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Development of Divertor Simulator Enabling Simultaneous Irradiation of Steady-State High Heat Flux Plasma and Plasmoid

プラズモイド-定常高熱流プラズマ複合照射装置の開発

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For a fusion reactor, it is indispensable to develop the divertor with tungsten which can bear intense transient heat and particle loads, such as ELMs and disruptions. In order to simulate pulse plasma like ELMs, it is necessary to develop a device which irradiates transient heat and particle loads to generate with steady-plasma. In this study, the experiments using the plasma gun are performed. Mo samples were irradiated by a plasmoid in order to investigate the impurities produced.

1. Introduction

In fusion devices, transient huge heat and particle loads are critical problems for the damage of plasma facing components (PFCs). Especially, type-I edge localized modes (ELMs) and disruptions, transient heat and particle loads, are considered as the damage for divertor plates in ITER. It is necessary to investigate the damage of tungsten (W) for transient heat and particle loads, such as ELMs.

To simulate the condition under ELMs, experiments by using a laser [1], an electron beam [2], and a plasma gun [3] were conducted. However, these experiment were not enough to simulate ELMs. Therefore, an experimental device which irradiates pulsed heat and particle loads under steady-plasma is required to simulate ELMs. The purpose of this study is to develop the divertor simulator enabling simultaneous irradiation of steady-state high heat flux plasma and plasmoid. In this study, experiments by using the plasma gun are shown, as the first step.

2. Experimental setup

Figure. 1 shows a schematic of a plasma gun that we developed [4]. An internal electrode is coated with W in order to prevent scattering of the impurities from the electrode. However, it may be possibility that W scatters. To investigate the distance dependence of the amount of scattered W from the electrode, we conducted following experiments. Molybdenum (Mo) samples were irradiated with five shots of hydrogen discharges. In these shots, gun voltage was 5 kV. The size of these

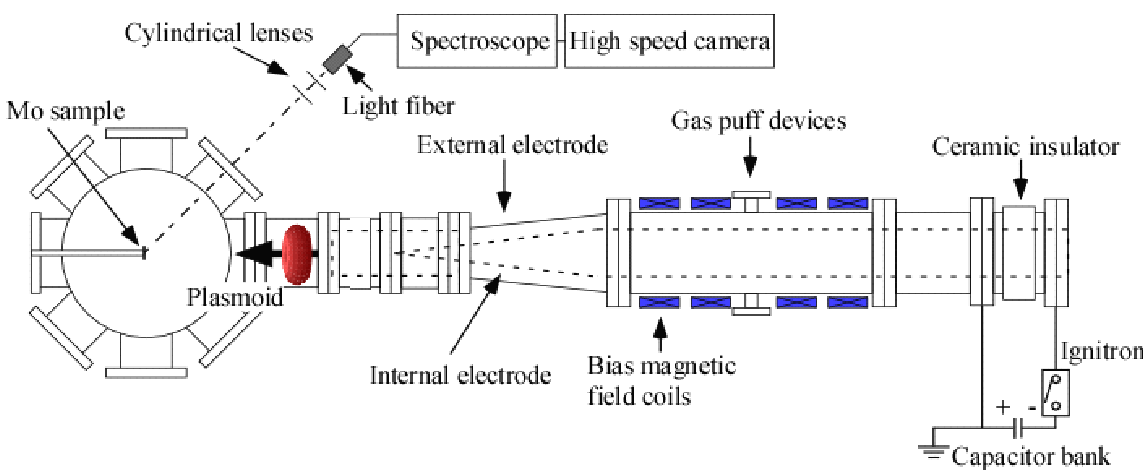


Fig. 1 A schematic of the plasma gun [4].

samples was φ24 mm and the thickness was 2 mm. The positions of the samples were 327.5 mm, 467.5 mm, and 607.5 mm from the electrode respectively. We observed the surface structure of the irradiated samples by scanning electron microscope (SEM) and these samples were analyzed by energy dispersive x-ray spectroscopy (EDX) and rutherford backscattering spectrometry (RBS) to measure the elemental ratio. Additionally, the spectroscopic measurement was conducted using a high speed camera with a visible spectroscope to observe time evolution of emission of the plasmoid.

3. Results and Discussion

Figure. 2 shows the result of RBS of Mo samples. It shows the relationship between the distance from the internal electrode and the concentration of W. From this result, it was found that the amount of W deposition on Mo samples decreases with distance from the internal electrode.

Figure. 3 (a) and (b) show the characteristic spectra of the emission of the plasmoid measured by the spectroscopic measurement and the time evolution of the emission of H_b, W I, and Cr I. The emission of Cr I was observed because we use the stainless screwes in a vacuum vessel in order to fix Mo samples. From Fig. 3 (b), it was found that Cr I emission was delayed approximately 0.05 ms, as compared with that of H_b and W I. This was caused by the fact that Cr I emitted light after the temperature rise of stainless screwes. Moreover, about H_b and W I, the second peak was observed at 0.5 ms. This suggests that the plasmoid was irradiated twice in a single shot.

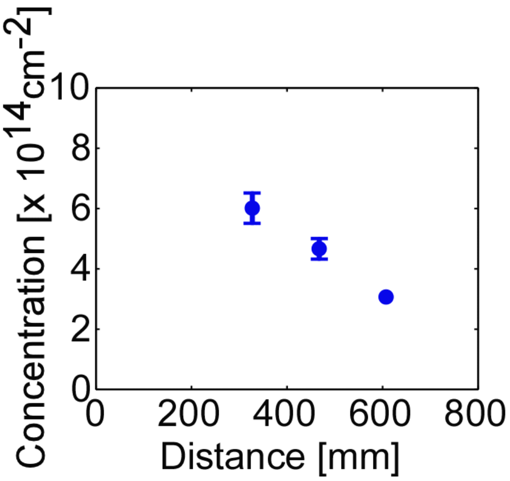
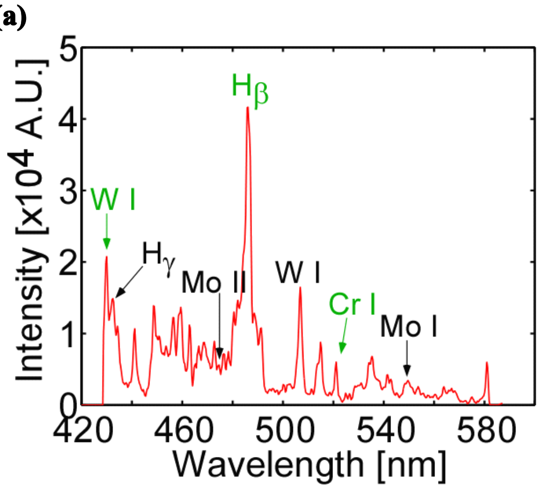


Fig. 2 Result of RBS for Mo samples.

(a)



(b)

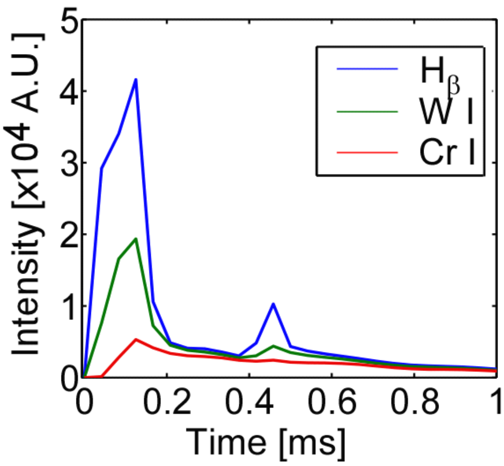


Fig. 3 (a) The characteristic spectra of the emission of the plasmoid (b) Time evolution of emission of H_β, W I, and Cr I

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