# 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 ), Advanced Nuclear Engineering ( 1 )

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)

Center for Mineral Processing and Metallurgy ( 1 )

Cyclotron and Radioisotope Center (CYRIC)

Division of Instrumentations ( 1 )

Department of Quantum Science and Energy Engineering

| Laboratory | Professor / Associate Professor | Theme of research |
|---|---|---|
| Energy Physics Engineering (Advanced Fusion Reactor Engineering) | Professor<br>Hidetoshi HASHIZUME<br>Associate Professor<br>Satoshi ITO<br>Associate Professor<br>Shinji EBARA<br>Senior assistant professor<br>Weiying CHENG<br>(Collaborative Chair: Fusion Reactor System Engineering)<br>Professor (Visiting member)<br>Nagato YANAGI | The realization of fusion reactors as a long-term energy source with low environmental loads is one of the most important engineering issues to be solved in the 21st century.<br>Based on interdisciplinary field of superconducting technology, thermo fluid dynamics and electromagnetic structural engineering, our laboratory carries out the following unique researches to design most attractive fusion reactors,<br>1.Development of re-mountable high temperature superconducting magnet system to produce strong magnetic fields necessary for plasma confinement,<br>2.Research of high heat removal system for advanced fusion divertor,<br>3.Design of novel fusion systems for transmutation of fission products and minor actinoide,<br>4.Establishment of non-destructive testing by using microwave. |
| Energy Physics Engineering (Fusion Plasma Diagnostics and Advanced Plasma Research) | Professor<br>Kenji TOBITA<br>Associate Professor (Visiting member)<br>Akinobu MATSUYAMA | Based on plasma experiments, diagnostic techniques and numerical simulations, the research on fusion plasma is conducted. Fusion reactor systems research is also conducted. The current research themes are:<br>1.Experimental research on divertor plasma<br>2.Development of plasma diagnostic techniques<br>3.Numerical simulation of fusion plasma<br>4.Conceptual study of fusion reactor systems |
| Energy Physics Engineering (Neutron Device Engineering) | Professor (Concurrent post)<br>Hidetoshi HASHIZUME | The research interest is the application of neutron reaction to energy production, nuclear transmutation and radiation application in various systems and devices such as fission reactor, fusion reactor and accelerator. The following are the main topics:<br>1."Accelerator-driven system" -advanced safety reactor system<br>2."Nuclear transmutation reactor system" for reduction of nuclear waste<br>3."Space power supply device" for space exploration<br>4."Neutron source device" for radiation application |

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| Safety Engineering of Nuclear Systems (Nuclear Energy-Flow Environmental Engineering) | Professor Yuichi NIIBORI<br>Associate Professor Taiji CHIDA<br><br>(Collaborative Chairs: Fundamental Engineering for Nuclear Decommisioning)<br>Associate 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.<br>The practical themes are:<br>1. Development of self-healing barrier of radioactive wastes by promoting interaction of radionuclides and cement-based materials,<br>2. Transport phenomena of supersaturated silicic acid in alkali and thermal front, and its application to the design of geological disposal system,<br>3. Formation mechanism of high performance natural barrier by deposition of calcium silicate hydrate in a flow system through rock fracture,<br>4. Retardation effect of nuclide migration in unsaturated porous formation, and its application to performance assessment of the interim storage facility of contaminant soils,<br>5. Numerical simulation of sorption processes of actinide elements into natural clay minerals, and so on. |
| Safety Engineering of Nuclear Systems (Measurement Technology and Reliability Quantification) | Professor Noritaka YUSA | 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<br>1.Development of nondestructive testing and evaluation techniques using DC-GHz electromagnetic fields,<br>2.Development of nondestructive inspection and health monitorinig teqhniques using guided waves,<br>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<br>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.<br>1.Mechanistic studies in materials degradation of LWR components.<br>2.Matrials evaluation studies for supercritical water cooled reactors.<br>3.Development of monitoring methodologies of materials degradations in their initiation satages.<br>4.Development of anti-degradation alloys for nuclear systems.<br>5.Corrosion prediction and prevention studies for safe decommissioning Fukushima Daiichi Nuclear Power Plant. |
| Safety Engineering of Nuclear Systems (Nuclear Energy System Safety Engineering) | Professor Makoto TAHAHASHI (Department assigned：Department of Management Science and Technology)<br>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.<br><br>1.Enhancement of organizational safety in nuclear power plant<br>2.Evaluation of human-machine interface using human brain mapping method<br>3.Human factor study for air traffic control (ATC) system<br>4.Diagnosis system for early recognition of cyber attack |

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| Particle-Beam Engineering (High Energy Materials Engineering) | Professor (Concurrent post)<br>Shigeo MATSUYAMA<br>Associate Professor<br>Shuhei NOGAMI<br>(Collaborative Chairs: Materials Engineering for Fusion Reactors)<br>Professor (Visiting member)<br>Takeo MUROGA<br>Professor (Visiting member)<br>Takuya NAGASAKA | Development of the reliable and high performance structural materials is essential for the advanced future power systems such as fusion reactor because they will be used in the harsh environment such as high energy particle beam exposure and high heat load. This division focuses on the following researches based on the material science, metallurgy, and mechanics of materials.<br>1.Development of high performance refractory metals for fusion reactor<br>2.Fundamental research on the interaction between high energy particle beam and materials<br>3.Development of life prediction method of energy systems<br>4.Development of low radio-activation structural materials for nuclear systems<br>5.Development of ceramics matrix composites for high temperature applications |
| Particle-Beam Engineering (System Engineering of Particle-Beams) | Professor<br>Shigeo MATSUYAMA<br>Associate Professor<br>Yohei KIKUCHI<br>Professor (Visiting member)<br>Tomihiro KAMIYA | Particle beams is applicable to fabrication of functional materials, analysis of specimen, RI production for medical imaging and radiation therapy. Their applications covers in various fields including engineering, environment, medicine and archeology. Our main research subject is system engineering of particle-beams which is systemize by combining the technologies of beam acceleration and optics, the particle irradiation, RI production and radiation measurements. Especially, we conduct research on beam focusing and are developing a micro- and nano-beam system. The system is combined with particle-induced X-ray emission (PIXE) method and micron-CT and applied for various fields. We also developing a positron emission tomography (PET) using RI produced by particle irradiation. |
| Particle-Beam Engineering (Applied Quantum Medical Engineering) | Professor (Concurrent post)<br>Shigeo MATSUYAMA<br>Senior Assistant Professor<br>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;<br>1.Quantification of physiological functions in human body<br>2.Computer-aided virtual clinical trial for efficient development of radioligands<br>3.Numerical observer model for prediction of detection ability in medical imaging<br>4.Radiation dosimetry in both diagnostic and therapeutic purposes |
| Particle-Beam Engineering (Advanced Radiation Application) [Branch in Rokkasho-mura] | Professor (Concurrent post)<br>Shigeo MATSUYAMA<br>Associate Professor<br>Keitaro HITOMI | 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. |
| Particle-Beam Engineering (Nuclear Fuel Science) [Branch in Rokkasho-mura] | Professor (Concurrent post)<br>Yuichi NIIBORI<br>Associate Professor<br>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<br>1.Nuclide separation processes of high level liquid waste using impregnated adsorbent and ionic liquids.<br>2.Separation between strontium and yttrium using impregnated adsorbent to reuse for radiotherapy.<br>3.Electrochemical of metal speciation in the solution of the reprocessing plant. |

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| Energy Materials Engineering (Irradiation Effects in Nuclear and Their Related Materials) <Cooperative Laboratories><br><br>[Irradiation Effects in Nuclear and Their Related Materials, IMR] | Professor<br>Yasuyoshi NAGAI<br>Associate Professor<br>Koji INOUE<br>Associate Professor<br>Takeshi TOYAMA<br>Associate Professor<br>Kenta YOSHIDA | 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><br><br>[Nuclear Materials Engineering, IMR] | Professor<br>Ryuta KASADA<br>Associate Professor<br>Sosuke KONDO | 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><br><br>[Environmentally Robust Materials, IMR] | Professor<br>Eiji AKIYAMA<br>Associate Professor<br>Motomichi KOYAMA | 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><br><br>[Actinide Materials Science, IMR] | Professor<br>Dai AOKI<br>Senior Assistant Professor<br>Kenji SHIRASAKI | 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. |
| Energy Chemical Engineering (Radiochemistry) <Cooperative Laboratories><br><br>[Center for Mineral Processing and Metallurgy, IMRAM] | Professor<br>Akira KIRISHIMA | “Research on Nuclear Waste Management and Nuclear Facility Decommissioning by Radiochemistry”<br>Nuclear energy is one of the most important energy resource of our modern society, therefore, it is strongly demanded to make nuclear fuel cycle more reliable. Also, decommissioning of the severely damaged reactors by Fukushima NPP accident in 2011 and recovery of the contaminated environment, are urgent issues in Japan. To respond these demands, our group investigates chemistry of nuclear fuel debris and 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 agent. |
| Accelerator Radiation Engineering (Nuclear Radiation Physics and Engineering) <Cooperative Laboratories><br><br>[Division of Instrumentations,CYRIC] | Professor<br>Atsuki TERAKAWA | We are conducting researches 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+81-22-795-7901〕