Department of Mechanical Engineering

- Mechanical Systems Design
- Materials and Mnufacturing
- System Control and Robotics
- Environment and Energy

Materials and Structural Mechanics Laboratory

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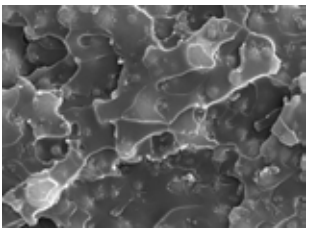
Laboratory URL	http://solid.me.tut.ac.jp/		
Key words	Material mechanics, material engineering, tribology, structural mechanics, surface engineering, impact engineering, friction, wear, biomechanics, mechanical properties of materials, ultrasonics		

The Materials and Structural Mechanics Laboratory studies, develops and designs materials and structures with functions appropriate for various purposes from the perspectives of material mechanics, material engineering and tribology through experimental and theoretical methods as well as numerical simulation. The study targets polymeric material, metallic material, ceramic material and their composite materials ranging from nano/micro-size to the large structures. The lab also designs and produces new measuring devices and develops software.

Theme 1 ▶ Mechanical properties of polymeric materials and polymeric composite materials

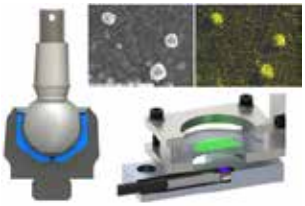
Polymeric materials and polymeric composite materials, which are lightweight and have excellent mechanical properties, are used in many machine structures and machine components. This study conducts mechanical assessments of polymeric material and polymeric composite material aiming at using them in machine structure. The laboratory also designs and develops materials to acquire more excellent mechanical properties. Specifically, the lab conducts the study on submicron/nano-sized particles as the reinforcing materials that affect mechanical properties, the influence of fiber distribution along with temperature dependence and time dependence, including impacts, of mechanical properties.



Fracture surface of an epoxy composite filled with nano silica particles

Theme 2 ▶ Tribology (Solid lubricants)

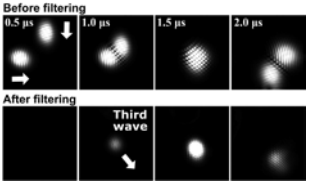
Oil or grease is generally used as a lubricant to reduce friction and wear of the sliding parts of machinery, but oil lubricators cannot be used to the parts that are utilized under harsh conditions of pressure, temperature and the like. In relation to this theme, this laboratory performs the study on the solid lubricants that are used under such conditions. Specifically, aiming at improving lubrication properties of various solid lubricants and reducing wear of the materials, the lab seeks to improve the lubrication properties of metallic composite oxide under high temperatures and understand the mechanism; clarifies the sliding mechanism of polymeric materials; and conducts experimental work on reduction of wear, etc.



Research on the lubrication mechanism of various applications

Theme 3 ▶ Nondestructive evaluation of plate structures by non-collinear mixing of Lamb waves

When two ultrasonic beams intersect each other, the third wave is generated due to the nonlinear interaction. This phenomenon is called the non-collinear mixing and has recently attracted much attention in the field of non-destructive testing for more sensitive evaluation of material soundness than the conventional testing techniques using the linear wave propagation behavior, such as the wave velocity and attenuation. The lab is trying to elucidate the non-collinear mixing of Lamb waves in plate structures by using the theoretical and numerical analysis as well as experiments in order to establish a new ultrasonic nondestructive testing which can sensitively detect the damage in plate structures including fatigue and plastic strain in its early stage.



FEM simulation of non-collinear mixing of Lamb waves

Machine Dynamics Laboratory

Staff	• Professor **Kawamura, Shozo** (E-mail：kawamura.shozo.qk@tut.jp) • Assistant Professor **Matsubara, Masami** (E-mail：matsubara.masami.od@tut.jp)
Laboratory URL	http://dynaweb.me.tut.ac.jp/
Key words	Vibration engineering, Dynamic analysis, Modeling, Structural health monitoring, Sports engineering, Human dynamics

The Machine Dynamics Laboratory conducts the study on modeling, analysis and design of artifacts, such as machinery/structures/equipments and human body movements based on vibration engineering.

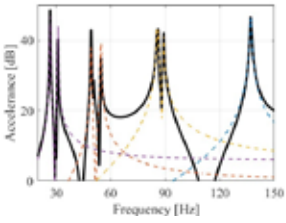
Evaluation of SHM
(three-layer structure)

Theme 1 ▶ Study on modeling, evaluation and diagnosis of machines and structures

This laboratory researches the modeling of bolted joints, the effect of shape machining on the modal parameters and the structural health monitoring (SHM) using strain data. Moreover, as the inverse analysis, the studies on identification of external force acting on the structures and random force of ground motion.

Theme 2 ▶ Study on dynamical design and experimental modal analysis

This laboratory designs the isolation equipment against the long period earthquake and wheel chair to get over the step stably. And this laboratory develops the new experimental modal analysis method which is called linear fit method, and the grouping method of similar vibration modes and the extraction method of vibration modes which behave like dynamic damper.



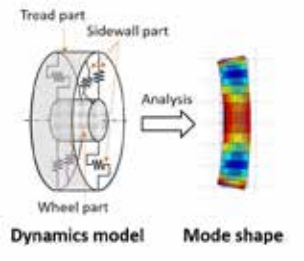
Comparison of the FRF based on modal analysis and representative mode analysis

Theme 3 ▶ Study on modeling of tires

Tire dynamics are of crucial importance for the dynamic behavior of the road vehicle. This laboratory researches modeling of cornering and vibration characteristics of tire. In particular, we are developing analytical method using three-dimensional elastic ring model. Furthermore, we are working on development of a measurement system for deformation of the tire tread block.

Theme 4 ▶ Study on damping material

T It is known that damping characteristics are improved by complexing fine particles in a viscoelastic material, but the relevant mechanism is unknown. In this study, to investigate the filler / matrix interface, an X-ray computer tomography image was obtained with a tensile load applied to the test piece, and the interface state was observed through image processing.



Three-dimensional elastic ring model for tire

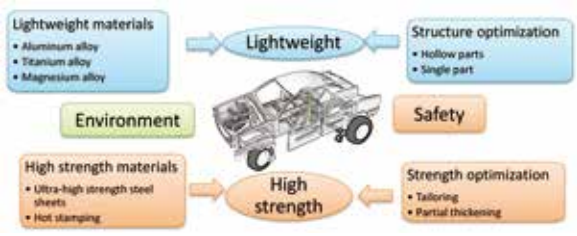
Theme 5 ▶ Study on sports engineering and human dynamics

This laboratory engages in analysis and design of sports equipment; identification of dynamic characteristics of sports surface, and running state analysis of human body considering sports surface. In addition, the lab carries out the study of inverse analysis of running motion and the study of effect of supports surface on running motion. And measuring techniques by using the wireless motion sensors are also developed.

Analysis of human body in running

Frontier Forming System Laboratory

Staff	• Project Professor **Mori, Ken-ichiro** (E-mail：mori@plast.me.tut.ac.jp) • Associate Professor **Abe, Yohei** (E-mail：abe@plast.me.tut.ac.jp)
Laboratory URL	http:// plast.me.tut.ac.jp/index.eng.html
Key words	Production processes, forming process, high strength steel sheets, cold stamping, hot stamping, forging, joining by plastic deformation



Aiming at safe and environmentally friendly automobiles, the Frontier Forming System Laboratory develops the production processes for forming and joining of lightweight structural parts made of lightweight materials, including high-strength steel, magnesium alloys, aluminum alloys and titanium alloys, as well as hollow parts, and optimizes the processes. This laboratory contributes to environment and safety through the production of lightweight automobiles.

Theme 1 ▶ Forming process of lightweight materials

(1) Hot stamping and die quenching of ultra-high strength steel parts; (2) Hot and warm shearing of ultra-high strength steel parts; (3) Cold stamping of ultra-high strength steel sheets; (4) Cold punching of hot-stamped sheet and evaluation of qualities of sheared edge; (5) Seizure prevention in ironing of stainless and high strength steel sheets

Hot stamping of ultra-high strength steel part

Theme 2 ▶ Joining of lightweight sheets

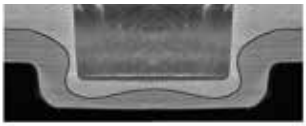
(1) Mechanical clinching and self-pierce riveting of high strength steel and aluminum alloy sheets; (2) Mechanical clinching of high strength steel sheets; (3) Hemming for joining of high strength steel sheets and assembling of hollow part; (4) Joining of nut with hot-stamped sheet by punching; (5) Joining of bolt with hot-stamped sheet by punching

Cold stamping of ultra-high strength steel sheet

Theme 3 ▶ Forming of lightweight structural parts

(1) Stamping of sheet metals using plastic tools made with 3D printer; (2) Plate forging of tailored blanks having partial thickening; (3) Lubricant containing nanoparticles for ironing; (4) Enhancement of stiffness and fatigue strength of products by local thickening; (5) Increase in formability by local work-hardening of blanks

Hemming for joining of high strength steel sheets and assembling of hollow part



Mechanical clinching of high strength steel and aluminum alloy sheets

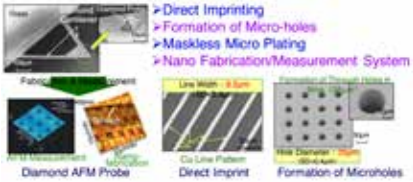
MEMS/NEMS Processing Laboratory

Staff	• Professor **Shibata, Takayuki** (E-mail：shibata@me.tut.ac.jp) • Associate Professor **Nagai, Moeto** (E-mail：nagai@me.tut.ac.jp)
Laboratory URL	http:// mems.me.tut.ac.jp/
Key words	Micro/nano fabrication, MEMS/NEMS, BioMEMS, Cell Processing, Bioactuator

In MEMS/NEMS Processing Laboratory, we study the basics and applications of Micro Electro Mechanical Systems (MEMS) that are produced by micro/nano fabrication. Our consistent concept is to “investigate MEMS technologies and create a bridge between MEMS and nano and biology.” We strive to develop the next-generation “basic technology for interdisciplinary fabrication” in micro/nano scale. The fundamental policies are free from process principles, processing targets, and parts. Application fields are the development of the MEMS devices/systems to support innovation in medicine and life science. Currently, our group focuses on the three projects.

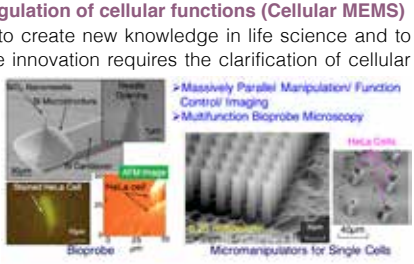
Theme 1 ▶ Micro/Nano-structure fabrication technologies

Novel and interdisciplinary fabrication technologies of micro/nano-structures are essential to create MEMS devices having innovative functions. Our group studies the development of original and advanced micro/nano-process technologies through creation of special tools based on the MEMS technologies. Especially, our research aim at the establishment of mass production technologies based on mask-less and vacuum-less methods, which are different from semiconductor manufacturing technologies.



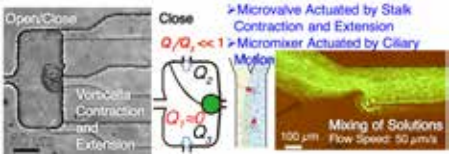
Theme 2 ▶ Lab-on-a-chip platforms for analysis and regulation of cellular functions (Cellular MEMS)

For the realization of a safe and secure life, it is critical to create new knowledge in life science and to facilitate the innovation in life science and medicine. Life innovation requires the clarification of cellular functions, where a cell is the basic unit of living organisms. We are developing various MEMS devices to perform massively parallel manipulation of single cells and analysis/control of cellular functions at the single cell-level. One example is a bioprobe consisting of a hollow nanoneedle and cantilever, which can be used for measuring multiple cellular functions.



Theme 3 ▶ Microorganism-based MEMS (Actuation technologies)

Microorganisms are sophisticated machines and expected to work in microsystems. We create microorganism-actuated MEMS by integrating the microstructure produced by microfabrication and microorganism actuators. Microorganisms work autonomously and do not require either an external power supply or a control circuit. These actuators are suitable for further downsizing and information processing of microsystems because they are small and work autonomously. We study the fabrication of useful microdevices using environment-responsive microorganisms, such as Vorticella, Volvox, and Euglena.



Materials Function Control Laboratory

Staff	• Professor **Todaka, Yoshikazu** (E-mail：todaka@me.tut.ac.jp) • Assistant Professor **Adachi, Nozomu** (E-mail：n-adachi@me.tut.ac.jp)
Laboratory URL	http://martens.me.tut.ac.jp/
Key words	micro-/nano- structure control, lattice defect, severe plastic deformation, alloy design, steel, metal

Through multi-scale microstructure control using deformation process and alloy design, we are studying for “properties and function improvement”, and “development of novel metallic materials”. In order to expand newly developed material to industrial world, we are also developing new process and improving conventional techniques.

Theme 1 ▶ Micro-/nano- structure control of steels

Steels are used most widely because it is possible to extensively create their properties through micro-/nano- structure control and alloy design. We investigate to high-functionalize steels by controlling heat/deformation history (optimizing phase transformation, precipitation behavior, etc.).

Theme 2 ▶ Creation of bulk nanostructured metals with high-density lattice defects by severe plastic deformation

Plastic deformation forms lattice defects, such as vacancy, dislocation and grain boundary, in metallic materials. Severe plastic deformation can endlessly introduce strains, and it is possible to prepare bulk nanostructured metals with high-density lattice defects. Bulk nanostructured metals show high-strength and high-ductility, as shown in Fig.1. We investigate to clarify the mechanism of high mechanical properties in the bulk nanostructured metals.

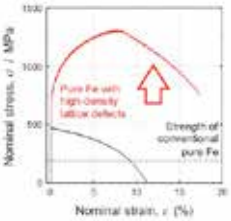


Fig.1 Mechanical property improvement in pure Fe via introduction of high-density lattice defects by severe plastic deformation (high-pressure torsion straining).

Concrete objectives:

(1) To achieve mechanically high-functionalization of general metallic materials through clarifying the role of high-density lattice defects for high-strength and high-ductility.
(2) To understand destruction phenomenon through clarifying the deformation mechanism of metallic glass (amorphous metals).
(3) To understand high-pressure phase stabilization behavior by means of lattice defect control.

Theme 3 ▶ Creation of surface nanostructured metals by severe plastic deformation

Physical and chemical properties of metallic materials largely depend on surface properties. Grain refining to nano-scale is effective to enhance the properties. We have succeeded to create high-grade surface nanostructured metals, as shown in Fig.2. We investigate to clarify the mechanism of excellent properties in the surface nanostructured metals. Moreover, we investigate to clarify the mechanism for formation of nanostructure by severe plastic deformation aiming at developing new processes.

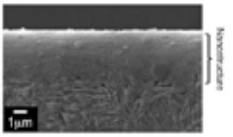


Fig.2 High-grade surface nanostructured SUJ2 bearing steel produced by severe plastic deformation (surface-nanostructured wearing).

Concrete objectives:

(1) To achieve friction coefficient control by using high reactivity of surface nanostructure (Fig.3).
(2) To achieve excellent rolling fatigue properties through clarifying the role of surface nanostructure.

Theme 4 ▶ Creation of thermoelectric materials

Thermoelectric materials, which can directly convert thermal energy into electrical energy (Seebeck effect), can be effectively used for the development of a clean and environmentally compatible power-generation technology. We seek highly efficient thermoelectric materials without toxic and/or expensive elements. Recently, we have successfully synthesized a new thermoelectric material, CaMgSi, by combining mechanical ball-milling and pulse current sintering processes.

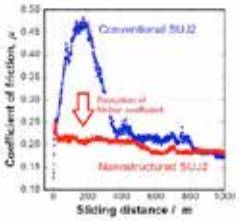


Fig.3 Stable tribological behavior with low friction coefficient during ball-on-disk test under Poly-α-Olefin oil in surface nanostructured SUJ2 steel disk.

Development and Evaluation of High Strength Materials Laboratory

Staff	• Professor	**Miura, Hiromi**	(E-mail：miura@me.tut.ac.jp)
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Laboratory URL	http://str.me.tut.ac.jp/		
Key words	Severe plastic deformation, high strength, microstructure control, dynamic recrystallization, high-temperature processing, biomaterial, bulk nanostructured metals		

Focusing on non-ferrous metal materials, the “Development and Evaluation of High Strength Materials Laboratory” develops materials with high strength and superior formability through thermomechanical treatments, etc., along with the techniques to evaluate deformation/fracture mechanisms and reliability.

Theme 1 ▶ Study on high-temperature processing and the issues relevant to light weight materials

Magnesium alloys are expected as the next-generation lightweight structural materials to replace aluminum alloys. However, because of low actual strength, their application to the structure members of automobiles, etc., has not been advanced yet. This laboratory seeks to strengthen and functionalize magnesium alloys by employing multi-directional forging, which is one of severe plastic deformation methods.

Fig. 1 Magnesium alloy parts (Theme 1)

Theme 2 ▶ Study on microstructure control and material-quality improvement through thermomechanical processing

For the purpose of improving the balance between higher strength and superior workability of metal-based mechanical materials, this laboratory works on microstructure control using “dynamic recrystallization”, which is a phenomenon taking place during the high-temperature processing. This causes significant improvements of processing productivity at high temperatures and balance between strength and formability at room temperature.

Theme 3 ▶ Study on the material evaluation using synchrotron radiation

This laboratory works on the development of the techniques necessary to evaluate three-dimensional deformation/fracture mechanisms of materials using synchrotron radiation at SPring-8, which is the world’s largest facility to generate synchrotron radiation. We have started this project using aluminum alloys.

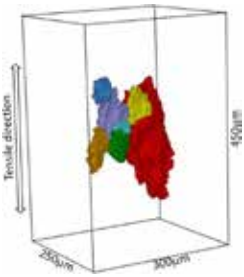


Fig. 2 3D grains obtained by synchrotron CT (Theme 3)

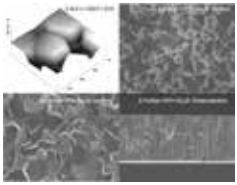
Thin Film Laboratory

Staff	• Professor **Izaki, Masanobu** (E-mail：m-izaki@me.tut.ac.jp) • Associate Professor **Yokoyama, Seiji** (E-mail：yokoyama@me.tut.ac.jp) • Assistant Professor **Sasano, Junji** (E-mail：sasano@me.tut.ac.jp)
Laboratory URL	http://tf.me.tut.ac.jp/index_e.html
Key words	Electrochemistry, oxide, organic, semiconductor, nano-structure, photovoltaic, electrochromic materials, waste treatment, composite materials

Thin Film Laboratory conducts the study and education concerning the science and technology to use effectively the energy and to reduce the carbon dioxide emission in material processing and to generate the sustainable energy by inorganic and organic photovoltaic devices. The lab also carries out the environment-related study, including recycling and reuse of wastes. Following research themes are carried out in Thin Film Laboratory.

Theme 1 ▶ Thermodynamic design of chemical solution process for smart oxide preparation

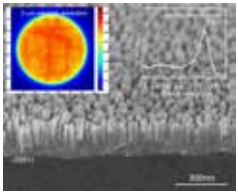
The electrochemical and chemical processes for preparing smart oxide layers with semiconducting and ferromagnetic characteristics have been developed based on thermodynamics and is an energy effective and environmentally friendly process. The process using hydroxide and proton generation reactions in aqueous solutions have been proposed for the direct preparation, and the preparation of semiconducting oxide layers of zinc oxide, indium oxide, cerium dioxide, titanium dioxide, tungsten oxide, tin dioxide, cupric oxide, and cuprous oxide, and ferromagnetic oxide layers of magnetite and Zn-ferrite have been demonstrated to approve the ability and applicability. (Image 1)



(Image 1)
ZnO, Cu_2O, and Ag_2O layers prepared by electrochemical reactions

Theme 2 ▶ Crystal growth and design for oxide and organic nanostructure fabrication

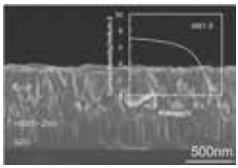
The nanostructure and quality of oxide semiconductor layers have been controlled by using the electrochemical heteroepitaxial growth. The <0001>-oriented ZnO vertical nanowire with a room temperature strong ultraviolet-light-emission has been prepared by the heteroepitaxial growth and has been operated as a high spatial resolution scintillator for industrial and medical applications. (Image 2) And, highly-oriented organic semiconductor layer has been prepared on inorganic single crystal substrate with gas-phase deposition technique.



(Image 2)
<0001>-oriented ZnO vertical nanowires and the resolution image of the scintillator

Theme 3 ▶ Sustainable energy generation by oxide photovoltaic devices from sunlight

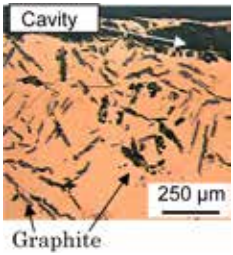
The next generation oxide photovoltaic device composed of n-zinc oxide and p-copper oxide of 2.1-eV-Cu_2O and 1.3-eV-CuO has been prepared by electrochemical process and realized world-class photovoltaic performance. (Image 3) The science and technology to enhance the performance for generating electricity from sunlight have been studied to realize high performance oxide photovoltaic device available to apply on earth based on solid state physics.



(Image 3)
Electrochemically constructed Cu_2O/ZnO photovoltaic device and the performance

Theme 4 ▶ Waste treatment and physical chemistry of materials

Slag and dust are generated from the smelting process of steel. They contain valuables as well as environmentally regulated substances. Collecting valuables from these substances makes it possible to use and reuse them as resources. This laboratory performs the fundamental study on their elution into a solution and applicability of slag to mortar. In addition, this laboratory performs preparation of graphite dispersed copper composite based on chemical thermodynamic study of copper – graphite system.(Image 4) This composite is expected to be used as a sliding contact. Furthermore, this laboratory performs the fundamental study of strengthening of iron by nitrogen.



(Image 4)
Graphite particles precipitated from carbon saturated molten copper.

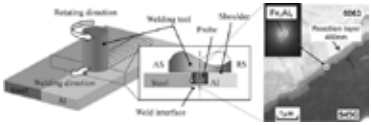
Interface and Surface Fabrication Laboratory

Staff	• Associate Professor **Yasui, Toshiaki** (E-mail：yasui@tut.jp) • Assistant Professor **Yamada, Motohiro** (E-mail：yamada@me.tut.ac.jp)
Laboratory URL	http:// isf.me.tut.ac.jp/
Key words	Dissimilar materials joining, Surface Modification, Friction Stir Welding (FSW), Cold Spray, Suspension Plasma Spray (SPS), Microwave Spraying, Plasma Electrolytic Oxidation (PEO)

Development of advanced joining process is the main objective of the laboratory research. It involves both advanced joining processes based on friction stir welding (FSW) for the bulk materials and advanced surface modification technologies, such as cold spray (CS), suspension plasma spray (SPS), microwave plasma spray, and plasma electrolytic oxidation (PEO).

Theme 1 ▶ Welding between dissimilar materials by friction stirring

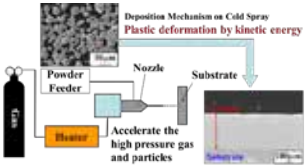
Friction stir welding (FSW) is non melting plastic flowing process instead of normal fusion welding should give a remarkable benefit and an infinite possibility to joining in dissimilar materials. The laboratory established the principle for FSW between aluminum and steel with high weld strength. This is attributed to the suppression of reaction layer growth in the weld interface by low heat input during welding. The laboratory aspires to expand the range of application as three-dimensional structure joints and dissimilar materials welding (aluminum/plastics, aluminum/ceramics) through clarifying the welding mechanism.



Dissimilar welding by FSW.

Theme 2 ▶ Cold spray

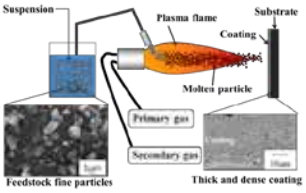
Cold spray is a solid particle deposition and thick and dense coating process. This process can avoid the thermal oxidation and phase transformation due to relatively lower heat input to the feedstock powder material. It realizes to fabricate high quality metallic coatings under atmospheric ambient. This laboratory mainly focuses on the fabrication of functional ceramic coatings by cold spray process and investigates the bonding mechanism of solid ceramic particles to the substrate.



Cold spray

Theme 3 ▶ Suspension spray process for functional coatings

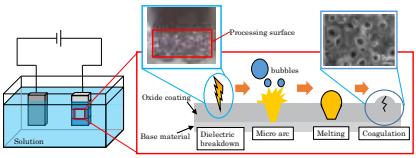
Conventional thermal spray coatings include pores and defects because of relatively larger size of particle deposition. In order to improve the density of the coatings, suspension spray process has an advantage. This process uses liquid feedstock which consists of sub-micrometric- or several micrometers of particles dispersed in a solvent. This laboratory investigates the influence of spray conditions to the coating microstructure and the properties.



Schematic images of suspension spray process.

Theme 4 ▶ Plasma electrolytic oxidation

Plasma electrolytic oxidation (PEO) is a kind of anodizing process with generation of small and minute spark discharge (micro-arc) on the anode. The coating gives excellent corrosion and wear protection properties to light metal. The laboratory investigate the coating formation mechanism by PEO and the control method by laser irradiation.



Plasma Electrolytic Oxidation (PEO)

Robotics and Mechatronics Laboratory

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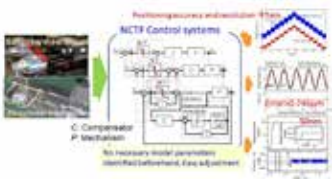
Laboratory URL	http://www.rm.me.tut.ac.jp/
Key words	Precision motion control, Manipulator, Precision robot, Learning, Actuator

Our research group aims to achieve practical and excellent mechatronics systems which have high operability, maintainability and high motion performance such as high precision and high-speed motion, for a wide variety of application fields and contribution to the convenience of the society.

Theme 1 ▶ Practical and Intuitive Controller Design for Precision Motion Systems

In order to provide high performance control systems independent of their nonlinear characteristics easily, practical control system design procedures for precision positioning and precision motion control have been proposed and evaluated experimentally. The proposed design procedures can be used without special knowledge of control theory, the information of the detailed characteristics and the model parameters prepared beforehand.



Practical control system design and its performance

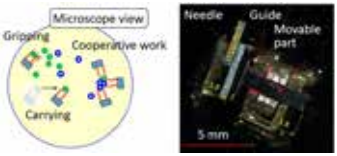
Theme 2 ▶ Precision robot for long-term stable operation

For making sustainable society amid the downward trend in the labor force population, robots are required to maintain and improve themselves, and they need to be useful over a long time without any problems. In addition, the robots need to provide high precision motion for fine and precise works. Our group has studied the precision robots and their element technologies in order to satisfy the above requirements.

Overview of testing robot

Theme 3 ▶ Micro-Manipulator with Wireless Actuators Using Lasers and Thermo-Sensitive Magnetic Material for Operating Microparts and Cells

Actuators comprising thermo-sensitive magnetic material (TSMM) parts and permanent magnets (PMs) and using laser beams, have simple structures and are free from wiring problems. These features are suitable for downsizing. Our research group studies their micro-actuators and a micro-manipulator system with them.



Works using micro-manipulator systems and a prototype of gripper unit

Theme 4 ▶ The design of the practical robot system and its control design.

Recently, the demand of the practical robots is increasing and they are studied actively at various places. This laboratory develops the human-operated and autonomous robot. In particular, the operational support control for the human-operated mobile robot and the localization and tracking control for the autonomous mobile robot.

Ionic polymer metal composite

Theme 5 ▶ Modeling and control of polymer actuators and the development of robot using polymer actuator.

As new actuator, the polymer actuators is focused. We study on the modeling and the control system of them. In particular, We aim at the realization of the self-sensing actuator by IPMC(Ionic Polymer Metal Composite) and the development the systems using the IPMC actuator.

Instrumentation Systems Laboratory

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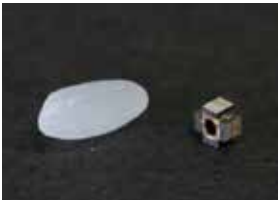
Key words	Signal processing, image processing, intellectual diagnosis, behavior measurement/ modeling, safe driving support, abnormality diagnosis, human interface

Theme 1 ▶ Micro Piezoelectric Sensors and Actuators

Piezoelectric ultrasonic actuators have two significant advantages, namely their high energy density and their simple structure, which both contribute to their miniaturization. We have proposed a micro ultrasonic actuator using a stator with a volume of approximately one cubic millimeter. This novel motor is now the smallest micro ultrasonic motor that has been developed with a practical torque in the world.There are diverse applications ranging from consumer products such as mobile phones and smart watches to medical products such as endovascular medicines and biological manipulations.



Micro ultrasonic actuator using a stator with a side length of 1 mm.

Theme 2 ▶ Minimally-invasive Medical Diagnosis Applications

The micro piezoelectric sensor and actuator technologies aim to be applied for minimally-invasive medical diagnosis and treatment devices. For example, micro actuators can control the orientation of the endoscopic camera with auto-focus and zoom mechanisms and the miniature robot arm driven by micro ultrasonic motors cut a tissue inside our body. We are developing the medical diagnosis devices using our original micromechanisms. Besides, we are starting a collaboration with medical devices companies for the practical applications.

Future medical endoscopic robot.

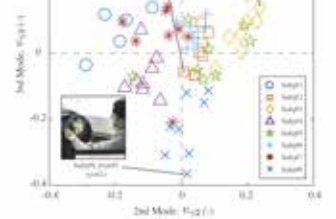
Theme 3 ▶ Soft Sensor for Measuring and Monitoring Driver State

Soft sensors are a method for estimating the response of state variables based on multivariable signals and machine learning technics. We are developing algorithms for measuring and monitoring the driver's state, such as driver's fatigue and drowsiness, which are difficult to measure directly, based on the soft sensor approach. Our approach also aims to detect and analyze for distracted driving behaviors by combining physiological and behavioral signals.

Overview of our safety driving system

Theme 4 ▶ Feature Extraction for Personal Identification

Human body movement in activities such as car driving, sport, and daily living includes components of both style and characteristics: style is defined as a common component to all subjects and characteristics is defined as a set of differences component to each subject. The goal of our research is to present a method of extracting these components features in human motions from sensor data for analyzing and evaluating human skills.



An example of feature space for classifying driver's individuality based on driving behavior

Systems Engineering Laboratory

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Laboratory URL	http://ise.me.tut.ac.jp		
Key words	Design, control and motion planning of industrial machines, Optimization, Production system, Scheduling, Supply chain management		

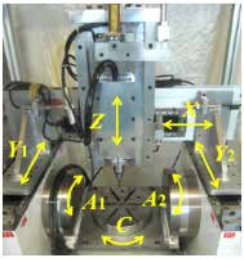
The Systems Engineering Laboratory deals with theoretical development of optimization, control, motion planning, and scheduling methods for industrial systems, and their application to industrial machinery and production systems. Current studies include the following themes:

Theme 1 ▶ Design and motion generation of industrial machinery and robotic systems based on optimization methods.

(1) Generation of energy-saving motion for machine tools/industrial robots (Figure 1);
(2) Precision control of industrial machinery using a two-dimensional pico-order sensor;
(3) Inspection system using a four-rotor helicopter (Figure 2);
(4) Conveyance robotic system by throwing and catching objects (Figure 3); and
(5) Design and control of mobile robots (wheel-type/walking-type) for industrial applications (Figure 4).

Theme 2 ▶ Study on support systems for decision-making in design/planning on manufacturing activities

(1) Multi-agent based simulation for supply chain optimization;
(2) Process planning, manufacturing execution systems;
(3) Integration of operation planning and scheduling (Figure 5);
(4) Production scheduling; and
(5) Planning support systems for nursing home



Energy-saving control for 5-axis machining (Fig. 1)


Multicopter for inspection of a wall surface (Fig. 2)


Robotic manipulator for catching a falling object (raw egg) (Fig. 3)


Robotic lawn mower (Fig. 4)


Optimization of cutting layout (Fig. 5)

Energy Conversion Engineering Laboratory

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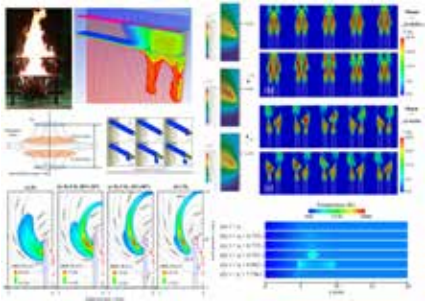
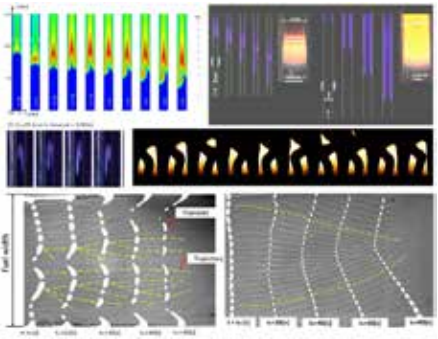
Key words	Combustion, Numerical modeling, Scale modeling, Fire safety, Reacting flow, Space		

Even today, combustion plays an important role in the world's energy systems and its control is of great importance from the two perspectives: one is to improve of energy conversion systems (e.g., engines of automobile, air plane, rocket etc.) and the other is to prevent natural disaster (fire). In terms of environmental hazard, it is noteworthy that the wildland fire causes enormous CO2 so that its prevention (control) provides huge impact to the global warming issue. The Energy Conversion Engineering Laboratory cultivates a deep insight into complicated combustion/fire phenomena to control the combustion/fire well then help to renovate/upgrade an environmental-friendly, yet secured and safe society. To cover the wide range of scale (time and space) featured in reactive-flow system, introducing the "scale modeling concept" is one of key ad unique strategies in our lab. Here are example research topics supervised in our lab.

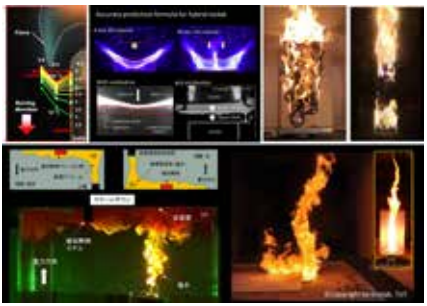
Theme 1 ▶ Numerical modeling



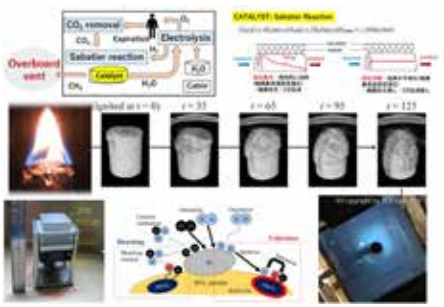
Theme 2 ▶ Combustion instability



Theme 3 ▶ Fire safety (Scale modeling researches)



Theme 4 ▶ Visualization / Novel measurement technique



Thermo-Fluid Engineering Laboratory

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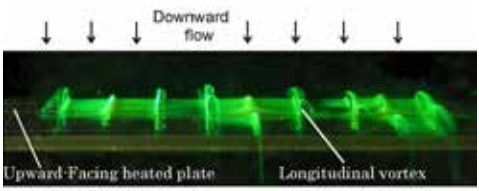
Key words	Convective heat transfer, visualization of flow and temperature fields, heat transfer performance, liquid atomization, spray characteristics, thermo-fluid analysis, computational fluid dynamics

The Thermo-Fluid-Engineering Laboratory implements the research and development of heat transfer equipment and fluid devices that enable environment-friendly and high-efficiency energy conversion and transport. To tackle a variety of thermo-fluid problems that encountered in environment and industrial equipment, we first investigate the mechanisms of heat and fluid transport through measurements and computations, and, then, clarify the parameters that govern the transportation of heat and fluid.

Theme 1 ▶ Development of visualization techniques of flow and temperature fields and evaluation of heat transfer performance

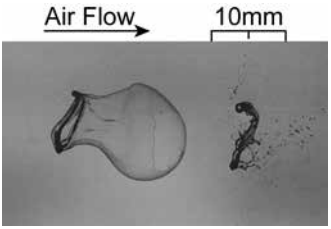
This laboratory develops various techniques to visualize flow and temperature fields encountered in heat transfer equipment and devices. The techniques differ from fluid to fluid and also depend on the objective of visualization. In light of the visualization, we subsequently assess the heat transfer performance.



Longitudinal vortices over heated plate

Theme 2 ▶ Investigation of liquid atomization process and measurement of spray characteristics

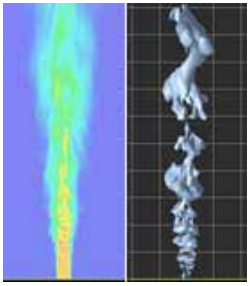
The laboratory investigates the mechanism of liquid atomization through visualizing basic atomization processes, such as droplet breakup and liquid column breakup, with use of high-speed video camera and flash photography. The lab develops the measuring system of spray characteristics and evaluates the performances of pressure-type atomizer, twin-fluid atomizer, rotary atomization device, etc.



Deformation and breakup of droplets in air-flow

Theme 3 ▶ Development and application of numerical computations for various problems concerned with heat and momentum transfer

The laboratory develops numerical models to simulate the flow/temperature fields encountered in various industrial equipment and devices. The effort is also paid to develop techniques that enable fast and efficient numerical computations applicable to the specific thermos-fluid problems.



Numerical analysis on mixing process of jet flow

Natural Energy Conversion Science Laboratory

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Laboratory URL	http://aero.me.tut.ac.jp (Iida group) http://wind.me.tut.ac.jp (Sekishita group)		
Key words	Aerodynamics, Turbulent flow, Aeroacoustics, Diffusion, Control of flow, Wind tunnel experiment, Fluid measurement, Computational fluid dynamics, Wind turbines, Musical instruments, Fluid-acoustic interactions, Automobile		

Most of the flows in the natural world and industrial products are turbulent flows. Therefore, it is necessary to clarify the characteristics of turbulent flows and examine the control method in order to develop efficient fluid machine and to predict and control pollutant diffusion. The Natural Energy Conversion Science Laboratory seeks to clarify the turbulent flow phenomenon and conducts the study on its control.

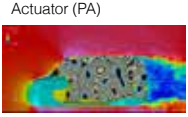
Theme 1 ▶ Technology for aeroacoustic analysis
With the aim of clarifying the generation mechanism of aerodynamic noise, which is an issue associated with fluid-related machines and high-speed vehicles, this laboratory carries out the development of measurement technologies of flows and noise as well as the study on the reduction of aerodynamic noise through controlling flows. These include hot-wire anemometer, PSP, PIV, and smoke-wire visualization. The control methods include Plasma Actuators and blowing jets.


Experimental setup of Pressure Sensitive Paint (PSP)

Theme 2 ▶ Large-scale computational technique for aerodynamic analysis
The laboratory performs coupled analysis of flows, noise, heat and vibration using the large-scale computational analysis technique. This analysis clarifies the microscopic fluid structures or characteristics of flows under special conditions, which cannot be easily observed by experiments, and seeks to develop a new technology based on that knowledge.


Flow control by Plasma Actuator (PA)

Theme 3 ▶ Natural energy-related study
This laboratory implements the study on natural energy/waste heat recovery relating to wind power generation system, thermoacoustic refrigeration system, etc.


Predicted results of interior noise of automobile

Theme 4 ▶ Study on micro-/bio fluid
The laboratory conducts the study on measurement and engineering applications of flows in the natural environment, such as flying of insects and swimming of fish.

Theme 5 ▶ Wind tunnel experiment on thermal/substance diffusion in large-scale turbulent flows
This laboratory conducts the wind tunnel experiment on diffusion of heat/substance emitted from chimneys, thermal/wind environment in the cities and blown sand on sand dunes, etc.

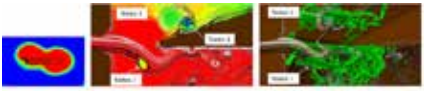

Predicted flow fields around wind turbine

Theme 6 ▶ Wind tunnel experiment on aerodynamics of racing bicycles
This laboratory conducts various experiments on wireless helicopters in addition to the product development focusing on resistance phenomenon of bicycles.

Theme 7 ▶ Musical instruments
To clarify the mechanism of acoustic radiation and propagation around musical instruments such as air-reed instruments and reed instruments, direct simulations of flow and acoustic fields and experiments by using PIV are performed.


Flow visualization of heated and unheated


Large-scale turbulent flow generator


Predicted flow and acoustic fields in musical instrument

Energy Conservation Engineering Laboratory

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Laboratory URL	http://ec.me.tut.ac.jp/index_en.html		
Key words	Liquid Purification, Resource Saving, Electrohydrodynamics, Fluid Power, Rotating Fluid Machinery, Acoustic Energy, Thermoacoustic Phenomena, Two-phase Heat Transfer		

The Energy Conservation Engineering Laboratory performs the study on energy saving and resource saving including environmental load reduction by reusing lubricating oil, enhancement of performance for fluid machinery with low noise and thermoacoustic device and development of heat transport devices using capillary force.

Theme 1 ▶ Development of high-performance lubricating oil purification system

The laboratory carries out the development of a high-speed electrostatic filter with the aim of removing minute contaminants from lubricating oils, which cause machine failure.

Theme 2 ▶ Basics and applications of electrohydrodynamics (EHD) flow

This laboratory seeks to clarify the fundamental principle of EHD flow and develops efficient pumps without impeller, actuators and heat control equipment.

Theme 3 ▶ Friction characteristics of fluid power actuators

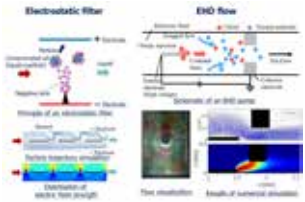
The laboratory proposes a new mathematical model allowing for the dynamic characteristics of lubricating film and seeks to improve prediction accuracy of fluid power actuator motions.

Theme 4 ▶ Phenomena related with fluid, sound and energy

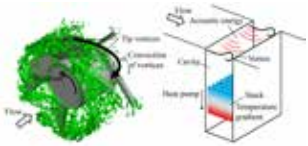
To achieve both the high performance and noise reduction for fluid machinery and high-speed transport vehicles, flow and acoustic fields need to be clarified. To do this, wind tunnel experiments and large-scale computations are performed for the flow around an axial-flow fan and cavity flow. The flow control such as a plasma actuator is also conducted for reduction of energy loss and aerodynamic noise. Also, to utilize the acoustic energy, thermoacoustic phenomena including conversion between heat and sound energy are also researched.

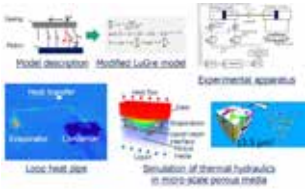
Theme 5 ▶ Clarification of liquid-vapor phase-change phenomenon within porous media in loop heat pipe evaporator

This laboratory performs three-dimensional simulation and visualization experiments with a view to clarifying the heat transfer mechanism and unstable phenomenon in loop heat pipes that can transfer heat over a long distance without electric power.



Study on lubricating oil purification and EHD


Predicted vortices around fan (left) and thermoacoustic heat pump in cavity flow (right)



Study on dynamic behavior of friction and loop heat pipes