Division of Transdisciplinary Sciences

Department of Advanced Materials Science

Laboratory	Faculty	Introduction of research activities and laboratory	Key words	Projects or activities summer program students can participate
Arima-Tokunaga Laboratory	Dr. Taka-hisa ARIMA Dr. Yusuke TOKUNAGA	We are interested in transition-metal oxide compounds which show novel physical responses like 1) control of electric polarization of matter with a magnetic field, 2) change in shape of matter with a magnetic field, 3) control of magnetism of matter with an electric field, 4) control of optical property with a magnetic or electric field, and 5) directional birefringence/dichroism. All of these physical responses are related to the simultaneous breaking of more than one symmetry operation, referred to as 'multiferroicity'. We design multiferroic materials which are expected to host such novel responses, grow crystals, measure their physical properties, and investigate the origin of the physical responses from the microscopic point of view. We often utilize synchrotron and neutron facilities to reveal the symmetry breaking.	Multiferroics, Magnetism, Ferroelectrics, Optical spectrum	Summer-program students can participate in crystal growths of some transition-metal oxide compounds by a floating zone method, flux method, or chemical vapor transport method. They can perform measurements of x-ray diffraction to characterize the obtained crystals and to analyze the crystal structure. They can experience measurements of dielectric properties, magnetic properties, and optical spectra at low temperatures as well as room temperature. The student can also try the asymmetric crystal growth of inorganic compound.
OTANI Laboratory	Dr. YoshiChika OTANI	The concept of spin current, a flow of spin angular momentum, appeared in the end of 20th century, and evolved a new spintronic principle based on the atomic-scale angular momentum conservation such as spin-transfer-torque. The methods to generate, transport and detect the spin currents have been well established in the following decade, leading the spintronics research to a new phase. Recent studies revealed interconversions among quasi-particles such as electron, spin, phonon, photon and magnon etc. via spin current in a solid. These interconversions, called as "spin conversion", often take place in the nano-scale regions at the interfaces of deferent materials, and thus, have great versatility and application possibility.	Spintronics, Topological materials, Rashba interface, Spin momentum locking	We are currently working on the following projects; 1. Mechanisms of pure spin current generation and detection 2. Magnetic phase transition by using spin current 3. Spin-to-charge current conversion in the interface of topological insulator 4. Spin injection into organic materials 5. Spin injection into superconductor from ferromagnet

		Our fundamental researches explore new processes of the spin conversion and clarify their mechanisms. We also develop the spintronics devices to control a variety of spin conversion processes using nanofabrication technologies.		
Terashima and Ito Laboratory	Dr. Kazuo TERASHIMA Dr. Tsuyohito ITO	99% of the visible universe is in the plasma state and today's technologies and devices such as computers, smartphones etc. would not be a reality without plasmas and plasma processing. Our research focuses on the development of new, exotic plasmas, to push the frontiers of materials research even further. Plasma Materials Science is evolving as a major foundation for the development of advanced technological materials that find application in a large variety of emerging fields such as biotechnology, pharmaceutics and medicine, opto- and nanoelectronics. To address the challenges that the fabrication of new nanomaterials demands, the development of novel plasma techniques that allow to synthesize and process materials more efficiently, economically and ecologically, is necessary. This requires an interplay between different scientific and engineering disciplines. We hope to attract highly motivated students including summer program students who are capable to "think outside of the box" and are interested to work in an exceptionally interdisciplinary field and a research group that fosters international collaboration and exchange.	Plasma, Nanomaterials, Composite materials, Materials processing, Optical diagnostics	Various projects about/with plasma are available. While we can probably provide further choices according to your interests, some examples are; (i) optical diagnostics of plasma in/on water; (ii) cryogenic plasma treatment of polymer surface; and (iii) plasma nanoparticles synthesis via laser-ablation plasma in liquids. (i) Plasma generated in/on water is investigated with optical diagnostics. Optical emission spectroscopy with high-temporal resolutions (~1 ns) is applied to detect various reactive species and to reveal gaseous temperatures. Here, we would like to understand how to create low temperature environments with high densities of radicals (e.g. H and OH) originating from water. (ii) Effects of cryogenic temperature on plasma treatment of polymer surface are studied. The surface properties, such as wettability, are discussed with plasma properties. (iii) Laser-ablated plasma is formed by focusing a laser light on a solid target in liquids. The evaporated target materials are condensed to form nanoparticles. The properties of the nanoparticles depend on processing parameters; liquid properties, laser intensity, etc. The

				purpose is to control the properties of the particles via understanding the formation mechanisms of the particles.
Nakatsuji Laboratory	Dr. Satoru NAKATSUJI Dr. Takahiro TOMITA Dr. Akito SASAKI Dr. Tomoya HIGO	Material innovation has made various breakthroughs in basic science and applications. Recent research has shown that magnetic materials have great potential when they have topological properties. To advance our understanding of novel and potentially useful electronic and magnetic materials, our research utilizes a combination of high quality single crystal growth, thin film growth and measurements under extreme conditions (low temperature, high magnetic field, and high pressure). One of our primary aims is to search for new materials that exhibit exotic topological properties, which is currently a flourishing field in condensed matter physics. Recently, a large anomalous Hall effect, which has been seen only in ferromagnet, was discovered in an antiferromagnet at room temperature. The novel phenomena may come from topological structure called the Weyl points in the momentum space. Such novel properties in topological magnets can be potentially useful for spintronics application such as high-density non-volatile memory devices in smartphones and computers, and energy harvesting for the internet of things.	New Materials, Topology, Magnetism, Spintronics	We are planning to perform the following studies in the summer program. (1) Probing the Fermi surface of materials through quantum oscillation in their transport properties and magnetization in high fields up to 16 T and at low temperatures using the dilution and Helium-3 refrigerators. Students will learn the basics of high magnetic field and low temperature measurements, and how these conditions can be utilized to study the structure of the Fermi surface of quantum materials. (2) Searching for room temperature energy harvesting materials through a combination of single crystal growth and electrical and thermal transport measurements. Students will learn how to grow single crystals using various techniques and the method for measuring their electrical and thermoelectric properties. Students may choose one of these for their program, and we will guide them accordingly.