Department of Metallurgy

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Metallurgical Process Engineering	Professor: Tetsuya Nagasaka Associate Professor: Takahiro Miki	The main objective is to physicochemically investigate the production and recovery process of base metals such as steel, aluminum, copper, zinc from raw ore as primary resources and waste and by-products as secondary resources. Also, material flow analysis of accompanying rare elements during production, use and recycling of these base metals is carried out. In addition, ecological processes of recovering rare elements from slag and dust as secondary resources are developed.
Materials Forming and Structural Control (Computational Microstructure Design)	Professor: Ryosuke Kainuma Associate Professor: Toshihiro Omori	Microstructure is one of the most important factors to change the properties of materials. Our group experimentally determines the phase diagrams and diffusion coefficients of various alloy systems, which provides vital information for the control of microstructure. Based on these experimental findings, the databases for thermodynamic and diffusion (mobility) calculations are also constructed. Using the above information, we develop new materials with superior functions and properties, including heat resistant alloys, high strength alloys, shape memory alloys and magnetic materials.
Materials forming and Structure control (Forming Process Technology)	Professor: Katsunari Oikawa	Parts of industrial products are made by forming process such as rolling and forging etc. In this field, we investigate forming process of hardly workable materials. Furthermore, we try to predict the microstructure, material property, processing accuracy and processing defects during processing for efficient process design and development new process. Specifically, the target materials are steels, high temperature materials and magnetic materials etc.
Advanced Materials Physical Chemistry (Materials Physical Chemistry)	Professor: Hongmin Zhu Associate Professor: Osamu Takeda	We develop various functional materials (e.g. oxidation-resistant film and photo-catalyst) by using chemical and electrochemical methods. Furthermore, innovative production and recycling processes for rare metals are under development. We also aim to reveal physico-chemical properties of high temperature melts such as molten salts, molten metals, and molten semi-conductors based on the deep understanding of the phenomena of melts in scale of ion and atom, and to apply the findings to process control.
Institute for Material Research (Microstructure Design of Structural Metallic Materials)	Professor: Tadashi Furuhara Associate Professor: Goro Miyamoto	We study the principles of microstructure evolution in metallic structural materials for advanced control of microstructure and properties. Through detailed characterization of micro/nano-structures, such as atomic structures of crystalline interfaces, chemistry in an atomic scale and so on, by using advanced experimental and theoretical techniques, fundamentals of microstructure formation (thermodynamics, kinetics, crystallography) are examined and key factors for improvement of mechanical properties are clarified.
Institute for Material Research (Structure-controlled functional materials)	Professor: Tetsu Ichitsubo Associate Professor: Norihiko Okamoto	In this division, based on the phase transition theory such as microstructure formation theory, thermal statistical thermodynamics, micromechanics theory, electrochemistry etc., we aim at understanding/development of novel material that exhibits new functions by controlling the microstructure structure through various phase transformations. The specific research subjects at present are: metallic glass (correlation between relaxation behavior and structure), new thermoelectric materials, development of new storage battery system, elucidation of ultrafast phase transition mechanism of photo-induced phase change materials.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Institute of Multidisciplinary Research for Advanced Materials, (Division of Process and System Engineering, Material Separation Processing)	Professor: Hiroyuki Shibata Associate Professor: Sohei Sukenaga	We have been investigating high temperature processes to manufacture metals, oxides and semiconductors. In order to understand and control the processes, chemical and thermophysical properties of materials are essential. Then, we have been measuring the viscosity and thermal conductivity of molten silicates and glasses, and observing high temperature metallurgical phenomena of crystal growth of silicon carbide, metals and silicates in-situ. Functions of the materials should be clarified from micro mechanism of each phenomenon combining with structural property of the materials. On the basis of the obtained knowledge, we aim to develop high efficiency processes for materials manufacturing.
Institute of Multidisciplinary Research for Advanced Materials, (Division of Process and System Engineering, Environmental-Conscious Material Processing)	Professor: Hiroshi Nogami	To reduce the consumptions of energy and resources in material production processes, we aim at improving process efficiency and developing novel production systems. For these purposes, we are approaching through 1) Analysis of reaction characteristics of raw materials and reactors, 2) Development of mathematical models of material production processes based on the thermal fluid engineering techniques, and 3) Kinetic-based numerical process simulation of various material production systems. Furthermore we are developing new recovery, storage and conversion processes of thermal energy by applying novel boundary layer control methods.
Institute for Exellence in Higher Education (Particle Beam Materials Science and Engineering)	Professor: Yoshitaka Kasukabe	・Fundamental study on property-modification of thin films and surfaces and creation of new-functional materials by using particle beams ・Characterization of materials properties by using electron beam and/or particle beam ・Fundamental study on growth processes of nitrides for diffusion barrier layers between metals and semiconductors and of compound semiconductor super lattice layer for detector of infrared beam ・Fundamental study on chemical activity of silicon surfaces and its surface modification

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Department of Materials Science

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Materials Electrochemistry	Professor: Izumi Muto Associate Professor: Yu Sugawara	The goal of our research is to provide a molecular-level understanding of electrochemical reactions on metal surfaces and utilize the knowledge to prevent corrosion and to modify surface properties of materials. We develop experimental techniques and devices for micro/nano-electrochemistry, fluorescence chemical imaging, and real-time in situ observation of corrosion and electrochemical processes. Topics include: 1) mechanism and prevention of localized corrosion, 2) environmentally-friendly coatings and inhibitors, 3) application of scanning probe microscopy to electrochemistry, 4) performance and durability of fuel cell catalysts.
Nano-materials Science (Materials QuantumScience)	Professor: Junsaku Nitta Associate Professor: Makoto Kohda	The present electronics is based on utilization of charge of electron. The electron has the spin degree of freedom as well as charge. So far, the spin of electron had been manipulated by a magnetic field because the spin has a magnetic moment. We are clarifying electronic and magnetic properties in various materials. Based on these studies, we will establish electrical means to control spins in semiconductor nano-structures for future spin-functional devices, e.g. a spin filter and a spin-transistor.
Nano-materials Science (Device Reliability Science and Engineering)	Associate Professor: Yuji Sutou	We investigate mechanical (adhesion, friction, wear), chemical (surface reaction, intermixing), and electrical properties (capacitance, leakage current, ohmic contact, resistive switching) of thin films and their interfaces. Our aim is to improve and to control the properties and reliability of advanced semiconductor devices, non-volatile memories, solar cells, and tribology hard coatings, and so on. We also investigate the mechanical property-microstructure relation of magnesium alloys with an aim to improve strength and ductility for possible application to light-weight structural materials for automobiles and airplanes.
Nano-materials Science (Ultra-high Temperature Materials)	Professor: Kyosuke Yoshimi Associate Professor: Nobuaki Sekido	・Development of Ultra-High Temperature Materials Based-on Refractory Metals and Ceramics for Ultra-High Temperature Applications ・Development of Heat-Resistant High-Strength Titanium-Based Alloys for Aviation and Transportation Applications ・Design of Advanced Heat-Resistant Steels for High-Efficiency Power Generation ・Analysis of High-Temperature Physical and Mechanical Properties of Intermetallic and Inorganic Compounds
Materials and Devices for Information Technology (Opto-electronic Materials)	Professor: Yutaka Oyama Associate Professor: Tadao Tanabe	・Crystal Growth of Layered Semiconductor Materials for THz Spintronic ・Devices　Development of Non-destructive Inspection by using THz Waves ・Fabrication of Solar-blind UV Photodetector Based on Nitride-based Semiconductor
Materials and Devices for Information Technology (Magnetic and Spintronics Materials)	Professor: Satoshi Sugimoto Associate Professor: Nobuki Tezuka	Magnetic materials, which magnetic properties are based on electron spins, are now used in many industries. Nowadays, we control/utilize their nanostructure, and fabricate high performance and/or new functional materials. For the contribution to development of industries,we are aiming to develop new magnetic materials and improvement of magnetic properties in the field of permanent magnets, high frequency magnetic materials, and spintronics.
Materials and Devices for Information Technology (Energy Materials)	Professor: Hitoshi Takamura	For a sustainable society, it is important to use energy efficiently. To make energy conversion devices more efficient including fuel cells and secondary batteries, novel materials are being demanded. The focus of our group is to develop new functional materials such as solid electrolytes and mixed conductors and apply them to the energy conversion and storage devices.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Institute for Material Research (Chemical Physics of Non-Crystalline Materials)	Professor: Kazumasa Sugiyama Associate Professor: Kunio Yubuta	Fundamental properties of functional materials such as metallic glasses, semiconductors and ceramics are strongly associated with their structures. Recently, these interesting materials indicate sophisticated structures with unique atomic arrangements. In order to clarify interesting physico-chemical properties, advanced analytical techniques using advanced X-ray sources are strongly required in the field of materials science. The fine structural images of materials serve a creative idea for producing a variety of functional materials. Our current topics are as follows, 1) Complex metal structures associated with quasicrystals. 2) Structure of disordered materials such as amorphous alloys and oxide glasses.3) Synthesis and characterization of micro-porous cavities occluded by organic molecules. 4) Development of new oxide crystals activated by rare earth elements.
Institute for Materials Research (Non-Equilibrium Materials)	Professor: Hidemi Kato Associate Professor: Takeshi Wada	This laboratory is engaged in the research and development of new metallic glasses and their composites with a superior viscous flow workability, through the essential understanding of stabilization of supercooled liquid and its nanocrystallization, as well as the structure/stress relaxation of the metallic glasses. Also, based on the originally developed liquid metal dealloying, we study the preparation of novel nanoporous materials and their applications for functional materials.
Institute for Materials Research (Materials Design by Computer Simulation)	Professor: Momoji Kubo Associate Professor: Michito Suzuki	For solving the energy and environmental problems and for realizing the safe and secure society which need urgent actions worldwide, the development of advanced high-functional and high-performance materials as well as innovative super-precise and super-miniaturized system is strongly required in a wide variety of research fields such as fuel cell, solar cell, aerospace instrument, electric car, tribology, micromachine, electronics, lithium-ion secondary battery, power plant, clean energy, etc. Therefore, our research division is utilizing various simulation methods from atomic- and molecular-scale to macro-scale and is pioneering the professional education and research on materials and systems design with high-accuracy and high-speed in a wide variety of research themes for solving energy and environmental problems and for realizing the safe and secure society. Especially, we are realizing the specialized education and research on the super-large-scale and super-high-speed simulations by fully utilizing our supercomputer system in Institute for Materials Research.
Institute for Materials Research (Magnetic Materials)	Professor: Koki Takanashi Associate Professor: Takeshi Seki	Magnetic materials have been used as magnets, magnetic cores, and parts of various magnetic devices such as magnetic recording, which have played important roles for our life since a long time ago. However, the ever-increasing demand for an ultrahigh magnetic recording density requires a technological breakthrough. Furthermore, a new electronics called "spintronics", which utilizes the correlation between electric transport and magnetism caused by electron spins, has been developing as a key technology to support an IoT/AI society. Our group works on the development of useful materials for cutting-edge magnetic devices and the fundamental study on physical phenomena by the artificial fabrication of nanomagnetic structures and the search for novel functionalities.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Institute for Materials Research (Materials Science of Non-Stoichiometric Compounds)	Professor: Toyohiko J. Konno Associate Professor: Takanori Kiguchi	We investigate the origin of phase stability of alloys and oxides, based on variety of structural characterization techniques, especially transmission electron microscopy. Current interests include phase transformation behavior of light-weight metals, ferroelectric properties of oxide thin films.
Institute of Multidisciplinary Research for Advanced Materials (Division of Process and System Engineering, Laser Applied Material Science)	Professor: Shunichi Sato Associate Professor: Yuichi Kozawa	The 21 century is considered the age of light. The lasers, which would play an important role there, are increasingly improving their features such as narrow bandwidth, high power and short wavelength even in the field of material science for the development of material processing at the atomic and molecular level. In this laboratory, by using the state-of-the-art laser technologies, we are challenging to synthesize novel materials and nano-particles in an intense laser field produced by femto-second laser pulses, to investigate vector beams and their applications such as optical tweezers, nano-imaging and laser processing, and to develop electron beam control technique based on the light-electron interaction.
Institute of Multidisciplinary Research for Advanced Materials (Division of measurements Quantum Beam measurements)	Professor: Atsushi Momose Associate Professor: Wataru Yashiro	Quantum beams, such as X-rays, are probes for revealing three-dimentional material structures with the scales from atomic to macroscopic sizes. It has also been important to extracting functional information by the measurement of dynamics. This laboratory is exploring the frontier of X-ray imaging technology, especially X-ray phase imaging. Based on this background, we are developing sophisticated imaging methods for evaluating materials consisting mainly of light elements (polymers, composite materials, light metals, biomedical materials) and devices composed of such materials.
Frontier Research Institute for Interdisciplinary Sciences (Advanced basic Science)	Professor: Junji Saida	We study structure, transformation and mechanical deformation in metallic materials with random atomic configuration such as metallic glasses or amorphous alloys using the advanced analysis and interdisciplinary approach. Such random atomic structured materials have significantly different properties with those of conventional crystalline alloys and are highly expected for industrial uses in the next generation. Especially, we focus on a relaxation phenomenon in metallic glasses, which strongly correlates to mechanical properties. We address an important challenge to control the relaxation behavior in order to improve their mechanical properties and to contribute to their applications. We are also interested to develop the new nano-structured and non-equilibrium materials such as nano-crystalline, nano-quasicrystalline, multilayered materials, ultra-fine particles based on glassy structure.

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Department of Materials Processing

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Interface Science and Engineering of Joining	Professor: Yutaka Sato	Many industrial products, including aerospace parts, automobiles and electronic components, are assembled by welding, joining and bonding processes. It is well known that the service limits of the products are directly related to properties and reliabilities of the welded parts which are generally weakest in the products. Moreover, weldability of new materials is a key issue for their practical use. In our laboratory, understanding of fundamental phenomena and mechanisms of welding, joining and bonding processes, and the control and design of the weld interface are conducted on the basis of metallurgy and materials science in order to produce the welded parts with better properties and higher reliability more efficiently during the actual manufacturing sequence.
Microsystems Design and Processing (Mechanics and Design of Material Systems)	Professor: Fumio Narita	Composite materials and structures have found applications in many advancing technologies (e.g., robotics, automotive, aerospace, sporting goods). They are easy to fabricate, low cost, and often characterized by excellent mechanical and physical properties. The members of our Lab. are engaged in research to design and develop polymer-based composite materials incorporating magnetostrictive fibers and piezoelectric nanoparticles for smart device applications. We are making extensive use of state-of-the-art electromagneto-mechanical characterization techniques, in combination with computational modeling to gain insights into fundamental structure-property relationships of complex multifunctional composite materials. We are also conducting research on the biodegradable composites with fillers such as cellulose nanofiber.
Microsystems Design and Processing (Micro-powder Processing and Systems)	Professor: Naoyuki Nomura	To achieve highly functional and high-performance materials used at severe conditions, we need to develop various superior functions systematically. To realize mult-functional materials, it is necessary to research materials design based on mechanics and physics, sophisticated materials synthesis, and materials evaluation methods. We comprehensively study reuired basic properties of constituents in the materials system and macrospic bulk properties in terms of powder metallurgy science.
Microsystems Design and Processing (Materials Evaluation and Sensing)	Professor: Tsuyoshi Mihara Associate Professor: Yoshikazu Ohara	Various engineering products and infrastructures can suffer damage and defects due to manufacturing conditions and aging. The aim of this laboratory is to establish nondestructive evaluation method to ensure the function of components and material strength. To this end, we have developed measurement systems including the design and fabrication of sensors, electronic devices, and analysis method. Our main research topics follow; [1] Damage evaluation of concrete, composite, water pipelines by low-frequency ultrasonics [2] Accurate measurement of cracks in steel structures by large-amplitude nonlinear ultrasonic systems [3] Development of high-frequency ultrasonic measurement systems for delaminations and micro voids

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Physical Metallurgy and Physicochemistry of Biomolecular and Biomaterial Systems (Physicochemistry of Biomolecular Systems)	Professor: Masaya Yamamoto Associate Professor: Nobuyuki Morimoto	Materials processing by understanding biofunctions in biological systems from a physicochemical viewpoint plays a pivotal role in designing biofunctional materials for advanced medicine, such as regenerative medicine and drug delivery systems. Our objective is to molecularly understand biofunctions in biological systems to create novel biofunctional materials as well as to pursue fundamental researches on organic-inorganic hybrids and soft materials to be applied for biological systems. Based on the fundamental findings, we design and synthesize biofunctional materials, such as hydrogels, peptides, polymeric particles, stimuli-responsive polymers, and their hybrids with inorganic materials, and investigate their applications for regenerative medicine and drug delivery systems.
Physical Metallurgy and Physicochemistry of Biomolecular and Biomaterial Systems (Biomedical Materials)	Professor: Takayuki Narushima Associate Professor: Kyosuke Ueda	Our research group focuses on the use of metallic biomaterials such as Ti alloys, NiTi, Co-Cr alloys, and Mg alloys in biomedical implants. It is predicted that the number of patients suffering from falls and deterioration of body functions will increase in today's super-aged society. As a result, the demand is increasing for high-performance and inexpensive devices for reconstructing the body function. Metals are candidate materials of implants; in fact, 80% of the implants are made of metals. Therefore, our group is working toward developing "new-generation metallic biomaterials" and "novel processing methods" to fabricate and modify them from the viewpoint of their surface modification and composition/microstructure control. Some of the research studies are conducted under close cooperation with Institute of Development, Aging, and Cancer, Tohoku University, Graduate School of Dentistry, Tohoku University, and a few private companies.
Institute for Materals Reasearch (Deformation Processing)	Professor: Akihiko Chiba Associate Professor: Kenta Yamanaka	Study on novel materials processing technologies based on additive manufacturing (3D printer) technologies. In order to maintain the sustainable development of the society for human being, it is of crucial importance to develop the new types of highly functional structural materials such as heat-resistant Ni-base superalloys, titanium alloys, and Co-based alloys for biomedical applications. In our laboratory, we are aiming at systematizing the processing-structure-property relationships in these structural metallic materials through the systematic examination and analyses for microstructures evolved during advanced processing technologies based on thermomechanical processing and additive manufacturing using electron beam melting (EBM). By employing the state-of-the-art techniques for characterization and computer simulations, fundamental studies are carried out to reveal mechanisms of occurrence of some specific properties for such advanced materials and to establish the processing for producing the most favorable microstructures to realize the best performance of the materials. We pursue the basis of EBM technologies.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Institute for Materials Research (Advanced Crystal Engineering)	Professor: Akira Yoshikawa	We are carrying out our research activity related with the materials design, synthesis, crystal growth, and characterization of new inorganic materials in order to create novel crystalline materials to enable highly-functional devices for safety, security, IoT, energy, and etc.. We discuss the phase diagrams and the stability of structures from the solid-state chemistry viewpoint. We are trying to understand the influence of doping elements and defects in crystals on basic properties from the solid-state physics viewpoint. Based on the results of these studies, we try to understand the mechanism of their phenomenon. By advancing material design on the basis of the understanding, we are trying to further improvement of the functionality. We are intensively studying with emphasis on what is actually useful and how is the mountability to actual equipment. Studying the optimal synthesis process for newly developed materials and evaluating substances from the viewpoint of device integration are also the research subjects of our laboratory.
Institute for Materials Research Cooperative Research and Development Center for Advanced Materials, Micro-scale Controlled Materials	Professor: Naoya Masahashi Associate Professor: Satoshi Semboshi Rie Umetsu	Material functions depend on microstructure and composition, and it is an effective method to improve the functions using process technology such as plastic deformation, surface modification, electro-chemical treatment and powder metallurgy. In our laboratory, structural (strength, superplasticity, corrosion etc.) and functional (electronic, medical, environment purification, etc.) metallic materials have been studied focusing on materials science like diffusion, phase equilibrium and lattice defects. Especially, we have studied non-ferrous metals such as Ti, Cu, Al and Ni for biocompatible, electronic, light-weight and high temperature resistant materials, respectively. Further, we are engaged in industry, academia and government cooperation activities in order to build the matured society through solving industries' technical problems and educating researchers and technicians in industry. We are aiming to develop materials useful for society and to do academic contribution in the material science.
Institute of Multidisciplinary Research for Advanced Materials Center for Exploration of New Inorganic Materials (Inorganic Crystal Structural Materials Chemistry)	Professor: Hisanori Yamane Associate Professor: Takahiro Yamada	We are searching new multinary inorganic compounds, analyzing their crystal structures, and charactering their properties. The novel methods developed for the synthesis of the new compounds are applied to the preparation of conventional ceramics and inorganic materials in order to improve their qualities and performances. - Synthesis of multinary oxides by solid state reaction - Synthesis of nitrides, silicides, clathrates, suboxides, and Zintl compounds using fluxes - Crystal structure analysis and characterization of new multinary inorganic compounds - Development of novel synthetic routes for advanced ceramic materials using active metals

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Frontier Research Institute for Interdisciplinary Sciences (Advanced Interdisciplinary Research Division)	Professor: Hiroshi Masumoto	Development research of the multi-layer or nano-composite metal-ceramic films are carried out in order to create the next generation multi-functional thin film material and its high function. Especially, nano-composite films preparation with magnetic-metal nano-particles dispersed in the dielectric ceramics is research aiming at the expression of multifunctional physical property by the nano quantum effect (proximity effect), that is, the seepage effect of the physical property governed by the three-dimensional interface state. Recently, new multi-functional properties such as "tunnel magneto-dielectric effect" and "tunnel magneto-optical effect" which can control dielectric constant and transmittance by changing magnetic field have been newly discovered in our laboratory. We are studying the enhancement of the high function and the elucidation of the mechanism of these new effects, and are exploring further new multi-functional physical properties.
Frontier Research Institute for Interdisciplinary Sciences (Advanced Interdisciplinary Research Division)	Professor: Kenji Tsuda	For the developments of nanoscale functional materials and devices toward energy saving, space saving and high efficiency, it is crucial to investigate correlations between their nanoscale local structures and physical properties. For this purpose, we have been developing methods of local crystal structure and electrostatic potential analysis using convergent-beam electron diffraction (CBED). We are applying the methods to ferroelectrics with structural phase transformations, strongly-correlated electron oxides, solid oxide fuel cell (SOFC) materials, long-period stacking order alloys, etc.

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