

Department of Mechanical Systems Engineering
Department of Finemechanics
Department of Robotics
Department of Aerospace Engineering

Department of Mechanical Systems Engineering, Department of Finemechanics, Department of Robotics, and Department of Aerospace Engineering consist of following Core Laboratories, Research Centers/Institutes and Cooperative Laboratories.

[The figure in parenthesis indicates the number of laboratories.]

Department of Mechanical Systems Engineering

- ① Core Laboratories
Functional Systems Engineering (3), Energy Systems Engineering (3)
- ② Collaborative Chair (Graduate School of Biomedical Engineering)
Biomechanical Engineering (1)
- ③ Research Center/Institutes
Fracture and Reliability Research Institute (FRRI) [Division of Research:2]
Strength and Reliability for Advanced Energy and Environmental Materials (1), New Energy Systems Science (1)
- ④ Cooperative Laboratories
Institute of Fluid Science (IFS) [Division of Research:3, Research Center:2]
Creative Flow Research Division (1), Complex Flow Research Division (2), Lyon Center(1),
Innovative Energy Research Center(2), Nanoscale Flow Research Division (1)
Institute of Multidisciplinary Research for Advanced Materials (IMRAM) [Division of Research :1]
Division of Process and System Engineering (1)

Department of Finemechanics

- ① Core Laboratories
Materials Physics and Engineering (3), Nanomechanics(2), Biomechanics (2)
- ② Research center/Institutes
Fracture and Reliability Research Institute (FRRI) [Division of Research: 2]
Division of Strength Reliability for Advanced Energy and Environmental Materials(1), Division of Advanced Electric Power Technologies (1)
- ③ Cooperative Laboratories
Institute of Fluid Science (IFS) [Division of Research:2, Research Center:1]
Nanoscale Flow Research Division (3), Innovative Energy Research Center(1), Creative Flow Research Division (2)
International Center for Synchrotron Radiation Innovation Smart (SRIS) [Division of Research:1]
Cross Fertilization Division (1)

Department of Robotics

- ① Core Laboratories
Robot Systems (2), Nanosystems (3)
- ② Collaborative Chair (Graduate School of Biomedical Engineering)
Biomechanical Engineering (1), Biomedical Engineering for Health and Welfare (1)

Department of Aerospace Engineering

- ① Core Laboratories
Aeronautical Engineering(3), Astronautical Engineering (3)
- ② Cooperative Laboratories
Institute of Fluid Science (IFS) [Division of Research:2]
Creative Flow Research Division (2), Complex Flow Research Division (2)
- ③ Collaborative Laboratories [JAXA]
Next Generation Space Transportation Systems (1)

Department of Mechanical Systems Engineering

Laboratory	Professor / Associate Professor	Theme of research
Functional Systems Engineering (Micro-Nanomechanical Architectonics)	Professor Takahito ONO Associate Professor Masaya TODA	Micro/nanomechanical systems are key technologies in the fields of information technology (IT), environmental engineering and biomedical engineering. Based on nanotechnology, nanomachining and advanced integration technology, our group is developing advanced precision mechanical systems consisted of nano/micro-mechanical elements and electrical elements. The examples of our research topics are following: 1. Biological 3D nano-imaging. 2. Ultimate sensing 3. Nano electromechanical systems
Functional Systems Engineering (Nano-Precision Mechanical Fabrication)	Professor Tsunemoto KURIYAGAWA* Associate Professor Masayoshi MIZUTANI	Our lab aims to promote innovations of nano-precision Micro/Meso Mechanical Manufacturing (M4 process) at the frontier of manufacturing technology, including ultra-precision mechanical manufacturing technologies for various shapes, nano-precision fabrication for 3D microstructures, atom/molecule manipulation for anostructures and so on. Our goal is not only to create high-precision shapes, but also to generate functional structures on the shape by controlling the micro textures. 1. Development of Nano-precision Micro/Meso Mechanical Manufacturing (M4 process) 2. Creation of bio-medical interface utilizing Laser processing 3. Creation of functional interface with Mechanical / Non-conventional process
Functional Systems Engineering (Tribology and Nanointerface Engineering)	Professor Koshi ADACHI	The limit of performance and reliability of almost all machines are associated with friction and wear at the tribological contact interface. Therefore, we aim to understand and control them from nanoscale view points for creation of future highly-reliable and highly-functional mechanical systems. 1. Design and creation of highly-functional surface/ interface 2. Smart tribological systems by control of nanointerface 3. Creation of self-healing ultra-low friction system
Energy Systems Engineering (Renewable Energy Conversion Engineering)	Professor Hiroo YUGAMI Associate Professor Makoto SHIMIZU	Our laboratory study two major research topics “high efficiency usage of thermal energy by thermal radiation control” and “development of energy conversion devices for renewable energy resources based on solid state ionics and various mechanics” to solve global energy demand and global-scale environmental disruption to achieve sustainable growth society. 1. Spectral shaping technologies of thermal radiation 2. Advanced solar energy conversion technology using thermophotovoltaics 3. Study of solid oxide fuel cell practical application and future research

Laboratory	Professor / Associate Professor	Theme of research
Energy Systems Engineering (Fluid Mechanics)	Professor Masaya SHIGETA	<p>We study unique phenomena of flow and heat transfer in high-energy fluid processes such as material fabrication using plasma over 10,000 K. We develop innovative methods to “see, observe, and diagnose” those invisible phenomena with the purposes of mechanism elucidation and new process creation.</p> <ol style="list-style-type: none"> 1. Development of simulation method for high enthalpy plasma flow systems 2. Particle method simulation of molten metal flow in welding processes 3. Visualization measurements for high-temperature manufacturing processes 4. Numerical prediction of nanopowder formation in plasma flows
Energy Systems Engineering (Control of Heat Transfer)	Professor Tetsushi BIWA	<p>Our research focuses on understanding of various thermoacoustic and heat transfer phenomena to design and build advanced energy conversion systems based on acoustic gas oscillations and thermofluid dynamics including interfaces.</p> <ol style="list-style-type: none"> 1. Understanding of thermal phenomena induced by oscillatory flow 2. Development of heat engines and heat transport devices using acoustic waves 3. Development of optical measurement techniques for oscillatory flow 4. Understanding of nano-scale dynamics of wetting phenomena
<Collaborative Chair (Graduate School of Biomedical Engineering) > Biomechanical Engineering (Medical Nanosystem Engineering)	<p>Professor Tetsu TANAKA (Department assigned : Graduate school of Biomedical Engineering)</p> <p>Associate Professor Takafumi FUKUSHIMA</p>	<p>Semiconductor neural engineering is a discipline that uses semiconductor process/device/circuit technologies to further understand the properties of neural systems and to create novel fusion systems of living bodies and machines. One of the goals in this laboratory is to establish semiconductor neural engineering and develop biomedical micro/nano integrated systems. Another goal is to educate the next generation of leaders in biomedical engineering through research including:</p> <ol style="list-style-type: none"> 1. Fully-implantable retinal prosthesis system 2. Intelligent Si neural probe and brain-machine interface 3. Self-assembly technology and high-performance flexible sensor system 4. 3D integration technology and analog/digital IC design
Fracture and Reliability Research Institute [Division of Strength Reliability for Advanced Energy and Environmental Materials, FRR] (Laboratory for Surface Modification And Interfacial Control on Strength Reliability of Materials and Structures)	Professor Kazuhiro OGAWA Associate Professor Yuji ICHIKAWA	<p>State-of-the-arts energy materials and components have been using at high temperatures, high pressure, or high-loading environments. Therefore, nano-level cracks or defects on surface or at the interface between crystal grains or materials can affect the lifetime of the materials and components. In this laboratory, the safety and reliability researches for energy materials and components based on surface modification and interface control have been studying.</p> <ol style="list-style-type: none"> 1. Degradation mechanism analysis of energy materials and components 2. Development of thermal and environment barrier coatings for improvement of reliability for structural materials and components 3. Development of room-temperature bonding technique without heat affected zone 4. Study of high accuracy non-destructive evaluation for energy materials and components

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Fracture and Reliability Research Institute [New Energy Systems Science, FRRRI] (Laboratory for Earth Energy Systems Reserch) (Laboratory for Energy Cycle Systems Research)	Professor Toshiyuki HASHIDA** Associate Professor Kazuhisa SATO	<p>Establishment of environment-conscious energy systems is a prerequisite for the sustainable development of our society.</p> <p>Our research focuses on the development of next generation energy systems for subsurface energy extraction/cycling and energy conversion, and energy-substance systems based on nanomaterials.</p> <ol style="list-style-type: none"> 1. Design and development of geothermal energy extraction systems based on complex mass/heat flow model 2. Supercritical CO₂/water/rock interactions for CO₂ geological storage and its reliability assessment 3. Mechanical reliability and durability of solid oxide fuel cells (SOFCs) and secondary battery systems such as lithium-ion batteries 4. Fabrication and functionalization of novel composites reinforced by carbon nanotubes for novel energy-substance systems
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Electromagnetic Functional Flow Dynamics, IFS)	Associate Professor Hidemasa TAKANA	<p>Our group conducts researches on advanced electroresponsive fluids and reactive plasma flows with focusing on the clarification of their complex thermofluid interactions in spatio-temporal multiscale, establishment and optimization of the intelligent fluid flow systems, as well as their advanced applications to environment, energy and innovative material fields.</p> <ol style="list-style-type: none"> 1. Improvement of CO₂ absorption by ionic liquid electrospray 2. Innovative cellulose material fabrication by electrostatic fibril alignment 3. Computation simulation on ignition enhancement by nano-second pulsed discharge 4. Development of electromagnetic energy conversion device for efficient utilization of wind energy.
<Cooperative Laboratories> Complex Flow Research Division, Institute of Fluid Science (Heat Transfer Control, IFS)	Professor Atsuki KOMIYA	<p>Precise and active controls of heat and mass transfer under extreme conditions such as micro/nano scale and zero-gravity environments are important for future science and technology. This laboratory has been conducting research on the fundamentals of heat and mass transfer controls using an advanced optical system, and applies them to the low emission energy system and heat transfer enhancement. Heat transfer in intra-vital condition are also investigated.</p> <ol style="list-style-type: none"> 1. Evaluation of protein mass transfer and its active control 2. High heat flux cooling by phase change heat transfer in microscale 3. Heat and mass transfer enhancement by applying supercritical fluids 4. Investigation of bio heat transfer and its application to medical devices
<Cooperative Laboratories> Complex Flow Research Division, Institute of Fluid Science (Advanced Fluid Machinery Systems, IFS)	Professor Yuka IGA Associate Professor Junnosuke OKAJIMA	<p>In our laboratory, we are studying complex phenomenon caused by high-speed gas-liquid mixture flow in an effort to acquire the high efficiency and reliability of next-generation fluidmachinery systems by using numerical and experimental analyses.</p> <ol style="list-style-type: none"> 1. Clarification of mechanism of cavitation instabilities in liquid propellant rocked engine and development of the suppression technieque. 2. Clarification of thermodynamic suppression effect of cavitation. 3. Thermal transport in two-phase flow with phase change and its application.

Laboratory	Professor / Associate Professor	Theme of research
<p><Cooperative Laboratories> Lyon Center, Institute of Fluid Science (Mechanical Systems Evaluation, IFS)</p>	<p>Professor Tetsuya UCHIMOTO</p>	<p>In order to achieve higher reliability and safety of next-generation transportation systems and energy plants, we conduct research activities on intelligent sensing.</p> <ol style="list-style-type: none"> 1. Characterization of metals degradation and damage by electromagnetic nondestructive evaluation method. 2. Development of high temperature sensors and their applications to online monitoring. 3. Development of nondestructive testing method for quality assurance of carbon fiber reinforced composites. 4. Advanced sensing with sensor fusion and inverse analysis.
<p><Cooperative Laboratories> Innovative Energy Research Center, Institute of Fluid Science (Energy Dynamics, IFS)</p>	<p>Professor Kaoru MARUTA Associate Professor Hisashi NAKAMURA</p>	<p>For realizing combustion system with renewable and synthetic fuels including hydrogrn and ammonia, various new concept combustion technologies are studied with domestic and international collaboration partners.</p> <ol style="list-style-type: none"> 1. Analysis and construction of detailed combustion kinetics with a micro flow reactor with a controlled temperature profile for automobile engine and gas turbine combustor. 2. Fundamental and applied studies on microcombustion. 3. Microgravity combustion experiments for comprehensive combustion limit theory. 4. Research and development of high temperature oxygen combustion.
<p><Cooperative Laboratories> Innovative Energy Research Center, Institute of Fluid Science (System Energy Maintenance,IFS) ※</p>	<p>Professor (Concurrent post) Tetsuya UCHIMOTO Associate Professor Hiroyuki MIKI</p>	<p>To improve the reliability and stability of the system by enhancing the functionality of mechanical materials, we conduct research to establish novel energy-saving material processes and to realize energy-saving and highly efficient mechanical systems using sensing technology and material evaluation technology.</p> <ol style="list-style-type: none"> 1. High-performance and multifunctional materials using dynamic material interface control technology 2. High-performance material forming technology by plastic process in the middle and low temperature region 3. Advanced electromagnetic functional materials for sensors and actuators. 4. Functional thin film materials using nanocluster metals
<p><Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (Biological Nanoscale Reactive Flow, IFS)</p>	<p>Professor Takehiko SATO</p>	<p>We carry on creation and development of next-generation medical technologies such as plasma treatments and plasma sterilization by clarifying the interaction between the atmospheric-pressure plasma flow and the living organisms from the viewpoint of the biological reaction phenomena and the nanoscale flow phenomena.</p> <ol style="list-style-type: none"> 1. Biological interaction mechanism by the atmospheric-pressure plasma flow 2. Reaction flow mechanism of the gas-liquid plasma 3. Discharge and the nanoscale flow phenomena of underwater plasma 4. Development of the method for sterilization and inactivation of pathogenic microorganisms by the plasma flow
<p><Cooperative Laboratories> Division of Process and System Engineering, Institute of Multidisciplinary Research for Advanced Materials (Solid State Ionic Devices, IMRAM)</p>	<p>Professor Koji AMEZAWA Associate Professor Takashi NAKAMURA</p>	<p>Our laboratory contributes to solve environmental and energy problems throughout fundamental and application researches on environmental-friendly energy-conversion devices, such as solid oxide fuel cells and lithium ion secondary batteries. In particular, focusing on solid-state ion-conducting materials, we are challenging to establish an academic discipline on “solid-state ionics”, and applying this to develop novel materials and to improve performance/reliability of the energy conversion devices. We are also working for the development of advanced <i>in situ</i> analytical techniques for solid-state ionic devices.</p>

Note: For more detailed information, please contact the director. (Professor Tetsushi BIWA , TEL +81-22-795-3874)

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※ No students will be assigned in 2022.

[Faculty member]

* Scheduled to retire in March 2022 (will not accept any Master students.)

** Scheduled to retire in March 2023 (will not accept any Master students.)

Department of Finemechanics

Laboratory	Professor / Associate Professor	Theme of research
Materials Physics and Engineering (Intelligent Sensing of Materials)	Professor Hitoshi SOYAMA	<p>In order to realize sustainable society, researches on enhancement and evaluation of materials properties are conducting for light weighting of automobile and for extension and reliability of life time of power-and chemical-plants.</p> <ol style="list-style-type: none"> 1. Research and development of mechanical surface treatments and evaluation of modified layer 2. Production of novel materials by considering biomineralization 3. Evaluation of surface modified layer by using numerical simulation and experiment
Materials Physics and Engineering (Mechanics and Material Design)	Associate Professor Yoshiteru AOYAGI	<p>Complicated behavior of materials is calculated using multiscale plasticity that simultaneously express phenomena of different scales such as an atomic scale on microstructures and a continuum scale on macroscopic structures. Furthermore, we aim to unite the data obtained by experiment with computational research and to create new prediction</p> <ol style="list-style-type: none"> 1. Creation of Practical CAE System for Prediction of Mechanical Properties Based on Microstructure of Materials 2. Simulation on Mechanical Properties of Ultrafine-Grained Metals Based on Dislocation Behavior 3. Effect of Transcrystal on Fiber Reinforced Thermoplastic Composites
Materials Physics and Engineering (Intelligent Systems Engineering)	Professor Kazuo HOKKIRIGAWA* Associate Professor Takeshi YAMAGUCHI	<p>We aim to establish life support engineering that supports life and livelihood through the development of plant based novel carbon materials, investigation of fall mechanism, development of footwear and floor for fall prevention, and development of high-performance sport equipment and livingware, etc.</p> <ol style="list-style-type: none"> 1. Development and applications of hard porous carbon materials made from rice bran 2. Biomedical engineering study on understanding fall mechanisms and fall prevention technology 3. Fundamental and applied research of soft materials
Nanomechanics (Precision Nanometrology)	Professor Wei GAO Associate Professor Hiraku MATSUKUMA	<p>In Precision Nanometrology Laboratory, research activities are focused on nano-scale measurement and control of multi-degree-of-freedom surface forms and machine motions by combining unique precision nanometrology technologies with advanced machining technologies and control technologies in terms of nanometric metrology, control, fabrication and their applications.</p> <ol style="list-style-type: none"> 1. Multi-dimensional ultra-precision optical sensors/actuators 2. Measurement and fabrication of multi-degree-of-freedom precision surface forms and machine motions 3. Measurement and control of micro/nanom-motions

Laboratory	Professor / Associate Professor	Theme of research
Nanomechanics (Mechanics of Materials System)	Professor Hironori TOHMYOH	<p>Based on interdisciplinary approach, we aim at comprehensively evaluating the strength and functionality of various advanced materials system, which varies from the plant in mega-scale to small materials in micro/nano scale.</p> <ol style="list-style-type: none"> 1. Joining and Modification of Fine-Scale Materials for Creating Advanced Materials System 2. Nondestructive Evaluation of Materials System Using Acoustic Resonance or Electromagnetic Induction 3. Characterization of Hair and Nail for Understanding Higher-Dimensional Materials System
Biomechanics (Biodevice Engineering)	Professor Matsuhiko NISHIZAWA	<p>Recent rapid progress in molecular cell biology generates a new field of biodevice engineering that utilizes functions of biomolecules and cells. We are developing enzymatic and cellular sensors and power devices with high sensitivity and efficiency by soft micromachining of biomaterials.</p> <p>Followings are our concrete research themes.</p> <ol style="list-style-type: none"> 1. Enzymatic fuel cell devices 2. Medical and environmental sensors 3. Biolithography for controlling self-assembling of biomaterials 4. Molecular engineering of human / device interface 5. Hydrogel-based biohybrid machines
Biomechanics (Biological Flow Studies)	<p>Professor Takuji ISHIKAWA (Department assigned : Graduate school of Biomedical Engineering)</p> <p>Associate Professor Kenji KIKUCHI</p>	<p>Biomechanics is a research field to understand biological, physiological and pathological phenomena in terms of physical principles. The methodology gives novel knowledge, which has not been accessible by conventional biological, medical and chemical tools. Our group focuses on biological flow related to microorganisms and a human body, and try to overcome environmental and health problems.</p> <ol style="list-style-type: none"> 1. Prediction and control of microbial flora in the intestine 2. Physiological and pathological flow in the cardiovascular, respiratory and digestive systems 3. Large scale GPU computing of biological cells, such as micro algae and cancer cells 4. Transdermal absorption of medicine enhanced by mechanical stimulations 5. Medical needle device development by bio-inspired design
Fracture and Reliability Research Institute, [Division of Strength Reliability for Advanced Energy and Environmental Materials, FRRRI] (Laboratory for Prediction and Prevention of Fractures)	<p>Professor Hideo MIURA</p> <p>Associate Professor Ken SUZUKI</p>	<p>New methods for predicting and preventing fractures of various devices, products, plants, and materials have been developed based on the explication of atomic-scale mechanism of characteristics and long-term reliability of materials. Main research topics are as follows.</p> <ol style="list-style-type: none"> 1. Atomic-scale design of highly-reliable advanced materials using quantum molecular dynamics 2. Development of highly sensitive health-monitoring sensors for detecting various external and internal loads in nano-scale 3. Visualization of the damage of materials during the operation in atomic-scale and the development of nondestructive inspection system
Fracture and Reliability Research Institute, [Division of Advanced Electric Power Technologies, FRRRI] (Joint Reserch with Tohoku Electric Power co., Inc.)	<p>Professor (Concurrent post) Hideo MIURA</p> <p>Associate Professor Yoichi TAKEDA</p>	<p>With aiming to establish sustainable operation of the energy conversion systems, investigations related to improvement of efficiency in the turbine system and degradation mechanisms of structural materials in electric power generation plants are carried out.</p> <ol style="list-style-type: none"> 1. Advanced technology for improving the efficiency of fossil fueled power generation 2. Advanced technology for distributed energy system using micro-gas turbine system 3. Improvement of efficiency and reliability of the turbine systems in fossil and nuclear power plants

Laboratory	Professor / Associate Professor	Theme of research
<p><Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (Molecular Heat Transfer Laboratory, IFS)</p>	<p>Professor Taku OHARA</p>	<p>Molecular-scale thermophysical phenomena such as transport of thermal energy and mass, and interfacial phenomena among various phases play important roles in advanced technologies including biotechnology, design of thermal fluid and nanoscale fabrication process. Basic mechanism of the elementary process is being studied, which leads to the cutting-edge applications in mechanical engineering and thermal engineering.</p> <ol style="list-style-type: none"> 1. Molecular-scale transport phenomena in liquids and solid-liquid/liquid-gas interfaces 2. Analysis and control of molecular-scale transport phenomena of thermal energy and momentum aiming at the design of thermal fluids with required thermophysical properties 3. Study of advanced coating 4. Thermal and mass transport characteristics in molecular membranes such as cell membrane 5. Basic studies for biomimetic fluid machinery
<p><Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (Molecular Composite Flow Laboratory, IFS)</p>	<p>Professor (Concurrent post) Taku OHARA</p> <p>Associate Professor Gota KIKUGAWA</p>	<p>From nanoscale to macroscale, various thermal and fluid phenomena, in which composite molecular-scale physics is integrated, are of critical importance in the wide range of engineering and industrial processes. In particular, an essential understanding of these phenomena is indispensable to improve the performance of next-generation semiconductor devices or to explore and develop novel polymeric substances. By using large-scale numerical simulations such as the molecular dynamics method, we investigate heat and mass transfer phenomena in the thermal and fluid engineering from the microscopic viewpoint. The underlying microscopic mechanisms governing macroscale thermofluid properties are examined as well. Moreover, industrial applications based on this knowledge are also explored.</p> <ol style="list-style-type: none"> 1. Molecular-scale mechanisms governing macroscale thermofluid properties 2. Development of molecular dynamics analyses in the thermal and fluid engineering 3. Control of interfacial transport properties by surface modification techniques such as self-assembled monolayer (SAM) 4. Microscopic mechanism of interface affinity and wettability on the surface of organic molecular films 5. Multiscale analyses regarding design of transport properties for polymeric materials

Laboratory	Professor / Associate Professor	Theme of research
<p><Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (Quantum Nanoscale Flow Systems Laboratory, IFS)</p>	<p>Professor Takashi TOKUMASU</p>	<p>"Hydrogen" and "Battery" are very important issues in the next-generation new energy system. When considering these two issues, the influence of the "quantum characteristics" of a substance on a macro "fluid phenomenon" must be evaluated. An extremely light atom such as hydrogen cannot be regarded as a mass point, and its effect appears in a macroscopic phase diagram of a substance. In addition, the efficiency of the battery is determined by the correlation between "chemical reaction (quantum characteristics)" and "mass transport (flow characteristics)". In this research field, we will focus on next-generation energy devices and analyze the correlation between "quantum characteristics" and "flow phenomenon" of fluids that occur in these devices. Moreover, we aim at applying the knowledge to some engineering devices.</p> <ol style="list-style-type: none"> 1. Study for the chemical/transport phenomena of materials in polymer electrolyte fuel cell 2. Study for the chemical/transport phenomena of material in secondary batteries. 3. Study for fabrication process of semiconductor manufacturing. 4. Molecular simulation study of reactive mass transport phenomena in artificial ion channels for biosensor.
<p><Cooperative Laboratories> Innovative Energy Research Center, Institute of Fluid Science (Green Nanotechnology, IFS) ※</p>	<p>Professor Seiji SAMUKAWA</p>	<p>Nano-process is getting more and more important to realize fabrication of ultrafine three-dimensional structures and novel functional films in the field of nanotechnology including semiconductor devices, MEMS/NEMS, optical devices, and biotechnology. We are studying on novel nanomaterials and nanofabrication processes by systematic investigation on physics and chemistry of interaction between particles such as atoms, molecules, electrons, ions, and photons and solid, liquid, and gas.</p> <ol style="list-style-type: none"> 1. Novel devices fabricated by fusion of biotechnology and nanotechnology 2. Ultra-high-quality processes (etching, deposition) for leading-edge semiconductor devices 3. Precise plasma process system by fusion of plasma monitoring and computer simulation 4. Low environmental impact gas processes
<p><Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Integrated Simulation Biomedical Engineering Laboratory, IFS)</p>	<p>Associate Professor Kenichi FUNAMOTO</p>	<p>For technical innovation of treatment and prevention for diseases, it is essential to elucidate mechanisms of homeostasis and <i>in vivo</i> phenomena involved in development and progression of the diseases. We are investigating individual cell responses to spatiotemporal variations of microenvironment, as well as cell-cell and cell-extracellular matrix interactions, and conducting research to control them.</p> <ol style="list-style-type: none"> 1. Development of microfluidic devices to reproduce <i>in vivo</i> microenvironments. 2. Analysis and control of cell dynamics and their interactions. 3. Elucidation of biofunctions by measurement-integrated simulation and their medical applications.
<p><Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Biomedical Flow Dynamics Laboratory, IFS)</p>	<p>Professor Makoto OHTA</p>	<p>We have a high motivation for leading researches for medical device with medical doctors. Our topics and topics are the followings.</p> <ol style="list-style-type: none"> 1. Development of in-vitro model for supporting evaluation of new medical device and education. 2. Computational simulation for treatment with medical devices 3. Optimization of medical devices 4. Analyses of cell responses with medical devices 5. Contribution to standardization for medical devices

Laboratory	Professor / Associate Professor	Theme of research
<Cooperative Laboratories> Cross Fertilization Division, International Center for Synchrotron Radiation Innovation Smart (SRIS) (Next-Generation Detection System Smart Lab, SRIS)	Professor Wataru Yashiro	<p>In the 4D world we live in, the world of three dimensions (3D) plus time, there is a vast unknown spatio-temporal region that cannot be accessed even with the most advanced measurement technology. In this laboratory, we are developing new imaging technologies that dramatically exceed the conventional limits by making full use of the quantum nature of high-energy beams such as X-rays, advanced micro- and nano-fabrication technologies, and data science technologies, and are trying to explore the uncharted 4D world.</p> <ol style="list-style-type: none"> 1. Development and application of millisecond time-resolution 4D X-ray tomography 2. Development of X-ray elastography for medical diagnosis and soft material research 3. Fabrication of optical elements for X-rays and neutrons using advanced micro- and nano-fabrication techniques. 4. Exploration of new modalities based on quantum phenomena

Note: For more detailed information, please contact the director. (Professor Hironori TOHMYO , TEL +81-22-795-4026)

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Department of Robotics

Laboratory	Professor / Associate Professor	Theme of research
Robot Systems (Neuro-Robotics)	Professor Mitsuhiro HAYASHIBE Associate Professor Dai OWAKI	<p>Recently, the current era is referred to as a century of robotics. However, there are still a lot of things we need to deeply learn from advanced and robust motor control and sensory functions which humans have, for the next step forward. Robotics is also useful as a computational tool to understand human motor learning mechanisms. We study on neuroscience for robotics and robotics for neuroscience as “Neuro-Robotics”.</p> <ol style="list-style-type: none"> 1. Study of human motor control, learning mechanism 2. Modeling and identifying biological signals and functions 3. Development of robot technology to Neuro-Rehabilitation 4. Deep learning and AI for Robot motion control
Robot Systems (Design of Intelligent Machines)	Professor Yasuhisa HIRATA Associate Professor Yusuke TAMURA	<p>We are researching human-assistive robots for nursing care and healthcare for the super-aging society, and systems that can be applied to a wide range of tasks from human assistance to infrastructure maintenance by cooperatively using multiple robots. Furthermore, we are researching next-generation industrial robots that can dramatically increase the productivity of garment production lines by realizing robots that can handle flexible objects, and we are proposing new manufacturing methods through research and development of next-generation 3D printing technology.</p> <ol style="list-style-type: none"> 1. Welfare Robot Systems 2. A Haptic Feedback Device for Guiding Human Motion 3. Coordinated Control of Multiple Robots 4. Human-Robot Interaction Considering Human Attention and Intention
Nanosystems (Molecular Robotics)	Professor Satoshi MURATA Associate Professor Shinichiro NOMURA	<p>Thanks to the progress of molecular biology and other life sciences, the mechanisms of biological molecular machineries have been elucidated in considerable detail. This knowledge is now ready to apply to various fields of engineering, such as fabrication of complicated nanostructures and functional molecular devices. In our laboratory, we are focusing on design and fabrication of nanostructures and molecular devices utilizing biomaterials such as DNA, lipid and proteins. Further, we seek for a systematic methodology called “molecular robotics”, to integrate them into a consistent system with desired autonomy.</p> <ol style="list-style-type: none"> 1. Design and fabrication of nanostructures made of nucleic acids and lipids. 2. Design and fabrication of molecular devices for computation, sensing and actuation. 3. System integration of those structures and devices into a functional molecular robot or an artificial cell.

Laboratory	Professor / Associate Professor	Theme of research
Nanosystems (Smart System Integration)	Professor Shuji TANAKA Associate Professor Takashiro TSUKAMOTO	<p>Interface between “machines” and human is getting more important to consider the applications of advanced mechanical systems. Also, future “machines” will have advanced control, autonomy and functions as networked systems, as is the case with next-generation robots. This laboratory is studying “smart systems” enabling such advanced “machines” by integrating functional components in a small size. Our research interests include material development, process development, device fabrication and system demonstration (see examples below), all of which are necessary to implement “smart systems.” Through such a synthetic approach, high-level education and research in the field of Nanosystems are conducted.</p> <ol style="list-style-type: none"> 1. Sensors for human-friendly robots 2. Wireless communication devices 3. Bio-sensors for medical diagnostics 4. System integration 5. Integration and packaging technology 6. Fundamental technology for sensors and actuators
Nanosystems (Informative Nanosystems)	Professor Yoshiaki KANAMORI	<p>To realize freely light controlling on demand, manufacturing technologies of metamaterials (artificial optical material with sub-wavelength structures smaller than light wavelength as unit element) by micro/nano processing technologies, reconfigurable metamaterial that changes their optical properties, and applications of metamaterial have been developed. Also, highly efficient nano-optical devices by applying biomimetics has been studied. It is expected to be widely applied in the fields of information, energy, environment, medical care, welfare, etc.</p> <ol style="list-style-type: none"> 1. Development of ultra-small spectroscopy system using metamaterials and high sensitivity biosensors. 2. Study of high efficiency color filters and anti-reflection structures that imitate peacock’s wings and moth-eyes. 3. Research on force sensor and wavelength selective control with integrated micromachines. 4. Research on polarization and absorption control technology of terahertz wave.
<Collaborative Chair (Graduate School of Biomedical Engineering) > Biomedical Engineering for Health and Welfare (Medical Welfare Engineering)	Professor Mami TANAKA (Department assigned : Graduate school of Biomedical Engineering) Associate Professor Takeshi OKUYAMA	<p>With low birthrate and aging, staying healthy and the maintenance and improvement of the quality of life (QOL) are strongly desired. To stay healthy, early detection and treatment of diseases is important. In order to solve these, we treat the advanced mechatronics and signal processing technologies, and develop sensor/actuator systems for medical welfare apparatus. The topics are as follows:</p> <ol style="list-style-type: none"> 1. Intelligent artificial finger 2. Development of a palpation sensor system 3. Elucidation of mechanism of human tactile and touch feeling 4. Measurement and analysis of human hand/finger motion
<Collaborative Chair (Graduate School of Biomedical Engineering) > Biomechanical Engineering (Nanodevice Engineering)	Professor Yoichi HAGA (Department assigned : Graduate school of Biomedical Engineering)	<p>Minimally invasive medicine with less injury to the body, and healthcare devices which promote and maintain health are becoming more important in medical field.</p> <p>Using microfabrication technologies including MEMS (Micro Electro Mechanical Systems) technologies, research and education to develop novel and useful medical devices and healthcare devices are conducted.</p> <p>Our studies range from basic research and development of fabrication process to clinical application and practical research.</p> <ol style="list-style-type: none"> 1. Minimally invasive medical diagnostic and therapeutic devices with high-performance and multi-function. 2. Novel healthcare devices using new structure or principle. 3. Development of nonplanar microfabrication technology which is suitable shape for insertion and use in the living body.

Note: For more detailed information, please contact the director. (Professor Yoshiaki KANAMORI , TEL+81-22-795-4893)

◎Meaning of the symbols in the table

[Laboratory or Institute]

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[Faculty member]

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Department of Aerospace Engineering

Laboratory	Professor / Associate Professor	Theme of research
Aeronautical Engineering (Aerodynamic Design)	Professor Soshi KAWAI	<p>Our research draws from theoretical analysis, computational physics, data science, and high-performance computing to develop novel high-fidelity numerical simulation techniques for uncovering the basic physics underlying complex compressible, multiscale and multiphysics flows in aerospace engineering and for next-generation aircraft aerodynamic design tools.</p> <ol style="list-style-type: none"> 1. High-fidelity numerical methods based on computational physics 2. Wall modeling in LES for realistic high Reynolds number flows 3. Aerodynamic prediction methods over the whole aircraft flight envelope 4. High-fidelity modeling of turbulent combustion in engine combustors 5. Accurate/fast hierarchical Cartesian flow solver toward exascale computer
Aeronautical Engineering (Smart Systems for Materials and Structures)	Professor Tomonaga OKABE Associate Professor Go YAMAMOTO Associate Professor Keiichi SHIRASU	<p>This research group is developing and implementing a variety of numerical modeling tools for the advanced composites, and an aircraft traffic flow simulation as follows;</p> <ol style="list-style-type: none"> 1. Numerical method for failure simulation of fiber-reinforced composites 2. Multi-objective design of composite aircraft structures 3. Virtual testing of composite aircraft structures 4. Multi-scale modeling of advanced composite structures 5. Aircraft traffic flow simulation for optimal operation
Aeronautical Engineering (Experimental Aerodynamics)	Professor Keisuke ASAI* Associate Professor Taku NONOMURA	<p>In developing next-generation aircrafts, it is indispensable to understand the air flow around the vehicle and clarify the aerodynamic characteristics of it. In our laboratory, we study experimental aerodynamics for next-generation aircrafts. We are focusing on research on innovative aerodynamics that combines high-precision measurement using various wind tunnel experiments from low speed to hypersonic speed with information engineering.</p> <ol style="list-style-type: none"> 1. Advanced measurement techniques (PSP/TSP, GLOF, etc) 2. Radical improvements of aerodynamic characteristics by flow control 3. Dynamic wind tunnel testing using new-generation magnetic suspension and balance system (MSBS) 4. Study on low Reynolds number and high Mach number flow
Astronautical Engineering (Propulsion Engineering)	Professor Naofumi OHNISHI Associate Professor Masayuki TAKAHASHI	<p>New propulsion schemes by plasma, hypersonic flow dynamics, nonequilibrium gas dynamics, and numerical techniques for them are investigated by computer simulations for future aerospace engineering applications.</p> <ol style="list-style-type: none"> 1. Feasibility study of beamed energy propulsion 2. Plasma acceleration analysis and improvement on electric propulsion 3. Proposal of advanced flow control technique by unsteady plasma 4. Prediction of nonequilibrium radiation from hypersonic flow 5. Numerical simulations relevant to astrophysical flow

Laboratory	Professor / Associate Professor	Theme of research
Astronautical Engineering (Space Exploration)	Professor Kazuya YOSHIDA Associate Professor Toshinori KUWAHARA	We are working on space robotics technology for application to various space exploration and space development missions. <ol style="list-style-type: none"> 1. Study on core technologies for space robotics and space flight systems, such as motion dynamics and control, sensing and navigation, teleoperation and autonomy 2. Dynamics and control of free-flying space robots for operation in orbital or micro-gravity environment 3. Research and development of exploration robots for the surface of Moon, planets and asteroids 4. Research and development of micro-satellites for scientific observation, remote sensing and disaster monitoring missions
Astronautical Engineering (Space Structures)	Professor Kanjuro MAKIHARA	We are engaged in analytical and experimental research on dynamics, aeroelasticity and shape control for space structures, such as space stations, lunar bases, and artificial satellites. <ol style="list-style-type: none"> 1. Self-powered vibration control for space structures 2. Autonomous energy-harvesting using smart devices 3. Impact-proof tether systems for debris removal 4. Modeling for Mars-airplane with folding wings 5. Dynamics analysis and construction for large space structures
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Aerospace Fluid Engineering, IFS)	Professor Shigeru OBAYASHI	We are working on experimental fluid dynamics, computational fluid dynamics, and their integration for the innovation, safety, and creation of aerospace systems. <ol style="list-style-type: none"> 1. Innovative design and manufacturing assisted by “Multi-Objective Design Exploration” 2. Innovative engineering design driven by “Data Assimilation” 3. Innovative aerospace plane experiment by “Magnetic Suspension and Balance System”
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Fluids Engineering with Data Science, IFS)	Associate Professor Koji SHIMOYAMA	Our laboratory studies fluid analysis techniques integrated with mathematical and data-scientific approaches to create optimal, robust, and intelligent fluid machinery and their system; from small devices such household appliances to large systems such as automobiles and aircraft. <ol style="list-style-type: none"> 1. Multi-objective design optimization of fluid machinery 2. Uncertainty quantification in fluid analysis and design 3. Surrogate modeling for efficient fluid analysis and design
<Cooperative Laboratories> Complex Flow Research Division, Institute of Fluid Science (High Speed Reacting Flow, IFS)	Professor Hideaki KOBAYASHI** Associate Professor Akihiro HAYAKAWA	Combustion phenomena represented by gas turbine combustion of aircraft engines are highly complicated where turbulent flows interact with chemical reactions in extreme conditions. In this lab, researches on high-speed combustion phenomena and new combustion technologies with globally low environmental impact are performed using advanced laser diagnostics and numerical simulations. <ol style="list-style-type: none"> 1. Turbulent combustion in a high pressure and high temperature environment 2. High-pressure spray combustion in gas turbine combustor conditions 3. Supersonic combustion phenomenon and its control 4. Laser diagnostics for rocket engine combustion 5. Fundamentals and applications of carbon-free ammonia combustion

Laboratory	Professor / Associate Professor	Theme of research
<Cooperative Laboratories> Complex Flow Research Division, Institute of Fluid Science (Complex Shock Wave, IFS) ※	Professor (Concurrent post) Hiroki NAGAI Associate Professor (Concurrent post) Kiyonobu OHTANI	We are working on study of complex propagation phenomena of shock wave in gas-liquid-solid three-phase for understanding a fundamental mechanism and its interdisciplinary application 1. Study on shock wave propagation phenomena for human body tissue protection 2. Establishment of shock wave pressure active control method 3. Study on supersonic free-flight projectile for aerodynamics
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Spacecraft Thermal and Fluids Systems Laboratory, IFS)	Professor Hiroki NAGAI	We are working on study of thermal and fluids system for spacecraft, and development of their control technique. 1. Study on aerodynamic characteristics and heating when space vehicle enters into planet having atmosphere 2. Study on thermal control system and device for next-generation spacecraft 3. Study on airplane which flies in planet having atmosphere 4. Research and development of novel optical measurement technique for thermal and fluid dynamic phenomena

Note: For more detailed information, please contact the director. (Professor Kazuya YOSHIDA, TEL+81-22-795-6992)

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