Department of Metallurgy

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Metallurgical Process Engineering	Professor: Nagasaka Tetsuya Associate Professor: Miki Takahiro	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: Kainuma Ryosuke Associate Professor: Omori Toshihiro	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: Oikawa Katsunari	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: Zhu Hongmin Associate Professor: Takeda Osamu	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.
Advanced Materials Physical Chemistry (Materials Processing Design)	Professor: Sergey Komarov Associate Professor: Yoshikawa Noboru	We conduct experimental and theoretical (numerical simulation) researches aiming at devolping new high efficiency processes for material treatment and fabrication. Our research activity involves systematic investigations on transport phenomena including fluid flow, heat and mass transfer. Specifically, we are attempting to apply “physical fields” to metarials’ processing. They include ultrasound field, microwave, electromagnetic force, turbulent fluid flow and impact treatment.
Institute for Material Research (Microstructure Design of Structural Metallic Materials)	Professor: Furuhara Tadashi Associate Professor: Miyamoto Goro	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: Ichitsubo Tetsu Associate Professor: Okamoto Norihiko	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: Shibata Hiroyuki Associate Professor: Sukenaga Sohei	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~~,~~ (Center for Mineral Processing and Metallurgy, Base Materials Processing)	Professor: Ueda Shigeru	To build a sustainable society, it is necessary to maintain and develop a base material supply system that is the infrastructure of society. Onthe other hand, there is a strong demand for resources in the world today, and the problems of deteriorating natural mineral resources andthe generation of CO_2 and harmful by-products are becoming apparent. We focus on the production process of base materials such as steel,and study on the theme of developing a sustainable resource-recycling society through the research of material processes with lowenvironmental impact based on high-temperature physical chemistry, chemical engineering, and reaction kinetics.
Institute of Multidisciplinary Research for Advanced Materials~~,~~ (Division of Process and System Engineering, Environmental-Conscious Material Processing)	Professor: Nogami Hiroshi Associate Professor: Natsui Shungo	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 through synchronized high-speed imaging, 2) Kinetic-based numerical process simulation of various material production systems, 3) Application of data-centric science to characterization of reaction field, 4) Development of novel electrolytic technique for refining high-temperature melts, and 5) Development of innovative recovery, storage and conversion processes of thermal energy by applying novel boundary layer control methods.
International Center for Synchrotron Radiation Innovation Smart (Data Visualization Smart Lab)	Professor: Takahashi Yukio Associate Professor: Shinoda Kozo	Many practical materials are complex systems with spatial hierarchical structures ranging from atoms to millimeters. Therefore, when designing and developing new materials, it is important to clarify the correlation between structure and function at the mesoscale, which connects the micro and macro scales. By utilizing imaging and spectroscopic techniques using synchrotron radiation, it is possible to visualize the structure, elements, and electronic state of the entire practical bulk material in a multidimensional manner. We develop next-generation synchrotron radiation imaging and spectroscopic techniques using advanced X-ray optics and informatics to establish a basis for visualizing the functions of practical materials.
Institute for Exellence in Higher Education (Particle Beam Materials Science and Engineering)	Professor: Kasukabe Yoshitaka	・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: Muto Izumi Associate Professor: Sugawara Yu	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: Nitta Junsaku Associate Professor: Kohda Makoto	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)	Professor: Sutou Yuji Associate Professor: Ando Daisuke	Our research aim is to enhance and to control the properties and reliability of electrical devices (thin films and bulk materials) such as non-volatile memories (phase-change memory), piezoelectric devices (thin film chalcogenides), interconnects and resistors (metal- and semiconductor-based) etc, and structural materials (bulk materials and thin films) such as lightweight components (magnesium alloys, aluminum alloys), tribology components (nitrides, carbides, galvannealed film), ceramic alloys etc, through“phase” control and “interface” control.
Nano-materials Science (Ultra-high Temperature Materials)	Professor: Yoshimi Kyosuke Associate Professor: Sekido Nobuaki	・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 (Magnetic and Spintronics Materials)	Professor: Sugimoto Satoshi Associate Professor: Tezuka Nobuki Lecturer: Matsuura Masashi	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: Takamura Hitoshi	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: Sugiyama Kazumasa	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: Kato Hidemi Associate Professor: Wada Takeshi	We study stabilization of supercooled liquid, structure, relaxation, nano-crystallization, and viscous flow property of metallic glasses (MGs). By applying the alloy design strategy of MGs, we develop novel high entropy alloys (HEAs) and study their phase, microstructure, thermal stability, short-range order, and mechanical properties. We also develop new porous metals by using liquid metal dealloying (LMD). We study evolution microstructure during LMD and evaluate the various properties of porous metals for the application as functional material.
Institute for Materials Research (Materials Design by Computer Simulation)	Professor: Kubo Momoji Associate Professor: Ootani Yusuke Associate Professor: Terada Yayoi Associate Professor: Belosludov Rodion Vladimirovich	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 is strongly required in a wide variety of research fields such as fuel cell, aerospace instrument, tribology, electric car, structural material, electronics, lithium-ion battery, etc. Therefore, our research division is utilizing various simulation methods from atomic-scale to macro-scale and the supercomputer system “MASAMUNE-IMR” in Institute for Materials Research and is pioneering the professional education and research on the super-large-scale simulations for materials design.

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, Laser Applied Material Science)	Professor: Sato Shunichi Associate Professor: Kozawa Yuichi	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: Momose Atsushi	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: Saida Junji	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: Sato Yutaka	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 (Micro-powder Processing and Systems)	Professor: Nomura Naoyuki	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: Mihara Tsuyoshi Associate Professor: Ohara Yoshikazu	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
Physical Metallurgy and Physicochemistry of Biomolecular and Biomaterial Systems (Physicochemistry of Biomolecular Systems)	Professor: Yamamoto Masaya Associate Professor: Morimoto Nobuyuki	Materials processing by molecularly understanding biofunctions in biological systems plays a pivotal role in designing biofunctional materials for advanced medicine. Our objective is to pursue fundamental research on molecular design of soft materials and organic-inorganic hybrids to be applied for the biological systems. Based on the fundamental findings, we also investigate their applications in regenerative medicine and drug delivery systems (DDS) as well as in the assessment of environmental threats of nano/microplastics in terms of biological effects.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Physical Metallurgy and Physicochemistry of Biomolecular and Biomaterial Systems (Biomedical Materials)	Professor: Narushima Takayuki Associate Professor: Ueda Kyosuke	The demand for high-performance devices to restore functions of the human body is steadily increasing. This is due to the decline or loss of biological functions of elderly person in today's super-aged society. Our research group focuses on the basic and applied research pertaining to the enhancement of the functionality and durability of implantable devices (implants) through surface and composition/microstructural control of metallic biomaterials, such as Ti, NiTi, Co-Cr, and Mg alloys. We conduct basic research on controlling surface reactions of metallic/ceramic biomaterials in a biological environment. In addition, on the applied research front, we develop materials having surfaces with both antivirus/antibacterial activity and bone-compatibility, as well as design materials for artificial joint and stent applications, under close cooperation with the Institute of Development, Aging, and Cancer and Graduate School of Dentistry, Tohoku University.
Institute for Materials Research (Advanced Crystal Engineering)	Professor: Yoshikawa Akira Associate Professor: Yokota Yuui	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: Masahashi Naoya Umetsu Rie Associate Professor: Semboshi Satoshi	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 (magnetic, electronic, medical, environment purification, etc.) metallic materials have been studied focusing on materials science like diffusion, phase equilibrium, lattice defects and degree of order. 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.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Institute of Multidisciplinary Research for Advanced Materials (Division of Inorganic Material Research, Inorganic Crystal Structural Materials Chemistry)	Professor: Yamane Hisanori Associate Professor: Simura Rayko	We are searching new multinary inorganic compounds, analyzing their crystal structures, and characterizing 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
Institute of Multidisciplinary Research for Advanced Materials (Division of Inorganic Material Research, Metallurgical Design for Material Functions)	Professor: Kameoka Satoshi Senior Lecturer: Fujita Nobuhisa	Catalyst is one of the key materials for realizing a decarbonized society. In recent years, precious metal–free and development of precious metal alternative alloy catalysts have become the most important issues. The research of our laboratory is focused on creation of catalytic materials with excellent properties in terms of metallurgy and exploration of alloys with novel structures. The main research theme is to design and fabricate metallic materials with novel catalytic functions. We will create a catalytic material with a unique structure and morphology that cannot be obtained using conventional chemical methods. We will also study about the synthesis and structure of quasicrystal related intermetallic compounds, to take advantage of the knowledge gained as the basis of novel catalyst development.
Frontier Research Institute for Interdisciplinary Sciences (Advanced Interdisciplinary Research Division)	Professor: Masumoto Hiroshi	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: Tsuda Kenji	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 new methods of local crystal structure and electrostatic potential analysis using convergent-beam electron diffraction (CBED) with the help of information science such as machine learning. We are applying the methods to ferroelectrics with structural phase transformations, strongly-correlated electron oxides, solid oxide fuel cell (SOFC) materials, etc.

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