Department of Quantum Science and Energy Engineering

Department of Quantum Science and Energy Engineering consist of following Core Laboratories, Cooperative Laboratories, and etc.

Department of Quantum Science and Energy Engineering

① Core Laboratories

Energy Physics Engineering (3), Safety Engineering of Nuclear Systems (4), Particle-Beam Engineering (5)

② Cooperative Laboratories

Institute for Materials Research (IMR)

Energy Materials Engineering (2), Quantum Theoretic Material Engineering (2)

Institute of Multidisciplinary Research for Advanced Materials (IMRAM)

Energy Chemical Engineering (1)

Research Center for Accelerator and Radioisotope Science (RARIS)

Accelerator Radiation Engineering (1)

Department of Quantum Science and Energy Engineering

Laboratory	Professor / Associate Professor	Theme of research
Energy Physics Engineering (Advanced Fusion Reactor Engineering)	Associate Professor Satoshi ITO Associate Professor Shinji EBARA Senior assistant professor Weiying CHENG Assistant professor Hiroki SHISHIDO (Collaborative Chair: Fusion Reactor System Engineering) Professor (Visiting member) Nagato YANAGI	The realization of fusion reactors as a sustainable energy source with low environmental loads is one of the most important engineering issues to be solved in the 21st century. Based on interdisciplinary field of superconducting technology, thermofluid dynamics and electromagnetic structural engineering, our laboratory carries out the following unique research to design most attractive fusion reactors, 1. Development of re-mountable high temperature superconducting magnet system to produce strong magnetic fields necessary for plasma confinement, 2. Research of high heat removal system for advanced fusion divertor, 3. Design of novel fusion systems for transmutation of fission products and minor actinides.
Energy Physics Engineering (Fusion Plasma Science)	Associate Professor Tetsutarou OISHI Senior Assistant Professor Hiroyuki TAKAHASHI	Based on plasma experiments, diagnostic technique development and numerical simulations, fusion plasma studies are conducted. The current research themes are: 1. Experimental research on divertor plasma 2. Development of plasma diagnostic techniques 3. Numerical simulation of fusion plasma 4. Diagnostics of impurities in high-temperature plasma
Energy Physics Engineering (High Energy Materials Engineering)	Professor Yuji HATANO	Fusion energy is key to a sustainable future. We are developing plasma-facing materials that can withstand the harsh environment of hydrogen isotope plasma and high-energy neutrons in fusion reactors. Additionally, we investigate the behavior of tritium, a crucial fuel and radioisotope of hydrogen, within fusion systems for safe and efficient utilization. Our research encompasses several key areas: 1. Development of robust plasma-facing materials for fusion reactors 2. Evaluation and control of tritium dissolution, diffusion, and permeation in fusion reactor materials 3. Purification, separation, and measurement of tritium 4. Hydrogen isotope interactions with lattice defects in materials Study of hydrogen behaviors in nuclear and industrial materials using tracer techniques.

Laboratory	Professor / Associate Professor	Theme of research
Safety Engineering of Nuclear Systems (Nuclear Energy-Flow Environmental Engineering)	Associate Professor Taiji CHIDA Assistant Professor Tsugumi SEKI (Collaborative Chairs: Fundamental Engineering for Nuclear Reactor Decommissioning) Professor (Visiting member) Masayuki WATANABE	Based on geosphere transport phenomena, chemical reaction engineering and radiochemistry, the fundamental studies on the safety assessment of radioactive waste disposal system are conducted. The practical themes are: 1. Development of self-healing barrier of radioactive wastes by promoting interaction of radionuclides and cement-based materials, 2. Transport phenomena of supersaturated silicic acid in alkali and thermal front, and its application to the design of geological disposal system, 3. Retardation effect of nuclide migration in unsaturated porous formation, and its application to performance assessment of the interim storage facility of contaminant soils, 4. Immobilization of hazardous substances in structural materials of disposal system for reducing environmental impacts, and so on.
Safety Engineering of Nuclear Systems (Measurement Technology and Reliability Quantification)	Professor Noritaka YUSA Assistant Professor Saijiro YOSHIOKA	Assuring the reliability of structures is one of the most important issues for the safe operation of nuclear power plants. Our laboratory conducts various studies for evaluating the structural integrity of large systems such as 1. Development of nondestructive testing and evaluation techniques using DC-GHz electromagnetic fields, 2. Development of nondestructive inspection and health monitoring technique using guided waves, 3. Development of methods to probabilistically evaluate signals of nondestructive inspections for evaluating the safety of nuclear systems.
Safety Engineering of Nuclear Systems (Degradation Science and Plant Life Management)	Professor Yutaka WATANABE Associate Professor Hiroshi ABE	This lab does interdisciplinary studies based on mechanical engineering and materials science to understand materials degradation mechanisms and to improve plant life management methodologies for light water reactors and other nuclear systems. 1. Mechanistic studies in materials degradation of LWR components. 2. Materials evaluation studies for supercritical water cooled reactors. 3. Development of monitoring methodologies of materials degradations in their initiation stages. 4. Development of degradation resistant alloys for nuclear systems. 5. Corrosion prediction and prevention studies for safe decommissioning of Fukushima Daiichi Nuclear Power Station.
Safety Engineering of Nuclear Systems (Nuclear Energy System Safety Engineering)	Professor Makoto TAKAHASHI (Department assigned：Department of Management Science and Technology) Associate Professor Daisuke KARIKAWA (Department assigned：Department of Management Science and Technology)	In order to achieve higher level of safety in nuclear power plant, the interaction between human and machine should be carefully designed. In our laboratory, the problems of human factors are studied from variety of viewpoints. 1. Enhancement of organizational safety in nuclear power plant 2. Evaluation of human-machine interface using human brain mapping method 3. Human factor study for air traffic control (ATC) system 4. Diagnosis system for early recognition of cyber attack

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Particle-Beam Engineering (System Engineering of Particle-Beams)	Professor Shigeo MATSUYAMA Associate Professor Wataru KADA Assistant Professor Naoto AIZAWA	Based on the understanding of 1) the methods of radiation production using accelerators and nuclear reactors, and 2) the phenomena based on the interaction of radiation with matter, we carry out research that develops applications in various fields, including not only science and engineering, but also medicine, biology, environmental science and energy. Current research topics include; 1) Development of micro- and nano- beam systems through the optimization of MeV-class ion accelerators and the refinement of particle beam transport and beam optics technologies. 2) Imaging of various information on subjects using micro- and nano-beam systems (i.e. super-resolution fluorescence imaging, elemental microscopes) 3) Development of functional imaging devices (PET) for the clinical and basic medical use of radiation, development of X-ray fluoroscopy systems for ultra-minimally invasive surgery, and development of high-performance sensors for dose evaluation in radiation therapy 4) Development and application of evaluation facilities for semiconductor devices for space use, especially for "New Space" 5) Development of next-generation nuclear reactors with high safety and transmutation processing capabilities
Particle-Beam Engineering (Quantum Biomedical Instrumentation)	Associate Professor Yohei KIKUCHI	Biomedical imaging technologies, such as X-ray CT, molecular imaging modalities and so on, are essential tools for medical related fields; clinical medicine, drug discovery, basic medical science and life science. To create novel benefits or values of the technologies, we conduct interdisciplinary R&D based on the knowledges of hardware/software on image engineering and the aspects/methodologies of brain science and psychology. 1. Super-resolution PET (positron emission tomography) 2. Development of X-ray fluoroscopy systems for ultra-minimally invasive surgery (interventional radiology) 3. Image specification optimization of medical modalities applying biometrics data of medical professionals' thought and mentality
Particle-Beam Engineering (Applied Quantum Medical Engineering)	Associate Professor Miho SHIDAHARA	We aim to contribute on future medicine by developing practical and efficient technologies and evaluation methodologies in the field of nuclear medicine (PET and SPECT) and related imaging modalities. Detailed projects are listed as follows. 1. Quantification of physiological functions in human body 2. Computer-aided virtual clinical trial for efficient development of radioligands 3. Numerical observer model for prediction of detection ability in medical imaging 4. Radiation dosimetry in both diagnostic and therapeutic purposes
Particle-Beam Engineering (Advanced Radiation Application) [Branch in Rokkasho-mura]	Professor Keitaro HITOMI Assistant Professor Mitsuhiro NOGAMI	Our group focuses on development of compound semiconductor radiation detectors for advanced radiation applications including ultra-high resolution PET systems, ultra-high resolution SPECT systems, photon counting CT systems, and Compton cameras. The main research subject of our group is developing material purification methods, crystal growth methods and detector fabrication technologies for thallium bromide (TlBr) semiconductor radiation detectors.

Laboratory	Professor / Associate Professor	Theme of research
Particle-Beam Engineering (Nuclear Fuel Science) [Branch in Rokkasho-mura]	Professor Seong-Yun KIM	One of the most important problems needing to be solved in nuclear fuel cycle is the high-level liquid waste management. To minimize the waste and to reduce the radiotoxicity, our group is mainly engaged in the studies of chemical separation of fission produces such as 1. Nuclide separation processes of high-level liquid waste using impregnated adsorbent and ionic liquids. 2. Separation between strontium and yttrium using impregnated adsorbent to reuse for radiotherapy. Electrochemical of metal speciation in the solution of the reprocessing plant.
Energy Materials Engineering (Irradiation Effects in Nuclear and Their Related Materials) <Cooperative Laboratories> [Irradiation Effects in Nuclear and Their Related Materials, IMR]	Professor (Concurrent post) Ryuta KASADA Associate Professor Koji INOUE Associate Professor Kenta YOSHIDA Assistant Professor Peng SONG	We are studying defects, nano-scale precipitates and interface segregations of impurity/solute atoms in materials. Our target extends from nuclear materials such as reactor pressure vessel steels and shroud stainless steels to semiconductors such as silicon and silicon-germanium. We employ positron annihilation [two-dimensional angular correlation of annihilation radiation (2D-ACAR), coincidence Doppler broadening and positron lifetime], 3D atom probe and transmission electron microscope. By combining first-principles calculations and molecular dynamics simulations using the IMR super-computer with the above experiments we are clarifying the formation and microscopic structures of these defects, precipitates and interface segregations.
Energy Materials Engineering (Nuclear Materials Engineering) <Cooperative Laboratories> [Nuclear Materials Engineering, IMR]	Professor Ryuta KASADA Associate Professor Sosuke KONDO Associate Professor Kiyohiro YABUUCHI Assistant Professor Hao YU Assistant Professor Yasuyuki OGINO Assistant Professor Minha PARK	Materials are key to realize the advanced base-load-energy sources, such as nuclear fusion and next-generation fission reactors, because they suffer severe environments including high temperature, high pressure, and high-energy-particle bombardment. We are studying nano-particle dispersion strengthened materials made by mechanical alloying method and multi-material design towards improvement of environmental resistance. Structural ceramics like silicon carbide are also other option currently we are exploring. Our strategy of the material R&D essentially incorporates the knowledge of mechanical strengthening even under the complex set of loads such as irradiation, liquid metal flow, and high flux heating. Recently, we are trying to develop and investigate the ultra-small testing technologies (USTT) such as nanoindentation for mechanical property evaluation and other advanced surface analysis method to test the specimens under the various environment.
Quantum Theoretic Material Engineering (Science and Technology of Functional Materials) <Cooperative Laboratories> [Environmentally Robust Materials, IMR]	Professor Eiji AKIYAMA Associate Professor Motomichi KOYAMA Assistant Professor Saya AJITO Assistant Professor Hiroshi Kakinuma	Hydrogen intruding into metallic materials used under stress causes fracture phenomenon, so-called hydrogen embrittlement. Hydrogen embrittlement is one of the quite important issues of structural materials used for energy production, automobiles, aircraft, infrastructures and so forth. In our laboratory, we investigate hydrogen uptake in corrosive environments and behaviors of hydrogen in metals to clarify the mechanism of hydrogen embrittlement. We also conduct research attempting to apply the interaction between hydrogen and phase transformation for novel structural control.
Quantum Theoretic Material Engineering (Engineering for Actinide Materials) <Cooperative Laboratories> [Actinide Materials Science, IMR]	Professor Dai AOKI Associate Professor Atsushi Miyake Assistant Professor Yoshiya HOMMA Assistant Professor DeXin LI Assistant Professor Ai NAKAMURA	The physics of f-electron systems, including both actinide and rare earth compounds, are an important aspect of strongly correlated electron systems. A large variety of fascinating phenomena, such as coexistence of magnetism and superconductivity, multipole order, quantum critical phenomena, are found. We grow high quality single crystals of actinide and rare earth compounds. By means of precise measurements under extreme conditions (low temperature, high field, high pressure), we aim to discover new phenomena and new physics. We also study actinide chemistry. Not only domestic collaborations but also international collaborations are strongly promoted.

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Energy Chemical Engineering (Radiochemistry) <Cooperative Laboratories> [Center for Mineral Processing and Metallurgy, IMRAM]	Professor Akira KIRISHIMA Senior Assistant Professor Daisuke AKIYAMA Assistant Professor Yuki YOKOTA	"Research on Nuclear Waste Management and Nuclear Facility Decommissioning by Radiochemistry" Nuclear energy is one of our modern society's most important energy resources. Therefore, making the nuclear fuel cycle more reliable is strongly demanded. Also, decommissioning the severely damaged reactors by the Fukushima NPP accident in 2011 and recovering the contaminated environment are urgent issues in Japan. To respond to these demands, our group investigates the chemistry of nuclear fuel debris and the leaching behavior of actinides in it by synthesizing simulated fuel debris with actinide tracers. Furthermore, we are developing novel and unique nuclear waste solidification processes using functional aluminum silicate minerals as fixation agents.
Accelerator Radiation Engineering (Nuclear Radiation Physics and Engineering) <Cooperative Laboratories> [Division of Applied Nuclear Physics, RARIS]	Professor Atsuki TERAKAWA Assistant Professor Chihiro IWAMOTO	We are conducting research on charged-particle therapy which has physical and biological advantages of charged-particles in cancer treatment, and boron-neutron capture therapy (BNCT) which selectively kills cancer cells. Particular attention is paid to development of high-precision irradiation techniques, accelerator-based neutron sources, real-time beam monitoring using micro-pattern gas-detector technologies, and three-dimensional dose measurements using polymer gel.

Notes: if you need more any details information, please tell the Director. 〔Professor Shigeo MATSUYAMA TEL+81-22-795-7930〕
**: Scheduled to retire in March 2026.
* : Scheduled to retire in March 2027.