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Future Prospects of International Collaboration on PWI research
今後の国際PWI共同研究の展望

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Plasma-wall interaction (PWI) research is one of key issues to realize fusion reactors. The research activities have been taking an important role in improving plasma performance and developing the plasma facing components required for reactor grade plasmas. Recently, however, the focusing point in PWI research is changing from the impact on plasmas to on materials. As an example, the international collaboration research on PWI with linear plasma machines is presented.

1. Introduction

Research in the field of plasma-wall interaction (PWI) is of increasing importance for the fusion community in view of the urgent R&D needs for ITER, and also PWI is seen as a key research area on the way towards the realization of steady state fusion power facilities. Since the international collaboration on PWI research was started in FZJ by mainly using TEXTOR tokamak device, the collaboration activities have been taking an important role in the progress of PWI research and the development of plasma facing components. However, the research in interdisciplinary field between plasmas and materials enters a new stage, in which the focusing point is placed in the impact of PWI on materials, that is, lifetime of first wall (erosion) and safety (tritium retention and neutron damage). Towards DEMO reactor, new challenges are required for particle and heat flux densities, tritium retention and neutron irradiation onto plasma facing components. In order to characterize PWI under these conditions, a new framework of international collaboration on PWI research with dedicated linear plasma devices, which allow for detailed investigations not possible in magnetic confinement devices, is proposed in Europe (FZJ). Here the outline of activities is presented.

2. New trend of PWI research

The term “plasma-wall interaction” is used to describe the processes close to and just at the surface of plasma facing components in fusion devices. These processes are responsible for heat loads to wall components, particle recycling, He-exhaust, erosion and deposition of wall materials, tritium retention and plasma purity. The PWI research has largely contributed to reach one solution for burning fusion plasmas with sufficient confinement. Questions related to steady state operation in future fusion devices are now moving into the focus of present fusion research. The issues related to large fluence make more prominent such as erosion/deposition, surface morphology, dust accumulation, fuel retention, fatigue effects associated with transients, the impact of neutron damage on PWI processes and thermo-mechanical properties of plasma facing components. The PWI research is now of great importance for retaining the integrity of wall materials rather than for keeping the sufficient confinement of core plasmas. The impact of PWI on wall materials is extensively discussed.

3. PWI research for future fusion reactors

In view of PWI in ITER and DEMO, we have to extend operational regimes with respect to particle and heat flux densities onto plasma facing components, tritium retention and the impact of neutron irradiation onto first wall materials. To characterize PWI under these condition, dedicated plasma surface interaction (PSI) facilities such as linear plasma devices and open systems can be used. Such dedicated PSI experiments are complementary to studies in toroidal confinement devices and a coherent program on PSI topics in both configurations is essential for a successful development of concepts for future fusion reactors.

In Europe, a new project already builds up and new devices are currently being constructed and planned in the Trilateral Euregio Cluster (FZJ, FOM, SCK/CEN). In this program, they have specialized linear plasma devices such as MAGNUM-PSI, JULE-PSI, VISION I as shown in Table 1. The superconducting linear plasma device MAGNUM-PSI has a steady state high flux density like reactor relevant particle fluence and works as a

New challenges	MAGNUM-PSI PILOT-PSI	JULE-PSI (inside Hot Cell)	VISION I (inside T laboratory)
Reactor like divertor conditions (steady state loads)	YES, divertor simulator	NO, but reactor like plasma fluence and ion energies	NO
Reactor like transient heat loads	YES, pulsed plasma source under development	YES, **JUDITH** (electron beam facility inside Hot Cell), laser irradiation	NO
Tritium	NO	no T- plasma but T handling capabilities	YES
Toxic materials (Be)	NO	YES	YES
Neutron irradiated materials	Simulation of neutron damage by ion beam irradiation planned	YES	Limited to moderately activated samples

Table 1. Dedicated plasma surface interaction facilities in TEC

divertor simulator (Fig. 1). Figure 2 shows a schematic view of JULE-PSI, which is planned at Forschungszentrum Jülich. The new device will be installed inside the Hot Material Laboratory of FZJ and it is capable to expose neutron activated and toxic wall materials to reactor relevant particle fluence and ion energies. Both the plasma device and the analysis chamber shall be located inside a Hot Cell. Plasma diagnostics and in-situ PWI diagnostics will be also arranged. The surface analysis chamber is equipped with laser-aided diagnostics (Laser induced desorption, laser induced ablation and laser induced breakdown spectroscopy to determine fuel content and material composition). Moreover, usual sample analysis (TDS, SEM, NPA, SIMS) is capable for activated and toxic materials. Centering these devices, an IEA implementing agreement with international collaborations on integrated PWI research has been arranged including Japan fusion comunity.

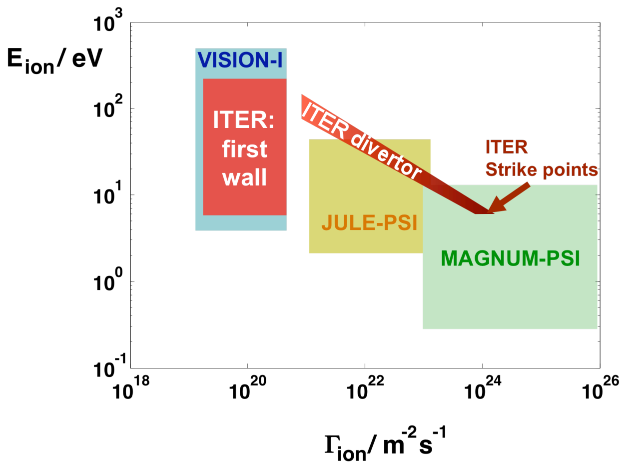

Fig. 1. Operational regime on plasma ion flux and energy

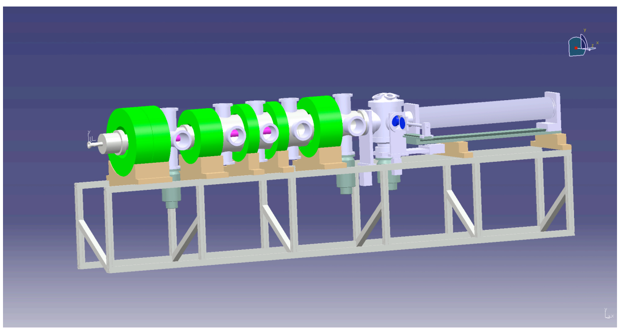

Fig. 2. Schematic view of JULE-PSI device

4. Summary

Development of wall materials available under harsh environments is still one of critical issues to realize fusion reactors. It depends on the progress of PWI research. The dedicated PWI research towards material development will contribute to fill the gaps, which current toroidal devices show with respect to new challenges in ITER and DEMO. The international collaboration on PWI research will make more successful.