§23. Identification of Ablation Rate of Hydrogen Ice Pellet from Plasma-cloud Parameters

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The ablation rate of hydrogen ice pellets has been experimentally and locally identified for the first time from the parameters of a plasma cloud surrounding pellets. The parameters of the plasma cloud such as electron density, electron temperature and volume are experimentally measured for the identification by a novel method of spectroscopy with different narrow-band optical filters using a photodiode and a fast camera[1)].

Figure 1 shows the temporal evolution of the ablation rate in the calculation of HPI2 code based on Neutral Gas and Shielding (NGPS) model, which has been applied to LHD[2)]. There are two plots in Fig. 1. One is the output itself of the ablation rate from HPI2 code, and the other is the value of the ablation rate evaluated from the following equation using the output of plasma cloud parameters in the calculation[3)].

$$\frac{dN}{dt} \simeq 2\pi R_{\rm cloud}^2 n_{\rm e}^{\rm cloud} \sqrt{\frac{T_{\rm e}^{\rm cloud}}{m_{\rm H}}} \qquad (1)$$

Here, $R_{\rm cloud}$ is the diameter of the plasma cloud, $n_{\rm e}^{\rm cloud}$ is the electron density of the plasma cloud, $T_{\rm e}^{\rm cloud}$ is the electron temperature of the plasma cloud and $m_{\rm H}$ is the proton mass. In this equation, it is assumed that the cigar-shaped plasma cloud is expanded at speed of sound with constant electron density. The factor 2 in the equation means that the particles in the plasma cloud are expanded bidirectionally. The temporal evolution is similar in both cases, suggesting that the ablation rate can be possibly evaluated from the plasma cloud parameters in the equation (1).

Figure 2 shows the temporal evolution of the ablation rate experimentally evaluated. In Fig. 2, the calculation result and the ablation rate evaluated from the Balmer-β emission, which is conventionally employed in various magnetic devices, are also included. The temporal ablation rate evaluated from the plasma cloud parameters shows different behavior from the Balmer-β emission at the latter phase of the ablation. In the latter phase, the plasma-cloud electron density is higher, resulting that the ablation rate becomes higher. On the other hand, the volume of the plasma cloud is smaller and thereby the emission from the plasma cloud is low. They seem the reasonable explanation of the different behavior. Besides, at the early phase of the ablation, the temporal ablation rate seems to be different from that of the calculation.

In summary, the new evaluation method of the ablation rate is provided in this study. The ablation rate shows the different temporal evolution from the Balmer-β emission and the calculation. The validation of the new evaluation will be conducted as a next step of the analysis.

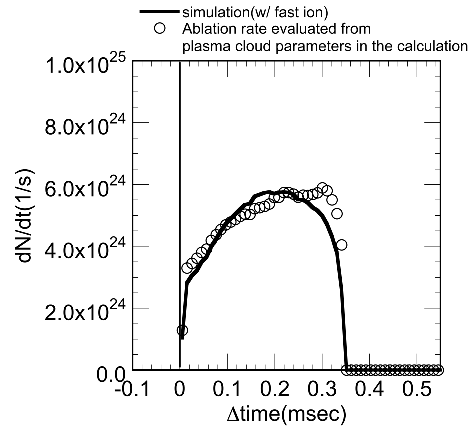

Fig. 1: Time evolution of the ablation rate in the calculation. In the calculation, an over ablation effect of fast ions is taken into account. Solid line denotes the output itself from the HPI2 code. Open symbols represent the ablation rate evaluated from the plasma cloud parameters in the calculation.

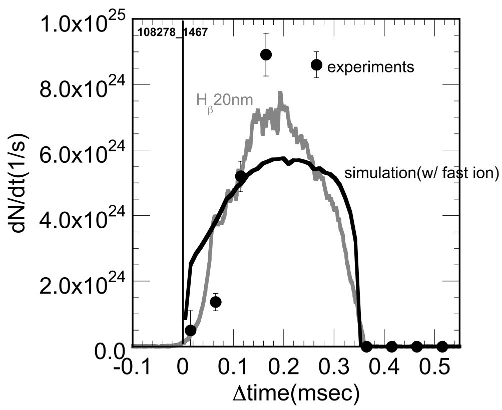

Fig. 2: Time evolution of the ablation rate experimentally evaluated from the plasma cloud parameters as shown in filled circles. Black solid line denotes the ablation rate in the calculation. Thin solid line is the Balmer-β emission.

1) G. Motojima et al., Rev. Sci. Instrum. **83**, 093506 (2012).

2) A. Matsuyama et al., Plasma Phys. Control. Fusion **54**, 035007 (2012).

3) V. A. Rozhansky et al., Plasma Physic Reports **31** 1068 (2005).