2. TEXTOR Collaboration

The TEXTOR collaboration contributes to a wide range of activities in the fusion programme, but its principal areas of expertise are plasma wall interaction (PWI), stochastic plasmas, diagnostics, fusion technology and heating systems. The major topics of research are oriented along the urgent needs for ITER. On the other hand, the Jülich group is discussing a new research program of PWI with linear machines installed in a hot laboratory. The operation of TEXTOR will be gradually phased out and the main research efforts will concentrate on its research program on the areas of PWI. The 4th international workshop on "Stochasticity in Fusion Plasmas (SFP-4)" was held at Jülich Research Centre in March 2009 and five Japanese scientists attended to this workshop and several papers were presented based on results of the collaborations. All the activities in this fiscal year are summarized in the following table. Highlights in some of individual programs are described in this report

Test limiter experiments in TEXTOR

Melt layer behavior of tungsten in a strong magnetic field was studied by exposing tungsten thin plates (2 mm thickness) with gaps with straight and round edges (radius of curvature : 1 mm). The W plates were installed on a graphite roof limiter. The experiments were performed in the TEXTOR NBI discharges. By placing the limiter at r = 46 cm, melting near the tip of the plates was observed. To take a first look at samples, melt layer motion was dominated by the JxB force with the current induced by thermionic emission of electrons. No bridging in both gaps (straight and round) was observed. Carbon deposition in toroidal and poloidal gaps as a function of gap width (0.2 mm ~ 1.5 mm) was studied. 2 sets of gap assemblies were mounted on the ion drift side (toroidal gap assembly) and the electron drift side (poloidal gap assembly) on the same roof limiter. The toroidal gap plates were made from tungsten, while the poloidal gap plates and the holders were made from SUS. Analysis of carbon deposition layer will be made by using SIMS, EPMA, XPS, and NRA. The results will be compared with those by simulations. Recently, linear plasma simulator experiments showed that surface bubbles and cotton-like nano-structures on tungsten were formed by He plasma exposure in the temperature above ~850 °C. We studied how the nano-structure changes under actual edge plasma conditions in TEXTOR. In this study, He pre-exposed samples with two different thicknesses of the structure were exposed to the TEXTOR edge plasma at two different temperatures (~300 °C and ~800 °C). In the TEXTOR experiments, this structure was eroded near the top of the roof limiter (high flux region).

DED experiments

Weakly damped Alfven eigenmodes (AEs) excited by high energy ions such as alpha particles created by DT fusion reaction are recognized as one of important topics

Japanese Participation in 2008-2009

Subjects	Participants	Term	Key Persons *etc.*
1. PSI studies with test limiters	Y. Ueda (Osaka Univ.) M. Fukumoto (Osaka Univ.)	09. 3. 15 - 3. 22 09. 3. 15 - 3. 22	Y. Ueda/ V. Philipps
2. Tangential X-ray Camera			K. Toi / H. R. Koslowski
3. Tritium measurement	Y. Torikai (Toyama Univ.) A. Taguchi (Toyama Univ.)	08. 10. 7 - 10.17 09. 3. 14 - 3. 20 09. 3. 14 - 3. 22	M .Matsuyama /V. Philipps
4. DED experiments	T. Shoji (Nagoya Univ.) A. Tsushima (Yokohama National Univ.) K. Toi (NIFS)	09. 2. 22 - 3. 11 09. 2. 25 - 3. 8 09. 2. 28 - 3. 8	T. Shoji / K. H. Finken
5. Millimeter-Wave Imaging	N. Ito (Kyushu Univ.) A. J. H. Donne (FOM)	08. 3. 21 - 3. 29 08. 9. 9 - 9. 14	A. Mase/ A. J. H. Donne
6. H recycling			M. Sakamoto/ K. H. Finken
7. Divertor plasma simulation	A. Kirschner	08. 9. 6 - 9. 25	Y. Tomita / A. Kirschner
8. International WS on SFP	F. Watanabe (NIFS) T. Ito (NIFS)	09. 2. 28 - 3. 8 09. 2. 28 - 3. 8	Y. Nakamura / U. Samm
9. He measurements in LHD			H. Funaba/ M. Lehnen

for confinement of alpha particles themselves in the International Thermonuclear Experimental Reactor (ITER). Due to the interaction of AEs with energetic ions, the modes become possibly unstable and the particle orbits are modified to enhance the loss and affect the ignition process in fusion reactors. We use the DED coil in TEXTOR as an antenna to excite AEs and aim to investigate not only their characteristics but also the effects of edge field ergodization on AEs. New multi-channel data acquisition system brought from Nagoya University for the detection of fast Mirnov signals (-1MHz) was tested. The shear Alfven continume for n=1 modes as a function of minor radius were calculated by using AE3D code [1] for the m/n=3/1 excitation experiment. The rf current of ≤5A with frequencies swept from 100kHz to 1MHz was applied on the DED coils. The coil impedance was measured as a function of frequency for Ohmic plasmas (Ip = 300 kA, Bt = 2.25 T, n_e~$2x10^{19}$ m^{-3}). Wave fields of AEs ware measured using poloidal array of Mirnov coils showed that AEs (TAE and EAE) were excited by the RF current (50kHz-1MHz, 5A) on DED coils (3/1 modes). Estimation of the poloidal numbers of AEs is now underway. Suppression of AEs by introducing DED DC field perturbation was investigated especially for low DED field region. It was observed that the TAE mode around 200kHz are reduced by the small magnetic field perturbations produced by DED (DC) current up to ~300A.

Tritium release from SS316

The plasma side surface of the ITER vacuum vessel made of low carbon austenitic stainless steel type 316L will retain tritium during operation of the machine and become radioactive. Transmutation reactions with component elements of the steel will additionally contribute to the tritium inventory. It is important to understand the mechanisms governing the release of tritium. As-received type 316 stainless steel specimens were cleaned and preheated at 673 K under vacuum and loaded with tritium either by exposure to 1.2 kPa HT at 573 K or submersion into liquid HTO at ambient temperature. All tritium-loaded specimens showed a characteristic thin layer on the surface of tritium concentrations much exceeding those in the bulk. Release rates of tritium determined at 423 and 573 K under vacuum conditions were found to be non-discernable from those into a stream of argon. Using a one-dimensional diffusion model, the diffusion coefficient of tritium through SS316 at 573 K was calculated to be 2.0 x 10^{-7} cm^2/s in vacuum, i.e. (1.3 – 2.6)x10^{-6} Pa, as well as in a stream of argon. The shapes of the tritium depth profiles in the bulk of SS316 obtained by chemical etching after thermal treatments were very similar regardless of the ambient conditions, i.e. vacuum or an argon stream. The agreement of diffusion coefficients between the one obtained from thermally-induced changes in tritium depth profile and the other obtained from prolonged tritium release data at temperatures in the range 300 – 573 K was good. The activation energy was found to be 61.3 kJ/mol. It can be concluded that thermal releases of tritium from stainless steel into argon or vacuum take place with essentially the same rate. The rate of liberation is mainly governed by diffusion through the bulk and basically independent from surface reactions. Only the chemical form of the released tritium, i.e. HT or HTO, is dictated by the environmental conditions.

Millimeter-Wave Imaging Diagnostics

New heterodyne IF system based on multiplexer and band-pass filter bank is designed and fabricated using microwave integrated circuit (MIC) technology. The good performances in S parameters (S_{11} and S_{12}) are achieved. The system has been or will be applied to ECE and ECEI of LHD and KSTAR, and possibly to collective scattering system. A 2D (60 GHz, 5×8 channels) detector array, IF amplifier, and quadrature demodulator have been newly developed for microwave imaging reflectometry (MIR). These devices enable us to fabricate a multi-channel microwave imaging system for 3D observation of plasma density fluctuations. Optimization of the millimeter-wave devices such as imaging array antenna and beam shaping/steering phased-array antenna will be performed for the advancement of imaging diagnostics. The collaboration experiments on ECEI/MIR will be continued at TEXTOR, LHD and ASDEX under the TEXTOR and the US-Japan collaboration program

Simulation study in divertor region

The one-dimensional plasma modeling along the magnetic field lines in boundary plasma layer, which is the region between SOL/divertor plasma and plasma facing wall (PFW), is studied by the fluid approach. The boundary toward the PFW is the entrance of the magnetic presheath, where the ion flow speed is the ion sound speed. In the boundary plasma region, plasma is the quasi-neutral and there is no net current because of the floating wall. By solving the equations of plasma particle flux, kinetic momentum, energy fluxes of electrons and ions, and Ohm's relation, the plasma profiles are obtained. For the case of the system length of 3 m, the plasma density at the SOL/divertor boundary of 5×10^{18} m^{-3} and the electron and ion heat inputs from the SOL/divertor region of 5 MW/ m^2, respectively, it is clarified that the collisional presheath is formed just in front of the PFW, which width is around 0.2 m and the total heat input to the PFW is reduced from 10 MW/m^2 to around 7.0 MW/m^2: electron = 3.78 MW/m^2, ion = 3.19 MW/m^2. By applying the developed boundary plasma modeling to the boundary plasma in ERO code, the dynamics of the carbon impurity from the LHD divertor is investigated. For the case the peaks of density and temperature of 10^{19} m^{-3} and 40 eV, respectively, the carbon redeposition on the PFW at the private region comes from the divertor plate at the opposite side. Concerning about the amount of carbon redeposition on the first wall near the x-point of SOL/divertor plasma, the carbon impurities from the opposite divertor becomes half of that from the divertor of the same side.

(Nakamura, Y.)