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 Associate Professor: Xu Xiao	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	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: Miyamoto Goro Associate Professor: Zhang Yongjie	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 Assistant Professor: 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.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
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. On the other hand, there is a strong demand for resources in the world today, and the problems of deteriorating natural mineral resources and the 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 low environmental 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 Assistant Professor: Takahashi Junichi	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: Abe Masaki	Practical materials are complex systems that exhibit hierarchical structures ranging from the atomic scale to the millimeter scale. Therefore, elucidating the correlation between mesoscale structures—bridging the micro and macro scales—and material functionalities is crucial for the design of new materials. The Smart Lab focuses on the development of next-generation synchrotron-based imaging and spectroscopy techniques utilizing advanced X-ray optics. By integrating these methods with informatics, we aim to establish a comprehensive platform for the multidimensional visualization of structure, elemental composition, and electronic states in bulk materials.

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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 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 Assistant Professor: Shuang Yi	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: Takahiro Kaneko	This research aims to establish fundamental design principles for advanced structural materials by integrating the mechanistic understanding of deformation and fracture—based on atomic-scale theories and lattice defect physics—with investigations into atomic diffusion phenomena, microstructural stability at elevated temperatures, and environmental resistance. Furthermore, these efforts are coupled with the implementation of materials digital transformation (DxMT), including deep learning methodologies, to accelerate the development of high-performance structural materials.
Materials and Devices for Information Technology (Optoelectronic Materials)	Professor: Kohda Makoto Assistant Professor: Ishihara Jun	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 (Advanced Magneto-Materials)	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 functional magnetic materials, spintronics, permanent magnets and high frequency magnetic materials.
Materials and Devices for Information Technology (Energy Materials)	Professor: Takamura Hitoshi Assistant Professor: 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
Green Goals Initiative (Research Center for Green X-Tech Functional Electronic Materials)	Professor: Saito Yuta	The realization of the future information society cannot rely solely on the extension of current semiconductor device technology; innovative advancements through new materials and principles are essential. In our research group, we focus on developing electronic materials with unprecedented functionalities, including 2D layered materials and non-equilibrium amorphous materials. Our research spans from theoretical groundwork in constructing functional materials at atomic and electronic levels to the practical design of novel thin film materials for next-generation information society devices.
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: 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 for Materials Research (Magnetic Materials)	Professor: Seki Takeshi Associate Professor: Sakamoto Shoya Assistant Professor: Ito Keita Yamazaki Takumi	Magnetic materials have widely been used as permanent magnets, magnetic cores, and parts of magnetic devices such as magnetic memory and magnetic recording. Magnetic and spintronic materials, in which the correlation between electric transport and magnetism caused by electron spins is utilized, are key for various challenges of the IoT/AI society and energy & environment we are facing today. Our group works on the development of useful materials with new functionalities for cutting-edge magnetic devices and the fundamental research on physical phenomena for magnetics and spintronics based on techniques for nanostructure-control and composite.
Institute of Multidisciplinary Research for Advanced Materials (Division of measurements Quantum Beam measurements)	Professor: Momose Atsushi Associate Professor: Seki Yoshichika	Quantum beams such as X-rays are probes that can three-dimensionally investigate material structures at various levels, from atomic to macroscopic scales. In addition, attempts to visualize material functions through dynamic measurements of quantum beams are becoming increasingly important. In this laboratory, we are developing advanced imaging techniques based on the world-leading imaging methods using X-rays and neutrons, especially phase measurement techniques, for various materials mainly made of light elements (polymeric materials, composite materials, light metal materials, medical and biological materials, etc.) with X-rays, and metallic and magnetic materials with neutrons, including devices made of these materials.
Institute of Multidisciplinary Research for Advanced Materials (Division of Process and System Engineering, Laser Applied Material Science)	Professor: Yuichi Kozawa Assistant Professor: Yuuki Uesugi	Laser beams, characterized by monochromaticity and directionality as coherent light, can produce a high-intense light field in a localized spatiotemporal region by utilizing the short pulse and superior focusing nature, inducing diverse interactions with matter. Based on the advanced laser technique, our research group aims to pursue novel process developments including material processing and reaction control, and to develop high-performance measurement techniques based on optical imaging by leveraging the unique features that emerge from controlling the spatial distribution of the amplitude, phase, and polarization of light waves.

Course or Research Center (Specialized Field or Research Division)	Faculty Name	Theme of Research
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 Assistant Professor: Suzuki Kiyoaki	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 Assistant Professor: Dong Mingqi	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 Associate Professor: Nagakubo Akira	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 utilize 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 Assistant Professor: Tomoki Uchiyama	To realize a sustainable, prosperous, and secure society, further innovation in energy conversion technologies, including IoT devices, is essential. Our laboratory focuses on developing new materials that enable the conversion of mechanical, electrical, and optical energy through an approach that combines material development, advanced measurement techniques, and computational science. In addition, we develop energy conversion devices that harness mechanical, electrical, and optical energy, as well as innovative diagnostic systems for structural health applications.
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 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 Lecturer: Kiyohara Shin Assistant Professor: Bae Soungmin Vu Thi Ngoc Huyen Masuda kairi	Our research topics are materials informatics and 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)	Professor: Umetsu Rie Assistant Professor: Huang Yin-Chen	The functions of materials depend on their composition, structure, and electronic state, and controlling these factors directly leads to extracting the functionality. Our laboratory aims to develop new magnetic functional materials with functions that lead to applications, such as magnetic materials for spintronics, magnetic shape memory alloys, and magnetostrictive materials, and to elucidate the mechanisms. We treat a wide range of materials, from non-equilibrium materials such as amorphous and disordered alloys to single crystals and investigate not only their magnetic properties but also their thermal and electrical transport properties, and develop discussions related to their electronic states. We also occasionally conduct research using high magnetic field facilities and quantum beams such as neutrons and synchrotron radiation.

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 Associate Professor: Hosono Akira	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, dielectric 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 Assistant Professor: Morikawa Daisuke	To elucidate the mechanisms of novel material properties induced by local structures, we develop and apply nanoscale local crystal structure and electrostatic potential analysis methods based on convergent beam electron diffraction (CBED) using a nano-electron probe, and 4D-STEM combining CBED with scanning transmission electron microscopy (STEM). We are working on local structure analysis of semiconductor heterojunctions and heterogeneous structures of ferroelectric relaxors, and are also focusing on the development of new structural analysis methods using deep learning.
Frontier Research Institute for Interdisciplinary Sciences (Advanced Interdisciplinary Research Division)	Professor: Masumoto Hiroshi	In pursuit of the next generation of multifunctional thin film materials, significant research efforts are directed towards the development of multi-layered or nano-composite metal-ceramic films. 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. Our laboratory has recently discovered novel multifunctional properties such as the 'Tunnel Magneto-Dielectric (TMD) effect' and 'Tunnel Magneto-Optical (TMO) effect', which allow for the manipulation of dielectric constant and transmittance through changes in magnetic field. We are actively engaged in enhancing the functionality and elucidating the mechanisms behind these new effects, while also exploring additional multifunctional physical properties.

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