Institute of Advanced Energy

Kyoto University

2017

http://www.iae.kyoto-u.ac.jp

Foreword

Director

Yasuaki Kishimoto

The various forms of energy that sustain the existence and activities of humanity and the matter generating them were created in the ingenious and subtle workings in nature, some of which seem to have been incredibly fortuitous, such as the birth of the universe—estimated to have occurred 13.8 billion years ago—and the later emergence of the sun, the earth, and life itself. Reflecting on all this, we could be requested to understand how such energy and matter have been produced in universe and how such subtle mechanisms of nature have been existed, and then to pursue the safe forms of 21-century energy that excels in terms of both "quality" and "quantity".

The Institute of Advanced Energy was established in May 1996 for the purpose of conducting energy science by probing into the laws and basic principles of nature, as well as investigating new, next-generation forms of energy under the development of state-of-the-art technology to utilize them for practical applications. For this purpose, the institute's 14 sections are organized as three divisions, each dedicated to one of the three basic kinds of energy processes: energy generation, energy conversion, and energy utilization. On top of this, we set up the Laboratory for Complex Energy Processes. This laboratory organically integrates the 14 disciplines to enable us to tackle complex research projects and academically demanding research challenges. Already, this unique lab has produced a wealth of research findings. Furthermore, we actively pursue the internationalization of research exchanges and participate in industry–academia–government collaboration to channel the fruits of our research back into society for the public good. The institute is also in charge of the Graduate School of Energy Science's Cooperating Chair, which conducts student education and trains researchers in a leading-edge research environment.

In 2011, the institute began operating as a "Joint Usage / Research Center" under the name Zero-Emission Energy System, applying the energy ideals of the institute to the challenge of "zero emissions". Under this initiative, the institute employs its broad variety of resources to promote collaboration/cooperation and the formation of communities across multiple academic disciplines. As it happens, the research center was launched around the time of the Great East Japan Earthquake, an event that spurred Japan to look more deeply at the question of energy, and ever since the center has grown apace with national efforts to recover from the disaster. We would like to express our sincere gratitude to everyone for their support and cooperation thus far in the efforts of this unique research center.

At this point of the 21st century, scientific research is at an important crossroads, both in Japan and internationally, because the integration of different disciplines is now indispensable to achieving significant development, just as the cross-stitching of different two vertical and horizontal threads is essential to creating a beautifully patterned fabric. The integration of different disciplines is no easy matter, however. It cannot be achieved just by the limited staff of one research institute. New knowledge and new people must be constantly brought in from the outside to stimulate spirited debate and bold initiatives. Then through such efforts, new ideas are developed and applied in the real world, to explore new value, which then returns to the institute. Integration can be truly achieved only through a "circular" process such as this. Internationally too, as an energy research adopts assorted new ideas and technological innovations in the pursuit of scientific advancement, what we select and what we aim at are the important key issue. Keeping this firmly in mind, everyone at the institute works together and contributes actively to discovering insights, without limiting themselves to existing methods and concepts. Through exhaustive debate within a broad context that encompasses the whole of society, the institute is constructing a foundation for a new style of energy science and technology suited to 21st-century needs. As we make this effort, we look forward to your support and cooperation.

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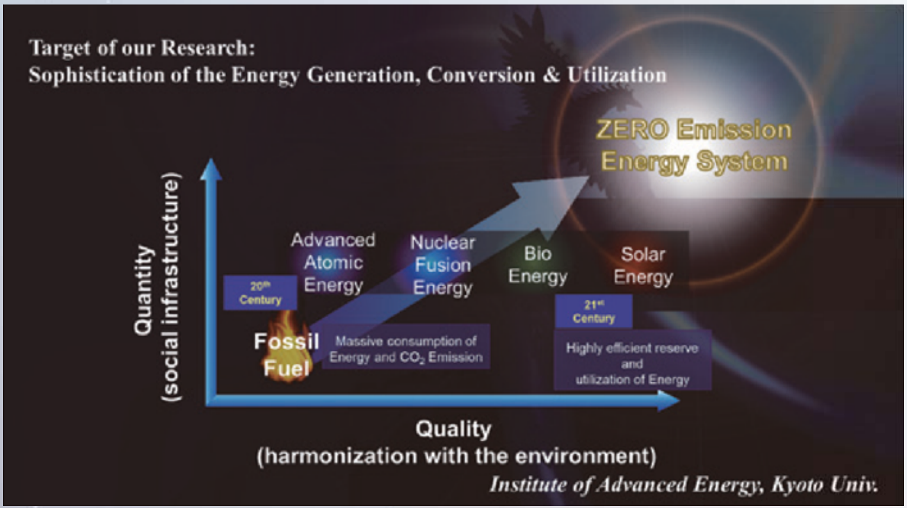
Mission and Goal

The Institute of Advanced Energy (IAE) was established to promote researches to sophisticate the generation, conversion, and utilization of energy. Our goals are
(a) to conduct pioneering research on advanced energy science and technology,
(b) to propose solutions to energy and environmental issues associated with rapid global population expansion,
(c) to contribute to the sustainable progress of humankind.

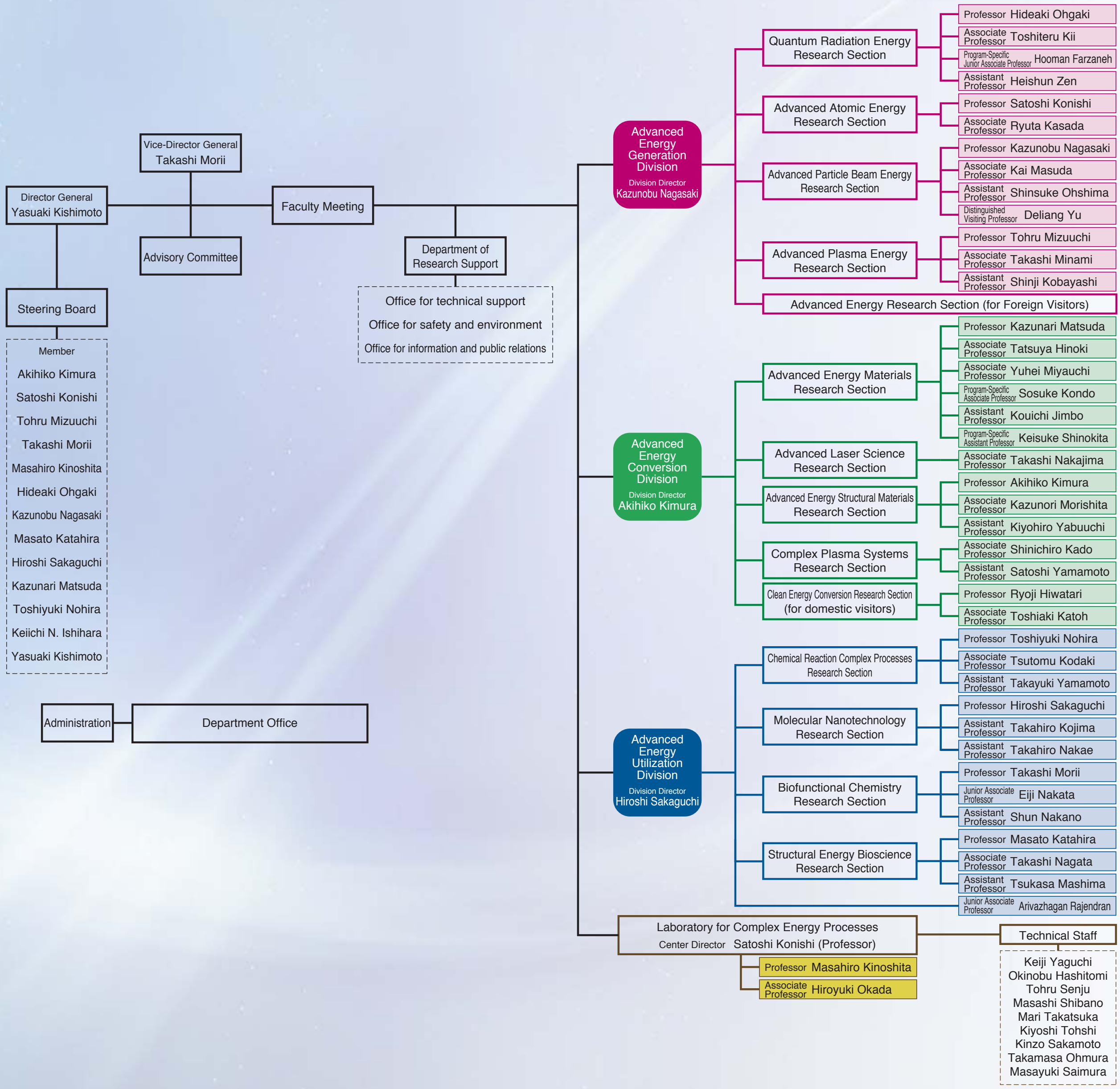
We perform comprehensive approach towards development of next-generation energy systems, which have the potential to replace existing energy systems, with two viewpoints, Quality (harmonization with the environment) and Quantity (social infrastructure). In order to secure sustainable energy resources or systems, our research activities emphasize improving the performance of energy systems, developing new energy resources, and realizing systems for effective use of energy resources, which can be named as Zero-Emission Energy System. Moreover, through these endeavors, we aim to foster scientists and engineers who possess advanced knowledge and skills in energy science and technology.

To meet our objectives, we strive to further develop the research field of Advanced Energy (or Zero-Emission Energy) by building an innovative energy system that has high social receptivity, as well as by developing a system capable of incorporating various sources of energy. Human and research resources at IAE, which are from diverse academic backgrounds, will be strengthened and organically coordinated among different research fields, thereby promoting interdisciplinary and fused research. IAE serves as a hub for advanced energy research in Japan and around the globe.

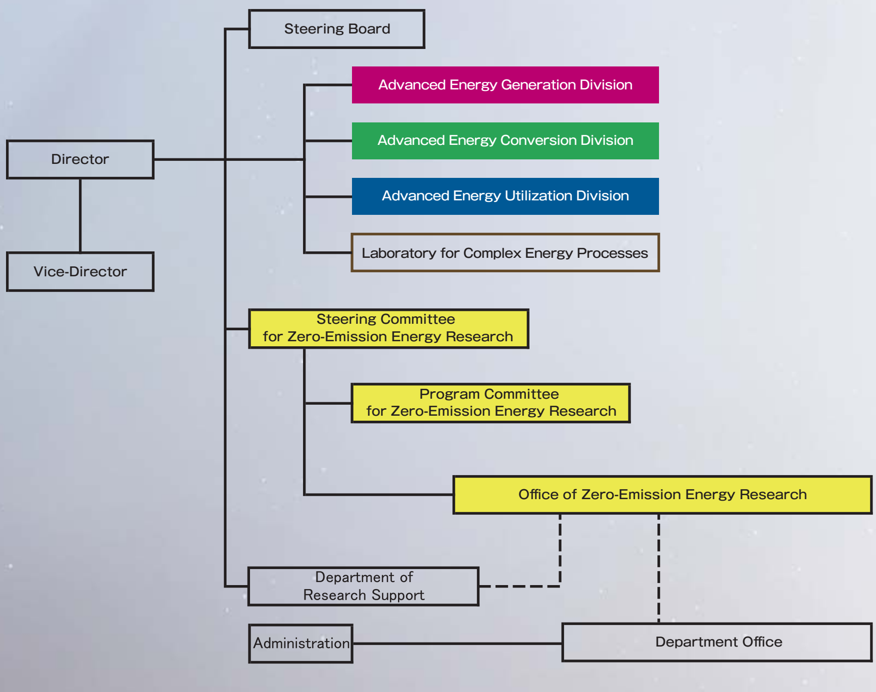
These activities will further pioneer and develop advanced energy research to bridge us to the next generation and contribute to the growth of society.



Organization Chart



Organization for Zero-Emission Energy Research Project



History


Engineering Research Institute


10th Anniversary of Kyoto University Engineering Research Institute

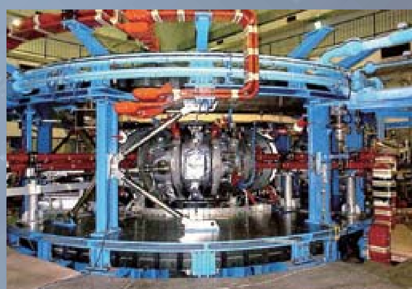

Institute of Atomic Energy

Institute of Advanced Energy Inaugurated

- **1914** Research Center in Faculty of Engineering
- **1941** Engineering Research Institute with 5 divisions
- **1959** Heliotron A
- **1960** Heliotron B
- **1965** Heliotron C
- **1966** Plasma Physics Laboratory (Faculty of Engineering)
- **1968** Moved from the Main Campus to Uji Campus
- **1969** Laboratory for Nuclear Reactor Safety Analysis
- **1970** Heliotron D
- **1971** Renamed to Institute of Atomic Energy with 8 Research divisions
- **1972**
- **1975**

Plasma Physics Laboratory

- **2016** Start of "Joint Usage/Research Program on Zero-Emission Energy" (2016-2021)
- **2011** Start of "Joint Usage/Research Program on Zero-Emission Energy" (2011-2015)
- **2010** NMR
- **2006** Laboratory for Complex Energy Processes reorganized
- **2004** National University Corporation Kyoto University
  - Laboratory for Photon and Charged Particle Research, DuET, KU-FEL
  - Laboratory for Energy Nano-Science Research
- **1999** Heliotron J
- **1996** Institute of Advanced Energy
  - Laboratory for Complex Energy Processes
- **1983** Plasma Energy Direct Energy Conversion Laboratory
- **1981** High Temperature Liquid Sodium Heat Transfer Experimental Facility
- **1980** Heliotron E
- **1976**
- Heliotron DM
- Magneto Plasma Research Laboratory



Heliotron J

DuET

NMR

KU-FEL

Division Introduction

Advanced Energy Generation Division

We promote the development of socio-friendly and fundamental "zero-emission energy system" that should be an inevitable issue sustainable future of humankind, and innovative energy sources with particular function including their application technology.

Advanced Energy Conversion Division

Aiming at the efficient conversion of energy functions and the generation of new energy functions, this division studies fundamental energy-material interaction and its applications, efficient energy-conversion processes, and the development of functional energy materials.

Advanced Energy Utilization Division

The aim of division is the establishment of 'Emergent Materials Science' having a similar concept seen in energy-related processes in nature, efficiently converting 'soft energy' into 'electricity' and 'valuable chemicals' without huge consumption. The research projects ongoing cover the researches of energy-related materials sciences, chemistry and biosciences for the development of new technologies for renewable energy conversion and utilization.

Laboratory for Complex Energy Processes

This Laboratory is a core research center for multidisciplinary collaboration studies in IAE, offering a lot of important functions of the cooperative academic activities in the field of the advanced energy. The Laboratory have three divisions for promotion of (1) "Advanced Studies on Plasma Energy and Quantum Energy", (2) "Innovative Studies of Nano-Bio Functional Materials for Energy Technology", and (3) "International Collaborative Research". In addition, the study of plasma energy is performed also under the inter-university collaboration of the Bilateral Collaborative Research Program by National Institute for Fusion Science, Japan.

Interactions among Divisions

The Institute of Advanced Energy has three divisions including "Advanced Energy Generation Division", "Advanced Energy Conversion Division", and "Advanced Energy Utilization Division". Each division conducts distinct research from their own viewpoints as described in next section. In addition to these researches, interdisciplinary research is also necessary to develop advanced energy indispensable for the sustainable development of humankind and to realize next generation energy systems, especially our current targeted energy, "Zero-Emission Energy".

Towards this goal, the Laboratory for Complex Energy Processes has been promoting interdisciplinary collaborative research projects among three divisions since the establishment of the laboratory. Such collaborations through the projects now focused on two research fields of "Advanced Plasma & Quantum Energy" and "Photon-&-Nano-Technology for Energy". This multilayered structure of our research activities has enhanced the comprehensive capabilities of the institute, thereby creating a unique research institute that differs from the other energy related institutes.

Quantum Radiation Energy Research Section

Research on Generation and Application of New Quantum Radiations, i.e. Compact MIR Free Electron Laser, Table-Top THz FEL, Laser-Compton Gamma-ray, and clean energy policy. International collaboration research on efficient utilization of low rank coal and biomass and renewable implementation in ASEAN.

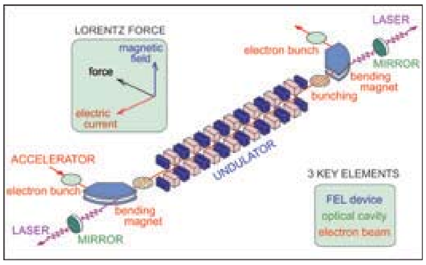
Generation and Application of New Quantum Radiation

Professor
Hideaki Ohgaki

Associate Professor
Toshiteru Kii

Assistant Professor
Heishun Zen

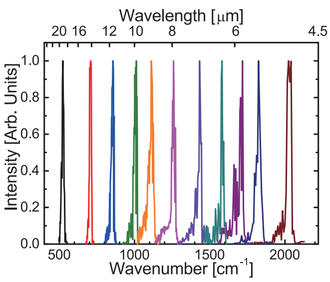
Generation and application of new quantum radiations from relativistic electron beams have been studied. Free electron laser, which is generated by a high brightness electron beam from accelerator, is considered as one of new generation radiation sources. FEL is tunable laser with a high power. We have developed a thermionic cathode RF gun with our original RF control system to generate mid-infrared FEL with compact accelerator system. In 2008 we succeeded in FEL power saturation at 13.6μm in wavelength and now the FEL can provide the intense laser light in the wavelength region from 3.6 to 25μm. As application researches, we promote the mode-selective phonon excitation experiment to contribute research on "next generation solar cell" in cooperation with in-house users as well as outside users. Generation and application of Laser-Compton Gamma-ray beam which will be a powerful inspection probe for hidden material for securing national security. A short period undulator consists of bulk high Tc superconducting magnet and table- top THz SASE-FEL have been studied as well.



Principle of FEL

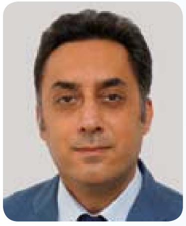
Generation of Free Electron Laser (FEL) is based on the micro-bunching phenomenon driven by a high brightness electron beam which interacts with electro-magnetic field.

Wavelength Tunability of KU-FEL



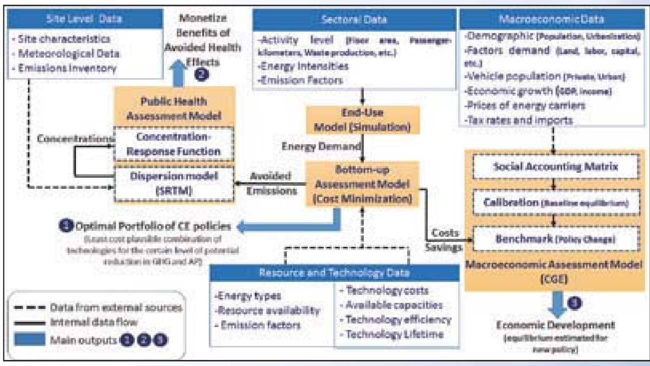
This graph shows the wavelength tenability of KU-FEL. We can freely change the FEL wavelength from 5 to 20μm by changing the electron beam energy from 36 to 20 MeV. The spectral width of the FEL is around 3 percent in FWHM.

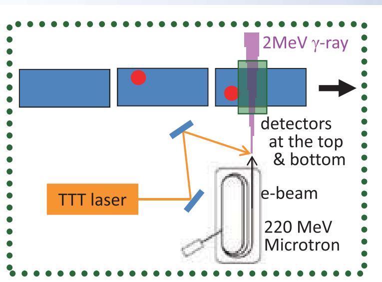
Assessing the benefits and impacts of clean energy development in Asian mega cities



Program-Specific Junior Associate Professor
Hooman Farzaneh

Within Asia, the most significant increase of energy consumption and climate change is expected to take place in mega-cities, whose rapidly expanding populations enjoy higher living standards and material affluence than do people in rural areas and smaller cities. My research focuses on demonstrating how clean energy policies and programs can help achieve multiple energy, environmental, public health and economic benefits in a cost-effective way in Asian mega cities. To this aim, a robust integrated modeling framework is developed which tends to be characterized by extensive underlying data and relatively complex formulation that represents the fundamental engineering and economic decision making of the society at a city level. The four mega-cities which will be evaluated in detail in this research are Tokyo, Seoul, Delhi and Shanghai. In the first phase of the research, activities will focus on evaluating the existing clean energy policy developments, countermeasures and challenges in selected cities. In the second phase, activities will concentrate on designing strategic plans that achieve greater or border benefits in selected cities. This project is supported by the Unit of Academic Knowledge Integration Studies of Kyoto University.





Conceptual drawing of the assay system for hidden material by using Laser-Compton backscattering gamma-rays

Quasi-monochromatic gamma-ray beam generated by collision between a high energy electron beam and a high power laser can be used for detection of hidden dangerous material.

Advanced Atomic Energy Research Section

We design and develop the zero-emission energy system powered by fusion, from its generation to utilization, and analyze it from environment, socioeconomics, and sustainability aspects.

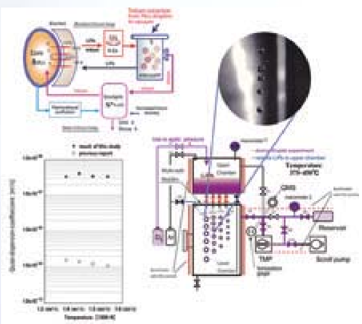
Design, Development and Assessment of Fusion Energy Systems

Professor
Satoshi Konishi

Associate Professor
Ryuta Kasada

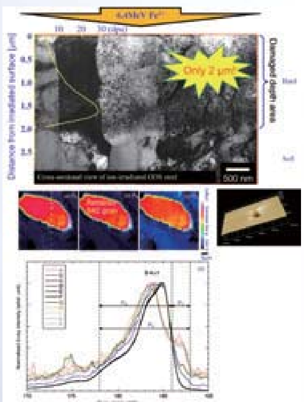
Zero-emission energy system that has little constraints of resource and environment is expected to provide ultimate solution of the environmental problem and sustainable development of human in the global scale. We study the fusion energy system design and development, as well as the integrated evaluation from social and environmental aspects. Development of new type of fusion device to generate neutron beam, conversion of fusion energy using advanced divertor and blankets, and application of energy for the production of biomass-based hydrogen and synthetic fuel are performed. Behavior of fusion fuel tritium to prove its self-sufficiency in the reactor and minimize the impact in the environment, social risk literacy of fusion energy are also studied. Thus fusion energy system is investigated from its generation to the application and adaptation to the future society and its evaluation. We are one of the leading research team of fusion technology, and regarded as a key station of international collaboration. Study of "Sustainability" on energy and environment is also our major topic.

R&D to achieve a viable fuel self-sufficiency for the fusion reactor system



We study advanced high temperature fusion reactor blankets using liquid lithium-lead eutectic alloy and lead the world in the development and of innovative tritium recovery system so-called vacuum sieve tray. In addition, we conduct integrated research including compatibility between lithium-lead and various structural materials, heat transfer performance and so on.

A new approach to evaluate irradiation hardening of ion-irradiated materials using nano-indentation technique



Toward the realization of innovative atomic energy materials and systems, we are developing irradiation-resistant and environmentally-concious materials by multi-scale and multidisciplinary approach in bird's-eye views from nano-scale matters to the energy strategy. To do this, we are also promoting the development of advanced materials analysis methods, such as ultra-small testing technologies (USTT), which can be utilized to the evaluation of the structural and physical properties of other energy materials.

Advanced Particle Beam Energy Research Section

High-power microwave system, compact neutron/proton sources driven by fusion plasmas, plasma diagnostics, highly brilliant relativistic electron beam are being developed by controlling charged particles and electromagnetic field.

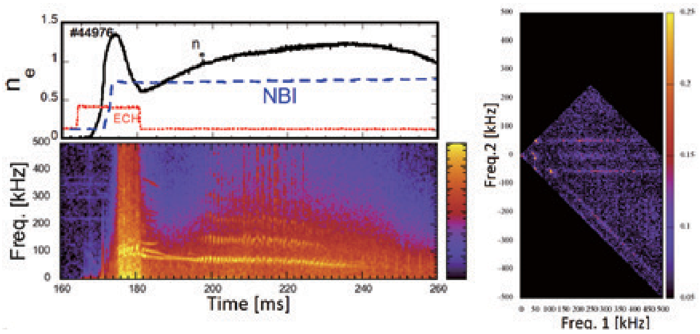
Development of Advanced Energy by electromagnetic waves and particle beams

Professor
Kazunobu Nagasaki

Associate Professor
Kai Masuda

Assistant Professor
Shinsuke Ohshima

Advanced and innovative control methods for the collective behavior of charged particles are being developed in this research section to bring about enormous contributions to the human beings. Emphasized are particularly studies of nonlinear interactions between charged particles and electromagnetic fields. Production, heating, current drive and MHD suppression of fusion plasmas by electron cyclotron resonance are studied by using high-power microwave sources such as magnetrons and gyrotrons. Application of microwaves is also targeted for the development of heating and current drive systems. Clarification and understanding of physical mechanism of fluctuations existing inside the plasma is also a key issue to achieve high performance plasma because a variety of instabilities can act to transport plasma and determine the plasma confinement. Hence, advanced diagnostic tools with higher spatio-temporal resolutions such as microwave diagnostics and multichannel Langmuir probes and novel technique of fluctuation data analysis are developed and approached. Also studied are production and application of energetic particles: Production of highly brilliant relativistic electron beams are studied for the development of advanced light sources such as free electron lasers. Compact neutron/ proton sources based on Inertial Electrostatic Confinement fusion are being developed for versatile applications such as PET isotope production and detection of illicit materials. Studies of advanced D-^{3}He fuel fusion are also being pursued by the use of the compact fusion device.



Measurement and spectrum analysis of fluctuations in high temperature plasma

Various fluctuations appear in plasmas and cause transport. Measurement and analysis of those fluctuations in the frequency range from kHz to MHz are important issues to understand properties of plasma transport.

Advanced Plasma Energy Research Section

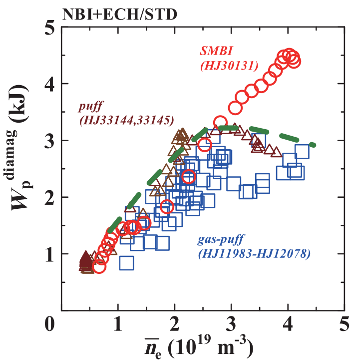
The research in this section concerns the physics of high temperature plasmas in complex electromagnetic field, and the development of advanced plasma control technology for plasma energy application.

Boundary Plasma Control for Improvement of Core Plasma Performance

Professor

Tohru Mizuuchi

My major field of study is high temperature plasma physics and engineering to develop fusion energy reactor and to open new windows of high-temperature plasma application in the energy science. Boundary plasma control is one of the important key issues not only to obtain high performance fusion plasma but also to realize optimized plasma-material interactions. Recent studies are focused on boundary plasma control for improvement of core plasma performance. Studies of advanced fueling system, surface modification of plasma facing materials for recycling control, characterization of edge plasma turbulence by using advanced diagnostics, etc. are in progress under domestic/ international collaborations.



Expansion of plasma operation range by using an advanced fueling method

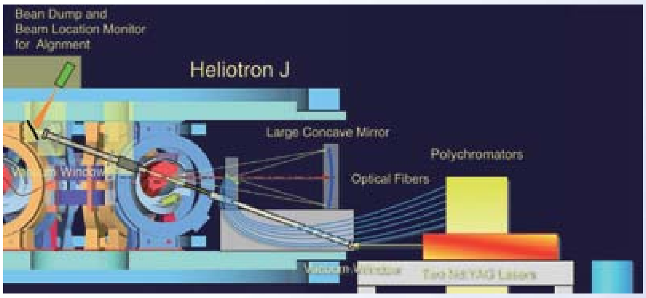
An advanced fueling method (SMBI) is successfully applied to ECH/NBI plasma in Heliotron J. The stored energy (W_p) can reach to about 150% of the maximum value obtained with conventional fueling method (gas-puff) without degradation in higher density ($\bar{n}_e$) region.

High temperature plasma profile measurement with a high repetition rate Nd:YAG laser Thomson scattering system

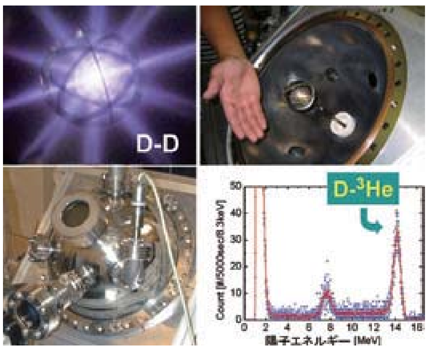
Associate Professor

Takashi Minami

The improved confinement phenomena of the nuclear fusion plasma will be investigated with a high repetition rate Nd:YAG laser Thomson scattering system on the Heliotron J device. It was formerly thought that the plasma profile has stiffness, and the shape of the plasma profile is determined only by global parameters. However, the magnetic confined plasma has a diversity of the plasma profile and the profile shape closely relates to the confinement characteristics, and especially the improved confinement phenomena. The control of the plasma profile can improve the confinement performance of the fusion device. Therefore, the main purpose of this study is to realize the improved plasma confinement by the active profile control based on the time evolution measurement of the plasma profile with the Nd:YAG Thomson scattering measurement.



Schematic diagram of the Nd:YAG laser Thomson scattering system for Heliotron J



Neutron/Proton Sources based on Inertial Electrostatic Confinement Fusion

Ions focused within the transparent gridded cathode undergo fusion reactions that produce energetic neutrons. Protons produced with a moderate applied voltage of tens kV gain a huge energy of 14.7 MeV via D-^{3}He fusion reactions.

High-power microwave source "Gyrotron"

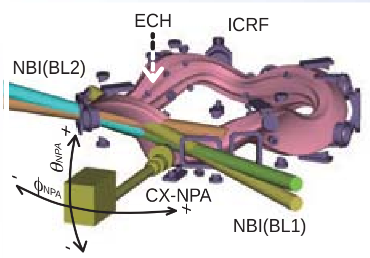
A gyrotron produces a Gaussian-shaped microwave beam of 70GHz 500kW power, which is used for production, heating and current drive of fusion plasmas.

Neutral Beam Injection heating for production and control of high performance plasma

Assistant Professor

Shinji Kobayashi

In magnetically confined fusion plasmas, Neutral Beam Injection (NBI) is widely utilized for the plasma heating and fueling to obtain high temperature and density plasmas. Recently, we are developing the NBI heating technique to Heliotron J for the dynamic control of the high temperature plasmas though the plasma rotation and current controls to achieve high performance plasmas. The plasma diagnostics are also developing for the ion temperature and the rotation profile (Charge eXchange Recombination Spectroscopy; CXRS) and the density fluctuation (Beam Emission Spectroscopy; BES) measurements.



NBI injection system for Heliotron J

Two beamlines of Neutral Beam Injection (NBI) heating systems are installed in Heliotron J. Each NBI beamline has the maximum beam energy and injection power of 30keV and 0.7MW, respectively.

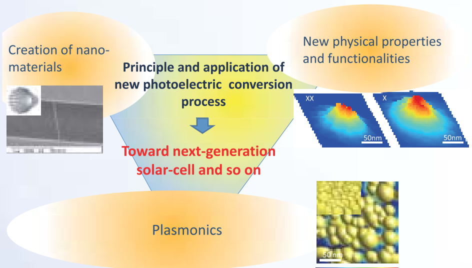
Advanced Energy Materials Research Section

We are investigating the scientific principle and applications of new nano-materials including advanced energy materials, and exploring the physical properties and functionalities of these materials based on nano-science.

Manifestation of Optical Functionalities and Highly Efficient Photoelectric Conversion Based on Nano-science

Professor
Kazunari Matsuda

Recently, the highly efficient photoelectric conversion using sunlight is required toward the realization of sustainable society. It is required the creation of nano-materials including artificial complex nano-materials with potential applications and the understanding of physical properties. We are investigating the fundamentally quantum physical processes of the nano-material systems (carbon nanotube, graphene, semiconductor, metal nanoparticles and these complex nano-materials) using advanced laser spectroscopy. Furthermore, we are investigating the scientific principle and applications of highly efficient photoelectric conversion processes toward the next-generation solar cells.

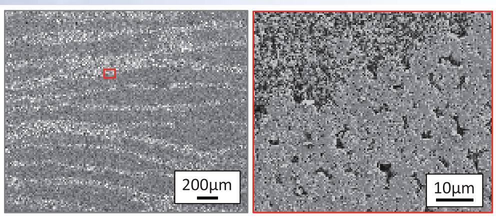


Our Scheme toward Highly Efficient Photoelectric Conversion Process for Next Generation Solar Cells
The scientific principle and applications of highly efficient photoelectric conversion processes are studied based on nano-science. Especially, we are investigating the creation of new nano-material systems, understanding of physical properties, and manifestation of optical functionalities using plasmonics techniques.

R&D of ceramic material for advanced energy application

Associate Professor
Tatsuya Hinoki

The research activity puts emphases on R&D of the advanced ceramic materials like SiC/SiC composites for nuclear advanced fission, fusion and aerospace application utilizing nano-technique. The R&D include development, applications and environmental effects from basic science through engineering. Many collaborative researches are ongoing with domestic and international institutions in US, Italy, France and OECD.

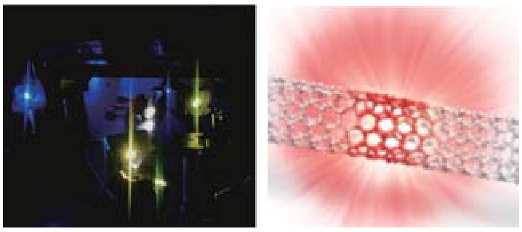


Ductile Porous SiC Ceramics with Fiber Reinforcement
Novel porous SiC ceramic material was developed by reinforcement of SiC fibers. It has very high strength with pseudductile fracture behavior and excellent oxidation and corrosion resistance.

Photophysics and Applications of Nanomaterials

Associate Professor
Yuhei Miyauchi

Our research focuses on photophysical properties and applications of nanomaterials including carbon nanotubes, graphene, and atomically thin semiconductors in which distinct quantum effects dominate their physical properties. We make use of advanced optical spectroscopic techniques to clarify the physical properties of nanomaterials for developing novel photonic and energy conversion devices.

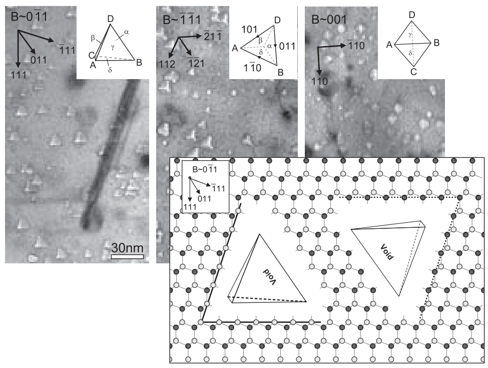


Images of optical experiment (left) and light emitting carbon nanotube (right)
We explore novel photophysical properties and functions of various nanomaterials using advanced optical spectroscopic and physical chemistry techniques.

Accumulation of point defect clusters in SiC irradiated in DuET

Program-Specific Associate Professor
Sosuke Kondo

During the last decades, SiC and advanced SiC/SiC composites have been subjected to an extensive irradiation experiments. The excellent irradiation tolerance is now widely perceived, demonstrating the promise of those materials for use in severe irradiation environments leading to higher efficiency of the fusion energy systems. Our work scope is microstructural evolution in SiC under irradiation because lattice defects are believed to strongly influence on the material property change. DuET/MUSTER work may provide clear insights into the stability of the irradiated microstructure in SiC and underlying mechanisms.



Tetrahedral voids in SiC
The tetrahedral voids induced by irradiation in SiC were found to be spatially oriented in only one of two possible directions. The tetrahedral shape was unexpected as the surface-to-volume ratio is larger than the alternative {111} octahedral void common in both metals and ceramics. From a geometric viewpoint, all faces of the observed voids are either Si- or C-terminated surfaces.

Advanced Laser Science Research Section

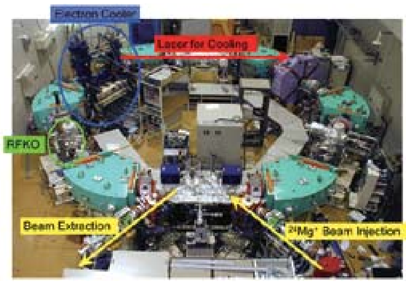
Our research interest is to explore, understand, and then control/utilize the various responses of materials, such as atoms/molecules, nanoparticles, and thin films, to the irradiation of lasers.

Transverse Laser Cooling of a Magnesium Ion Beam by Synchro-Betatron Resonance

Assistant Professor

Kouichi Jimbo

As collaboration research with Advanced Research Center for Beam Science, Institute for Chemical Research, Kyoto University, K. Jimbo engages in a laser cooling experiment of a magnesium ion ($^{24}Mg^{+}$)beam at Small Laser-equipped Storage Ring (S-LSR). As shown in the picture, the wavelength variable UV laser (280 nm) is guided into a straight section of S-LSR and co-propagates with ions so that they constitute $3s^2S_{1/2} \rightarrow 3p^2P_{3/2}$ absorption-emission cycle for laser cooling. Cooling in the longitudinal direction has already been achieved for both coasting and bunched ion beams. Now we try to cool ion beams in the transverse direction by the synchro-betatron resonant coupling.



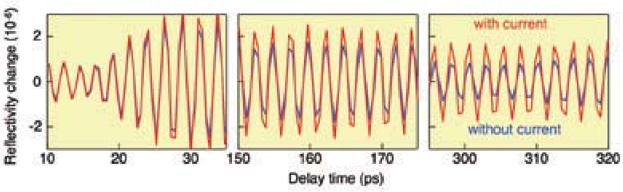
Small Laser-equipped Storage Ring (S-LSR)
S-LSR located at Advanced Research Center for Beam Science, Institute for Chemical Research, Kyoto University has 6-fold symmetry with circumference 22 m.

Amplification of Sound Waves at Extreme Frequencies

Program-Specific Assistant Professor

Keisuke Shinokita

At Max Born Institute in Germany, I had studied several ultrafast phenomena in condensed matters including amplification of acoustic phonon. The acoustic phonon in sub-THz region with a few nm wavelength in semiconductor superlattice is ideal for imaging of semiconductor nanostructure and biological materials with very high spatial resolution that cannot be probed with longer-wavelength visible light waves. However this would require a strong coherent acoustic phonon source. We showed the intensity of phonons moving through a semiconductor superlattice can be amplified by a factor of 2 via an electrical current. Here at Institute of Advanced Energy, the ultrafast spectroscopic experiences with device fabrication will be engaged in observation and control of exotic quantum states in two-dimensional materials where spin and valley indices of charge carriers are coupled.



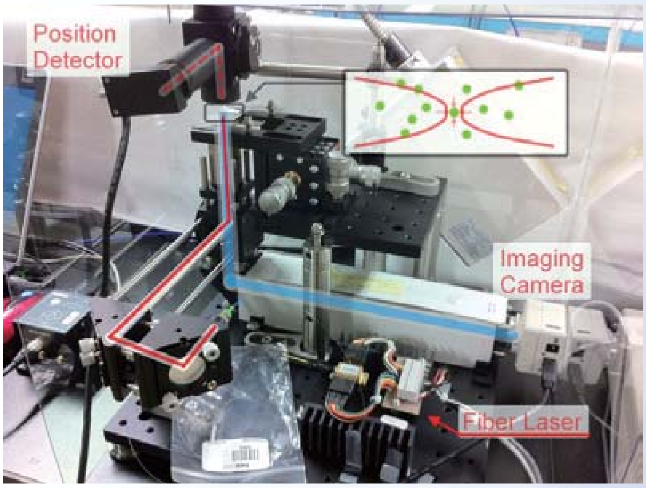
Amplification of acoustic phonon via an electrical current
Changes of the sample reflectivity as a function of the delay time after the pump pulse. The blue curve shows the results without the current through the superlattice, the red curve with a current of 1 A. With current the amplitude is always larger than without current.

Ultrafast phenomena and their applications

Associate Professor

Takashi Nakajima

By irradiating ultrashort laser pulses with picosecond, femtosecond, or attosecond durations to the various kinds of targets, we are able to perform the real-time observation of the motion/relaxation of the lattices, nuclei, and electrons in the targets. We carry out the theoretical as well as experimental study of ultrafast phenomena in atoms/molecules, nanoparticles, and ultrathin films using lasers.



Optical tweezer:
An optical tweezer consists of a trapping laser and an objective lens, and it allows us to spatially trap sub-micron objects for *in-situ* observation.

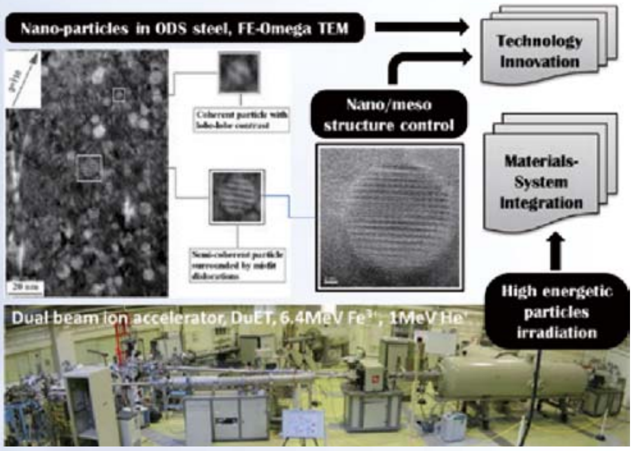
Advanced Energy Structural Materials Research Section

Innovative structural materials R&D with focusing on nano-meso structural control, and basic research for understanding materials performance and behavior.

Fundamental Studies of Energy-Materials Science and Technology

Professor
Akihiko Kimura

Innovative structural materials R&D is essential towards future advanced energy plants of high thermal efficiency. Nano- technology to disperse very fine (3nm) oxide particles (Y_2O_3) into steels in high density improved the strength at elevated temperatures remarkably together with bearing high corrosion resistance and irradiation tolerance. In order to make clear the mechanism of high performance, nano- scaled micro-analysis have been done using FE-TEM, FESEM, FE-AES and FE-EPMA to investigate the mechanism of material high-performance by nano-scaled oxide particles. Fundamental studies on ion-irradiation damage mechanism have been done to understand materials behavior under high-energy particles irradiation environment.

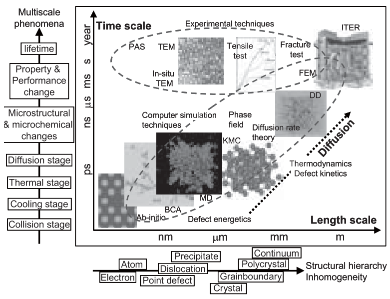


Materials nano-technology and dual ion-beam accelerator (DuET)
An example of high-resolution TEM microstructure of oxide particles in an ODS steel. The oxide particles, which consist of Y and Al, drastically improve material performance by controlling their size, number density and interfacial structure. DuET is a dual ion-beam accelerator.

Multiscale Modeling of Irradiation Processes of Fusion Materials

Associate Professor
Kazunori Morishita

Many international programs are being underway for developing nuclear fusion reactors, which are one of the promising earth-friendly candidates for future energy sources. Material's issues are of critical importance, because reactors' integrity is basically determined by the component materials that suffer from severe irradiations. For developing irradiation-resistant materials, the database on materials' behavior during irradiation is required. However, they should reluctantly be obtained using the alternative, existing irradiation facilities such as fission reactors and ion accelerators, because of no actual fusion reactors at present. To overcome the difficulties caused by the difference between the two environments, a methodology to predict material's behavior in the actual environment using the existing materials' data is required. Our efforts have been made to establish the methodology. Molecular dynamics, kinetic Monte-Carlo, ab-initio calculations, and rate-theory equations are powerful tools to understand radiation damage processes, which occur at a wide variety of time and length scales.

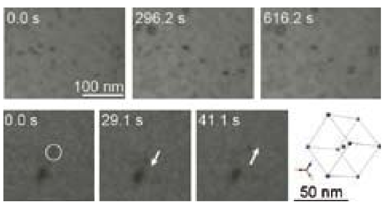


Multiscale radiation damage process
Radiation damage processes show different behavior depending on time- and length-scales that you are observing. To understand these multiscale phenomena, various investigation methods using computer simulations and experiments should complementarily be employed.

Lattice Defects Behavior in Metal

Assistant Professor
Kiyohiro Yabuuchi

Metals have crystal structures, but lots of lattice defects exist in them. The properties of metals are directly related to the lattice defects and their behavior. So, understanding of lattice defects are fundamental science of materials science. For effective investigation of lattice defects behavior, we introduce lots of lattice defects into materials with an ion accelerator, DuET, and observe their behavior. We study with both atomic scale observation using various electron microscopes and computational approaches such as DFT and MD.



One dimensional motion of lattice defects in iron
The effects of alloying elements on the behavior of defect structures have been investigated. It was revealed that Mn strongly suppressed the one dimensional motion of lattice defects.

Complex Plasma Systems Research Section

Nonlinear and synergetic physics of high-temperature plasma is investigated experimentally and theoretically with special regard to the magnetic confinement improvement of fusion plasma, which would also contribute to the complex plasma systems research.

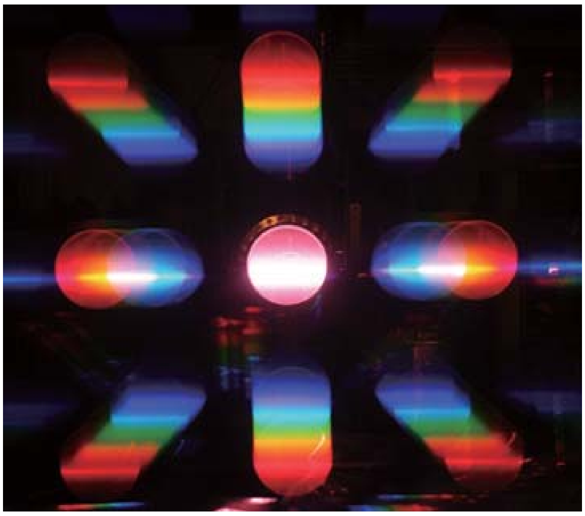
The True Plasma Comes out in Optical Emission

Associate Professor

Shinichiro Kado

"Plasma Diagnostics" is referred to as the physics researches based on the measurements and data analysis. Optical emission from plasmas in particular includes plenty of information such as density, temperature, ionic species and their fluctuations, so that it is useful in investigating the spatio-temporal behaviors of the plasma. "Know the enemy (plasma) and know yourself (measurement methods and data), then you can fight the hundred battles without fear" --- the real plasma properties that have never been known to anyone will be in our hands.

Optical emissions are much brighter where ionization from gas to plasma, and recombination from plasma back to gaseous state take place frequently. The ionization acts as an important fuel source while the volumetric recombination is a key process to achieve the plasma that is hot in the core but cool in the edge, i.e. "fusion plasma sweet to the wall".



Hydrogen's red is a famous Balmer alpha line spectrum

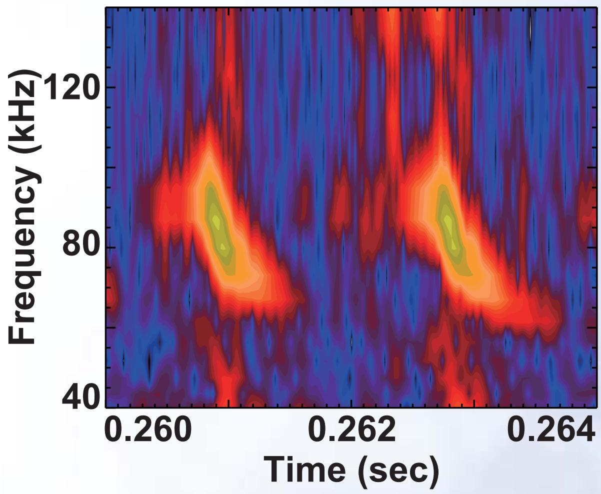
A spectral kaleidoscope demonstration picture for MAP-II divertor plasma simulator in collaboration with the University of Tokyo. Similarly, we have developed "spectra camera" for the measurement of 2-dimensional images of temperature and density of the plasmas.

Performance improvement of magnetically confined plasmas by suppression of fluctuations

Assistant Professor

Satoshi Yamamoto

Nuclear fusion power plant is one of the best ways to solve the energy problem and greenhouse warning. I am experimentally and numerically studying the magnetically confined high temperature plasmas for the realization of nuclear fusion power plant using both helical-axis heliotron device Heliotron J and supercomputer. My aim is particularly to improve the performance of plasma confinement by the suppression of several kinds of fluctuation in high temperature plasmas. Moreover, I study the resonant interaction between wave and particle in plasmas.



Nonlinear resonant interaction of wave and particle

Shear Alfvén wave which is the magnetohydrodynamics (MHD) wave in plasma would be resonantly excited by the energetic ions of which velocity is similar to phase velocity of shear Alfvén wave.

Chemical Reaction Complex Processes Research Section

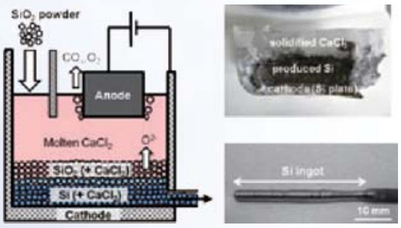
We are studying materials and systems to realize renewable energies like photovoltaics and bioenergy as the major primary energy source for human beings. We are conducting innovative researches that cover the phases from basic research to applications mainly based on electrochemistry and biochemistry.

Development of new production processes for solar silicon utilizing molten salt electrolysis

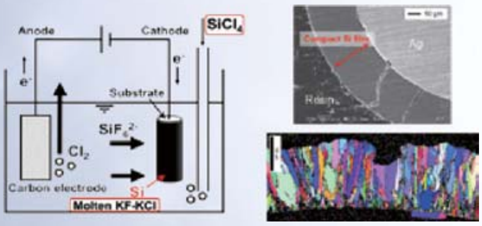
Professor
Toshiyuki Nohira

Assistant Professor
Takayuki Yamamoto

Crystalline silicon solar cells are the most spreading in the world owing to the advantages of high efficiency, high durability, harmlessness for the environment, and abundant resources. Naturally, they are expected to play a major role in the era of full-fledged dissemination of solar cells. However, high purity silicon (or solar-grade silicon, 6N purity), which is necessary for the solar cells, is currently produced by a similar method that was developed for the production of semiconductor-grade silicon (11N purity). A new production method of solar-grade silicon is required because the conventional production method has the disadvantages of low energy efficiency, low productivity, and high cost. From this background, we have proposed a new production method of silicon from the purified silica (SiO_2) feedstock by using molten salt electrolysis. We have already verified the principle of the method, and are now tackling the development of continuous electrolysis process and the improvement of purity. The conventional production process of crystalline silicon solar cells also has several other problems such as the large kerf loss and the complex process of cell production. So, we have proposed a new production method of crystalline silicon film by molten salt electroplating. For this method, we have already confirmed the principle as well. We are now taking on the research on the improvement of film quality and the utilization of $SiCl_4$ as a silicon source.



A new production method of solar-grade silicon by the electrochemical reduction of silica in molten salt
We have proposed a new production method of silicon which utilizes electrochemical reduction of powdery SiO_2 in molten $CaCl_2$ (left). A photo of the sample obtained in the principle verification experiment (top right). A photo of the crystalline silicon rod prepared from the electrochemically produced silicon powder by a floating zone method (bottom right).

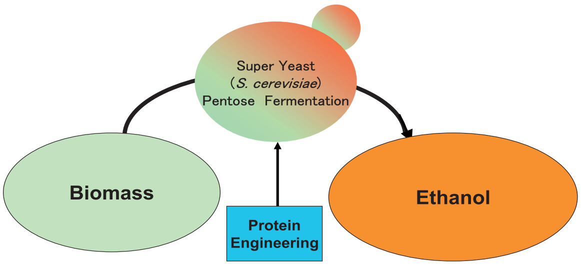


A new production method of silicon films for solar cells by the molten slat electroplating
We have proposed a new production method of crystalline silicon films by electroplating in molten KF-KCl (left). An SEM image of the crystalline silicon film electroplated on a silver wire (top right). An EBSD image of the electroplated silicon film showing its high crystallinity (bottom right).

Highly efficient energy production from biomass

Associate Professor
Tsutomu Kodaki

The more efficient use of biomass is demanded to solve the global crises such as exhaustion of fossil fuel and global warming. Our group is focused on the highly efficient production of ethanol from biomass using genetic engineering.



Strategy for construction of efficient ethanol production system from biomass.

Molecular Nanotechnology Research Section

Nanoscience and technology, ultimate method for producing new materials assembling from single molecules, are studied for energy sector such as organic transistors and solar cells.

Nanoscience and technology using single molecules

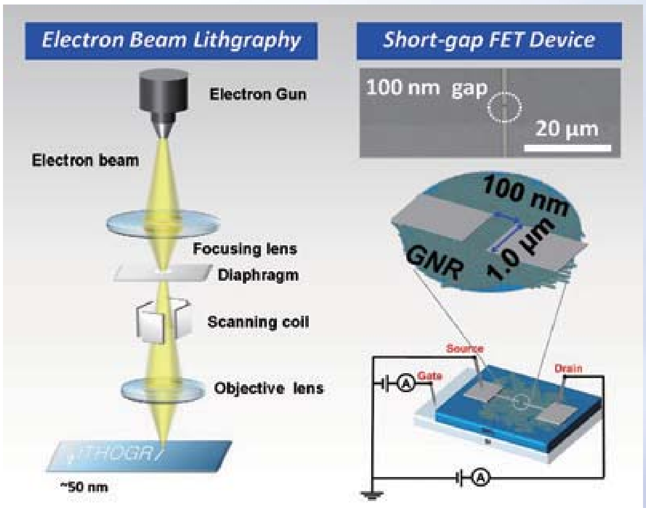
Professor
Hiroshi Sakaguchi

Assistant Professor
Takahiro Kojima

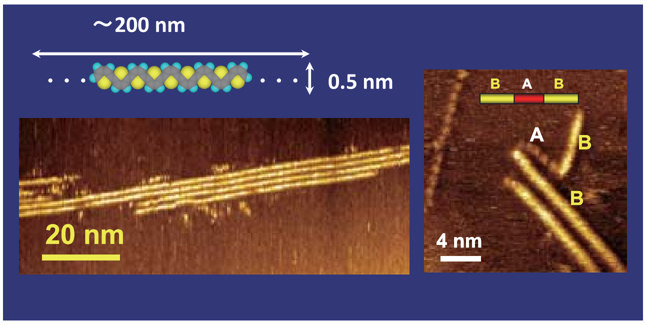
Assistant Professor
Takahiro Nakae

Nanoscience and technology, ultimate techniques for producing new materials assembling from single molecules, are desired to apply in energy sector. Highly efficient devices such as field-effect transistors, solar cells, batteries could be realized by using nanotechnology. We have developed “Electrochemical Epitaxial Polymerization” technique which is a totally new molecular assembling technique of molecular wires on metal surface from single molecules using intense electric field at solid- solution interface (electric double layer). Also, “radical-polymerized chemical vapor deposition” technique which is totally new method to produce graphene nanoribbons using high concentration of monomer radicals at interface between substrate and gas has been developed. Unprecedented molecular-wire materials consisting of carbon for energy usage will be developed by the use of these techniques. Polycyclic aromatic hydrocarbon molecules for a monomer of molecular wire and for molecular electronics will be synthesized using our new methodology. Organic electronic devices such as field effect transistors, photovoltaics, batteries and photocatalysis will be developed using our new techniques.

Bottom-up synthesis of graphene nanoribbons
Extremely narrow carbon wires developed by our bottom-up surface synthesis technique.



Graphene nanoribbon-nanogap electrode FET devices
FET nanogap electrode devices of graphene nanoribbon fabricated by electron beam lithography.



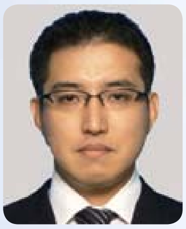
Conducting polymer wires array
Conducting polymer wires array on metal surface by the use of ‘Electrochemical Epitaxial Polymerization’ technique.

Biofunctional Chemistry Research Section

Our research group is exploring the design and the construction of biomacromolecules "tailored" for pursuing highly efficient energy utilization.

A design principle of functional biomolecules for highly effective energy utilization

Professor
Takashi Morii



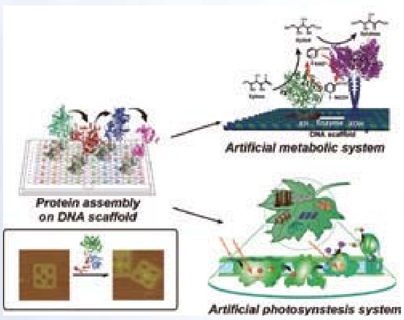
Junior Associate Professor
Eiji Nakata

Assistant Professor
Shun Nakano

A transition to renewable energy technologies requires new chemistry to learn from nature. It is our challenge to understand the efficient bioenergetic processes of nature and to construct human-engineered energy utilization systems. The research interests in our group focus on the design and assembly of biomacromolecules for energy conversion, catalysis and signal transduction in water, the solvent of life.

We take synthetic, organic chemical, biochemical and biophysical approaches to understand the biological molecular recognition and chemical reactions. Miniature proteins and protein/nucleic acids assemblies are explored to construct artificial biomimetic devices mimicking the function of biological systems, transformation of cellular signals by fluorescent biosensors, directed self-assembly of peptides and proteins, artificial receptors and enzymes based on the complex of RNA and protein, and photosynthesis of chemicals currently made industrially.

Nanoassembly of enzymes and receptors to realize artificial photosynthesis & metabolic systems



Cellular chemical transformation processes take place in several reaction steps, with multiple enzymes cooperating in specific fashion to catalyze sequential steps of chemical transformations. One is the most popular natural system is photosynthesis system. Such natural systems are effectively reconstructed in vitro when the individual enzymes are placed in their correct relative orientations.
DNA nano-structure such as DNA-origami can be used as "molecular switchboards" to arrange enzymes and other proteins with nanometer- scale precision. A new method was developed based on proteins, to locate specific proteins by means of special "adapters" known as DNA binding proteins. Several different adapters carrying different proteins can bind independently to defined locations on this type of nanostructure. By using the system, nanoassembly of enzymes and receptors will be constructed as the multi-enzymatic reaction system to realize artificial photosynthesis & metabolic systems.

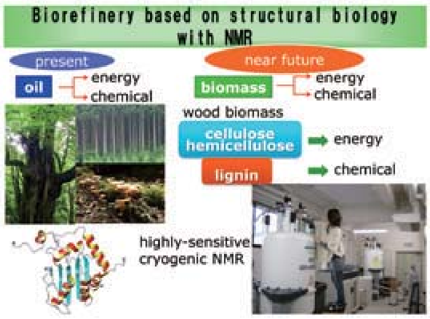
Structural Energy Bioscience

We aim at the establishment of biorefinery through the development of

Toward biorefinery through the development of biomass and biomolecules based on structural biology

Professor
Masato Katahira

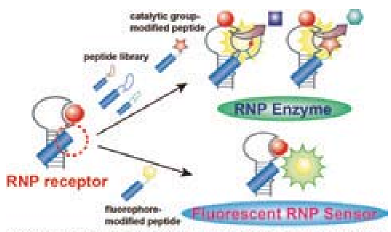
We explore the way how biomolecules such as proteins (involving enzymes) and functional nucleic acids (DNA and RNA) work at atomic resolution based on structural biology with NMR. For example, we have elucidated how functional RNA can trap the protein that causes prion diseases. We are also engaged in development of the new methodology to elucidate the underlying mechanism of functions of these biomolecules. We have successfully developed the way to monitor the base conversion reaction by anti-HIV enzyme in real-time by NMR for the first time. Currently, we are developing the way to extract energy and valuable materials that can be used as starting materials of various products from wood biomass. Thus, we pursue to contribute to the paradigm shift from oil refinery to biorefinery.



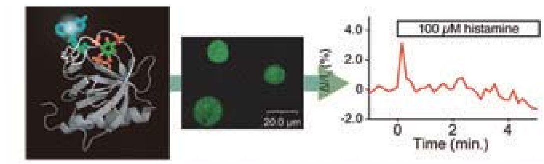
Biorefinery based on biodegradation of wood biomass studied by NMR
Establishment of biorefinery on the basis of biodegradation of wood biomass studied by NMR.

Exploring functional biomacromolecules by using RNP complexes

Design strategies to tailor receptors, sensors and enzymes are explored by utilizing structurally well-defined protein-RNA complexes. Stepwise strategies of the structure-based design, in vitro selection and the chemical modification afford highly specific receptors for biologically important ligands, such as ATP and the phosphorylated tyrosine residue within a defined amino acid sequence.



Stepwise molding of functional ribonucleopeptide (RNP) complexes



Real-time fluorescent monitoring of IP_4 production in the single cells

Exploring functional biomacromolecules by using RNP complexes
Structure-based design provide alternative strategy to construct protein-based biosensors that assess intracellular dynamics of second messengers and metabolites.

biomass and biomolecules based on structural biology.

Molecular Basis for Utilizing Biomass: Structural Bioscience Approach

Associate Professor
Takashi Nagata

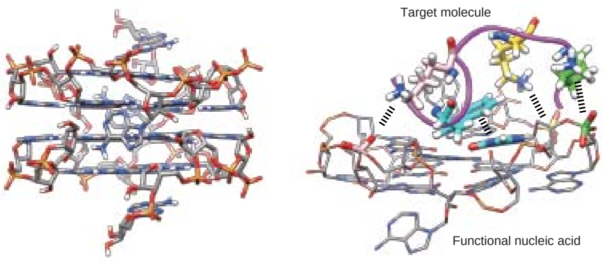
Our laboratory is dedicated to the construction of the molecular strategies to produce energy and useful compounds from biomass. Our current projects are to develop tools to degrade woody biomass with fungus, enzyme, and catalyst, and to monitor the structures of the degradation products. We have been using structural bioscience techniques (NMR spectroscopy, genetic engineering, etc.) to analyze the molecular roles of disease- and virus-infection-related proteins, functional nucleic acids, and small compounds that are drug candidates in the viewpoint of structure and molecular motion. The knowhow we have built up over years is going to be evolved to realize the shifting from fossil resources to biomass, which is a renewable resource.

NMR structures of the protein: nucleic acid complexes
Oogenesis regulator, PARN, is bound to the mRNA 5'-cap (left). Musashi, which maintains pluripotency of the stem cells, is complexed with the mRNA 3' region (middle). GT-1, a light-responsive transcription factor in plants, formed complex with the target DNA (right).

Understanding of mechanism of activity by biomolecules based on the tertiary structure

Assistant Professor
Tsukasa Mashima

Organisms use various biomolecules in the reaction to produce energy. These molecules achieve specific molecular recognition and catalytic activity through folding into the inherent tertiary structures. NMR spectroscopy and X-ray crystallography provide the information of spatial arrangement of atoms comprising the biomolecules. By using these methods, we are analyzing the biomolecules, especially the enzyme of microorganism that can degrade the wood biomass, from the point of view of what shape they are and how they work. Our ultimate goals are to design novel biomolecules with high activity based on structural insight by our findings.



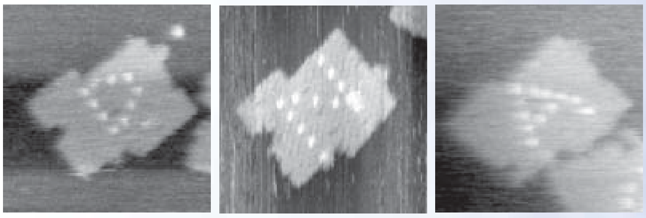
Molecular recognition of biomolecule
We have determined a tertiary structure of a functional nucleic acid (left) and its structural basis for recognition of a target biomolecule (right). Both findings were revealed by NMR spectroscopy at atomic resolution.

The aim of this research is to utilize the DNA nanostructures for the construction of enzyme cascades. Such an enzyme assembly will be successfully applied for the biomolecular energy conversion.

DNA nanotechnology for biomolecular energy conversion

Junior Associate Professor
Arivazhagan Rajendran

DNA molecules are not merely associated with genetics and the carrying of information. They have been used as excellent construction units in structural DNA nanotechnology due to their unique structural motifs and robust physicochemical properties. I have been working on the self-assembly of DNA origami (a method to create nanostructures by folding DNA) nanostructures to create micrometer scale structures that can be used for several applications such as fabrication of nanodevices. Further, I have been using these structures for the analysis of various biomolecular reactions and functions. Now, I am using these DNA origami nanostructures for the assembly of enzyme cascades in predetermined patterns. Such an assembly is promising to mimic the biomolecular systems and can be successfully applied for the biomolecular energy conversion through controlled enzymatic reactions.



DNA origami structures
Atomic force microscopy images of the DNA origami structures carrying the letters, D, N, and A. The image size: 200 × 200 nm.

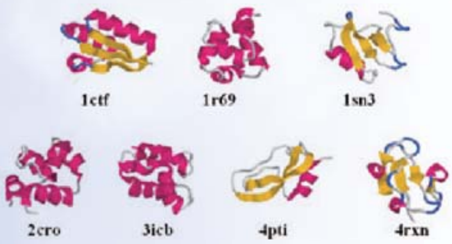
Complex Energy Processes Research Section

We are investigating such subjects as the biological self-assembly sustaining life and the heating and confinement of hightemperature plasmas.

Chemical Physics of Life Phenomena Arising from Correlations of Water and Biomolecules

Professor
Masahiro Kinoshita

We are theoretically investigating the mechanisms of biological processes sustaining life such as protein folding, molecular recognition, and association of proteins. In our studies, the emphasis is on the roles of water through its translational configuration entropy, and the feature is in the development of an original statistical-thermodynamics theory accounting for a protein and water in the atomic detail. Major subjects are microscopic mechanisms of protein folding and denaturation (pressure, thermal, and cold denaturating), calculation of the free-energy change upon receptor-ligand binding, prediction of the native structure of a protein, functions of ATP-driven and proton-motivated proteins, and mechanism of molecular recognition by intrinsically disordered proteins. We have recently started developing a fast method of predicting mutations leading to higher stability of GPCR. We have tackled a variety of unresolved problems and been successful in elucidating them in a unified manner within the same theoretical framework.



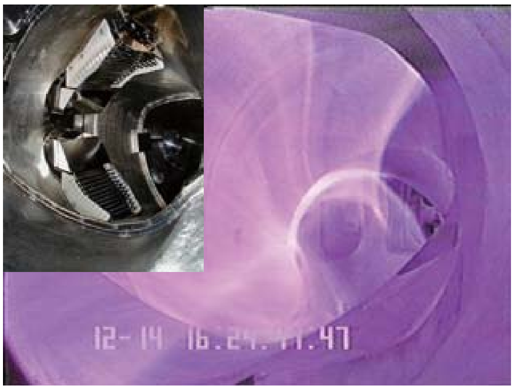
Free-Energy Function for Predicting the Native Structure of a Protein

We have developed a free-energy function which allows us to discriminate the native structure of a protein from thousands of misfolded decoy structures. It has been tested for 133 proteins and the native structure has been discriminated with almost 100% accuracy. Of course, this is a world record in the protein research community.

Plasma harmonizes with the magnetic field

Associate Professor
Hiroyuki Okada

Nuclear fusion power plant using dueterium and lithium in the sea as a fuel is considered to be one candidate of solutions for the energy resource problem. Realizing fusion power plant is very valuable in a poor resource country, Japan. My research subject is to generate and confine high temperature plasmas aiming at nuclear fusion with special emphasis on the plasma heating and diagnostics. A plasma and a helical coil form the combined spiral shape in Heliotron J. On the basis of understanding the behavior of the fast ions and the sponteneous toroidal current, the better confinement of plasmas is investigated.



Heliotron J plasma and antennas for plasma heating

Hydrogen plasma observed from a tangential view port in Heliotron J. The hydrogen gas near the edge of the plasma radiates light. The antennas for the plasma heating using radio frequency wave in VHF band are installed in the vacuum chamber of Helitoron J.

▶ Advanced Energy Conversion Division Clean Energy Conversion Research Section

Visiting Professor

Ryoji Hiwatari

Rokkasho Fusion Institute, National Institutes for Quantum and Radiological Science and Technology, Principal Researcher

Dr. Ryoji Hiwatari received his Ph.D from the University of Tokyo. His research area is in the field of the next generation energy system. First, fusion energy is the main topic. Now, He focuses on developing the conceptual design of Japanese fusion DEMO. He also has studied a next-generation vehicle system and has developed a traffic simulator EV-OLYENTOR for next-generation vehicles, which is applied to make an introduction scenario of EV quick charge stations for all prefectures in Japan. Moreover, He has developed an evaluation method for utility function of each characteristics of electric power production system, to discuss the energy mix and public acceptance, etc.

▶ Advanced Energy Conversion Division Clean Energy Conversion Research Section

Visiting Associate Professor

Toshiaki Kato

Department of Electronic Engineering, Tohoku University (Electronic Engineering) Associate Professor

Dr. Toshiaki Kato received his PhD from Tohoku University under the direction of Prof. R. Hatakeyama in 2007. He became a faculty member at Tohoku University as an Assistant Professor in 2007, Lecturer in 2013, and Associate Professor in 2016. Current research interests include precise structural-controlled growth of atomically-thin layered materials such as carbon nanotube, graphene, graphene nanoribbon, and transition metal dichalcogenides. He is also interested in developing an innovative nano-energy device with those novel nanomaterials.

▶ Advanced Energy Generation Division Quantum Radiation Energy Research Section

Lecturer (Part-Time)

Kazuyuki Sakaue

Waseda Institute for Advanced Study, Waseda University, Associate Professor

Dr. Kazuyuki Sakaue received his PhD from Waseda University under the direction of Prof. M. Washio in 2009. He spent five years at Faculty of Science and Engineering, Waseda University as a Junior Researcher and an Assistant Professor. In 2015, he moved to Waseda Institute for Advanced Study, Waseda University as an Assistant Professor and Associate Professor. Current research interests include high quality electron beam generation and its application researches. As an application, he is now focused on the radiation from the high quality electron beam and laser-electron interactions.

▶ Advanced Energy Conversion Division Advanced Energy Materials Research Section

Lecturer (Part-Time)

Hiroki Ago

Global Innovation Center, Kyushu University, Professor

Dr. Hiroki Ago received his PhD from Kyoto University in 1997. He stayed at Cavendish Laboratory, Cambridge University, supported by JSPS during 1997-1999. Then, He worked at National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba as a researcher for four years. In 2003, he moved to Kyushu University as an associate professor and became a full professor in 2016. His current research focuses on exploring science and applications of nanomaterials, particularly graphene and related 2D materials.

▶ Advanced Energy Utilization Division Biofunctional Chemistry Research Section

Lecturer (Part-Time)

Daisuke Umeno

Department of Applied Chemistry and Biotechnology, Graduate School of Chiba University, Associate professor

Dr. Daisuke Umeno received his PhD from The Kyushu University under the direction of Prof. Mizuo Maeda in 1998. He spent six and a half years in the United State under the supervision of Professor Frances Arnold (Caltech) and Professor Larry A Loeb (UW, Seattle). In 2005, he moved to Chiba University as an Associate Professor. His current research field is evolutionary synthetic biology and his lab. is creating a variety of genetic networks and biosynthetic pathways toward non-natural compounds.

Laboratory for Complex Energy Processes

The Core Institution for Collaboration Research in the Field of Advanced Energy Science and Technology

The Laboratory for Complex Energy Processes

The Laboratory for Complex Energy Processes is a core research center of Institute of Advance Energy (IAE) for multidisciplinary collaboration studies. The Laboratory offers several important functions for the cooperative project studies in the field of advanced energy science. The organization of the Laboratory consists of research and technical staff s, who performed the maintenance and development of the experimental facilities so that the research programs are performed smoothly and effectively.

Objectives

The project studies in the Laboratory are focused on two specific priority-fields, (1) “Advanced Studies on Plasma Energy and Quantum Energy” and (2) “Innovative Studies of Nano-Bio Functional Materials for Energy Technology”.

The multidisciplinary collaboration projects are promoted in these two fields at each research section in the Laboratory; (1) Section of promotion for advanced plasma and quantum energy, (2) Section of promotion for Photon and Energy Nano-Science Research. The third section for international collaboration R&D, Section of promotion for international collaborative research, arranges and promotes international and domestic collaboration researches, including collaborations with industries. In addition, joining the Bilateral Collaborative Research Program in National Institute for Fusion Science (NIFS), the study of plasma energy is promoted under the inter-university collaboration.

Through these activities, we aim to make a network of energy research for resolving global problems of energy and environment. Moreover, as activities in Kyoto University, we also develop human resources in the advanced energy field.

Activities

The Laboratory organizes the cooperative research programs for the scientists from various energy-relating fields inside/outside IAE. The Laboratory also provides the functions for exchanging the scientific information among the collaboration members by organizing various kinds of symposiums, seminars for the specific topics on the fields of energy science and technology. A number of significant results have been published from these multidisciplinary collaboration projects in the Laboratory.

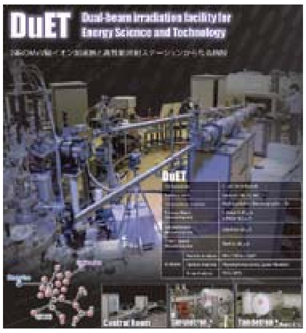
The Laboratory has several large-scale research facilities for the collaborations; (1) Advanced energy conversion experimental devices (Heliotron J and DuET), (2) Free electron laser (KU-FEL), (3) NMR facilities, (4) Multiscale testing and evaluation research systems (MUSTER), (5) Compact and portable inertial-electrostatic confinement (IEC) fusion neutron/proton sources, (6) System for creation and functional analysis of catalytic material, etc.


Transmission lines in the laboratory

100t crane


Motor generator

The Core Facilities and Equipment of The Institute



The Laboratory is consolidating several core facilities for the research programs of the Institute of Advanced Energy. Outlines of the facilities which are described below.

- Heliotron J
  In our Institute, a unique helical device Helitoron J is now in operation, which is based on a Kyoto-University original concept of "helical-axis heliotron", to investigate the high-level compatibility between (i) good plasma confinement and (ii) MHD stability in the heliotron line. This project is expected to open up a new frontier of the novel plasma parameter regime in the toroidal fusion devices. The major radius of the torus is 1.2 m and the maximum magnetic field strength is 1.5 T.
- DuET/MUSTER Facility
  This facility is for fundamental research on the interaction between materials and multiple charged particles with wide range of energy levels under well-controlled irradiation conditions, as well as for R&D of innovative structural materials through the unique fabrication processes of non-equilibrium and ultra-functional materials. In order to accelerate the achievement of industrial technology innovations, the comprehensive materials/system integration studies have been performed by means of multi-scale evaluation method covering from nano-scaled analysis to the practical size of mechanical tests.
- KU-FEL (Kyoto University Free Electron Laser)
  The KU-FEL provides coherent and tunable laser in Mid-IR region ranging from a 3.6 to 23 μm. The tunable IR laser has been utilized for basic study of high-efficiency solar cells, mass measurement of chemicals from biomass and selective phonon mode excitation in wide-gap semiconductors by collaboration research.
- NMR Facilities
  Four NMR machines, including three 600 MHz machines equipped with super-high sensitivity cryogenic probes, are operated to elucidate the three-dimensional structure and dynamics of biomass and biomolecules at atomic resolution. On the basis of the obtained knowledge, we are developing the way to extract the energy and valuable materials from the biomass and biomolecules.
- Cooperation with industries and national institute by using advanced facilities through Collaborative research office
  Dual-Beam Facility for Energy Science and Technology (DuET), Multi-Scale Testing and Research facility (MUSTER), KU-FEL, and NMR Facilities are open for industries to evaluate materials performance from the viewpoint of multi-scale structure; atomic size, defect size, grain size, etc. to understand the materials behavior in practical applications. Our facilities have supported about 85 companies to contribute in their progress of innovative materials R&D.

Cooperative Research

Besides of an inter-university collaboration program for researchers of energy relating communities, which is promoted by Joint Usage/ Research Center of Zero-Emission Energy Research, IAE, the Laboratory organizes an original cooperative research program for IAE researchers. The Laboratory also provides the functions for exchanging the scientific information among the collaboration members by holding various kinds of symposiums, seminars for the specific topics on the fields of energy science and technology.

Category		No. of adopted subjects
A1	Section of Promotion for Advanced Plasma and Quantum Energy	5
A2	Section of Promotion for Photon and Energy Nano-Science Research	12
A3	Section of promotion for international collaborative research	8
Total		25

FY 2016 (Apr. 2016 – Mar. 2017)

Organization of Research Projects in the Laboratory

Division of Advanced Plasma and Quantum Energy Research

This division promotes studies on advanced plasmas and quantum energy for realizing future energy systems, integrating plasma energy science and advanced energy material research. In particular, based on the results obtained in each related group, we aim at extending the research fields and contributing to human society by utilizing the existing key devices such as Heliotron J, DuET, MUSTER and IEC (Inertial Electrostatic Confinement) device, which have been developed in IAE.

Group of advanced plasma energy control and application research	This group promotes fundamental understanding of self-regulated plasma, development of its control system, putting emphasis on generation of advanced plasma energy from experimental and theoretical viewpoints. Extension and enrichment of plasma energy application are also investigated.
Group of plasma, hydrogen, and material integration research	This group promotes the research on optimization of plasma reaction process in hydrogen cycle and understanding the mechanism of plasma-materials interactions in order to develop highly efficient and controllable energy systems.
Group of advanced energy materials- nuclear systems research	This group promotes the research on nano-meso structure control for high performance materials and materials-systems integration in order to develop innovative energy materials for advanced nuclear energy systems.

Division of Photon and Energy Nano-Science Research

This division promotes studies on emergent materials and systems for realizing next generation soft energy system. In particular, functional nano- and bio-materials to utilize solar energy and bio-energy are studied by unifying laser science, nanotechnology, and bio-technology. We aim at extending our research fields by utilizing the existing devices such as System for Creation and Functional Analysis of Catalytic Materials, SEMs, SPM, Solar Simulator, TW fs laser, KU-FEL and so on.

Group of nano-bioscience research	This group aims at the study on the function and the structures of bio molecules from the basic to application level. Understanding the fundamental aspects of molecular recognition, protein folding, enzymatic reactions, and the assembly formation by proteins and nucleic acids will explore a new horizon of the bio energy related nano-bioscience research, such as the development of nano-bio devices that accelerate the efficient utilization of solar energy and the biomass resources.
Group of quantum radiation and optical science research	For contributing to innovative progress in quantum radiation and photon energy science, this group aims at demonstrating potential abilities of light and radiation through the development of advanced coherent radiation sources with novel functions and their applications to materials control and photoreaction dynamics research.
Group of surface and interface science research	This group studies surface science to produce the various functional materials used in energy sector. Surface and interface of matters can be used as a template to synthesize extra-ordinal materials because of their different atomic arrays from the bulk. Research involves in semiconductor porous materials, molecular wires and organic materials for photovoltaic cells in next generation.

Division of International Collaborative Research

This division promotes international collaborative research on advanced energy to lead the field of energy science and technology as an international pioneer. Collaborative researches between the institute and domestic/international organizations are supported towards realization of advanced energy systems as practical applications with contributions to human society. This section also promotes personal exchange, cooperative research activities and multi-lateral collaborative research with industries. Establishment of infrastructure and human resource development are supported for execution of collaborative R&D activities on advanced energy.

Group of promotion for international collaborative research	This group promotes international collaborative research to solve global issues on advanced energy.
Group of promotion for domestic collaborative research	This group promotes domestic collaborative research to lead advanced energy science and engineering with focusing on human resource development.
Group of promotion for collaborative research with industries	This group supports research projects founded by government and/or industries to accelerate the progress in the researches with high social acceptance.
Collaborative research office	This office member supports industrial research and engineering for energy materials development and materials integration researches as an advanced project with DuET, MUSTER, KU-FEL and NMRs.

Major Projects

A number of projects are currently underway in both scientific and engineering fields of advanced energy to realize a sustainable society that is in harmony with the environment through advanced generation, conversion, and utilization of energy.

Inter-University Research Program (MEXT)

Research Project for Zero-Emission Energy System

- Leader : Director of IAE
- Project Period : the 1st term : FY2011–2015
  the 2nd term : FY2016–2021

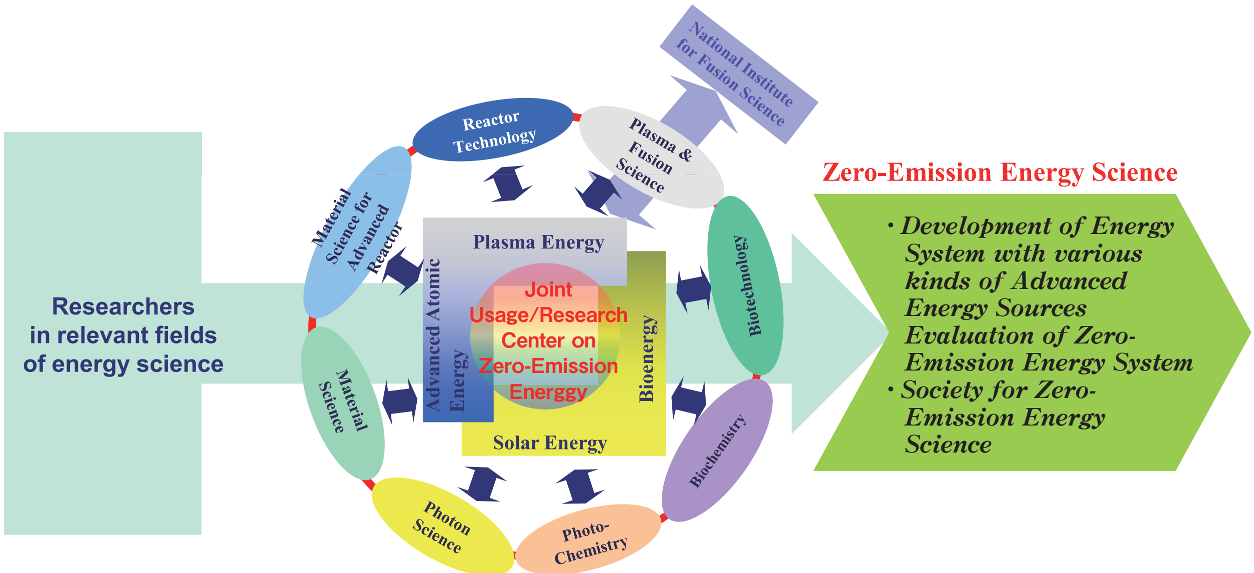
The energy system for next generation should be an environmentally friendly or ecological one, we propose an innovative concept of Zero-Emission Energy. IAE Zero-Emission Energy Research aims at the realization of environmentally friendly energy system for sustainable society with minimum emission of environmental pollutants (Greenhouse Gases, Air Pollutions, Waste Energy, Hazardous Wastes, etc.), and with maximum utilization of energy and resources. This project promotes interdisciplinary researches of energy relevant fields, education and training of young students and researchers in the field of advanced energy science.

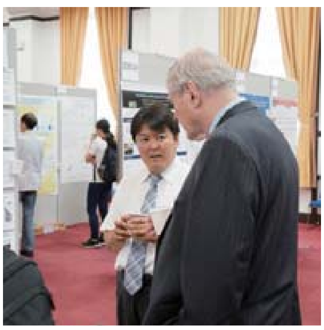
Activities in FY2016

- Joint Usage/Research Collaborations:
  Total 92 subjects with 170 participants from 40 organizations
- International Symposium (September 5 – 7, 2016)
  "The 7th International Symposium of Advanced Energy Science"
  ~ Frontiers of Zero-Emission Energy ~
- Zero-Emission Energy Network activities for information exchange on Zero-Emission Energy Research.
- Briefing Meeting of Inter-University Collaborations in FY2016 (March 6, 2017).
- Promotions of other Workshops/Seminars of ZE Research.

Joint Usage/Research Center at IAE on "Zero-Emission Energy"

- **To promote interdisciplinary collaboration researches for Zero-Emission Energy Science & Technology,**
- **To explore new horizon of Advanced Energy System for sustainable development,**
- **To promote education & practical training for young researchers.**



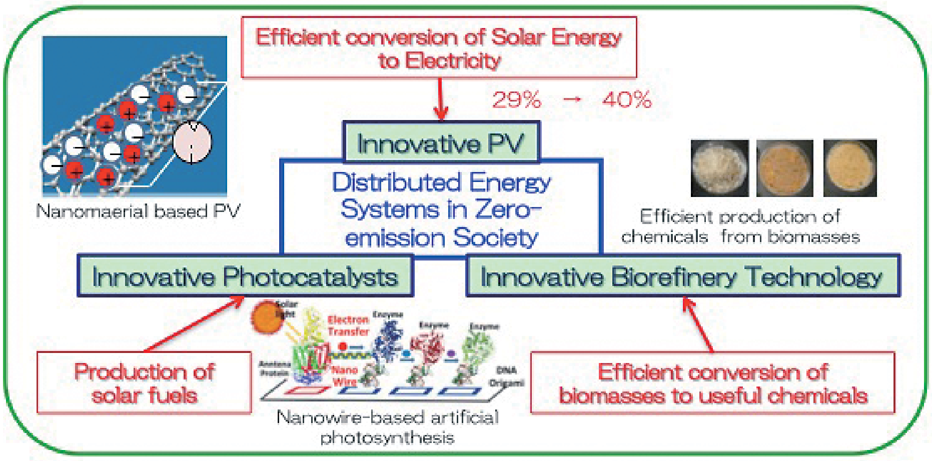


MEXT Special Budget (Project) (MEXT)

Innovative strategy for highly efficient utilization of solar energy
—Exploring novel principles for highly efficient utilization of solar energy—

- Leader : Prof. Takashi Morii
- Project Period : FY2013 – FY2018

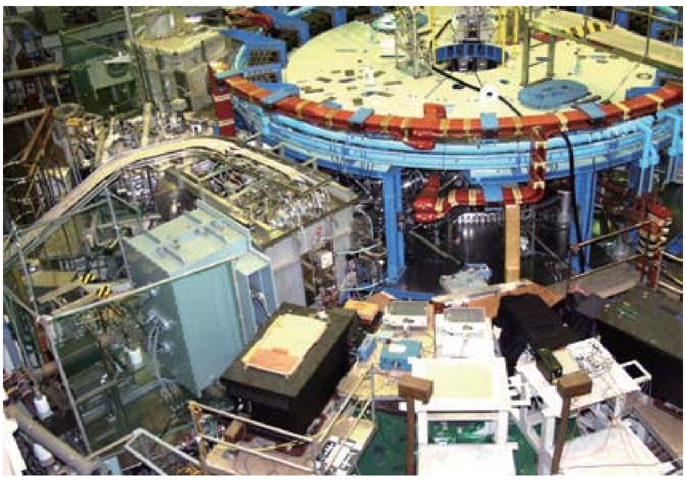
This interdisciplinary research project is aimed to uncover principles that govern highly efficient utilization of solar energy. Four research groups, each based on different disciplines of chemistry, biochemistry, physics and nanotechnology, simultaneously propel the cutting-edge research on the next generation photovoltaic cells, solar fuels, and biorefinery. Research topics include novel solar-light energy utilization by nano-carbon materials, one-dimensional carbon-based polymers for energy utilization, assembly of enzymes on molecular switchboards, development and application of methodology to investigate wood biomass utilization by solution NMR, and applications of mid-infrared laser to investigate the excitation states of nanomaterials. Mutual interactions between the research groups provide an ideal environment to incubate the original ideas, which stimulates creation of an innovative paradigm in solar energy utilization technology.



Bilateral Collaboration Research Program (National Institutes of Natural Sciences)

- Leader : Prof. Tohru Mizuuchi
- Project Period : FY2004 –

Bilateral collaboration research program promotes joint research bilaterally between National Institute for Fusion Science (NIFS), and the research institutes or research centers of universities that have each unique facility for nuclear fusion research. Under this collaboration scheme, the facilities are open to researchers throughout Japan as a joint-use program of NIFS. Our research subject under this program is to investigate experimentally and theoretically the transport and stability control through advanced helical-field control.



MEXT Special Budget Project (MEXT)

Joint Research Project “Smart-Materials”

- Institute for Chemical Research, Institute of Advanced Energy, Research Institute for Sustainablr Humanosphere
- Project Period : FY2015 – FY2020

Since April of 2015, the Institute for Chemical Research (ICR), the Institute of Advanced Energy (IAE), and the Research Institute for Sustainable Humanosphere (RISH) have been working in cooperation on the “Smart-Materials” project, supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. The ever-increasing demand for materials and energy by the present social system has almost reached its limit, and the environment is heavily burdened by harmful by-products and surplus heat from mass production. In order to overcome these issues, this project aims to fabricate smart materials and develop a joint research organization, achieving green innovation through “zero loss” at the production/transportation/usage of materials/energy. The model for the target materials is a biological system with molecular recognition ability, autonomy, and activity. The key to success is interdisciplinary research with flexibility and rapidity. Taking advantage of the three institutes being located at the same campus (Uji campus of Kyoto University), the under-one-roof scheme is expected to deliver internationally excellent results, contributing significantly to this research field.

Science and Technology Research Partnership for Sustainable Development (SATREPS: Project Type Technical Cooperation)

Development of clean and efficient utilization of low rank coals and biomass by solvent treatment

- Leader : Specially Appointed Prof. Kouichi Miura
- Project Period : FY2013 – FY2018

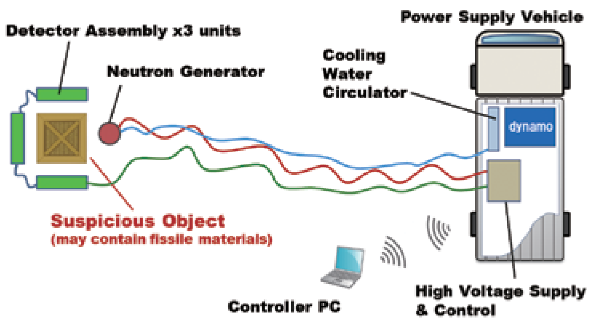
This project develops new technologies to convert low rank coals and biomass wastes to clean intermediates of low molecular weight compounds using a new concept called “degradative solvent extraction” and to convert the intermediates to new biofuel, solid fuel, and carbon materials. Implementation of the technologies in Thailand and in Asian countries in the near future is also planned.

Research project: Support for the Promotion of Collaboration on Creation of Innovative Manufacturing Industries (NEDO)

Title: Portable Non-Destructive Detection System of Fissile Materials for Counterterrorism Infrastructure Development

- Project Leader : Assoc. Prof. Kai Masuda
- Collaborators : Profs. Tshuyoshi Misawa, Yoshiyuki Takahashi, Yasunori Kitamura, and so on
- Collaborate with : Pony Industry Co. Ltd.
- Project Period : FY2015 – FY2017

The objective of this project is to provide an inspection device capable of detecting hidden U-235, which can hardly be detected by the use of existing devices for combatting global nuclear terrorism. R&D are pursued for this purpose on the world's first portable detection system, comprising a neutron-based fissile materials interrogation technique developed at Kyoto University coupled with an innovative neutron detector technology by Pony Industry Co. Ltd. The proposed system has the goal to be deployed in the market place before 2020 Tokyo Olympic/Paralympic Games.

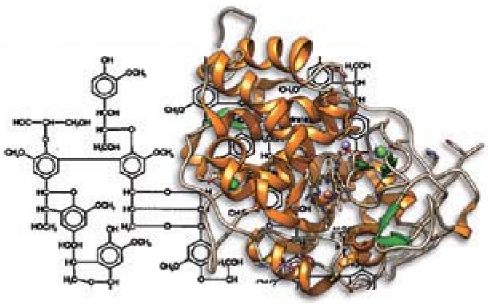


The world's first portable fissile materials detection system to be developed

Strategic Basic Research Programs, Advanced Low Carbon Technology R&D Program (ALCA) Japan Science and Technology Agency (JST)

Research area: White Biotechnology

Research project: Advanced lignin degradation with enzymes of marine microorganisms and production of artificial Urushi -Development of highly active enzymes to produce aromatic monomers, GHP/SHP, on the basis of structural biology with NMR-



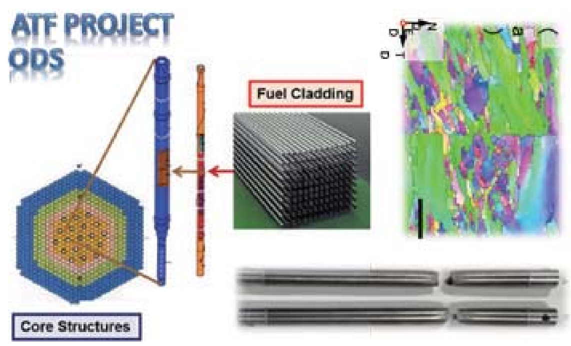
- Sub-theme Leader : Prof. Masato Katahira
- Project Period : FY2015 – FY2017

METI Project for Development of Technical Basis for Safety Improvement at Nuclear Power Plants

"Development of Technical Basis for Introducing Advanced Fuels Contributing to Safety Improvement of Current Light Water Reactors"

- Leader : Japan Atomic Energy Agency
- Leader in IAE : Prof. Akihiko Kimura
- Project Period : FY2015 – FY2021

Accident tolerant fuel cladding R&D has been conducted to substitute Zircaloy claddings, which are so reactive with hot water that a lot of hydrogen is produced during accident like Fukushima-I, with Fe-based steel. The FeCrAl-ODS steel modified from "Super ODS steel" has been developed for application to the fuel cladding of BWR.

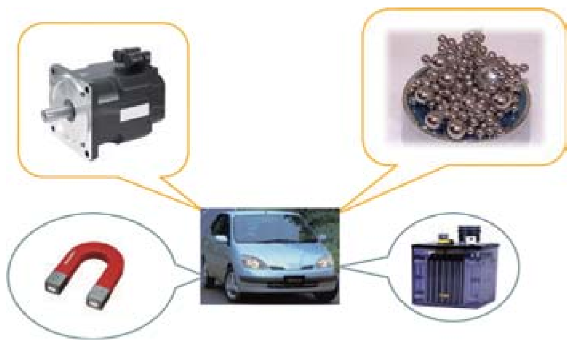


METI Projects to Support the Advancement of Strategic Core Technologies

"Development of Massive Production Processing of High Performance Nd-Fe-B Sintering Magnets"

- Leader : Specially Appointed Professor Masato Sagawa
- Project Period : FY2016 – FY2018

The development of the world No. 1 magnet has been conducted. The demands for Neodymium magnet has rapidly growing and the massive production processing of Nd-Fe-B magnets are highly required by many fields of magnet users. The evaluation methodology of nano/mezo structure control towards high performance is progressing.



Research Unit for Smart Energy Management

- Leader : Prof. Yasuo Okabe (Academic Center for Computing and Media Studies)
- Leader in IAE : Prof. Toshiyuki Nohira
- Project Period : FY2016 – FY2021

This research unit aims to enhance the interdisciplinary R&D on Smart Energy Management by developing and deepening the various results obtained in Graduate School of Engineering, Graduate School of Energy Science, Institute of Advanced Energy, Graduate School of Economics, Graduate School of Informatics, and Academic Center for Computing and Media Studies, Kyoto University. The unit especially focuses on the fusion of current communication network technology and information processing technology. The unit will also conduct cooperation research projects with industry, government, schools.

Kyoto University Research Coordination Alliance, Research Units for Exploring Future Horizons

In this program, Kyoto University establishes the "Research Units for Exploring Future Horizons" and strengthens the communication and coordination between the research institutes and centers that covers various fields of academic research, and interdisciplinary studies for the establishment of new research field by bottom-up approach with international research partners.
Under the Kyoto University Research Coordination Alliance, 4 projects are ongoing as the organization "research unit", where IAE is involved in 2 projects.

Unit of Academic Knowledge Integration Studies

- Leader : Prof. Seiichiro Hara (Center for Southeast Asian Studies)
- Leader in IAE : Prof. Hideaki Ohgaki
- Project Period : FY2015 – FY2019

In this program, 14 departments collaborate to integrate academic knowledge accumulated in Kyoto University by using an advanced information technology, especially on database. The unit studies an interdisciplinary field of the digital-humanism targeting on the human security problems in south-east Asian countries as a practical field. The goal of the program is to offer an academic "big data" system to integrate the social science and natural science.

Unit for Development of Global Sustainability

- Leader : Prof. Toshiaki Umezawa (Research Unit for Development of Global Sustainability)
- Leader in IAE : Prof. Kazunobu Nagasaki
- Project Period : FY2015 – FY2019

The Institute of Sustainability Science, which pursued sustainability study in the past 10 years by the collaboration of 7 departments, has reformed itself into "Unit for Development of Global Sustainability". This research unit aims at exploring and developing the idea and method of such plans focusing on the lifetime, on the basis of interdisciplinary collaborative researches.

Research Facilities

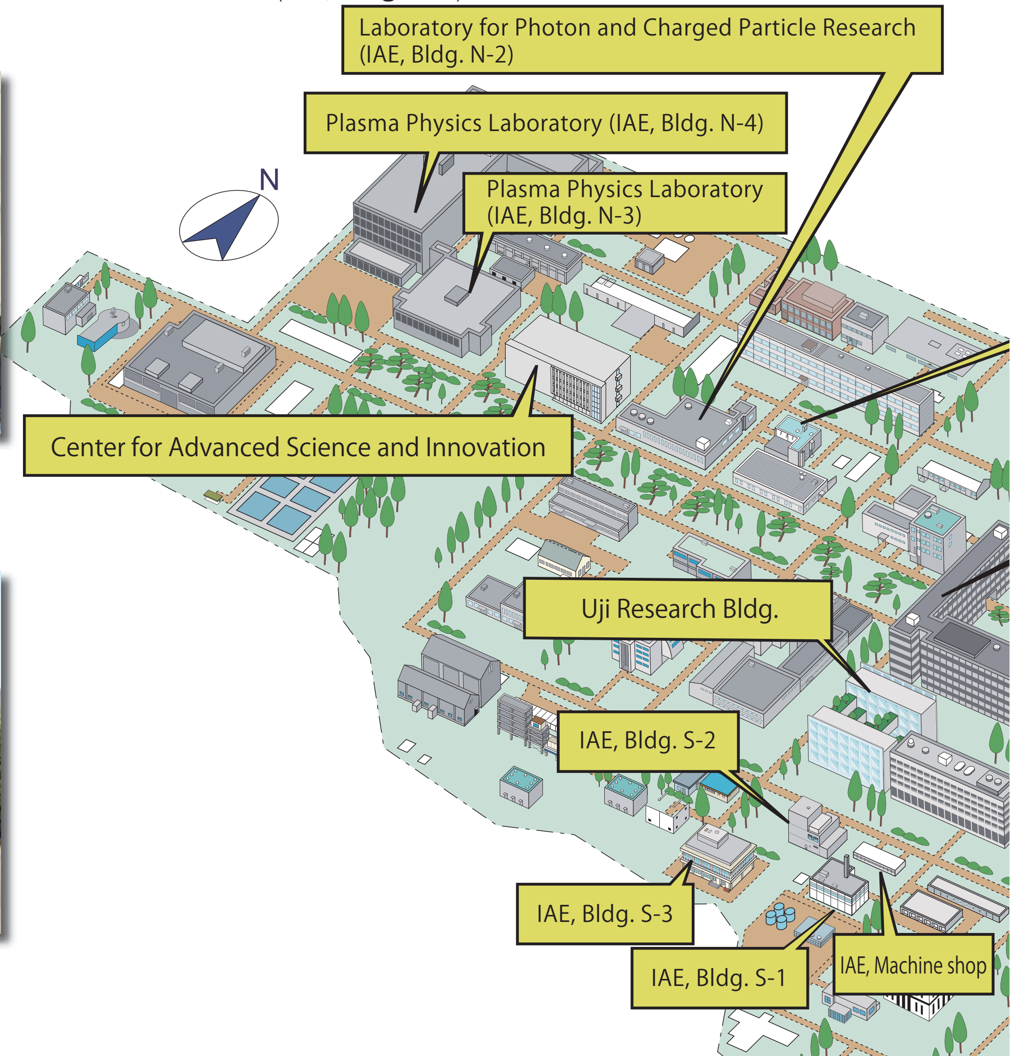
The Institute of Advanced Energy conducts research at several buildings, including the main building on the Uji Campus.

Laboratory for Energy Nano-science (IAE, Bldg. N-1)

Laboratory for Photon and Charged Particle Research (IAE, Bldg. N-2)

Plasma Physics Laboratory (IAE, Bldg. N-3)

Uji Campus Main Bldg. (W wing)



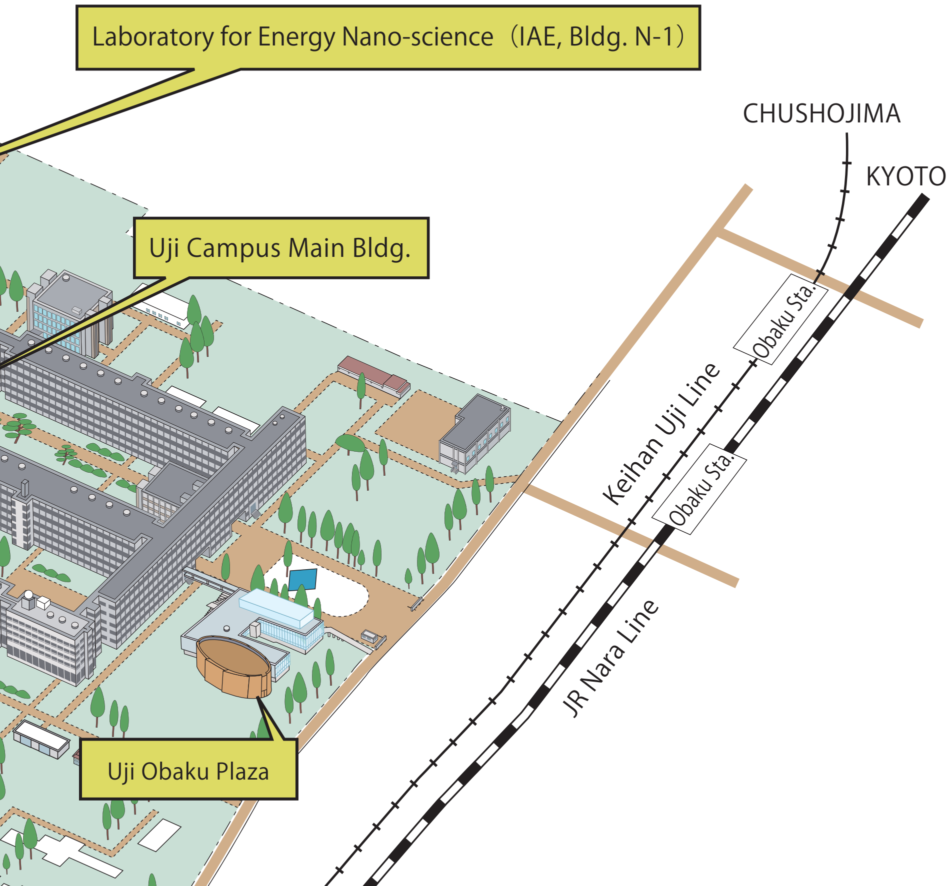
Uji Campus Main Bldg. (M wing)

IAE, Bldg. S-1

IAE, Bldg. S-2

Plasma Physics Laboratory (IAE, Bldg. N-4)

Center for Advanced Science and Innovation



Uji Research Bldg.

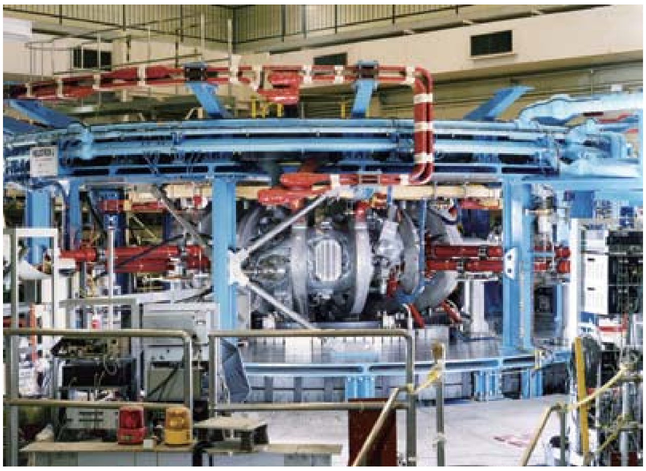
Uji Obaku Plaza

IAE, Bldg. S-3

IAE, Machine shop

Heliotron J

One of the objectives of the Heliotron J project is to explore the confinement optimization of the "helical-axis heliotron" configuration which is original to Kyoto University in its design concept, in order to develop the advanced and high-performance fusion reactor. Heliotron J started its plasma operation in 2000, and continues the improvement of performance as a unique fusion plasma experiment device.



(IAE, Bldg. N-4)

Mid-infrared Free Electron Laser Facility KU-FEL

KU-FEL is a tunable MIR laser which is generated by a relativistic electron beam interacted with synchrotron radiation in the periodic magnetic field. Researches on energy materials by using high peak power MIR-FEL have been conducted by cooperation researchers.

(IAE, Bldg. N-2)

Dual-Beam Facility for Energy Science and Technology DuET

DuET is a powerful tool for introduction of lattice defects, modification of surface structure, and in-beam analysis. Two ion-beams of a different species are able to be irradiated simultaneously to the metals and/or ceramics under various environmental conditions.

(IAE, Bldg. N-2)

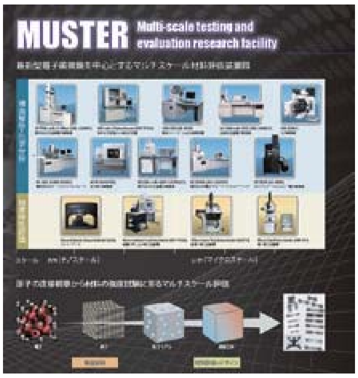
NMR Machines

Four NMR machines, including three 600 MHz machines equipped with the superhigh sensitivity probe, are operated to develop the way to extract the energy and valuable materials from biomass and biomolecules.

(IAE, Bldg. S-2)

Multi-Scale Testing and Research Facility MUSTER

MUSTER is a research facility installed with high-resolution microscopes, TEM, FE-TEM, SEM and FE-SEM, chemical analyzers, FE-AES and FE-EPMA, and mechanical testing machines, fatigue test machine, impact test machine, high temperature tensile test machine and nano-indenter, etc.



(IAE, Bldg. N-1, N-2)

Research Facilities for Energy Nanoscience

Analytical instruments for investigation of the energetic function of nanocomposites and biomaterials are provided. These involve scanning probe microscopes, atomic force microscopy, fluorescence microscope, CD spectrometer, ultraviolet and visible spectrophotometers, a fluorescence spectrometer, iso-thermal titration calorimetry, differential scanning calorimetry, MALDI-TOF mass spectrometer, ESI mass spectrometer, FT-IR spectrometer and photo-electron spectroscopy. (IAE, Bldg. N-1)

Functional Analytical Systems for the Generation of Catalytic Materials

Instruments are set up to purify, analyze chemical compositions and structures, and to evaluate functions of various biomolecules, organic and inorganic molecules. These include 300 MHz and 600 MHz NMRs, a protein purification chromatography system, a DNA sequencer, a time-resolved fluorescence spectrometer, a FESEM, and a solar simulator. (IAE, Bldg. N-1)

Plasma Energy Direct Conversion Experiment Device

This device can generate 30kV-6A hydrogen beam and is now conditioning for the research of innovative liquid metal concepts for high heat flux divertor and breeding blanket for fusion in-vessel components.

(IAE, Bldg. S-3)

Advanced Energy Conversion Experiment

This device simulates the high particle and heat flux environment on the fusion plasma facing components by hydrogen beam, and 950 C LiPb liquid metal loop for the study of interaction between material and energy on the energy conversion components such as divertor, blanket and heat exchanger with advanced materials and heat transfer media.

(IAE, Bldg. S-1)

CEP-Stabilized High-Intensity, Ultrashort-Pulse Laser

This Ti:sapphire laser using the chirped-pulsed amplification technique produces intense few-cycle optical pulses with stabilized carrier-envelope-phase, which allows us to approach new strong-field and attosecond regimes in studying interaction of light with matter.

(Uji Campus Main Bldg.)

The Institute strives to train graduate students who are specialists with a global perspective capable of solving energy issues in the twenty-first century.

Education

Since being simultaneously launched with the Graduate School of Energy Science, Kyoto University in 1996, each laboratory in the Institute has participated in training graduate students via a cooperative course. The steady flow of research achievements has been attracting more and more students to our Institute. Both the recent increase in the number of Ph.D. students and the higher percentage of foreign students in our student body attest to the fact we are becoming an international institute. Additionally, many of our graduate students are attracted to the Institute's unparalleled quality of advanced equipment and the diversity of our staff engaging in advanced research.

We hold briefing sessions for prospective graduate students in conjunction with Graduate School, so that potential students are familiar with issues such as our enrollment policy and selection procedure. The notable activities of our Institute include briefing sessions of our graduate school, which have been held concurrently with our open seminars, to disseminate our activities to a broad audience. These efforts have increased the student body at our Institute to 96 in FY2016, which includes 32 Ph.D. students (21 from foreign countries). We are leveraging both the Institute's Research Assistant (RA) system to increase opportunities for graduate students to network with other research institutes in Japan and abroad as well as to encourage them to present at research meetings in and out of Japan. To broaden their international perspective, many of our graduate students have participated and/or presented at international conferences. Attending international conferences plays a major role in our training activities at the Institute. We are also making efforts to expand the professional careers of our graduates, and numerous graduates have found employment at research institutes in Japan and abroad. Additionally, we jointly host public lectures with technical colleges to further our education and training activities.

We also strive to include the general public in our activities via public lectures and an open campus policy. Visitors are always welcome. We aim to contribute to a broad spectrum of our society, including the local public activities. Additionally, the latest information is disseminated through the Institute's website, annual reports and publicity activities of the University. Since 2003, we have held annual public lectures on our campus and in the city of Kyoto to facilitate participation from the general public.

We also actively participate in Kyoto University Research Institutes' Symposium to impart our achievements. Moreover, efforts have been made to develop innovative and creative initiatives of the advanced energy fields and training activities in the nuclear power field. We are dedicated to disseminating and practically applying intellectual properties through activities such as i) collaborating with industry, government, and academia, ii) holding joint symposia, iii) actively conducting collaborative research and engaging in commissioned research, iv) providing technical guidance to industry, and v) implementing systems for the effective collaboration of industry, government, and academia. Results from these initiatives will be used in a broad array of fields to further our contributions in the international arena and to strengthen our international collaborative network.

International Symposium of Advanced Energy Science "Frontiers of Zero Emission Energy"

The 7th International Symposium of Advanced Energy Science titled "Frontiers of Zero Emission Energy" was held at the Kyoto University Clock Tower Centennial Hall and Uji campus for 3 days from 5th September 2016. The symposium was supported by Joint Usage/Research Center Program of MEXT, jointly held with the International Workshop on Energy Science Education. We had 13 distinguished speakers from home and abroad in the field including bioenergy, nuclear fusion, optics, material science, nanotechnology, and more. The symposium gathered 328 participants from all over the world. Specialized and detailed discussion was carried out at the parallel seminar sessions, which has successfully satisfied the participants who wished to discuss in more depth.

Public Lectures

"The 21st Public Lecture of Institute of Advanced Energy" was held on 23rd October, 2016 at Kihada Hall of Obaku Plaza on Uji campus, jointly held with Uji Campus Open for Public. This series of annual public lectures have been held to introduce our recent research activities to the public including industrial workers, college students, high school and junior high school students, etc. in an easy-to-understand manner. In the opening address, T. Mizuuchi, the director of institute, introduced current status and feature prospect of energy research in our institute and emphasized the importance of our contribution to society by promoting academic development and discovery of new technologies in zero-emission energy science. Three professors introduced their recent research activities in the following clear, substantial and exciting lectures: T. Kii gave a talk on "Construction and Use of Accelerators", A. Kimura showed "Research Development of Energy Structural Materials", and finally M. Katahira introduced "Cross point between Life Innovation and Green Innovation" together with introduction of the way how to take doctoral thesis and become academic staff, and the research life style. A. Kimura, the vice director, concluded the session with closing remarks showing appreciation to participants. Following the lectures, there were poster presentations, and laboratories of Heliotron J, DuET/MUSTER, KU-FEL, IEC and NMR were open for public, jointly held with Uji Campus Open.

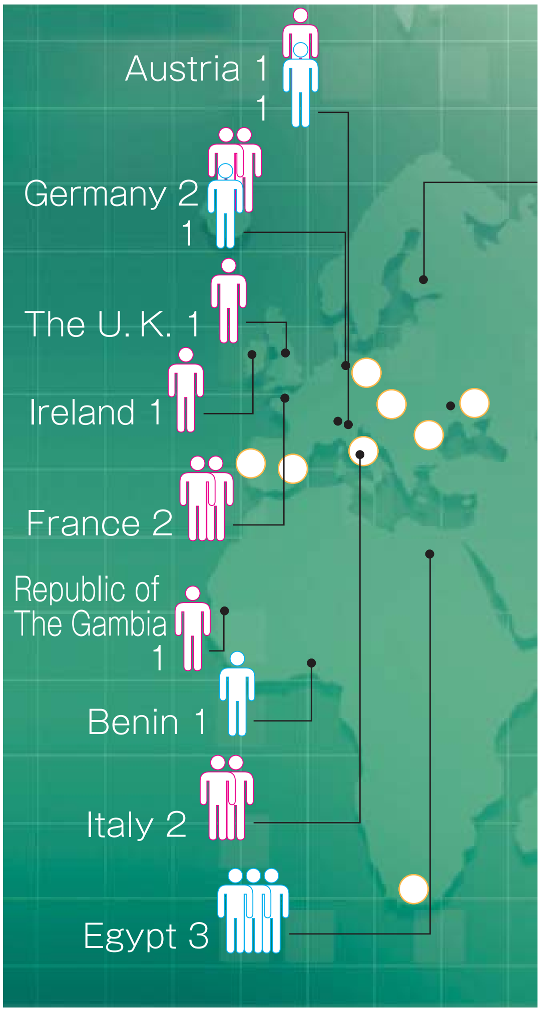
International Activities

We have signed collaborative research agreements with numerous research institutes around the world to actively conduct joint research, including research visits and international conferences.

Academic Collaboration Agreements

Date signed	Name of Institute	Country
Sep. 29, 1995	Fusion Technology Institute, University of Wisconsin-Madison	U.S.A.
Oct. 3, 1995	Fusion Studies Laboratory, University of Illinois Urbana-Champaign	U.S.A.
Oct. 6, 1995	Russian Research Centre "Kurchatov Institute"	Russia
Nov. 6, 1995	Center for Fusion Science, Southwestern Institute of Physics	China
Jun. 3, 1996	Institute of High Energy Physics, Chinese Academy of Sciences	China
Jun. 4, 1996	China Institute of Atomic Energy	China
Nov. 19, 1996	Center for Beam Physics, Lawrence Berkeley National Laboratory, University of California	U.S.A.
Nov. 20, 1996	Free Electron Laser Center, Hansen Experimental Physics Laboratory, Stanford University	U.S.A.
Dec. 12, 1996	Department of Physics, Flinders University of South Australia	Australia
Mar. 10, 1997	Institute of Material Failure, University of Science & Technology, Beijing	China
Aug. 10, 1997	Plasma Research Laboratory, Australian National University	Australia
Feb. 6, 1998	Torsatron/Stellarator Laboratory, University of Wisconsin-Madison	U.S.A.
May. 11, 1998	National Science Center 'Kharkiv Institute of Physics and Technology'	Ukraine
Aug. 1, 1998	Department of Materials Science and Chemical Engineering, Politecnico di Torino	Italy
May. 7, 1999	Industry-University Cooperation Section, Dong-eui University	Republic of Korea
July. 24, 2000	Dong-eui University (Engineering school)	Republic of Korea
Sep. 10, 2000	Korea Basic Science Institute	Republic of Korea
Jan. 9, 2001	Graduate School of Physics, University of Sydney	Australia
Jan. 25, 2001	Slovak University of Technology in Bratislava (Faculty of Electrical Engineering and Information Technology)	Slovak Republic
Jan. 5, 2001	Rajamangala University of Technology Thankyaburi	Thailand
May. 16, 2001	Spanish National Research Centre for Energy, Environment and Technology, CIEMAT	Spain
July. 24, 2001	University of Erlangen-Nuremberg (Department of Material Science, School of Engineering)	Germany
Apr. 6, 2006	National Fusion Research Institute	Republic of Korea
Nov. 28, 2006	Research Institute of Industrial Science and Technology, Pukyong National University School of Engineering	Republic of Korea
Feb. 20, 2009	Atomic Energy Materials, Global Security, Lawrence Livermore National Laboratory	U.S.A.
Oct. 19, 2009	Joint Graduate School of Energy and Environment	Thailand
May.18, 2010	City University of New York, Energy Institute	U.S.A.
Apr. 12, 2012	Nano and Energy Center, Vietnam National University, Hanoi	Vietnam
Jun. 28, 2012	Universidade de Aveiro	Portugal
Jan. 23, 2013	Fusion Plasma Transport Research Center, Korea Advanced Institute of Science and Technology	Republic of Korea
Mar. 20, 2013	Korea Atomic Energy Research Institute	Republic of Korea
Oct. 29, 2013	The Convergence of It Devices Institute Dong-Eui University and Ulsan Technopark	Republic of Korea
Sep. 18, 2014	Center for Advanced Material & Energy Sciences, University Brunei Darussalam	Brunei
Oct. 6, 2014	Horia Hulubei National Institute of Physics and Nuclear engineering	Romania
Dec. 1, 2014	Nelson mandela metropolitan university	South Africa
Dec. 3, 2014	Ulsan National Institute of Science and Technology (UNIST), Fusion Plasma Stability and Confinement Research Center (FPSCRC)	Republic of Korea
Jun. 15, 2016	Center for Science and Technology of Advanced Materials, Indonesia National Nuclear Energy Agency-Batan	Indonesia
Jul. 7, 2016	University of California, Santa Barbara	U.S.A.
Jul. 28, 2016	IAEA (International Atomic Energy Agency)	Austria

The number of visitors



International Exchange Promotion: ASEAN-JAPAN

▶ **Leader: Prof. Hideaki Ohgaki**

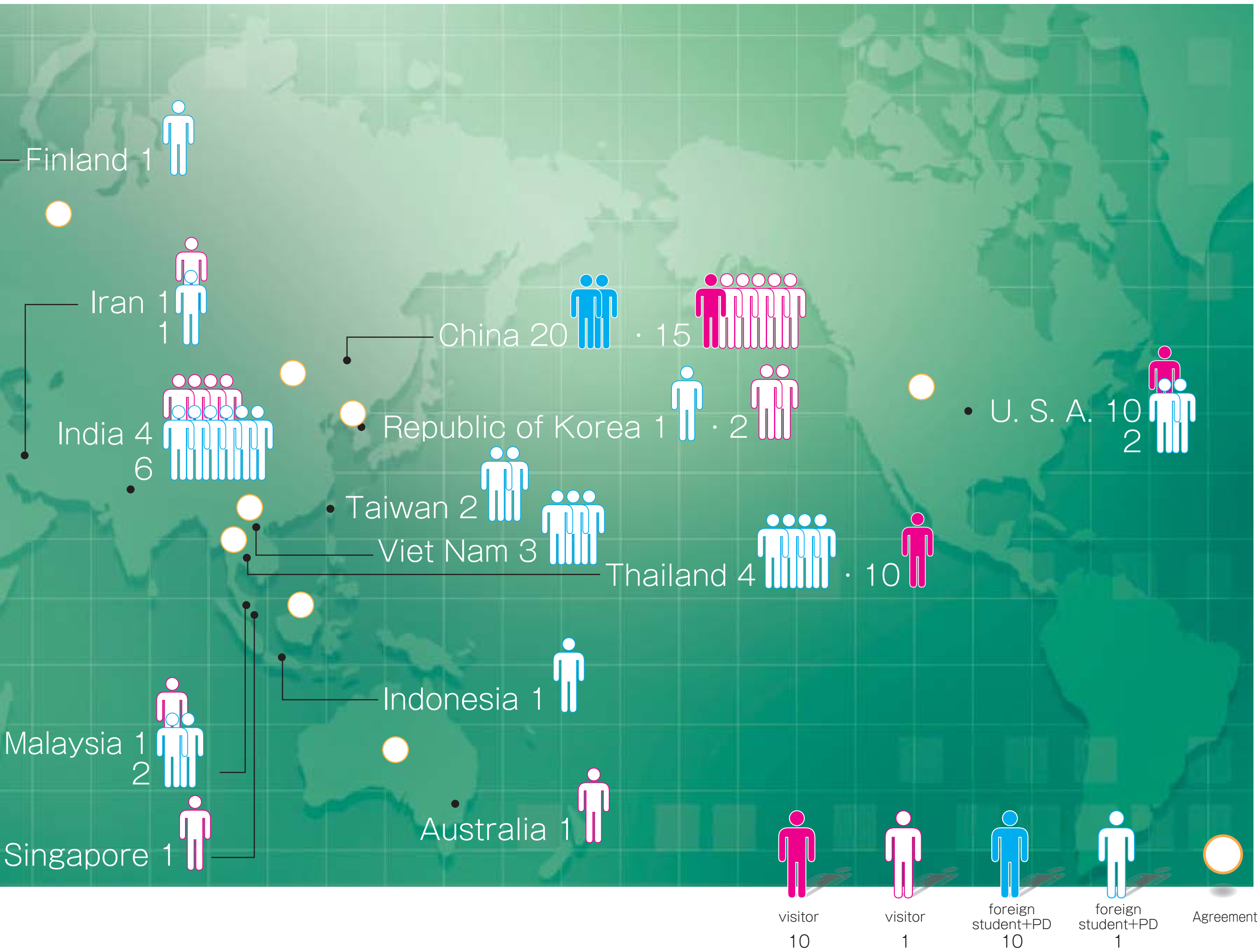
International exchange promotion activities among ASEAN countries are started by the 21st century COE program from 2006 through establishing the Asian academic network named SEE Forum (Sustainable Energy and Environment Forum). In FY2016, SEE Forum meeting was held in Thailand to promote the international exchange as well as collaboration research between Japan and Asia regions. In Thailand we also have the Eco-Energy and Materials Science and Engineering Symposium (EMSES) in almost every year in cooperation with Rajamangala University of Technology Thanyaburi from 2001. In FY2016, 13th EMSES was held in Udon Thani, Thailand and attracted about than 100 regional researchers in Thailand as well as nearby countries. By this cooperation we foster energy researchers in ASEAN countries.

These international activities among ASEAN region have been appreciated by counterpart universities, research institute in Asia, Japanese government and UNESCO. In this connection we started to cooperation with UNESCO COMPETENCE program from 2009 in cooperation with UNESCO Jakarta. As the extension activity we started the ODA-UNESCO Assist program on Energy for Sustainable Development in Asia (Vietnam in 2011, Laos in 2012, Cambodia in 2013, and Myanmar in 2014, http://www.oda-unesco-iae-kyoto-u.com/).

In 2012 based on the MOU between Kyoto University and AUN which was initiated IAE activities, the AUN – KU Student Mobility Program towards Human Security Development (HSD) has been selected to accelerate internationalization of university. In 2015, the Japan ASEAN Science and Technology Innovation Platform (JASTIP) has been adopted in JST SICORP. We have started to establish the collaboration research platform in the field of Energy and Environment.

JASTIP WP2 Kick-off workshop held in NSTDA on Feb. 29, 2016.

and foreign students (2016)



JSPS/NSFC Bilateral Collaboration Research Program "Research on Coherent Synchrotron Radiation and Super-radiation Free Electron Laser based on Ultra-Short Electron Bunches"

▶Leader : Prof. Hideaki Ohgaki

▶Period : From April 1, 2016 to December 31, 2018

This collaboration research aims at developing intense coherent radiations from high brightness electron beams in cooperation with Japan (Kyoto University and Tohoku University) and China (University of Science and Technology China, and Peking University).

Japanese team will mainly work on experimental study on generation of ultra-short bunch electron beams and coherent radiations. Chinese team will mainly work on theoretical study of these topics as well as development of simulation code.

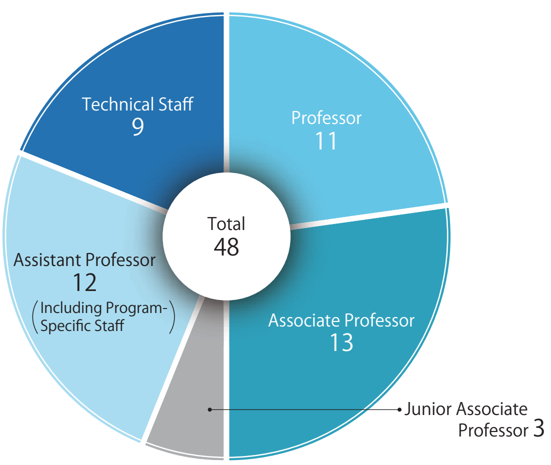
In Kyoto University, the existing 40 MeV electron linac where we can generate intense coherent synchrotron radiation and a newly installed small photocathode rf-gun based THz radiation machine will be used for this program. In Tohoku University, the originally designed thermionic rf-gun based linac will be studied in this program. In Peking University, the super-conducting linac which can generate strong coherent radiation will be studied. In University of Science and Technology Chine, theoretical studies will be carried out to understand the generation of ultra-short bunch electron beams with rather low energy (a few to 50 MeV) as well as generation of coherent super-radiation including development of simulation code.

Workshop on THz FEL held in USTC from December 22 to 23, 2016

Data

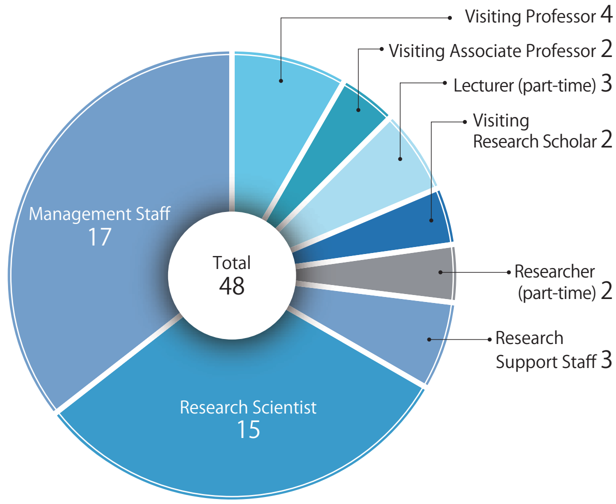
Faculty Member

2016



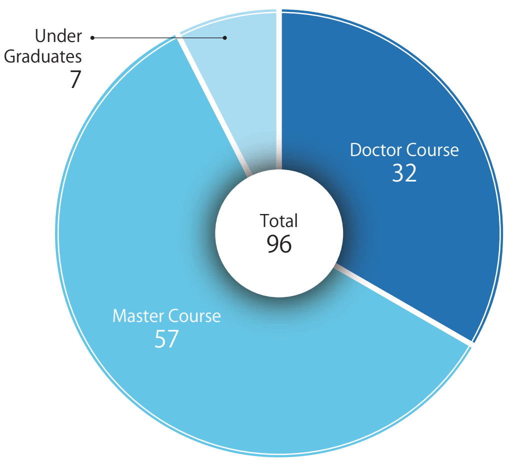
Adjunct Member

2016



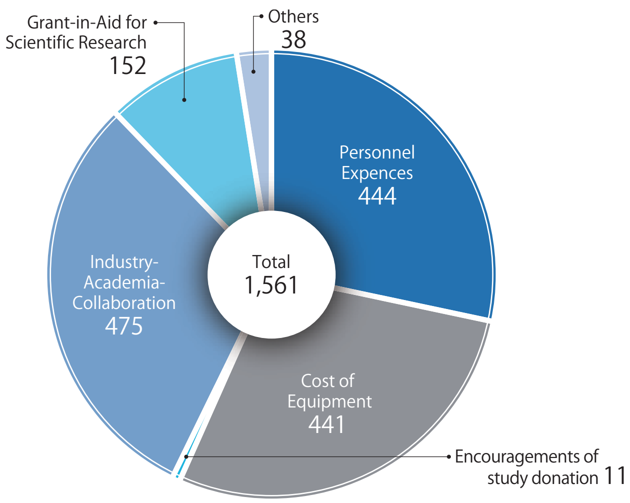
Students

May. 2016

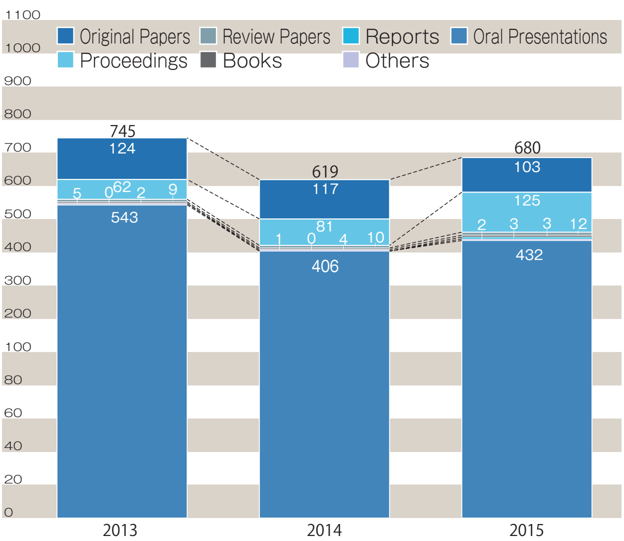


Budget

FY2015 [unit: 1 million yen]



Research Presentations

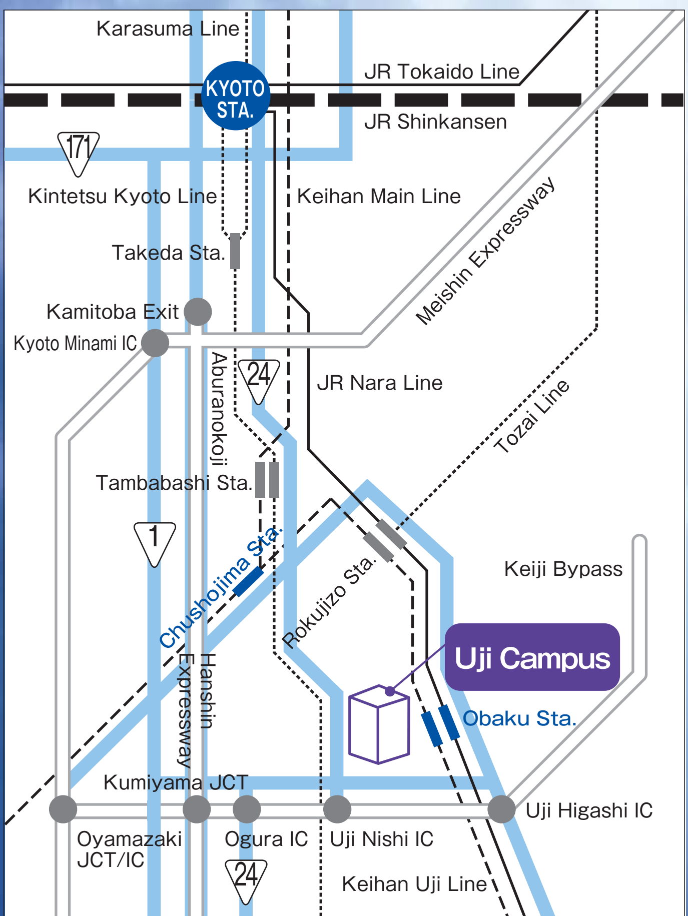


The number of applicants to the collaboration program of the Laboratory for Complex Energy Processes

Category	2016
A1: Section of Promotion for Advanced Plasma and Quantum Energy	5
A2: Section of Promotion for Photon and Energy Nano-Science Research	12
A3: Section of Promotion for International Collaborative Research	8
Total	25

The number of applicants to the collaboration program of Joint Usage/Research Center on Zero-Emission Energy

Category	2016
(A) Core research subject	33
(B) Research subject	47
(C) Facility usage	11
(D) Workshop	1
Total	92



ACCESS

1 By JR Line

JR Kyoto Station → JR Obaku Station → Uji Campus

22min JR Nara Line Local; 7min Walk

2 By Keihan Line

Keihan Chusyojima Station → Keihan Obaku Station → Uji Campus

9min Uji Line Local; 10min Walk

INFORMATION

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