§101. Advanced Evaluation of Radiation Effects on Fusion Materials

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Eight research proposals have been accepted after reviews at NIFS and International Research Center for Nuclear Materials Science, IMR, Tohoku University (hereafter the Center). The following is the report on "Advanced evaluation of radiation effects on fusion materials (the principal investigator: T. Shikama, Tohoku University)" which is the fundamental project that provides an improved research scheme for all of the proposed studies at the Center.

The feature of the fusion reactor environments is that hydrogen isotopes and helium are produced and their transport and retention occur under neutron irradiation. It is hence indispensable to clarify the effects of neutron irradiation on the behavior of hydrogen isotopes and helium in the candidate plasma facing materials (PFMs) including tungsten and its alloys and then to assess the feasibility of their use in future fusion reactors. As a first step to conduct this key research subject, a TDS (Thermal Desorption Spectrometer) with an ion gun, IG-TDS, was installed in the radiation controlled area at the Center through fiscal 2010-2012. The IG-TDS is open to researchers in Japan and overseas.

Of importance as the second step that the Center should take the initiative in pioneering studies in this field is to increase the capability of the IG-TDS device: That is to unite the IG-TDS to a linear plasma irradiation device with the range of ion energy and high flux density required for steady state plasma relevant to the divertor plasma condition. Therefore, the development of a new, compact divertor plasma simulator with a high efficient dc plasma source, designated as C-DPS, was initiated in 2013 at Nagoya University based on the prototype of the C-DPS device. The system of C-DPS integrated with the existing IG-TDS device, C-DPS/IG-TDS, will be completed and installed at the Center in fiscal 2014.

The C-DPS system is designed to be capable of producing a high plasma density ~ 10^{19} m^{-3} at 2-2.5 kW and 20 mT that permits steady state plasma relevant to the divertor plasma condition. In view of various restrictions on laboratory work in the radiation controlled area, the C-DPS features a compact, essentially maintenance-free design with low consumptions of electricity and gas, cooling with a water chiller, etc.

Fig. 1 shows the design of C-DPS/IG-TDS to be set in the radiation controlled area at the Center. Since the system installed at the Center will offer the following attractive features, pioneering results will be expected.

(1) The analyses of neutron irradiated and plasma exposed surfaces of PFMs can be performed *without air exposure following plasma exposure*. (2) Various analytical apparatus such as TEM (Transmission Electron Microscopy), SEM, FIB (Focused Ion Beam), 3D-AP (3 Dimensional Atom Probe), PA (Positron Annihilation), etc, are available in the radiation controlled area at the Center. Advanced technologies for nanostructure analysis can be utilized at hand. (3) Many neutron irradiated specimens of PFMs are available at the Center.

In Fig. 1, a neutron irradiated sample (ϕ 3.0 mm, t 0.1~0.2 mm) will be mounted on the sample holder. The sample temperature can be controlled by air cooling on the rear side of the sample. After exposure to the plasma, the sample is transferred to the IG-TDS device and then subjected to TDS measurement *without breaking vacuum*. For this, the existing IG-TDS device is under renovation for the extension so as to enable the following:

The plasma exposed sample will be dropped from the sample holder to the bucket of TDS, moved to the infrared heating unit for TDS measurement, then moved back to the original position, and finally dropped to the bottom of the chamber by turning over the bucket.

This type of integrated system has never been available throughout the world, and therefore the system of C-DPS/IG-TDS will offer an exclusive contribution to the advancement of PMI (Plasma Material Interaction) studies particularly by increased reliability of the results obtained. The Center will thereby reinforce capability in hosting international research collaboration also in PFMs.

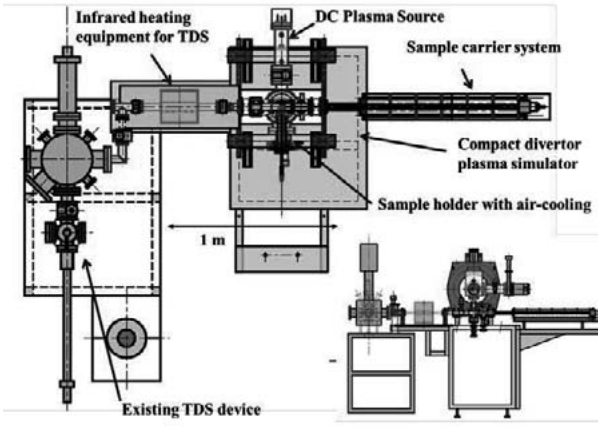

Fig. 1 Design of the system of C-DPS/IG-TDS that enables the TDS analyses of neutron and plasma irradiated surfaces of PFMs without air exposure following plasma irradiation.