§ 24. Interaction Between High-Density Hydrogen Plasmas and a Graphite Plate

Maeda, T., Aramaki, M., Sasaki, K., Kadota, K.
(Nagoya Univ.),
Goto, M., Muto, S., Morita, S.

As we reported last year [1], we constructed a high-density plasma source excited by helicon-wave discharge. This plasma source can be used as a compact divertor simulator since it can produce high-density hydrogen plasmas with electron densities close to 10^{13} cm^{-3}. In this year, we installed a graphite plate in the plasma source. We investigated high-density hydrogen plasmas interacting with the graphite target by optical emission spectroscopy (OES) and laser-induced fluorescence (LIF) spectroscopy. In addition, we analyzed the surface of the graphite plate after the irradiation of high-density hydrogen plasmas by scanning electron microscopy (SEM).

High-density hydrogen plasmas were produced in a compact linear machine with a uniform magnetic field by applying rf powers to a helical antenna wound around a discharge tube. A graphite plate terminated the plasma column. Optical emission from the interface region between the plasma and the graphite target was measured using a monochromator and a photomultiplier tube. A tunable laser beam at a wavelength of 516.5 nm yielded from an optical parametric oscillator was injected in front of the graphite target. We detected laser-induced fluorescence from C_2 produced by the plasma-target interaction.

An optical emission spectrum observed at a target temperature of 400 °C is shown in Fig. 1. We observed emissions from CH and C_2 as the products of the plasma-target interaction. The emission intensities from the reaction products increased with the target temperature, while the emission intensities from H decreased with the target temperature. When we irradiated helium plasmas with electron densities close to 10^{14} cm^{-3}, we observed no emissions from C_2 as well as CH. These results suggest that the interaction mechanism between the high-density hydrogen plasma and the graphite target is mainly chemical sputtering.

Figure 2 shows the C_2 density measured by LIF as a function of the gas pressure at a target temperature of 400 °C. The variation of the C_2 density was not consistent with the variation of the electron density, supporting the production of C_2 by chemical sputtering. In addition, the variation of the C_2 density contradicted the variation of the emission intensity of C_2. This result indicates that OES is not sufficient for the diagnostics of the plasma-target interaction. The use of advanced diagnostics such as LIF is necessary.

Finally, Fig. 3 shows a SEM image of the target surface irradiated by the high-density hydrogen plasma. As shown in Fig. 3, we observed the production of carbon particulates. It is noted that we observed no particulates when we irradiated helium plasmas to the graphite target.

Reference
[1] M. Aramaki, K. Kato, K. Sasaki, K. Kadota, M. Goto, S. Muto, and S. Morita, Annual Report of National Institute for Fusion Science, April 2001-March 2002, p. 251.

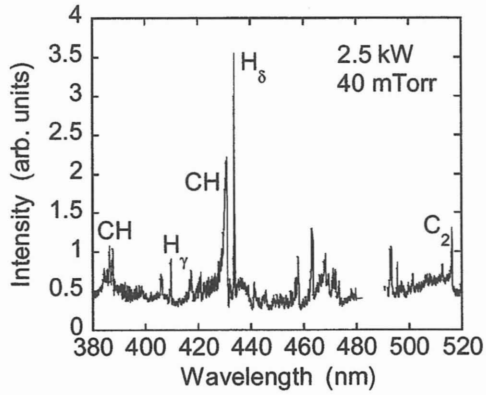

Fig.1 Optical emission spectrum observed from the interface region between the high-density hydrogen plasma and the target graphite plate.

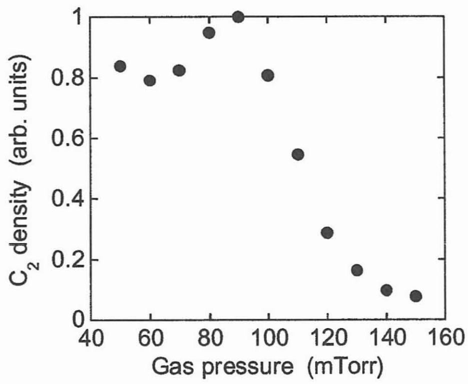

Fig.2 The C_2 radical density measured by LIF as a function of the gas pressure.

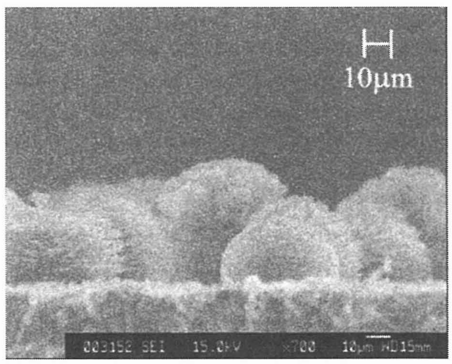

Fig.3 A SEM image of particulates produced on the surface of the carbon target.