2. TEXTOR Collaboration

The IEA TEXTOR Implementing Agreement was decided to be amendment to the new IA, "Development and Research on Plasma Wall Interaction Facilities for Fusion Reactors" (PWI IA). The objective of this Agreement is to advance physics and technologies of the plasma-wall interaction research by strengthening co-operation among plasma–wall interaction facilities (in particular, by using dedicated linear plasma devices), to enhance the research and development effort related to the first wall materials and components for fusion reactor. The amendment needs the approvals of the participants, and it was approved by US-DOE on 29 May 2013 and by NIFS on 3 September 2013. The approval by European Commission is not yet available. It is considered that the modification of the European fusion research organization from EFDA to EUROfusion causes the delay of the approval. Therefore the amendment to the IA has not been completed. On the other hand, the IEA CERT (Committee on Energy Research and Technology) approved the extension of the TEXTOR IA for the term from 1 July 2013 to 30 June 2018, and the collaboration research activities are not affected by the delay of the amendment.

The TEXTOR tokamak was shut down at the end of 2013 as planned. In this fiscal year, collaboration on PWI studies and plasma diagnostics were carried out. All the collaboration activities are summarized in the following table. Highlights in some of individual activities are described in this report.

Deuterium retention in tungsten exposed to mixed D+N plasma at Magnum-PSI at elevated temperatures

To evaluate deuterium retention in tungsten at 1000 K-1400 K during mixed D+N plasma exposure was conducted in the MAGNUM-PSI in DIFFER. After the exposure, the irradiated samples were investigated by using XPS and NRA in the IPP Garching. NRA analysis ongoing but data indicates the following: D retention in bulk observed even up to T~1300 K. NRA depth profiles indicate trap filling effect at T~1100 K. These results are not consistent with laboratory experiments which show no effect of N in the inward D diffusion flux at T > 800 K. May indicate observed effects at T > 800 K may arise from other impurities.

Japanese Participation in 2014-2015

Subject	Participants	Term	Key Persons *etc.*
Deuterium retention in tungsten exposed to mixed D+N plasma at Magnum-PSI at elevated temperatures	Lee Heun Tae (Osaka Univ.)	7-13 Sep. 2014	L. Cheng, T. Morgan (DIFFER), T. Schwarz-Selinger, G. Meisl, T. Hoeschen (IPP Garching)
2D tritium distribution on tungsten tiles used in JET ILW project	Yuji Hatano (Univ. Toyama)	28 Sep.-12 Oct. 2014	A. Widdowson, N. Bekris, C. Ayres (CCFE), J. Likonen, S. Koivuranta (VTT), J. Ikonen (University of Helsinki,)
Collaboration of plasma diagnostic study on Magnum-PSI and Pilot-PSI	Masashi Yoshikawa (Univ. Tsukuba)	26-31 Oct. 2014	H.V. Meiden (DIFFER)
Tritium loading study of tungsten pre-irradiated to TEXTOR D-plasmas	Yuji Torikai (Univ. Toyama)	23 Jan.-1 Feb. 2015	A. Kreter (FZJ)
Experimental investigation of vapor shielding effects under steady-state and pulsed plasma irradiation on Pilot-PSI	Ikko Sasaki (Univ. Hyogo)	25 Jan.-1 Feb. 2015	T. Morgan (DIFFER)
Analysis of expression of dust from arcing on nanostructured tungsten surface caused by the pulse plasma irradiation	Miyuki Yajima (NIFS)	12-21 Mar. 2015	K. Bystrov, T. Morgan, D. Aussems (DIFFER)

2D tritium distribution on tungsten tiles used in JET ILW project

Post-mortem measurements of 2-dimensional tritium (T) distribution using an imaging plate (IP) technique were performed for tungsten (W) divertor tiles (W-coated CFC) used in JET-ITER like wall (ILW) project. The observed T distributions were clearly inhomogeneous, and there were band-like regions with high T concentrations that extended in the toroidal direction on tiles 1, 3, 4 and 6. The concentrations of T in the band-like regions were higher by an order of magnitude than the concentrations in other parts. The inhomogeneous T distributions were explained by non-uniform co-deposition with other elements such as beryllium. The concentrations of T on the outboard vertical tiles (tiles 7 and 8) were low and relatively uniform in comparison with other tiles.

Collaboration of plasma diagnostic study on Magnum-PSI and Pilot-PSI

In this collaboration program, we plan to develop a two dimensional (2D) density measurement system by using the microwave interferometer and reflectometry system and to install them to Pilot-PSI. In the device, there is no microwave interferometer system. The 2D electron density and its fluctuation studies are important. In this fund year, we installed the one channel 70 GHz microwave interferometer system to Pilot-PSI and to measure electron line density and its fluctuation. The frequency multiplier type 70 GHz microwave interferometer system was developed in GAMMA 10/PDX. I sent it to DIFFER and installed it to Pilot-PSI. The electron line density and its fluctuation measurements were carried out in the low magnetic field condition and higher hydrogen gas pressure. Hydrogen plasma with magnetic field of 0.8 T and plasma duration of 7 s was used. The line density is about 8.8×10^{17} m^{-2}. The averaged electron density is about 4.4×10^{18} m^{-3}. The FFT analysis of the line density shows the low frequency fluctuation of about 13.7 kHz. The rotation velocity is about 8.6 × 102 m/s, which is much lower than that obtained by E×B drift rotation velocity about 6 × 103 m/s, albeit for different plasma condition. For understanding the involved mechanisms, a continuation of this study is required to perform detailed analysis of electron density fluctuations.

Tritium loading study of tungsten pre-irradiated to TEXTOR D-plasmas

Re-crystalized W specimens manufactured by A.L.M.T. Corp. were irradiated to PSI-2 D-plasma and D-plasma with 5% of Ar, N_2, He or Ne to a fluence of 1×10^{26} D/m^2 at the temperature of W surface about 493 K or 700 K. After D-plasma irradiated, specimens surface were analyzed by a scan electron microscopy (SEM). Large blisters with size of the order of micrometers and small blisters with size of less than micrometers are observed after irradiated by D-plasma and D-plasma with Ar, N_2 or Ne. On the other hand, little number of blisters were obtained after irradiated by D-plasma with He. The blister creation behavior is quite different between irradiation by D-plasma with He and other plasma gas condition. The blister creation behavior of D-plasma irradiated at 700 K was changed from that of irradiated at 493 K. Blisters were obtained after irradiated by D-plasma and D-plasma with N2. But few or little blisters were obtained after irradiated by D-plasma with Ar, He or Ne. Creation of blisters on W surface were different from deuterium impurities and irradiated temperature. Tritium trapping on above specimens will be examined near future.

Experimental investigation of vapor shielding effects under steady-state and pulsed plasma irradiation on Pilot-PSI

In Pilot-PSI device, bulk Al sample, and Al coated W samples were exposed to the steady plasma, and high power pulse plasma simultaneously. During the plasma exposure, Al vapour layer was observed by spectroscopy and a fast camera. The sample surface temperature was reduced with the formation of the vapour layer. Vapour shielding, and the laten heat are considered to be the cause of the reduced temperature.

Analysis of expression of dust from arcing on nanostructured tungsten surface caused by the pulse plasma irradiation

In Pilot-PSI device, Fuzz-W samples were exposed to the steady plasma, and high power pulse plasma simultaneously. Arcing on the surface of the samples, and the dusts released from the surface during the arcing were observed by the fast camera. Spectroscopy measurement detected WI line, and that suggests the W released during the pulse plasma irradiation. From the spectrum, electron temperature can be estimated, and it will be compared to the temperature measured by Thomson scattering measurement. In post mortem analysis, the surface of the samples were investigated by using SEM, and the arc trails were observed. The dust released from the samples were collected by using collection box during discharges, and the detail dust analysis will be conducted.

(Masuzaki, S.)