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Kansai Institute for Photon Science (KPSI)

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Photos provided by RIKEN

QST National Institutes for Quantum Science and Technology
Kansai Institute for Photon Science

Kansai Institute for Photon Science

関西光量子科学研究所

Pioneering a Brilliant Future with Photon Science

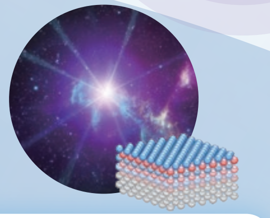
We aim to become one of the world's leading research and development centers that contribute to the development of quantum science and technology and the creation of innovation in Japan by making full use of cutting-edge laser and synchrotron radiation application technologies.

Quantum Beam Science Area

Quantum Technology Innovation Research Area

Quantum Medical Science Area

Quantum Energy Science and Technology Area

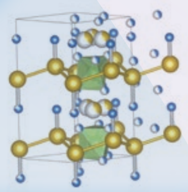


Contributions to Academia

Social Implementation of Laser Ion Acceleration

Applications to Quantum Technology

Medical and Industrial Applications



Realization of a Hydrogen-based Society

Ultra-high intense laser research and development of new quantum beam sources

Laser application research utilizing ultrafast measurement technology, etc.

Development of synchrotron radiation application including advanced non-destructive operand measurements

Theoretical simulation

Large-scale research and development facilities at Kansai Institute for Photon Science

Advanced Laser Research Facilities

QST synchrotron radiation beamlines at SPring-8

Realization of a sustainable future society through quantum science and technology research, etc.

Basic Research on Quantum Technology

Kansai Institute for Photon Science (KPSI) promotes "quantum technology innovation" in Japan by making effective use of the world's highest performance laser technology and synchrotron radiation measurement technology. As one of the government-designated "Fundamental Quantum Technology Hubs" , we promote the development of evaluation technologies for quantum materials, etc., and the development of technology and devices utilizing photonics and quantum technology.

Quantum Technology

Quantum technology is a technology that utilizes the behavior of quantum particles, which are microscopic particles such as atoms and electrons. It will be used in quantum computers, highly sensitive quantum measurement and sensing, and highly secure quantum networks, and is expected to develop in various fields such as medicine, materials manufacturing, finance, energy, and transportation.

Ultrafast laser technology to capture and control quantum dynamics

In collaboration with QST Takasaki Institute for Advanced Quantum Science

The dynamics of "quantum" particles such as electrons in atoms and molecules governs chemical reactions and the operation of electronic devices. Using ultra-short pulse lasers, we can observe atoms and electrons moving on a time scale of femto (1/1000 trillion) seconds and atto (1/1000000 trillion) seconds, respectively. We are exploring the frontier of "ultrafast dynamics research" by developing methods to monitor and control the properties of matter.

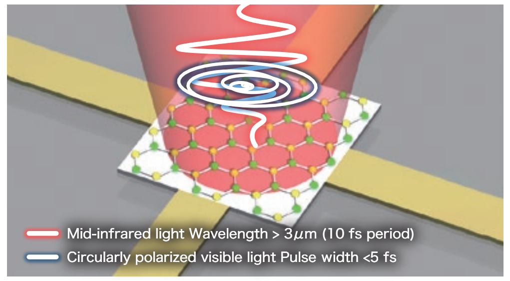
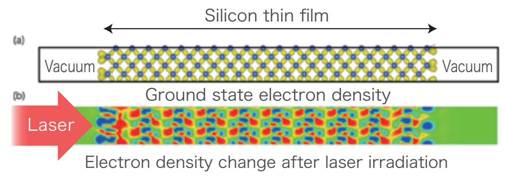


Image of ultrafast control of electronic devices using advanced laser technology

Simulation Technology to Understand Quantum motion in Materials

To manipulate quantum materials with lasers, it is essential to have a precise understanding of quantum phenomena such as electrons and spin within these materials. Through the development and operation of SALMON, a program that accurately describes the motion of light and electrons, we promote the elucidation of light-electron dynamics and facilitate applied research.



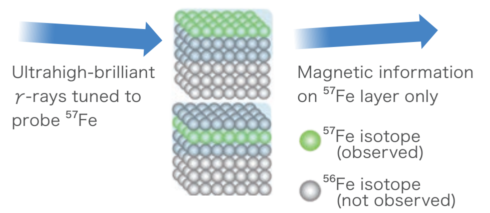
Electron density change induced in a silicon (Si) crystal by intense laser light, as predicted by SALMON

Magnetic Measurement Technology for the Development of Next-Generation Spintronics Materials

In collaboration with QST Takasaki Institute for Advanced Quantum Science

To accelerate the development of next-generation spintronics materials, which are quantum in nature, it is effective to microscopically investigate their magnetic properties. We are developing advanced magnetic measurement techniques that can achieve atomic-layer resolution using ultrahigh-brilliant γ-rays generated from synchrotron radiation.

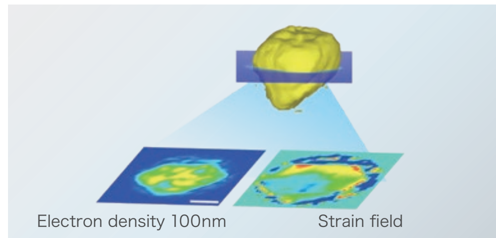
Probe layer method



Local magnetic measurement is realized by introducing a ^{57}Fe probe layer and using ultrahigh-brilliant γ-rays resonant with this layer.

Nondestructive Technology for internal imaging Quantum Material microcrystals

Nondestructive imaging techniques are essential for evaluating the quality of quantum materials, such as diamonds utilized in quantum sensors. To meet this critical demand, we are advancing a high-resolution technique that leverages high-quality coherent X-rays derived from synchrotron radiation to visualize strain distributions within microcrystals.



Nondestructive imaging technique for microcrystals

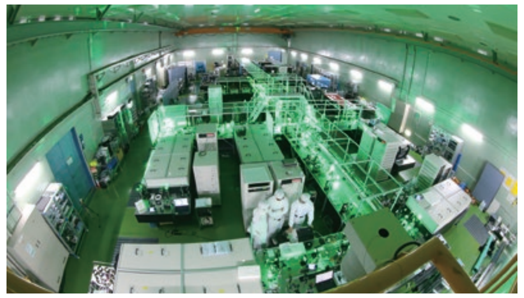
Cutting-Edge Laser Research

Cutting-edge lasers pioneer new scientific fields and create new industries

We are pursuing cutting-edge laser technology and developing the world's highest performance laser equipment. Academic research, which is only possible using these devices, opens up new scientific fields and produces results useful for industry and medicine. To this end, we are conducting intense laser science research, laser-driven ion acceleration technology, X-ray laser research, ultrafast optical properties research, and industrial medical applications of laser technology.

World's Top-Class High-Intensity Laser (J-KAREN-P)

The peak power of the J-KAREN-P laser we have developed is 1,000 trillion watts (petawatt), equivalent to 1 billion MW (Megawatt)-class power generation facilities, making it one of the world's most powerful lasers. This laser can generate ultra-high pressure, ultra-high temperature, and ultra-strong electric and magnetic fields that cannot be generated by any other means.



J-KAREN-P laser at Kansai Institute for Photon Science (KPSI)

Development of “Future” Compact Accelerators Using high-intensity Lasers

We are conducting research towards future compact accelerators using high-intensity lasers. Charged particles such as electrons and ions are accelerated using plasma to create higher acceleration gradients than ever before, producing high-quality charged particle beams over shorter distances. With ions we aim to miniaturize particle cancer therapy equipment and are currently developing advanced laser and irradiation technology with a target of 200 MeV for proton beams. In the future, we aim to accelerate not only protons but also heavy particles such as carbon beams. We have succeeded in accelerating electrons to 2 GeV and are developing a compact X-ray free electron laser system and a compact gamma-ray system. This will accelerate innovation in areas such as materials science and drug discovery.

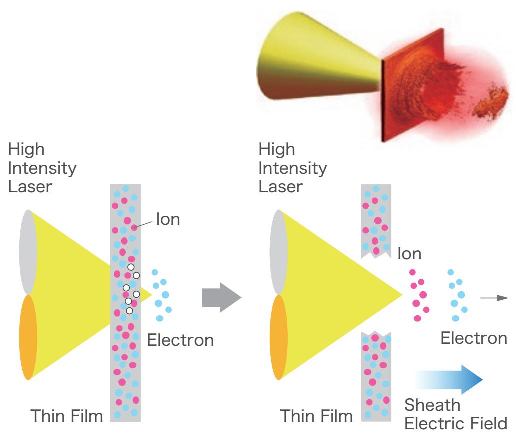
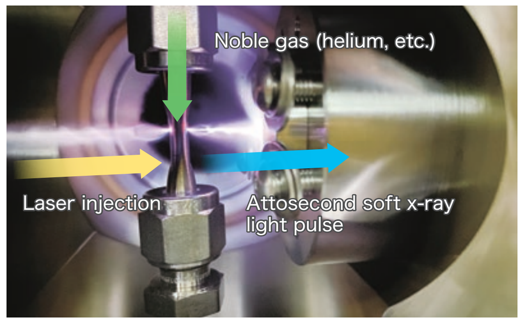


Image of laser plasma ion acceleration

Attosecond Soft X-ray Light Pulses Capturing Quantum Dynamics

The Nobel Prize in Physics in 2023 was awarded for the generation of attosecond light pulses as a tool for observing electron dynamics in matter. Kansai Institute for Photon Science has succeeded in the generation of attosecond light pulses in the soft x-ray region and is aiming to capture quantum dynamics in photosynthesis and semiconductor devices.



Attosecond soft X-ray light pulse generation

Soft X-ray Laser Processing Approaching the Quantum World

By utilizing quantum interference of light, we are developing laser processing technology to form microstructures such as electronic circuits with a width and depth of nanometer size, which is the size of several atoms. We are also developing a high-power coherent soft x-ray source and simulation calculation of the processed shapes.

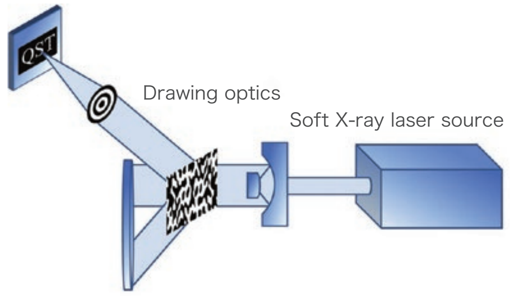
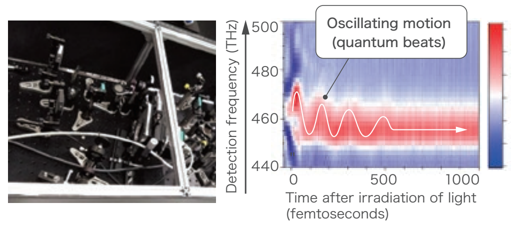


Image of laser processing using quantum interference

Development of Advanced Spectroscopies to Investigate Quantum Effects

In collaboration with QST Quantum Life Science Institute

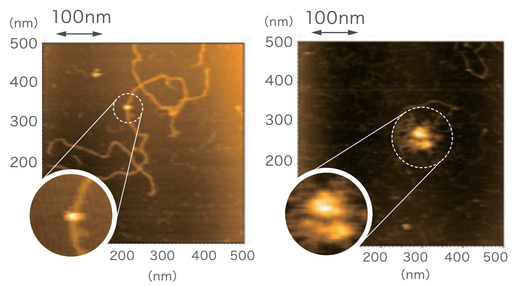
We are developing a two-dimensional electronic spectrometer using sub-10 femtoseconds laser pulses to observe energy transfer in photosynthetic proteins synthesized at the QST Quantum Life Science Institute (Chiba area), with the aim of elucidating the initial process of photosynthesis, especially the presence of quantum effects.



(Left) Two-dimensional electronic spectrometer.
(Right) Quantum beats observed in allophycocyanin (Constituent of photosynthetic protein) excited by femtosecond laser pulses

DNA Damage-Repair Research Using Advanced Laser Technology

We investigate how DNA damage occurs by irradiating lasers and laser-driven quantum beams. In addition, by utilizing advanced technologies such as fluorescence resonance energy transfer and atomic force microscopy, we are investigating DNA damage repair and mutagenesis processes. Our goal is to obtain knowledge that will be useful for cancer treatment and prevention.



Isolated base damage

Complex clustered damage

Advanced Synchrotron Radiation Research

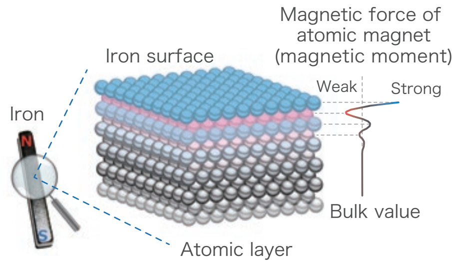
Using ultra-powerful X-rays to understand how quantum effects determine the properties of matter.

Our mission is to develop advanced measurement methods using high-brilliance synchrotron radiation. Novel and unique methods, such as ultra-local magnetic surveys with single-atomic layer depth resolution are used for the research and development of quantum materials such as spintronics materials and quantum sensors, and materials for environmental and energy applications such as hydrogen storage.

Technology for Layer-by-Layer Measurement of Magnetism in Magnetic Multilayers of Spintronic Materials

In collaboration with QST Takasaki Institute for Advanced Quantum Science

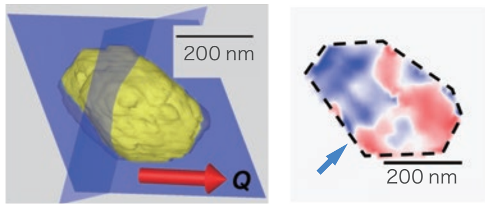
We have developed a new technology that enables magnetic measurements with depth precision at the atomic-layer level, and using this technology, we have revealed that the magnetic force of iron varies from the surface through each subsequent atomic layer in a wave-like manner. We are applying this technology to magnetic measurement of interfacial atomic layers of magnetic multilayers to develop new high-speed and energy-efficient magnetic devices.



Observation of the change in the magnetic state of each atomic layer on the iron surface

Visualization of Strain Inside Microcrystals of Quantum Materials, etc.

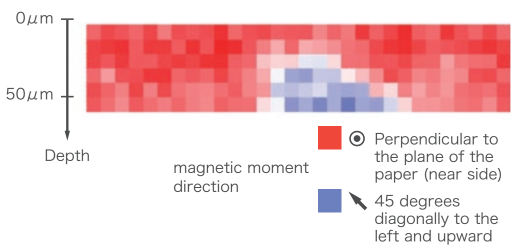
We have developed a Bragg coherent X-ray diffraction imaging technique using coherent X-rays and have achieved three-dimensional imaging within microcrystals at the100-nanometer level. We have also applied this technique to the high-resolution observation of the internal strain of materials for capacitors, etc., which will contribute to the improvement of their quality.



3D image of a microcrystal and strain field within the microcrystal

New Magnetic Microscope to Observe Magnetic Domains Inside Magnets

We have developed a magnetic microscope that enables nondestructive measurements of magnetic domains inside magnetic materials using a new magneto-optical effect in the hard X-ray regime. We are applying this microscope to study magnetic materials such as electrical steel sheets used in transformers and are conducting research that contributes to the improvement of their performance by observing the magnetic domain structure inside the materials.

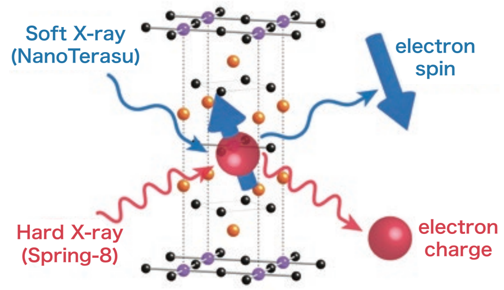


The observed magnetic domain structure of an electrical steel sheet

Measurement of electronic states responsible for physical properties and functionalities of materials through complementary use of hard and soft x-rays

In collaboration with QST NanoTerasu Center

We investigate the charge and spin states of electrons as well as the interactions acting on the charge and spin, which are responsible for the physical properties and functionalities of quantum materials and energy/environmental materials by means of various advanced spectroscopies using hard and soft x-rays in addition to computer simulations. Our goal is to clarify the mechanism of the physical properties and to improve the functionalities of materials.

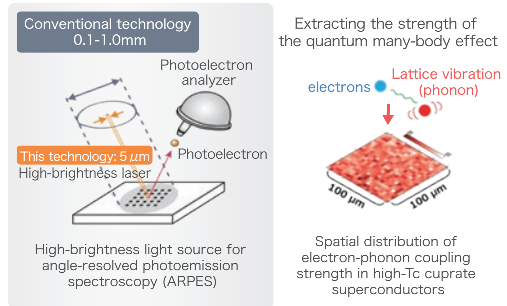


Complementary use of hard and soft x-rays enables us to measure both charge and spin states of electrons.

Technology for Visualizing the “Quantum Many-Body Effect” in High-Temperature Superconductors

In collaboration with QST NanoTerasu Center

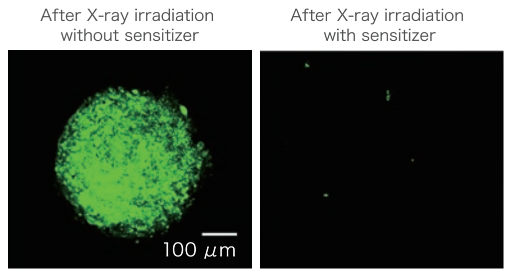
By combining advanced measurement instruments and data informatics, we have developed a technique for microscopically visualizing the “quantum many-body effect” at the micrometer scale. This effect, a unique force acting on electrons, is considered responsible for high-temperature superconductivity. By leveraging the high-brilliance soft X-rays from Japan’ s newest synchrotron radiation facility, NanoTerasu, we aim to achieve even higher spatial resolution and further advance the research and development of quantum materials.



High-resolution visualization of quantum many-body effects via angle-resolved photoemission spectroscopy

Cancer Radiation Therapy using Synchrotron Radiation X-rays

We are conducting research and development to use X-ray irradiation for killing cancer cells by utilizing both monochromatic X-rays and white X-rays containing various wavelengths. We have found that monochromatic X-rays with specific wavelengths can effectively eliminate cancer cells into which a sensitizing agent has been introduced.



Fluorescence microscope image of cancer cells after synchrotron radiation X-ray irradiation

Medical and Industrial Application Research for Social Implementation

Contributing to Society through Innovation with photonics and quantum beam technology

New technologies are being developed one after another for social implementation in the medical and industrial fields, utilizing the knowledge gained from the cutting-edge photon technologies developed at the Kansai Institute for Photon Science. Specifically, these include contributions to the medical field, such as cancer treatment and blood glucose level measurement, disaster prevention through high-speed diagnosis of defects in concrete buildings, and hydrogen production and storage technology, which is indispensable for realizing a decarbonized society.

Development of a "Heavy-ion Injector for Quantum Scalpel" that significantly downsizes a radiotherapy facility

QST aims to significantly reduce the size of a heavy-ion radiotherapy facility to promote the widespread use of "heavy-ion radiotherapy", which is highly effective and allows patients to maintain their daily lives. The Kansai Institute for Photon Science is working to downsize the injector device by using a novel technology called "laser-driven ion acceleration" to generate the heavy ion beams for the quantum scalpel.

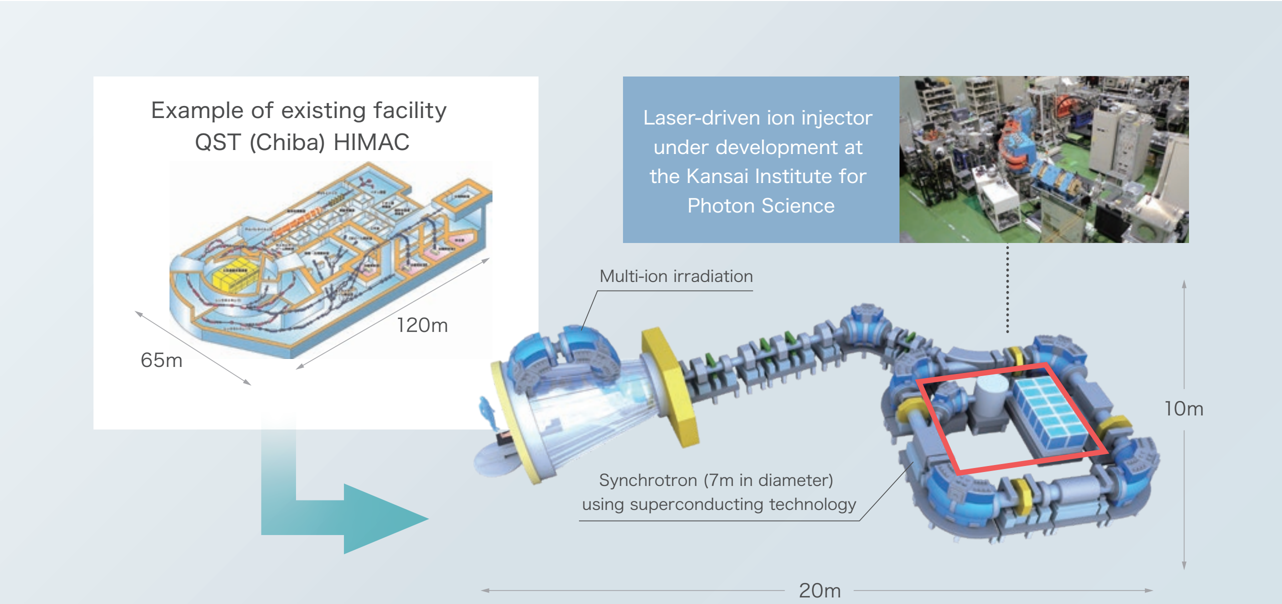


Image of the completed “quantum scalpel” under development at QST

Blood Glucose Sensor Developed to Eliminate the Need for finger pricking

More than 500 million diabetics worldwide must have their blood glucose levels measured multiple times a day by blood sampling, causing pain, mental stress, and the risk of infection. The Kansai Institute for Photon Science has developed a mid-infrared laser with an order of magnitude higher brightness than conventional devices, and established a new blood glucose measurement technology that does not require the insertion of a needle insertion.

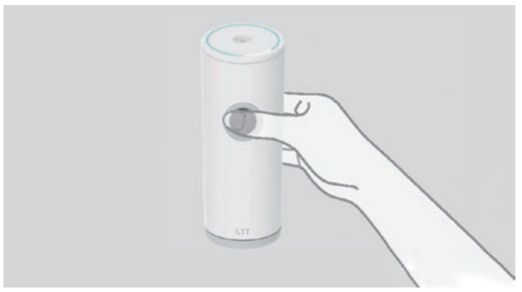
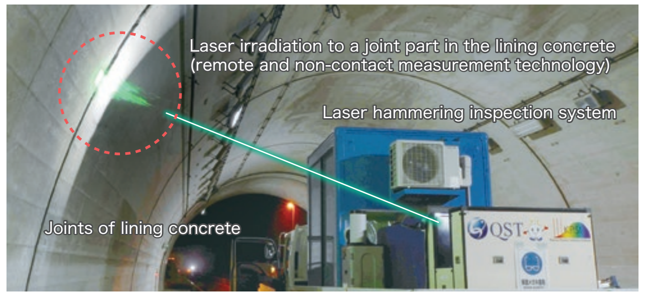


Image of a device that can check blood glucose levels in just 5 seconds
(Photo courtesy of Light Touch Technology Co.)

Development of Non-destructive and Non-contact Infrastructure Inspection Technology

We are developing laser hammering inspection technology using lasers to remote and digitize the hammering inspections to detect defects inside concrete. Mechanization and automation of inspections of infrastructure such as tunnels (left photo) and bridges (right photo) are being realized. This technology has been registered in the Inspection Support Technology Performance Catalog established by Ministry of Land, Infrastructure, Transport and Tourism and is now being used for actual inspections.



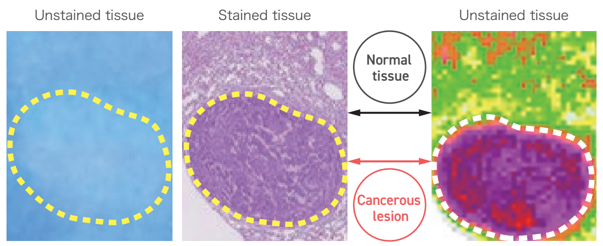
Laser hammering inspection in a road tunnel

Laser hammering inspection on a bridge

Development of “Microscope for Cancer Diagnosis” using Mid-Infrared Laser Technology

In collaboration with QST Institute for Radiological Science・Institute for Quantum Life Science

We are developing a microscopic imaging system for cancer diagnosis using this property. Traditionally, staining has been necessary for histological diagnosis. In this study, our goal is to enable rapid, accurate, and reliable cancer detection without tissue staining.

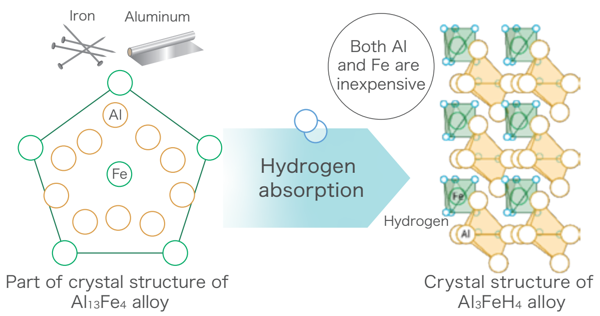


Images obtained with a visible light microscope (left) and a mid-infrared microscopic imaging system (right)

Development of Hydrogen Storage Materials without Expensive Rare Metals

In collaboration with QST Takasaki Institute for Advanced Quantum Science

Hydrogen storage alloys in practical use contain expensive rare metals. Utilizing in situ high-temperature and high-pressure X-ray diffraction experiments using synchrotron radiation, we have discovered that an alloy containing aluminum and iron, two inexpensive and abundant metals, can take up about 1000 times its volume of hydrogen. We are improving the alloy so that it can be used under practical pressure-temperature conditions and aim to implement it in society.



Crystal structure of a newly synthesized alloy of aluminum and iron (left) and its hydrogen storage (right)

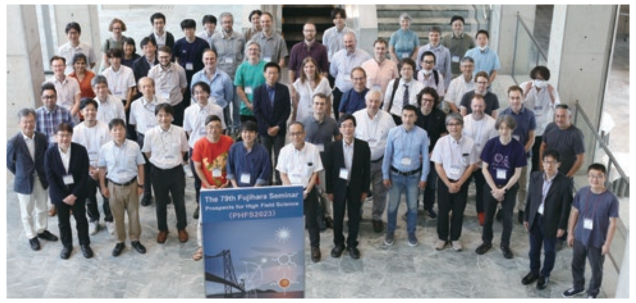
Activities for Various Collaboration, Human Resource Development and Public Relation & Outreach

Collaboration with Industry, Academia, Government, International and Local Communities

We promote research and development activities in cooperation and collaboration with domestic and foreign universities and research institutes and make our own experimental facilities available for external use. In addition, we participate in events in the region where we are located and actively accept facility tours and give lectures to promote understanding of science and technology. In addition, the Kids' Science Museum of Photons is also located in the same site, providing opportunities for visitors to experience science.

International Collaboration

KPSI is actively promoting domestic as well as international collaboration. We are improving the performance and experimental techniques of laser light and synchrotron radiation to the world's top level and accepting many researchers from overseas to conduct advanced experiments. In addition to experiments, we promote open science through collaboration in theory and simulation research.



Group photo at an international conference we hosted

Collaborative Research

To conduct joint research with external parties, we accept proposals for academic research and industrial technology development using advanced laser and synchrotron radiation equipment. (In principle, the results must be made public).

Facility Public Usage

We have established the "Facility Public Usage System" to make our state-of-the-art research facilities available for use by external parties. Under this system, external users can use the facilities for their own research and development, industrial use, or other purposes for a fee. Research proposals are solicited twice a year. (General industrial use and some facilities are available at any time).

Communication with the local Community

To further deepen interaction with the local community, we promote outreach activities such as opening our facilities to the public and participating in local events, and we are promoting various initiatives with the aim of becoming an "open research institute" that can contribute to society through optics.
The Keihanna Science City, where the Kizu district is located, is home to more than 150 research and university facilities, of which KPSI is positioned as a core research institute.
The institute actively participates in various events held in this city and promotes exchanges with local research institutions, universities and local residents.

Open-house exhibition (Upper: Kizu - Lower: Harima)

Facility Tours and Lectures

KPSI offers tours of its facilities to the general public at any time to promote interest in and understanding of science and technology, including optics. We are also actively engaged in human resource development and public relations activities.

Tour of the facility

Lecture at S-Cube

information

The Kids' Science Museum of Photons

KPSI has established the Kids' Science Museum of Photons for the purpose of promoting and educating visitors about quantum science and technology. In addition to the exhibition zone, the science museum has a planetarium where visitors can enjoy learning about and experiencing light and quantum technology. The museum also holds various events, such as crafts and experiments, especially for elementary school students, to encourage them to create the future.

きっづ光科学館ふぉとん
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