Department of Applied Physics

Laboratory	Professor / Associate Professor	Theme of research
Applied Interface Physics (Spin Electronics)	Mikihiko Oogane, Professor Takafumi NAKANO, Associate Professor	The spintronics field has been attracting attention. In our laboratory, we are discovering new phenomena utilizing character of spins in ferromagnetic thin films and multi-layers. In addition, we have been developing novel spintronic devices such as ultra-sensitive bio-magnetic field sensors that can detect weak magnetic field from human heart and brain.
Applied Solid State Physics (Mathematical Physics)	Takashi YOSHIDOME, Associate Professor	We study the motion of nano-scaled molecules based on mathematical physics and statistical mechanics. The data obtained by computer simulation are analyzed to (1) elucidate the mechanism of protein motors, (2) classify the data of protein simulations by using the method of manifold learning, (3) accurately predict the hydration structures around proteins using a deep learning, and so on.
Applied Solid State Physics (Solid State Physics)	Yukihiro SHIMIZU, Associate Professor	Quantum computers are expected to be used to understand highly entangled quantum states. Our laboratory conducts research on quantum algorithms for efficient use of quantum computers. Based on quantum mechanics, condensed matter physics, and quantum information theory, we aim to develop new computational methods for handling multi-degree-of-freedom systems. For example, we are developing quantum algorithms for computing the time evolution of strongly correlated states using time-dependent variational algorithms and mapping algorithms of tensor networks to quantum circuits.
Applied Solid State Physics (Quantum Computational Materials Science)	Hiroki TSUCHIURA, Associate Professor	Established in October 2023, our group specializes in the theoretical study of superconductors and magnetic materials with topological quantum states, based on theoretical physics and quantum computational methods. Current research areas include topological superconductivity with broken spatial symmetries, the analysis of anomalous transport properties in magnetic topological materials, and the application of the VQE algorithm to the study of strongly correlated superconductors.

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Applied Solid State Physics (Quantum Information Physics)	Hiroaki MATSUEDA, Professor	Quantum information-theoretical knowledges such as entanglement are powerful tools in many branches of theoretical physics. We aim to construct mathematical basis for next-generation interdisciplinary physics by dealing with various problems such as condensed matter physics, mathematical physics, and space-time physics. Issues of particular interest are: nonequilibrium dynamics of quantum many-body systems (dynamic phase control and relaxation processes of qubit-many-body systems), basic physics of quantum technologies such as quantum measurement and quantum calculation, topological physics, techniques of many-body physics (composite operators, tensor networks, and singular value decomposition), and research on information and space-time based on quantum/classical correspondence.
Applied Material Physics (Functional Crystalline Materials)	Yuzuru MIYAZAKI, Professor Kei HAYASHI, Associate Professor	We have been exploring novel energy-harnessing materials, such as thermoelectric materials, photovoltaic materials, cathode materials for rechargeable batteries and high transition-temperature superconductors. Functions of a solid substance primarily depend on the electronic structure, directly derived from its crystal structure. Through high-quality structure analyses using neutron and X-ray diffraction, combined with first-principles calculations, we have been fabricating materials with desired functions.
Applied Material Physics (Low Temperature Physics and Superconductivity Physics)	Taro YAMASHITA, Professor **Masatsune KATO, Associate Professor	We are exploring novel superconducting quantum devices and investigating their underlying physics. We are developing superconducting qubits (such as transmons and flux qubits) for quantum computers, ferromagnetic π-junctions as superconducting spintronics devices, quantum amplifiers for detecting extremely weak quantum signals, and single-photon detectors essential for optical quantum computing.
Applied Material Physics (Biophysics and Bioengineering)	Shoichi TOYABE, Professor Shuichi NAKAMURA, Associate Professor	We are exploring the physics and engineering of autonomous and soft systems like biological phenomenon. Especially, with a focus on the mechanical motions such as the bacterial motion and biological nano-motors and the information processing such as the gene replication, we are studying the physics of nano-sized autonomous system subjected to thermal fluctuations. Furthermore, we are developing a novel engineering concept to produce artificial nanomachines by imitating the biological nano machineries.
Applied Material Physics (Photofunctional Materials Physics)	Madoka ONO, Professor	This lab is newly found in 2023. We aim to accelerate quantum communication technology by creating photofunctional materials with glass and amorphous. They possess random structure without grain boundary suitable for light manipulation. But even for glass, structural fluctuation limits the optical loss. By suppression of the fluctuation, glass with ultimate transparency is made. Controlling fluctuations in the structure, or conversely, activating inhomogeneity in structures enable us to create new functional materials.

Laboratory	Professor / Associate Professor	Theme of research
Institute for Materials Research (High Field Laboratory for Superconducting Materials)	Satoshi AWAJI, Professor Shojiro KIMURA, Associate Professor Yuji TSUCHIYA, Associate Professor	Our laboratory is one of five steady high magnetic field facilities in the world. We develop high filed magnets and superconducting materials. In addition, the research in high magnetic fields on a solid state physics and superconducting materials, and a material development under magnetic fields are performed using a 30 T hybrid magnet, a 25T cryogen-free superconducting magnet and a 20T superconducting magnet and so on.
Institute of Multidisciplinary Research for Advanced Materials (Nanoscale Magnetism)	Satoshi OKAMOTO, Professor	Magnetic material is one of the key materials for future automobile and aircraft electrifications and carbon neutrality issue such as motor cores and power-electronics passive devices. Our target is to explore the nanoscale magnetism and physics of various practical magnetic materials and to realize the high-performance magnetic devices which contribute to our future society.
Institute of Multidisciplinary Research for Advanced Materials (Synchrotron Radiation Soft X-ray Microscopy)	Takeo EJIMA, Associate Professor Susumu YAMAMOTO, Associate Professor	In our laboratory, we focus on developing optical components, optical techniques, and innovative measurement methods that utilize cutting-edge soft X-ray light sources such as NanoTerasu. Our three main goals are: (A) to visualize functional properties (specifically electronic structures) of materials at the nanoscale, (B) to establish design principles for novel functional materials, and (C) to contribute to the advancement of science and technology in this field. Our current primary research areas include: 1. Utilizing NanoTerasu, a 3 GeV high-brilliance synchrotron radiation facility, 2. Developing soft X-ray optical components for next-generation semiconductor lithography systems, 3. Developing soft X-ray operando measurement techniques and applying them to surface and interface reaction processes, 4. Applying next-generation semiconductor optical components to soft X-ray microscopy.
Institute of Multidisciplinary Research for Advanced Materials (Quantum Electron Science)	Masahiko TAKAHASHI, Professor Noboru WATANABE, Associate Professor	Properties of matter, such as reactivity and functionality, are determined by the motion of electrons bound in matter. For this reason we develop and employ new spectroscopic methods using high-energy electron scattering in order, for instance, to visualize the electron motion in stable species and more importantly the change of electron motion in transient species, which is the driving force behind any chemical reactions. The project involves: 1. Development of a real-time spectroscopic complex for visualizing electron and nuclear motions during chemical reaction, 2. Molecular orbital imaging by electron momentum spectroscopy, 3. Development of multidimensional coincidence techniques for studies of stereo-dynamics in electron-molecule collisions.

Laboratory	Professor / Associate Professor	Theme of research
Institute of Multidisciplinary Research for Advanced Materials (Quantum Optoelectronics)	Shigefusa CHICHIBU, Professor Kohei SHIMA, Associate Professor	The main research themes are basic research and application of optoelectronic semiconductor materials such as (BAlGaIn)N and oxide semiconductors: epitaxial growth of their films and quantum structures; luminescence dynamics of excitons in them; coherent light source based on cavity polaritons.
Advanced Institute for Materials Research(AIMR) (Device/System Group)	Shigemi MIZUKAMI, Professor Hiroki MORISHITA, Associate Professor	Electrons and photons have a quantum mechanical property called "spin”. Our research focuses electronic and photonic devices fully utilizing “spin”, the physics behind, and advanced materials for these devices. For example, we are conducting research on magnetoresistive devices utilizing both magnetic materials and semiconductors to enhance the performance of nonvolatile spintronic memory. We are also conducting research on Quantum sensing using the semiconductor diamond to enhance the performance and functionality of quantum-spintronic sensors.

Note: For more detailed information, please contact the Electronic Information System and Applied Physics Academic Affairs Section [Phone: 022-795-7186].

◎Meaning of the symbols in the table

〔Faculty member〕

* Scheduled to retire in March 2026

** Scheduled to retire in March 2027