Department of Mechanical Engineering

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

Materials and Structural Mechanics Laboratory

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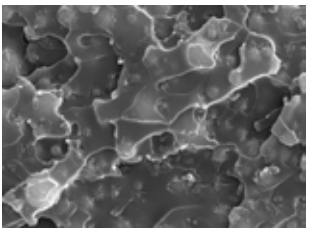
Laboratory URL	http://solid.me.tut.ac.jp/
Key words	Material mechanics, material engineering, tribology, structural mechanics, surface engineering, impact engineering, friction, abrasion, biomechanics, mechanical properties of materials, ultrasonics

The Materials and Structural Mechanics Laboratory studies, develops and designs materials and structures with functions appropriate for various purposes both 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

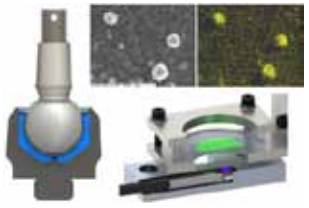
Polymeric materials and polymeric composite materials, which are lightweight and have excellent mechanical properties, are used in many machine structures and machine components. This study conducts mechanical assessments of polymeric material and polymeric composite material aiming at using them in 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)

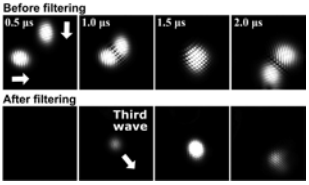
Oil or grease is generally used as a lubricant to reduce friction and abrasion of the sliding parts of machinery, but oil lubricators cannot be used to the parts that are utilized under harsh conditions of pressure, temperature and the like. In relation to this theme, this laboratory performs the study on the solid lubricants that are used under such conditions. Specifically, aiming at improving lubrication properties of various solid lubricants and reducing abrasion loss 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 abrasion loss, 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	**Shozo KAWAMURA**	(E-mail：kawamura@me.tut.ac.jp)
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Key words	Vibration engineering, dynamic analysis, modeling, structural health monitoring, rotor dynamics, sports engineering, human dynamics

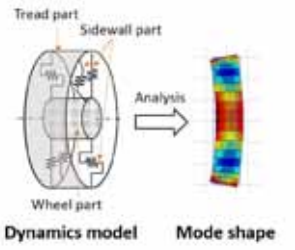
The Machine Dynamics Laboratory conducts the study on modeling, analysis and design of artifacts, such as machinery/structures/equipments, and body movements based on vibration engineering.

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

This laboratory develops the new experimental modal analysis method and transfer pass analysis technique, and identifies the acting external force to the structure and material properties of the structure. Moreover, the lab carries out the study on the structural health monitoring; the active monitoring using frequency modulation and the diagnosis using the strain data of the structures.

Theme 2 ▶ Study on modeling of dynamic characteristics

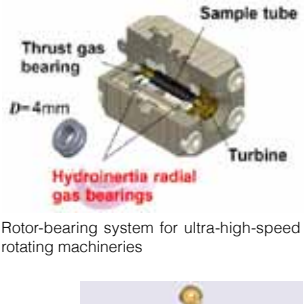
Complex physically based models such as FE models are better-suited to examining the effects of changing physical parameters such as the material stiffness and details of tire structure, facilitating analysis of vibration behavior in detail. It is necessary to have details of tire structure and material parameters available when building an FE model; however, this information is generally secret. Thus, this laboratory develops simplified dynamics models of machinery/structures, and analyzes vibration behavior based on analytical dynamics and mechanics of material. Especially, we do research on tire dynamics and structures including bolted joints.



Three-dimensional flexible ring-based model for the tire

Theme 3 ▶ Study on rotor vibration generated in fluid bearings

This laboratory researches rotor vibration generated in fluid bearings. Damping characteristics of fluid bearings for ultra-high-speed rotating machineries have been verified by using numerical analysis and experiments. Novel fluid bearings have been developed to support large unbalanced rotor and methods of vibration reduction is studied.



Rotor-bearing system for ultra-high-speed rotating machineries

Theme 4 ▶ 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 the human body taking into account sports surface. In addition, the lab carries out the study on measuring techniques by using the wireless motion sensors, etc.

Analysis of landing reaction force using musculo-skeletal model

Frontier Forming System Laboratory

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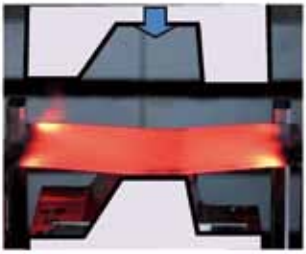
Laboratory URL	http:// plast.me.tut.ac.jp/index.eng.html
Key words	Production processes, forming process, high strength steel sheets, cold stamping, hot stamping, forging, joining by plastic deformation

Aiming at developing 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 and high-strength 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) Seizure prevention in ironing of stainless and high strength steel sheets; (5) Cold punching of hot-stamped sheet; (6) Hot stamping of titanium alloy and aluminum alloy sheets using resistance heating



Hot stamping of ultra-high strength steel part

Theme 2 ▶ Joining of lightweight sheets

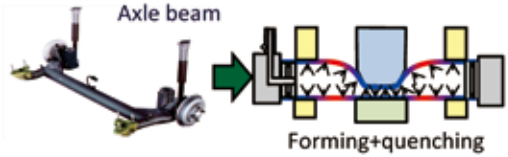
(1) Mechanical clinching and self-pierce riveting of high strength steel and aluminum alloy sheets; (2) Mechanical clinching of high strength steel sheets; (3) Hemming for joining of high strength steel sheets; (4) Joining of nut with hot-stamped sheet by punching

Cold stamping of ultra-high strength steel sheet

Theme 3 ▶ Forming of lightweight structural parts

(1) Gas forming of aluminum alloy and ultra-high strength steel tubes using resistance heating; (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; (6) Plate forging of plates using automatic re-lubrication by load pulsation; (7) Cold forging of cup with internal spline by controlling of elastic deformation of dies

Mechanical clinching of high strength steel and aluminum alloy sheets



Gas forming of ultra-high strength steel hollow parts

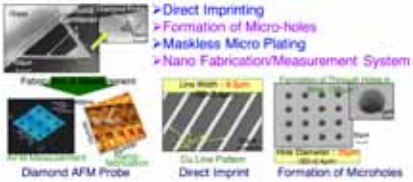
MEMS/NEMS Processing Laboratory

Staff	• Professor **Takayuki SHIBATA** (E-mail : shibata@me.tut.ac.jp) • Lecturer **Moeto NAGAI** (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.

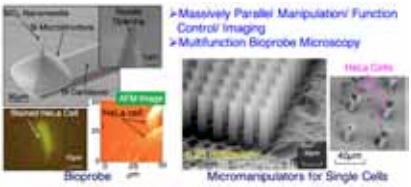
Theme 1 ▶ Micro/Nano-structure fabrication technologies

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.



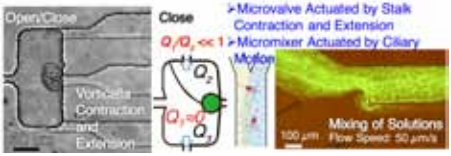
Theme 2 ▶ On-chip cellular function analysis systems (Cellular MEMS)

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. We bioprobe integrated with a hollow nanoneedle for novel AFM applications in cellular function analysis.



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 **Yoshikazu TODAKA** (E-mail : todaka@me.tut.ac.jp)
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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.

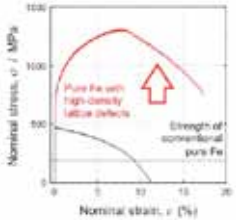

Fig.1 Mechanical property improvement in pure Fe via introduction of high-density lattice defects by severe plastic deformation (high-pressure torsion straining).

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.

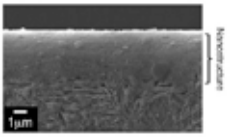

Fig.2 High-grade surface nanostructured SUJ2 bearing steel produced by severe plastic deformation (surface-nanostructured wearing).

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.

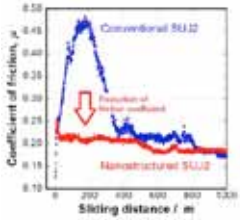

Fig.3 Stable tribological behavior with low friction coefficient during ball-on-disk test under Poly-α-Olefin oil in surface nanostructured SUJ2 steel disk.

Development and Evaluation of High Strength Materials Laboratory

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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.

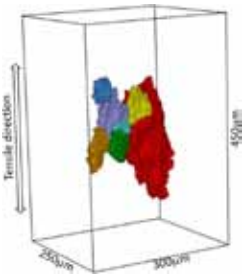


Fig. 2 3D grains obtained by synchrotron CT (Theme 3)

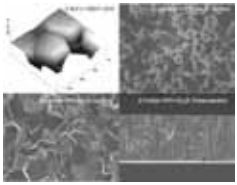
Thin Film Laboratory

Staff	• Professor **Masanobu IZAKI** (E-mail：m-izaki@me.tut.ac.jp) • Associate Professor **Seiji YOKOYAMA** (E-mail：yokoyama@me.tut.ac.jp) • Assistant Professor **Junji SASANO** (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

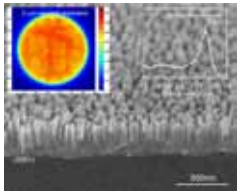
The electrochemical and chemical processes for preparing smart oxide layers with semiconducting and ferromagnetic characteristics have been developed based on thermodynamics and is an energy effective and environmentally friendly process. The process using hydroxide and proton generation reactions in 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

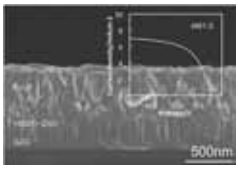
The nanostructure and quality of oxide semiconductor layers have been controlled by using the electrochemical heteroepitaxial growth. The <0001>-oriented ZnO vertical nanowire with a room temperature strong ultraviolet-light-emission has been prepared by the heteroepitaxial growth and has been operated 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

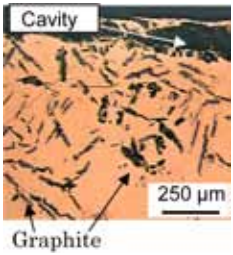
The next generation oxide photovoltaic device composed of n-zinc oxide and p-copper oxide of 2.1-eV-Cu_2O and 1.3-eV-CuO has been prepared by electrochemical process and realized world-class photovoltaic performance. (Image 3) The science and technology to enhance the performance for generating electricity 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	• Professor	**Masahiro FUKUMOTO**	(E-mail：fukumoto@tut.jp)
	• Associate Professor	**Toshiaki YASUI**	(E-mail：yasui@tut.jp)
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Laboratory URL	http:// isf.me.tut.ac.jp/		
Key words	Dissimilar materials joining, Surface Modification, Thermal Spray, Cold Spray, Aero-sol Deposition, Suspension Plasma Spray, Microwave Spraying, Friction Stir Welding		

Development of advanced joining process is the main objective of the laboratory research. It involves both advanced surface modification technologies and advanced joining processes for the bulk materials. Thermal spray, cold spray and aero-sol deposition are the main in the surface modification process for the materials. A common feature in these three processes is a thick coating formation with Particles Deposition, PD. Coating formation mechanism in the PD process is the current main interest. Friction Stir Welding, on the other hand, is the main in the bulk joining. Non melting plastic flowing process instead of normal fusion welding should give a remarkable benefit and an infinite possibility to the future welding or joining process field. Joining in dissimilar materials by friction stirring is the main interest in this theme.

Theme 1 ▶ Control of thermal spray process by analysis of flattening behavior of single splat

In order to establish the controllability of the thermal spray process and to obtain the desired coating properties, the flattening behavior of an individual particle on the flat substrate surface has been fundamentally investigated. Especially, flattening behavior of the single particle plasma sprayed onto the flat substrate surface was systematically investigated by changing the substrate temperature, and transition phenomenon from a splashing splat to a disk splat in the flattening pattern for each particle material was identified. Moreover, similar transition behavior in a flattening related to changing the ambient pressure has been recognized. Both transition temperature, Tt, and transition pressure, Pt, have been defined and proposed as a controlling principle for the practical coating formation (Fig. 1).

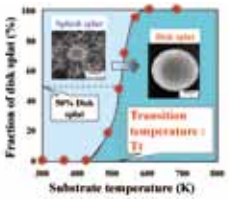

Fig. 1 Dependence of splat shape on substrate temperature and definition of the Transition temperature, Tt.

Theme 2 ▶ Welding between dissimilar materials by friction stirring

Energy saving of transportation vehicles by weight reduction demands the assembling multi-material body by means of dissimilar materials welding. Friction stir welding (FSW) is a solid state welding technique which is highly effective for aluminum welding. The laboratory established the principle for friction stir welding between aluminum and steel with high weld strength (Fig.2). 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.

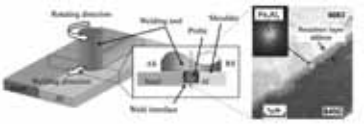

Fig. 2 Friction stir welding between aluminum and steel.

Theme 3 ▶ Suspension spray process for functional coatings

Conventional thermal spray process has been developed to form thick coatings. However, the thermal spray coatings includes pores and defects because of the several tens micrometers 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 nanometric particles dispersed in a solvent. This laboratory investigates the effect of spray conditions to the coating microstructure and the properties. Especially, the optical and the electrical properties of the coatings are investigated to fabricate functional ceramic coatings with dense structure.

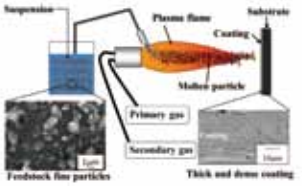

Fig. 3 Schematic images of suspension spray process.

Robotics and Mechatronics Laboratory

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Laboratory URL	http://www.rm.me.tut.ac.jp
Key words	Robotics, Mechatronics, actuator, control, system identification

Recently, various robots have been developed by sensors, actuators and computers that are cheap and high performance. Therefore, the importance to make the useful model to design the control system and to simulate the mechanical system. to design the control system makes a model of a useful control target to such high control system is also rising with that. From such background, the Robotics and Mechatronics Laboratory conducts the study on mechanism, measurement technique, actuator and control aiming at enhancing accuracy and functions of robot system and its underlying technology in addition to mechatronics systems.

Theme 1 ▶ 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.

electrical wheel chair

Theme 2 ▶ 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.

Ionic polymer metal composite

Theme 3 ▶ Experimental design for the system identification

For the control design, it is important to make a good model. To identify the model parameter exactly, it is necessary to use data which are less affected by the disturbance or modelling uncertainty. We have proposed that it is important to evaluate the upper bound of the parameter estimation error when the disturbance and the unstructured model uncertainty exist. Basing on this idea, we research that what kind of signal is suitable to identify a model from the prior information obtained about identified object.

System and Control Engineering Laboratory

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Laboratory URL	http://www.syscon.me.tut.ac.jp		
Key words	System control engineering, robotics, mechatronics, man machine interface, industrial robot, medical and welfare robot, vibration control, tele operation control, power assist control, next-generation personal vehicle		

Aiming at changing industry, society and welfare through “System control”, the Systems and Control Engineering Laboratory carries out the study on control and robots for advanced manufacturing as well as for medical and welfare assistance. With a view to developing the control technology to enrich the super-aging society, this laboratory works on the “control and robot development to save people and society” based on the “system control design theory”. The common key words for the research development are “Motion control”, “Omni-directional mobile mechanism”, and “Assist control”.

Theme 1 ▶ Development of the vibration control system

The laboratory develops the high-speed vibration and transfer control technology of the transfer systems, such as crane. The lab proposes the hybrid shaped approach to design control systems allowing for time and frequency specifications in addition to the design methods for reference governor that enables transfer with quick vibration control in consideration of equipment constraints. Furthermore, this laboratory develops vibration control joy stick, with which even a novice can convey a load without vibration by incorporating the digital filter to suppress excitation of natural vibration.

Theme 2 ▶ Manufacturing support and liquid process control

This laboratory promotes the development of automation process control technology to secure safe work environment for humans. The lab engages in the development of self-propelled liquid transferring robot and sand mold press casting method as the automatic control technology for foundry process, which usually takes place under harsh conditions. The laboratory seeks to construct the control technology that affects the manufacturing process of medicines and foods that handle liquid as well as the technology for next-generation service robots.

Theme 3 ▶ Development of tele-control system

With the aim of supporting home care and rehabilitation, the laboratory engages in the development of the systems for remote care/upper limb rehabilitation using the tele-control technology. The lab realized the tele-control system, which allows for interactive communication via the Internet and motion compensation for communication delay/loss. In addition, the laboratory carries out the verification experiment on remote communication in Japan as well as between Japan, Europe and America.

Theme 4 ▶ Development of the technology for nursing care and rehabilitation assistance

This laboratory works on the development of the power assist technology to carry a load just by lightly holding it using the overhead crane. Moreover, based on the power assist technology, the lab implements development of nursing-care robot and walking robot for rehabilitation to assist transfer.

Theme 5 ▶ Development of next-generation personal vehicle

This laboratory works on the development of personal vehicle, which provides four-wheel omni-directional movement and can surmount difference in level based on the proposal of new-style driving mechanism (Differential Drive Steering System (DDSS)) so that anyone can move comfortably at any time and at any place. In addition, the lab engages in the development of two-wheeled vehicle with the excellent ability of rotation to realize safe and stable driving based on lower gravity design and posture control system. The laboratory also carries out the development of joy stick to assist obstacle avoidance in addition to power assist technology for helpers.

Innovative system control and robot technology researches

Instrumentation Systems Laboratory

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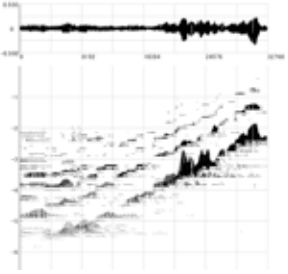
Key words	Signal processing, image processing, intellectual diagnosis, behavior measurement/ modeling, safe driving support, abnormality diagnosis, human interface

Focusing on the technologies for signal/image processing, the Instrumentation Systems Laboratory engages in the study and development of instrumentation, assessment, tracking, prediction, diagnosis and modeling technologies of intellectual state based on measurement engineering and intellectual systems engineering.

Theme 1 ▶ Construction and application of the theory on wavelet transforms

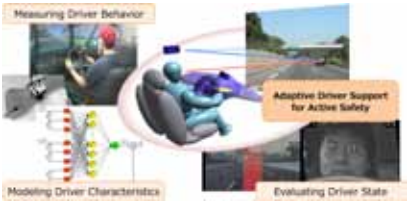
This laboratory seeks to construct a theory for faster and higher-precision wavelet transform, which is one of the time-frequency analysis methods, and to promote development of industrial testing technique using signal processing, such as image, voice and vibration. Based on them, the lab aims to develop unpretendingly innovative signal processing (noise reduction and specific signal extraction).



(1) Construction and application of the theory on discrete wavelet transforms based on the perfect translation invariance theorems
(2) Construction and application of the theory on Variable band filter discrete wavelet transforms
(3) Application to abnormality diagnosis/extraction in image processing/biosignal processing
(4) Application to real time signal processing systems

Theme 2 ▶ Development of the active safety support system for automobile driving

With a view to eliminating car accidents, the laboratory aims at developing the technology and the methods to early detect drivers' behaviors that are the underlying causes for accidents.



(1) Instrumentation of notice action using image processing technology
(2) Estimation of sleep-onset time based on the change in facial expression
(3) Estimation of driver's intention
(4) Development of non-invasive/contact-type biosensor combined with driving operation device

Theme 3 ▶ Development of human interface technology

Using gaze direction and notice action, the laboratory develops gaze interface to support operation of household device; and hands-free voice interface based on the localization of sound source and noise-isolation technology.

(1) Gaze interface for environmental control device
(2) Voice processing, including sound source localization and sound source isolation
(3) Development of new interface through integration of image and voice

Theme 4 ▶ Development of intellectual diagnosis processing and modeling technology

This laboratory aims to construct a design theory on Deep learning and to apply this theory to classification-related issues as well as mechanical modeling; and conducts the study on intellectual diagnosis mechanism, including dynamic relational network, support vector machine and self-organization maps.
Based on them, the lab implements research on extraction of motion characteristics using orbit attractor; the mathematical modeling method focusing on human sensory information, such as perception; and application to virtual reality.

(1) Extraction of motion characteristics using orbit attractor
(2) Development of the mathematical modeling methods relating to human sensory information, such as perception
(3) Application of virtual reality in bio-behavioral instrumentation

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

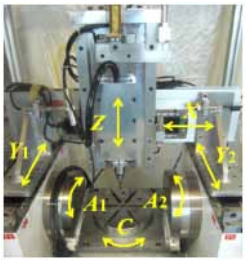
The Systems Engineering Laboratory deals with theoretical development of optimization, control, motion planning, and scheduling methods for industrial systems, and their application to industrial machinery and production systems. Current studies include the following themes:

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

Staff	• Associate Professor **Yuji NAKAMURA** (E-mail：yuji@me.tut.ac.jp) • Assistant Professor **Tsuneyoshi MATSUOKA** (E-mail：matsuoka@me.tut.ac.jp)
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Key words	Combustion, fire, reacting flow, modeling, numerical analysis, scale modeling

Fire (combustion) is a symbol of civilization that Prometheus handed to human beings by disobeying the Zeus' order. (As a result, Prometheus was severely punished.) Thanks to this special gift from god, our lives were dramatically improved; it is well-known that the industrial revolution via energy conversion had largely contributed to our civilized lifestyle. On the other hand, it brings another concerns about environmental destruction and disasters due to ferocity triggered by combustion products and fire-related disaster (explosion, urban fire etc). We, human beings, are responsible for the wise use of "fire", a gift from Prometheus, and control of disasters. 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. Concretely, our laboratory performs the researches on the fundamental combustion and fire phenomena ranging from micro to macro scale. They include micro combustion; combustion-caused instability and pure oxygen combustion that serves as a basis for typical energy-conversion system (e.g., burner, engine, rockets). Various other issues have been also examined including energy career (infrastructure); global warming; massive fire and fire in space (low-gravity, low-pressure).

Theme 1 ▶ Fire safety in space

Burning behavior and limit of substances in a microgravity environment, such as a space station, is different from that on the earth. With a view to reducing the danger of fire in such an environment, our laboratory studies and clarifies the methodology to predict a firing criterion in the microgravity field by the flammability data obtained on the ground.

(Left) Microgravity experiment by parabolic flight. (Right) Flammability limit of plastic of various thickness, upper; under normal gravity, lower; under microgravity.

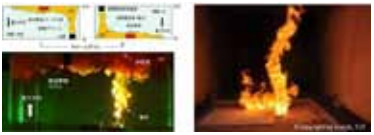
Theme 2 ▶ Micro-scale combustion (microflame technology)

Since the energy density of flames is 100 times larger than that of electricity, it is expected that combustion is applied to a power source of mobile devise. It is generally considered difficult to achieve the stable combustion in small scale, but we found that there are certain conditions under which combustion is promoted assisted by utilizing the scale effect. our laboratory performs the fundamental study on the microflame technology aiming at developing microenergy devices leveraging this technology.

A small flame established over microburner, so-called "microflame".

Theme 3 ▶ Scale modeling researches

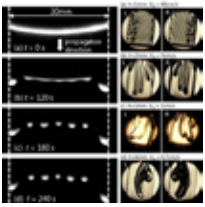
When one needs to study large-scale phenomenon (prototype), like massive fire, in the laboratory, it is quite demanded to "reproduce" the phenomenon at the laboratory-scale (scale model). Scaling law is the one to hold the acceptable static and dynamic similarity between phenomena in different scales and environment. Our laboratory devote how to find/propose the proper scaling law in various ways, then, perform the scale model experiment to understand the real-scale phenomena. This concept is useful not limited to the massive fire but any other phenomena, likely, fire in space, reproduction of accidental automobile collision.



(Left) Salt water experiment reproducing the high-temperature plume flow of the exposure fire. (Rigt) Fire whirl experiment performed in large wind tunnel.

Theme 4 ▶ Combustion in pure oxygen

Since burning a solid in pure oxygen produces enormous energy, it often be used for thrust of hybrid rockets. On the other hand, unusual phenomena occur when using pure oxygen. Below is the separation of flame (fingering) burning on the thick plastics, which was discovered in our laboratory. We seeks to clarify such newly-found phenomena through conducting experiments and analysis and using the theories.



Fignering behavior found for thick thermoplastic.

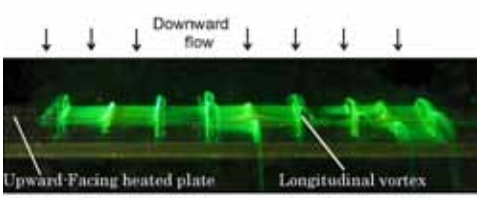
Thermo-Fluid Engineering Laboratory

Staff	• Associate Professor **Takashi SUZUKI** (E-mail：takashi@me.tut.ac.jp) • Assistant Professor **Akihiko MITSUISHI** (E-mail：mituisi@me.tut.ac.jp)
Laboratory URL	http://www.me.tut.ac.jp/~takashi/
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

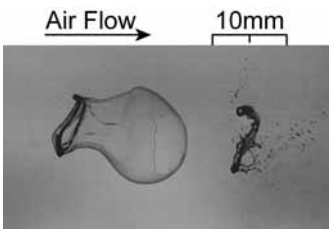
This laboratory develops various techniques to visualize flow and temperature fields encountered in heat transfer equipment and devices. The techniques differ from fluid to fluid and also depend on the objective of visualization. In light of the visualization, we subsequently assess the heat transfer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



Longitudinal vortices over heated plate

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

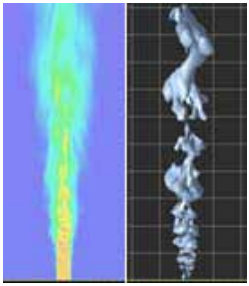
The laboratory investigates the mechanism of liquid atomization through visualizing basic atomization processes, such as droplet breakup and liquid column breakup, with use of high-speed video camera and flash photography. The lab develops the measuring system of spray characteristics and evaluates the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



Numerical analysis on mixing process of jet 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.



Deformation and breakup of droplets in air-flow

Natural Energy Conversion Science Laboratory

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	• Assistant Professor	**Hiroshi YOKOYAMA**	(E-mail：h-yokoyama@me.tut.ac.jp)
Laboratory URL	http://aero.me.tut.ac.jp (Iida and Yokoyama 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.

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.


Predicted results of interior noise of automobile

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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	• Professor	**Hideki YANADA**	(E-mail : yanada@me.tut.ac.jp)
	• Assistant Professor	**Masahito NISHIKAWARA**	(E-mail : nishikawara@me.tut.ac.jp)
	• Assistant Professor	**Yosuke KAWAMURA**	(E-mail : y-kawamura@me.tut.ac.jp)
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Key words	Two-phase flow, supersonic, heat transfer enhancement, liquid purification, resource saving, electrohydrodynamics, friction model

The Energy Conservation Engineering Laboratory performs the study on energy saving and resource saving, including efficiency enhancement of air conditioning and refrigeration system, use method of environmentally-friendly refrigerant, environmental load reduction by reusing lubricating oil and heat transport equipment using capillary force.

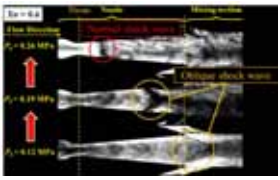
Theme 1 ▶ Study on the improvement of refrigerating/air-conditioning equipment using two-phase flow ejector

With regard to refrigerating/air-conditioning equipment, new refrigerant with low global warming potential has been developed to prevent global warming. This refrigerant, however, wastes enormous energy at the inflation time. Therefore, this laboratory develops the technology to enhance efficiency using the power recovery device called two-phase flow ejector. The achievement of the laboratory was incorporated into the air-conditioning equipment in the latest hybrid cars, helping to construct the high-performance systems.

Two-phase flow ejector

Theme 2 ▶ Fundamental study on compressible and high-speed two-phase flow

Reduction in greenhouse gas emission is the most urgent issue, which was incorporated into the Paris Agreement. Under such circumstances, environmentally friendly natural refrigerants, starting with carbon-dioxide, attract attention. This laboratory conducts the study on the basic flow phenomenon of high-speed two-phase flow generated in the refrigerator/air-conditioning equipment focusing on the natural refrigerants, such as carbon-dioxide, water and isobutane.



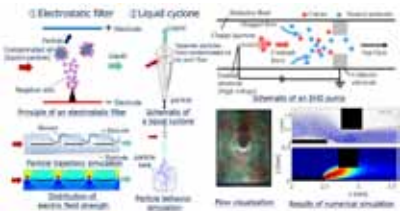
Two-phase flow shock wave

Theme 3 ▶ Development of the high-performance lubricating oil purification system

The laboratory carries out the development of high-speed purification electrostatic filter and the study on liquid cyclone with the aim of removing minute contaminants in lubricating oil, which cause machine failure.

Theme 4 ▶ Basics and application of electrohydrodynamics (EHD) flow

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



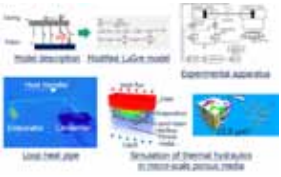
Study on lubricating oil purification and EHD

Theme 5 ▶ Dynamic behavior and mathematical model of friction

The laboratory proposes a new mathematical model allowing for the dynamic characteristics of lubricating oil film and seeks to improve prediction accuracy of various types of machine systems.

Theme 6 ▶ 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 pipe that can transfer heat a long distance without electric power.



Study on dynamic behavior of friction and loop heat pipes