§37. Surface Ablations of Reactor Plasma Facing Components with Intense Particle and Laser Beams, and Associated Pulsed Power Developments

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The reactor plasma facing components are ablated with the high flux pulsed radiations of various kinds including photons and particles. It is very important to know the conditions in reactor chambers after these ablations. In the worst case of IFE, the produced mists of the wall materials remain at the chamber center and prevent the survival of the injected fuel targets. In the worst case of MFE, diverter surfaces cannot survive under the severe conditions of the ITER-ELM modes. So that, we continued to investigate how the candidate materials respond to (1) such intense particle beams (which are produced with the fusion reactions) and to (2) such intense laser lights (which leak from the main laser driver lights to irradiate the fuel targets).

An intense pulsed proton source and an ArF laser were used to ablate various sample materials. The surface analyses after the beam irradiations were performed with various diagnostic tools in Institute of Laser Engineering, Osaka University and Department of Energy Sciences, Tokyo Institute of Technology. The most recent results concerning these research works were published, for example in reference [1].

The first author proposed a new type of Marx generator [2]. The insulator oils for the conventional Marx generators up to now were mineral oils, which were more flammable and regulated under the law of fire-brigade stations. In some case, we must prepare halon fire extinguisher systems. On the contrary, if we can use plant oils (which are not so flammable as the mineral oils), the Marx generators can be installed in wider ranges of experimental site areas without such difficulties.

To realize the above idea, we investigated the electric breakdown voltage of plant oil, as a function of the electrode gap length. One of the results is shown in Fig. 1. The insulation endurance is enough high for this oil to be used as the insulating oil of a new Marx generator. After this investigation, we could move one of our medium sized pulsed power systems (pulsed ion beam machine called as "PICA-3") from Yokohama to Faculty of Engineering, Gunma University in this fiscal year. This will be operated again very soon.

Various candidate materials for diverter surfaces were irradiated with an electron beam apparatus at JAEA Naka Laboratory (JEBIS) to investigate the response against the ELM-like electron beam thermal loads [3].

The vacuum pressure of the irradiation chamber, electron beam acceleration voltage, current, and time duration were 2×10^{-2}Pa, 65kV, 2.00A 1ms (or 1.5ms). The thermal loads on the material surface (960-200MW/m^2) were measured with calorimeters simultaneously. The total numbers of shots on the same spots of the targets were changed from 1 to 4 (or 5), 10 and 20. The surface craters were measured with a frame camera and a surface profiler. The depth of the crater valley was plotted against a typical surface line. Examples of the results were shown in figures with the abscissa and the ordinate as the ablated depth and the total (accumulation) numbers of shots on the same sample spot. In the case of the heat load with 1ms duration, the ablated thickness of CFC (Carbon Fiber Composite), W and C was about 0, 20 and 120 micron, respectively, and there was no thickness change with the increase of the heat load accumulations on the same spot. On the contrary, the thickness changed from about 150 to 650 micron, with the increase of the heat load accumulations on the same spot from 1 to 20, in the case of CFC with 1.5ms duration. In place of the ablation depth, the total volume of the crater valley was also measured. An additional surface temperature measurement with an infrared camera was also performed to check the qualitative behavior of the surface temperature.

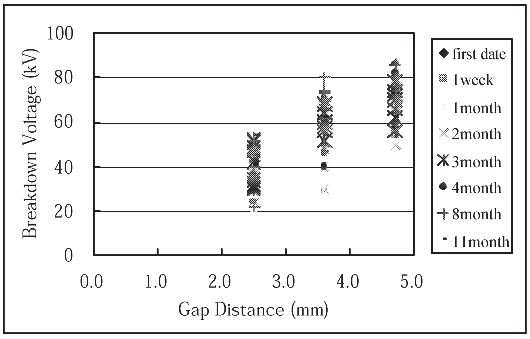

Fig.1. Breakdown-voltage of plant oil vs. electrode gap distance. The parameter is the numbers of days or months after oil filing.

References

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