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 Research Institute (0)

③ Cooperative Laboratories

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

Division of Measurements (1), Polymer Hybrid Materials Research Center (3)

Department of Chemical Engineering

① Core Laboratories

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

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 (2), Research Center (1)]

Division of Inorganic Material Research (1), Division of Process and System Engineering (1), Center for Exploration of New Inorganic Materials (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)

Polymer Hybrid Materials Research Center (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	We propose a new academic research frontier, "Vacuum Science & Engineering for Solid-Liquid Interfaces"; taking advantage of both the existing vacuum and solution processes, novel fabrication/synthesis routes and characterization/analysis tools that have been developed in material science. Research in this laboratory includes thin film and crystal growth processes controlled at the atomic, molecular levels, vacuum electrochemistry, and *in situ* high-temperature laser microscopy for solid-liquid interfaces. It is our goal to obtain basic insight into structures and properties characteristic of nano-sized liquids stabilized on a solid surface in a vacuum, some of which are key to realizing vacuum processes at solid-liquid interfaces, in which we aim at the exploration of new functionalities of materials useful for electronic information, energy and environmental technologies.
Resources and Environment (Energy Resource Chemistry)	Professor Keiichi Tomishige Associate Professor Yoshinao Nakagawa	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 (Electrochemical Science and Technology※)	Professor Hitoshi Shiku Associate Professor Kosuke Ino	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.
Chemistry of Molecular Systems (Synthetic Chemistry of Advanced Materials※)	Professor Hirotsugu Takizawa Associate Professor Yamato Hayashi	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 reearch 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 Associate Professor Masanori Koshimizu	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.

Laboratory	Professor / Associate Professor	Description of Research
IMRAM Polymer Hybrid Materials Research Center (Hybrid Material Fabrication)	Professor Tomoyuki Akutagawa	Electrical conducting, magnetic, emission, and dielectric properties are our essential research targets in molecular assembly structures such as organic □-molecules and molecular clusters. Various types of molecular assemblies from single crystals, liquid crystals, Langmuir-Blodgett films, nanowires, to micelles can be applied for future molecular devices and organic – inorganic hybrids are also one of the useful building blocks for design of future thermoelectric and photoelectric energy conversion systems.
IMRAM Polymer Hybrid Materials Research Center (Polymer Hybrid Nanomaterials※)	Professor Masaya Mitsuishi	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 (MOFs) 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.
IMRAM Polymer Hybrid Materials Research Center (Photo-Functional Material Chemistry)	Professor Masaru Nakagawa Associate Professor Takahiro Nakamura	Our research topics address the material and process science necessary to nanofabricate innovative electronic and optical nanodevices. The keywords related to our research group are light, interface, organic polymer, metal, inorganic material. Nanoimprint lithography involving electron beam lithography is selected as a mass-productive and cost-effective nanofabrication method. Studies of photo-curable resins for resist materials, screen printing with laser-drilled polymer masks, fluorescence alignment, plasma and ion dry etching, directed self-assembly for densification, atomic layer deposition, and sequential infiltration synthesis are dealt with to achieve sub-15 nm nanofabrication.
IMRAM Division of Measurements (Polymer Physics and Chemistry)	Professor Hiroshi Jinnai Lecturer Hironori Marubayashi	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 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).

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

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 Yohsuke Matsushita	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 porous material strength and the numerical simulation of reaction tube fouling in naphtha crackers. Our objective is to achieve high-efficiency industrial processes by applying both experimental studies and numerical simulations.
Chemical Process Engineering (Material Processing)	Professor Daisuke Nagao	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	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 for bio-based fuels and chemicals using heterogeneous catalysts, 2) separation and purification processes of natural bioactive compounds, 3) production processes of high value added substances using biological reactions, 4) oxidation and antioxidant mechanisms of bioactive compounds in food and biological systems.
Process Systems Engineering (Material Control Process Engineering)	Professor Takao Tsukada Associate Professor Masaki Kubo	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.
Process Systems Engineering (Chemical Systems Engineering)	Associate Professor Yasuhiro Fukushima	Establishment of diverse symbiotic industrial systems tailored to maximize wealth under socioeconomic and environmental constraints is expected to contribute to the realization of a sustainable society. Substantial reduction on our dependence of fossil resources is among the most important constraints that needs to be met by thoughtful use of locally available resources in industries and communities. Innovative processes and materials are the key to this challenging endeavor. We use analytical tools such as Life Cycle Analysis (LCA) and Material Flow Analysis (MFA) and Decision Sciences to develop methods for 1) integrated design of symbiotic industrial systems, and 2) coordinated innovation of emerging technologies, on the basis of theories and simulation tools in process systems engineering.

Laboratory	Professor / Associate Professor	Description of Research
RCSCF (Engineering Fundamentals)	Professor Hiroshi Inomata	Supercritical fluids (SCFs) have been expected to be environmental friendly solvents because it is possible to vary their physical properties by tuning temperature or pressure. Among the many candidates for SCFs, carbon dioxide (CO_2) and water (H_2O) are mostly our focus due to their unique and safe environmental characteristics. We have proposed original technologies by applying SCFs as alternatives to hazardous organic solvents in various chemical processes through performing both fundamental and applied researches. Examples of on-going research topics are as follows: i) measurement of physical properties and phase equilibria of SCF mixtures, ii) thermodynamic prediction models for phase equilibria, iii) molecular simulation of the solution structure of SCF mixtures, iv) extraction/fractionation of bioactive components from natural plants, v) supercritical dry cleaning/recycling technology, vi) supercritical impregnation for functional materials.
RCSCF (System Development)	Professor Masaru Watanabe	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, varolization of resources are targeted. Based on the basic knowledge of high pressure fliuids with ionic species, development of the process and system is also studied.
IMRAM Center for Exploration of New Inorganic Materials (Design of Advanced Inorganic Materials)	Professor Masato Kakihana (†) Associate Professor Hideki Kato	Our research interest focuses on the fabrication of high-performance photoceramics, such as photocatalysts and phosphors, which can contribute to sustainable society. We also develop superior precursors in terms of solubility and stability to synthesize high-functional photoceramics by "green" synthetic processes using aqueous media. In addition, we design new photoceramics based on knowledge in solid state chemistry and study strategies based on engineering of crystal-sites and band potentials to give new functions or to control the performance of photoceramics precisely.
IMRAM Division of Inorganic Material Research (Development of Hybrid Nano-System※)	Professor Kiyoshi Kanie	Functional hybrid materials have large potentials for our sustainable future life. We focus on design and synthesis of novel-types of hybrid materials beyond the conventional frameworks of organic, inorganic, and biochemical syntheses. From a viewpoint of application of the hybrid materials toward practical usage to improve qualities of future society and life, development of the fabrication process of the materials is also our important research target. Researches such as artificial control of quantum effects of nanomaterials and construction of macro-scale bulk materials through self-organization are our representative targets. The researches not only lead to clarify mechanism of introduction of unique material features but also social implementation of the hybrid materials.
IMRAM Division of Process and System Engineering (Supercritical Fluid and Hybrid Nano Technologies)	Professor Tadafumi Adschiri (AIMR) Associate Professor Takaaki Tomai	Using reactions in supercritical fluids, we develop novel nanosized/nanostructured materials and study their applications. We also develop chemical processes to solve environmental and energy problems, such as low-temperature waste heat recovery, hydrogen production, and resource recycling. Based on the interdisciplinary viewpoint of chemical engineering, materials science, and energy environmental science, we create novel nanomaterials for science and technology.

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1. An asterisk (†)indicates that the professor is scheduled to retire in March 2020.

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Department of Biomolecular Engineering

Laboratory	Professor / Associate Professor	Description of Research
Applied Life Chemistry	Professor Toru Nakayama Associate Professor Seiji Takahashi	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 (Functional Mactromolecular Chemistry)		
Bioorganic Chemistry (Applied Organic Synthesis)	Professor Tetsutaro Hattori Associate Professor Naoya Morohashi	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 Yasyuhiro Ishimaru	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	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 Polymer Hybrid Materials Research Center (Organic- and Bio-Nanomaterials)	Professor Hitoshi Kasai	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.

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