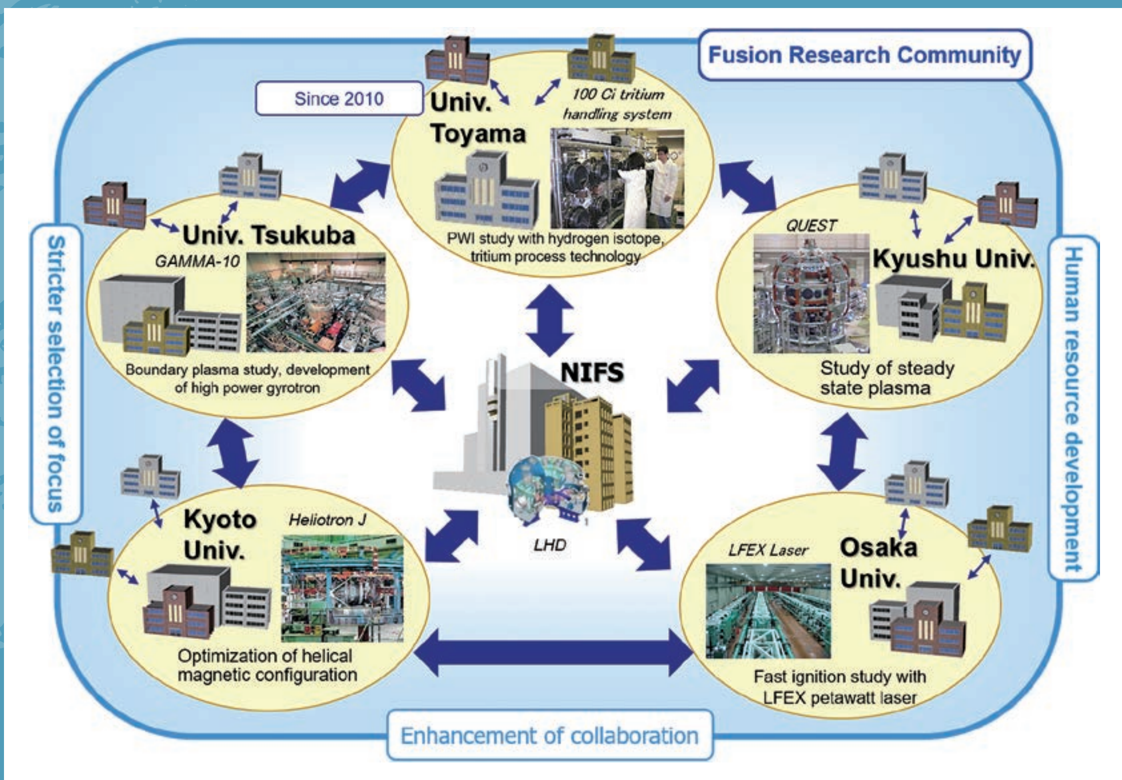
3. Bilateral Collaboration Research

The purpose of the Bilateral Collaboration Research Program (BCRP) is to reinforce the activities of nuclear fusion research in universities by using their middle-size experimental facilities of specific university research centers as joint-use facilities for all university researchers in Japan. The current program involves five university research centers as follows:

- Plasma Research Center, University of Tsukuba
- Laboratory of Complex Energy Process, Institute of Advanced Energy, Kyoto University
- Institute of Laser Engineering, Osaka University
- Advanced Fusion Research Center, Research Institute for Applied Mechanics, Kyushu University
- Hydrogen Isotope Research Center, University of Toyama

In the BCRP, each research center can have its own collaboration programs, using its main facility. Researchers at other universities can visit the research center and carry out their own collaboration research there, as if the facility belongs to NIFS. These collaboration research efforts are supported financially by NIFS as research subjects in the BCRP. They are proposed from all over Japan every year. The collaboration research committee, which is organized under the administrative board of NIFS, examines and selects the subjects.

(Y. Todo)


Fusion Research Community
Since 2010
Univ. Toyama
100 Ci tritium handling system
PWI study with hydrogen isotope, tritium process technology
Univ. Tsukuba
GAMMA-10
Boundary plasma study, development of high power gyrotron
QUEST
Kyushu Univ.
Study of steady state plasma
NIFS
LHD
Kyoto Univ.
Heliotron J
Optimization of helical magnetic configuration
LFEX Laser
Osaka Univ.
Fast ignition study with LFEX petawatt laser
Stricter selection of focus
Human resource development
Enhancement of collaboration

University of Tsukuba

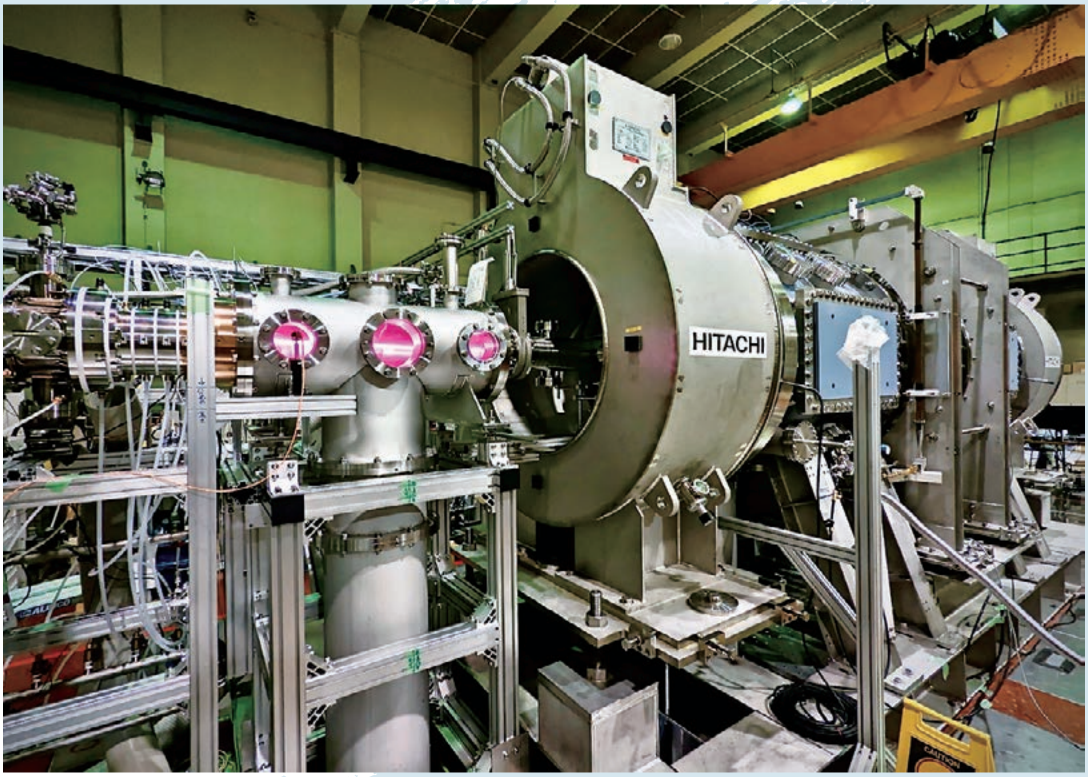


Fig. 1 Picture of the superconducting mirror machine “Pilot GAMMA PDX-SC.”

Highlight

Study of boundary plasmas by making use of open magnetic field configuration and development in high power gyrotrons towards the DEMO project

In the Plasma Research Center, University of Tsukuba, studies of boundary plasma and development of high-power gyrotrons have been done under a bilateral collaboration research program. Processes of plasma detachment have been studied by introducing hydrogen and impurity gases into the end-loss plasma in a divertor simulation experimental module (D-module) installed at the west end of GAMMA 10/PDX. In FY2023, we studied the influence of gas injection positions and timings on the process of detached plasma formation, the impact of impurity ions on reducing ion-particle flux, and the spatial distribution of detached plasma due to variations in V-shaped target plate angles and the position of the plasma center axis. A new linear plasma device Pilot GAMMA PDX-SC (Fig.1) was constructed. The first plasma was successfully created in October 2022, and then ECH and ICRF antenna systems were installed. Preliminary experiments in ECH heating were conducted. ECH power of ~100 kW was applied to plasma sustained by a cascade arc plasma source, and the plasma was expanded and the density was increased.

A divertor simulation study has been carried out by using end-loss plasma of GAMMA 10/PDX. A divertor simulation experimental module (D-module) was installed in the end region of GAMMA 10/PDX to be exposed to the end-loss plasma. To clarify the effect of an impurity gas injection position on the formation and control of the detached plasma, impurity gases were injected from the inlet (Up-port) or the V-shaped target corner of the D-module and observed by a high-speed camera with a four-branch optical system (Alba prism). When nitrogen gas was introduced as an impurity, it was observed that the ratio of emission intensity from nitrogen atoms to that from nitrogen molecules was higher upstream and lower at the V-shaped target corner. Additionally, nitrogen atoms emitted weakly at the plasma axis and strongly at the periphery. It indicates that the Nitrogen Molecule Activated Reaction (N-MAR) process follows different reaction paths in space.

Measurements with an ion-sensitive probe (ISP) in the D-module were done during the injection of hydrogen and nitrogen. The ion collector current of the ISP increased and decreased with hydrogen and nitrogen gas injection. Since the ion collector current is sensitive to ions with a larger Larmor radius due to its structure, the increase in the current seems to be attributed to the formation of impurity ions with mass greater than hydrogen. Therefore, the results obtained suggest that impurity ions such as NH_x^+ are formed at multiple periods during the injection of hydrogen and nitrogen, and it is considered that the reaction between nitrogen and hydrogen is involved.

The effects of different angles of the V-shaped target plate and plasma center axis positions (strike points) on the spatial distribution of detached plasma and its formation process were investigated. The spatial distribution of the Balmer line intensity ratio $I_{H\alpha}/I_{H\beta}$ (an index of H-MAR) for different plasma center axis positions was compared, and a significant change in the distribution of the H-MAR region was observed when the strike point was moved to the upper part of the target.

As for the advanced diagnostic development, a multichannel (multi-frequency) Doppler reflectometer system has been developed to simultaneously measure turbulent fluctuation flows at different radial locations in the central cell of GAMMA 10/PDX. An azimuthal flow profile was observed when the axial current and radial potential distribution of the plasma were altered by changing the ground resistance of end plates. It was found that the flow structure during ECH was changed by modifying the ground resistance, suggesting a difference in the electric field structure is one of the factors causing the flow structure change.

Regarding fluid simulations of open-field-system plasmas, progress was made in research on kinetic effects in parallel ion conductive heat flux by using a heat-flux-limiting technique and heat-flux transport equations. Temporal simulations of pellet injection experiments in GAMMA 10/PDX were also started and reproduced experimental observations qualitatively. In addition, kinetic analyses of plasmas in mirror magnetic fields were started by using a quasi-one-dimensional particle-in-cell model.

A gyrotron with the frequency of 14 GHz has been developed to apply to a fusion reactor with a low magnetic field. Problems of this development are a large divergence of electromagnetic wave beams due to the long wavelength and a difficulty with the electron beam parameter due to the low magnetic field. To improve the efficiency of electromagnetic wave transmission at low frequencies, the distance between the mirrors (optical path length) in the gyrotron was minimized, and the design was changed so that the coupling waveguide, which had been installed in the external matching unit, was built into the gyrotron.

In order to further promote the divertor simulation study, a new linear plasma device Pilot GAMMA PDX-SC (Fig.1) was constructed and the first plasma was successfully made in October 2022, and then ECH and ICRF antenna systems and three concentric ring plates for suppression of MHD instability were installed in the main chamber. At the east end, a differential pumping system and the plasma source were installed. As the plasma source, a cascade arc plasma source and a helicon plasma source were developed.

ECH power of ~100 kW was applied to the plasma sustained by the cascade arc plasma source, and the line-averaged electron density increased by one order of magnitude to 8×10^{17} m^{-3}. Although the plasma was expanded due to ECH, the line-averaged electron density was evaluated with a line length of 7 cm, which was the diameter of the plasma before applying ECH, indicating the actual electron density during ECH was a few times lower. Even taking that into account, the ECH power was used for plasma production due to high neutral pressure in the main chamber. It is necessary to develop the differential pumping system to reduce neutral pressure in the main chamber.

(M. Sakamoto)

Kyoto University

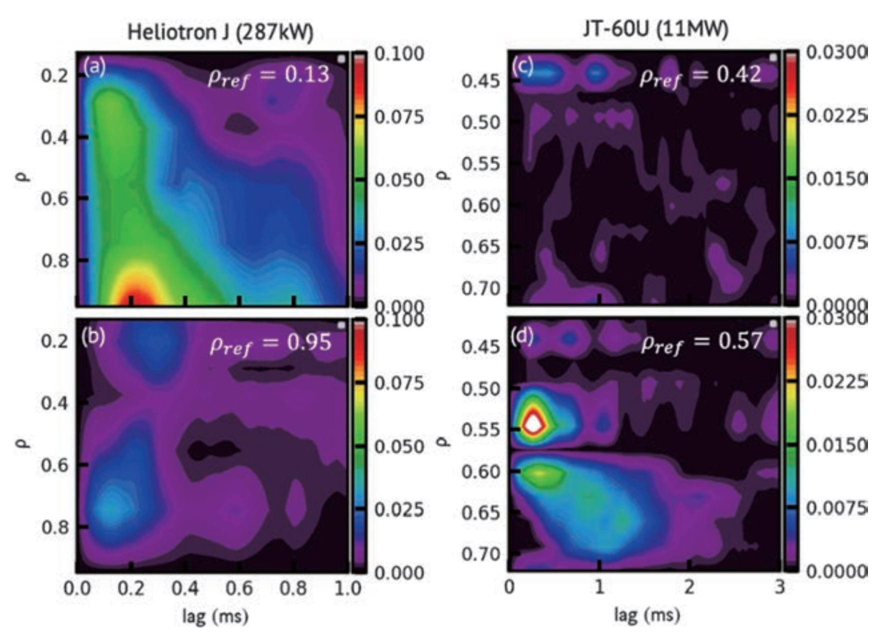


Fig. 1 The transfer entropy of electron temperature fluctuation in (a) and (b) Heliotron J and (c) and (d) JT-60U. The direction of information flow is represented as a reference location ρ_{ref}, which is indicating $T_{\rho_{ref} \to \rho_{others}}$. [F. Kin *et al.*, *Nucl. Fusion* **64**, 066023, 2024]

Highlight

Experiments utilizing magnetic field configuration and turbulence measurement

The Heliotron J device features a wide flexibility of configuration control. Rotational transform control experiments do not show a clear dependence of the energy confinement on a helical ripple, implying turbulent-dominated transport. Indeed, electron-thermal fluctuations show avalanche-type features [F. Kin *et al.*, PoP **30**, 112505 (2023)].

This fiscal year, we have reported on a comparative study of an avalanche-type of heat transport in Heliotron J with the JT-60U tokamak. We found that electron-heat propagation in Heliotron J was mainly generated from the heat-source region. Despite the increase in heating power, we observed similar temperature profiles in both devices. The electron-heat avalanches in Heliotron J were measured using an electron cyclotron emission (ECE) diagnostic. The transfer entropy analysis showed that the temperature perturbation clearly propagated from the core to the edge with one-third of the diamagnetic drift velocity. The Hurst exponent depended on total ECH power, rather than local heating power density or a local temperature gradient. In JT-60U, we observed electron and ion heat avalanches using ECE and CXRS diagnostics. The electron-heat avalanches originated from the peak of the temperature gradient, which propagated in an order of a few tenths of diamagnetic drift velocity. The Hurst exponent tended to be independent of the heating power but abruptly decreased with a rise in the temperature gradient. It was found that the large avalanche events relaxed the ion temperature gradient significantly. The different characteristics of avalanches, i.e., place of origin, propagation velocity, and dependence of the Hurst exponent, could help to understand the different profile formations observed in stellarator/heliotrons and tokamaks [F. Kin *et al.*, *Nucl. Fusion* **64**, 066023, 2024].

Research Topics from Bilateral Collaboration Program in Heliotron J

The main objectives of the research in the Heliotron J device under this Bilateral Collaboration Program are to experimentally and theoretically investigate the transport and stability of fusion plasmas in an advanced helical field and to improve plasma performance through advanced helical-field control.

Picked up in FY2023 are the following seven research topics; (1) plasma transport control by magnetic- field coordination and related plasma structure formation control in advanced helical plasmas, (2) high-density NBI plasma generation and high-beta plasma confinement using an advanced particle supply method, (3) electron thermal fluctuation transport with self-organized criticality, (4) MHD control and a physics mechanism using ECH/ECCD, (5) boundary plasma control using ECH/ECCD, (6) generation of energetic electrons (MeV) by non-resonant microwave, and (7) development of new plasma measurement and analysis methods.

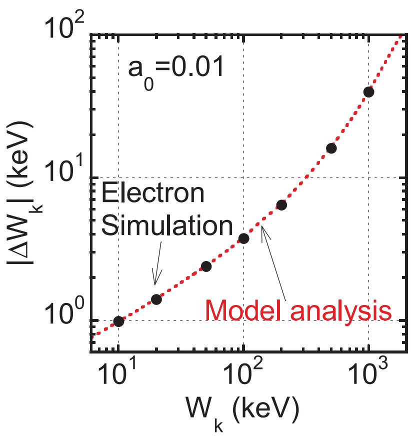
Twenty-four projects, including our baseline one, were adopted. High magnetic-field experiments were conducted for about 14 weeks, from October to the beginning of February.

Statistical acceleration using non-resonant wave heating

In Heliotron J, fast electrons exceeding 2 MeV were observed when non-resonant 2.45 GHz O-mode microwaves were injected into a vacuum magnetic-field of about 1 T [S. Kobayashi *et al.*, PPCF **62**, 065009 (2020)]. Experiments and simulations have shown that the normalized vector potential a_0 is less than 0.04, that relativistic electron production requires multiple accelerations by an electric field, that the electron energy spectrum follows the power-law, and that it exhibits a “slow heating” feature. From these points, statistical acceleration would be a possible mechanism. Simulation studies of the diffusion process of electron-energy distribution show that the diffusion coefficient is proportional to the electron energy E to the power of 3.6, and that this strong energy dependence is the essence of the power-law spectrum formation.

We performed electron acceleration simulations by changing the initial electron energy in the range of 10 keV ~ 1 MeV and investigated the amount of change in the kinetic energy of electrons as they added, subtracted, or decelerated in an electric field, and found that the model equation and the results obtained from the simulations agreed, confirming the validity of the model. On the other hand, in order to model the diffusion coefficient, it was necessary to evaluate the incremental energy determined by both the initial and final phases when exiting the electric field range, and the issue was how to incorporate the randomness of the phase, considering the electron orbit in the confining magnetic-field.

Many research topics have continuously made progress with collaborative researchers under the Bilateral Collaboration Program in the Heliotron J project. Progressing are (i) microwave reflectometry for zonal flow search, (ii) 320 GHz submillimeter-wave interferometry, and (iii) 2D visible high-speed spectroscopic diagnosis of pellet dissociative clouds.



Comparison of the amount of change in electron kinetic energy added, subtracted, or decelerated in a microwave electric field, obtained from model equations and electron acceleration simulations, assuming the initial face of the electric field at the entrance of the electric field area is zero.

(K. Nagasaki)

Osaka University

Study on Fast Ignition Scheme of Laser Fusion and Ultra-High Dense Plasma Physics

We have performed fundamental research of laser fusion with a fast ignition (FI) scheme, which enables us to separate the laser fusion process into three phases, i.e., compression, heating, and burning, using GEKKO XII and LFEX laser systems at the Institute of Laser Engineering, Osaka University. The research includes a) a high-density implosion experiment, b) a fast heating experiment using a mixed laser light of fundamental and second harmonics, and c) the effects of a kilo-tesla magnetic field on ignition burning in FI. In FY2023, the following are summary of our achievements through the Bilateral Collaboration Research Program with NIFS and other collaborators from universities and institutes (NIFS12KUGK057 as the base project).

1. High-density implosion of solid ball target with three-stage laser pulses

Laser fusion requires the generation of high-density core plasma more than 1000 times solid density. In the past, high-density plasma was generated by imploding shell targets, but in fast-ignition laser fusion, there is no need to form a hot spot in the core, so in this study, a solid ball is compressed by a three-stage shock wave driven by high-power laser lights. Solid balls are resistant to hydrodynamic instabilities, but a laser irradiation profile requires the same level of inhomogeneity as shell implosion. Last year, the non-uniformity of laser irradiation was improved by introducing a random phase plate. In FY2023, a solid ball implosion was carried out using a precisely tuned three-stage pulsed laser, shown in Fig. 1 (left). By improving the non-uniformity and the accuracy of the waveform shaping of the three-stage pulses, we were able to achieve a more uniform implosion than that in the previous year's experiment.

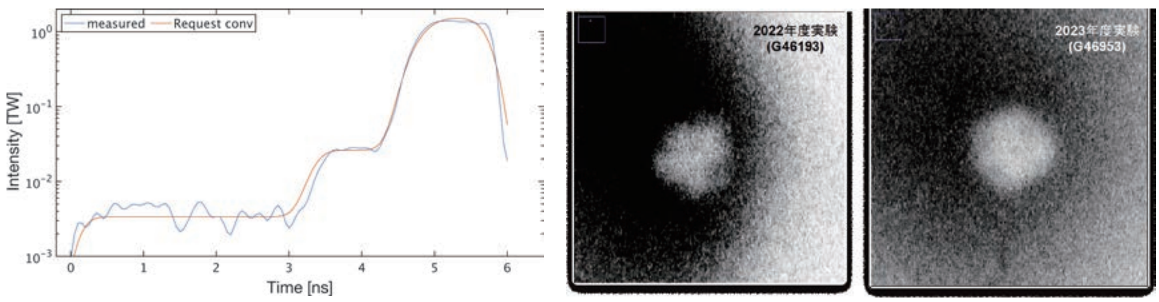


Fig. 1 (Left) Three-stage pulses are generated as requested by hydro-simulation. (Right) Backlight images of imploded plasma observed in FY2022 (Middle) and in FY2023 (Left).

2. Heating mechanism of imploding plasma by a 10 PW-class heating laser

In fast-ignition fusion, the core will be heated by a 10 PW-class laser after the formation of a high-density implosion core to drive ignition burning. The imploding core plasma is surrounded by a corona plasma of several hundred microns, and it is an important issue to elucidate the mechanism that efficiently delivers the heating laser to the core region. In the FIREX-NEO project, we used a plasma particle code (PICLS) to design fast-ignition laser fusion with 10 PW-class laser pulses.

We found that in corona plasmas, up to a critical density of several tens of times higher, the waveguide of the heating laser could be formed by a hole-boring mechanism with a 1 kJ petawatt laser. Theoretical and simulation studies for stable-waveguide formation by hole boring are underway. Calculations of core heating by

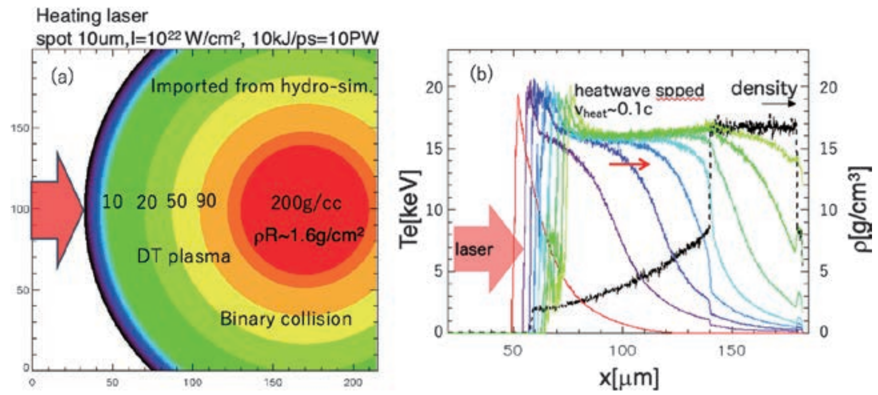


Fig. 2 (a) Initial conditions of the calculation: density profile of the detonation plasma calculated by PINOCO; (b) Time evolution of the bulk-electron temperature on the laser axis (0.5 ps intervals). Propagation of thermal waves.

a 10 PW laser after waveguide formation have also been carried out. The density profile of the imploding plasma calculated with the radiation fluid code PINOCO was loaded into the PICLS code, which incorporated Coulomb collision processes extended to relativity (Fig. 2 (a)), and a heating calculation lasting five picoseconds was carried out. Fig. 2 (b) shows the temporal evolution of the bulk- electron temperature output in every 0.5 picosecond. We found that the thermal wave propagated from left to right over a region of more than 100 microns at approximately 10% of the speed of light. Since the thermal waves are a phenomenon in the region where the mean free path is comparable to the temperature gradient, the driving conditions and propagation characteristics of thermal waves will be clarified in order to develop a more efficient fast-ignition laser fusion design in the future.

3. Development of fast neutron detectors using EO polymers

An EO polymer quickly changes its transmittance of electromagnetic waves in a certain wavelength region, as a response to induced electric voltage by radiations. We successfully created a high quality EO polymer layer with 4cm diameter and 1μm thickness on a silicon wafer (Fig. 3). A section of the EO polymer layer cut out to 1 mm × 1 mm × 0.3 mm was attached to a device. We then tested its response characteristics against energetic electrons and protons which were accelerated by irradiating the LFEX laser on a thin target. The measured data is encouraging since it is showing temporal resolution of 10 ps. The data will be verified in detail and developed for use as a fast-neutron instrument for laser fusion study.

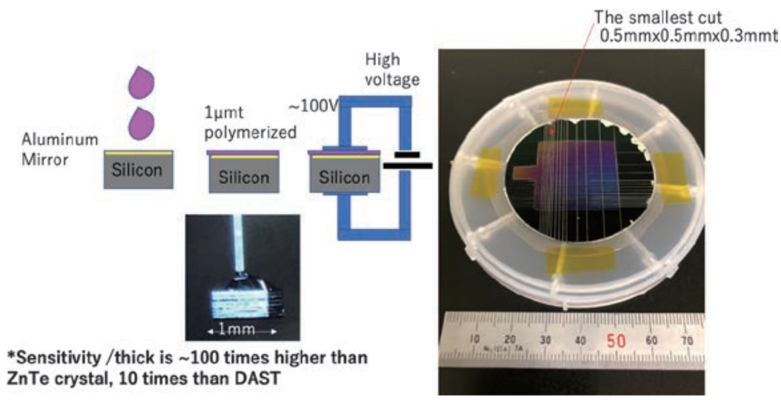


Fig. 3 Process of creation of EO polymer layer on a silicon wafer.

(Y. Sentoku)

Kyushu University

Research activities on QUEST in FY2023

We will summarize the activities of the Advanced Fusion Research Center, Research Institute for Applied Mechanics in Kyushu University during April 2023 – March 2024. QUEST experiments were executed during 13th Jun. – 14th Sep. (2023 Spring/Summer, shot no. 51226–52223) and 31st Oct. – 19th Jan. (2023 Autumn/Winter, shot no. 52224–53076). The main topics of the QUEST experiments in FY2023 are listed below.

1) Electron cyclotron plasma ramp-up with a retarding field has been conducted to suppress the growth of highly energetic electrons. When the retarding field stopped being applied, bulk-electron temperature (~150 eV) could not be maintained, and hard X-rays from the energetic electrons rapidly increased around the zero field. In coaxial helicity injection experiments, larger closed-flux surfaces were formed with high-plasma current (~90 kA) by applying higher-discharge voltage in short pulses. A pulse width with significant plasma current was extended by applying induction.
2) The Directional Material Probe (DMP) method was used in the PWI study at QUEST. DMPs were placed above and below the MH-16 port in a QUEST vacuum vessel during the 2020S/S-2 and 2021S/S-1 campaigns, respectively. There were four DMPs (top, ion- and electron-drift sides, plasma-facing side) at each position. After 2021S/S-1, visible directionality of the change of color of the surfaces of each DMP was not observed, suggesting a deposition layer was formed isotropically. The DMPs retrieved after the 2020S/S-2 campaign showed a difference between the ion- and electron-drift sides. However, with the DMPs after 2021S/S-1 this was not the case. Further investigation is ongoing to determine the cause of this difference between the campaigns.
3) Hydrogen isotope retention in the QUEST plasma wall was evaluated by ion-beam analysis. The aim of this collaboration is to understand the surface transformations and hydrogen-isotope retention of plasma-facing materials occurring in QUEST. The results quantitatively revealed that a carbon-implanted layer may suppress hydrogen diffusion.
4) Floating potential fluctuation measured by a divertor probe array in QUEST has been analyzed. Complex behavior has been found as follows. There is a strong correlation between channels near the strike point, while coherence quickly decays radially outward. The fluctuation propagates from the center channel in both inner and outward directions at an initial phase of discharge, but the propagation direction changes in a later phase.
5) EC breakdown characteristics were studied in detail with the CS (central solenoid) energized. The vertical field required for fast breakdown with the CS was found to be stronger than that without it. The shape of the plasma at breakdown was also different with the CS that led to higher electron temperature.
6) The radial profiles of T_e and n_e were measured in QUEST midplane, using the helium line intensity ratio method. The measured T_e and n_e were compared with those obtained by the Thomson scattering method, and they agreed within factors of approximately two and six, respectively.
7) Incoherent digital holography (IDH) has attracted attention in recent years due to advances in sensor and optical technologies; however, it is still far from being put to practical use. In this project, we aim to clarify the technical issues for applying IDH 3D spectroscopy to plasma measurements and to resolve them.
8) Installation of a rotation motor in an energetic particle probe (EPP) enabled rapid and reliable pitch-angle distribution measurement of fast electrons during a single discharge. The energy spectrum of fast electrons largely changed with the pitch-angle, verifying that the velocity distribution of fast electrons in the far SOL of EC driven plasma was strongly distorted.

9) Several W samples were installed in QUEST and exposed long-time plasma discharge at 320~340 °C. XPS was performed to analyze the chemical state of a sample surface, namely W-10% Re and W-K. On the top surface, C was deposited by plasma exposure. The chemical state of the sample surface was not largely different among these samples. In future, we are planning to evaluate hydrogen-retention behavior in C-deposited advanced plasma-facing materials.
10) We considered using an improved RNN method called long short-term memory (LSTM) to predict the waveform of fuel particles being fed into the plasma. Predicting values ten seconds ahead was compared, using both RNN and LSTM. It was found that LSTM did not cause any oscillation and agreed relatively well with the measured values, while RNN did so.
11) Electron cyclotron wall conditioning with argon gas (Ar-ECWC) has been performed on QUEST. Hydrogen retained in the wall was removed, and the wall pumping capability was recovered. However, many defects such as voids, bubbles, and dislocation loops were formed on the tungsten surface exposed to the Ar-ECWC plasma.
12) A direct detection of an electron Bernstein wave (EBW) in QUEST is one of the important issues to improve and optimize heating and current drive, using the wave. A hydrogen cyanide (HCN) laser is introduced as a scattering source for the direct detection of the EBW. A highly sensitive detection system at HCN laser wavelength (337 μm) is being developed utilizing a harmonic mixer system at 400 GHz. To estimate and predict the power flux of the EBW and the scattered-power flux owing to the EBW as well, an extended Quasi-optical beam tracing code (EQUASI) that can account for the structures of the medium of less than the order of the beam size is under development.
13) To determine the relationship between particle recycling and plasma performance, it is planned to implement the Non-Evaporative Getter (NEG) pump unit HV400 in QUEST. A new proposal was submitted in FY2023 to discuss the port where the HV400 will be installed.
14) In addition to the quasilinear ECH model, we have introduced a model of acceleration due to multiple resonances to the GNET code. We performed the GNET simulations assuming the QUEST magnetic configuration. It was confirmed that the fast electrons generated by the second harmonic ECH were further accelerated by the third and fourth harmonic waves.
15) A divertor biasing experiment has been conducted using four biasing electrodes installed on the upper divertor plate. Small crashes of plasma current were observed during the divertor biasing. These crashes may be attributed to the loss of energetic electrons. Whole plasma oscillation is coincident with the biasing, even though the current driven by the biasing is quite small in the scrape off layer.
16) Tomography based on visible light camera images was applied, incorporating the effect of reflected light from the inner walls of the vacuum vessel. A machine learning model based on BERT, which is one of large-scale language models, was also developed to predict the vertical positional variation of the plasma.

IDEI Hiroshi (Kyushu University) 1)
MASUZAKI Suguru (NIFS) 2)
YAJIMA Miyuki (NIFS) 3)
KOBAYASHI Masahiro (NIFS) 4)
TSUJII Naoto (University of Tokyo) 5)
SHIKAMA Taiichi (Kyoto University) 6)
NISHINO Nobuhiro (Bauhuette Ltd.) 7)
IKEZOE Ryuya (Kyushu University) 8)
OYA Yasuhisa (Shizuoka University) 9)
HASEGAWA Makoto (Kyushu University) 10)
FUKUMOTO Masakatsu (QST) 11)
KUBO Shin (Chubu University) 12)
MOTOJIMA Gen (NIFS) 13)
MURAKAMI Sadayoshi (Kyoto University) 14)
ONCHI Takumi (Kyushu University) 15)
TSUTSUI Hiroaki (Tokyo Institute of Technology) 16)

(H. Idei)

University of Toyama

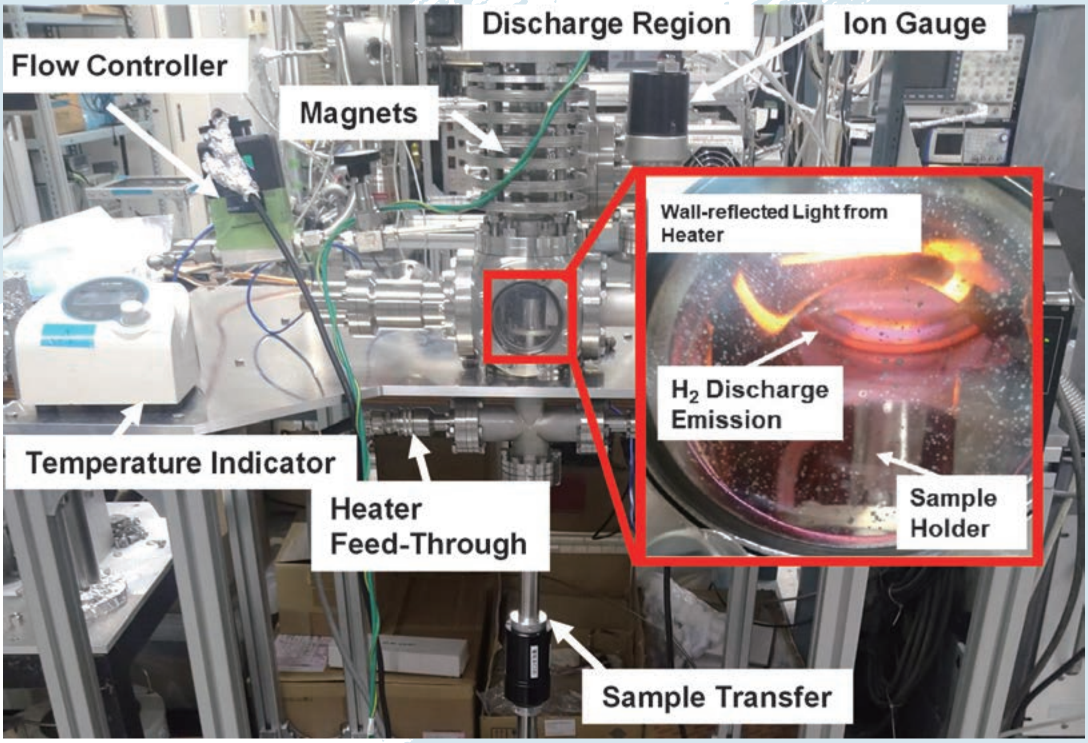


Fig. 1 Newly constructed compact plasma device to be installed in a radiation-controlled area for measurements of tritium retention and distribution in liquid and solid Sn.

Highlight

Research Activities in Hydrogen Isotope Research Center, Organization for Promotion of Research, University of Toyama

The flow of high heat flux to a divertor region is one of critical issues for magnetic confinement fusion. A liquid metal divertor has larger heat removal capability than a solid divertor plate. Tin (Sn) is a candidate for liquid metal divertor material because of low vapor pressure. However, data on the transport parameters of fuel particles such as solubility and diffusivity are scarce. The objective of this study is to evaluate transport parameters of tritium (T) in Sn in liquid and solid states. To reach this goal, a new plasma device was constructed to expose liquid/solid Sn to T plasma, as shown in Fig. 1. The uniqueness of this device is a small internal volume that realizes the plasma exposure with a relatively small amount of T. Hence, the device can be operated without a glove box. [*Precise evaluation of tritium profile in solid/liquid tin exposed to tritium plasma (H. Toyoda, Nagoya University)*]

Tritium transport in fusion reactor materials (Y. Hatano, U. Toyama): Permeation of T through steam generator piping in a fusion power station may result in the risk of uncontrolled T leakage into the environment. Hence, the T permeation must be precisely evaluated and minimized. Nickel alloys are widely used as pipe materials. In 2022, we evaluated the T permeation through Inconel 600 film under exposure to high temperature, high-pressure water and found that the permeation could be suppressed by the addition of O_2 gas in water. In 2023, we examined the effects of O_2 gas on the oxidation of Inconel 600.

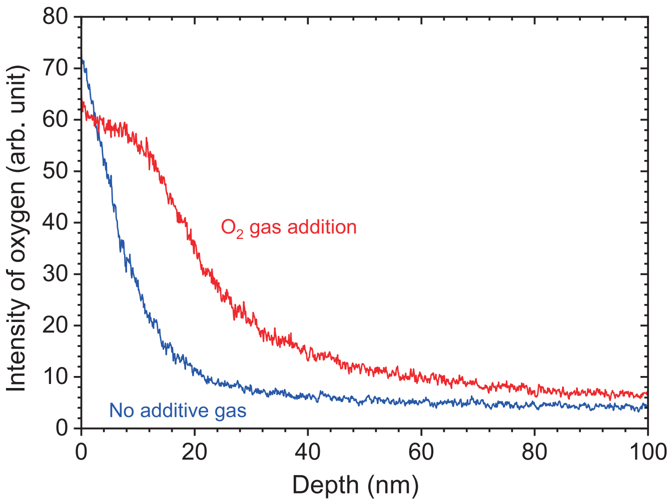


Fig. 2 Depth profiles of oxygen in oxide films formed on Inconel 600 alloy samples by exposing to steam at 280 °C and 6.4 MPa.

Plates of Inconel 600 were exposed to high-pressure water at 280 °C for 14 and 28 hours with and without O_2 gas addition. Then, the oxide films were analyzed using glow-discharge optical spectrometry. The depth profiles of oxygen obtained after oxidation for 14 hours are shown in Fig. 2. The thickness of the oxide film increased with addition of O_2 gas but it was still a few tens of nanometers. The increase in oxide thickness with the elapse of time followed a parabolic law. It meant that the oxide layer had a protective nature even under O_2 gas addition.

Other experimental studies performed in the Hydrogen Isotope Research Center in the fiscal year 2023 are listed below.

- *Nano-fiber formation on tungsten alloy by helium plasma irradiation* (Y. Ueda, Osaka U.)
- *Effect of transmutation or irradiation damage on hydrogen isotope transport dynamics* (Y. Oya, Shizuoka U.)
- *Effective tritium removal under vacuum conditions* (N. Ashikawa, NIFS and Y. Torikai, Ibaraki U.)
- *Effects of heat and particles load on hydrogen isotope retention in tungsten materials* (K. Tokunaga, Kyushu U.)
- *Release behaviors of hydrogen isotopes from tungsten materials exposed to hydrogen isotope plasma during oxidation* (T. Otsuka, Kindai U.)
- *Depth analysis of co-deposited H, He and impurity atoms on plasma exposed W by means of GDOES* (N. Yoshida, Kyushu U.)
- *Hydrogen isotope pick-up and retention in He-exposed W-Mo alloys* (E. Jimenez-Melero, The University of Manchester)
- *Suppression of tritium permeation in stainless steel by laser peening* (Y. Nobuta, Hokkaido U.)
- *Development of liquid DT fusion fuel for high repetition laser fusion reactor* (Y. Arikwa, Osaka U.)
- *Understanding and optimization of tritium absorption into titanium target for 14 MeV neutron irradiation experiments* (I. Murata, Osaka U.)
- *Correlation between hydrogen isotopes trap density and vacancy concentration in tungsten* (M. Kobayashi, NIFS)