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 （２）, Energy Systems Engineering （３）
② Collaborative Chair (Graduate School of Biomedical Engineering)
  Biomechanical Engineering （１）, Medical Device Innovation （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),
    Global Collaborative Research and Education Center for Integrated Flow Science (１),
    Nanoscale Flow Research Dvision (１)
  Institute of Multidisciplinary Research for Advanced Materials (IMRAM) [Division of Research : １]
    Division of Process and System Engineering (１)
  Green Goals Initiative[Research Center: １]
    Green X-tech Research Center (１)

Department of Finemechanics

① Core Laboratories
  Materials Physics and Engineering (２), Nanomechanics (３), Biomechanics (２)
② Research center/Institutes
  Fracture and Reliability Research Institute (FRRI) [Division of Research: 1]
    Advanced Mechano-Materials Science (１)
③ Cooperative Laboratories
  Institute of Fluid Science (IFS) [Division of Research:2, Research Center:1]
    Nanoscale Flow Research Division (３), Creative Flow Research Division (２), Global Collaborative Research and Education Center for Integrated Flow Science（１）
  International Center for Synchrotron Radiation Innovation Smart (SRIS) ［Division of Research:1］
    Cross Fertilization Division （２）
  Green Goals Initiative[Research Center: １]
    Green X-tech Research Center (１)

Department of Robotics

① Core Laboratories
  Robot Systems (３), Nanosystems (３)

② Collaborative Chair (Graduate School of Biomedical Engineering)
  Biomechanical Engineering （１）, Biomedical Engineering for Health and Welfare （１）

③ Cooperative Laboratories
  Institute of Fluid Science (IFS) [Division of Research: １]
    Division, Institute of Fluid Science (１)

Department of Aerospace Engineering

① Core Laboratories
  Aeronautical Engineering(２), Astronautical Engineering (３), Advanced Aerospace Engineering（１)
② Cooperative Laboratories
  Institute of Fluid Science (IFS) [Division of Research:3, Research Center:3]
    Creative Flow Research Division (１), Complex Flow Research Division (１) ,
    Global Collaborative Research and Education Center for Integrated Flow Science (３)
    Green Goals Initiative[Research Center: １]
    Green X-tech Research Center (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 Associate Professor Ngyuen Van TOAN	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 consisting 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 (Tribology and Nanointerface Engineering)	Professor Koshi ADACHI Associate Professor Motoyuki MURASHIMA	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 4. Development of carbon neutral tribotechnology by controlling molecular adsorption and growth at nano-interfaces
Energy Systems Engineering (Renewable Energy Conversion Engineering)	Associate Professor Makoto SHIMIZU	To realize a sustainable society, it is essential to maximize the efficiency of existing energy sources and promote the advanced utilization of renewable energy. Our laboratory is dedicated to pioneering next-generation energy technologies by leveraging nanotechnology to control thermal radiation and developing innovative engineering approaches based on this capability. 1. High-efficiency energy conversion through control of radiation–matter interactions 2. Thermal management technologies using nanostructure for thermal radiation control 3. Development of advanced energy systems harnessing waste heat
Energy Systems Engineering (Fluid Mechanics)	Professor Masaya SHIGETA Associate Professor Hitoshi MUNEOKA	We study unique phenomena of flows and heat-mass transfers at energy conversion in high-energy fluid processes such as material fabrication and decomposition 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. 1. Mechanism and application of plasma-induced turbulence 2. High-speed detoxification of persistent substances 3. Model experiment and calculation systems for natural disasters 4. Nonequilibrium synthesis of functional nanomaterials by plasma flows
Energy Systems Engineering (Control of Heat Transfer)	Professor Tetsushi BIWA Associate Professor Eita SHOJI	Our research focuses on understanding various thermoacoustic, heat and mass transfer phenomena to design and build advanced energy conversion systems based on acoustic gas oscillations and thermofluid dynamics including phase interfaces. 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

Laboratory	Professor / Associate Professor	Theme of research
<Collaborative Chair (Graduate School of Biomedical Engineering) > Biomechanical Engineering (Biomedica1Medical Nanosystem Engineering)	Professor Tetsu TANAKA (Department assigned: Graduate school of Biomedical Engineering)	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: 1. Fully-implantable retinal prosthesis system 2. Body-machine interfaces for biological activity manipulation (record and stimulation) 3. 3-dimensional semiconductor integration technology using through-silicon vias (TSV) 4. Analog/Digital IC design for health-tech devices
<Collaborative Chair (Graduate School of Biomedical Engineering) > Medical Device Innovation (Holistic Integration Engineering)	Professor Takafumi FUKUSHIMA (Department assigned: Graduate school of Biomedical Engineering)	Holistic Integration Engineering is a research field that uses a systematic holistic approach to device creation, based on semiconductor packaging engineering, which significantly affects the performance of integrated circuits. We are researching manufacturing technology that contributes to cutting-edge AI chips and high-performance wearable devices through valuable experience using a cleanroom that is on a par with the best in the world. 1. Wearable devices to detect the onset of illness and monitor health conditions 2. Low-power light therapy devices for orthodontics, wound healing, depression 3. Non-invasive biomedical sensors with information from tears, sweat, blood 4. 3D artificial intelligence chips that apply medical device packaging technology
Fracture and Reliability Research Institute [Division of Strength Reliability for Advanced Energy and Environmental Materials, FRRI] (Laboratory for Surface Modification And Interfacial Control on Strength Reliability of Materials and Structures)	Professor Kazuhiro OGAWA Associate Professor Yuji ICHIKAWA	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. 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
Fracture and Reliability Research Institute [New Energy Systems Science, FRRI] (Laboratory for Energy Cycle Systems Research)	Associate Professor Kazuhisa SATO	Establishment of environment-conscious energy systems is a prerequisite for the sustainable development of our society. Our research focuses on the development of next generation energy systems for energy-substance systems based on nanomaterials. Specifically, research will focus on energy conversion devices such as fuel cells, all-solid-state batteries and electrolysis. 1. Mechanical reliability and durability of solid oxide fuel cells (SOFC) 2. Fabrication and design of highly durable all-solid-state batteries 3. Development of non-destructive evaluation methods for heterophase functional laminates 4. Study on life prediction of heterophase functional laminates.

Laboratory	Professor / Associate Professor	Theme of research
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Electromagnetic Functional Flow Dynamics, IFS)	Professor Hidemasa TAKANA	Our group conducts researches on advanced electro-responsive fluids and reactive plasma flows with focusing on the clarification of their complex thermofluid phenomena in spatio-temporal multiscale, establishment and optimization of the autonomous fluid flow systems, as well as their advanced applications to environment, energy and innovative material fields. Our group also aims to elucidate the flow phenomena created by electro-responsive flow by data-driven analysis. 1. Improvement of CO_2 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. Clarification of plasma flow control mechanism using data assimilation
<Cooperative Laboratories> Complex Flow Research Division, Institute of Fluid Science (Heat Transfer Control, IFS)	Professor Atsuki KOMIYA	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. 1. Evaluation of protein mass transfer and its active control 2. Heat and mass transfer enhancement and energy harvesting by using natural energy and resources 3. Development of novel cooling system using elastocaloric effect 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	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. 1. Clarification of mechanism of cavitation instabilities in liquid propellant rocked engine and development of the suppression techniequie. 2. Clarification of thermodynamic suppression effect of cavitation. 3. Fundamental study on boiling flow and its heat transfer Development of high-performance cooling system and clarification of its phenomena
<Cooperative Laboratories> Lyon Center, Institute of Fluid Science (Mechanical Systems Evaluation, IFS)	Professor Tetsuya UCHIMOTO	In order to achieve higher reliability and safety of next-generation transportation systems and energy plants, we conduct research activities on intelligent sensing. 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. Advanced sensing with sensor fusion and inverse analysis.
<Cooperative Laboratories> Global Collaborative Research and Education Center for Integrated Flow Science, Institute of Fluid Science (Energy Dynamics, IFS)	Professor Kaoru MARUTA	For realizing combustion system with renewable and synthetic fuels including hydrogen and ammonia, various new concept combustion technologies are studied with domestic and international collaboration partners. 1. Hyper lean-burn engine study with extremely high thermal efficiency. 2. Analysis of detailed combustion kinetics with a micro flow reactor with a controlled temperature profile for future fuels. 3. Fundamental and applied studies on microcombustion. 4. Microgravity combustion experiments at IIS Kibo for comprehensive combustion limit theory. 5. High-fidelity Direct Numerical Simulations on reactive fluids.

Laboratory	Professor / Associate Professor	Theme of research
<Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (BiologicalNanoscaleReactiveFlow, IFS)	Professor Takehiko SATO	Research is being conducted on the creation of next-generation medical technologies through high-speed nano-droplets and plasma-based medical treatments by elucidating the interference with biological systems from the perspective of nano-fluidic phenomena. 1. Creation of an ultra-water-saving, non-wetting, drug-free sterilization and cleaning method using high-speed nano-droplets, as well as a method for cell control, and elucidation of nano-droplet physics. 2. Elucidation of the gas-liquid interface phenomena of charged cavitation bubbles and the development of methods for generating hydrated electrons and high-density energy. 3. Development of an integrated sterilization and medical method using plasma, bubbles, and droplets. 4. Development of a method for suppressing cancer metastasis using X-rays.
<Cooperative Laboratories> Research Center for Green X-Tech, Green Goals Initiative (Manufacturing Process)	Professor MasKwayoshi 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 nanostructures 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 and phenomenon elucidation of Nano-precision machining process 2. Creation of bio-medical interface utilizing Laser processing 3. Creation of functional interface with Mechanical / Non-conventional process
<Cooperative Laboratories> Division of Process and System Engineering, Institute of Multidisciplinary Research for Advanced Materials (Solid StateIonic Devices, IMRAM)	Professor Koji AMEZAWA Associate Professor Yuta KIMURA	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 *in situ* analytical techniques for solid-state ionic devices.
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Design of Structure and Flow in the Earth, IFS)	Professor (Concurrent post) Kaoru MARUTA Associate Professor Anna SUZUKI	To use natural energy resources in our society, we study on estimation, prediction, and design of complex natural structures and the flow of water and heat through them that cannot be controlled by humans. In addition, our research aims to explore the role of technology in diverse societies and to promote people's behavior change to address social issues. 1. development of mathematical models for evaluation and estimation of complex structures and flows 2. understanding flow phenomena through structure-controlled flow experiments 3. data-driven geothermal reservoir modeling 4. design of co-creation communities for natural resource utilization

Note: For more detailed information, please contact the director. (Professor Takahito ONO TEL +81-22-795-5806)

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※ No students will be assigned in 2026.

〔Faculty member〕

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** Scheduled to retire in March 2027 (will not accept students.)

*** Scheduled to retire in March 2028(will not accept Doctoral students)

Department of Finemechanics

Laboratory	Professor / Associate Professor	Theme of research
Materials Physics and Engineering (Intelligent Sensing of Materials)	Professor Hitoshi SOYAMA	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. 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	The complicated behavior of materials is calculated using multiscale plasticity that simultaneously expresses 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 1. Development of practical CAE system for prediction of mechanical Properties Based on Microstructure of Materials 2. Simulation on mechanical properties of advanced alloys based on dislocation behavior 3. Effect of transcrystal on fiber-reinforced thermoplastic composites
Nanomechanics (Softmechanics)	Professor Takeshi Yamaguchi Associate Professor Toshiaki NISHI	Based on the soft mechanics research such as contact and friction control of soft materials including rubber and living organisms and human motion analysis, we are conducting research to improve the health and function of mechanical systems, to prevent falling accidents, and to extend human motor functions. 1. Synchrotron science and tribology: Strain behavior in rubber friction 2. Interfacial science and tribology: Influence of water distribution on fabric friction 3. Sports science and tribology: Tactile perception in baseball pitching 4. Sensor shoe system: Gait analysis using footwear
Nanomechanics (Precision Nanometrology)	Professor Wei GAO Associate Professor Hiraku MATSUKUMA	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. 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
Nanomechanics (Mechanics of Materials System)	Professor Hironori TOHMYOH Associate Professor Keiichi SHIRASU	In order to create advanced materials system with higher value added, we have developed various peripheral technologies form the fabrication of fine-scale materials to their applications, as well as studied principles and methods for evaluating reliability of materials system. 1. Fabrication, joining, characterization and application of fine-scale metallic, polymer and carbon materials 2. Nondestructive evaluation of materials system using sound or current Characterization of human hair and nail for understanding higher-dimensional materials system

Laboratory	Professor / Associate Professor	Theme of research
Biomechanics (Biodevice Engineering)	Professor Matsuhiko NISHIZAWA	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. Followings are our concrete research themes. 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)	Professor Takuji ISHIKAWA （Department assigned：Graduate school of Biomedical Engineering） Associate Professor Kenji KIKUCHI Associate rofessor Toshihiro OMORI	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. 1. Prediction and control of microbial flora in the intestine 2. Large scale GPU computing of biological cells, such as algae and sperm 3. Transdermal absorption of medicine enhanced by mechanical stimulations 4. Medical needle device development by bio-inspired design 5. Development of micro-robot propulsion principle using microorganisms as a model 6. Elucidating the evolutionary path of organisms in terms of biomechanics
Fracture and Reliability Research Institute [Advanced Mechano-Materials Science]	Associate Professor Zihao WANG (appointment effective June 1, 2025)	To deepen the understanding of various mechano-material degradation fields in the emerging decarbonized society, this lab leverages cutting-edge nano-analysis techniques to explore structural properties across multiple scales at elevated temperatures. Advanced in-situ materials characterization and testing methods will be employed to mechanistically investigate and visualize the material failure process, surpassing the current state-of-the-art. 1. Application of cutting-edge microscopic characterization techniques on mechano-materials degradation. 2. Mechanistic evaluation of Mechanical failure of high temperature alloys in extreme environments. 3. First-principle calculation on corrosion-resistant-alloy development.
<Cooperative Laboratories> Research Center for Green X-Tech, Green Goals Initiative （Design of Function and Reliability of Materials）	Professor Ken SUZUKI	To elucidate the mechanisms of functional expressions and improve the reliability of material systems under various harsh environments, we are developing design, manufacturing, and evaluation techniques for high-performance, high-reliability materials using atomic-level simulations, experiments, and measurements. 1. Design of functional reliability for a wide variety of material systems, including metals, semiconductors, ceramics, and polymers, based on electronic structure 2. Elucidation of the mechanisms of functional damage and strength degradation in materials using atomic-level simulations 3. Development of methods and devices for evaluating the integrity of materials: design and development of carbon nanomaterial-based strain sensors and chemical sensors

Laboratory	Professor / Associate Professor	Theme of research
<Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (Molecular Heat Transfer Laboratory, IFS)	Professor Taku OHARA*** Associate Professor SURBLYS Donatas	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. 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. Measurement and control of solid/liquid interface wettability affected by nanostructures and surface modifications 5. Development of thermophysical and interfacial transport property analysis methods and their application to new materials via molecular simulation
<Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (Molecular Composite Flow Laboratory, IFS)	Professor Gota KIKUGAWA	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. 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
<Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (Quantum Nanoscale Flow Systems Laboratory, IFS)	Professor Takashi TOKUMASU	"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 (quantitum characteristics)” and “mass transport (flow characteristics)”. In this research field, we will focus on next-generation energy devices and analyze the correlation between "quantitum characteristics" and "flow phenomenon" of fluids that occur in these devices. Moreover, we aim at applying the knowledge to some engineering devices. 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.
<Cooperative Laboratories>Global Collaborative Research and Education Center for Integrated Flow Science, Institute of Fluid Science (Green Nanotechnology, IFS)	Professor Kazuhiko Endo	As a key device for the next generation of green nanotechnology, it is essential to achieve high energy efficiency by miniaturization and integration of semiconductor nanodevices. In order to achieve high energy efficiency, controlling the characteristics of semiconductor nanodevices at the atomic level is necessary. For this purpose, it is necessary to control processes such as microfabrication, functional thin film formation, surface modification, and cleaning at the atomic level. Therefore, in this research field, we will search for experimental solutions to the following research topics. 1. Research on new channel materials for semiconductor nanodevices and control of them at the atomic level 2. Atomic-level control of thin film deposition process for semiconductor nanodevices 3. Atomic-level control of microfabrication processes for semiconductor nanodevices
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Integrated Simulation Biomedical Engineering Laboratory, IFS)	Professor Kenichi FUNAMOTO	For technical innovation of treatment and prevention for diseases, it is essential to elucidate mechanisms of homeostasis and *in vivo* 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. 1. Development of microfluidic devices to reproduce *in vivo* microenvironments. 2. Analysis and control of cellular dynamics in response to environmental factors. 3. Elucidation of biofunctions by measurement-integrated simulation and their medical applications.
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Biomedical Flow Dynamics Laboratory , IFS)	Professor Makoto OHTA Associate Professor Hitomi ANZAI	We have a high motivation for leading researches for medical device with medical doctors. Our topics and topics are the followings. 1. Development of in-vitro model for supporting evaluation of new medical device and education. 2. Computational simulation for treatment with medical devices. Especially, simulation of arterial shape and blood flow using machine learning. 3. Optimization of medical devices 4. Analyses of cell responses with medical devices 5. Aerosol droplet simulation in lungs and airways

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	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, (synchrotron radiation from state-of-the-art facilities such as NanoTerasu, a 3 GeV high-brilliance synchrotron radiation facility, and X-ray sources used for medical diagnosis, etc.), advanced micro- and nano-fabrication technologies, and data science technologies, and are trying to explore the uncharted 4D world. 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
<Cooperative Laboratories> Cross Fertilization Division, International Center for Synchrotron Radiation Innovation Smart (SRIS) (International collaboration smart lab)	Professor Daichi CHIBA Associate Professor Hikaru NOMURA	We are exploring new possibilities with ultrathin solid films that are flexible and utilize ‘mechanical behavior’. With these films, we are proposing principles for controlling magnetic (spin) properties. We are also developing mechanical sensing technologies and exploiting the new scientific field of 'spin-elastonics' and also 'nano-elastonics' with NanoTerasu. Our themes are, Creating new functional materials by reversibly controlling atomic spacing, 1. Creating information processing systems using nano-magnets, 2. Broadening the application of spintronics through 1 and 2, integrating NanoTeras and other metrology, digital transformation of measurement and control, and developing use cases.

Note: For more detailed information, please contact the director. (Professor Takeshi YAMAGUCHI TEL +81-22-795-6897)

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Department of Robotics

Laboratory	Professor / Associate Professor	Theme of research
Robot Systems (Robot Systems)	Professor Kimitoshi YAMAZAKI	We aim to develop automated machines that can move quickly and accurately under any conditions and perform a variety of tasks. To achieve this goal, we are pursuing the intelligence of autonomous robots. We are conducting elemental research on recognition, motion generation, and action learning; innovative hardware that can perform complex tasks; methods for analyzing human work capabilities and applying them to robotics; and methods for constructing highly intelligent systems by combining different types of functions. We are also actively engaged in industry-academia collaboration (practical application of robotics research results) in areas such as life support, product manufacturing, construction, and recycling. 1. Action learning for intelligent robots using basic models 2. New multi-degree-of-freedom robots and their application to human behavior support 3. Elucidation of intelligence based on analysis of human manipulation behavior and its application to robotics
Robot Systems (Neuro-Robotics)	Professor Mitsuhiro HAYASHIBE Associate Professor Dai OWAKI	Recently, the current era is referred 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 next step forward. Robotics is also useful as computational tool to understand human motor learning mechanism. We study on neuroscience for robotics and robotics for neuroscience as “Neuro-Robotics”. 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	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. 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	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. 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	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. 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 Associate Professor Naoki INOMATA	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, applications of metamaterial, and high-performance sensing devices 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, human sensing, medical care, welfare, etc. 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. Research on highly sensitive thermometers under difficult measurement conditions such as human body or biological cell.
<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	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: 1. Intelligent artificial finger 2. Development of a palpation sensor system 3. Elucidation of mechanism of human tactile and touch feeling Measurement and analysis of human hand/finger motion

Laboratory	Professor / Associate Professor	Theme of research
<Collaborative Chair (Graduate School of Biomedical Engineering) > Biomechanical Engineering (Nanodevice Engineering)	Professor Yoichi HAGA （Department assigned： Graduate school of Biomedical Engineering）	Both minimally invasive medicine with less injury to the body and healthcare that promote and maintain health are becoming more important in the medical field. Research and education are conducted using microfabrication technologies, including MEMS (Micro Electro Mechanical Systems), to develop novel and useful medical and healthcare devices. Our studies range from basic research and development of the fabrication process to clinical application and practical research. 1. Minimally invasive medical diagnostic and therapeutic devices with high-performance and multi-function. 2. Novel healthcare devices using new structures or principles. 3. Development of nonplanar microfabrication technology, which is a suitable shape for insertion and use in the living body.
<Cooperative Laboratories> Nanoscale Flow Research Division, Institute of Fluid Science (Biomolecular Flow Systems Laboratory, IFS)	Associate Professor Takuya MABUCHI	Ion channels, nanopores present within cellular membranes, are crucial biomolecules that control the flow of ions between the interior and exterior of cells, thereby regulating the essence of cellular energy processes. Research aimed at biomimicking the complex structure and function of ion channels with artificial molecules is a significant challenge across various fields, from industry to medicine. Using theoretical approaches such as molecular simulations, we aim to elucidate the "nanoflow phenomena," which are difficult to observe experimentally, and develop the theoretical design of highly functional artificial biomolecules with desirable properties. The ultimate goal is to apply these biomolecules in engineering applications, such as constructing artificial cells and molecular systems. 1. Reactive transport mechanisms of protons in nanopores 2. Theoretical design of artificial ion channels with selective permeability 3. Liquid-liquid phase separation using artificial polypeptides

Note: For more detailed information, please contact the director. (Professor Yasuhisa HIRATA TEL+81-22-795-6940)

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Department of Aerospace Engineering

Laboratory	Professor / Associate Professor	Theme of research
Aeronautical Engineering (Aerodynamic Design)	Professor Soshi KAWAI	Our research draws from computational and mathematical science on various complex flow and aerodynamic phenomena in the aerospace field, including the aerodynamic design of aircraft and spacecraft. Our research interests cover a wide range of research fields such as complex flow phenomena, computational physics, data-driven science, machine learning, flow modeling and control, etc. We aim to conduct academic research in terms of quality and originality. 1. Next-generation high-fidelity computational fluid dynamics 2. Complex compressible multiscale and multiphysics flow phenomena 3. Mathematical and data-driven analysis of large-scale complex flow data 4. Next-generation predictive science for aircraft digital flight
Aeronautical Engineering (Smart Systems for Materials and Structures)	Professor Tomonaga OKABE Associate Professor Go YAMAMOTO	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; 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
Astronautical Engineering (Propulsion Engineering)	Professor Naofumi OHNISHI Associate Professor Masayuki TAKAHASHI	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. 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
Astronautical Engineering (Space Exploration)	Professor Kazuya YOSHIDA*	We are working on space robotics technology for application to various space exploration and space development missions. 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 Associate Professor Keisuke OTSUKA	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. 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 for large-scale aerospace structures

Laboratory	Professor / Associate Professor	Theme of research
Advanced Aerospace Engineering (Advanced Aerospace Engineering)	Associate Professor Kai FUKAMI	Our group studies a range of unsteady flow phenomena leveraging data science, nonlinear machine learning, complex network theory, information theory, and computational fluid dynamics. Our ultimate goal is to build the data-oriented foundation for real-time analysis, modeling, and control of unsteady flows ubiquitously appearing in a variety of situations around small-sized air vehicle, airplane, motor vehicle, and fluid-based industrial machine. 1. Generalized super-resolution analysis for spatiotemporal flow reconstruction from sparse sensors. 2. Low-rank manifold identification for unsteady flow modeling 3. Network and causality-based analysis of causal vortical interactions 4. Interdisciplinary unsteady flow analysis through nonlinear machine-learning-based coordinate transformation 5. Computational, experimental, and theoretical fluid flow data fusion
<Cooperative Laboratories> Creative Flow Research Division, Institute of Fluid Science (Aerospace Fluid Engineering, IFS)	Associate Professor Aiko YAKENO	In the Aerospace Fluid Engineering lab., we aim to precisely understand "flow" based on numerical simulations, experiments, and theory, and to propose and demonstrate innovative engineering technologies; 1. Research for innovative high-speed transportation – hypersonic flying object, laminar flow wings, jet engines, aerodynamic control using microfabrication of object surfaces, etc., 2. Aerodynamic experiments using magnetic suspension and balance system and ballistic range facilities, 3. Research into faster and precise flow predictions using mathematical sciences such as causal inference and data assimilation.
<Cooperative Laboratories> Global Collaborative Research and Education Center for Integrated Flow Science, Institute of Fluid Science (Reactive Flow Systems Laboratory)	Professor Hisashi NAKAMURA	We aim to elucidate and model chemical kinetics in reactive flow fields related to propulsion systems and energy conversion devices used in aerospace aircraft and other applications; 1. Elucidating and modeling chemical kinetics of carbon-free and low-carbon fuels such as ammonia, hydrogen, biofuels, and e-fuels, 2. Advancement of fundamental experimental methods for reactive flow fields using micro flow reactors and counterflow flames, 3. Fire mitigation based on understanding of chemical kinetics of battery electrolyte, refrigerants, and flame retardants added to them, 4. Simplification of detailed chemical kinetic models assisted with machine learning.
<Cooperative Laboratories> Global Collaborative Research and Education Center for Integrated Flow Science, Institute of Fluid Science (Multi-Physics Design, IFS)	Associate Professor Yoshiaki ABE	In aircraft design, numerous phenomena described in distinct physics, such as fluid and solid mechanics, must be considered concurrently. Our area of interest is numerical simulation, which helps us comprehend and utilize those multi-physics phenomena, towards a new field named "aeroscience". 1. Modern hardware and high-fidelity computational fluid dynamics 2. Design optimization and aeroelastic analysis of composite aircraft 3. Multi-physics simulation for the use of advanced materials 4. Data-driven multi-physics formulation with high-fidelity simulations

Laborator y	Professor / Associate Professor	Theme of research
<Cooperative Laboratories> Global Collaborative Research and Education Center for Integrated Flow Science, Institute of Fluid Science (High Speed Reacting Flow, IFS)	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. 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
<Cooperative Laboratories> Research Center for Green X-Tech, Green Goals Initiative （Space Infrastructure Engineering）	Professor Toshinori KUWAHARA	We engage in space development, utilization, and exploration. Our research topics are space infrastructure technologies, such as spacecraft system integration, on-orbit servicing, space robotics, and autonomous/cooperative control, ranging from fundamental research to orbital demonstrations. 1. Space infrastructure technologies, such as satellite, re-entry vehicle, orbital transfer vehicle, in-orbit servicing spacecraft, lunar and planetary exploration probes/rovers/robots, and crewed space systems. 2. Experimental and analytical research on orbit mechanics, attitude dynamics, motion estimation, GNC (guidance, navigation, and control), sensing, and manipulation technologies of spacecraft. 3. Autonomous/cooperative spacecraft control by artificial intelligence. 4. Research and development of spacecraft, in-orbit operation, and lunar/planetary/deep space exploration.
<Cooperative Laboratories> Complex Flow Research Division, Institute of Fluid Science (ComplexShockWave, 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 artodynamics
<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

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