Department of Applied Chemistry
Department of Chemical Engineering
Department of Biomolecular Engineering

1. Departments of Applied Chemistry, Chemical Engineering and Biomolecular Engineering are made up of the following Core Laboratories, Research Centers/Institutes and Cooperative Laboratories:
(Values in parentheses indicate the number of laboratories. A senior faculty member (associate or full professor) is associated with each laboratory.)

Department of Applied Chemistry

① Core Laboratories

Molecular Materials Design (1), Resources and Environment (2), Chemistry of Molecular Systems (2)

② Environment Conservation Center (1)

③ Cooperative Laboratories

IMRAM - Institute of Multidisciplinary Research for Advanced Materials - [Division of Research (2), Research Center (2)]

Division of Inorganic Material Research (1), Division of Measurements (1),

Materials-Measurement Hybrid Research Center (2)

Department of Chemical Engineering

① Core Laboratories

Energy Process Engineering (1), Chemical Process Engineering (2), Process Systems Engineering (1)

② RCSCF - Research Center of Supercritical Fluid Technology

Engineering Fundamentals (1), System Development (1)

③ Cooperative Laboratories

IMRAM - Institute of Multidisciplinary Research for Advanced Materials - [Division of Research (1), Research Center (1)]

Division of Process and System Engineering (1), Materials-Measurement Hybrid Research Center (1)

Department of Biomolecular Engineering

① Core Laboratories

Applied Life Chemistry (1), Bioorganic Chemistry (2), Biofunctional Chemistry (2)

② Cooperative Laboratories

IMRAM - Institute of Multidisciplinary Research for Advanced Materials - [Research Center (1)]
Materials-Measurement Hybrid Research Center (1)

Green Goals Initiative [Research Center (1)]

Research Center for Green X-Tech (1)

2. In the interview, the applicant will be queried about preferred research areas (laboratories) in more detail.

Department of Applied Chemistry

Laboratory	Professor / Associate Professor	Description of Research
Molecular Materials Design	Professor Yuji Matsumoto Associate Professor Shingo Maruyama Assistant Professor Kenichi Kaminaga	As chemical knowledge-driven technologies for the next generation electronics, we are engaged in studies on the vacuum deposition of condensed thin film materials, i.e., in solid and liquid, through a powerful combination of vacuum technologies and chemistry. Here, the thin films are defined as the materials whose thickness is less than 1 μm, sometimes can be down to the nanoscale, and they are one of the material categories that is most indispensable for the modern electronics industry. The materials that dealt with in our laboratory are widely ranged from inorganic electronic, magnetic and superconducting materials to organic semiconductors, liquid crystals and ionic liquids, aiming to develop new processes and characterization tools, to explore new material properties and functionalities and to fabricate test devices with these film materials.
Resources and Environment (Energy Resource Chemistry)	Professor Keiichi Tomishige Associate Professor Yoshinao Nakagawa Assistant Professor Mizuho Yabushita	Highly effective utilization of fossil and renewable hydrocarbon resources is very important to address environmental and energy challenges related to global warming, depletion of fossil resources and energy security. Hydrocarbon resources can be converted into chemicals through safe and efficient operations in which catalytic technologies play important roles in energy consumption and environmental-benign processes for natural gas, petroleum, biomass and other resources. Our research target is the development of new heterogeneous catalysts consisting of metal nanoparticles, metal oxide clusters and their combination. The catalysts are applied to the conversion of biomass and to produce value-added chemicals such as fuels, monomers for the polymer synthesis and building blocks for pharmaceuticals.
Resources and Environment (Functional Macromolecular Chemistry)	Professor Masaya Mitsuishi Assistant Professor Aki Kashiwazaki	Polymer is a wonderful building block, which is essential to life. We are interested in bottom-up nanoscience and nanotechnology of hybrid polymer assemblies. The unique characteristics of polymer enable us to assemble diverse nanomaterials such as metals, oxides, and metal-organic-frameworks at the nanometer scale. Elucidation of structure-property relations in terms of interactions of hybrid polymer nanoassemblies with photons, electrons, and molecules is our particular research interest. Our research topics cover a wide range of fundamentals with applications in hybrid polymer nanoarchitecture for nanoelectronics/nanophotonics, surface and interface, high performance hybrid nanomaterials.
Chemistry of Molecular Systems (Synthetic Chemistry of Advanced Materials ※)	Professor Hirotsugu Takizawa Associate Professor Yamato Hayashi Assistant Professor Jun Fukushima	Structure and bonding in solid-state materials are very relevant to modern science and technology. This laboratory deals with material design, synthesis and characterization of advanced functional inorganic materials based on "Solid State Chemistry". Our main research topics include: 1. Materials processing under microwave and non-equilibrium reaction fields. 2. High-pressure synthesis and crystal chemistry of inorganic compounds. 3. Sonochemical processing of inorganic materials.
Chemistry of Molecular Systems (Quantum Physical Chemistry)	Professor Keisuke Asai AssociatProfessor Yutaka Fujimoto Assistant Professor Hiroki Kawamoto	Our research focuses on design and creation of novel materials with excellent electronic properties with the aim of applying them to the fields of optical and radiation engineering. Our research involves investigating a variety of electronic properties of matter employing techniques in material engineering, including nanotechnology. The primary research topics involve creation of as yet unachieved electronically excited states using hybridization of different materials and their heterostructures, controlling the electronic properties of condensed matter via dimensionality of electronic structure, and fabrication of electronic systems with strong interactions and correlations. The developed materials and technologies will contribute immensely to the advancement of optical devices and radiation sensors.
Environment Conservation Center (Environment Conserving Chemistry)	Professor Shuichi Oi Senior Assistant Professor Shinya Tanaka	We are developing new material conversion reactions by appropriately controlling the reaction field such as solvent and temperature combining new catalysts and reactants appropriately. We focus on the development of material conversion reactions centered on organic chemistry. Specifically, development of chemical conversion reactions of carbon dioxide and carbon monoxide to useful substances, new addition reactions and coupling reactions using homogeneous catalysts, new electrophilic reactions using Lewis acids have been achieved.

Laboratory	Professor / Associate Professor	Description of Research
IMRAM Materials-Measurement Hybrid Research Center (Hybrid Material Fabrication)	Professor Tomoyuki Akutagawa Assistant Professor Shun Dekura Assistant Professor Tetsu Sato	Electrical conducting, magnetic, emission, and ferroelectric properties are our essential research targets in molecular assembly structures such as organic π-molecules and metal coordination compound . Various types of molecular assemblies from single crystals, liquid crystals, plastic crystals , nanowires, organogels, to micelles can be applied for future molecular devices and organic – inorganic hybrid materials are also one of the useful building blocks for design of future thermoelectric and photoelectric energy conversion systems.
IMRAM Materials-Measurement Hybrid Research Center (Photo-Functional Material Chemistry)	Professor Masaru Nakagawa Associate Professor Tomoya Oshikiri Assistant Professor Hiromasa Niinomi	We pursue photonics, photochemistry, and photophysics of molecules on "metasite," which we propose as an artificially created nano-clearance between/among metal and/or dielectric nanostructures with single-digit-nanometer accuracy to induce unprecedented chemical reactions and physical phenomena. To realize this goal, we focus on the mold-using nanoimprint technology with atomic-scale accuracy and develop polymer resists for electron beam exposure, photocurable molecular resists, super precise coating processes, processes and materials for optical alignment and lamination, and nanolithography.
IMRAM Division of Measurements (Polymer Physics and Chemistry)	Professor Hiroshi Jinnai Senior Assistant Professor Tomohiro Miyata Assistant Professor Shusuke Kanomi	Polymers self-assemble to form highly periodic nano-scale structures that are useful in manufacturing advanced devices, such as super high-density memory, batteries, tire treads, and high-performance membranes. We focus on fundamental and basic aspects of the self-assembling processes and their resulting nano-structures that occur in the phase transition and phase separation in polymeric systems. For a complete understanding of the static and dynamic features of nano-structures, we specialize in developing advanced electron microscopy, including electron tomography (three-dimensional transmission electron tomography, 3D TEM).
IMRAM Division of Inorganic Material Research (Inorganic Materials for Chemical Transformation)	Professor Hideki Kato Assistant Professor Shunya Yoshino	Our research interest focuses on the construction of high-performance inorganic materials for photon energy conversion to chemical energy called as artificial photosynthesis and utilization of biomass. To improve properties of inorganic materials, we control physical properties of solids, such as band structures, defects, and electron traps, and change the reaction properties, enhancement of the target reaction and suppression of backward reactions, by surface modification. We also examine synthesis processes to control morphology and surface structure. In addition, exploring of new inorganic compounds and development of new reaction processes are also studied.

Notes： 1. For laboratories marked with ※, please make initial contact in advance with the office, Appl. Chem., Chem. Eng. and Biomol. Eng. 〔TEL(022)795-7205〕

2. Please obtain more detailed information on the topics from the office of Appl. Chem., Chem. Eng. and Biomol. Eng. 〔TEL(022)795-7205〕.

Department of Chemical Engineering

Laboratory	Professor / Associate Professor	Description of Research
Energy Process Engineering	Professor Hideyuki Aoki Associate Professor Yoshiya Matsukawa	Energy conversion and its utilization must be carried out considering environmental impact. Our laboratory aims to: 1) ensure environmental protection, 2) design processes that use energy efficiently, and 3) design systems that make effective use of resources. A few examples are: numerical analysis of spray painting process by using LES and VOF methods, chemical reaction dynamics analysis of soot formation and depression, numerical simulation of coal gasification and combustion for high-level coal utilization, numerical estimation of biomass-containing porous material strength by using FEM or RBSM with the aid of machine learning and the numerical simulation of reaction tube fouling in naphtha crackers. Our objective is to achieve high-efficiency industrial processes and to reduce CO_2 emissions by applying both experimental studies and numerical simulations.
Chemical Process Engineering (Material Processing)	Professor Daisuke Nagao Associate Professor Keishi Suga Assistant Professor Kanako Watanabe Assistant Professor Hikaru Namigata Assistant Professor Tom Welling (FRIS)	Control over micro- or nano-structures of materials are essential for creating new functional materials. Our group focuses on materials processing for preparation of monodisperse particles having uniform sizes, morphologies and chemical compositions. We study the building-up processes of such monodisperse particles for development of advanced functional materials. Synthetic processes on composite particles and thin films, self-assembling process of monodisperse particles and clarification of particle formation mechanisms are also studied.
Chemical Process Engineering (Reaction Process Engineering)	Professor Naomi Shibasaki-Kitakawa Associate Professor Atsushi Takahashi Assistant Professor Kousuke Hiromori	We are developing a novel and efficient production process based on chemical and biological reaction engineering, targeting a wide range of fields such as environmental, food and pharmaceuticals, and functional materials. Specifically, we are working on the following topics: 1) continuous production process of bio-based esters using heterogeneous catalysts, 2) separation and purification processes of natural bioactive compounds, 3) production processes of high value added substances using biological reactions, 4) conversion process of high value-added products from renewable resources using heterogeneous catalysts, 5) oxidation and antioxidant mechanisms of bioactive compounds in food and biological systems.
Process Systems Engineering (Material Control Process Engineering)	Professor Masaki Kubo Assistant Professor Takamasa Saito	To provide the guidelines for design and control of the macroscopic flow, temperature and concentration fields in materials processing and manufacturing, and moreover the higher-order structures and their related functions of materials, the studies on the following subjects are conducted using both in-situ observations and numerical simulations: Crystal growth processes of semiconductors and oxides, Electromagnetic levitation processes of molten metals and semiconductors, Manufacturing processes of functional polymer thin films, Processes using nanoparticles, etc.
RCSCF (Engineering Fundamentals)	Associate Professor Masaki Ota	Aiming to realize a sustainable society, we are developing higher-order systems by functionally using functional molecules that are compatible with the environment, that is, environmental solvents and their mixtures. Specifically, based on thermodynamics and transport phenomenology, we design new environmental molecules and their mixed systems for effective use of natural/synthetic compounds according to the purpose, and verify their functionality. In addition to basic thermodynamics/transport properties, we are also studying the theoretical systemization using chemical engineering dimensionless numbers. As a final product, we are targeting a wide range of targets such as cosmetics, perfumes, chemical products, as well as pharmaceuticals, foods and beverages, and we will also develop effective biomass utilization technology that applies the functionality of environmental solvents and supercritical/subcritical solvents.

Laboratory	Professor / Associate Professor	Description of Research
RCSCF (System Development)	Professor Masaru Watanabe Assistant Professor Yuya Hiraga Assistant Professor Yuta Nakayasu (FRIS)	In order to develop green processes for the issue of environmental, energy and resource circulation (sustainability), green solvent such as CO2 and water is managed to utilize for various applications, in particular by focusing ionic behavior in the solution and/or the surface of functional solid materials. Biomass upgrading, recycle of unused or waste materials, valorization of resources are targeted. Based on the basic knowledge of high pressure fluids with ionic species, development of the process and system is also studied.
IMRAM Materials-Measurement Hybrid Research Center (Hybrid Carbon Nanomaterials)	Professor Hirotomo Nishihara (AIMR) Associate Professor Takeharu Yoshii Assistant Professor Hirotaka Nakatsuji	We have developed a variety of advanced functional carbon materials and their composite materials by means of organic chemistry and materials chemistry from the view point of materials process engineering. Also, we focus on the elucidation of physicochemical properties of carbon materials including reactivity, durability, and catalysis from the view point of chemistry and reaction engineering by using advanced analysis techniques. Moreover, we proceed in the application of our advanced carbon-based materials for supercapacitors, secondary batteries, fuel cells, heat pump, new energy devices, functional adsorbents, catalysis, and healthcare, with many collaborators including research organizations and companies.
IMRAM Division of Process and System Engineering (Supercritical Fluid and Hybrid Nano Technologies)	Professor Takaaki Tomai (FRIS) Senior Assistant Professor Kazuyuki Iwase	Our research characterized by the use of supercritical fluid as a "reaction field" focuses on interdisciplinary nanomaterial science crossing chemical engineering, materials science, and energy engineering. We are developing the control strategy of higher-order structured nanomaterials by understanding and controlling the interactions in nanomaterial processes thermodynamically and electrochemically. Furthermore, based on the new nanomaterials technology, we are developing chemical processes that contribute to the realization of a carbon-neutral society, such as low-temperature waste heat recovery, carbon dioxide/waste recycling.

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Department of Biomolecular Engineering

Laboratory	Professor / Associate Professor	Description of Research
Applied Life Chemistry	Associate Professor Seiji Takahashi Assistant Professor Toshiyuki Waki	The research of this laboratory deals with basic and applied aspects of biochemistry and molecular biology of microbial and plant specialized metabolisms, which are highly diverse in terms of catalytic competence and specificity of enzymes and chemical structures of metabolites. The research topics include identification, functional characterization, elucidation of catalytic mechanisms, and determination of 3D structures of novel enzymes/biosynthetic machineries in plant specialized metabolism, such as flavonoid and isoprenoid biosynthesis, as well as their protein and metabolic engineering studies.
Bioorganic Chemistry (Bioelectrochemistry)	Professor Hitoshi Shiku Associate Professor Kosuke Ino Associate Professor Hiroya Abe (FRIS)	Our research focuses on the development of electrochemical methods and optimal analyses for characterization of medical, energy and environmental materials. Examples are: 1. New sensing technologies to evaluate biomolecular and cellular functions by combining scanning probe microscopy, electrochemical and microfabrication methods. 2. Detection of localized ionic and electron transfer rate with sub-micro meter scale of various functional materials including cell-nanomaterials complexes and functionalized electrodes.
Bioorganic Chemistry (Applied Organic Synthesis)	Professor Tetsutaro Hattori Associate Professor Naoya Morohashi Assistant Professor Yuichi Kitamoto	We develop novel organic reactions and reaction methods to efficiently prepare only what is needed, and functional molecules based on molecular recognition chemistry, on the model of enzymes that exhibit excellent molecular recognition ability and highly-active and selective catalysis. In particular, the following issues are under investigation: regio- and stereoselective derivatization of calixarenes and the development of their functions, a study on molecular recognition abilities of nanoporous molecular crystals and its application to the development of separation materials, fixation of carbon dioxide to unsaturated compounds, electrophilic alumination and borylation of unsaturated compounds, control of optical resolution and asymmetric reactions using solvent polarity.
Biofunctional Chemistry (Applied Biophysical Chemistry)	Professor Nobuyuki Uozumi Associate Professor Yasuhiro Ishimaru Assistant Professor Masaru Tsujii	Our laboratory's research is directed at the elucidation of membrane transport machinery known as "ion channel and transporter" mediating crucial signal transduction pathways to ensure intracellular homeostasis and integrity of bacteria including E. coli, cyanobacteria and yeast, and plant cells. We develop experimental approaches in molecular biology (genetic engineering), biochemistry and electrophysiology to identify biochemical molecules implicated in adaption to various abiotic stress, in particular, salinity and drought stress, leading to enhanced production of biomass and solar-derived natural energy.
Biofunctional Chemistry (Protein Engineering)	Professor Mitsuo Umetsu Associate Professor Hikaru Nakazawa Assistant Professor Tomoyuki Itou	We design and create functional molecules based on protein structure format and on genomic techniques. Crystal structure information and evolutional engineering are used in creating available proteins for the therapeutic, environmental, and nanotechnology fields. In addition, the designed proteins are assembled with organic and inorganic nanomaterials for opening new frontiers for recombinant proteins.
IMRAM Materials-Measurement Hybrid Research Center (Organic- and Bio-Nanomaterials ※)	Professor Hitoshi Kasai Senior Assistant Professor Hiroki Oka	For the design of conventional drug compounds, it is common to add a water-soluble substituent to a compound having a pharmacological effect. In our laboratory, we take the reverse strategy and design novel anti-cancer drugs and eye drops composed in the dimer or the compounds chemically-combined with poorly water-soluble substituents to overcome the existing clinical problems. Using our reprecipitation technique for fabrication of organic nanoparticles, we have established the methods to obtain nano-prodrugs having particle sizes of 100 nm or less. We are aiming at practical application of these nano-prodrugs and are also expanding our nano-technological methods to cover a wide range of fields.

Green Goals Initiative Research Center for Green X-Tech (Bioresource Engineering)	Professor Yutaka Tamaru	The biological macromolecules that make up living organisms consist of various individual molecules or complex molecules formed by their combination. These are synthesized through catalytic reactions involving enzymes and other factors. In this field, Ｉ focus on synthetic biology based on biochemistry and molecular biology, leveraging bioinformatics for green chemical production, and developing bio-pharmaceuticals by harnessing biological functions. Specifically, they explore efficient techniques for biomanufacturing by studying various metabolic and synthetic pathways found in microorganisms, plants, and animals that thrive at room temperature and pressure, often utilizing model organisms.

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