carbon cycling

Mitsuo Umetsu
Professor, Graduate School of Engineering, Tohoku University

Cellulose biomass is a water-insoluble matter that is hard to degrade. In this research, cellulolytic enzymes called cellulases are three-dimensionally reconstructed on the surface of nano-material to drastically improve the degradation activity. A bioprocess, in which useful organic molecules are produced from cellulose biomass with low energy and low environmental load, is constructed to establish a carbon circulating system in which carbon dioxide is bypassed.

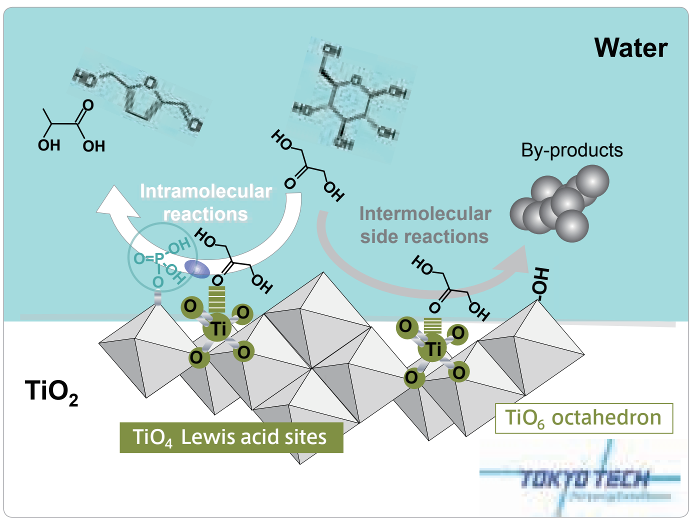


H24

Development of multifunctional heterogeneous catalysts

Michikazu Hara
Professor, Laboratory for Materials and Structures, Tokyo Institute of Technology

Based on cellulose-containing biomass, we are aiming at producing furan-based monomers such as 2,5-furan dicarboxylic acid (FDCA) and 2,5-bis (aminomethyl) furan (AMF) and the like through 5-(hydroxymethyl)-2-furaldehyde (HMF). By solving this science and technology problem, we can sustainably achieve engineering plastics and high added-value polymers without using fossil resources and the CO_2 emission.

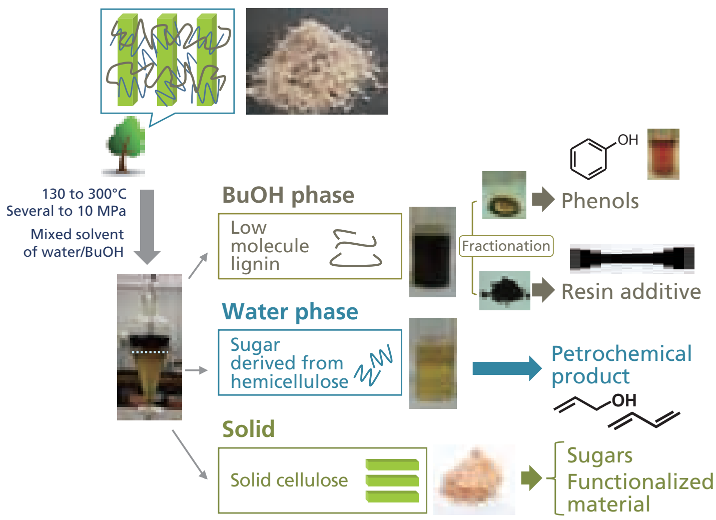


H24

Development of isolating and manufacturing technology of single-cyclic aromatics from natural polycyclic aromatics

Takao Masuda
Professor, Faculty of Engineering, Hokkaido University

By separating cellulose, hemicellulose and lignin constituting woody based and glass plant based biomasses and by developing technology converting each component centered on lignin into useful chemical substances, it can lead to the development of a system for creating all resources of biomasses.



Enabling technology project

Next-Generation Smart Community

Shigehito Deki
Emeritus professor, Kobe University

As a part of reduction of GHG emission, it is promoted to create the future low carbon society where renewable energy is aggressively introduced. In this project, we aim at creating and socially implementing the science-based core technology with an eye on a disaster resilient smart community which hopes to be a low carbon and autonomous distributed energy community, for core social infrastructure such as buildings, platforms, transportation and so on.

We develop new high-efficiency solar battery revised from material level and an innovative power storage device which balances fluctuation in electricity generated by the amount of sunlight and variation in the amount of consumption by season and period of time.

In addition, by combining the high energy density battery and the high-efficiency fuel cell with high output and long-life to the developed high-efficacy solar battery, the stable supply of recyclable energy in the smart community is sought after.

Further, we also attempt to realize an advanced energy consumption saving by introducing an innovative heat insulating technology and low power consumption electric equipment.

In this project, we integrate the accumulated elemental technologies in the ALCA research so far and enhance the cooperation with the industry. In this way, we make each elemental technology closer to the practical use phase, and intend to contribute the formation of a low carbon society.

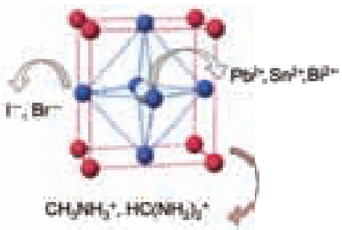
H25

Development of organic inorganic hybrid high performance solar cells

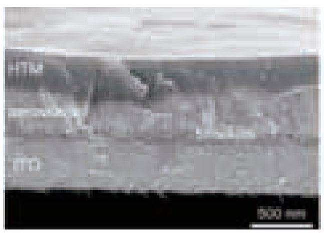
Tsutomu Miyasaka
Professor, Graduate School of Engineering, Toin University of Yokohama

The perovskite solar cell which was first invented by Tsutomu Miyasaka, ALCA PI, is a low cost solution-printable solar cell which has so far attracted the most global attention for high conversion efficiency over 22%. By optimizing the material, the crystal structure and the process in the past ALCA research, the efficiency and reproducibility are greatly increased.

The goal of research is to improve the cell performance and reliability which surpass those in Si solar cells and to convert the perovskite to lead-free structures. In addition, we collaborate with other research groups on tandem combination of perovskite solar cell with other photovoltaic cell for efficiency enhancement.



Hybrid perovskite crystal



High-efficiency perovskite solar cell fabricated on plastic film.

ITO-PEN(250μm)/SnO_x/mp-brookite/$CH_3NH_3PbI_{3-x}Cl_x$/Au

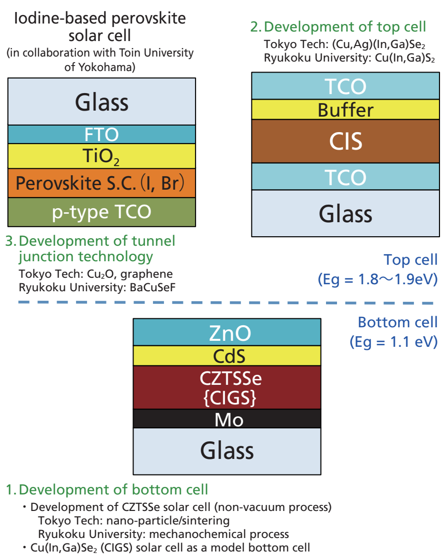
H22

Development of thin-film-based tandem-type solar cells for future generations

Akira Yamada
Professor, Graduate School of Electrical and Electronic Engineering, Tokyo Institute of Technology

The aim of this research project is to develop high-efficiency tandem-type solar cells. They consist of a bottom and top cell with different bandgaps. The bottom cell is a chalcogenide-based solar cell, and the top cell is either a chalcopyrite or perovskite solar cell. In past ALCA project, we have already developed $Cu_2ZnSn(S,Se)_4$ solar cells with an efficiency of 9.1%. The cell was fabricated by a spray-printing/sintering process, that is, the process is a non-vacuum and low-cost process, and it is a candidate of the bottom cell.

In the present ALCA project, we will develop iodine-based perovskite solar cell in collaboration with Toin University of Yokohama as a top cell. By the combination of the bottom and top cell, the tandem-type solar cell can absorb a wide range of wavelengths in the solar spectrum, which boosts the cell efficiency. The targeted efficiency of the project is a 27% efficiency.



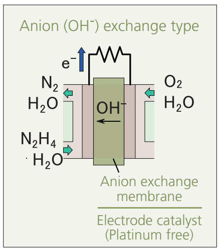
Tandem-type solar cell (Perovskite-Chalcogenide)

H22

Pt-free fuel cell vehicle using liquid fuel as storage medium of electricity

Susumu Yamaguchi
Daihatsu Motor Co., Ltd.
Chief Coordinator, Advanced R&D Center

Fuel cell technology using hydrazine hydrate which is one of the liquid fuels is developed in this project. Because liquid fuels like hydrazine hydrate can be transported and preserved by plastic bottle easily, electricity for vehicles and home use can be generated in smart communities. Moreover, precious-metal catalysts are not needed due to reaction in alkaline environment by anion exchange membrane. In the first stage of ALCA, high performance and durability anion exchange membrane has developed. In this stage of ALCA which aim to realize this technology in the world, new synthesis technology with low energy is also developing.



Precious-metal Free Liquid feed Fuel Cell

Stack cut model

FC Deco Deck

H22

Development and evaluation of carbon alloys with electrocatalytic activity for cathode reaction in proton exchange membrane fuel cell

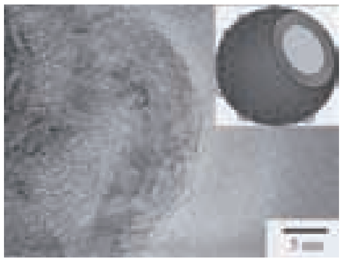
Jun-ichi Ozaki
Professor, Graduate School of Science and Technology, Gunma University

The carbon alloy catalysts which have been developed by Ozaki *et al.* are innovative carbon materials which are expected to be substitute for noble metal catalysts used for proton exchange membrane fuel cells. Through past ALCA research the catalyst having a performance of about 650 mW/cm^2 in maximum output was developed.

Powder of carbon alloy catalyst

In the future, the characterization of the carbon alloy catalyst and an effort for securing long-term durability will be conducted and diffusion of proton exchange membrane fuel cells will finally be promoted to contribute to the formation of a next-generation smart community.

Transmission-type electron microscope image of nano-shell carbon (one of the carbon alloy catalysts)



High magnification image and model of nano-shell structure

H22

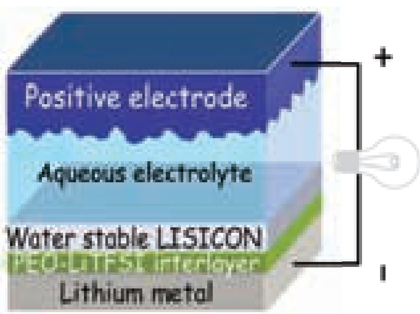
Development of advanced hybrid capacitor (AdHiCap)

Wataru Sugimoto
Professor, Center for Energy and Environmental Science, Shinshu University

A novel hybrid supercapacitor (Advanced Hybrid Capacitor; AdHiCap™), which utilizes a water based electrolyte with a solid electrolyte was developed. This new ground breaking supercapacitor affords 10 times higher energy density compared to current state-of-the-art hybrid capacitors and has superior safety. As part of the on-going R&D of the AdHiCap™ based on ALCA project, we have now improved the long-term stability of the water stable Li-based anode.

Our performance goal is 400 Wh/kg in energy density and 3 kWh/kg in power density, which should be realized through further improvement in anode performance as well as new electrolytes.

The newly developed 4 V water based hybrid capacitor (AdHiCap™)



By using a water stable lithium anode in combination with a high capacity supercapacitor electrode as the cathode, a 4 V cell voltage is achieved even when using aqueous electrolyte, realizing both safety and environmental benigness.

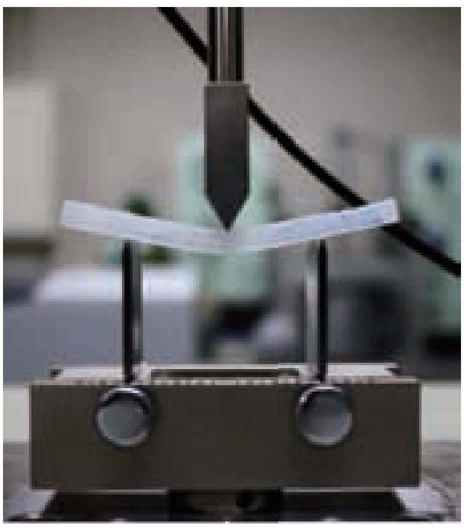
H22

Development of multi-purpose insulation materials based on organic-inorganic hybrid aerogels

Kazuki Nakanishi
Associate professor, Graduate School of Science, Kyoto University

The innovative heat insulating material polymethyl silsesquioxane (PMSQ) xerogel has twice the heat insulating property of conventional materials such as polymeric foam, glass wool and other materials and has transparency to visible light. In past ALCA research, the flexural strength of the heat insulating material was successfully improved, which had been a bottleneck.

In this project, establishing a manufacturing process of granular xerogel and film forming process and further improving the strength of the material and heat insulating property of PMSQ xerogel is aimed for.



Flexural behavior of polymethyl silsesquioxane (PMSQ) xerogel

Enabling technology project

Superconducting Electric Power Equipment using Liquid Hydrogen Cooling

Hiroyuki Ohsaki
Professor, The University of Tokyo

The energy system utilizing hydrogen as fuel or energy carrier is expected to greatly reduce the emission of CO_2, and various research and development is being conducted. In this project, an energy equipment system integrating the hydrogen technology and the superconductive technology, in which hydrogen is utilized in the form of liquid hydrogen also as extremely low temperature refrigerant, is developed as innovative low carbon technology. The superconductive electrical equipment with liquid hydrogen cooling is expected to be technology to improve the efficiency and to lower the CO_2 emission in the system and are largely progressed. These include the superconductive power generator with liquid hydrogen cooling applicable for the power generation system utilizing the hydrogen turbine and the controlling system for electrical system in which the fuel battery and the super conductive energy storage such as SMES (Superconducting Magnetic Energy Storage) are combined as an energy storage device suppressing the output power fluctuations of the renewable energy.

Hence, focused on the superconductive coil with liquid hydrogen cooling at a technical level for equipment application, a project is conducted by organically cooperating the various technologies from the applicable low cost superconductive long-length superconductive wires based on MgB_2 wires, REBCO superconductive wires and so on, to the cryogenic technology by liquid hydrogen and the equipment systems technology such as magnets and rotators, thereby accelerating the research and development for practical use.

JAXA Noshiro Rocket Testing Center

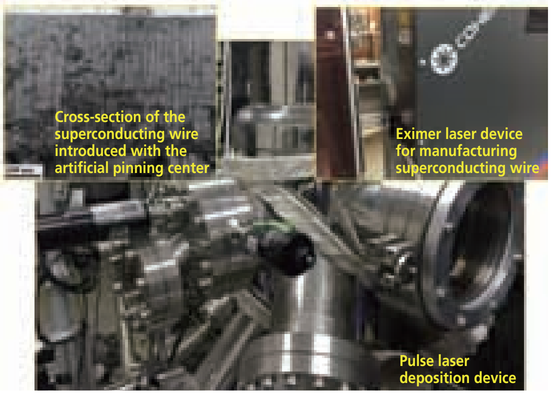
This center is also utilized as a field for Joint Research with Universities promoted by JAXA (Japan Aerospace Exploration Agency), and a lot of collaborative research is conducted, such as the test for thermal hydraulics of liquid hydrogen, in cooperation with Kyoto University.

H22

Development of low-cost REBCO coated conductors

Kaname Matsumoto
Professor, Graduate School of Engineering, Kyushu Institute of Technology

For superconducting equipment with liquid hydrogen cooling, long-length superconducting wire with high performance needs to be developed at a low cost, in addition to the improvements of the superconducting engineering and cryogenics. In the present work at ALCA, the artificial pinning center technology, in which high Jc is demonstrated at 77K by artificially introducing crystal defects of the nano-scale to rare earth based high temperature superconducting wire, is newly applied at 10 to 30K to achieve the improvement of the wire performance by several tens of times over. By using the artificial pinning center technology, the necessary thickness of superconducting film can be reduced to a fraction of the conventional one, and as a result, drastic cost reduction in wire manufacturing can be established.

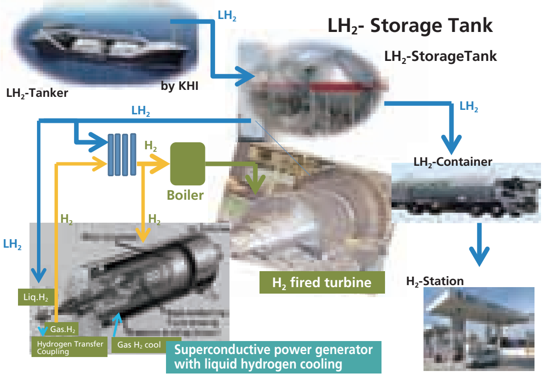


H22

Development of liquid hydrogen cooled MgB_2 superconducting power apparatus

Yasuyuki Shirai
Professor, Graduate School of Energy Science, Kyoto University

The issue is for low carbon technology based on the superconductive equipment with liquid hydrogen cooling and the hydrogen and electricity coordinated energy infrastructure based on it to be the key. We attempt to promote the introduction of a large renewable energy source by lowering the introducing hurdle of the hydrogen energy with positive utilization of the liquid hydrogen cooling, and by enhancing the flexibility of the more complex power system from introducing the high performance and high efficiency superconductive equipment. In the present ALCA research, we conducted development of elemental technology of superconductive equipment with liquid hydrogen cooling and its cooling system, investigation of the property of the superconductive wire for liquid hydrogen cooling, and the review of an effect upon introducing the hydrogen and electricity coordinated energy system.



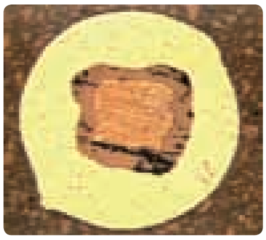
One example of superconductive power generators with liquid hydrogen cooling and hydrogen and electricity coordinated energy infrastructure

H22

Development of high performance MgB_2 long conductors

Hiroaki Kumakura
Senior Scientist With Special Missions, High temperature superconducting wires group, National Institute for Materials Science

Based on the development for MgB_2 superconducting wires in the past ALCA project, we develop 100m-1km long class single- and multi-filamentary MgB_2 superconducting wires applying an internal Mg diffusion process with the filaments composed of an intermediate B powder layer and an Mg core at the center. We investigate the prepared superconducting wires in detail, such as the microstructure of filaments and the local critical-current variations, and give feedback on the manufacturing process of superconducting wires. As such, we are aiming to develop a high-performance and low-cost MgB_2 superconducting wire with the applicable level critical-current property at the temperature of liquid hydrogen (20K) and at 5T in magnetic field. Further, long developed superconducting wires will be supplied to the Hamajima group and the Shirai group in ALCA Enabling Tech.



Cross sectional photograph (prior to heat treatment) Diameter: 0.88 mm

A 100m-long class single core MgB_2 superconducting wire having iron sheath (covering) has been manufactured. In the future, highly stable longitudinal MgB_2 superconducting wire having copper (alloy) coating will be developed, based on the same technique.

MgB_2 superconducting coil

This coil is a small one which is experimentally produced by using MgB_2 superconducting wires prepared with the PIT (power-in-tube) method. The MgB_2 superconducting wires are relatively easy to make in a long length without using expensive rare earth metals, and are promising for practical use. Incidentally, the MgB_2 that shows a super conductive phenomenon was found by Akimitsu *et al.* in 2001 in Japan.

42% of the global CO_2 emission is caused by thermal electric power generation. In addition, since the amount of the thermal electric power generation which occupies 68% of the current total electric power in the world is estimated to increase 1.4 times over or more in 2040, it is strongly requested that a next-generation thermal electric power generation system of the low CO_2-emission will be created.

Due to the law of thermodynamics, the thermal engine commencing with the gas turbine increases its electric power generation efficiency by operating at a high temperature thereby being an extremely effective means for decreasing CO_2 emission. The largest factor limiting the operational temperature is heat resistant materials. It is indispensable to develop a new ultrahigh heat resistant material which complies with the requirement for the operation at high temperature and high efficacy in various methods such as coal-fired thermal power, natural gas-fired power and so on.

In this project, we will seek to further promote the ALCA R&D so far as follows: (a) materials allowing higher efficiency thermal electric power generation such as gas turbine at 1800°C and thermal electric power generation at 800°C, (b) ferrite heat-resistance steel for thermal electric power generation at 700°C, (c) recyclable Ni-based superalloy.

In this way, we establish a basis for the empirical research in collaboration with industry in 5-years and social implementation in 2030 as well.

Enabling technology project

New Heat Resistant Materials for Low CO_2 Emission Type Next-Generation Thermal Electric Power Generation

Kohmei Halada
Invited researcher,
National Institute for Materials Science

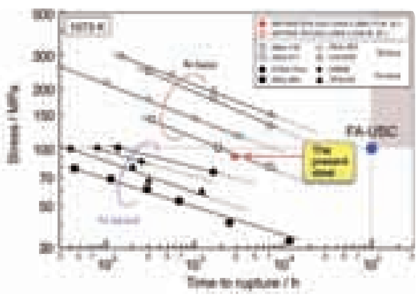
H22

Elemental technology for design and manufacturing of innovative 1073K class super austenitic heat-resistant steels

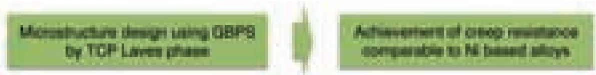
Masao Takeyama
Professor, School of Materials and Chemical Technology,
Tokyo Institute of Technology

It is possible to develop Fe based alloys with excellent creep resistance compatible to Ni based alloys!! In the first stage of ALCA project, we have worked on designing Fe based alloys as a potential heat resistant material for 800 °C class AUSC power plants with significantly increased efficiency, where we have established a design principle using a new strengthening mechanism, "grain boundary precipitation strengthening (GBPS)" and have demonstrated a possibility of its industrialization from the view of both creep strength and steam oxidation resistance. In the present project, we are going to develop elemental technologies for manufacturing steel pipes for boiler heat exchangers and turbine casing materials based on the established design principle with industrial partners.

Microstructure of super-heat resistant steel



Comparison of the creep rupture strength with the existing alloys (○◇□△●◆■▲)

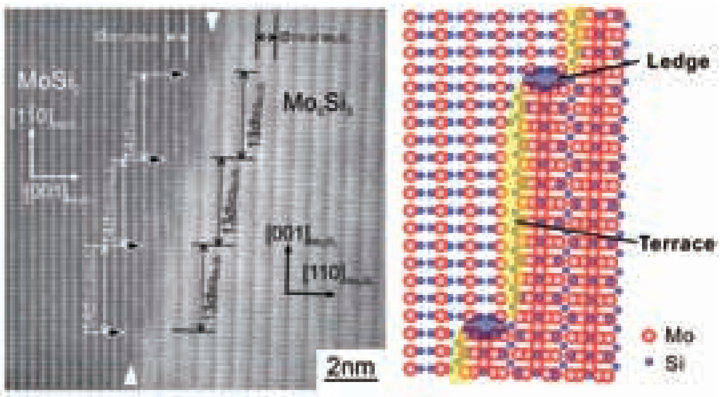


H22

Development of $MoSi_2$-based Brittle/Brittle multi-phase single-crystal alloys

Haruyuki Inui
Professor, Graduate School of Engineering,
Kyoto University

Under an entirely new concept of Brittle/Brittle multi-phase material, super high-temperature materials based on $MoSi_2$ will be developed by simultaneously achieving high thermal stability of microstructures, high strength and high toughness through controlling atomic structures of interphase boundaries and partitioning and segregation behaviors of alloying elements. In addition, we contribute to the realization of the burning temperature of 1800°C in gas turbine engines, which cannot be achieved with conventionally available alloys.

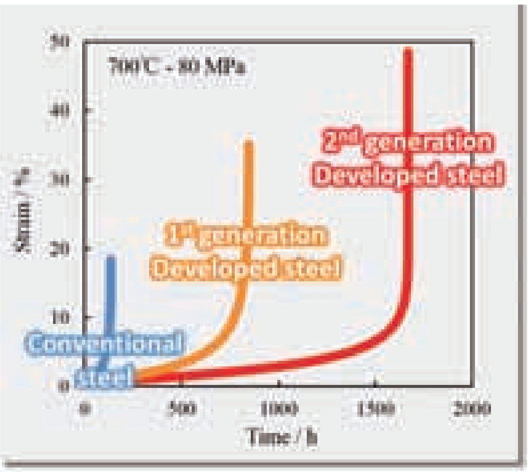


Atomic resolution STEM image of Ledge-Terrace structure of the interphase boundary in $MoSi_2/Mo_5Si_3$ duplex phase single-crystal alloy.

Integrated research of next-generation ultra-heat-resistant ferritic steels through efficient use of nitrogen

Hideharu Nakashima
Professor, Department of Engineering Sciences for Electronics and Materials, Kyushu University

The application of boiler tube for next-generation thermal electrical power generation at 700°C with high efficiency and low CO_2 emission is supposed to develop a high strength thermal resistant steel. By effectively adding nitrogen which is a low cost and exhaustless elemental resource, compatibility of strength at high temperature and economy is targeted. While nitrogen has received less attention as an additive element for the steel, the developed steel in the present research has achieved 10 times the strength or more at high temperature compared with the existing steel, indicating a possibility of new material design. In the future, we will proceed with our efforts to further improve the strength and the application into actual equipment.



The high strength and high ductility which goes beyond the existing steel was achieved.

Development of direct and complete recycling method for superalloy turbine aerofoils

Hiroshi Harada
Research adviser, Superalloy Group, Research Center for Structural Materials, National Institute for Materials Science

The purpose of this ALCA research is to reduce CO_2 emission by improving thermal efficiency and lowering the consumption of fossil fuel, and is also to largely disseminate the several kinds of gas turbines made with the direct and complete recycling method of the next-generation superalloy turbine blade material for which the higher cost is constrictive for its dissemination by reducing the life time cost to one fourth. There are two causes for alloy composition change and material deterioration; (i)change of main element concentration by the diffusion from metal coating and (ii)a contamination of impurity element depending on the environment such as sulfur. We aim to suppress them, to establish the recyclable technology while maintaining 100% strength and oxidation resistance, and to scale up to the extent that we can produce a large ingot.

We conduct research on recyclable technology that re-uses a turbine blade as a material having the equivalent or more of the original superalloy by re-solving the used nickel-base superalloy turbine blade in calcia crucible, removing impurities such as sulfur.

To Page 19

Enabling technology project

Innovative Light-Weight Materials for the Forward Energy-Saving Society

Kohmei Halada
Invited researcher,
National Institute for Materials Science

Under the globalization trend of the economy, transporting equipment has started to occupy a larger position. A weight saving design for components such as pistons and the like can largely improve the energy efficiency, and also contribute to the reduction of CO_2 emission, as well as reduce the weight of the mobile body in automobiles and aircrafts etc. The largest factor resulting in such a weight saving design is to employ a light-weight material. However, many of materials which are expected to be light-weight material have a relatively short history, and such material is greatly inferior to conventional material, in a comprehensive view not only of properties under a severe use environment as the mobile body and the driving portion, but also of those including cost performance and workability.

Focusing on the technological bottlenecks for the development of the future light-weight material, this present project is aiming at disseminating the developed light-weight material and greatly contributing to the reduction of CO_2 emission caused by the use of products and elucidating the technology basis for problem solution. More specifically, the project encompasses strong and ductile Mg alloys compatible for Al; a new smelting process of Ti which is expensive because of its refining process cost while largely surpassing the specific strength and the corrosion resistance of steel; and a self-healing function for fracture-crack propagation which is unavoidable for ceramic material. In order to make the paths to solutions clear and socially implement the light-weight material and its manufacturing technology around 2030, we promote the research and development for creating their basis, while strengthening the partnership with the industry.

From P18

Enabling technology project

Innovative Light-Weight Materials for the Forward Energy-Saving Society

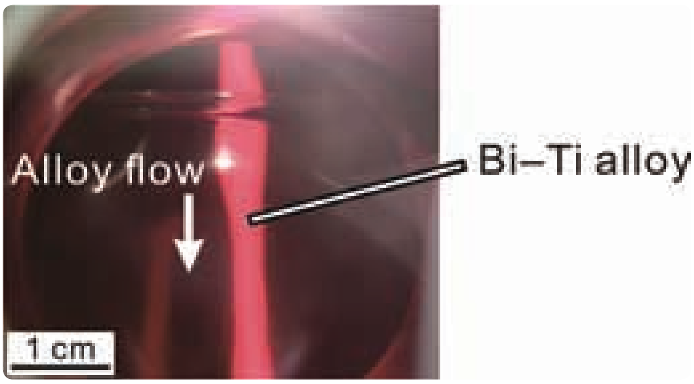
Kohmei Halada / Invited researcher, National Institute for Materials Science

H22

New continuous titanium production process for utilization as light vehicle and high corrosion resistance materials

Tetsuya Uda
Professor, Graduate School of Engineering, Kyoto University

Titanium is superior in corrosive resistance and specific strength, and it is free of resource restriction. To establish a new production process for low cost titanium, we conduct research on a continuous process. Until now, we succeeded to obtain titanium through Bi-Ti alloy which is reduced from titanium tetrachlorides by magnesium. According to the phase diagram of Bi-Ti, solubility of Ti in Bi is 30 mol % at reduction temperature but it decreases dramatically at segregation temperature. With this unique features, we propose a new process consisting of reduction, segregation and distillation cells. At present, practical research is being conducted.



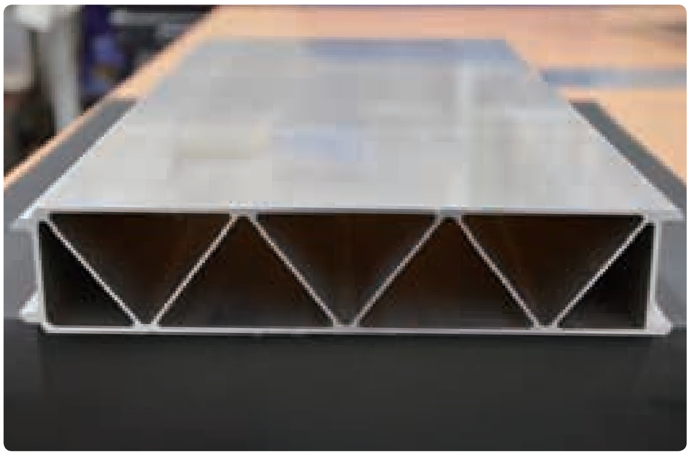
Titanium is reduced as Bi alloy and continuously tapped out from reduction vessel. This experimental demonstration is a key point for the new continuous titanium production.

H24

Innovative development of strong and formable wrought magnesium alloys for light-weight structural applications

Shigeharu Kamado
Professor, Faculty of Engineering, Nagaoka University of Technology

In order to reduce CO_2 emission from transportation vehicles by the weight reduction, strong, formable and low cost wrought Mg alloy is developed. To make it truly applicable to transportation vehicles, the developed alloy needs to have comparable room temperature formability and high strength with Al alloys. Using precipitation hardenable alloy, randomly oriented grain structure is formed to achieve the excellent formability, and nano-scale precipitates are dispersed to strengthen the final product. By establishing techniques to form such ideal microstructure based on the simulation studies and experiments, innovative wrought Mg alloys which can be used like Al alloy is developed.



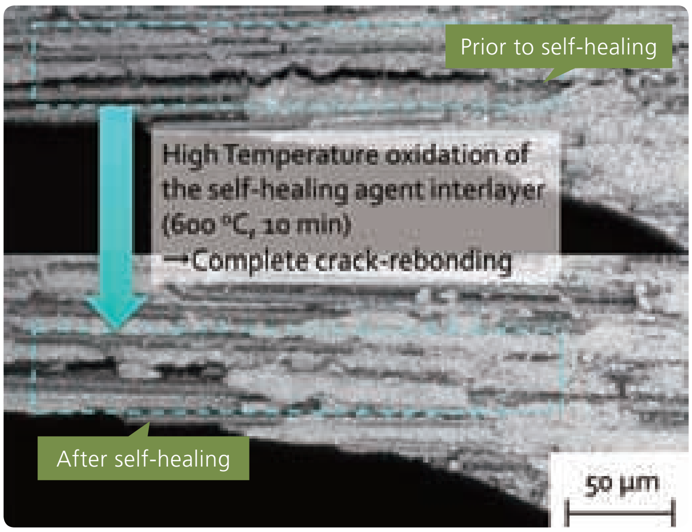
Shinkansen model structure which is extruded with high speed using a newly developed Mg-Al-Ca-Mn based dilute alloy

H24

Development of the novel ceramics having self-healing function for turbine blade

Wataru Nakao
Associate professor, Faculty of Engineering, Yokohama National University

We develop a self-healing ceramic with high mechanical reliability which can be applied as a jet engine member. Further, we propose and establish a new design standard utilizing damage tolerance due to the self-healing property which is the largest characteristic of the present material. By developing the unique-to-Japan light-weight and heat resistant new material, we contribute to the reduction of CO_2 emission by about 15% in the world aircraft industry.



Comparison between the photographs (surface photograph) prior to and after the self-healing

Enabling technology project

High-Quality and Large-Diameter GaN Wafer

Kenji Taniguchi
Specially appointed professor, Osaka University

In this project, a high-quality and large-diameter GaN wafer is developed to reduce energy and power losses in power devices and LEDs. Specifically, by reducing the crystal defects which affect the electrical property and by enlarging the wafer diameter, mass production and cost-saving of the devices can be possible.

In order to do that, using the Na flux method and point seed method, dislocation-free and non-strained crystals are grown from small seed crystals. In this way, 6-inch GaN wafers can be produced where are 100/cm^2 in line dislocation defect density and zero/cm^2 in screw dislocation defect density. In addition, superior electrical property can be obtained in a diode fabricated thereon, and it was confirmed that the reduction of the crystal defect was extremely effective for the device performance.

Just like in the case of Si semiconductors and compound semiconductors, the substrates with low crystal defect density is indispensable for producing excellent devices. However, it takes a long time and significant cost to produce them.

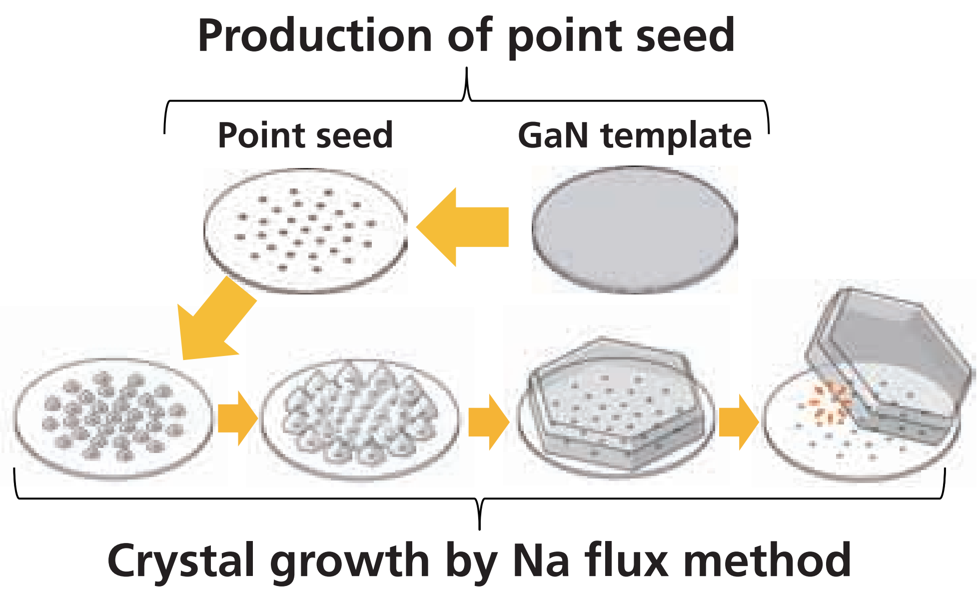
In this project, higher quality and larger diameter GaN crystal is largely improved upon developing a crystal growing apparatus. Finally, we aim at the mass production of the high quality 8-inches or more GaN wafer and low power loss devices and LEDs.

H24

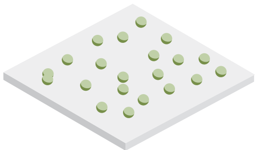
Over 8-inch large-diameter GaN wafers for energy-saving devices

Yusuke Mori
Professor, Graduate School of Engineering, Osaka University

Our group promotes crystal growth of GaN with large diameter and low crystal defects. High quality GaN crystals are expected for power devices and LED substrate. Combination of the Na flux method and the point seed method, which is our new technique, achieved the production of GaN wafer with 100/cm^2 in dislocation defect density and 6 inches in diameter. Our next goal is development of low-cost technology for producing 8 inches GaN wafers with comparable quality of Si wafers.



ALCA Game-changing Technology Areas (newly established in 2015)



Issue on Game-changing Technology areas

"Game-changing Technology Areas" were newly established at the same time as the Enabling Technology project and were launched in fiscal 2015. Promising issues not ready for transfer to the Enabling Technology project will be incubated in these "Game-changing Technology Areas". The projects were currently promoted with 13 issues in fiscal 2016.

ALCA Tech. Areas

Solar Cell and Solar Energy Systems

Makoto Konagai

Professor, Tokyo City University

Solar energy use, including solar cells, has already prevailed in the society as one of the extremely promising technologies for renewable energy. Competing with the commercial Si-based solar cell module technologies, we wish to further develop the solar cell and solar energy utilizing system which are addressed in ALCA.

Specifically, the project is to be subjected for development of the solar cell with high power conversion efficiency (compared with the conventional solar cell), production of new materials for solar cells, creation of manufacturing process of low cost solar cells such as large surface manufacturing technology, and development of a solar energy utilizing system integrated with these technologies. Especially, we are going to promote the research and development in perovskite solar cells, which were first reported by Miyasaka *et al.* in Japan and have been addressed in the ALCA Tech. Area. In addition, we also aim to develop other innovative solar thermal energy technology.

Superconducting Systems

Hiroyuki Ohsaki

Professor, The University of Tokyo

The "superconductive system" is a promising low-carbon technology utilizing the characteristic that the DC electrical resistivity is really zero. It is greatly expected to realize a low-carbon society with drastic energy-saving and to develop novel functions leading to low carbon technologies in various fields such as electricity, transportation, industry, information and so on.

For example, in the electricity field the research and development has so far been conducted in superconductive generators, superconductive electricity cables, superconductive energy storage devices and so on. If their outcomes solve the technological bottlenecks in the superconductive equipment system including cooling functions in the future, the superconductive technologies will have wide range of possibilities of changing the existing electric equipment systems. In addition to technological possibilities of the superconductive motor, it is also possible to achieve far higher efficiency of the energy equipment systems by utilizing high magnetic field superconductive magnets, and by combining it with each cutting-edge elemental technology.

In this ALCA Tech. Area of superconductive systems, we are addressing element technologies for superconductive systems and new conceptual technologies combining with other technologies. They will be adopted by superconductive systems which widely contribute to GHG reduction.

Electric Storage Devices

Tetsuya Osaka

Advisor to the Office of the President,
Senior Research Professor
Emeritus Professor, Waseda University

It is requested to further spread Electric Vehicles (EVs) and renewable energy generation for reducing GHG emission. For example, in order to improve the cruising distance of EVs, the electricity storage device has to provide both higher energy density and higher power. In addition, as the power generation based on the renewable energy increases, the stationary electricity storage devices become more necessary for stabilizing the short-term fluctuation load in the electricity system. In this ALCA Tech. Area, we are promoting the R&D for the innovative electricity storage device as the key technologies.

Until now, we have been promoting R&D of various game changing technologies such as the battery, electrical capacitor, and fuel cell. Especially, with regard to the battery, some PIs have been transferred to the ALCA top-down proposal type technology area, "ALCA-SPRING (see pp. 05-06)" through the stage gate evaluation. Besides battery technology, we have been promoting research on the structure-property relationship of the carbon-based material which are keys to electricity storage devices such as the battery system, cathode material, anode material, electrolytic solution, graphene, graphene-like graphite, carbon alloy catalyst and so on. We will go forward towards further improvement of the performance of electricity storage devices from now on, considering the property needed in the context of social implementation.

Ultra Heat-Resistant Materials and High Quality Recyclable Steel

Shuji Hanada

President, The Honda Memorial Foundation

Towards realizing a low carbon society, it is indispensable to develop technology and systems with high efficiency energy utilization. Also, it is an urgent issue to reduce GHG emission especially in the fields of electricity generation, metallurgy-based industry and transportation with huge emission. Far higher energy efficiency can be achieved by drastically improving the characteristics of the high-temperature resistant materials used for steam and gas turbines for thermal power generation plants, jet engines and so on. Further, through such higher energy efficiency, we are aiming at drastic improvement of heat resistant materials with high temperature strength, toughness at room temperature, oxidation resistance, a long life and so forth, and establishment of its manufacturing technologies and innovative thermal barrier coating.

In addition, we are also developing the manufacturing technologies for higher specific strength materials based on recycled or depleted materials, and creation of structural control technology for higher strength with less rare metal in the scope of a large reduction of the energy consumption in recycling.

Further, we are addressing the development, the design and manufacturing technologies for innovative metallic materials and ceramic materials being both light-weight and having improved strength that can greatly reduce the energy consumption of transportation equipment.

Biotechnology

Akihiko Kondo

Professor, Kobe University

From the view point of energy-saving such as carbon neutral and bioprocess with the advanced technologies in various domains of biotechnology, we are contributing to a large reduction of GHG emission. Specifically, we cover the research and development of carbon fixation technology by biomass plant breeding, biomass conversion technology, direct conversion technology of CO_2, and other conversion technologies of various organic resources. We also promote the interdisciplinary research and development based on microbial science, plant science and bioprocessing science, which goes beyond the conventional framework.

Innovative Energy-Saving and Energy-Producing Chemical Processes

Takashi Tatsumi

President, National Institute of Technology and Evaluation

On the basis of chemistry, we are going to conduct the research for development of game-changing low carbon technology. We cover the research and development for chemical processes that can create a paradigm shift and pave a way to realize a low carbon society while greatly reducing CO_2 emission. Specifically, we promote cutting-edge research and technical development such as energy-saving technology for manufacturing chemical products with efficient conversion technology from biomass into chemicals and fuels, and new CO_2 separating technology with low energy and cost, long-term CO_2 fixation technology and so on.

Innovative Energy-Saving and Energy-Producing Systems and Devices

Kenji Taniguchi

Special appointed professor, Osaka University

We are going to conduct the research and development of advanced technology based on physics. We address a wide range of problems from new conceptual research to technological development aimed at social implementation. Taking into consideration the social return as outcomes of energy-saving or energy-creating technologies, we promote them. Specifically, we cover research and development which has great potential to reduce GHG emission such as an innovative power device system and ultra-low loss technology for the existing system.

Solar Cell and Solar Energy Systems

(1) Perovskite solar cell

The perovskite-type was found to be promising material for solar cells, and was actually strongly promoted in this ALCA Tech. Area. Since it is expected that the perovskite solar cell will have high power conversion efficiency almost comparable with the existing Si-based solar cell, it has already been attracting global attention for future solar cell with high power conversion efficiency. In this ALCA Tech. Area, the targeted goal is to improve the cell performance and reliability which surpass those in Si-based solar cells and to convert the perovskite into lead-free structures.

(2) Polymer-based solar cell

ALCA PI, Osaka is now conducting the ALCA research on polymer-based solar cells with the potential high power conversion efficiency, and has developed a low-cost and environment-conscious process to improve the power conversion efficiency and durability, and further succeeded in developing a new semiconductor polymer "PTzNTz".

(3) Fabricating thin layer solar cell by non-vacuum approach

Aiming at elementally substituting rare earth contained in a part of the existing solar cell, ALCA PI, Yamada *et al*. have already developed Cu_2 Zn Sn $(S,Se)_4$ solar cells with an efficiency of 9.1%. The cell was fabricated by a spray-printing / sintering process, that is, it is a non-vacuum and low-cost process.

Superconducting Systems

(1) Base technologies for development of superconducting device with liquid hydrogen cooling system

ALCA PI, Shirai has created worldwide unique basic technologies which are important for the development of superconductive devices with a liquid hydrogen cooling system such as the construction of a database of heat transfer in liquid hydrogen transfer and the fabrication of "in situ", measuring apparatus under a magnetic field of superconductive materials.

(2) Development of high-performance superconducting wire

ALCA PI, Kumakura succeeded in developing the highest-performance MgB_2 wire in the world, and has already started the longer length MgB_2 wire (over 100m), which has been relatively weak in the Japanese research community, aiming at the low-cost superconducting wire adaptable to superconducting devices with liquid hydrogen cooling system.

In addition, ALCA PI, Matsumoto managed to realize the top-level property of superconductivity in the field of high-temperature superconducting wire of rare earth, albeit only one meter.

(3) Removing iron oxide particles from boiler feed-water in thermal power plants

ALCA PI, Nishijima proposed a superconducting high gradient magnetic separation system for scale removal from feed-water in thermal power plants which can directly lead to the reduction of GHG emission. Its feasibility has been confirmed at the laboratory level.

Electric Storage Devices

(1) Low-temperature operation of reversible solid oxide fuel cell/steam electrolysis cell and demonstration of hydrogen production

ALCA PI, Uchida is developing reversible SOFC/SOEC. In SOEC mode, hydrogen and oxygen are efficiently produced by steam electrolysis with use of a large-scale renewable power. The sored H_2 and O_2 are, when necessary, supplied to the same device that acts as SOFC for high-efficiency power generation. Because the electric power is stored as gases in tanks outside the SOEC stack, its footprint and cost can be reduced. Uchida *et al.* succeeded in achieving highly reversible performances by the use of newly developed hydrogen electrode and oxygen electrode at 800°C, which are comparable to those obtained only at about 1000°C so far. They also demonstrated hydrogen production at 10L/h in a large cell stack.

(2) Improvement of energy density of hydrogen/air secondary battery

The hydrogen/air secondary battery using hydrogen storage alloy in the negative electrode with a high volumetric energy density has an advantage in safety because the battery uses a nonflammable aqueous solution as the electrolyte.

ALCA PI, Morimitsu has been developing the positive and negative electrodes and achieved 800 Wh/L in volumetric energy density which is the highest one in the world.

(3) A sophisticated composite electrode for advanced all-solid-state battery

All-solid-state battery (SSB) is promising as the next-generation rechargeable battery. However, the SSB has a bottleneck in ion transfer at the electrode/solid-electrolyte interface. ALCA PI, Iriyama has focused on "in-situ" materials formation process, and developed low-resistive with tight-binding electrode/solid-electrolyte interfaces by aerosol deposition. A sophisticated composite cathode with 20 μm in thickness was successfully formed on high Li+-conductive solid electrolyte, LLZ, at room temperature and combined with Li metal anode. The SSB repeated stable charge-discharge reactions for over 90 cycles at 100°C.

(4) Fabrication of High Performance Supercapacitors

It is necessary to develop a capacitor that has a superior performance in order to provide a stable power supply and to store instantaneously a large amount of energy in automobiles where a braking energy harvesting system is installed.

The graphene-based supercapacitor makes it possible to adsorb a larger number of ions on its surface with an increased specific surface area. Using a layered graphene structure with an interval of the ion size of the electrolyte and nanopores introduced, the energy density as well as the power density can be largely improved in comparison with the conventional activated carbon based supercapacitors.

Ultra Heat-Resistant Materials and High Quality Recyclable Steel

(1) Development of heat-resistant alloy

Based on innovative alloy design and structural control, ALCA PIs, Takeyama and Nakashima succeeded in improving the property of heat-resistant and in reducing the cost of Fe-based heat-resistant alloy, ferrite-based steel and austenite-based steel for thermal power generation plant, leading to higher efficiency of thermal power generation. A tube for thermal power generation and so on has been experimentally produced with the developed steel.

In order to recycle expensive single crystal Ni-based super alloy turbine blades, ALCA PI, Harada developed a recycle technology, which amends the change in composition of the Ni-based superalloy created during flight by diffusing between heat-resistant coating layer and the super alloy, and removes intruding sulfur, from the fuel. Harada also succeeded completely in recovering the creep property and oxidation resistance of single crystal Ni-based superalloy turbine blade recycled material.

(2) Development of ultra-light-weight material

ALCA PI, Kamado developed ultra-light-weight Mg alloy for transporting devices superior in formability and strength with which the application to the lightened body of the Shinkansen is currently being investigated, overcoming the disadvantage in cold formability in Mg alloy due to the hcp structure by alloy design based on the simulation studies and experiments.

Standing on the fundamental principle of the current Kroll method, ALCA PI, Uda proposed a new continuous reducing process where the reduced Ti was recovered as low-melting point liquid alloy, succeeded in obtaining high purity titanium powder from ingredient titanium tetrachloride, and demonstrated the continuous reducing process at the laboratory.

Biotechnology

5 main previous outcomes are listed as follows. (1) to (4) are currently promoted in the ALCA Enabling Technology project.

(1) Plant productivity control of stomatal opening and closing mechanism

ALCA PI, Kinoshita elucidated the molecular mechanism relating to stomatal movement and found that the biomass production can be increased by controlling the aperture of the stoma. Further, Kinoshita also succeeded in making dryness-resistant plants by closing the stoma to prevent water evaporation from their leaves. Based on these outcomes, other applications for the practical plants are expected.

(2) Research on improvement in productivity of xylem

ALCA PI, Mitsuda aims at developing plant generating new wood which is more feasible for bioethanol production by adding various genes to the mutant plant with no wood. Illuminating a structure of gene sets, which greatly promotes the productivity of xylem, Mitsuda managed to attain favorable outcomes for improvement in the productivity of woody material and highly-strengthened wood.

(3) Creation of innovative solid-degrading enzyme

ALCA PI, Umetsu is drastically improving the degradation activity, with the cellulolytic enzymes three-dimensionally reconstructed on the surface of non-material. By this bioprocess, useful organic molecules can be produced from cellulose biomass with low energy and environmental load.

(4) New synthesis of bioplastics

By using microbial biomass, useful monomer ingredient was produced with far less steps than those in the conventional petroleum-based process, and a new polymer was also synthesized by a chemical approach. The obtained bioplastic exhibits the world's highest heat resistance temperature and high transparency.

(5) Direct production of chemicals from CO_2 by microalgae

ALCA PI, Osanai succeeded in enhancing the outward productivity of succinic acid enormously by genetic modification of blue-green algae, which is microalgae having photosynthesis ability. Osanai exhibited a photosynthetic possibility of producing succinic acid, which is an ingredient for bioplastic, directly from CO_2.

Innovative Energy-Saving and Energy-Producing Chemical Processes

(1) HMF production from glucose

5-(hydroxymethyl)-2-furaldehyde (HMF) is considered on important intermediate for furan-based monomers such as FDCA(2,5-furan dicarboxylic acid) and AMF(2,5-bis(amino methyl)) furan.

By achieving new water-resistant Lewis acid catalysis and suppression of intermolecular side reaction without dilution, the catalytic low-cost HMF production process was succeeded at the laboratory level. This outcome can be greatly expected as the promising catalytic process converting the biomass material into an intermediate for biomass-based plastic.

(2) Separation, collection and utilization of lignin

Utilization of the cellulosic biomass has been actively conducted and made considerable progress. On the other hand, lignin which occupies about 30% of the total composition is not effectively utilized without fuel use. If lignin can be utilized as a natural resource for polycyclic aromatic upon its structure, all of the biomass can be utilized as chemicals.

In the present research, three main components of biomass were successfully separated using mixture of water and organic compounds. In this separation system, lowered molecular weight lignin is recovered in the organic phase and hemicellulose-derived sugars and solid cellulose are separately recovered in the water phase. This lower molecular weight lignin can exhibit the compatible property with the commercial functional resin additive. Further, the isolation of single-ring aromatic has been conducted by catalytic cracking.

(3) Improvement of energy efficiency of methanol synthesis

Methanol is an important basic chemical and there are accommodations for about 8,300 tons to be globally produced annually. Since the synthetic process for methanol has been operated under the strong limitation of equilibrium at high temperature, the improvement of its process efficiency is a big target. In order to obtain higher yield beyond the equilibrium constraint for the methanol synthesis process, an unique "internal condensation reactor" in which methanol is removed from the reaction system by cooling unit was developed. ALCA PI, Omata succeeded in increasing the single stream conversion to 95% (equilibrium conversion 65%) using the reactor and the catalyst optimized for the reactor. A circulating process for unreacted gas with large energy consumption became unnecessary by increasing the single stream conversion and the reduction of CO_2 emission is expected by about 23%.

Innovative Energy-Saving and Energy-Producing Systems and Devices

In this ALCA Tech. Area, the development of various technologies for the power consumption saving and electric power generation technologies utilizing waste heat are being promoted.

There have been some outcomes in this Area. First, a display technology in which the ultra-low power consumption realizes 1/10 to 1/100 times lower power consumption compared with conventional displays by omitting unnecessary light and converging light near the eyes of the observer.

Second, as for the illumination technology, high-efficient and high-intensity lighting using hollow nanoparticles was being developed, and it is expected to be applied to the luminance of flat display panel and LED by suppressing the scattering of light.

Third, in the heat utilizing technology, a prototype of the "tri-lateral cycle steam engine" is demonstrated. In addition, a magneto-caloric effect material covering a range of normal temperature is developed and is applied to "the magnetic heat pump with layered structure magnetic heat accumulation". In addition to these, fundamental research on CNT (carbon nanotube) and high pressure resistant device was promoted.

Further, "the high-quality large- diameter GaN wafer" and "the lower electric power for large-volume magnetic recording technology" were developed into other projects respectively, taking the opportunity of the ALCA research.

Outcomes

Major press releases (2015)

Content	Presenter	Date of presentation
Seawater cultivation of freshwater cyanobacterium	Takashi Osanai Assistant professor, Meiji University	April 8, 2015
Characterization of cooperative bicarbonate uptake into chloroplast stroma in the green alga Chlamydomonas reinhardtii	Hideya Fukuzawa Professor, Kyoto University	May 26, 2015
Genetic engineering and metabolite profiling for overproduction of polyhydroxybutyrate in cyanobacteria	Takashi Osanai Assistant professor, Meiji University	August 27, 2015
Highly efficient and stable solar cells based on thiazolothiazole and naphthobisthiadiazole copolymers	Itaru Osaka Senior research scientist, RIKEN	September 24, 2015
Increasing succinate excretion from unicellular	Takashi Osanai Assistant professor, Meiji University	September 24, 2015
A highly durable fuel cell electrocatalyst based on double-polymer-coated carbon nanotubes	Tsuyohiko Fujigaya Associate Professor, Kyushu University	November 24, 2015
Wood reinforcement of poplar by rice NAC transcription factor	Nobutaka Mitsuda Senior scientist, National Institute of Advanced Industrial Science and Technology	January 28, 2016

Major awards (2015)

Content	Awardee
14th GSC award and the Minister of Education Award "A study on depolymerization of cellulosic biomass by solid catalyst"	Atsushi Fukuoka Professor, Hokkaido University
The Young Scientists' Prize “Application of temperature-responsive nanogel particle into functional material”	Yu Hoshino Associate professor, Kyushu University
Paper prize, The Carbon Society of Japan (2015) “Effects of graphite oxide additions on the oxygen reduction reaction activity of a carbon alloy catalyst for solid macromolecular type fuel cell cathode”	Jun-ichi Ozaki Professor, Gunma University

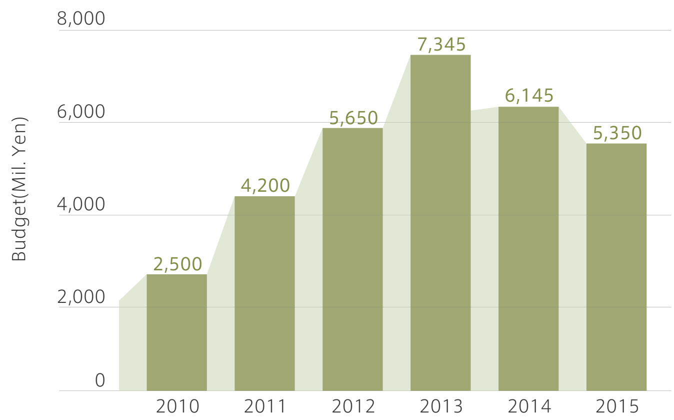
Case examples for developing into other R&D programs

The outcome of “Verification of new theory for electric field operating magnetic recording and Challenge for low electricity large volume recording” (PI: Masashi Sahashi) from the ALCA tech. area of “innovative energy-saving and energy-creating system and device” is developed into the Cabinet Office, Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT) “Achieving Ultimate Green IT Devices with Long Usage Time without Charging” from fiscal 2015.

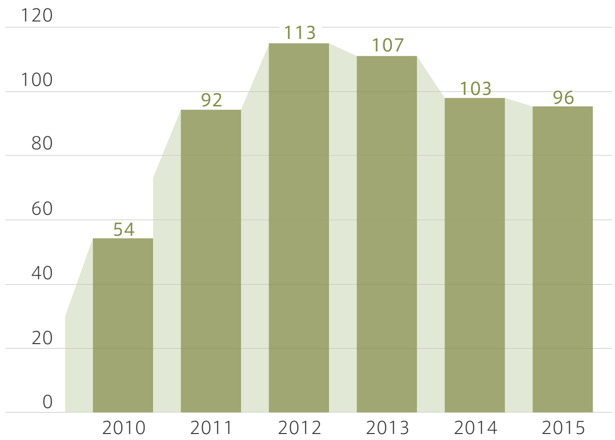
In addition, the “Production of universal type CO_2-selective permeable membrane towards the achievement of innovative energy-saving and energy-creating chemical process” (PI: Hideto Matsuyama) from the ALCA tech. area of “innovative energy-saving and energy-creating system and device” is developed into the “Development of energy-saving type air conditioning and ventilation system using ionized liquid” in the JST Adaptable and Seamless Technology transfer Program through target driven R&D (A-STEP).

Data Charts

Changes in the budget



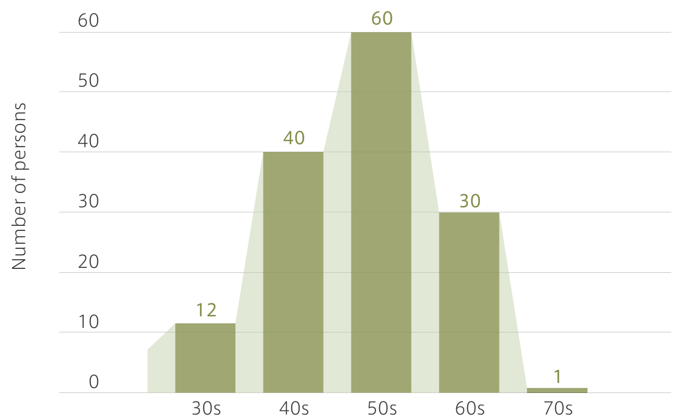
Changes in the number of PIs



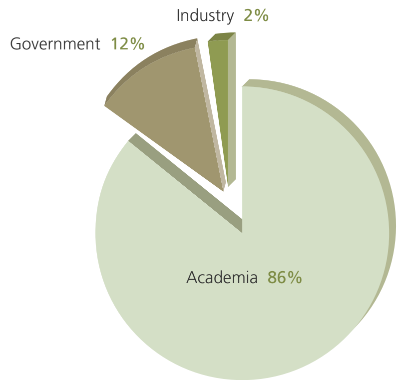
Changes in the number of ALCA PIs and development

After adopting 54 PIs in the first fiscal year (FY2010), new PIs have been adopted every year after the second (FY2011) or later fiscal years. The number of PIs each fiscal year reached the maximum in the third fiscal year (FY2012) (113 PIs), and about 100 PIs have been transited under the equilibrium of adoption and stage gate evaluation.

Age distribution of ALCA PIs at employing



Affiliation of ALCA PIs by sectors

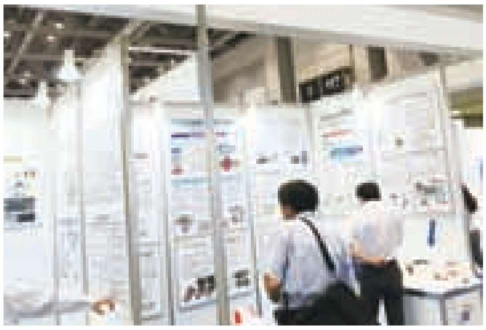


Activities in 2015

Event / July 29 to 31, 2015

The 10th RENEWABLE ENERGY 2015 EXHIBITION

Tokyo Big Sight



Event / August 27 to 28, 2015

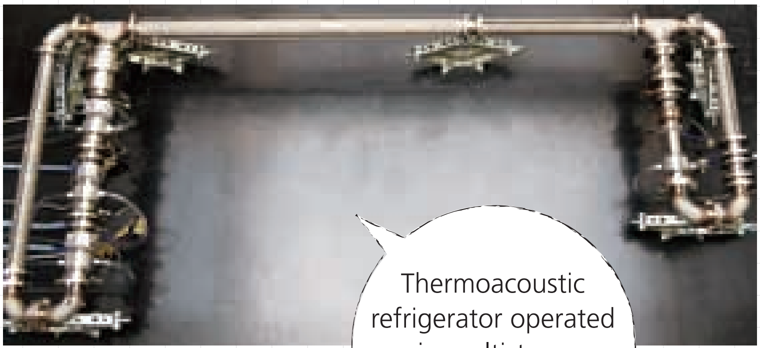
JST Fair 2015

Tokyo Big Sight

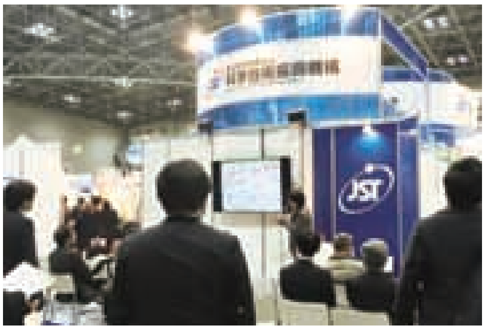
Event / October 28 to 29, 2015

The 5th Revival of Fukushima Renewable Energy Industrial Fair

Big Palette Fukushima



Thermoacoustic refrigerator operated in multistage thermoacoustic engine



Event / January 27 to 29, 2016

nano tech 2016

Tokyo Big Sight

Event / February 9, 2016 and March 1, 2016

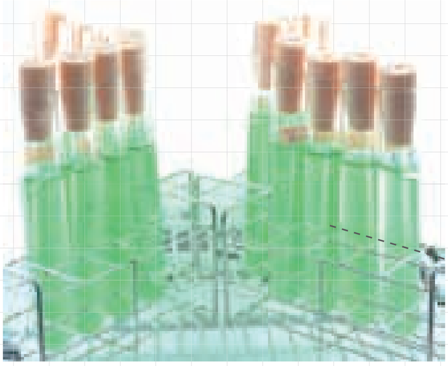
New Technology Presentation Meetings

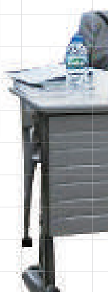
Annex of JST Tokyo Head office

Event / October 14 to 16, 2015

BioJapan 2015 — World Business Forum —

Pacifico Yokohama





Sight Visits /

Committee / March 4 to 6, 2016

External Evaluation Committee

Annex of JST Tokyo Head office

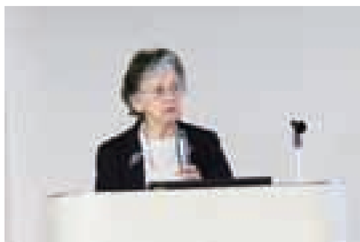
For management and outcome in ALCA for 5 years, the External Evaluation Committee (Chairman: Dr. Tetsuhiko Ikegami, Former President, The University of Aizu) by international experts was held. The mission and unique research system of ALCA received a favorable evaluation, and the result of the evaluation will be applied for further improvement of the future ALCA.

Robert Kleiburg

Richard Knight

Michael Hoffmann

Rita Colwell



Current ALCA PIs

ALCA Enabling Technology Projects

		High-Quality and Large-Diameter GaN Wafer	Kenji Taniguchi / Specially Appointed Professor, Osaka University	
1	H24	Over 8-inch large-diameter GaN wafers for energy-saving devices	Yusuke Mori	Professor, Osaka University
		Superconducting Electric Power Equipment using Liquid Hydrogen Cooling	Hiroyuki Ohsaki / Professor, The University of Tokyo	
1	H22	Development of liquid hydrogen cooled MgB_2 superconducting power apparatus	Yasuyuki Shirai	Professor, Kyoto University
2	H22	Development of high performance MgB_2 long conductors	Hiroaki Kumakura	Senior Scientist with Special Missions, National Institute for Materials Science
3	H22	Development of low-cost REBCO coated conductors	Kaname Matsumoto	Professor, Kyushu Institute of Technology
		New Heat Resistant Materials for Low CO_2 Emission Type Next-Generation Thermal Electric Power Generation	Kohmei Halada / Invited Researcher, National Institute for Materials Science	
1	H22	Elemental technology for design and manufacturing of innovative 1073 K Class super austenitic heat-resistant steels	Masao Takeyama	Professor, Tokyo Institute of Technology
2	H22	Development of $MoSi_2$-based Brittle/Brittle multi-phase single-crystal alloys	Haruyuki Inui	Professor, Kyoto University
3	H23	Integrated research of next-generation ultra-heat-resistant ferritic steels through efficient use of nitrogen	Hideharu Nakashima	Professor, Kyushu University
4	H25	Development of direct and complete recycling method for superalloy turbine aerofoils	Hiroshi Harada	Research Adviser, National Institute for Materials Science
		Innovative Light-Weight Materials for the Forward Energy-Saving Society	Kohmei Halada / Invited Researcher, National Institute for Materials Science	
1	H22	New continuous titanium production process for utilization as light vehicle and high corrosion resistance materials	Tetsuya Uda	Professor, Kyoto University
2	H24	Innovative development of strong and formable wrought magnesium alloys for light-weight structural applications	Shigeharu Kamado	Professor, Nagaoka University of Technology
3	H24	Development of the novel ceramics having self-healing function for turbine blade	Wataru Nakao	Associate Professor, Yokohama National University
		Next-Generation Smart Community	Shigehito Deki / Emeritus Professor, Kobe University	
1	H25	Development of organic inorganic hybrid high performance solar cells	Tsutomu Miyasaka	Professor, Toin University of Yokohama
2	H22	Development of thin-film-based tandem-type solar cells for future generations	Akira Yamada	Professor, Tokyo Institute of Technology
3	H22	Pt-free fuel cell vehicle using liquid fuel as storage medium of electricity	Susumu Yamaguchi	Chief Coordinator, Daihatsu Motor Co., Ltd.
4	H22	Development and evaluation of carbon alloys with electrocatalytic activity for cathode reaction in proton exchange membrane fuel cell	Jun-ichi Ozaki	Professor, Gunma University
5	H22	Development of advanced hybrid capacitor (AdHiCap)	Wataru Sugimoto	Professor, Shinshu University
6	H22	Development of multi-purpose insulation materials based on organic-inorganic hybrid aerogels	Kazuki Nakanishi	Associate Professor, Kyoto University
		Highly Efficient Production Process for Biomass-based Chemicals and Polymers	Yoshiharu Doi / President, Japan Synchrotron Radiation Research Institute	
1	H22	Generation of super-engineering plastics using microbial biomass	Tatsuo Kaneko	Professor, Japan Advanced Institute of Science and Technology
2	H23	Nanobio design for solid-degrading enzymes: CO_2 bypass carbon cycling	Mitsuo Umetsu	Professor, Tohoku University
3	H24	Development of multifunctional heterogeneous catalysts	Michikazu Hara	Professor, FRC, Tokyo Institute of Technology
4	H24	Development of isolating and manufacturing technology of single-cyclic aromatics from natural polycyclic aromatics	Takao Masuda	Professor, Hokkaido University
		Production of Effective Biomass Materials with Bioresource Technology	Akihiko Kondo / Professor, Kobe University	
1	H22	Promotion of photosynthesis and plant productivity by controlling stomatal aperture	Toshinori Kinoshita	Professor, ITbM, Nagoya University
2	H22	Advanced bioethanol production by acetic acid fermentation from lignocellulosics	Shiro Saka	Professor, Kyoto University
3	H23	Producing new wood in plant with no wood	Nobutaka Mitsuda	Senior Scientist, National Institute of Advanced Industrial Science and Technology

ALCA Technology Areas

		Next Generation Batteries	Kohei Uosaki / Fellow, National Institute for Materials Science	
1	H25	All-solid-state battery team	Masahiro Tatsumisago	Professor, Osaka Prefecture University
2	H25	Lithium-sulfur battery (with electrolyte-insoluble cathode) team	Masayoshi Watanabe	Professor, Yokohama National University
3	H25	Advanced generation battery team	Kiyoshi Kanamura	Professor, Tokyo Metropolitan University
4	H28	Accelerating and promoting team for practical use	Kiyoshi Kanamura	Professor, Tokyo Metropolitan University
		White Biotechnology	Yoshiharu Doi / President, Japan Synchrotron Radiation Research Institute	
1	H27	Basic chemicals prepared by bio and catalytic technology	Takashi Arai	Group Leader, R&D Promotion, R&D Headquarters, Daicel Corporation
2	H27	Innovative synthesis of high-performance bioplastics from polysaccharides	Tadahisa Iwata	Professor, The University of Tokyo
3	H27	Catalytic production of di-carboxylic acids and diols from biomass-derived carbohydrates	Kiyotaka Nakajima	Associate Professor, Hokkaido University
4	H27	Development of bioprocess using marine microbial enzymes for efficient lignin degradation and catalytic generation of super-urushiol from lignin monomers	Yukari Ohta	Deputy Group Leader, Japan Agency for Marine-Earth Science and Technology
5	H27	Development of microbial process for production of glycolate-based polymers from sugars	Ken'ichiro Matsumoto	Associate Professor, Hokkaido University
6	H27	New development of natural rubber by technological innovation of vulcanization	Yuko Ikeda	Professor, Kyoto Institute of Technology
7	H27	Sugar-independent bioproduction of muconic acid	Tomonori Sonoki	Associate Professor, Hirosaki University
8	H27	Development of high functional biosurfactant for mastering the bioplastic	Hiroshi Habe	Group Leader, Advanced Industrial Science and Technology
9	H27	Microbial conversion into polymer ingredient from biofuel waste based biomass	Toshiaki Nakajima-Kambe	Professor, University of Tsukuba
10	H27	Nanocellulose controls molecular chirality in heterogeneous asymmetric organocatalysis	Takuya Kitaoka	Professor, Kyushu University
11	H27	Preparation of cellulose nanofiber composite plastic foam with ultralight and high insulation performances	Masahiro Ohshima	Professor, Kyoto University
12	H27	Development of "SINAYAKA" cellulose nanofiber composite materials	Takashi Nishino	Professor, Kobe University
		Solar Cell and Solar Energy Systems	Makoto Konagai / Professor, Tokyo City University	
1	H26	Development of high-efficiency polymer-based solar cells	Itaru Osaka	Senior Research Scientist, RIKEN
2	H25	Electricity generation by combination of solar-pumped lasers and PV devices specially designed for monochromatic laser light.	Tomoyoshi Motohiro	Professor, GREMO, Nagoya University
3	H23	Printable organic solar cell based on liquid crystal science	Masanori Ozaki	Professor, Osaka University

4	H23	Advanced solar energy utilization systems based on high-temperature photonics	Hiroo Yugami	Professor, Tohoku University
Superconducting Systems			Hiroyuki Ohsaki / Professor, The University of Tokyo	
1	H26	Development of REBCO fully superconducting rotary machines	Masataka Iwakuma	Professor, Kyushu University
2	H25	Removing iron oxide particles from boiler feed-water of thermal power plants	Shigehiro Nishijima	Professor, Osaka University
3	H25	Waste-heat recovery thermoacoustic system with achievement of 60% of carnot efficiency	Shinya Hasegawa	Junior Associate Professor, Tokai University
4	H24	System of superconducting rotating machines for transport equipments that supports low carbon society	Taketsune Nakamura	Associate Professor, Kyoto University
5	H23	Superconductor electronic system combined with optics and spintronics	Akira Fujimaki	Professor, Nagoya University
Electric Storage Devices			Tetsuya Osaka / Advisor to the Office of the President, Senior Research Professor, Emeritus Professor, Waseda University	
1	H26	Development of graphene-based carbon materials for high-rate perfomance and high-capacity negative electrode of lithium ion battery	Yoshiaki Matsuo	Associate Professor, University of Hyogo
2	H25	In-situ study of lithium-ion (De)intercalation by using interface ion conduction microscope for creation of high-performance LIBs	Tomokazu Matsue	Professor, AIMR, Tohoku University
3	H24	Development of metal-free, Li-ion-air batteries *	Yuki Yamada	Assistant Professor, The University of Tokyo
4	H23	Development of innovative high-energy-density magnesium battery *	Tetsu Ichitsubo	Associate Professor, Kyoto University
5	H23	Development of high-power all-solid-state battery under the concept of "in-situ" formation	Yasutoshi Iriyama	Professor, Nagoya University
6	H23	Development of a reversible solid oxide electrolysis cell for efficient hydrogen production and power generation in the fuel cell mode	Hiroyuki Uchida	Professor, Clean Energy Research Center, University of Yamanashi
7	H23	Novel rechargeable non-lithium batteries using ionic liquids melting at middle-ranged temperatures	Rika Hagiwara	Professor, Kyoto University
Ultra Heat-Resistant Materials and High Quality Recyclable Steel			Shuji Hanada / President, The Honda Memorial Foundation	
1	H26	High temperature materials based on multi-element bcc solid solutions	Seiji Miura	Professor, Hokkaido University
2	H25	Progressive design and advanced casting process for MoSiB-Base ultra-high temperature materials	Kyosuke Yoshimi	Professor, Tohoku University
3	H23	Innovative thermal radiation reflection coatings for future thermal managing applications	Yutaka Kagawa	Professor, RCAST, The University of Tokyo
Biotechnology			Akihiko Kondo / Professor, Kobe University	
1	H26	Artificial control of cytoplasmic streaming as a platform system for plant biomass enhancement	Motoki Tominaga	Assistant Professor, Waseda University
2	H26	Methane/methanol conversion by an innovative bioprocess using gas phase microbial reaction	Katsutoshi Hori	Full Professor, Nagoya University
3	H25	Genetic engineering of cyanobacterial transcriptional regulators and circadian clocks for succinate production.	Takashi Osanai	Assistant Professor, Meiji University
4	H25	Multidimensional improvement of plant biomass productivity based on artificially induced heterosis technology	Keiichi Mochida	Team Leader, RIKEN
5	H24	Development of novel crop protection technology which can confer durable disease resistance to various crop species	Yoshiteru Noutoshi	Associate Professor, Okayama University
6	H23	Generation of diatom factory through physiolomics toward a novel energy source	Yasuhiro Kashino	Associate Professor, University of Hyogo
Innovative Energy-Saving and Energy-Producing Chemical Processes			Takashi Tatsumi / President, National Institute of Technology and Evaluation	
1	H26	Development of CO_2 separation membranes driven by the pKa shift of stimuli-responsive nanogel particles	Yu Hoshino	Associate Professor, Kyushu University
2	H25	Application of internal condensation reactor system for highly efficient methanol synthesis process	Kohji Omata	Professor, Shimane University
3	H25	Depolymerization of lignocellulose catalyzed by activated carbons	Atsushi Fukuoka	Professor, ICAT, Hokkaido University
4	H25	Innovative low-temperature and high-speed growth process for high-quality SiC single crystal films	Yuji Matsumoto	Professor, Tohoku University
5	H24	Irreversible hydrolysis of esters and direct transformation of alkenes directing toward energy reduction of water separation	Makoto Tokunaga	Professor, Kyushu University
6	H24	Creation of innovative technologies for a highly-functional multivalent cation battery using inclusion compounds *	Kazuhiro Yamabuki	Assistant Professor, Yamaguchi University
7	H24	Development of synthetic promoters for accerelation of biomass production	Yoshiharu Yamamoto	Professor, Gifu University
Innovative Energy-Saving and Energy-Producing Systems and Devices			Kenji Taniguchi / Specially Appointed Professor, Osaka University	
1	H26	Development of magnetic heat pump with layered active magnetic regenerator	Tsuyoshi Kawanami	Associate Professor, Kobe University
2	H24	Development of Trilateral steam cycle for waste heat recovery	Naoki Shikazono	Professor, IIS, The University of Tokyo

*This issue is managed by the special priority region "next generation battery".

Game-changing Technology Areas

Makoto Konagai / Professor, Tokyo City University				
	H27	Development of high efficiency silicon/perovskite two-terminal tandem solar cells	Takeshi Noda	Group Leader, National Institute for Materials Science
	H23	Integration of nanostructures in crystalline silicon solar cells for advanced management of photons and carriers	Noritaka Usami	Professor, Nagoya University
Hiroyuki Ohsaki / Professor, The University of Tokyo				
	H23	Low-cost high temperature superconducting wire	Toshiya Doi	Professor, Kyoto University
Tetsuya Osaka / Advisor to the Office of the President, Senior Research Professor, Emeritus Professor, Waseda University				
	H24	Development of metal hydride/air secondary battery	Masatsugu Morimitsu	Professor, Doshisha University
	H23	Development of 300Wh/kg capacitor by using peculiar properties and nano-layering of graphene.	Tang Jie	Group Leader, National Institute for Materials Science
Akihiko Kondo / Professor, Kobe University				
	H27	The plant breeding revolution through the development of artificial apomixis induction technique	Masaru Takagi	Professor, Saitama University
	H23	Genome-based research and development of thermo-tolerant microbes aiming at low-cost fermentation	Kazunobu Matsushita	Professor, Yamaguchi University
	H23	Development of highly-ordered vegetational bioprocess utilizing symbiotic interactions in rhizosphere	Masaaki Morikawa	Professor, Hokkaido University
Takashi Tatsumi / President, National Institute of Technology and Evaluation				
	H27	Energy-saving CO_2 capture process with phase separation solvent	Hiroshi Machida	Assistant Professor, Nagoya University
	H23	Lignocellulose refinery using ionic liquids and radicals	Kenji Takahashi	Professor, Kanazawa University
Kenji Taniguchi / Specially Appointed Professor, Osaka University				
	H27	Development of high-efficiency vertical deep-UV LED becoming the substitute of germicidal mercury lamps	Hideki Hirayama	Chief Scientist, RIKEN
	H24	Spacially imaged iris-plane ultra low power consumption display	Tohru Kawakami	Guest Associate Professor, Tohoku University
	H24	Development of high-efficient and high-intensity lighting using hollow nanoparticles	Masayoshi Fuji	Professor, Nagoya Institute of Technology

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