University of FUKUI (Univ. of FUKUI)

Research Institute of Nuclear Engineering (RINE)

On the basis of "Safety and Cooperation", performing unique and world-leading human resource development and R & D of nuclear energy, contributing not only to Japan's national nuclear energy policy but also to international human resource development, our goal is to contribute to the realization of a world with a stable, sustainable and environmentally friendly energy supply.

Research

- Fundamental research in nuclear energy focusing on commercial reactors, implemented in cooperation and collaboration with research institutions, companies and the local community in and around the Tsuruga region.
- Fundamental research on nuclear energy in an international setting, in collaboration with international partners.
- Research towards improved nuclear safety, disaster prevention and risk management.

Human resource development

- Undergraduate level education related to nuclear energy (minor degree, mechanical engineering).
- Specialized education "Course in fundamentals of nuclear engineering" for graduate students.
- Hosting of (inter)national researchers, high-quality international human resource development making use of the nuclear facilities in Fukui prefecture.

Cooperation and centralization

- Cooperation with universities and research institutions in neighboring prefectures.
- Instigation of a research hub based on nuclear facilities in the Tsuruga region.
- Cooperation with the Wakasa-wan Energy Research Center (WERC) and various research and education networks.
- As a member of our community, contribute with public lectures, seminars, etc.

Professors:

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Nuclear Reactor Thermal Hydraulics, Severe Accident Evaluation

Dr. **Masayoshi UNO**; uno@u-fukui.ac.jp

Nuclear Reactor Fuel and Materials, Nuclear Fuel, Property, Integrity

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Nuclear Reactor Fuel and Materials, Fuel Cycle, Waste Reduction

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Nuclear Reactor Construction and Systems, Nuclear Material Engineering, Radiation Effect, Material Science

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Nuclear Reactor Construction and System, Decommissioning & Dismantlement

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Nuclear Power Disaster Prevention and Risk Management,
Dose Assessment and Biological Influence

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Nuclear Power Disaster Prevention and Risk Management,
Severe Accident Assessment

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Nuclear Power Disaster Prevention and Risk Management, Radiation Chemistry, Radiation Biology, Radiation Protection, Dosimetry

Associate Professors:

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Nuclear Reactor Construction and Systems, Hazard of Earthquake and Tsunami

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Nuclear decommissioning, waste disposal

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Nuclear Power Disaster Prevention and Risk Management, Radiation Biology,
Dose Assessment, Biological Influence

Nuclear Reactor Thermal Hydraulics

Severe accident evaluation

Thermal-Hydraulic Safety Evaluation

Tadashi Watanabe (Professor)

- ✓ Improvement of thermal-hydraulic safety analysis
- ✓ Development of reliable safety system
- ✓ Optimization of accident management

Prevention and mitigation of nuclear disaster and severe accidents, and safety evaluation

1. Research Outline and Objectives

Thermal-hydraulic safety analysis methods are improved for plant transients, accidents, and severe accidents, and reliable safety system and optimum accident management (AM) method are developed for prevention and mitigation of nuclear disaster and for safety evaluation,

2. Research Results

「Thermal-hydraulic system behavior and operator action (AM) during accidents」Fig.1

The large-scale test facility and safety analysis codes are used to study the thermal-hydraulic phenomena and the efficiency of operator action during accidents. For the accident at Fukushima Daiichi power plant Unit 2, the core damage was found to be avoided if the sea water would have been injected four hours earlier.

「Reactor-specific two-phase flow phenomena and numerical simulation method」Fig.2

Reactor-specific two-phase flow phenomena and prediction methods are studied ranging from fundamental flows to complicated accident flows for evaluation of reliable safety systems. For emergency coolant injection, cold water was shown by numerical simulation to spread from the primary piping along the pressure vessel wall..

「Measurement technique for material properties related to severe accident evaluation」Fig.3

Measurement technique for properties of high temperature molten material is studied for severe accident evaluation . For surface tension measurement using levitated droplets, the relation between droplet shape and frequency shift was made clear and the best control parameters were found.

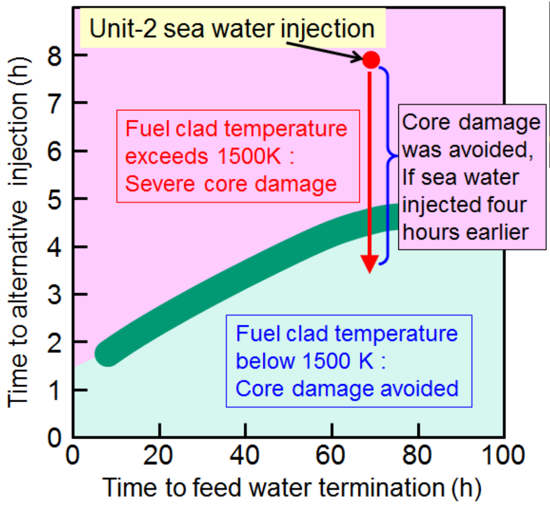


Fig.1 Efficiency of alternative injection

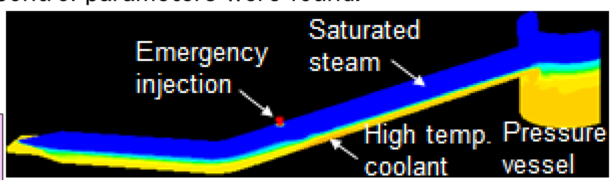
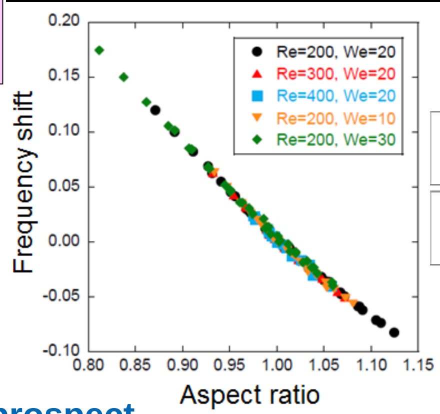


Fig.2 Thermal shock by emergency injection



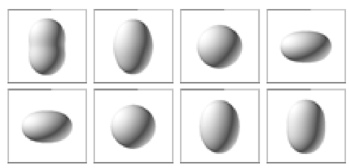


Fig.3 Development of measurement method using levitated droplet

3. Specific research points and prospect

Reactor thermal hydraulics from fundamental to applied and from micro to macroscopic phenomena.

Reliable safety system and optimum accident management are developed by studying thermal-hydraulic system and analysis methods

Progress of studies on nuclear disaster, severe accidents, and safety evaluation

Message for students

Research and education are performed mainly by using computer simulations as well as using experimental facilities and data at Japan Atomic Energy Agency and other organizations.

Nuclear Reactor Fuel and Materials

Keyword: nuclear fuel, property, integrity

Uno Lab.

Masayoshi UNO, Dr. (Professor)

Property estimation and integrity prediction of nuclear fuels and materials in normal and accident conditions

Property measurement of simulated fuels
Property estimation by chemical calculations
Development of measurement techniques

OUTLINE

Properties of pellets vary with burnup by FPs and metallurgical faults and Zr alloy claddings degrade by oxidation and hydrogen absorption in a reactor. Such variation of the properties are studied by experiments of simulated fuels and chemical calculations and the integrity of the fuel is estimated. Techniques for the property measurement of irradiated fuels in a hot cell are also developed.

RESEARCH WORKS

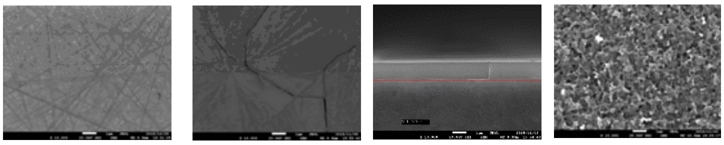
Reaction behavior of SiC as fuel cladding

In order to develop an accident tolerance fuel, reaction behavior of SiC/SiC cladding with UO_2, FPs in various atmosphere are demonstrated.

In air; $SiC+2O_2 = SiO_2 + CO_2$

In vacuum, $SiC + O_2 = SiO\uparrow + CO$

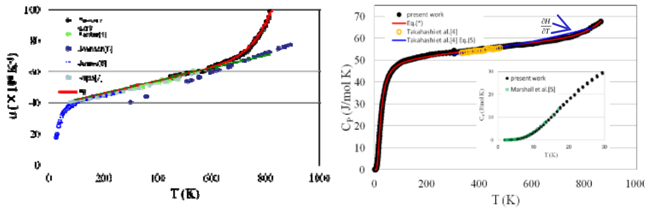
$SiC + Al_2O_3 = SiO\uparrow + Al_2O\uparrow + CO$



SEM images of the sample surface(X1000)
(a)before heating (b)heating in air (c)heating in air (cross section) (d)heating in vac.

Estimation of thermo-physical properties of CsI

In order to predict the behavior of volatile FPs during severe accident thermo-physical properties of CsI and related compounds are measured. The abnormal temperature dependence of the properties just below the melting temperature is discussed by the formation and migration of defect

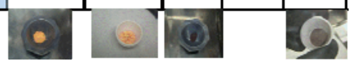


Temperature dependence of thermal conductivity and heat capacity of CsI

Reaction behavior of corium, sodium and concrete materials

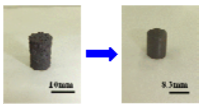
To develop estimation methods for integrity of container vessel of sodium fast reactor in a severe accident condition the reaction behavior of corium, sodium and concrete materials is studied by experiments using simulated material including uranium as well as sodium tests and thermodynamic calculations.

Material	α-Na_2UO_4	$Na_2U_2O_7$	$NaUO_3$	Na_3UO_4	Na_4UO_4
C. Structure	Ortho.	Monoclinic	Ortho.	Cubic	Cubic
Space G	Pbam	P2/a	Pbnm	Fd-3m	
Valence	6	6	5	5	4
Stability	×	◎	O	×	×
Hygroscopicity	◎	×	×	◎	◎
Transformation Temp	920℃	368℃	-	?	-



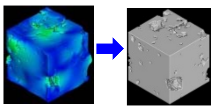
Relationship between porosity and properties of melted fuel debris

In order to accelerate the decommissioning of Fukushima Daiichi Nuclear Reactor, the property dependence of properties of fuel debris is clarified.



Formation of simulated fuel debris(U. of Fukui, Turuga)

X-ray CT measurement (JAEA･Oarai)



FEM analysis (U. of Fukui, Bunkyo)

Static compressive test (U. of Fukui, Turuga)

CHARACTERISTICS OF FUEL RESEARCH

Fuel study; exp. of simulated materials, chemical calc. and exp. of actual fuel in a hot cell

Researches using Uranium and Thorium in the Lab. in collaboration with Osaka university and/or JAEA

Study on behavior during severe accidents and treatment of melted fuels

MESSAGES FOR APPLICANTS

Students who study or want to study material science are welcomed. You will test Uranium and Thorium compounds and acquire calculation chemistry. You also have an opportunity for internship at JAEA and so on using more real materials .

Waste Reduction

Yuji Arita (Professor)

High temperature thermophysical properties of the materials related nuclear fuel cycle

Reduction of radioactive wasteand long life nucride by novel nuclear system

1. Outline of Research Areas

To develop a safety nuclear power plant from the view of the material science, materials for nuclear fuel, clads, control rods and reprocessing processes have been studied. Especially, the measurement of thermophysical properties of materials at high temperatures are promoted.

2. Research Topics

●**Development of the alloy fuels for transmutation of the minor actinides (MA).**

The radioactive waste which occurs from a fuel cycle can be reduced by burning minor actinides (Am, Cm, Np, etc.) ,they have with long half-lives, with a fast reactor. However, since radioactivity of MA is high, handling is difficult for it. Although utilization is aimed at by making it the alloy fuel which is easy to manufacture, neither the state of a melted metal nor the situation when it solidifies is known well. By clarifying such a fundamental high temperature property, the phase diagram (Fig. 1) used as the map of material development is improved.

Multi-component phase diagram is very precious data.

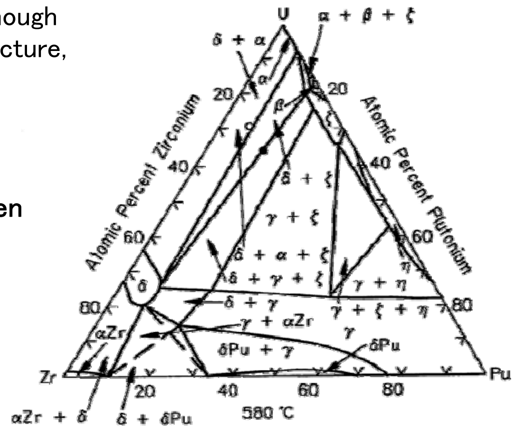


Fig.1 U-Pu-Zr phase diagram

●**Molten-salt properties for pyroprocess fuel reprocessing and molten salt reactors**

To develop the pyroprocess for FBR cycle and molten salt reactors , thermodynamic data (vapor pressure, activity, volatile species) for many melted salts are measured by using a mass spectrometer.

●**Molten salts Reactor.**

To evaluate the thermo-physical properties of molten salt used for MSRs (Molten Salt Reactors), vapor pressures of molten salts by using Q-mass.

Fig.2 Casted U-Zr-RE alloys

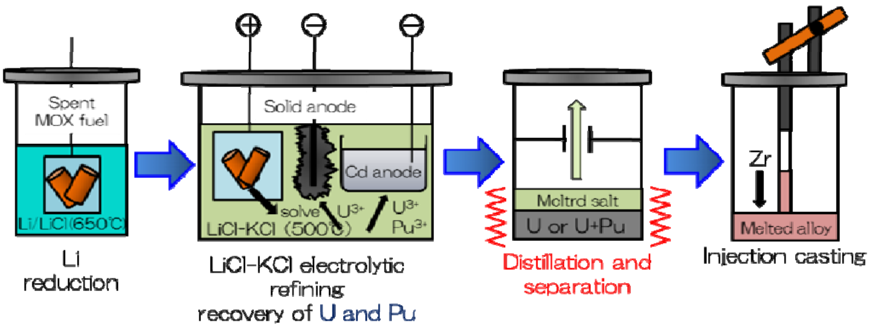


Fig.3 Pyroprocess for metallic fuel

Vision of nuclear power and nuclear energy

Reservation of safety for the fuel and the fuel cycle technology. (stability, waste reduction, etc.)

Thermopysical properties measurements and developments of the apparatus for it.

Based on basic physical-properties evaluation, nuclear safety and advanced nuclear technology will be developed.

Message to students

Since it inquires using various experimental devices, you can master various equipment skills. It is also emphasized at the simulation using a computer.

Nuclear Reactor Construction and Systems

Radiation effect, Material Science

Nuclear Material Engineering

K. Fukumoto (Professor) (URL):http:www.rine.u-fukui.ac.jp/fukumoto/

R&D of correlation between macroscopic material properties and microstructural changes under irradiation

Diagnostics and lifetime prediction of nuclear materials

1. Objectives

Our mission is to apply our nuclear material science and engineering-related expertise to corrosion and mechanics of materials and irradiation performance, especially ageing degradation, radiation damage process in metals and alloys, and environmental management for nuclear materials.

2. Research highlights

Fundamental study of interaction between dislocation and irradiation defects (Fig.1&2)

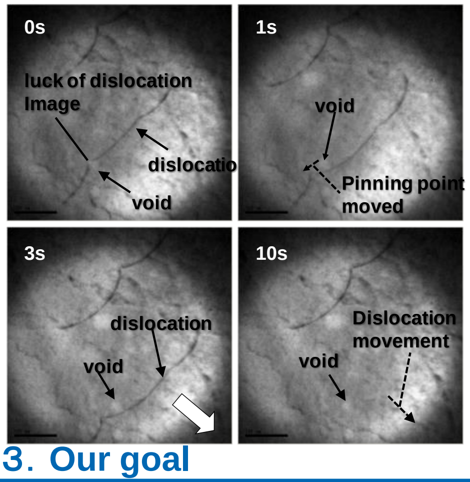
"Irradiation effects in materials" is a major long-range research effort in our activities. This task involves the experimental studies of an interaction between dislocation and irradiation through TEM observation in/after ageing or deformation test. From the experimental work, we will try to establish a kinetic model of dislocation behavior during/after irradiation

Microstructural evolution of nuclear materials under irradiation (Fig.3&4)

The purpose of this study is aiming at the safety evaluation of nuclear materials under irradiation including neutron and ions. The mechanisms of Irradiation hardening and irradiation-induced swelling are investigated by TEM observation and mechanical property measurement such as tensile test and nano-indenter works in the irradiation facilities including ion accelerator and nuclear reactor.

Fig.1 A tensile holder for in-situ TEM observation

Fig.2 An interaction between dislocation and void



Dislocation behavior of pure V in in-situ TEM observation during tensile test. A dislocation goes across a void in the tensile test.

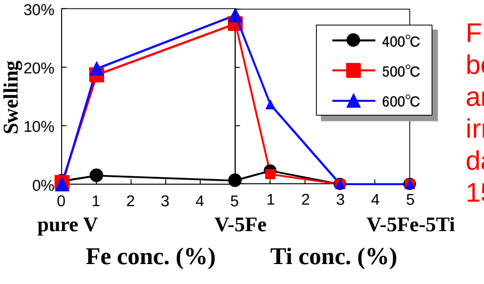


Fig.3 Swelling behavior in V-xFe and V-5Fe-xTi irradiated with damage level of 10-15dpa in FFTF

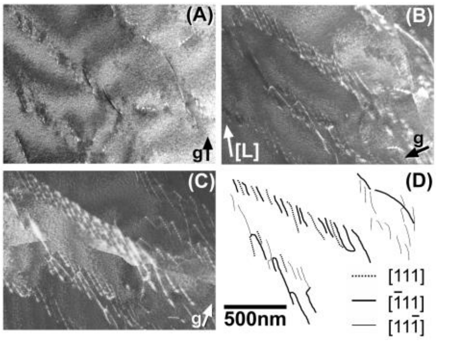


Fig.4 Characterization of dislocation structure in the V-4Cr-4Ti alloy after creep-tested at 1123K with a stress of 200MPa.

3. Our goal

Problems of nuclear power plants concerned with material degradation including ageing and radiation damage

Lifetime evaluation through advanced material analysis

From Tsuruga, Fukui

R&D of advanced safety for nuclear materials after Fukushima accident

A message for applicants

We will promise to do Education for international researcher and engineer who have ethical consideration as a proud-hearted human through nuclear material engineering study.

Nuclear Reactor Construction and Sysytem

Decommissioning & Dismantlement

Decommissioning Engineering

Satoshi Yanagihara (Professor)

Decommissioning is referred to as actions taken to remove regulatory control from a retired nuclear facility by removing radioactive materials for reuse of its site.

It is necessary to consider safe and rational implementation of such activities as dismantling, decontamination and rad-waste management.

1. ABSTRACT

The study is directed to systematize the methodology of decommissioning engineering using the data and lessons learned so far for safe and rational implementation of a decommissioning project. The study will be applied to decommissioning nuclear power plants such as Fugen NPP and Fukushima Daiichi Units 1 to 4.

2. RESEARCH ACTIVITIES

System Engineering for Decommissioning Projects

It is a necessary process to characterize a decommissioning project by precise estimation of project parameters such as cost, waste arising and worker dose. A study is underway to develop a computer system for calculating the project parameters taking into account the technology and working conditions to be applied to the decommissioning work. The study also include the research on optimization of a decommissioning plan and optimum combination of technology using MCDA (multi-criteria decision analysis) method (Fig 1).

Project Evaluation Methodology

Since decommissioning work requires a variety of technology, it is necessary to evaluate the applicability of these technologies. The methodology has been studied by constructing work break down structures (WBS) on a computer for analyzing decommissioning scenarios where potential applicability of the technology, safety, work efficiency are evaluated (Fig. 2). The methodology will be applied to the fuel debris removal work and planning of decommissioning at the Fukushima Daiichi Units 1 to 4 to select the best scenario.

Evaluation of Radioactive Inventory

It is important to evaluate accurate radioactive inventory in advancing the decommissioning work. A computer system for radioactive inventory estimation was developed by applying neutron transportation and radioisotope production/decaying codes. The study is in progress to evaluate characteristics of radioactive waste arising from decommissioning by using calculated results of the computer codes.

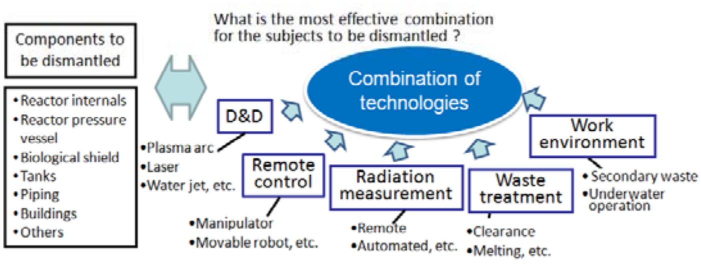


Fig.1 Conceptual drawing of optimization study

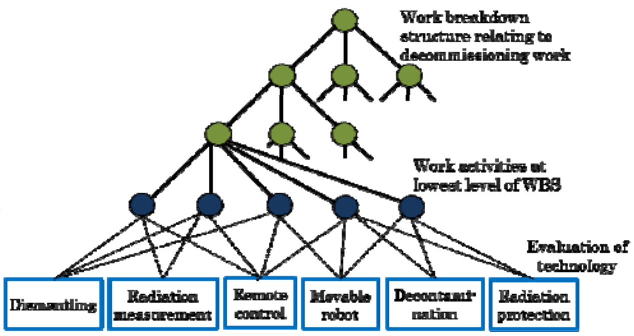


Fig.2 Sequence of data processing for evaluation of project parameters

3. FUTURE PERSPECTIVE

Plant life management is an essential factor throughout designing, construction, operation and decommissioning which is the final stage of the life. The study is intended to optimize a decommissioning plan by overlooking the plant life. Evaluation of radioactive inventory and technology availability are the major subjects for evaluation of rational decommissioning plan in the future.

Systematization of decommissioning engineering

Message for Applicants:

The social demand for science and technology might vary according to the times. It is important to consider application of knowledge by fulfilling the demand of times as well as gaining the basic knowledge in the university. Decommissioning engineering is a requirement of the present age. We will make an effort to educate students to be practicable to cope with the demand of times through the study on decommissioning.

Nuclear Power Disaster Prevention and Risk Management

Dose assessment and biological influence

Radiation measurement and Safety

Nakahiro Yasuda (Professor)

・Radiation measurement ・Low dose radiation effect
・Cooperation with local government

Inter-regional association for nuclear accident

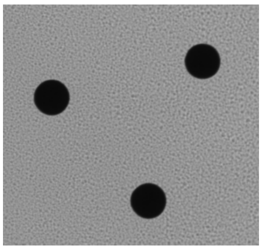
1. Research brief and purpose

This newly established lab conducts research and development into personal dosimetry and environmental radiation monitoring in preparation for a nuclear hazard. The lab specializes in track detection and in real time monitoring for in-house dosimetry with image analysis, and in development for a new automated biological analysis system for low-dose effect. This lab provides radiation education and nuclear disaster prevention not only to students but also to local governments and residents.

2. Establishments and current research subjects

○Establishments

「Visualization of radiation and measurement on nuclear reaction」



Invisible radiation can be visualized using its ionization processes in some materials. CR-39 plastic (eyeglass lens material) is a typical material which can realize the visualization of ionizing radiation. This lab is utilizing this materials as radiation detector for space radiation dosimetry with JAXA and for measurement on nuclear reactions for heavy ion cancer therapy with NIRS and WERC. For this purpose, we've established the new system [High speed imaging microscope] which can get microscopic images with a speed of 1cm^2/min (100 times faster than traditional microscope).

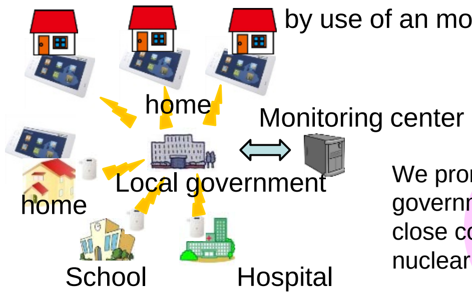
「Accumulation of lessons from nuclear disaster for prevention」

This lab is accumulating information about nuclear disaster at Fukushima, and is comparing some results with previous nuclear disasters to establish disaster prevention scheme in local region. Research subjects are varied from the facts and results of countermeasures, the prevention disaster system, the education system for radiation and technologies. This lab is sharing those information to researchers and municipalities which have (will have) nuclear power plant under the cooperation with local governments and related research institutes.

○Research subjects

「Dose information quick transfer system」

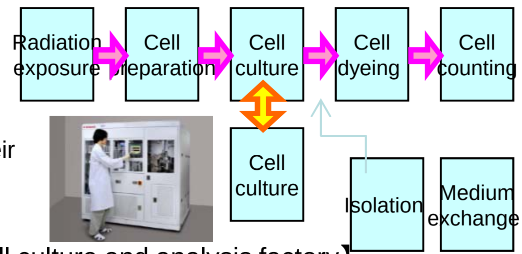
Dose rate information arrives at hand by use of an mobile terminal etc.



We promote knowledge spread in local government staffs and residents for their close cooperation in preparation for a nuclear hazard.

「Automated cell analysis system for low-dose effect」

Automatic mass disposal of the cell culture and analysis for observing the rare phenomenon by low-dose radiation.



【cell culture and analysis factory】

3. The appealing points and future views

Preparation (research)
・Radiation measurement
・Low dose radiation effect
・Nuclear disaster prevention

Association (outreach)
・Personnel training and education
・Knowledge spread
・Community outreach

Strong communities against disasters

Message for student

We can realize the technology and knowledge exchange / fusion between the different fields (physics, biology, chemistry, engineering, information, international, education, communication, medical, environment, industry) on "radiation safety" with local government and companies.

Nuclear Power Disaster Prevention and Risk Management

Keywords: Severe Accident

Severe Accident Assessment

Yoshinari ANODA, PhD (Professor)

- ✓ Improvement and assessment of safety analysis codes
- ✓ Improvement of accident management measures for prevention of severe accident,
- ✓ Development and evaluation of the passive safety systems

▶ To contribute to the higher level of safety for LWR

OUTLINE

In order to contribute to the higher level of safety for LWR, improvement and assessment of safety analysis codes, improvement of accident management measures for prevention and mitigation of severe accident, and development and evaluation of the passive safety systems are being investigated.

RESEARCH WORKS

Assessment of accident management measures for prevention of severe accident

For a station blackout (SBO) transient at the PWR, the secondary feed and bleed with use of the turbine-driven auxiliary feedwater (AFW) and the relief valves is effective to keep core cooling by the primary loop natural circulation (Fig.1). However, the experiments by using the LSTF of JAEA have shown that the non-uniform flow distribution among the steam generator (SG) heat transfer tubes and the multi-dimensional flow in the SG inlet plenum affect the flow characteristics of the primary loop natural circulation. In order to increase the applicability of the safety analysis code to such a multi-dimensional phenomena, the assessment of the best-estimate codes and the improvement of models have been carried out by using CFD code as a tool (Fig. 2).

Fig.1 Accident Management Measures for PWR Station Blackout (SBO) transient

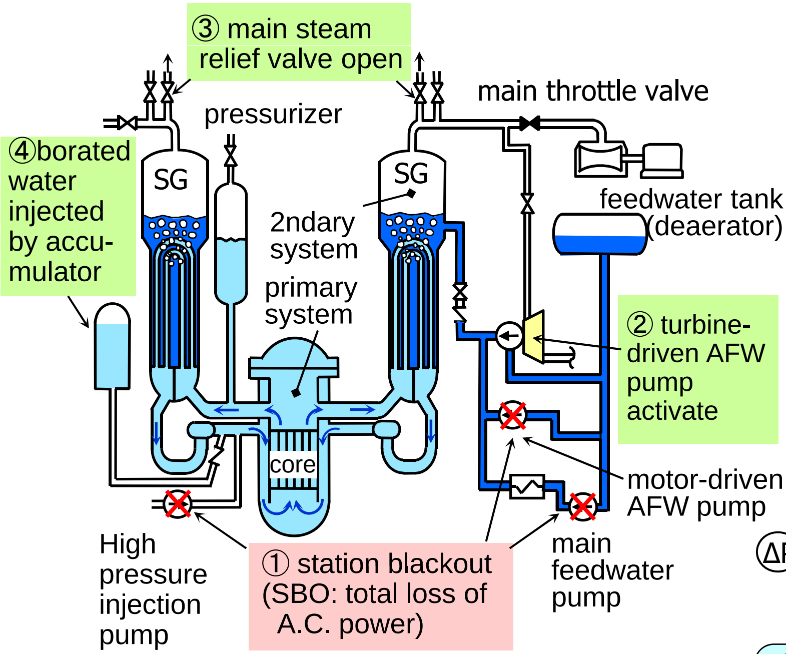
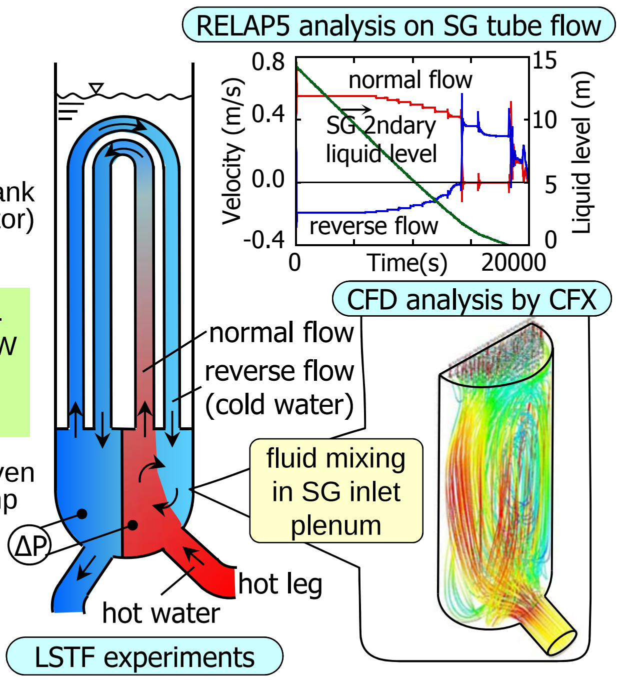


Fig.2 Experiments and Analyses on multi-dimensional flow in SG during SBO transient



PRESENT STATUS AND FUTURE PERSPECTIVE

Most important issue after Fukushima Dai-ichi accident is 'Prevention of severe accidents'

Based on lessons learned from the accident, the safety assessment codes, the accident management measures, and the passive safety systems are being investigated.

We must contribute to the higher level of safety for LWR

MESSAGES FOR APPLICANTS

Research and education are performed using not only our university but also research facilities at Japan Atomic Energy Agency (JAEA).

Nuclear Power Disaster Prevention and Risk Management

Dosimetry,
Radiation Effects

Radiation Chemistry and Dosimetry

Yoshinobu IZUMI, *Dr. in Eng.* (Professor)

Radiation effects of living cells and DNAs

Novel techniques of dosimetry
Advancement of radiological cancer therapy

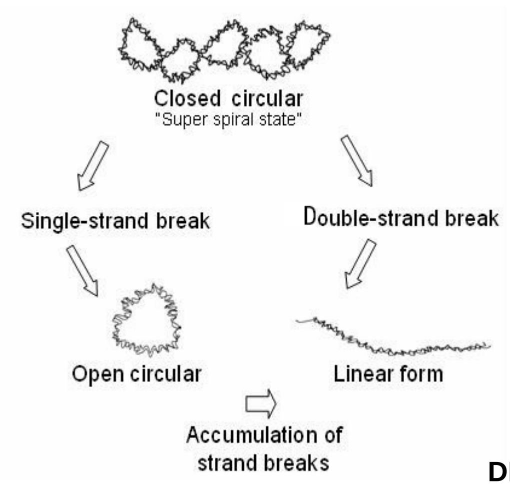
1. Research brief and purpose

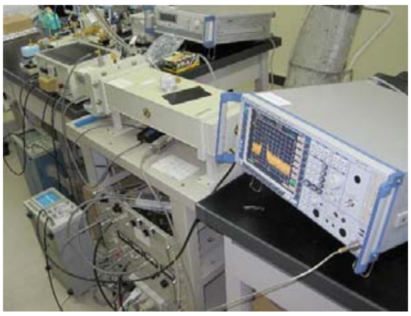
Recent several years, undamental studies on radiological treatment was carried out. In addition, radiation effects of living cells and living body for radiation protection has also been studied. I bring up the talented person who has enough experimental technique and wide knowledge about radiation physical, chemical and biological effects.

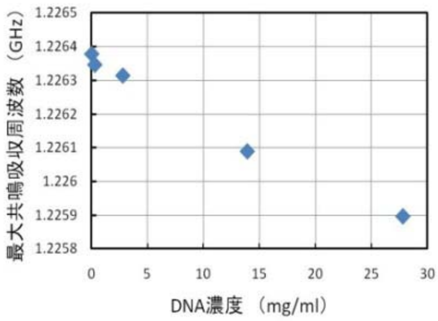
2. Establishments and current research subjects

Radiation Effects on living cells
Collaboration with Osaka Univ., Osaka Pref. Univ., WERC, JAEA-Takasaki, NIRS *etc.*
Our group studies radiation effects on living cells using various LET (g-, proton and carbon beams). We analyzed survival ratio, mutation frequency, genetic sequence of irradiated cells. From these results, we discuss from viewpoints of radiation chemistry and biology.

Novel dosimetry based on changein DNA-structure using micro-wave technique
Collaboration of Fukui University of Technology.
We developed a technique for evaluation of DNAs using microwaxe technology. We are studying the improvement of this technique for application to low-dose measurement and evaluation.
Novel dosimetry based on degradation of DNA chains are also studied.







Detection and evaluation of genomic DNA is succeeded.
DNA: extracted from a eukaryotic nucleus.

DNA evaluation system and results (example) using a microwave technique

3. The appealing points and future prospects

Integrated understanding (including physical , chemical, and biological reactions)

Various kinds of analytical techniques

Contribution to radiation safety and protection, Promotion of radiation application and processing

Message to students

I perform education and study under positive collaboration with other staffs whose fields are near from mine. Students in my Lab. can study via using accelerator facilities and ^{60}Co facilities. So, students can interchange with the frontier researchers in these fields.

Nuclear Reactor Construction and Systems

Research of Earthquake and Tsunami Hazard Evaluation

Hazard of Earthquake and Tsunami

Michihiro Ohori, Dr. Eng. (Associate Professor)

- ✓ Prediction of Near-Field Strong Ground Motion
- ✓ Lesson learnt from Large Earthquakes and Tsunamis
- ✓ Safety Evaluation of Nuclear Power Plants and their Surrounding Areas for Earthquakes and Tsunamis

▶ Contribution to Seismic Safety Improvement of both Nuclear Facilities and their Surrounding Areas

1. Research Outline and Objectives

We study the characteristics of the earthquake and tsunami during the 2011 Off the Tohoku Pacific Coast of Tohoku Earthquake (M9) and learn how such disastrous damages occurred. We also investigate the regional seismic characteristics, such as seismicity, locations of seismic active faults, soil and subsurface structures, historical damage patterns and so on. Incorporating lessons learnt from recent earthquakes and tsunamis with regional disaster factors, we carry out the rational hazard evaluation for the nuclear power buildings and their surrounding areas in Fukui Prefecture.

2. Research Activities

Prediction of Near-Filed Strong Ground Motion

Seismic waves generated at the source propagate through various paths and finally reach the ground surface after amplified in local shallow layered structures. To predict the strong ground motion from future earthquakes, we must study various kinds of factors, such as regional seismicity, locations of earthquake sources, seismic active faults, surface and subsurface structures, historical damage patterns, and so on. In particular, considering the low seismicity in and around Fukui Prefecture, it is significant to collect the data from small and/or moderate earthquakes and induce seismic parameters in common with large earthquakes. As a successful example of modeling moderate earthquake, we show results of source models and simulation results of strong ground motion for the 2001 Hyogo-Hokubu Earthquake (M5.4) in Figs. 1 and 2.

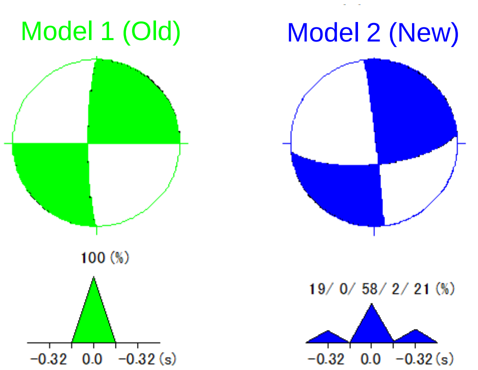


Fig.1 Source Models (Upper: Focal Mechanism, Lower: Source Time Function)

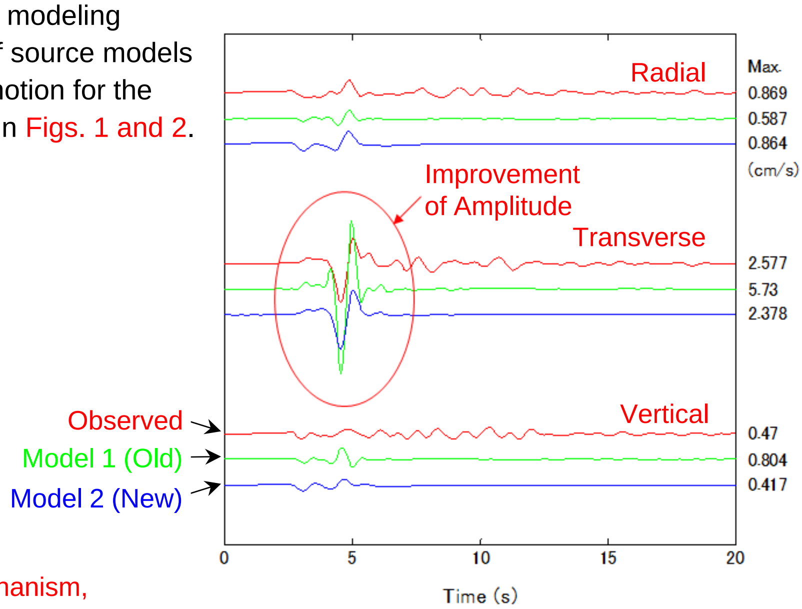


Fig.2: Simulation Results of Strong Ground Motion

3. Appeal of Research, Future Outlook

High Accuracy Prediction of Near-Field Strong Ground Motion

Incorporation of Lesson learnt from Large Earthquakes and Tsunamis with Investigated Regional Seismic Characteristics

Safety Improvement of Nuclear Facilities and the Surroundings

Message for Candidate Students

Let's tackle together the study on earthquake and tsunami to enhance the seismic safety of both nuclear power buildings and their surrounding areas, sharing the feeling of "no more tragedy we experienced in Fukushima on March 11, 2011 " from the bottom of the heart.

Nuclear Reactor Physics

Reactor Modeling and Simulation

Reactor Physics, Design and Engineering

W.F.G. van Rooijen (Associate Professor)

- Design, modeling and simulation of Nuclear Reactors
- Fuel cycle, transmutation, advanced reactor concepts

Advanced Modeling & Simulation to design the nuclear reactors of the future

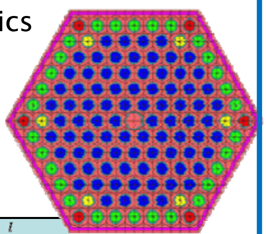
1. Outline of Research Areas

- Design, simulation, analysis and evaluation of advanced nuclear reactors
- Sustainability of nuclear power through resource optimization and waste transmutation
- Nuclear data evaluation and validation, numerical benchmarking, etc
- Analysis of re-criticality risk in severe accidents, criticality safety, etc

2. Research Topics

Transport theory and numerical simulation

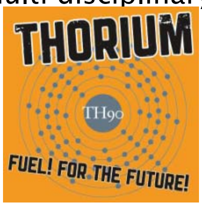
- 3D Method of Characteristics
- Void effect in fast reactors
- Self-shielding

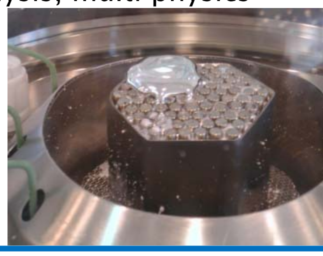


$$S_s(\mathbf{r},E,\mathbf{\Omega}) = \int_0^\infty dE' \sum_{l=0}^{\infty} \frac{2l+1}{4\pi}\Sigma_{sl}(\mathbf{r},E'\to E)\sum_{m=-l}^{l}\phi_{lm}(\mathbf{r},E',t)Y_{lm}(\mathbf{\Omega})$$

Fast reactors with thorium-MA fuel

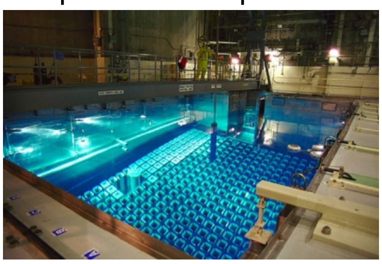
- Use Np, Pu, Am, Cm as fuel to create U-233
- Sustainable fuel cycle: resource availability and MA transmutation
- Core design and analysis, multi-physics multi-disciplinary

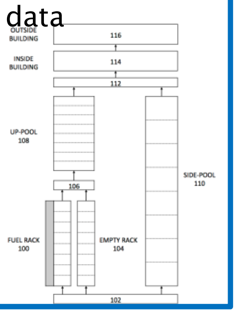




Criticalilty safety and re-criticality issues

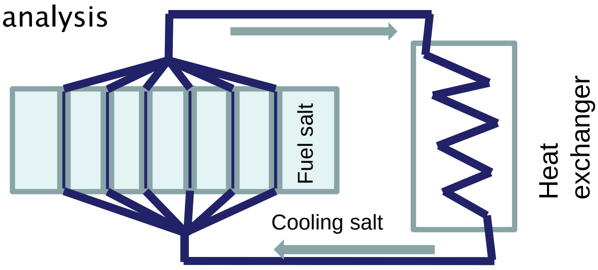
- Spent fuel pool risk of criticality under long-term loss of power
- Comparison to experimental data





Molten Salt Transmutation Reactor

- Core design and analysis of advanced molten salt reactor
- Transmutation performance and safety analysis



Vision of nuclear power and nuclear energy

Improve nuclear design, improve analysis methods and approaches, improve simulations

Advanced reactors and advanced nuclear fuel cycles

Safe, reliable, cheap and sustainable nuclear power for the future!

Message to students

Work in an interesting, exciting and challenging field, including physics, mathematics and computational science. An international orientation is required!

Nuclear Reactor Construction and System

Decommissioning & Dismantlement

Nuclear Decommissioning & Waste Disposal

Daisuke Kawasaki (Senior Assistant Professor)

1. ABSTRACT

Researches based on mathematical models and computer simulations are conducted towards rational safety strategies of nuclear decommissioning and disposal of radioactive waste. The research topics involve combinations of cost estimation, risk analysis, optimization methods, decision analysis, groundwater/nuclide migration analysis, etc. Emphasis is put on derivation of strategies under uncertain information, and methodologies are developed for these analyses to be carried out under various uncertainties.

2. RESEARCH ACTIVITIES

Model-Based Analyses of Nuclear Decommissioning Projects

A simulation model based on the work breakdown structure and the material flowchart for a decommissioning project is being developed. For each activity (e.g., dismantling and decontamination), the model accounts for duration, required resources (including manpower, devices, etc.), and the mass composition of the processed object. Given the rules and the conditions of the decommissioning project, the simulation code will build a whole plan of a project including the schedule of activities. The simulation code will be applied into cost analysis, worker exposure dose management, material flow analysis and waste characterization. All these analyses will be combined for optimization and decision making analysis.

Design and Analysis of Systems under Uncertainties

There are various kinds and extent of uncertainties in the decommissioning project (e.g., radioactivity concentrations and spatial distribution, work duration for a certain activity). Statistical analysis of manpower for each activity has been performed based on records of previously decommissioned plant. The obtained distributions of manpower will be applied to manpower estimation of another plant. The uncertainty distributions of the input parameters can be reflected in the output parameters through a number of realizations with Monte Carlo random sampling method. Optimization methodology and decision analysis methodology under uncertainties is also being developed.

Three-Dimensional Modeling of Hydrology and Radionuclide Migration in Fractured Porous Media

The long-term safety analysis of geologic waste disposal heavily involves a number of simulations of radionuclide migration thousands of years after closure of the waste repository. The subsurface radionuclide migration model is based on hydrogeologic models of the geologic formation, which is often fractured and porous to some extent. The challenges of hydrology analysis in the fractured porous medium arises from the discontinuity of permeability at the interfaces of rock matrix and the fractures, as the traditional mesh-based methods (including FEM) become impractical when the fracture network is large and complex. A new methodology is being developed using Monte Carlo particle tracking method for both hydrology and radionuclide migration simulations.

Long-Term Safety Assessment of Radioactive Waste Repository

The system performance assessment model describes the entire system of radionuclide migration pathways from the repository to biosphere (exposure to human). A robust modeling methodology is being developed based on time-domain random-walk theory. This methodology aims at the seamless build process of the performance assessment models from the more detailed 3D simulations mentioned above.

With the unavoidable uncertainties in time evolution of the disposal site, there are a number of scenarios to be considered in the safety assessment. With other sources of uncertainties taken into account, a tremendous number of calculation cases would be necessary. Study is under way in order to develop a systematic and sufficient evaluations for the safety assessment that needs to consider a large number of cases.

3. FUTURE PERSPECTIVE

The goal is to develop optimization and decision making methodologies based on comprehensive view of systems under uncertainties.

→ Rational safety strategies

Message for Applicants:

There are nuclear plants that need to be decommissioned sooner or later. There are nuclear wastes waiting for final disposal. We must make our best decision at every moment with the limited knowledge, in order to preserve living environment for our children. What's your decision?

Nuclear Power Disaster Prevention and Risk Management

Dose assessment and biological influence

Radiation Biology

Youichirou MATUO (Assistant Professor)

Analysis of an damage of the DNA by the radiation and Detection of the biological-response ▶ Elucidation of an biological-response and the influence by the irradiation

1. Research brief and purpose

When exposed to radiation, cells work to repair damaged DNA using a wide range of biological-response mechanisms. We aim to clarify biological-responses to low dose radiation, and to develop new methods of detecting their effects at the genetic and cellular level. This requires cultivation of human resources capable of correctly understanding the biological effects of radiation.

2. Establishments and current research subjects

Study on radiation-induced damage of DNAs using an oligonucleotide with fluorescence modification.

We designed the assessment system to evaluate radiation damage using a bio-material. The system employed an oligonucleotide sample consisting of several dozen base pairs and subjected to fluorescence modification as the bio-material, with a fluorescence spectrophotometer used to measure the amount of radiation-induced damage.

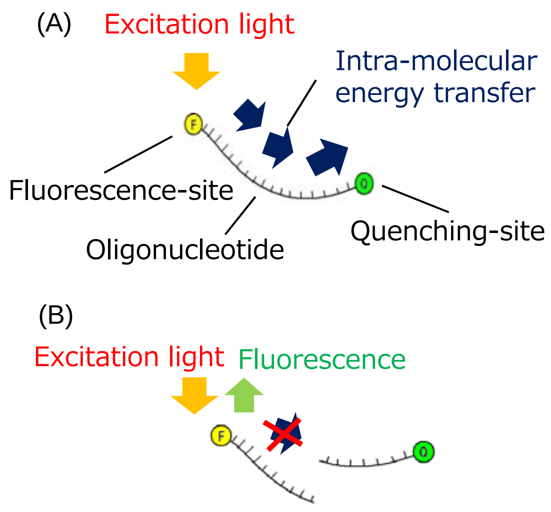


Figure 1. Essential idea of this study.

We focused on the oligonucleotide which was part of the DNA as an Bio-molecule. The modified oligonucleotide has fluorescence and quenching site on each terminals, respectively.

The optical energy deposited to the fluorescence site is transferred to the quenching site mainly along with main chain, and is released as optical energy of the longer wavelength. Fluorescence is suppressed *via* such a quenching effect when excitation light is applied (Figure 1. A).

When the modified oligonucleotide is broken by radiation, the reaction will be repressed, and emitted fluorescence as proof of biomolecule breaks. Thus, radiation damage on the biomolecule can be directly detected with fluorescence (Figure 1. B).

Application; Since its oligonucleotide sequence can be designed and synthesized to double strand structure, and the fluorescence and quenching sites can be selected to others. These flexibilities of this method might also be a strong point to the basic study for radiation induced DNA strand breaks.

3. Appeal points and future prospects

Development of new technique to evaluate influence by the radiation.

Elucidation of the biological-response mechanism by the irradiation.

▶ Influence of the radiation is understood definitely, judgment, Evaluation.

Message for student

Low-dosage radiation exposure is a field in which much remains unclear, and one which promises to reward further study. Our mission is to cultivate human resources with a comprehensive ability to understand, evaluate and make accurate judgments regarding the effects of Low-dosage radiation.

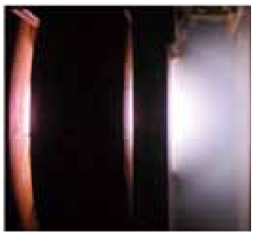
The Nuclear Engineering graduate major spans five departments in three schools: Mechanical Engineering(MECH), Electrical and Electronic Engineering(EE), Materials Science and Engineering(MAT), Chemical Science and Engineering(CAP), and Transdisciplinary Science and Engineering(TSE). In addition to fundamental science and engineering studies, students focus on the study and research of nuclear energy and radiation utilization while seeking solutions to environmental and social problems.

In the following professor information, the belonging of each professor is written such as <MECH, TSE>, in case of the professor belongs to MECH as a primary school and TSE as a secondary school.

Assoc. Prof. Hiroshi AKATSUKA

hakatsuk@nr.titech.ac.jp +81-3-5734-3379 Room: N1-413 〈EE, TSE〉

We are studying fundamentals of low-temperature plasmas. Even high-temperature plasmas in core of thermonuclear fusion reactors become colder near the reactor wall. We must understand them from comprehensive viewpoints, e.g., electric and electronic engineering, atomic and molecular physics, physical chemistry, rarefied gas dynamics, etc. They also have cross-disciplinary area with environmental science of atmosphere or ionosphere, or even with astronautics as thrusters for electric propulsion. In short, we study fundamentals of plasmas in scientifically interdisciplinary fields. The photo shows a supersonic plasma jet in a rarefied gas wind tunnel of my lab.



Akatsuka Lab.

Prof. Shunji IIO

siio@nr.titech.ac.jp +81-3-5734-3377 Room: N2-424 〈TSE〉

We study energy sources which should be utilized this century taking into account the global environmental issues. We will investigate socially acceptable fusion reactors chiefly by studying basics for the development of magnetically confined fusion reactors, experiments on small tokamaks, evaluation of hybrid reactors for nuclear transmutation, and R&D of laser diagnostics. The picture on the right-hand side shows a small tokamak device we have constructed to demonstrate the effects of helical fields on the positional stability of plasmas.

Iio Lab.

Prof. Masayuki IGASHIRA

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We are studying the transmutation of matter at the level of nuclear size experimentally and theoretically: nuclear reaction mechanism, nuclear transmutation database, nucleosynthesis by nuclear reaction and decay, nuclear fuel production, and nuclear transmutation of long-lived radioactive nuclides into short-lived or stable nuclides. We are also studying nucleosynthesis processes in the universe. We have utilized large instruments such as Pelletron accelerator of our laboratory and J-PARC at Tokai Village. We are aggressive for every thing, and we have collaboration with researchers at home and abroad. The high-efficient and -sensitive gamma-ray spectrometer is shown in the photo.

Igashira Lab.

Prof. Yoshiyuki OGURI

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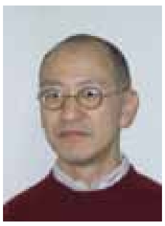


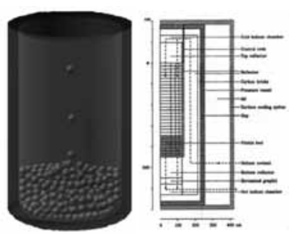
Currently the following studies are available for graduate students: 1) interaction experiments between heavy-ion beams and dense plasma targets related to heavy-ion inertial confinement fusion and high energy-density physics studies, 2) development of accelerator-based trace-element analytical techniques for environmental sciences, and 3) medical application of ion-induced quasi-monochromatic X-rays. The photograph shows the 1.6-MV electrostatic heavy-ion tandem accelerator being utilized for these experimental studies.

Oguri Lab.

Prof. Toru OBARA

E-mai: tobara@nr.titech.ac.jp +81-3-5734-2380 Room: N1-208 〈TSE〉

Our major research field is design study of innovative nuclear reactors with passive safety features for the next generation. Study of High Temperature Gas Cooled Reactors including simplified pebble bed reactor and prismatic fuel reactor is in progress. We are studying about small reactor for silicon semiconductor production and CANDLE reactor also. Criticality safety and calculation method in reactor physics are also our research field. The figure is the concept of fuel loading scheme in simplified pebble bed reactor and its calculation geometry.



Obara Lab.

Prof. Yukitaka KATO

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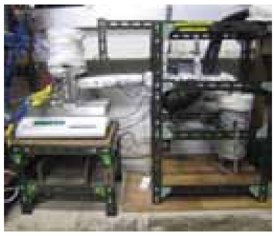
Contribution on energy saving and global environment protection through development of innovative and efficient energy conversion and storage technologies for nuclear, renewable and unused energies is the main theme of our laboratory. Thermochemical energy storage and conversion technologies for efficient utilization of thermal energy, hydrogen and other energy carriers, are examined in studies. Chemical heat pump, hydrogen production and system, and carbon recycling energy system are discussed experimentally. The photo shows a lab.-scale apparatus of Magnesium oxide/Water Chemical Heat Pump.



Kato Lab.

Assoc. Prof. Hiroshige KIKURA

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Research on the improvement in safety and the advancements of nuclear reactors is done by the diagnostic techniques developed from the measurement techniques and process control strategies used in light-water reactors, future-type reactors and fast reactors. We investigate the novel ultrasonic technique which can diagnose weld defects and measure flows with profound effects on materials. We also study Taylor Couette flow type liquid-liquid extractors and micro flow extractors which enable the small compact nuclide separation process, and research environmental problems.

Kikura Lab.

Prof. Yoshinao KOBAYASHI

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Our goal is to ensure the safety of nuclear reactor all through its service time with possible severe accident and decommission process by developing the metallic materials having high reliability and soundness. In addition, to assess the access root to the fuel debris for its removal in Fukushima Dai-ichi nuclear power plant, damage and collapse behavior of structural metals in the reactor core should be well understood. Stable finalization of fuel debris is also of great significance. For these purposes, control and reduction of impurities in materials are studied as well as reaction between fuel debris and stainless steel as reactor core materials. The photo shows an electric resistance furnace with MoSi2 heating element which realize high temperature beyond 1600℃ .

Kobayashi Lab.

Assoc. Prof. Hiroshi SAGARA

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We are pursuing studies on robust nuclear energy system against threats to safety, security and non-proliferation, by system designing. Accident-torrent fuel for inherent safety and security, and proliferation resistance of nuclear energy system for security and non-proliferation are one of our targets of researches. Non-destructive assay technology R&D are also being performed to quantify the nuclear material inside fuel debris by passive γ measurement, cooperating with Japan Atomic Energy Agency, aiming to be applied for safe& secure decommissioning of Fukushima Daiichi Nuclear Power Station. User interface development between environmental dynamics and decision making is performed for effective evacuation planning.

Sagara Lab.

Assoc. Prof. Koichiro TAKAO

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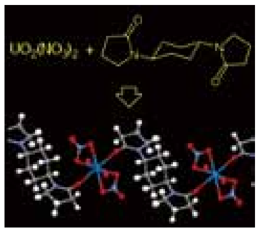
To guarantee feasibility and sustainability of nuclear energy system, it is important to understand coordination and solution chemistry of actinides and fission products, which are highly relevant to the nuclear fuel cycle. Main focus of this lab is understanding of fundamental chemistry of these metal ions in depth as well as exploring applicability of ionic liquids and microwave technology to develop bases of (1) fuel reprocessing and treatment of radioactive wastes, (2) effective use of depleted/recovered uranium, and (3) decontamination process for retrieval from Fukushima accident. Figure shows a 1-dimensional chain structure of uranyl nitrate complex bridged by uranium-selective precipitant.



Takao Lab.

Prof. Minoru TAKAHASHI

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We study fast reactor engineering for future generation IV nuclear reactor which is inherently safe and useful for efficient long-term utilization of uranium resource. Main fields are reactor engineering, thermal-hydraulics (boiling/condensation, two-phase flow, numerical simulation), material engineering (corrosion, oxygen control), and liquid metal technology. Lead alloy coolant is suitable both for plutonium breeding and for transmutation of radioactive wastes. The others are thermal-hydraulics of high conversion BWR and liquid metal fusion blanket technology.

Takahashi Lab.

Prof. Kenji TAKESHITA

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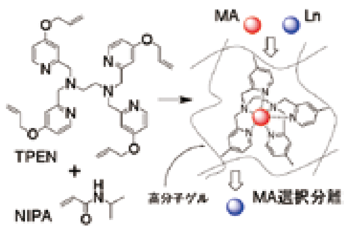
For stable energy supply and establishment of a sustainable low-emission society, we are studying new resource-conservation and recycling technologies based on chemical engineering and materials engineering. Especially, we focus on the development of nuclear fuel cycle technologies required in the future FBR age, such as the removal of minor actinides, heat-generated elements (Cs, Sr) and platinum-group metals from HLW, the stable vitrification of HLW and the LCA analysis of fuel cycle. These advanced technologies will be realized in the near future and contribute greatly to the establishment of sustainable industrial society.



Takeshita Lab.

Prof. Satoshi CHIBA

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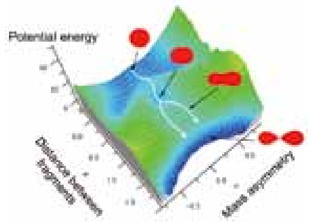
We study nuclear reactions as a fundamental process underlying nuclear energy. Neutron-induced reaction is the source of energy in nuclear reactors, while it serves as origin of elements such as Uranium and Thorium in the cosmos. Understanding of nuclear reactions is, therefore, basis for safe usage of nuclear energy as well as comprehending nature itself. Theoretical and computational studies are the main research style, but we have a close connection with JAEA for sophisticated experimental activities involving fissionable nuclei.



Chiba Lab.

Assoc. Prof. Takehiko Tsukahara

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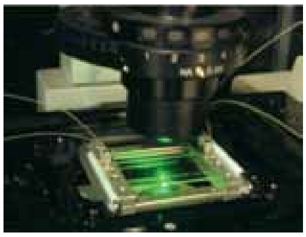
Nuclear waste management plays an important role for reducing radioactive wastes. We have investigated "simple-compact environmental-friendly chemical system" using micro-nano technologies. This system makes it possible to reduce/separation/recycle of actinides and lanthanides (rare-earth elements) from radioactive wastes, and to detect quickly and highly efficiency metal ions at trace amounts of sample. The basic science of actinides and lanthanides inside nuclear reprocessing solutions and/or geological disposal environments is also studied.
A right photograph shows a laser detection of uranium using micro-nano chemical chip.



Tsukahara Lab.

Assoc. Prof. Hiroaki TSUTSUI

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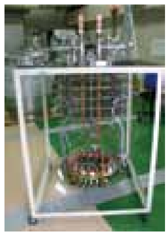
Both a nuclear fusion which generates energies and a superconducting magnetic energy storage system which stores energies are studied. We theoretically derived an optimum coil with a strong magnetic field based on the virial theorem which represents the relation of magnetic energy and stress. A small fusion device and a superconducting coil were designed and constructed, and their efficiencies were demonstrated. Equilibrium, stability and confinement of plasmas are also studied by numerical calculations and theoretical models. A right photograph shows a superconducting magnet which demonstrated the virial theorem.



Tsutsui Lab.

Assoc. Prof. Noriyosu HAYASHIZAKI

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We study charged particle beams such as ion and electron, particle accelerators and their new applications. Beam and electromagnetic simulations, 3D-CAD design, high precision manufacturing by introducing CAE/CAM and experiments are carried out for fundamental, or solution-oriented issues. The topics of under investigation are a Boron Neutron Capture Therapy (BNCT) irradiation system, a positron accelerator (photograph) for fine material analysis and an electron accelerator for sterilization. We will respond for social needs through the developments of these technologies.

Hayashizaki Lab.

Assoc. Prof. Yoshihisa MATSUMOTO

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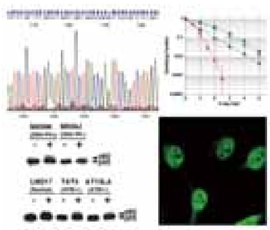
Radiation exerts its biological effects by generating various types of damages on DNA, among which DNA double-strand breaks (DSBs) are considered most critical. We are seeking to elucidate the molecular mechanisms of the recognition and repair of DNA DSBs through the integration of various cell and molecular biological techniques (Examples on right). Application of these mechanism will provide us with a novel approach to predict and/or control radiosensitivity and wll lead to the improvement of cancer radiation therapy.



Matsumoto Lab.

Faculty Members

Prof. Toyohiko YANO

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Materials used in nuclear systems such as high-temperature gas-cooled reactors, fast-breeder reactors or fusion reactors suffer from irradiation of high energy neutrons and other ionizing radiations under high temperature or highly corrosive environment. In this laboratory, property change of materials under extreme environments not only several kinds of nuclear reactors but also aerospace crafts or gas turbines is studied. Furthermore, we are developing new materials such as ceramic matrix composites capable for such severe environments. Right hand photograph is a high-resolution electron microscope for material characterization.

Yano Lab.

Assoc. Prof. Katsumi YOSHIDA

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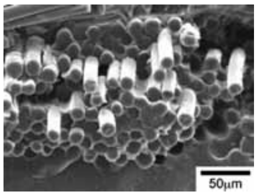
Ceramics have been recognized as attractive materials used in severe environment because they show excellent properties such as heat resistance, corrosion resistance, thermal stability and excellent wear resistance. Therefore, ceramics have been expected to be key materials for nuclear and fusion applications, environment and energy fields, and aerospace industries. In order to apply ceramic materials for these applications, their properties and functions corresponding to these applications must be improved in addition to their reliability as structural parts. Based on microstructure control in nano-, micro- and macro-scales, we have been developing high-performance advanced ceramic materials used in severe environment. Figure shows the SEM micrograph of the microstructure of the ceramic-based fiber-reinforced composite.



Yoshida Lab.

Assoc. Prof. Tatsuya KATABUCHI

buchi@nr.titech.ac.jp +81-3-5734-3378 Room: N1-310〈TSE〉

Study on Neutron Capture Reaction: We measure neutron capture cross sections for development of nuclear transmutation systems and study of nucleosynthesis. Measurements are performed in LANE and the Japan Proton Accelerator Research Complex (J-PARC).

Development of an Imaging System for Online Dosimetry in Boron Neutron Capture Therapy: We are developing an imaging system for dosimetry during treatment in boron neutron capture therapy. This system allows for evaluating the absorbed dose of a patient online, thereby improving determination of irradiation parameters and evaluation of treatment efficacy.

Katabuchi

Prof. Osamu Odawara

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Assistant Professors

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Liquid metals (Li, Pb, Sn, Ga, Pb-Li, Sn-Li and Pb-Bi) and molten salt (Flinak) have excellent nuclear characteristics and thermal properties as a coolant of generation IV nuclear reactors or a tritium breeder of advanced blanket system of fusion reactors. We have developed the liquid alloys and the molten salts having a high purity, and investigate their thermal properties and chemical characteristics at high temperature around 873K. We have developed some liquid metal loop systems for the investigation of heat transfer, mass transfer, material compatibility and corrosion-erosion mechanism. A right photograph shows a molten Pb, which is one of the candidates for the coolant of fast reactors.

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