Graduate School of Energy Science,
Kyoto University

2019-2020/Energy

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Kyoto University
Graduate School of
Energy Science

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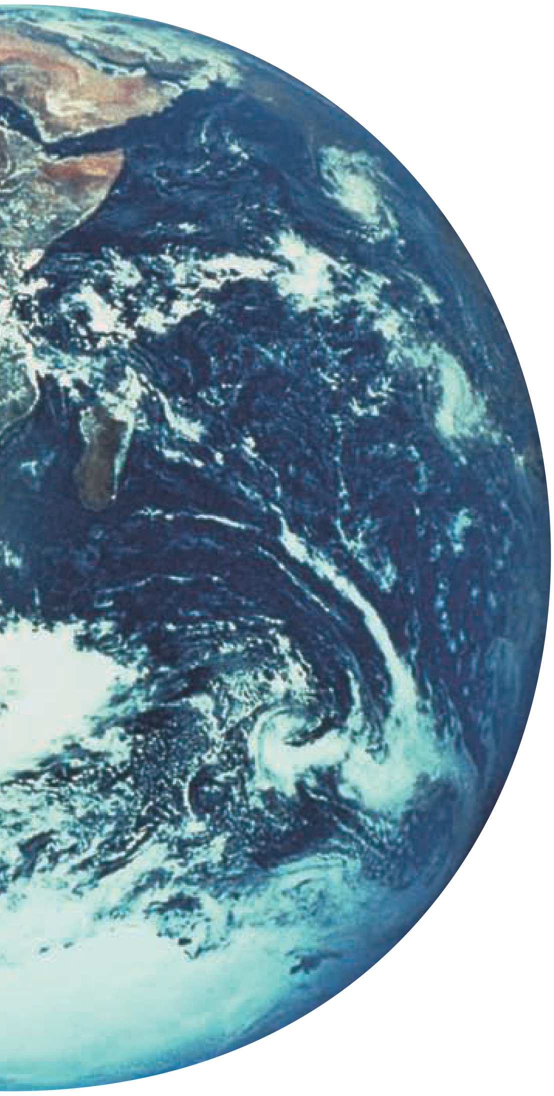
Introduction from the Dean

Prof. Keiichi Ishihara



Energy security and environmental protection are perhaps the most important issues for the sustainable development of our modern society. They have a great influence on the trends of politics, economy and industry, especially in Japan, which has minimal natural resources and professes to be a scientific, technology-oriented nation. In 2011, the earthquake off the Pacific coast of Tohoku, and the subsequent accident at the nuclear power plant gave us the opportunity to re-recognize that energy problems are closely related to the life of the individual and require the efforts of all members of society. Additionally, climate change at the global scale has become clearly overt and numerous large-scale natural disasters have happened each year in all parts of the world including Japan.

To solve such varied problems of energy and environment, the Graduate School of Energy Science was founded in 1996, gathering together experts in wide-ranging academic areas including technology, science, agriculture, economics, and law, among others. Since then, the Graduate School has been working on the creation of a novel learning base for energy science, the development of technology for energy and the environment, the cultivation of excellent human resources with specialized knowledge in energy and environment, and on making a contribution to society.

The Graduate School counts 22 chairs and 17 cooperative chairs from the Institute of Advanced Energy, the Institute for Integrated Radiation and Nuclear Science, and the Graduate School of Human and Environmental Studies. These chairs cover a spectrum of advanced and interdisciplinary research fields. The Graduate School has four departments, i.e., the Department of Socio- Environmental Energy Science, the Department of Fundamental Energy Science, the Department of Energy Conversion Science, and the Department of Energy Science and Technology.

The Graduate School accepts 130 students in its master's program and 35 students in its doctoral program each year. Students, especially those in the doctoral course, may enroll in the Graduate School on a part-time basis, meaning they need not resign from their professional occupations. To cultivate talented individuals toward excellence, it is especially important that students study both the natural and social science, and improve their practical skills. The Graduate School has devised a special curriculum featuring not only a variety of subjects in the natural and social science, but also off-campus research projects, which can be conducted, for example, in industry or national research institutes.

Students who graduate from the master's program pursue a variety of directions, for instance, some work in government, some in firms that deal with electricity, machinery, chemicals, automobiles, heavy industries, steel, gas, ceramics, fibers and so on. Those having graduated from the Doctoral program have pursued careers as researchers and expert professionals in universities, both national and international institutions, and private companies.

The Graduate School also has English-based courses both in the doctoral program (for all departments) and in the master's program (for three departments), these come under the banner of the International Energy Science Course (IESC). In the curriculum of the IESC, around 12 subjects are currently provided in English by both Japanese and foreign professors. Both the acquisition of required credits and undertaking research are possible in English (no Japanese requirement). An online application is open to applicants for the IESC, with initial online document submission and remote interview-based screening enabling candidates to take the entrance examination in their home country.

To further promote internationalization in the university, we frequently organize international symposia, short-term research internships and summer and winter schools. Furthermore, we have developed double master's degree programs and double doctoral programs with partner universities. Under these schemes, students can pursue their study in two universities and be awarded two degrees on fulfillment of both universities` requirements.

We welcome individuals who have motivation high enough to challenge the significant energy and environmental problems that are currently the most pressing global issues. We invite such individuals to join the Graduate School and succeed in partnership with our faculty members in creating a new world of energy science.

Graduate School of Energy Science, Kyoto University

Graduate Sch

Department of Socio-Environmental Energy Science

Helps students develop problem-solving capabilities for broad energy issues.

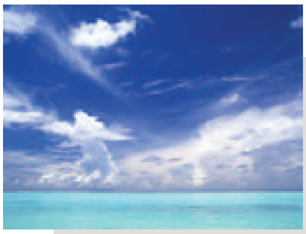
Department of Fundamental Energy Science

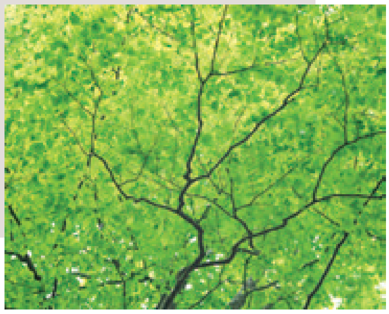
Focuses on basic science training (chemistry and physics) as related to energy problems.

The New Interdisciplinary Field

for Solutions to

Energy Problems





ool of Energy Science, Kyoto University

Department of Energy Conversion Science

Helps students obtain a thorough understanding of the principles and applications of energy conversion systems suited to natural environments.

Department of Energy Science and Technology

Trains students in thermal science and processing technologies for highly-efficient energy utilization.

Department of Socio-Environmental Energy Science

Seeking ideal energy and social systems in harmony with the natural environment.

The Department of Socio-Environmental Energy Science aims to establish ideal energy systems harmonizing with natural and human environments to sustain the continuous development of human civilization. For this purpose, various energy problems are systematically analyzed from sociological, political, economical, biological and environmental perspectives.

Department Organization

Division	Groups	Focus
Social Science of Energy	* Engineering for Social Systems * Energy Economics * Energy Ecosystems	Primary subjects of study include the technological and biological treatment of energy production, storage, distribution, utilization and its waste. Concurrently, great stress is placed upon the safety, economic, and environmental feasibility of available energy, targeting the ideal social system for energy utilization.
Socio-Environmental Energy Systems	* Energy and Information * Energy and Environment	The main focus is on the planning, design and evaluation of energy systems from, energy production to energy utilization, and safety countermeasures for environmental protection. The harmony of energy systems with society and the environment is seen as vital.
Societal Energy Science	* Energy Policy * Societal Energy Education * Energy and Communication	Research topics focus on energy policy and education related to international, societal and technological issues such as energy security and disaster prevention, and also on systems of human communication for safety culture related to energy supply and demand.
International Energy Issues	(visiting professors)	International energy issues

Curriculum

For the Master's Program

- Advanced Study on Socio-Environmental Energy Science 1, 2, 3, 4
- Socio-Environmental Energy Science I, II
- Energy, Society and Engineering
- Energy Economics
- Energy Systems Analysis and Design
- Energy Ecosystems
- Human Interface
- System Safety
- Atmospheric Environmental Science
- Energy Societal Education
- Energy Policy
- Energy Communication
- Environmental Economics
- Energy Sociology
- International Energy
- Field Research Project on Socio-Environmental Energy Science
- Special Fundamental Study 1, 2
- Industrial Ethics
- Special Seminar on Interdisciplinary Energy Science
- Future Energy:Hydrogen Economy (in English)
- Energy Systems and Sustainable Development (in English)

For the Doctoral Program

- Social Engineering of Energy, Adv.
- Energy Economics, Adv.
- Energy Ecosystems, Adv.
- Energy and Information, Adv.
- Energy and Environment, Adv.
- International Energy, Adv.
- Advanced Seminar on Socio-Environmental Energy Science (in English)
- Zero-emission Social System (in English)
- Field Research Project on Energy Science (in English)

Department of Socio-Environmental Energy Science

■ **Social Science of Energy**

Multidisciplinary Fusion of Social Science and Natural Science

Engineering for Social Systems

What is the progress of a society, and what kind of society is desirable and anticipated? Our research field involves sustainable use of energy and resources, which is vital from the perspective of our future society. Energy and resources are indispens able for social activities, and we systematically evaluate their production, storage, and distribution, based on an integrated view obtained from both technological and sociological aspects. The focus of investigations are, for instance, the energy and environmental assessment of recycling and industrial manufacturing, research and development of functional environmental materials, and the effectiveness of energy environmental education. Our final goal is to propose a social system in which social activities and use of energy and resources are harmonized with the environment.

(Prof. Keiichi ISHIHARA, Assoc. Prof. Hideyuki OKUMURA, Assist. Prof. Takaya OGAWA)

Energy and environmental issues must be tackled both sociologically and technologically based on a global perspective.

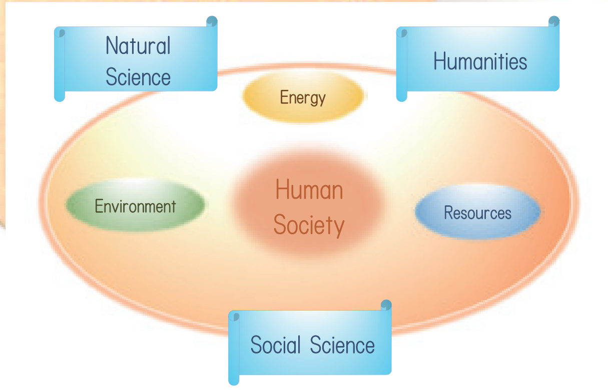
■ **Social Science of Energy**

Systems Study on Energy and Mineral resources

Energy Economics

One of the important properties common to the issues of energy and mineral resources and related environmental issues is that their supply and demand are systems where many elements interact with each other, and the research of these systems is closely related to the three broad research fields of Natural Science, Humanities and Social Science. What is especially characteristic is that human behavior plays an important role in the analysis, as well as physics and chemistry. There are a variety of perspectives - as many as the number of people and organizations included in the system. In analyzing and designing these systems we need to consider them from several different perspectives at the same time. In the “Energy Economics” research group, we are conducting research on Energy-Minerals Systems for analysis, evaluation and design of systems related to energy and material resources and related environmental aspects based on a variety of perspectives simultaneously, including the macroscopic and microscopic, natural and social sciences.

(Prof. Tetsuo TEZUKA, Assoc. Prof. Benjamin C. MCLELLAN, Assoc. Prof. Seiichi OGATA)



Energy Systems Study

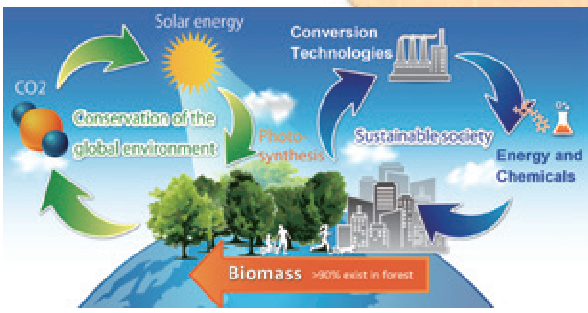
■ **Social Science of Energy**

Environmentally Friendly Conversion of Biomass to Fuels, Chemicals and Materials

Energy Ecosystems

Independent of fossil resources and harmonized with the global environment, sustainable approaches for biomass utilization have been explored in this laboratory, aiming at the future establishment of a biomass-based sustainable society. The laboratory focuses on both fundamental and applied types of research, including biomass conversion into renewable biofuels and biochemicals through controlled pyrolysis, supercritical/subcritical fluids, and plasma technologies, considering reaction mechanisms on the molecular level. Advanced bioethanol, biodiesel and other liquid/gas biofuels have been studied to establish biorefineries for useful biofuels, biochemicals, and biomaterials.

(Prof. Haruo KAWAMOTO, Assist. Prof. Eiji MINAMI)



Biorefineries to produce various biofuels, chemicals and useful materials

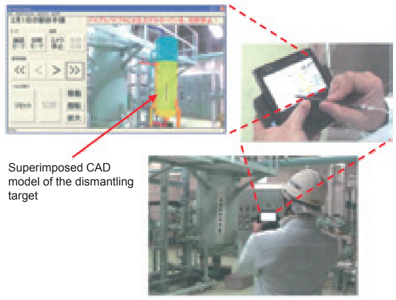
Socio-Enviromental Energy Systems

Harmony between Technology and Society - Advances in Human-Machine Interface

Energy and Information

To construct a future energy society, it is necessary to consider and organize the ideal systems from the viewpoint of humans, society and technology. Aiming at symbiosis and harmony between humans and technology, the Energy and Information group has been applying advanced information and communication technology to conduct research such as proposals for eco-friendly lifestyles, system development for safety and reliability of energy systems and improvement of intellectual productivity in energy saving offices.

(Prof. Hiroshi SHIMODA, Assoc. Prof. Hirotake ISHII)



Dismantling planning support system based on augmented reality technology

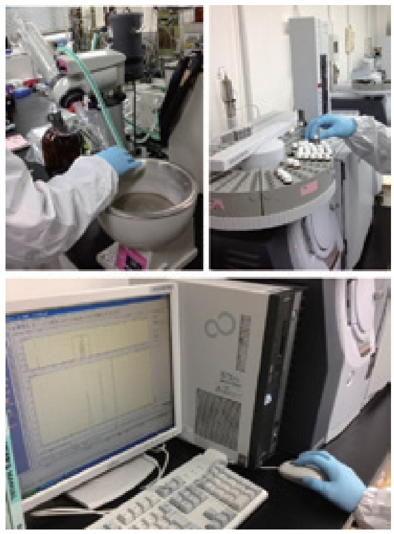
Socio-Enviromental Energy Systems

Analysis and Evaluation of Energy-related Atmospheric Environmental Issues

Energy and Environment

Environmental burdens associated with human activities, especially energy production and utilization, are assessed from the viewpoint of atmospheric environmental science to realize a sustainable society. Environmental impact of anthropogenic air pollutants is evaluated in terms of the human health effect of particulate matters, international impact of long-range transported secondary pollutants, and the regional radiative effect of aerosols. The combination of atmospheric environmental science with statistical approaches is tackled to conduct comprehensive analysis of the relationship between environmental issues and overall human activity.

(Assoc. Prof. Takayuki KAMEDA, Assist. Prof. Kouhei YAMAMOTO)



Chemical Analysis of Air Pollutants

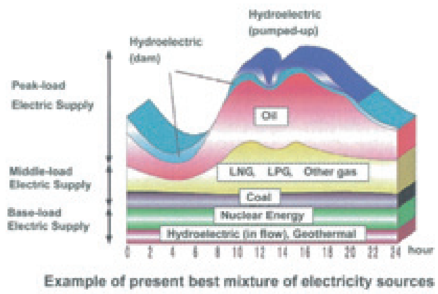
Societal Energy Science

Global Energy Policy - Focusing on Future Use of Nuclear Energy

Energy Policy

Sustainable energy futures can only be achieved through intensive efforts on both technology development and policy implementation, from the viewpoint of energy security and environmental protection. Among the various energy sources to be used, our laboratory focuses on the issues related to the future use of nuclear energy and its impact on global energy policy. Our interest covers the best mixt of electricity sources and primary energy, investigations of nuclear-specific topics including non-proliferation, physical protection and safeguards of nuclear materials, and technological aspects related to the introduction of an advanced nuclear energy system, including experimental studies on nuclear fuel cycles.

(Prof. Hironobu UNESAKI, Assist. Prof. Yoshiyuki TAKAHASHI)



The best combination of electricity sources

Energy Department of Socio-Environmental Energy Science

Department of Socio-Environmental Energy Science

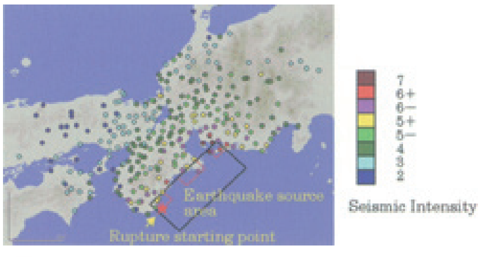
Societal Energy Science

Strategy for Disaster Prevention in Energy Systems : Safety culture

Social Energy Education

To understand the physical and chemical properties of nuclear fuels and materials used in nuclear reactors is an important issue, because they are directly linked to the safety and economics of nuclear reactors. Our group will promote materials science research for various nuclear fuels and materials based on solid-state physics and thermodynamics.
Social consensus regarding energy problems is essential to sustaining the development of humankind. In our laboratory, the strategy of disaster prevention is studied to construct safe nuclear systems focusing on anti-earthquake procedures and environmental risk assessment during nuclear accidents.
Current research topics are 1) estimation of hazards, 2) strategy of earthquake disaster reduction for stable energy supply, 3) Study on strong ground motion prediction to mitigate earthquake disasters, 4) systematization of disaster prevention systems.

(Prof. Ken KUROSAKI, Assoc. Prof. Hirotoshi UEBAYASHI)



Earthquake hazard (seismic intensity) map for the hypothetical Tonankai earthquake (M8.1)

Uranium dioxide pellets for nuclear fuels in light water reactors

Social Science Energy

Risk and Communication concerning Energy Problems

Energy and Communication

Contemporary society is a "risk society", in the sense that how to deal with global risks, represented by energy problems, is an urgent issue of society as a whole. Simultaneously, expansion of horizontal communication by information networks produces risks on the one hand, while also producing opportunities to deal with various risks on the other hand. From a sociological point of view focusing on both sides of "risk / chance", we approach the problem of risk and communication in contemporary society.

(Prof. Jun YOSHIDA)

International Energy Issues

Sustainable Global Systems

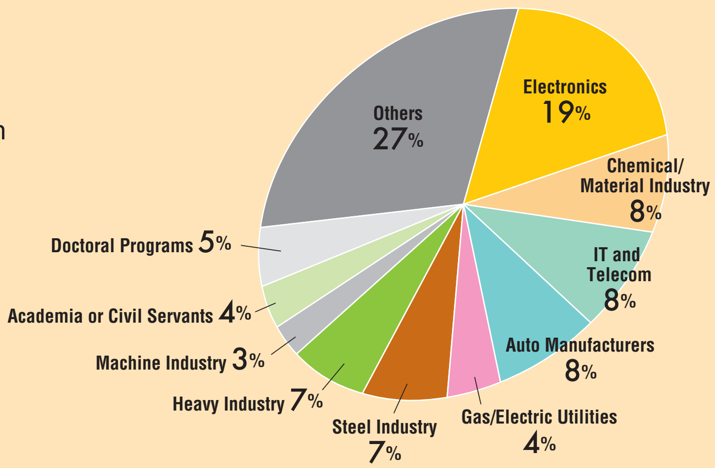
Presently, energy consumption is highest in the developed world. Energy consumption in developing countries, however, will increase rapidly in the near future. The global issues and problems set to arise as a result are studied in this program.

Energy Department of Socio-Environmental Energy Science

Post-Graduation

Academic Year 2018

Graduates of the Master's program in the Department of Socio-Environmental Energy Science:



Department of Fundamental Energy Science

Fundamental Science for the Exploration of New Energy Sources

We offer education and conduct research on fundamental science, seeking for solutions to energy problems. The research fields covered by this department include physical chemistry, material chemistry, electrochemistry, solid state chemistry, biochemistry, quantum mechanics, electromagnetics, statistical mechanics, plasma physics and nuclear physics.

Department Organization

Division	Groups	Focus
Energy Reactions	* Energy Chemistry * Quantum Energy Processes * Functional and Solid State Chemistry	This division focuses on education and research on chemistry for elementary processes, chemical reactions, reaction processes, substances and materials as related to the production, control and conversion of various kinds of energy, such as quantum, thermal, chemical and electrical energy.
Energy Physics	* Plasma and Fusion Science * Electromagnetic Energy * Plasma Physics	This division conducts research and teaching on energy physics based on mechanics, electromagnetism, statistical physic, and material physics. We target a thorough understanding of various physical processes that appear in fundamental energy science. We also pursue the peaceful use of nuclear fusion energy.
Plasma Science	* High-Temperature Plasma Physics * Energy Optical Properties	Based on plasma physics and magneto-hydro dynamics, various physical properties such as thermal equilibrium, stability and transport of high-temperature plasmas, that are heated by electromagnetic waves or particle beams, are investigated. Based on solid-state physics, nano-science and photonics, novel principles and methods for energy production and conversion are pursued.
Energy Materials Science	* Interfacial Energy Processes * Energy Nano Engineering * Biofunctional Chemistry * Bioenergy	Education and research activities are concerned with the chemical processes of materials and energy covering a wide field extending from quantum processes to molecular assemblies. This division aims to clarify the connection between microscopic and macroscopic aspects. Chemical principles and techniques enabling the effective utilization of energy resources are also actively pursued.
Nuclear Energy	* Fundamental Neutron Science * Energy Transport	To develop innovative high-performance nuclear systems for energy generation or neutron application, studies are focused on the scientific principles and neutronics design of nuclear systems, and on new principles and methods for energy transportation and storage.
Advanced Energy Creation	(visiting professors)	This division intends to promote discussion of the guiding principles of advanced energy creation and its underlying physics and technological basis from the perspective of fundamental energy science by visiting professors.

Curriculum

For the Master's Program

- Advanced Study on Fundamental Energy Science 1, 2, 3, 4
- Fundamental Energy Science Advanced Seminar on Energy Science I, II, III, IV
- Fundamental Energy Science
- Physical Chemistry for Energy Science
- Inorganic Chemistry for Energy Science
- Material Science for Energy I, II
- Introduction to Functional and Solid-State Chemistry
- Inorganic Solid State Chemistry
- Fundamental Plasma Simulation I, II (in English)
- Fundamental Energy Science Computer Programming
- Magnetohydrodynamics I, II
- Plasma Waves I, II
- Fusion Plasma Engineering
- High-Temperature Plasma Physics
- Plasma Heating
- Plasma Diagnostics
- Energy Electrochemistry
- Nanotechnology for Energy
- Molecular Science of Fluids
- Biofunctional Chemistry
- Structural Energy Bioscience
- Neutron Mediated Systems
- Introduction to Experiments Nuclear Reactor
- Energy Transport
- Advanced Energy Creation I, II, III
- Field Research Project on Fundamental Energy Science
- Special Fundamental Subject 1, 2
- Industrial Ethics
- Special Seminar on Interdisciplinary Energy Science

For the Doctoral Program

- Physical Chemistry for Energy Science, Adv.
- Materials Science for Energy, Adv.
- Functional and Solid-State Chemistry, Adv.
- Plasma Simulation Methodology (in English)
- Topics in Plasma Dynamics, Adv.
- Special Topics in Advanced Energy I, II, III
- Special Topics in Advanced Energy Creation I, II

Department of Fundamental Energy Science

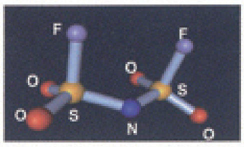
Energy Reactions

Energy Science on the Molecular Scale

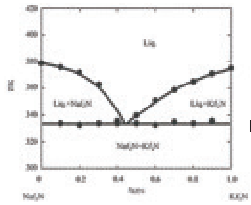
Energy Chemistry

Rechargeable batteries are key technologies for the utilization of renewable energies such as solar and wind energies. Our research interests are concerned with the chemical substances and materials, devices and systems related to energy conversion and storage, especially using ionic liquids. Chemical education and research programs in our laboratory are mostly based on inorganic, electrochemical and physical chemistry, to develop new substances including fluorine-containing materials and functional materials, and to raise scientists who can contribute to our society in energy-related fields.

(Prof. Rika HAGIWARA, Assoc. Prof. Kazuhiko MATSUMOTO)



Molecular structure of FSA anion



Phase diagram of the Na[FSA]-K[FSA] system

Practical Na secondary battery with ionic liquid electrolyte

Energy Reactions

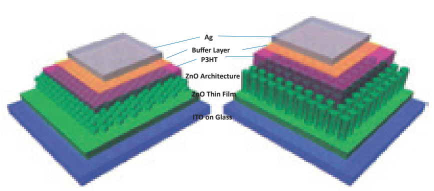
Materials Design for Energy Conversion through Utilization of Quantum States

Quantum Energy Processes

We are interested in the development of energy conversion systems utilizing light. We design new materials and processes for highly efficient light emitting, power generation, and/or other outputs via the relaxation process from the photoexited state to the ground state of organic molecular materials and inorganic semiconductors. In particular studies are focused on the fundamental science for demonstrating important functions of light-harvesting, photoelectron conversion, charge transport, storage, and light-emission through the development of nanosized structures made of organic and inorganic materials.

(e-mail: sagawa@energy.kyoto-u.ac.jp)

(Prof. Takashi SAGAWA, Assoc. Prof. Kan HACHIYA)



Inorganic-organic hybrid solar cells: glass-ITO/ZnO nanoparticle (left) or nanorod (right)/conducting polymer (P3HT)/buffer layer/Ag

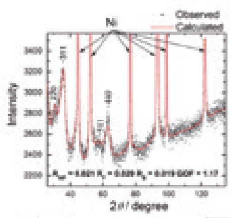
Energy Reactions

Creation of Functional Solid Material for Highly Efficient Energy and Environmental Concinnity

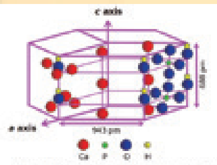
Functional and Solid State Chemistry

We are devoted to designing, synthesizing and analyzing functional solid state materials for efficient energy production and conversion as well as application to achieve sustainable environmental concinnity. Our research interests focus on the development of novel energy materials such as electrodes or electrolytes of rechargeable batteries, solid oxide fuel cells or electrochemical sensors, and also on the investigation of their mechanisms in terms of electrochemistry, inorganic chemistry, solid state chemistry and X-ray crystallography. We have revealed the structural change of electrodes in the relaxation process in charge-discharge cycles (see figure). We are also exploring biocompatible ceramics through soft chemistry process from aqueous solutions for biomimetics or drug delivery systems.

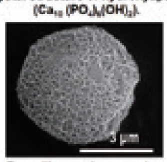
(Assoc. Prof. Shigeomi TAKAI, Assist. Prof. Takeshi YABUTSUKA)



Rietveld Analysis in X-ray diffraction and intracrystalline diffusion of Li ion.



Crystal structure of hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$).



Bone-like apatite capsule for drug and gene delivery.

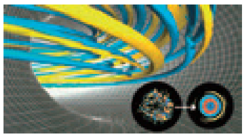
■ **Energy Physics**

Study of Theoretical Plasma Physics Targeting the Understanding of Nuclear Fusion, Laser-matter Interaction and Astrophysics

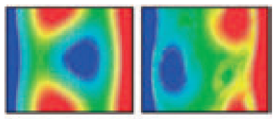
Plasma and Fusion Science

"Plasma", the most natural material state in the universe, is a charged particle system with an extremely high degree of freedom. The study of complex phenomena produced by such plasmas is crucial in nuclear fusion (expected to become the next generation energy source), space and astrophysics, and new material science. For this purpose, we develop non-local turbulence nonlinear dynamics, and methodology of various numerical simulations. In particular, we are performing large scale numerical simulations utilizing massive parallel super computers based on kinetic and fluid models. We also attack the problems of high power laser-matter interactions which opens up new science fields such as laser driven compact accelerators and laboratory astrophysics.
(e-mail : kishimoto@energy.kyoto-u.ac.jp)

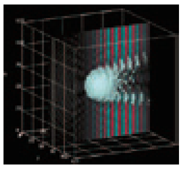
(Prof. Yasuaki KISHIMOTO, Assist. Prof. Kenji IMADERA)



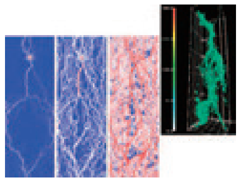
Turbulence simulation in fusion plasmas



Magnetic reconnection simulation in fusion/astrophysical plasmas



Simulation of high energy generated by the interaction of the cluster and the high-intensity laser



Simulation of the lighting in compressed neon gas

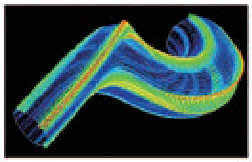
■ **Energy Physics**

Effective Use of Plasmic Electro-magnetic Energy

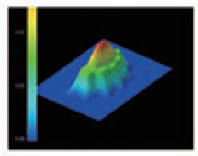
Electromagnetic Energy

In order to realize the controlled thermonuclear fusion reactor, it is very important to confine and control extremely high temperature plasmas in a strong magnetic field. Various physically interesting phenomena can be observed in such plasmas. Education and research on plasma theories, numerical simulations and theoretical analyses of plasma confinement experiments are performed to understand various phenomena concerned with the confinement and heating of high temperature fusion-oriented plasmas. Theoretical and numerical studies are conducted with respect to integrated plasma modeling for magnetically confined torus plasmas.

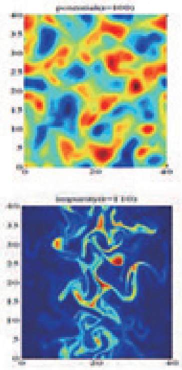
(Prof. Yuji NAKAMURA, Assoc. Prof. Akihiro ISHIZAWA)



MHD instability of non-axisymmetric helical plasmas



Pressure distribution in an equilibrium with magnetic islands



Impurity diffusion in drift wave turbulence

Energy
Department of Fundamental Energy Science

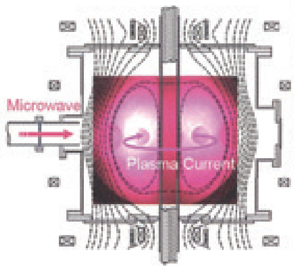
■ **Energy Physics**

Research on Plasma Physics by Means of Radio-frequency Electromagnetic Waves

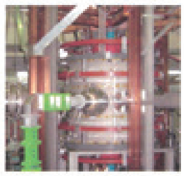
Plasma Physics

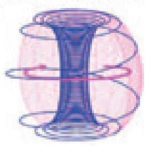
Our group studies magneto-hydro-dynamics and kinematic processes in magnetically confined toroidal plasmas by means of radio-frequency heating and current drive. These studies are closely related to fusion plasma research and, to some extent, to space plasma physics. We also study electron cyclotron resonance (E CR) plasma production and develop plasma diagnostic tools such as heavy ion beam probe systems. These plasma studies serve as fundamental experiments on the nonlinear phenomena of charged particles in electromagnetic fields.

(Prof. Hitoshi TANAKA, Assoc. Prof. Masaki UCHIDA)



Microwave Spherical Tokamak





Magnetic field line is closed by the plasma current and confines the plasma.

Department of Fundamental Energy Science

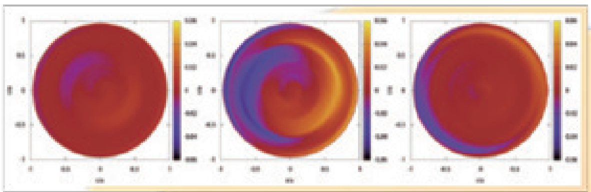
Plasma Physics

Fusion Plasma Physics Exploration as a Future Energy Source

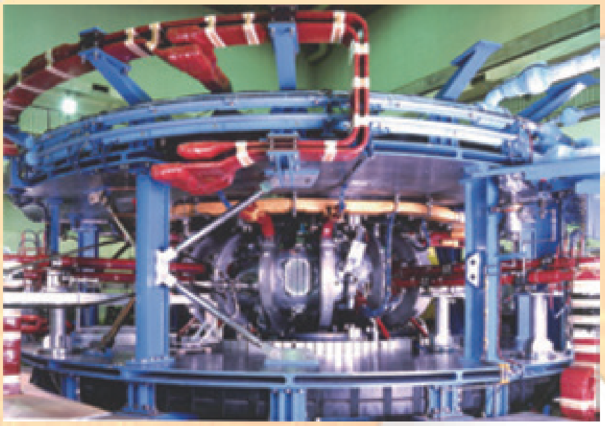
High-Temperature Plasma Physics

Controlled thermonuclear fusion energy is regarded as one of the promising future base load power sources from the viewpoints of resource abundance, environmental load and nuclear proliferation resistance. Its realization relies on the investigation of high-temperature, high-density magnetized plasma confinement. The research of plasma - the fourth state of matter - includes its features of collective particles of electrons and ions in motion and its magneto-fluidity. Energy distribution of the particles or the orbit in the magnetic field will be key issues in the former case, while the treatment of instability and turbulence will be key in the latter case. We are investigating such attractive yet complicated high-temperature plasma behavior in Heliotron J, a helical plasma confinement device, by means of various kinds of diagnostics and simulations. For the purpose of achieving better plasma particle and energy confinement, "plasma control schemes", such as magnetic configurations, heating conditions and fueling scenarios, are being investigated.

(Assoc. Prof. Hiroyuki OKADA, Assoc. Prof. Takashi MINAMI, Assoc. Prof. Shinichiro KADO, Assist. Prof. Shinsuke Ohshima)



Temporal behavior of the density fluctuations at a plasma cross section measured using beam emission spectroscopy (BES). Emergence and suppression phenomena of the helical structure of the fluctuations corresponding to instability events were visualized with non-linear analysis.



High-temperature plasma confinement device, Heliotron J

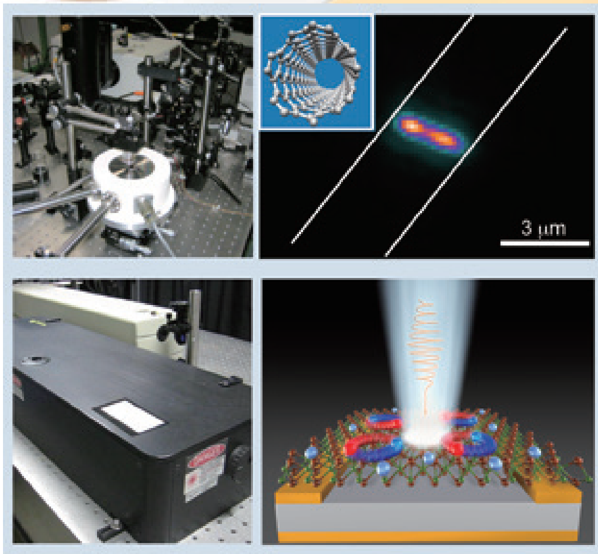
Plasma Physics

Optical Science and Energy Applications based on Nano-science

Energy Optical Properties

The research objectives in our group are “development of novel optical science and energy applications based on nano-science and nano-technology”. We are trying to open new horizons in energy science through the introduction of nano-materials, quantum optical physics, and devices. The understanding of physics of emerging quantum optical phenomena in extreme low-dimensional materials are important issues toward next generation light energy sciences. The following are current research subjects in our group 1) Elucidation of quantum optical phenomena in nano-carbon materials (carbon nanotubes, and graphene), 2) Application of thermal management and bio-imaging using nano-carbon materials, 3) Development of novel optical science (valley-spin photonics) in atomically thin materials, and 4) Development of next generation solar cell devices using novel materials (perovskite and atomically thin materials)

(Prof. Kazunari MATSUDA, Assoc. Prof. Yuhei MIYAUCHI)



Systems of advanced laser spectroscopy and optical images of nano-materials

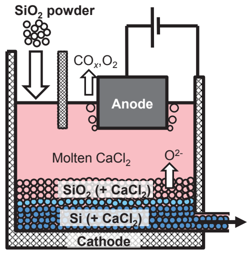
■ **Energy Materials Science**

Electrochemical and Biochemical Approaches toward the Expanded Introduction of Renewable Energy

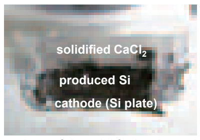
Interfacial Energy Processes

We are studying materials and systems to realize renewable energies like photovoltaics and bioenergy as the major primary energy source for human beings. We use electrochemistry and biochemistry as the core academic fields. For examples, we are developing “a new electrochemical production method of solar silicon” and “large-scale secondary batteries with high safety” by using molten salts and ionic liquids as electrolytes and controlling electrode-electrolyte interfaces. We also focus on the highly efficient production of ethanol from biomass using genetic engineering, aiming to solve global crises such as the exhaustion of fossil fuels and global warming.

(Prof. Toshiyuki NOHIRA, Assoc. Prof. Tsutomu KODAKI, Assist. Prof. Takayuki YAMAMOTO)

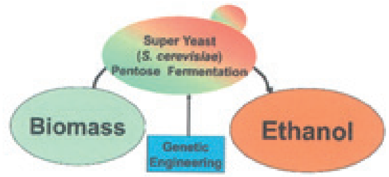


A new production method of Si by molten salt electrolysis.



A photo of the solidified molten salt and the produced Si on the bottom.

A crystalline Si rod made from the Si powders by floating zone melting.



Strategy for construction of efficient ethanol production system from biomass.

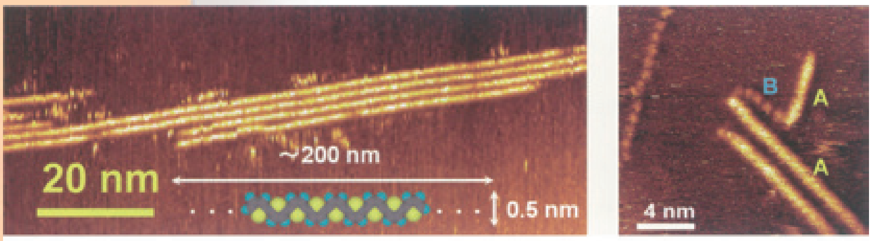
■ **Energy Materials Science**

Molecular Assembling on Surfaces Aiming at Organic Devices for Energy

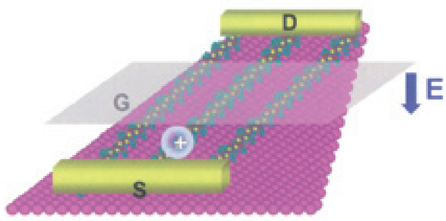
Energy Nano Technology

Nanoscience and technology, the ultimate methods for making new materials by assembling single molecules, are studied aiming at molecular devices for energy use. We have developed the ‘Electrochemical Epitaxial Polymerization’ technique which is a totally new molecular assembling technique for producing molecular wires on metal surfaces from single molecules. By the use of this technique, unprecedented materials for energy use will be developed. Organic electronic devices such as field effect transistors and solar cells will be developed using our new techniques. Studies of theoretical biophysics are also in progress.

(Prof. Hiroshi SAKAGUCHI, Prof. Masahiro KINOSHITA, Assist. Prof. Takahiro KOJIMA, Assist. Prof. Shunpei NOBUSUE)



Electrochemical-epitaxially polymerized conducting-polymer wires on metal surface



‘Molecular wires’ transistor

Department of Fundamental Energy Science

Department of Fundamental Energy Science

■ **Energy Materials Science**

Development of Highly Efficient Energy-Transformation Systems using Biomacromolecules

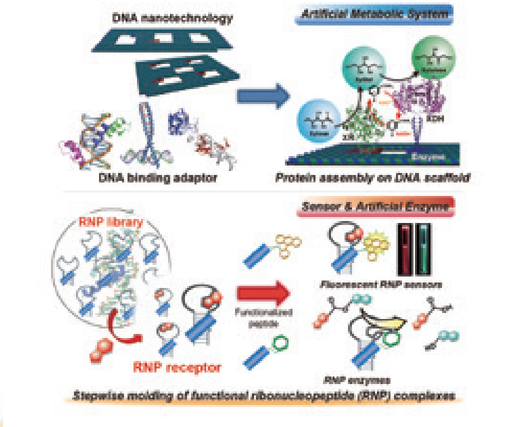
Biofunctional Chemistry

The research interests in our group focus on the design of novel biomacromolecules and their assemblies for application to energy conversion, catalysis and signal transduction in water, the solvent of life. We take synthetic, organic chemical, biochemical and biophysical approaches to construct novel proteins and protein/nucleic acid complexes with sensing or catalytic functions, and also to develop the assemblies of proteins and nucleic acids that emulate the function of biological systems.

A stable complex of peptides and RNA, namely, ribonucleopeptide (RNP), provides a new framework to construct macromolecular receptors for small molecules. The modular structure of RNP receptors enables further functionalization of RNPs into fluorescent biosensors and enzymes. Structure-based design and/or library-oriented screening provide alternative strategies to construct protein-based biosensors that assess intracellular dynamics of second messengers and metabolites.

Cellular energetic processes consist of multiple chemical reaction steps with various enzymes cooperating in a specific manner to catalyze the sequential reaction steps. Such natural systems are effectively reconstructed in vitro when the individual enzymes are placed in appropriate orientations. DNA nanostructures such as DNA origami, and protein "adapters" are used for the construction of "molecular switchboard" to arrange enzymes and other proteins with nanometer-scale precision that drives an artificial metabolic pathway consisting of multi-step chemical reactions for effective energy utilization.

(Prof. Takashi MORII, Assoc. Prof. Eiji NAKATA, Junior Assoc. Prof. Arivazhagan RAJENDRAN, Assist. Prof. Shun NAKANO)



Rational design of biomacromolecular assembly on the DNA nanostructure, the molecular switchboard, realizes a bio-inspired energy utilization system, such as the artificial metabolic system and artificial photosynthesis (upper).
Receptors, biosensors and enzymes are constructed from structurally characterized and protein-RNA complexes (lower).

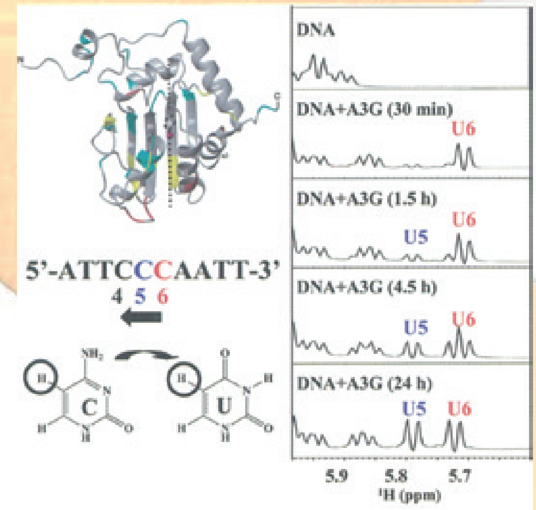
■ **Energy Materials Science**

Toward Biorefineries through the Development of Biomass and Biomolecules Based on Structural Biology

Bioenergy

We explore the ways in which biomolecules such as proteins (involving enzymes) and functional nucleic acids (DNA and RNA) work at atomic resolution based on structural biology with NMR. We determine both static and dynamic structures with the aid of our own new methodology and elucidate the underlying mechanism of functions of these biomolecules. For example, recently we have successfully developed a way to monitor the base conversion reaction by anti-HIV enzyme, A3G protein, in real-time with NMR for the first time. This new method has provided critical information on how this enzyme produces catalytic action on DNA. Currently, we are developing ways to extract energy and valuable materials that can be used as starting materials of various products from wood biomass. We aim to contribute to the paradigm shift from oil refineries to biorefineries.

(Prof. Masato KATAHIRA, Assoc. Prof. Takashi NAGATA, Assist. Prof. Tsukasa MASHIMA)



Structure of A3G protein which possesses anti-HIV activity and the interaction sites (colored) with target virus DNA (upper left). Real-time monitoring of the base-conversion reaction through deamination by A3G with NMR signals (lower left and right).

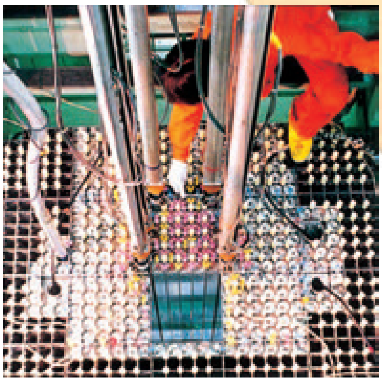
■ **Nuclear Energy**

Study of Innovative High-Performance Systems for Next Generation Nuclear Energy Utilization

Fundamental Neutron Science

The scientific principles and neutronics design of nuclear systems are investigated to develop innovative high-performance systems for next generation nuclear energy utilization. Specifically, basic studies on the nuclear characteristics of 1) high-performance next generation nuclear reactors 2) accelerator driven systems for transmutation of high-level nuclear waste, 3) reactors for the thorium fuel cycle, 4) nuclear criticality safety, and 5) radiation detection for various applications including nuclear security, are performed mainly through reactor physics experiments.

(Prof. Tsuyoshi MISAWA, Assist. Prof. Yasunori KITAMURA)



VIew of a reactor physics experiment using the Kyoto University Critical Assembly (KUCA)

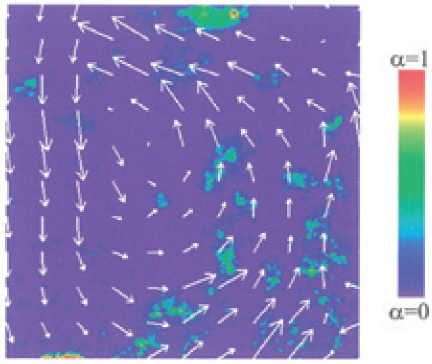
■ **Nuclear Energy**

Evolution of Thermo-Fluid Science toward Innovative Technology

Heat Transport System

This group is dedicated to basic research on the safe and efficient utilization of high intensity thermal energy produced by a next generation nuclear energy system, indispensable as an energy source in the 21st century. From this point of view, current research programs involve experimental and theoretical studies on heat removal at extremely high flux from advanced nuclear energy systems such as a nuclear fusion reactors and accelerator-driven systems (ADS), multiphase flow phenomena which are encountered in various energy systems, and the development of novel methods for fluid measurement such as particle beam radiography.

(Prof. Yasushi SAITO, Assoc. Prof. Kei ITO, Assoc. Prof. Cheol Ho PYEON, Assist. Prof. Daisuke ITO)



Velocity and void fraction profile in a liquid-metal two-phase flow measured by combined technique of neutron radiography and PTV method.
α is the time averaged local void fraction.

■ **Advanced Energy Creation**

Development of Organic Self-Assembling Materials

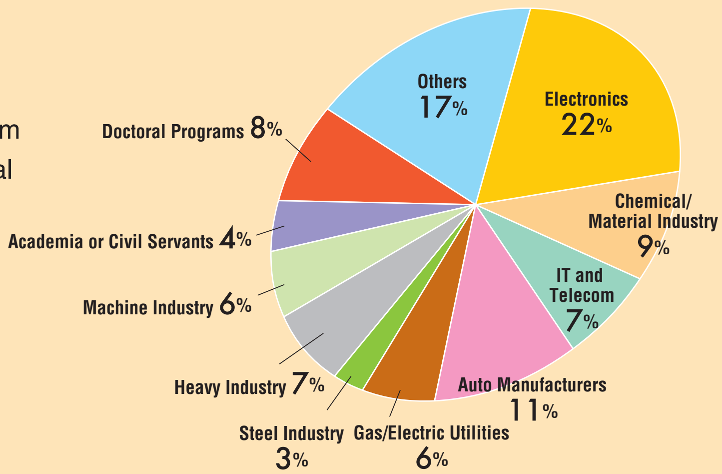
Organic self-assembling materials have attracted much attention for next-generation functional devices with several specific properties being highly oriented, light-weight, flexible, and easily applicable to large-area processing combined with introduction of electronically and optically functionalized groups. We have conducted research and development activities for optoelectronic devices such as wavelength converters, which are expected to be highly efficient energy-harvesting and energy- generating devices. In this context, the outlines, the state-of-the- art, and future perspectives in this rapidly-progressing field will be introduced.

(Visiting Prof. Andre DEL GUERZO)

Post-Graduation

Academic Year 2018

Graduates of the Master's program in the Department of Fundamental Energy Science:



Department of Energy Conversion Science

Energy Conversion Systems and their Functional Design in the 21st Century

In order to contribute to the development of a human society that coexists with the natural environment, and to establish efficient clean energy systems, we offer education and conduct research on the generation, conversion, control and utilization of various kinds of energy from the perspectives of science and engineering.

Department Organization

Division	Groups	Focus
Energy Conversion Systems	* Thermal Energy Conversion * Conversion Systems	With the objective of unifying fundamental theories on energy conversion and transportation, functional design and constitutive elements of systems, and investigating safety and highly-efficient energy conversion systems in harmony with the environment, the foundation and methodology of the related evaluation, design and control are being studied.
Design for Energy Conversion Functions	* Materials Design for Energy Systems * Design for Functional Systems	In order to convert, transport and store energy with high efficiency, areas of study include the functions to be embodied in a variety of machines and their composed systems, principles for the diversification of energy conversion, constitutive materials for hardware systems, design of associated machineries and software, and the foundation and application of their safety and reliability.
Functional Energy Conversion	* Advanced Energy Conversion * Highly Qualified Energy Conversion * Functional Energy Conversion Materials	In order to investigate highly-efficient safe energy conversion processes in harmony with the environment and to build systems, areas of study include the establishment of theories, application/evaluation and functional conversion systems from the manifold perspectives of fusion science and engineering, optical science, thermochemistry, advanced nuclear energy, energy materials science and engineering, among others.
Innovative Energy Conversion	(visiting professors)	

Curriculum

For the Master's Program

- Energy Conversion Fundamentals
- Rate Processes
- Heat Engine Systems
- Thermal Energy System Design
- Combustion Science and Engineering
- Fracture Mechanics for Energy Systems
- Science for System Integrity
- Theory of Plasticity
- Estimation Mechanics of Materials
- Continuum Thermodynamics
- Fundamentals of Fusion Energy System
- Advanced Energy System Technology
- Particle Energy Conversion
- Electromagnetic Energy Conversion
- Functional Energy Conversion
- Materials for Energy Conversion
- Advanced Energy Conversion Science
- Engine Combustion Analysis
- Nuclear Power Plant Engineering
- Advanced Engine Systems
- Field Research Project on Energy Conversion Science
- Special Fundamental Subject 1, 2
- Industrial Ethios
- Special Seminar on Interdisciplinary Energy Science
- Exploratory Project I, II , III, IV Conversion Science I, II, III, IV
- Fusion Energy Science and Technology
- Energy Conversion System Design and Functional Design
- Field Research Project on Energy Science

For the Doctoral Program

- Energy Conversion Fundamentals, Adv.
- Environmental Protection Science
- Continuum Thermodynamics
- Nuclear Power Plant Engineering, Adv.
- Field Research Project on Energy Science
- Advanced Energy Conversion Science
- Engine Combustion Analysis, Adv.
- Advanced Engine Systems, Adv.

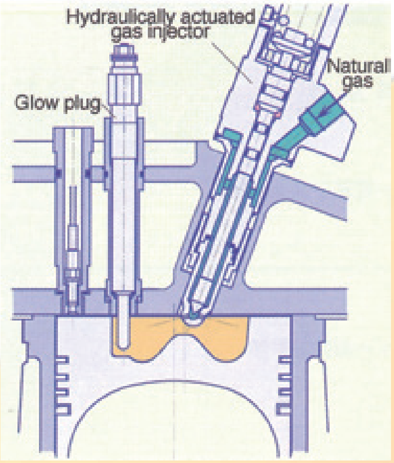
Energy Conversion Systems

Energy Conservation and Mitigation of the Environmental Impacts of Thermal Engine Systems

Thermal Energy Conversion

Our research interests focus on improvements in thermal efficiency and the mitigation of pollutant emissions in thermal engine systems. Current research subjects are: 1) the prediction of combustion processes in internal combustion engines, 2) the development of technologies for reducing pollutant emissions from engines, 3) fundamental studies on ignition and combustion of fuel sprays and jets, 4) the utilization of alternative fuels for combustion systems, and 5) engine systems for reducing and recovering energy loss.

(Prof. Takuji ISHIYAMA, Assist. Prof. Naoto HORIBE)



Direct Injection Gas Engine

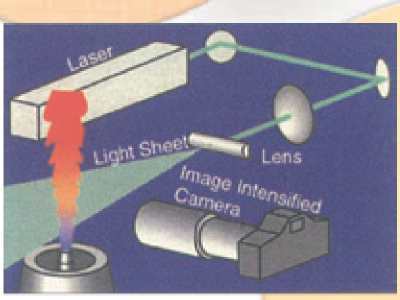
Energy Conversion Systems

Optimum Design and Control of Energy Conversion Systems

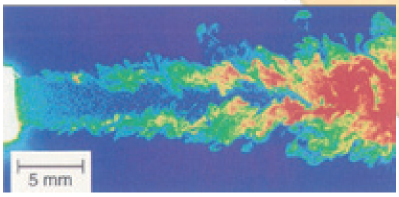
Conversion Systems

The aim is to design, control and access energy conversion systems with high efficiency and safety while protecting the environment, and in addition, to undertake investigation of physical and chemical processes in thermo-fluid substances to establish optimum conversion systems. Special attention is paid to the following issues and related matters: 1) ignition and combustion of homogeneous and heterogeneous mixtures, 2) chemical reaction kinetics of pollutant formation, 3) kinetics and fluid dynamics of turbulent diffusion flames, 4) laser diagnostics and image analysis for combustion research, and 5) numerical simulation of turbulent flows and combustion.

(Prof. Hiroshi KAWANABE, Assoc. Prof. Jun HAYASHI)



Laser Diagnostics and Image Analysis of Flame Structure



Tomographic Image of a Jet

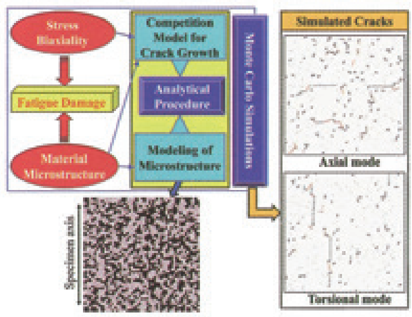
Design for Energy Conversion Functions

Design of Materials to Create New Functions and Energy-Related Machinery

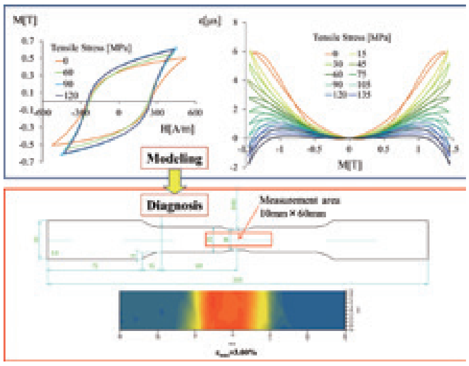
Materials Design for Energy Systems

The function, deformation and strength characteristics of materials and machinery, which are applied to energy conversion systems, should be adequately assessed. In this group, theoretical and experimental investigations are carried out to establish the most suitable methodology for the design of such materials and machinery. Work conducted in this group is summarized as follows. Research to evaluate macro material properties and machinery safety by analyzing the micro structure of the material and the related deformation, (1) strength evaluation of engineering materials based on fracture mechanics, (2) experimental and analytical investigations on biaxial fatigue of metals, (3) evaluation of static and fatigue strength of ceramic thin-film coated materials, and (4) experimental and analytical assessment of strength properties in porous ceramics, and so on. Research to understand deformation behavior and characteristics of various electromagnetic materials which play an important role in energy conversion systems, (1) model construction of electromagnetic materials considering electromagnetoelastic interaction, (2) development of material diagnosis methods using electromagnetic characteristics, and so on.

(Prof. Toshihiko HOSHIDE, Assoc. Prof. Masataka ABE)



Analytical procedure and simulated cracking morphology



Materials Design for Energy Systems

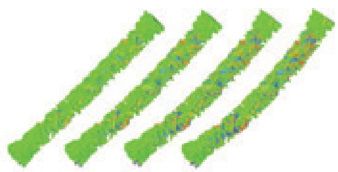
Design for Energy Conversion Functions

Design of Advanced Functional Material Systems and Nondestructive Evaluation of their Integrity

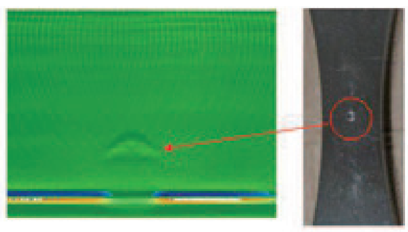
Design for Functional Systems

Advanced energy conversion systems in various fields require the component materials to possess not only sufficient stiffness and strength but also various functions such as electromagnetic and thermal properties as well as reliability when subjected to extreme environments such as large stress, high temperature and intense electromagnetic fields. This research group aims to develop a framework to analyze the behavior of such materials based on continuum thermo-electromagneto-mechanics and to design highly functional and smart material systems. In addition, modeling of complex materials with internal structures and new nondestructive methods are developed to evaluate the functional and structural integrities of material systems by means of acoustic, thermal and electromagnetic material properties including their interactions.

(Prof. Shoji IMATANI, Assoc. Prof. Katsuyuki KINOSHITA)



Direct simulation of bending process of porous metal.



Visualization in the sample by a phased array ultrasonic testing system.

Energy Department of Energy Conversion Science

■ **Functional Energy Conversion**

Design, Development and Assessment of Fusion Energy Systems

Advanced Energy Conversion

In this century, constraints of fossil resources and global environmental problems should be resolved while sustainable development and growth, mainly in developing countries, are required. Innovative energy technology based on advanced science is inevitable to completely reform the entire energy system, and fusion is seen as a promising candidate. For this purpose, we are carrying out research and development of advanced fusion energy systems using experimental, numerical and design studies, as well as integrated assessment, as part of a future energy system from the aspect of society and environment.

We are studying the design of fusion devices and their systems based on the advanced energy conversion components such as blankets and divertors that attract attention from international collaborators. We are also investigating hydrogen production processes and propose carbon free gaseous and liquid fuel supply from waste biomass. This biomass-fusion hybrid concept enables fusion to be applicable earlier to drastically replace fossil fuel. We also aim to develop a unique compact fusion neutron beam device that can be used for analytical, medical and various applications. Tritium behavior in plant systems and in the environment is evaluated to assess reactor safety. This energy evaluation study further involves all the carbon free renewable energy technologies and analysis from biological, environmental, economic and social aspects for the sustainability of the entire social system.

(Prof. Satoshi KONISHI, Lecturer Juro YAGI, Assist. Prof. Keisuke MUKAI)

Fig. Future recycling society with fusion-biomass hybrid system.

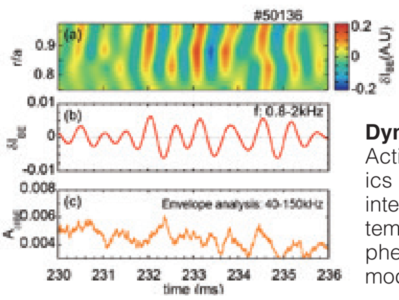
■ **Functional Energy Conversion**

Highly Qualified Energy Conversion through Advanced Control of Charged Particle Beams and Electromagnetic Waves

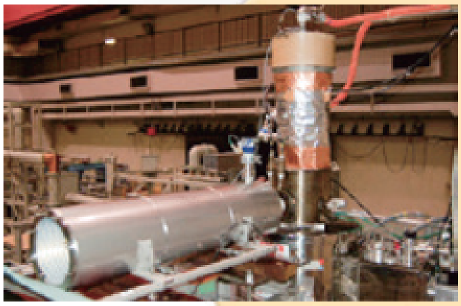
Plasma Energy Conversion

Intensive investigations of wave heating and current drive in fusion plasmas, as well as heat/momentum control using high-energy neutral particle beams are being conducted. Particular emphasis is put on studies of interactions between charged particles and electromagnetic fields. Physics and technology related to microwaves are investigated for plasma heating, current drive and diagnostics such as radiometers, reflectometers and interferometers. Utilization of high-energy neutral beams is studied for plasma heating and momentum control to obtain high performance plasmas. Plasma transport is investigated based on development of active beam spectroscopy. Computer simulations are extensively applied to all phases of research.

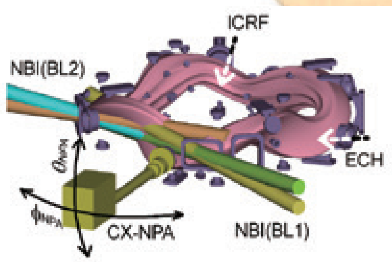
(Prof. Kazunobu NAGASAKI, Assist. Prof. Shinji KOBAYASHI)



Dynamics of plasma transport
Active beam spectroscopy reveals dynamics of plasma transport. The non-linear interactions by turbulent transport in high temperature plasmas lead to transition phenomena from low to high confinement mode.



High-power microwave source "Gyrotron"
A gyrotron produces a Gaussian-shaped microwave beam of 70GHz 500kW power, which is used for production, heating and current drive in fusion plasmas.



Neutral beam injection system and active beam spectroscopy
Neutral beam injection system (30kV, 0.7MW, 2units) is utilized for heating and momentum control of magnetically confined plasmas, as well as active beam spectroscopy for understanding plasma transport characteristics.

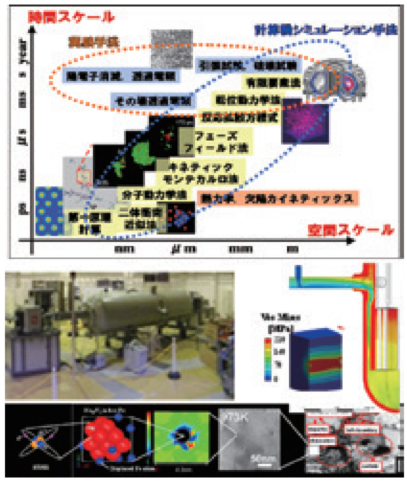
Functional Energy Conversion

Basic Research and Development of Nuclear Energy Materials

Functional Energy Conversion Materials

Energy systems with high efficiency, high performance and high functions are required for highly efficient energy utilization. Advanced materials development is essential for the realization of such advanced energy systems. In this research group, understanding materials behavior, investigating key technologies of materials development and basic research on lifetime estimation of plant materials has been carried out for development of high performance innovative structural materials. In addition, structure-fluid coupled analysis to understand complicated material environments in nuclear fission and fusion reactor systems, and multiscale material modeling studies to understand material degradation phenomena under fission/fusion environments at various time- and length-scales, are conducted toward the establishment of system maintenology for nuclear safety.

(Assoc. Prof. Kazunori MORISHITA, Assist. Prof. Kiyohiro YABUUCHI)



Basic research and development of nuclear energy materials

Innovative Energy Conversion

Education and research are conducted for innovative energy conversion.

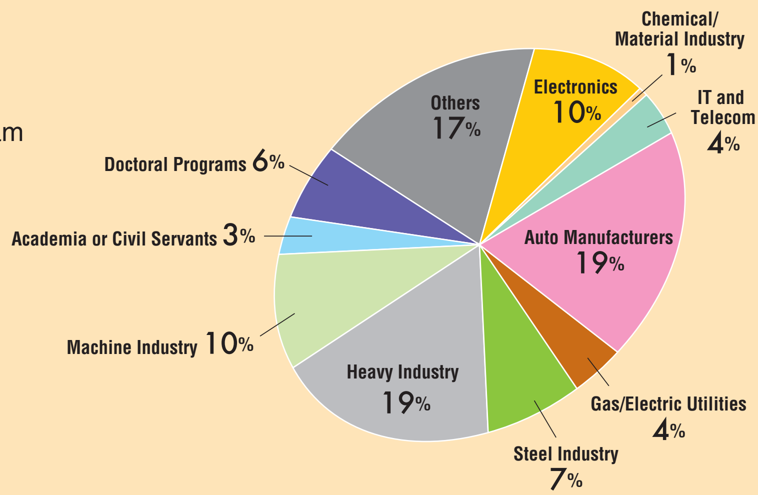
(Visiting Assoc. Prof.)

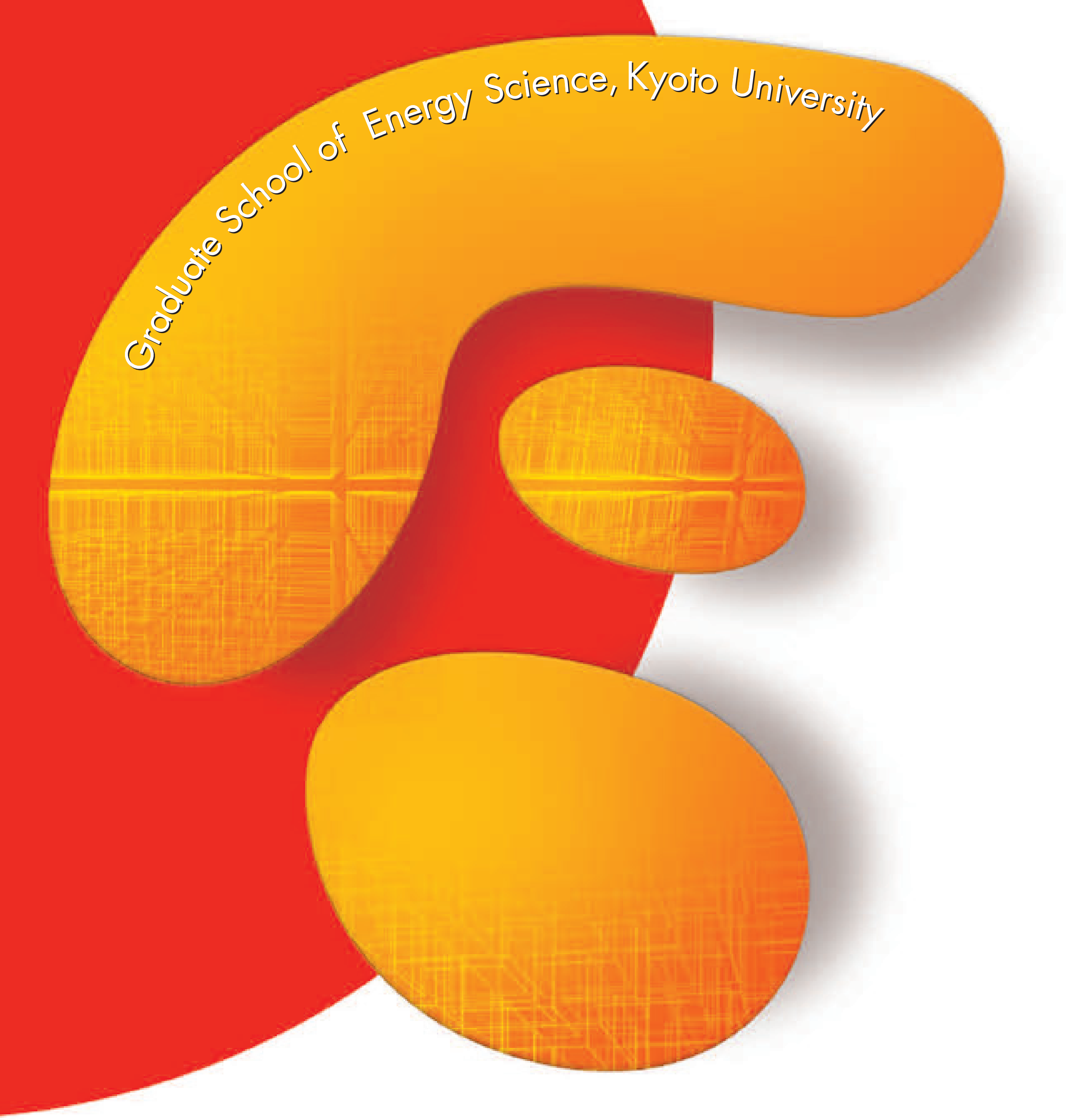
Energy
Department of Energy Conversion Science

Post-Graduation

Academic Year 2018

Graduates of the Master's program in the Department of Energy Conversion Science:





Department of Energy Science and Technology

To Establish Environmentally Friendly Process Technologies to Sustain the Development of Our Society

We offer education and research opportunities for the development of more efficient utilization of direct and indirect energy supplies based on disciplines such as resources, metallurgical, mechanical and electrical engineering.

Department Organization

Division	Groups	Focus
Materials Science & Engineering for Energy Systems	* Device Physics * Process and Energy	Fundamentals and applications of thermal science to advanced energy devices, advanced energy systems and superconducting apparatus.
	* Materials Process Science * Thermochemistry	Fundamentals and applications of thermochemistry for the creation, development and processing of materials for energy.
Resources and Energy	* Resources and Energy Systems * Advanced Processing of Resources and Energy * Mineral Processing	Education and research on supply systems and advanced processing of energy resources and materials, and related space technologies.
High Quality Energy	* Quantum Radiation Energy Science * The Physics of Energy Materials * Photon Energy Science	Education and research on the generation and application of high-quality quantum-radiation and energy materials, R&D for advanced energy systems and advanced photon energy with lasers.
Innovative Energy Science and Technology	(visiting professors)	

Curriculum

For the Master's Program

- Advanced Study on Energy Science and Technology 1, 2, 3, 4
- Introduction to Energy Science and Technology
- Advanced Energy Science and Technology
- Lecture on Advanced Integrated Circuits
- Thin Film Nanodevices
- Power System Engineering
- Materials Processing
- Functional Materials Processing
- Thermochemistry
- Resource and Energy System
- Ocean Resources and Energy Technology
- Numerical Approach to Working Processes
- Computational Physics
- Advanced Physical Chemistry
- Photon and Quantum Energy
- Electromagnetic Energy
- Effective Utilization of Energy
- Energy Development
- Field Research Project on Energy Science and Technology
- Special Fundamental Study 1, 2
- Industrial Ethics
- Special Seminar on Interdisciplinary Energy Science

For the Doctoral Program

- Applied Thermal Science, Adv.
- Energy and Processes, Adv.
- Resource and Energy System, Adv.
- Photon and Quantum Energy, Adv.
- Energy Development, Adv.
- Advanced Energy Science and Technology (in English)
- Field Research project on Energy Science

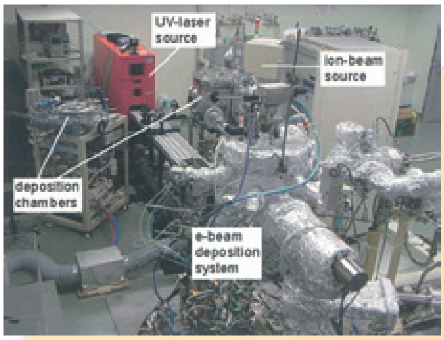
■ **Materials Science & Engineering for Energy Systems**

Crystal Alignment Techniques for Advanced Energy Materials

Device Physics

Our group focuses on high-performance devices based on utilization of renewable energy and highly efficient utilization of energy, and aims for the establishment of various crystal alignment techniques as production processes of materials for fully maximizing their functionalities. Currently, our targets are electronic materials containing superconductors and functional compounds for power generation. Novel crystal alignment processes, such as epitaxial thin film growth, and ion beam assisted deposition are investigated for precise and three-dimensional arrangement of crystalline grains like a single crystal.

(Prof. Toshiya DOI, Assoc. Prof. Yoshiaki KASHIWAYA)



Electron-beam deposition and pulsed-laser deposition systems for fabrication of high-quality thin films

■ **Materials Science & Engineering for Energy Systems**

Applied Superconductivity Engineering and Thermal Hydraulics in Liquid Gases for Innovative Energy Systems

Process and Energy

Research topics of this group are

1) Applied superconductivity apparatus for advanced energy systems, such as SMES (superconducting energy storage), Superconducting rotating machines, Fault current limiters etc.
2) Advanced electric power systems including renewable energy sources.
3) Thermal hydraulics in Helium, Hydrogen, Nitrogen etc., for high density heat removal, essential for applied superconductivity systems.

(Prof. Yasuyuki SHIRAI)

Experimental Setup for Liquid Hydrogen cooled Superconducting Energy Devices (right) and HTC Superconducting Fault Current Limiter (left)

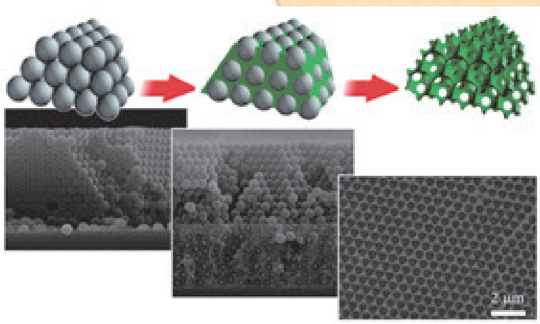
■ **Materials Science & Engineering for Energy Systems**

Electrochemical processing for functional materials

Materials Process Science

This group investigates production processes for functional materials based on electrochemistry, solution chemistry, and vapor-phase chemistry. The current research topics in this group are as follows: 1) Functional surface treatment by aqueous/non-aqueous processing, 2) Electrodeposition of metal and alloys using peculiar electrolytes, 3) Mist chemical vapor deposition of functional thin films, 4) Fabrication of porous materials for energy devices.

(Prof. Tetsuji HIRATO, Assoc. Prof. Masao MIYAKE, Assist. Prof Takumi IKENOUE)



A fabrication process of 3D photonic crystals using colloidal crystal template.

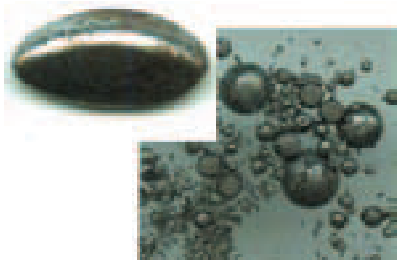
Materials Science & Engineering for Energy Systems

Thermochemistry for Energy Research

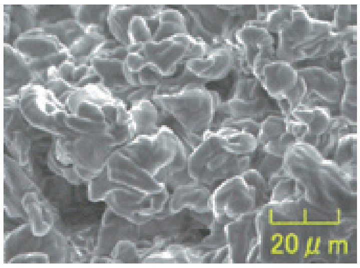
Thermochemistry

The main concern of this group is fundamental and applied studies of physical chemistry and thermochemistry for better understanding of existing materials, chemical and metallurgical processes and the generation of new concepts of material production and recycling, with a particular emphasis on minimizing the consumption of energy and resources, without affecting the global environment in future centuries.

(Assoc. Prof. Masakatsu HASEGAWA)



Iron droplet containing carbon, obtained through reduction with various waste



SEM micrograph of an inclusion compound containing chlorine

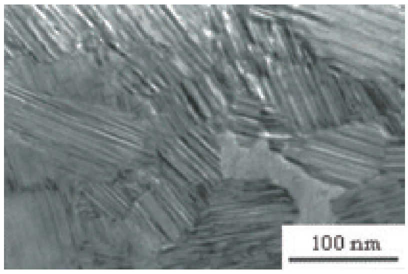
Resources and Energy

Eco-Metals & Nano-Metals for Next Generation Society

Resources and Energy Systems

Our group focuses on materials science related to resources, energy and environment for the next generation society. The main topics are eco-metals for energy and resource saving e.g., superlight Mg alloys and their up-grade recycling, nano-metals for innovative technologies e.g., hydrogen-storing nanoporous metals and ferromagnetic nanocrystalline metals, and fracture mechanisms of rocks for stable supply of energy e.g., analyses of pore spaces and cracks.

(Prof. Mamoru MABUCHI, Assoc. Prof. Masataka HAKAMADA, Assist. Prof. Youqing CHEN)



Ferromagnetic nanocrystalline metals with nanolamellar structure

Energy
Department of Energy Science and Technology

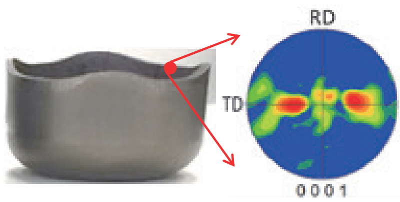
Resources and Energy

Computational Physics for Energy Resources and Materials Processing Technology

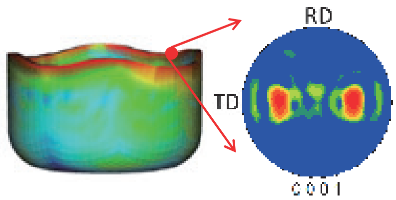
Advanced Processing of Resources and Energy

Materials for all products are supplied by resources, and energy is consumed in the process of converting materials to products. The "advanced processing of resources and energy" deals with the total processing of resources and energy from a theoretical as well as a practical perspective, using mainly numerical simulations based on computational physics. Current research subjects also include the design of materials processing and working, such as continuous casting, rolling and sheet forming, etc.

(Prof. Hirohiko TAKUDA, Assoc. Prof. Takayuki HAMA)



Experiment



Crystal plasticity finite-element simulation

Multiscale simulation of cup drawing of a commercially pure titanium sheet

Department of Energy Science and Technology

Resources and Energy

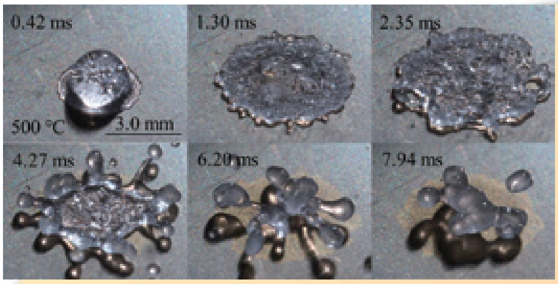
Contribution of mineral processing to energy, resources, materials, and environment

Mineral Processing

Our group focuses on various issues related to material processing, development of resource-circulation technology, and construction of environmental purification systems. Our current research interests are as follows:

1) Heat and Mass Transport Phenomena of Multiphase Flow in Material Production Process
2) Basic Properties of Methane Hydrate and CO_2 Hydrate
3) Utilization of Methane Fermentation Technology
4) Environmental Purification, Resource Recycling, and Mineral Processing

(Prof. Hitoshi FUJIMOTO, Assoc. Prof. Hiromu KUSUDA, Assist. Prof. Eishi KUSAKA)



Hydrodynamics and boiling phenomena of aqueous polymer solution droplet impinging on hot substrate

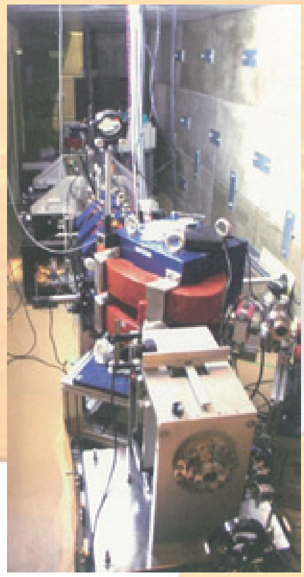
High Quality Energy

Generation of High-Quality Quantum Radiation Energy and its Application to Functional Materials

Quantum Radiation Energy Science

Generation and application of mid-infrared free electron lasers (KU-FEL) and compact THz radiation sources to develop high efficiency energy conversion materials are studied. Fundamental beam physics, optics, and laser technology are studied by developing new measurement systems and techniques. Laser-Compton backscattering gamma-rays have also been studied for nuclear safety and security applications. Evaluation of renewable energy systems and policy, implementation methodologies and their impacts are studied through international collaborative research.

(Prof. Hideaki OHGAKI, Assoc. Prof. Toshiteru KII, Assist. Prof. Heishun ZEN.)



KU-FEL accelerator and optical system

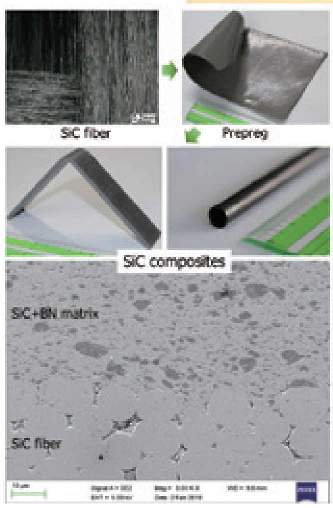
High Quality Energy

Ceramic Material for Advanced Energy Applications

The Physics of Energy Materials

The research activity in this group puts emphasis on R&D of advanced ceramic matrix composites like SiC composites reinforced with SiC fibers with 10 μm diameter for aerospace, nuclear advanced fission and fusion applications utilizing nano-techniques. The R&D includes development of novel materials, applications and environmental effects from basic science through engineering using DuET (Dual-Beam Facility for Energy Science and Technology) and MUSTER (Multi-Scale Testing and Evaluation Research) facilities.

(Assoc. Prof. Tatsuya HINOKI, Assist. Prof. Kouichi JIMBO)



SiC fiber reinforced SiC composites

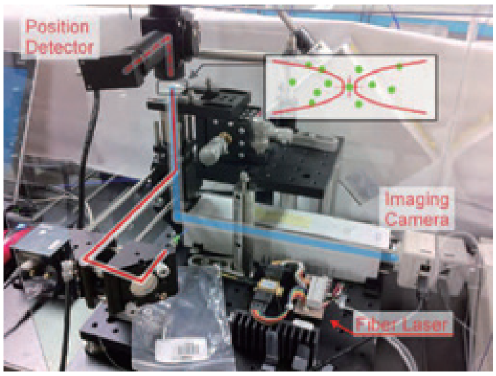
High Quality Energy

Generation and Applications of Advanced Photon Energy

Photon Energy Science

It was more than half century ago that the laser was invented, and it is no longer a special device only for specialists. Nowadays, it is widely used in many different fields to carry out in-situ observation of various dynamics, synthesize nanomaterials, etc.
In our group, using different kinds of lasers as tools, we explore novel nonlinear optical phenomena and study the optical response of various materials.

(Assoc. Prof. Takashi NAKAJIMA)



Laser trapping system

Innovative Energy Science and Technology

State-of-the-Art in Energy Science and Technology

Globally famous researchers and pioneers are annually invited as visiting professors, to introduce current issues in energy science and technology. The application of advanced electric devices, new material development and its processing, resource exploration and evaluation of energy redistribution, economic analysis for metal recycling, etc. have been discussed. The scientific and technological trends on energy utilization are demonstrated from international perspectives.

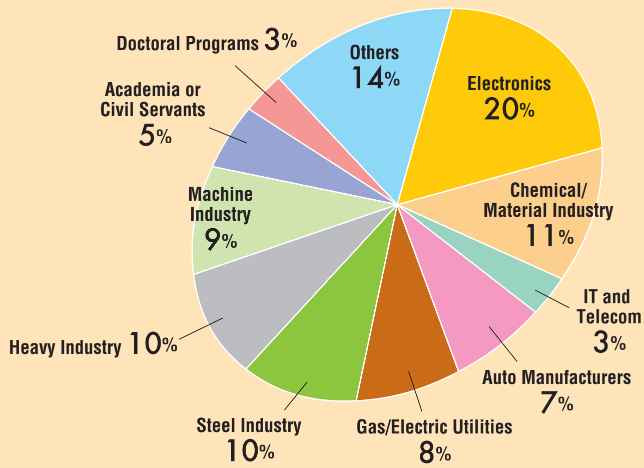
(Visiting Prof.)

Energy
Department of Energy Science and Technology

Post-Graduation

Academic Year 2018

Graduates of the Master's program in the Department of Energy Science and Technology:



Graduate School of Energy Science, Kyoto University

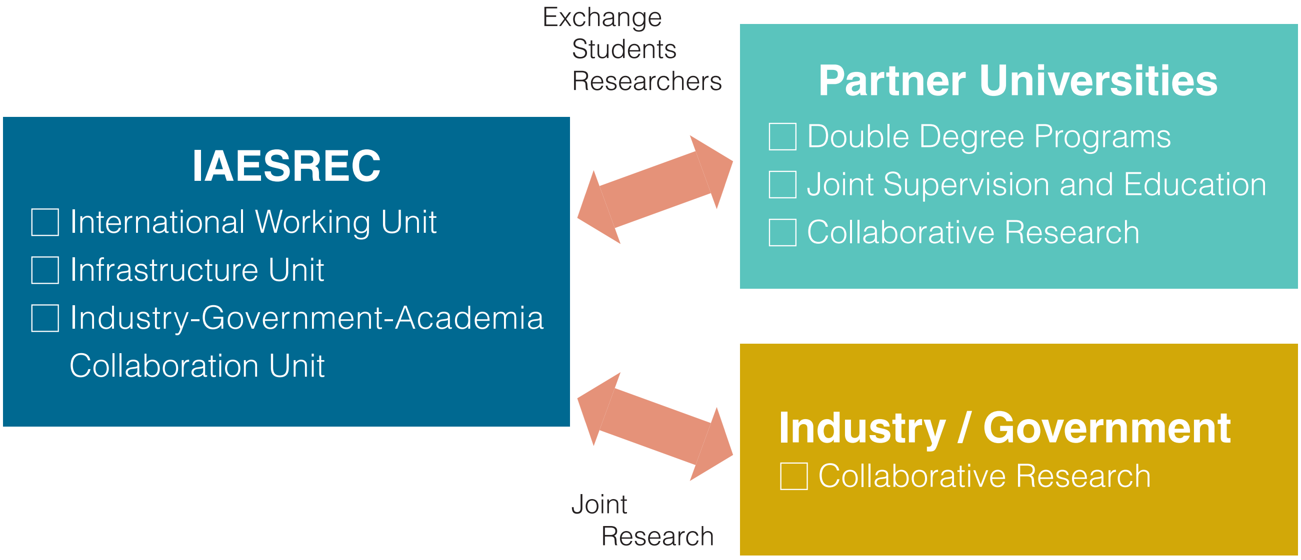
International Advanced Energy Science Research and Education Center (IAESREC)

International Research Platform for Energy Science

We offer education and research opportunities for the development of the global human resources through the international collaborative research.

International Advanced Energy Science Research and Education Center (IAESREC)

IAESREC was established with the aim of promoting research and education activities in international collaboration with other organizations such as academic institutions, government, and industry. IAESREC is responsible for not only conducting joint research, but also training students through advanced study. Additionally, we will develop international collaborative 'on-site laboratories' with our partner universities. Furthermore, IAESREC is expected to act as a nucleus for promoting international collaboration involving industrial partners.



Curriculum

For the Master's Program

- Applied Chemistry for Biomass Conversion
- Polymer Chemistry for Energy Science

Specialization and Profile Table

	Division	Group	Academic Staff	Engineering: Civil Engineering, Environment	Mechanical Engineering	Electrical & Electronics	Material Science	Earth Resources	Chemical Engineering	Nuclear Engineering	Mathematics & Information
Department of Socio-Environmental Energy Science	Social Science of Energy	Engineering for Social Systems	Prof. Keiichi ISHIHARA, Assoc. Prof. Hideyuki OKUMURA, Assist. Prof. Takaya OGAWA	○	○	○	◎	○	○		
		Energy Economics	Prof. Tetsuo TEZUKA, Assoc. Prof. Benjamin C. MCLELLAN, Assoc. Prof. Seiichi OGATA	○	○	○	○	◎	○	○	○
		Energy Ecosystems	Prof. Haruo KAWAMOTO, Assist. Prof. Eiji MINAMI	○			○		○		
	Socio-Environmental Energy Science	Energy and Information	Prof. Hiroshi SHIMODA, Assoc. Prof. Hirotake ISHII		○	◎				○	◎
		Energy and Environment	Assoc. Prof. Takayuki KAMEDA, Assist. Prof. Kouhei YAMAMOTO	◎			○	○	○		○
	Societal Energy Science	Energy Policy *	Prof. Hironobu UNESAKI, Assist. Prof. Yoshiyuki TAKAHASHI		○	○		○		◎	○
		Societal Energy Education *	Prof. Ken KUROSAKI, Assoc. Prof. Hirotoshi UEBAYASHI	◎	○	○	◎	○	◎	○	○
		Energy and Communication ***	Prof. Jun YOSHIDA								
	International Energy problems					○				○	◎
Department of Fundamental Energy Science	Energy Reactions	Energy Chemistry	Prof. Rika HAGIWARA, Assoc. Prof. Kazuhiko MATSUMOTO			○	○	○	○		
		Quantum Energy Processes	Prof. Takashi SAGAWA, Assoc. Prof. Kan HACHIYA			○	○	○	◎		
		Functional and Solid State Chemistry	Assoc. Prof. Shigeomi TAKAI, Assist. Prof. Takeshi YABUTSUKA			○	○	○	◎		
	Energy Physics	Plasma and Fusion Science	Prof. Yasuaki KISHIMOTO, Assist. Prof. Kenji IMADERA			◎	○			◎	○
		Electromagnetic Energy	Prof. Yuji NAKAMURA, Assoc. Prof. Akihiro ISHIZAWA			◎				◎	
		Plasma Physics	Prof. Hitoshi TANAKA, Assoc. Prof. Masaki UCHIDA			○				○	
	Plasma Science	High-Temperature Plasma Physics	Assoc. Prof. Hiroyuki OKADA, Assoc. Prof. Takashi MINAMI, Assoc. Prof. Shinichiro KADO, Assist. Prof. Shinsuke Ohshima		◎	◎				◎	◎
		Energy Optical Properties	Prof. Kazunari MATSUDA, Assoc. Prof. Yuhei MIYAUCHI			◎	○		○		
	Energy Materials Science	Interfacial Energy Processes **	Prof. Toshiyuki NOHIRA, Assoc. Prof. Tsutomu KODAKI, Assist. Prof. Takayuki YAMAMOTO			○	○	○	◎	○	
		Energy Nano Technology **	Prof. Hiroshi SAKAGUCHI, Prof. Masahiro KINOSHITA, Assist. Prof. Takahiro KOJIMA, Assist. Prof. Shunpei NOBUSUE			○	◎	○	○		○
		Biofunctional Chemistry **	Prof. Takashi MORII, Assoc. Prof. Eiji NAKATA, Junior Assoc. Prof. Arivazhagan RAJENDRAN, Assist. Prof. Shun NAKANO				○		○		
		Bioenergy **	Prof. Masato KATAHIRA, Assoc. Prof. Takashi NAGATA, Assist. Prof. Tsukasa MASHIMA						○		
	Nuclear Energy	Fundamental Neutron Science *	Prof. Tsuyoshi MISAWA, Assist. Prof. Yasunori KITAMURA		○	○		○		◎	○
		Heat Transport System *	Prof. Yasushi SAITO, Assoc. Prof. Kei ITO, Assoc. Prof. Cheol Ho PYEON, Assist. Prof. Daisuke ITO		◎	○			○	◎	○
	Advanced Energy Creation		Visiting Prof. Andre DEL GUERZO								

*: Research Reactor Institute, **: Institute of Advanced Energy, ***: Graduate School of Human and Environmental Studies

◎ : Closely related, ○ : Related

Agri-culture				Natural Science					Social Sciences							
Wood Science & Technology	Forest Science & Resources	Applied Biology	Bio-Environmental Science	Physics	Chemistry	Biology	Mathematics	Mineralogy & Geology	Economics	Business Administration	Politics	Law	Pedagogy & Education	Sociology	Social Psychology	**Keywords**
				○	○	○	○	○	○	○	○	○	○	○		Social Technology, Non-Equilibrium Systems, Energy Efficiency, Environmental Materials, Resources and Recycling, Applied Thermodynamics, Environmental Education
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	Energy Systems Study, Energy-system Evaluation and Planning, Framework Design, Renewable Energy, Macroscopic Viewpoints, Sustainability, Energy-Minerals Nexus
◎	◎	○	○		○	○			○							Biomass Energy, Supercritical fluids, Pyrolysis, Biorefinery, Biochemicals
			○	○		○	○			○			○	○	○	Human Interface, Man-Machine System, Augmented Reality, Communication Design
○	○	○	○	○	○	○		○					○			Atmospheric Environment, Aerosol, Hazardous Chemicals, Environmental Impact Assessment, Global Warming
				○	○				○		○	○				Energy Policy, Nuclear Energy, Energy Security, Nuclear Science, Non-Proliferation
				○	○								○			Nuclear Energy, Nuclear Fuels, Nuclear Materials, Earthquake Engineering, Strategy for Earthquake Disaster Prevention, Seismic Evaluation
											○			◎	○	Communication, Risk Society, Information Network, Public Sphere, Reflexive Modernization
							○								○	Cognitive Neuroscience, Cognitive Engineering, Human Factors, Brain Function Measurement
				○	◎											Molten Salt, Ionic Liquid, Electrochemistry, Rechargeable Battery, Fuel Cell, Functional Materials, Fluorine Chemistry
		○	○	○	◎	○										Organic Molecular Materials, Inorganic Semiconductors, Photochemistry, Solid State Physics, Photophysics, Solar Energy Utilization
		○	○	○	◎	○	○	○								Inorganic Materials Chemistry, Solid State Chemistry, Electrochemistry, Secondary Batteries, Fuel Cells, Biomaterials, Bioceramics
				◎			○									Nuclear Fusion and Plasma Theory, Turbulent Transport Physics, Space and Astrophysics Plasma, Laser-Matter Interaction
				◎												Plasma Electro-Magnetic Energy, Plasma Radiation, Plasma Diagnostics, Nonlinear Physics, Physics of Complicated System
				◎												Plasma Physics, Plasma Dynamics, Radio-Frequency Heating, Non-Neutral Plasma, Nonlinear Physics
																Heliotron J, Control of High Temperature Plasma, Plasma Heating, Plasma Diagnostics, Boundary Plasma Physics and Elementary Processes
				◎	○											Nanoscience, Nanotechnology, Solid State Physics, Solar Cell, Quantum Electronics, Data Driven Science
		○			◎	○										Electrochemistry, Molten Salt, Si Solar Cells, Secondary Batteries, Genetic Engineering, Bioenergy
		○	○	○	◎	○	○									Material Science, Physical Chemistry, Organic Synthesis, Computational Physics and Chemistry, Biochemical Engineering
		○	○		◎	○										Bioenergy, Synthetic Biology, Molecular Design of Functional Biomacromolecules, Artificial Photosynthesis
	○	○	○	○	○	○										Biomass, Bioenergy, Molecular Biology, Structural Biology, Biochemistry, Physical Chemistry
				○			○									Reactor Physics, Nuclear Characteristics, Criticality Safety, Nuclear Transmutation, Neutronics
				○			○									Thermo-Fluid Engineering, Fusion Engineering, Nuclear Engineering, Multiphase Flow Science, Particle Beam Radiography, Fluid Measurement
																Energy and Environment Problem, Sustainable Industrial Social Structure Formation, Industry-Government-University Cooperation

Specialization and Profile Table

	Division	Group	Academic Staff	Engineering							
				Civil Engineering, Environment	Mechanical Engineering	Electrical & Electronics	Material Science	Earth Resources	Chemical Engineering	Nuclear Engineering	Mathematics & Information
Department of Energy Conversion Science	Energy Conversion Systems	Thermal Energy Conversion	Prof. Takuji ISHIYAMA, Assist. Prof. Naoto HORIBE		◎			○	○		
		Conversion Systems	Prof.Hiroshi KAWANABE, Assoc. Prof. Jun HAYASHI,	○	◎				○		○
	Design for Energy Conversion Functions	Materials Design for Energy Systems	Prof. Toshihiko HOSHIDE, Assoc. Prof. Masataka ABE	○	◎		○	○			
		Design for Functional Systems	Prof. Shoji IMATANI, Assoc. Prof. Katsuyuki KINOSHITA	○	◎	○	○				○
	Functional Energy Conversion	Advanced Energy Conversion **	Prof. Satoshi KONISHI, Lecturer Juro YAGI, Assist. Prof. Keisuke MUKAI	○	○	◎		○	○	◎	○
		Plasma Energy Conversion **	Prof. Kazunobu NAGASAKI, Assist. Prof. Shinji KOBAYASHI		○	◎				◎	○
		Functional Energy Conversion Materials**	Assoc. Prof. Kazunori MORISHITA, Assist. Prof. Kiyohiro YABUUCHI		◎		◎		○	◎	
	Innovative Energy Conversion				○						
Department of Energy Science and Technology	Materials Science & Engineering for Energy Systems	Devices Physics	Prof. Toshiya DOI, Assoc. Prof. Yoshiaki KASHIWAYA			◎	◎		○		
		Process and Energy	Prof. Yasuyuki SHIRAI		◎	◎			○	○	
		Materials Process Science	Prof. Tetsuji HIRATO, Assoc. Prof. Masao MIYAKE, Assist Prof. Takumi IKENOUE			○	◎	○	○		
		Thermochemistry	Assoc. Prof. Masakatsu HASEGAWA				◎	○	○		
	Resources and Energy	Resources and Energy Systems	Prof. Mamoru MABUCHI, Assoc. Prof. Masataka HAKAMADA, Assist. Prof. Youqing CHEN	○	○		◎	◎			
		Advanced Processing of Resources and Energy	Prof. Hirohiko TAKUDA, Assoc. Prof. Takayuki HAMA		◎	○	○	○			○
		Mineral Processing	Prof. Hitoshi FUJIMOTO, Assoc. Prof. Hiromu KUSUDA, Assist. Prof. Eishi KUSAKA	○	○		○	◎	◎		
	High Quality Energy	Quantum Radiation Energy Science **	Prof. Hideaki OHGAKI, Assoc. Prof. Toshiteru KII, Assist. Prof. Heishun ZEN	○	○	○	○		○	◎	○
		The Physics of Energy Materials **	Assoc. Prof. Tatsuya HINOKI, Assist. Prof. Kouichi JIMBO		○	○	◎	○	○	◎	
		Photon Energy Science **	Assoc. Prof. Takashi NAKAJIMA		◎	◎	◎	◎	◎	○	
	Innovative Energy Sciece and Technology				○	○	○	○	○		
International Advanced Energy Science Research and Education Center (IAESREC)			Assist. Prof. Chen QU					○	◎		
			Assist. Prof. Yutaka OKAZAKI			○	○	○	◎		

*: Research Reactor Institute, **: Institute of Advanced Energy, ***: Graduate School of Human and Environmental Studies
◎ : Closely related, ○ : Related

Agri-culture				Natural Science					Social Sciences							
Wood Science & Technology	Forest Science & Resources	Applied Biology	Bio-Environmental Science	Physics	Chemistry	Biology	Mathematics	Mineralogy & Geology	Economics	Business Administration	Politics	Law	Pedagogy & Education	Sociology	Social Psychology	**Keywords**
○																Thermal Engineering, Power Engineering, Internal Combustion Engine, Air Pollutant Control
																Thermo-Fluid Dynamics, Combustion Science and Engineering, Laser Diagnostics and Image Analysis, Computational Fluid Dynamics
				○												Strength of Materials, Reliability & Integrity, Fracture Mechanics, Fatigue, Computer Simulations, Electromagnetic Materials, Material Diagnosis
																Functional and Intelligent Materials, Continuum Mechanics, Computational Mechanics, Electromagnetic Materials, Nondestructive Evaluation by Ultrasonics and Electromagnetic methods
○			○	◎	○		○									Plasma Physics, Fusion Technology, Energy Utilization, System Design, Environmental Impact, Economical Evaluation
				◎			○									Plasma Physics, Fusion Science, Microwave Technology, High-energy Neutral Beam, Plasma Diagnostics
				○												Materials Science, Advanced Nuclear Materials, System Maintenology, Computer Simulation, Material Design
				○												Engine Combustion, Optical Diagnostics, Strength of Elements, Devices for Next-generation Automobiles
				○	○											Crystal Alignment Techniques, Energy Materials, Thin Film Growth, Superconductors
																Applied superconductivity energy apparatus, Advanced electric power system, Thermal hydraulics in liquid gases
				○	◎											Materials Processing, Aqueous/Electrochemical Processing, Electrochemistry, Thin Film Coatings
					○											Chemical Thermodynamics, Thermochemistry, Steelmaking, Chemical Sensors
				○				○								Eco-Materials, Upgrade Recycling, Materials Nanotechnology
				◎			○									Thermal Fluid Engineering, Working Processes, Advanced Processing of Energy, Computational Physics, Process Simulation
				○	◎	○		○								Thermal Fluid Engineering, Resources Processing Physical Chemistry, Resource Geology, Earth System Chemistry, Materials Tailoring
				◎	○	○	○		○		○			○		Quantum-Radiation Energy, Free-Electron Laser, Accelerator Physics, Radiation Measurement, Renewable Energy Technology and Policy
				◎												Aerospace Materials, Nuclear Fission and Fusion Materials, Ceramic Matrix Composites, Environmental Resistant Materials
				◎	◎											Laser Science, Nanomaterials, Optoelectronics, Nonlinear optics
								○								State-of-the-Art in Energy Science and Technology
◎	◎	○	○													bioenergy, biomass, wood chemistry, microwave chemistry
		○	○	○	◎	○										Polymer Chemistry, Supramolecular Chemistry, Colloid and Surface Chemistry, Nanoarchitechtonics, Light Energy

Academic Programs

＊Admission Policy of the Graduate School of Energy Science

[Masters Program]

Securing energy and conserving the environment are the most critical challenges in pursuing sustainable development of the human race. To resolve urgent energy and environmental problems, the Graduate School of Energy Science was one of the first programs in the world to combine wide-ranging academic fields, including engineering, science, agriculture, economics, and law. Our philosophy is to develop a sustainable energy society by establishing theories in energy science, which is an interdisciplinary field that incorporates a humanistic perspective into science and technology, and fostering people who contribute to the harmonious coexistence in a global society with high-level abilities and an international perspective. Based on this philosophy, we provide education as described in the curriculum policy. We welcome students and working professionals from around the globe. We are looking for new students who embody the qualities below across all fields of study.

(1) A desire to solve energy and environmental problems and contribute to social development through research work in the energy science field;
(2) Individuality and creativity, not bound by the established principles;
(3) Basic academic abilities;
(4) Capacity to think logically; and
(5) Strong communication skills necessary to collaborate with energy science researchers around the world and society in general.

To realize the policy above, the Graduate School of Energy Science has introduced various entrance exams by combining written exams to assess basic academic abilities, including English and logical thinking, as well as specialized knowledge related to energy science, document screening of undergraduate performance, and oral exams as necessary.

[Doctoral Program]

Securing energy and conserving the environment are the most critical challenges in pursuing the sustainable development of the human race. To resolve urgent energy and environmental problems, the Graduate School of Energy Science was one of the first programs in the world to combine wide-ranging academic fields, including engineering, science, agriculture, economics, and law. Our philosophy is to develop a sustainable energy society by establishing theories in energy science, which is an interdisciplinary field that incorporates a humanistic perspective into science and technology, and fostering people who contribute to a harmonious coexistence in a global society with high-level abilities and an international perspective. We welcome students and working professionals from around the globe. We are looking for new students who embody the qualities below across all fields of study.

(1) A desire to pursue advanced research to solve energy and environmental problems and contribute to social development through research work in the energy science field;
(2) Individuality and creativity not bound by the established principles and a passion for solving challenges in new fields of study and research;
(3) Highly specialized knowledge, the capacity to think logically, and ability to advance research on energy science;
(4) Ability to pursue research by establishing and achieving goals and themes based on an international perspective and advanced specialized ability as an energy science researcher; and
(5) Logical and strong communication skills necessary to collaborate with energy science researchers around the world.

To realize the policy above, the Graduate School of Energy Science has introduced various entrance exams by combining written exams to assess basic academic abilities, including English and logical thinking, as well as highly specialized knowledge related to energy science, document screening of performance in the Masters program, Masters thesis, and research plans, and oral exams as necessary.

＊Curriculum Policy of the Graduate School of Energy Science

[Masters Program]

In each field of study, we provide introductory courses and specialized courses that combine lectures, exercises, experiments, and lab work to achieve the goal described in the diploma policy. Some courses are offered in English. The curriculum is developed based on the policy below.

(1) Courses are designed to develop basic academic abilities and specialties gained in the undergraduate program. An interdisciplinary curriculum is organized and implemented to cover natural sciences, humanities, and social sciences regardless of the field of specialization to help students obtain wide-ranging knowledge and specialized knowledge in their fields. Academic performance in each course is assessed based on written exams, a term paper, and/or the results of exercises, experiments, or lab work.
(2) Priority is given to writing a Masters thesis by actively working on theme-based research that contributes to energy science academically and practically through instructions, seminars, and practical education. Through these endeavors, students develop highly ethical values, the capacity to pursue research, and the ability to logically explain research results. Academic performance is assessed by three examiners.

The curriculum developed based on the policy above is given as a curriculum map. Additionally, a description of each course is clearly stated in the syllabus.

[Doctoral Program]

We provide specialized courses that combine lectures, exercises, experiments, and lab work to achieve the goal described in the diploma policy. Some courses are offered in English. The curriculum is developed based on the policy below.

(1) Courses are designed to develop wide-ranging academic knowledge and highly advanced specialized knowledge gained during the Masters program. The curriculum is organized and implemented to help students structure their research from a broad perspective to identify their position, learn more advanced specialized knowledge, and develop research techniques to address energy and environmental problems. Academic performance in each course is assessed based on written exams, a term paper, and/or the results of exercises, experiments, or lab work.
(2) Priority is given to writing a doctoral dissertation by actively working on advanced theme-based research that contributes to energy science academically and practically through instructions, seminars, and practical education. Through these endeavors, students develop highly ethical values, an outstanding capacity to plan and pursue research, and the ability to logically explain research results. Academic performance is assessed by three examiners.

The curriculum developed based on the policy above is given as a curriculum map. Additionally, a description of each course is clearly stated in the syllabus.

∗Diploma Policy of the Graduate School of Energy Science

[Masters Program]

To meet societal expectations, the Graduate School of Energy Science equip students with international perspectives, advanced specialized skills to address energy and environmental issues, and the ability to contribute to the coexistence within a global society. To this end, a Masters degree is conferred upon students who are enrolled for the specified number terms, successfully complete all courses according to the curriculum policy, surpass the minimum credit requirement, and pass the defense and exams for a Masters thesis. Students who make remarkable advancements in their studies and research can complete the Masters program in a shorter enrollment period. Additionally, students must achieve the following goals:

(1) Demonstrate highly advanced specialized knowledge to address energy and environmental problems based on broad perspectives and multilateral knowledge supported by a specialized academic ability;
(2) Possess highly ethical values in academic research in the energy science field;
(3) Exhibit the ability to pursue research by planning and executing goals and themes based on the knowledge, techniques, and capacity in the energy science field;
(4) Logically explain and effectively communicate an international appeal to develop a deeper mutual understanding with other researchers in their fields of specialty or related fields; and
(5) Defend a Masters thesis, which contains research results that contribute to energy science academically or practically.

[Doctoral Program]

To meet societal expectations, the Graduate School of Energy Science equip students with international perspectives, advanced specialized skills to address energy and environmental issues, and the ability to contribute to the coexistence within a global society. To this end, a Doctoral degree is conferred upon students who are enrolled for the specified number of terms, successfully complete courses according to the curriculum policy, surpass the minimum credit requirement, and pass the defense and exams for a doctoral dissertation, which is written based on required academic instructions. Students who make remarkable advancement in their study and research can complete their Doctoral Degree in a shorter enrollment period. Additionally, students must achieve the following goals:

(1) Demonstrate highly advanced specialized knowledge and research techniques to establish and practice measures to address energy and environmental problems, while further developing advanced specialized knowledge and broader knowledge as well as structuring research from a broad perspective;
(2) Possess highly ethical values in academic research in the energy science field;
(3) Exhibit the ability to pursue research by planning and executing goals and themes based on the knowledge, techniques, and the capacity in the energy science field to address, plan, and implement collaborative research with other research institutions as necessary;
(4) Logically explain and effectively communicate an international appeal to develop a deeper mutual understanding with other researchers in their fields of specialty or related fields; and
(5) Defend a doctoral dissertation, which contains remarkable research results that contribute to energy science academically or practically.

* Requirements for the Master's Program

A Master's degree candidate is required to take at least 30 credits from the following listed subjects, to submit a master thesis guided by his/her supervisor(s), and to pass thesis examinations. No credit is offered for a thesis.

Group A Subjects : Required subjects for the home department and a thesis.
Group B Subjects : Elective subjects offered by the home department.
Group C Subjects : Elective subjects offered by the three departments other than the home department.
Group D Subjects : Elective subjects offered by other graduate schools.

List of credit requirements and amounts:

Department	A	B[1]	B[2]	C	D
Department of Socio-Environmental Energy Science	8	≧ 14* **	≧ 8*		
	A	B		C	D
Department of Fundamental Energy Science	≧ 12*	≧ 10, ≦ 18*		≦ 10*	≦ 8*
Department of Energy Conversion Science	≧ 6	≧ 10, ≦ 22*		≧ 2, ≦ 10*	≦ 6*
Department of Energy Science and Technology	≧ 6	≧ 10		≦ 8*	≦ 6*

* Credits taken over these maximums will not be counted for the required 30 credits.
** Mandatory 4 credits from Required Subjects and minimum 10 credits from Elective Required Subjects

* Requirements for the Doctoral Program

A Doctoral Degree candidate is required to take at least 4 credits from the subjects offered by the Graduate School, to submit a doctoral thesis guided by his/her supervisor(s), and to pass thesis examinations.

Number of Overseas Students

	Academic Year									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Master's Program	11 (2)	13 (4)	14 (2)	14 (1)	19 (5)	18 (3)	20 (2)	26 (5)	29 (5)	39 (2)
Doctoral Program	42 (33)	46 (31)	47 (28)	49 (27)	41 (24)	31 (17)	28 (16)	35 (15)	34 (15)	33 (7)
Others	2 (1)	3	3 (1)	3	4 (1)	2	6 (2)	6 (2)	3 (1)	7 (3)
Total	55 (36)	62 (35)	64 (31)	66 (28)	64 (30)	51 (20)	54 (20)	67 (22)	66 (21)	79 (12)

(As of may 1st of each year)

( ) : Students who were supported by the government.

I. The Number of Students to be admitted in Academic Year 2020

Department	Master's Program	Doctoral Program
Department of Socio-Environmental Energy Science	29	12
Department of Fundamental Energy Science	42	12
Department of Energy Conversion Science	25	4
Department of Energy Science and Technology	34	7
Total	130	35

Overseas students may elect to apply under a category set aside specifically for international students.

II. Qualifications for Applications

＊ Master's Program

Applicants for the master's program must satisfy one of the following requirements.

1. Graduation from a university in accordance with Article 83 of the School Education Law (Law No.26, 1947).
2. Receipt of a Bachelor's degree in accordance with Article 104 Paragraph 4 of the School Education Law (Law No.26,1947).
3. Completion of 16 years of school education abroad.
4. Completion of 16 years of school education of a foreign country through correspondence courses offered by a foreign school while staying in Japan.
5. Completion of a university's program of a foreign school in Japan designated by the Minister of Education, Culture, Sports, Science and Technology. This solely applies to those completing 16 years of school education of said foreign country.
6. Receipt of a degree equivalent to a bachelor's degree by completing a curriculum with a term of residence of at least three years (including completion of such a curriculum by studying relevant subjects in Japan via a correspondence course provided by a school in a foreign country and completion of a curriculum at an educational facility that has been accredited as having an approved curriculum under the educational system of said country and is designated as such in the preceding paragraph) at a university or other school in a country other than Japan (only those universities or schools for which the overall conditions of education and research activities have been assessed by a party authorized by the government of said country or an organization concerned, or those corresponding to such entities as designated by the Minister of Education, Culture, Sports, Science and Technology)
7. Completion of a professional program at a vocational school accredited by the Minister of Education, Culture, Sports, Science and Technology after the date validated by the Minister.
8. Designation by the Minister of Education, Culture, Sports, Science and Technology (Notification No.5 of the Ministry of Education, 1953).
9. Recognition by the Graduate School as having completed prescribed credit hours with excellent results during 3 years in a university in Japan or recognition by the Minister of Education, Culture, Sports, Science and Technology as having an equivalent academic level in accordance with Article 102 Paragraph 2 of the School Education Law.
10. Recognition by the Graduate School through individual entrance qualification screening as having academic standards equivalent to those of university graduates and be at least 22 years old.

＊ Doctoral Program

Applicants for the doctoral program must satisfy one of the following requirements.

1. Possession of a Master's Degree, Professional Master's Degree or Juris Doctor Degree.
2. Completion of a program abroad equivalent to the Master's Program or the professional degree program of Kyoto University Graduate School.
3. Completion of the a program equivalent to a Master's Program or professional degree program of Kyoto University Graduate School by completing a correspondence course conducted by a graduate school of a university abroad while residing in Japan.
4. Completion of a foreign graduate school program (only if the program is equivalent to a Master's Program or professional degree program of Kyoto University Graduate School) in Japan at an educational facility that has been accredited as having an approved program under the educational system of said country and is so designated by the Minister of Education, Culture, Sports, Science and Technology.
5. Completion of a curriculum at the United Nations University (under the provisions of Paragraph 2 of Article 1 of the Act on Special Measures Incidental to Enforcement of the Agreement between the United Nations and Japan regarding the Headquarters of the United Nations University, Act No. 72 of 1976), and receipt

of a degree equivalent to a Master's Degree.

6. Applicants who have passed a Qualifying Examination or equivalent assessment at an institution in another country,and are recognized by Kyoto University as having academic ability on a par with or higher than that of a person with a master's degree.
7. Designation by the Minister of Education, Culture, Science, Sports, and Technology.
8. Recognition by the Graduate School of Energy Science of Kyoto University as having a scholastic ability on a par with or higher than that of a person eligible under Paragraph 1 as a result of an individual screening of qualifications, where the applicant is aged 24 or over.

III. Entrance Examination Dates (Academic Year 2020)

＊Exam. for Master's Program is scheduled in August.

The Department of Fundamental Energy Science schedule an additional 2nd time entrance exam. in September. Also as for international applicants, there is a special selection in February.
The above is the information in 2019. Please confirm the guidelines for applicants in 2020 for details.

＊Exam. for Doctoral Program is scheduled in August 2019 and February 2020.

The number of doctoral course students to be admitted listed above are for the academic year starting in April 2020. A small number of students (including overseas students) is admitted to enter the doctoral course from October 2020 through examinations held on the same day.

In addition to the entrance examination dates listed above, a small number of students (including overseas students) may be admitted through examinations held in February. This is not the exact guide for the entrance examination. For details, please contact the admissions office of the Graduate School of Energy Science (see IV).

IV. For further information, contact

The admissions office
The Graduate School of Energy Science.
Kyoto University
Yoshida Honmachi, Sakyo-ku,
Kyoto 606-8501 JAPAN
TEL: (+81) 75-753-9212
FAX: (+81) 75-753-4745

INTERNATIONAL EXCHANGE AFFAIRS

1. International Collaborations

The Graduate School of Energy Science (GSES) has established international exchange agreements with top level universities and institutes to promote mutual cooperation on education and scientific research. Under the agreements, the following general forms of cooperation will be pursued:

(1) Joint research activities

(2) Invitations to academics and researchers for lectures and seminars, and participation in conferences, colloquia and symposia

(3) Exchange of scientific material and information

(4) Exchange of faculty members and students for study and research

Currently, agreements with over 25 counterparts have been concluded, in cooperation with other schools and institutes of Kyoto University.

2. Promoting Student Mobility

Since its establishment, the GSES has received students from outside of Japan, and has also promoted short-term study abroad for our own students. The GSES has started a student mobility program with ASEAN University Network (AUN) member universities in cooperation with other graduate schools of Kyoto University. The summer/winter school programs have been held in Kyoto to create opportunities for the undergraduate students from AUN member universities and Kyoto to study about energy in both home and host universities. Furthermore, a double master’s degree program with some AUN universities and a double doctor's degree program with University of Bordeaux have been initiated.

IESC Orientation day

Fild trip to Kansai Electric Power Plant in Maizuru

3. Exchange of Researchers

GSES has invited visiting professors from abroad as teaching staff. They are selected from highly active researchers in various academic fields, who may collaborate with our faculty and give students an opportunity to learn specialized subjects in English.

Individual departments and chairs have received researchers from various countries such as France, Sweden, Singapore, Canada, China, Egypt, Malaysia, Australia, Thailand, and others. Annually, around 100 researchers are dispatched to universities and research institutions abroad, contributing greatly to development of the international academic network on energy science. In addition, members of the GSES have organized numerous international conferences. In the academic year 2018, the school organized or co-organized six international conferences in Japan (4), India (1) and South Korea (1).

International Energy Science Course

Energy is the challenge of our age, fundamentally involved in critical human survival issues of local and global concern such as climate change, economic growth, national and regional security. Individuals who have acquired systematic scientific knowledge in the relevant fields and broad and deep insight into underlying component technologies are therefore sought after across the world. To respond to this need, all the four departments of Kyoto University's Graduate School of Energy Science run postgraduate degree programs on energy in English-the "International Energy Science Course" (IESC). For the IESC, good command of academic English for course work and research is essential, while Japanese proficiency is not.

The two-year Master's program is a combination of coursework and research. Students are taught a wide spectrum of subjects - from the basics to cutting-edge research on production, storage, transportation and consumption of energy. At the same time, students conduct research on their own topic, chosen from a wide range of research areas offered by the school. The program aims to teach students methods for research and development of energy technology in support of a sustainable society.

Students are admitted based on application documents and an interview with staff of the Graduate School of Energy Science. The IESC Master's course commences in October each year. (Enrolment timing and conditions are subject to change. Please download the latest application guide from our website.) The research group or laboratory to which students will be assigned for their research is determined with consideration to their preferences and notified at the announcement of admissions results.

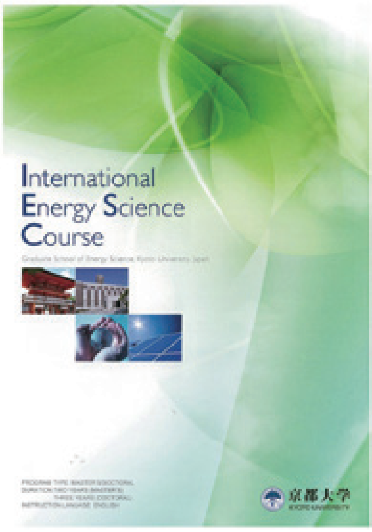
The IESC doctoral program provides Master's graduates with the opportunity to further their study toward a doctoral degree by conducting research of the highest standards. The medium of instruction is English and the standard course duration is three years full time. Prior contact to a prospective supervisor to discuss a research plan is essential.

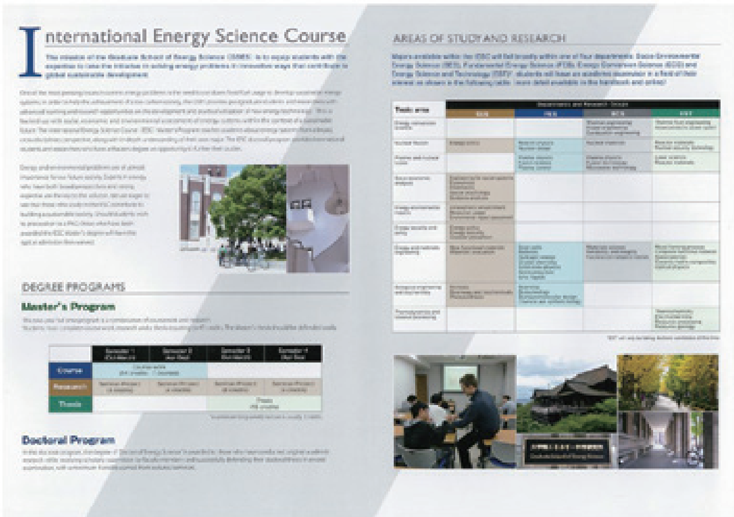
The IESC Master's program is offered by the departments of Socio-Environmental Energy Science, Fundamental Energy Science and Energy Conversion Science, while IESC Doctoral program is offered by all the four departments of Graduate School of Energy Science, including the department of Energy Science and Technology. For details of the research fields of these departments, please see pages 6-31 and the table on pages 34-37. For further information on the course, please see the website.

http://www.energy.kyoto-u.ac.jp/en/

A typical IESC class

	MASTER'S	DOCTORAL
Departments	Socio-Environmental Energy Science/ Fundamental Energy Science/ Energy Conversion Science	Socio-Environmental Energy Science/ Fundamental Energy Science/ Energy Conversion Science/ Energy Science and Technology
Degree conferred	Master's (Master of Energy Science)	Doctoral (Doctor of Energy Science)
Course duration	Two years, full-time	Three years, full-time
Required credits	Minimum of 45 credits	Minimum of 4 credits
Thesis & defence	Master's thesis, viva-voce	Doctoral thesis, viva-voce
Enrolment capacity	10 students per annum	10 students per annum
Enrolment	October	April and October
Application deadlines	January - February	June - July (April intake) January - February (October intake)





IESC brochure

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