Distribution of ionized carbon during sumilated plasma disruption

T. Sukegawa, H. Madarame and K. Okamoto
Nuclear Engineering Research Laboratory, University of Tokyo

Abstract

Using the Magneto-Plasma-Dynamic Arc Jet (MPD Arc Jet) device, the plasma-material interaction during simulated plasma disruption was experimentally investigated. To clarify the effects of the evaporation, the isotropic graphite was used as a target. The thermal conductivity of the isotropic graphite was much higher than that of the pyrolytic graphite, resulting in smaller evaporation. The light intensity distribution during the simulated disruption for the isotropic graphite was quite different from that for the pyrolytic graphite.

Introduction

During plasma disruptions the plasma facing components will subjected to intense heat loads for short periods of time. This phenomenon can be simulated using the MPD Arc Jet device as the heat source. The maximum heat flux on the specimen was about 3.6 MW/m^2 when the voltage was 400 V and the magnetic field was 0.98 T. In this study, to clarify the effects of the evaporation, the isotropic graphite (IG110) was used as a target. The thermal conductivity of the isotropic graphite was much higher than the pyrolytic graphite, resulting in smaller evaporation.

Result and Discussion

The CII line at 426.7 nm (3d^{2}D-4f^{2}F^0) and the CIII line at 465.2 nm (3s^{3}S-3p^{3}P^0) were selected for the measurements of C^+ and C^{++} ion distribution in the plasma. For the space resolved measurements, an $f = 250$ mm collector lens was used. The distance between the lens focal point and the specimen surface was varied to obtain the spatial distributions. For the time resolved measurements, 0.2 $\sim$ 2 msec scan duration were used. The scan duration depended on the light intensity. In the higher intensity case, the scan duration should be shorter in order to avoid the saturation of the photo detector. Therefore, the intensity was normalized as the intensity per 1 msec.

Before the experiment, the surface of the target specimen was planed to be flat. Then the specimen was set in the MPD Arc Jet device. Figures 1 and 2 show the variation of the intensity for several serial experiments at $x = 2.5$mm. The distance between the measured position and specimen surface was defined as the distance x. As shown in Figs. 1 and 2, the intensity at the initial pulse (1st) was much smaller than that at the following pulses. With repeating the pulses, the intensity had a tendency to increase. This tendency was observed for every experiments with the isotropic graphite targets(IG110).

In the 2nd and following pulses, there were twin peaks, 3 and 6 msec. The first peak was relatively sharp. Since the pulse duration time was about 5 msec, the second peak was observed after the heat input.

When the 1st pulse was applied, the carbon surface was eroded, resulting in the rough surface. The local thermal conductivity at surface decreased because of the rough surface.

Some of the evaporated carbon were re-deposited onto the carbon surface. The thermal conductivity between the re-deposited carbon and carbon surface might be smaller than that of isotropic carbon. Then, the 2nd pulse was applied, resulting in the re-deposited carbon to evaporate easily. This evaporation caused the first peak (3ms). Because the amount of the re-deposited carbon was not so large, the first peak was observed just only near the target surface. After the re-deposited carbon evaporation, the heat was still loaded onto the eroded rough surface, causing the evaporation, i.e., the second peak (6ms). By repeating the pulse heat load, these erosion and re-deposition were repeatedly accumulated. Therefore, the emission intensity increased with repeating the pulse.

Figures 3 and 4 show the microscope images of the isotropic carbon target surface before the heat load and that after the 6pulses. The surface before the heat load was almost flat with the small debris and machining lines. However, after the pulse applied, the surface had large roughness. This photo qualitatively confirms that the local thermal conductivity at the surface decreased with repeating the pulses. The re-deposited carbon was too small to visualize.

In the pyrolytic carbon target, the thermal conductivity was much smaller than that of isotropic carbon, showing the large amount of evaporation. Therefore the re-deposited carbon and surface roughness did not affect on the evaporation.

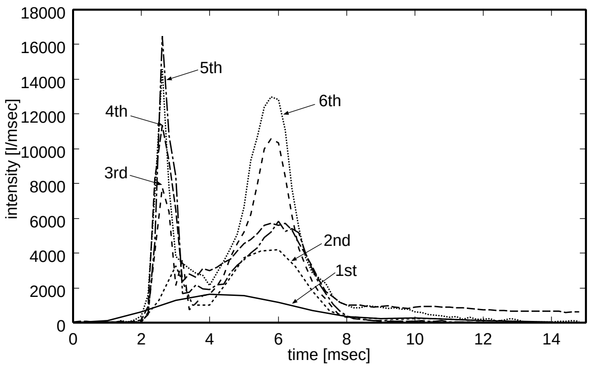

Fig.1 C^+ ion density variation at $x = 2.5$mm

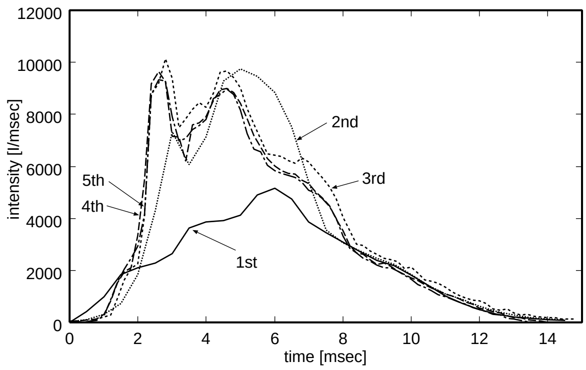

Fig.2 C^{++} ion density variation at $x = 2.5$mm

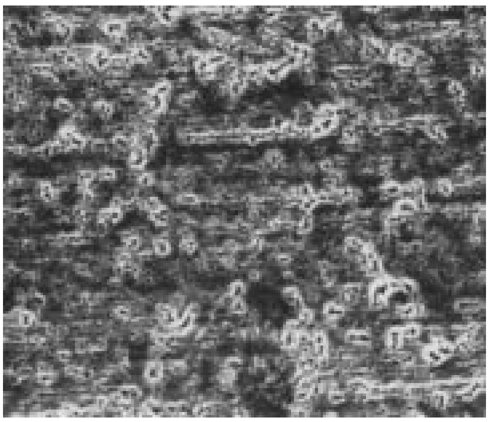

Fig.3 Surface before the experiment

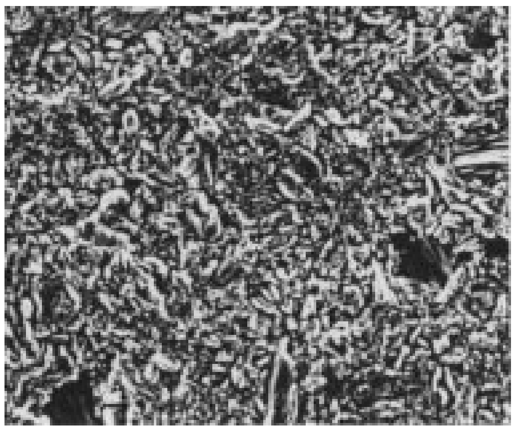

Fig.4 Surface after the 6 pulses