§22. Time Evolution of Plasma Cloud in Hydrogen Ice Pellet Ablation Process

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To understand the ablation process of a hydrogen ice pellet, time evolution of parameters of the plasma cloud surrounding the pellet is investigated in LHD by using spectroscopy measurements with narrow-band optical filters[1]. We clarify the time evolution of the plasma cloud parameters depends on plasma heating conditions. In the case that the ablation by high energy fast ions of NBI is dominant, the parameters of the plasma cloud show characteristics time evolution as shown in Fig. 1. (1)The electron density of the plasma cloud increases monotonically. (2)The volume of the plasma cloud becomes large at the early phase of the ablation and then decreases monotonically.

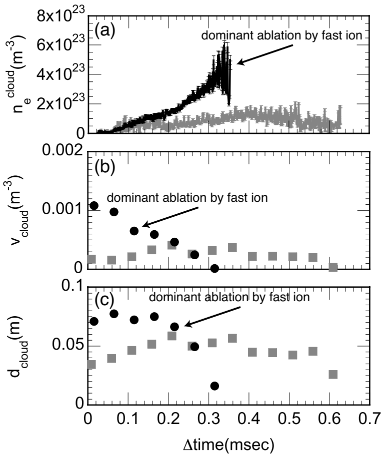

Fig. 1: Time evolution of the plasma cloud parameters. (a) electron density, (b) volume and (c) diameter of the plasma cloud are shown. The reference shot, in which the fast ion density is less by about a factor of ten than the case that the ablation by fast ions is dominant, is also shown in a grey color.

The increase of the electron density is considered due to the following explanations as shown in Fig. 2. The heat flux from the fast ions of NBI reaching the pellet increases and the size of pellet decreases, resulting that the ablation amount per pellet surface area becomes larger. Moreover, the volume of the pellet (also the plasma cloud) is smaller with time. Then the electron density of the plasma cloud continues to increase with time. As shown in Fig. 3, the time evolution of the electron density can be reproduced by the modeling of neutral gas and shielding (NGPS) model containing the interaction of the pellet with fast ions[3]. The larger volume at the early phase and the time evolution are probably associated with the ionization process inside the plasma cloud. The detail will be shown elsewhere.

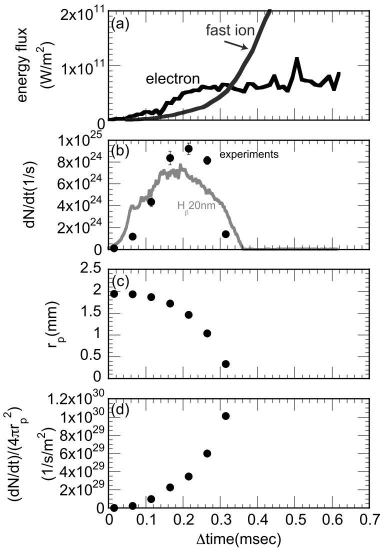

Fig. 2: Time evolution of (a) heat flux reaching the plasma cloud, (b) ablation rate, (c) pellet size and (d) ablation amount per pellet surface area. Electron heat flux q_e is evaluated from $q_e = \sqrt{2/\pi} T_e^{3/2} n_e / m_e^{1/2}$[2] and fast ion heat flux q_f is evaluated from $q_f = 1/2 n_f e E_b \sqrt{e E_b / m_H}$[3]. Ablation rate dN/dt is evaluated from $dN/dt \simeq 4\pi R_c^2 n_e^{cloud} \sqrt{T_e^{cloud}/m_H}$[4]. It is noted that the electron heat flux is higher than fast ion heat flux during the ablation, however, the heat flux of fast ions reaching the pellet surface is dominant (see Ref.[3]).

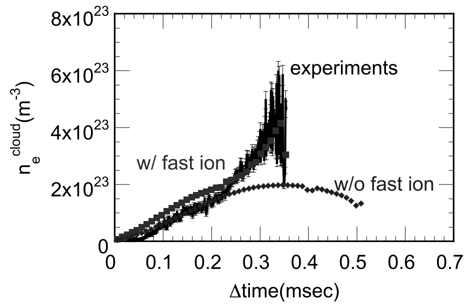

Fig. 3: Comparison of experimental time evolution of electron density of the plasma cloud with the modeling.

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

2) P. B. Parks et al., Phys. Fluids **21**, 1735 (1978).

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

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