§42. Development of CT Injection and Neutralization Technology toward Pulse Heat Flux Material Tests

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Heat flux tests for R&D of ITER plasma facing components (PFCs) are required to be investigated under realistic plasma parameters and conditions simulating transient events such as Type I edge localized modes (ELMs) and disruptions events in ITER. The ELM heat loads in ITER are expected to be 0.2–2 MJ/m^2 during 0.1–0.2 ms on the divertor plate during each event. The conditions typical for their transient events are difficult to achieve in electron/ion beams and plasma simulators which are used as static heat flux sources for the damage tests. The Compact Toroid (CT) injector is applicable as powerful transient heat load simulators satisfied ITER requirements for material damage tests[1]. The high pulsed heat flux produced by coaxial plasma guns will damage the divertor materials leading to surface evaporation, melting and cracking. The ablation rate is much lower than that found using lasers and electron beams due to the vapor shielding effect[1]. Thus, when compared with laser or electron beams facilities, the plasma guns have suitable facilities to incorporate the shielding effect into erosion simulation of the ELMs/disruptions. Earlier tests with the magnetized coaxial plasma gun at University of Hyogo showed enough test capacity to simulate for the ITER relevant high heat flux conditions[2].

In this experiment, the surface damage of the LHD divertor plates by the pulsed plasma irradiation has been for the first time examined by using the spheromak-type CT injector named by SPICA (SPheromak Injector using Conical Accelerator)[3]. The SPICA was constructed and developed for core fuelling the LHD device. The performances of the SPICA are described in detail in Ref. 3). Figure 1 shows a schematic of drawing of the SPICA device with a drift vacuum chamber in this experiment. We have tested a pure tungsten (W) sample, the graphite plate and the W coated graphite plate used at the divertor in LHD. These sample targets in the drift chamber are placed ~0.9 m away from the tip of accelerator inner electrode.

In this experiment, the SPICA was operated with acceleration capacitor banks (0.12 mF, 10-27 kV). The SPICA generates CT plasmoids having electron density n_e ~ 7× 10^{21} m^{-3} and velocity v=70-100 km/s. The gun pulse duration is 0.025 ms and the peak gun current is 200 kA at the charging voltage of 17 kV. The peaked absorbed energy density is 0.3 MJ/m^2 which is measured with a graphite calorimeter by changing the bias magnetic flux.

Surface morphology of the samples was examined by a scanning electron microscope (SEM). After the pure W is exposed to 45 H_2 plasma pluses of 0.3 MJ/m^2, surface cracking is clearly observed as shown by Fig.2 (a). Figure 2 (b) shows that the surface of the graphite plate becomes smooth after pulsed plasma exposures of 45 shots. As for the W coated graphite plate, there was no any indication of surface damage besides the edge after the same irradiation.

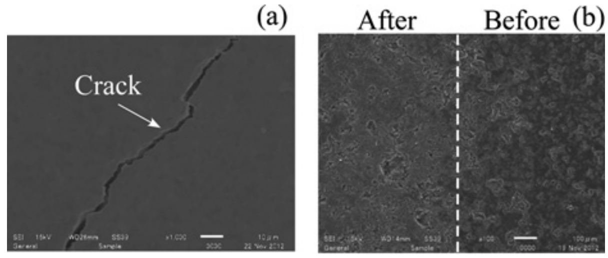

Fig. 2. SEM images show the surface morphology of (a) W after pulsed plasma irradiation, (b) graphite divertor plate before and after irradiation.

1) Nagata, M. et al.: IEEJ Tran. Electrical and Electronic Eng., **4**, (2009) 518.
2) Kikuchi, Y. et al.: J. of Nucl. Mater. **415** (2011) S55.
3) Miyazawa, J. et al.: Fusion Engineering and Design **54**, (2001) 1.

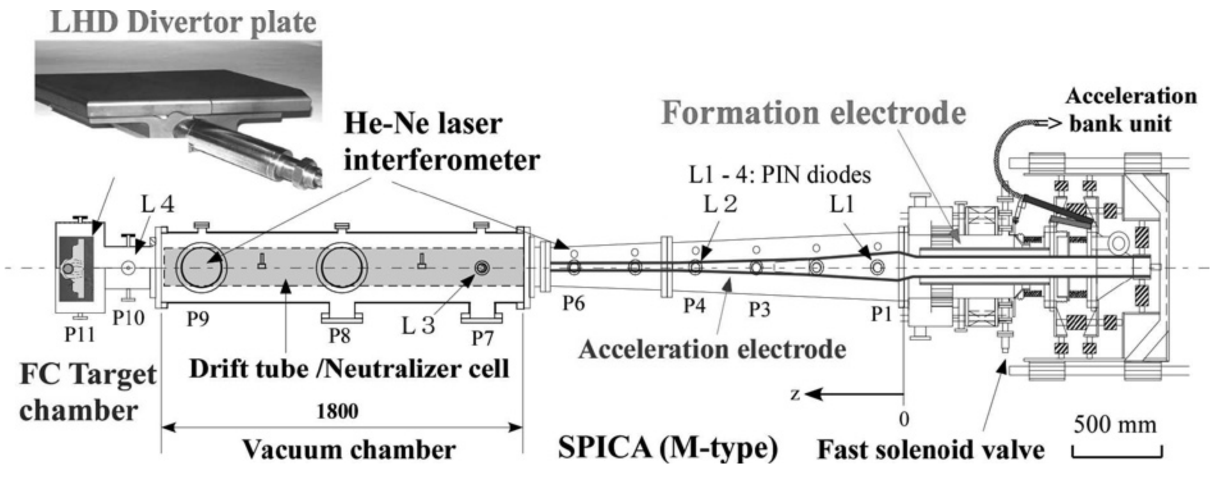

Fig.1 Schematic view of the pulse heat flux material test system by using the SPICA CT injector.