Department of Metallurgy

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Metallurgical Process Engineering	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, research of refining/upgrading process to obtain high purity 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 (Microstructure Control)	Professor: Kainuma Ryosuke	Microstructure control is a core technology in material processing, utilized widely in materials industry. We perform fundamental research on microstructure control in materials using phase stability and phase transformation on basis of knowledge of microstructure science. We also aim to develop new functional materials, such as shape memory alloy and magnetic alloy, focusing on interaction effects among magnetic, order-disorder and martensitic transformations.
Materials Forming and Structural Control (Computational Microstructure Design)	Professor: Omori Toshihiro Assistant Professor: Xu Xiao	Phase diagram is of great importance for the design of new materials. We experimentally determine the phase diagrams and assess the thermodynamic properties of specific substances with the aid of first-principles calculations, from which thermodynamic databases are constructed. By using the phase diagrams and thermodynamic databases, we develop new materials with superior functions and properties, including high strength alloys, heat resistant alloys, and magnetic materials.
Materials forming and Structure control (Forming Process Technology)	Professor: Oikawa Katsunari Assistant Professor: Ueshima Nobufumi	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 Assistant Professor: Zhu Shangping	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: Furuhara Tadashi Associate Professor: Miyamoto Goro Assistant Professor: Zhang Yongjie Kim Jihoon	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.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
Institute for Material Research (Structure-controlled functional materials)	Professor: Ichitsubo Tetsu Associate Professor: Okamoto Norihiko Assistant Professor: Tanimura Hiroshi Kawaguchi Tomoya	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. Currently, our specific research targets include the development of innovative battery electrode materials, metallic glasses (correlation between relaxation behavior and structure), phase transformation of titanium alloys, new thermoelectric materials, and elucidation of high-speed phase transition mechanisms of chalcogenide-based photo-phase change materials.
Institute of Multidisciplinary Research for Advanced Materials, (Center for Mineral Processing and Metallurgy, Base Materials Processing)	Professor: Ueda Shigeru Assistant Professor: Iwama Takayuki	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, 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 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. Based on 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: 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 Assistant Professor: Ishiguro Nozomu	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.

Note: For further details, please contact Administration office/ Educational Affairs Section of Metallurgy, Materials Science and Materials Processing [PHONE:+81 (22)795-7373]

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 Assistant Professor: Nishimoto Masashi	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 (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 Assistant Professor: Ida Shuntaro	・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 (Optoelectronic Materials)	Professor: Kohda Makoto	In the future information and communication society supported by semiconductor and quantum technologies, it is required to develop new materials and create new functions that can efficiently process vast amounts of information. In this research field, we are developing materials and creating new functions for next-generation information processing and quantum technology based on semiconductor materials that can create a spatial structure of spins and atomic layer materials that can produce a variety of physical properties in a single atomic layer. In addition, based on high-precision spin manipulation technology based on spin-orbit interaction, spintronics devices and proof-of-principle demonstrations will be conducted to establish the fundamental technology required for the next generation quantum information society.
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 improve 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 Assistant Professor: Oikawa Itaru Ishii Akihiro	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 Materials Research (Non-Equilibrium Materials)	Professor: Kato Hidemi Associate Professor: Wada Takeshi Assistant Professor: Yamada Rui	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 Belosludov Rodion Vladimirovich Assistant Professor: Asano Yuta Fukushima Shogo	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, electronics, lithium-ion battery, etc. Therefore, our research division is pioneering the professional education and research on the multi-scale simulation methods from atomic-scale to macro-scale, the AI-based informatics technologies, and the super-large-scale simulations utilizing the supercomputer system “MASAMUNE-IMR” in Institute for Materials Research.
Institute of Multidisciplinary Research for Advanced Materials (Division of measurements Quantum Beam measurements)	Professor: Momose Atsushi Associate Professor: Seki Yoshichika Assistant Professor: Ueda Ryosuke	Quantum beams, such as X-rays, are probes for revealing three-dimensional 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.

Note: For further details, please contact Administration office/ Educational Affairs Section of Metallurgy, Materials Science and Materials Processing [PHONE:+81 (22)795-7373]

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 Assistant Professor: Tokita Shun	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 Associate Professor: Zhou Weiwei	We aim to develop materials with new functions that cannot be achieved with conventional particles by creating functional tailor-made fine particles and utilizing and deploying them in the field of powder metallurgy, including sintering and 3D printing. We conduct a wide range of research related to green and life innovation based on powder metallurgy, for example, development of functional particles by freeze-dry pulsated orifice ejection method, research of graphene and carbon nanotube nanocomposites, development of ultrahigh-temperature heat-resistant materials, and low magnetic medical materials by 3D printing including fabrication of powder.
Microsystems Design and Processing (Materials Evaluation and Sensing)	Professor: Ohara Yoshikazu	Various engineering products, manufactured materials, and infrastructures can suffer from defects and damage due to manufacturing conditions and aging. An accurate nondestructive evaluation (NDE) method is indispensable to achieve a safe, reliable, and sustainable society. We develop novel ultrasonic NDE methods that utilizes state-of-the-art technologies, such as phased array, nonlinear ultrasonics, and laser, based on a deep understanding of complex physical phenomena, such as ultrasonic propagation and ultrasound-defect interactions.
Microsystems Design and Processing (Multi Conversion System)	Professor: Chao-Nan Xu Assitant Professor Tomoki Uchiyama	In our laboratory, we are creating a multi-piezo material that combines strong piezoluminescence and piezoelectricity. This material emits light with unprecedented sensitivity and stability when subjected to mechanical stress, and has attracted international attention as a new concept material. Our laboratory aims to achieve a breakthrough in hyper-multi-piezo by approaching the mechanism and material development of multi-piezo from both theoretical and experimental perspectives, and to pioneer and evolve the innovative field of multi-piezo photonics. Specifically, we aim to 1) clarify the mechanism of the multi-energy conversion process of force-electricity-light, 2) create hyper-multi-piezo materials with giant piezoelectricity and light emission functions,and 3) designing/engineering multi-conversion devices to create innovative nanosensors and ubiquitous light sources.
Biomaterials Systems (Biofunctional Materials)	Professor: Yamamoto Masaya Assistant Professor: Kobayashi Mako	Understanding biofunctions in biological systems at a molecular level plays a pivotal role in designing biofunctional materials for advanced medicine. Our objective is to pursue fundamental research on the molecular understanding and design of soft materials, plastics, biological materials, and organic-inorganic hybrids to be applied to biological systems. Based on the fundamental findings, we also investigate their applications in regenerative medicine, cancer research, 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
Biomaterials 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 Assistant Professor: Hanada Takashi Assistant Professor: Murakami Rikito	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 (Multi-Functional Materials Science)	Professor: Kumagai Yu Associate Professor: Shota Ono Assistant Professor: Kiyohara Shin Assistant Professor: Bae Soungmin	The research topic is computational material science based on quantum mechanics. Conventional materials research has been experiment-driven, and new materials have been discovered through repeated hypothesis testing. However, the improvement of computer performance has been tremendous, and by the beginning of the 21st century, it has become possible to predict physical properties by solving quantum mechanics numerically. More recently, it has become possible to perform first-principles calculations on hundreds of thousands of materials and compile a database of the calculated properties. Our group aims to develop new functional and structural ceramics and to elucidate the origin of their excellent material properties by generating large-scale computational data using these advanced computational techniques and analyzing them using informatics.
Institute for Materials Research (Cooperative Research and Development Center for Advanced Materials, Micro- scale Controlled Materials)	Professor: Umetsu Rie Assistant Professor: Sato Mitsutaka	Material functions depend on microstructure, composition and electronic structure, and they are improved by controlling these factors. In our laboratory, functional (magnetic, electrical, electronic, etc.) and structural (strength, toughness, durability, etc.) metallic materials have been studied focusing on materials science like phase transformation, phase equilibrium, diffusion, lattice defects and degree of order, and also focusing on materials processing like melting/casting, plastic working, powder metallurgy and surface modification. 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: Yamada Takahiro	There are many inorganic compounds that have not been discovered or whose functions have not been completely revealed and understood. We aim to explore novel inorganic compounds and develop new synthesis processes for high-quality samples in order to create new inorganic materials such as thermoelectric materials, hard ceramics and metallic materials, and superconductors. To achieve these goals, we analyze the crystal structures of the obtained compounds, focusing on mainly non-oxide compounds, and characterize their material properties and their functionalities, such as electronic and thermal properties.
Institute of Multidisciplinary Research for Advanced Materials (Division of Inorganic Material Research, Metallurgical Design for Material Functions)	Professor: Kameoka Satoshi 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.
Institute of Multidisciplinary Research for Advanced Materials (Division of Measurements, Nano-Electron Probe Diffractometry)	Professor: Tsuda Kenji Lecturer: Akase Zentaro Assistant Professor: Morikawa Daisuke	Local crystal structure analysis is becoming increasingly important in functional materials that exhibit intriguing physical properties induced by nanoscale local structures and crystal interfaces. Using the convergent-beam electron diffraction (CBED) method with nano-electron probe, we developed a quantitative local structure analysis method and applied it to various functional materials such as ferroelectric ceramics. Furthermore, we are working on the development of a new method to study spatial variations of local structures and electrostatic potential distributions in crystal interfaces and nanodomain structures.
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.

Note: For further details, please contact Administration office/ Educational Affairs Section of Metallurgy, Materials Science and Materials Processing [PHONE:+81 (22)795-7373]