Electric potential near the extraction region in negative ion sources with surface produced negative ions

A. Fukano and A. Hatayama[a]

Tokyo Metropolitan College of Industrial Technology, 1-10-40 Higashi-Ohi, Shinagawa-ku, Tokyo, 140-0011, Japan
[a] Faculty of Science and Technology, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama, Kanagawa, 223-8522, Japan

fukano@s.metro-cit.ac.jp

In study of negative ion sources, it is important to extract a large amount of hydrogen negative ions. Extraction of negative ions depends on a potential distribution near the extraction region. In surface production negative ion sources, negative ions produced on a plasma grid (PG) are accelerated by potential difference between plasma and a wall. In general, a sheath potential is formed in the plasma near the wall surface, but a general sheath potential accelerates surface produced negative ions toward an inner of the ion source, that is, the driver region.

One of the extraction mechanisms of surface produced negative ions is their Larmor motion around the filter magnetic field [1]. Negative ions produced on the PG surface change their direction by Larmor rotation and return to the PG surface and extracted from the extraction holes. However, recent experiment has suggested that the extracted current density of negative ions does not depend on the magnetic filter strength [2]. Thus, the physical mechanism of the extraction of surface produced negative ions from the PG has not been cleared. Since the plasma has a large amount of negative ions produced on the PG surface, there is a possibility that the potential distribution is different from the general distribution near the PG surface. Emmert *et al*. have investigated the sheath potential analytically considering both the plasma region and the sheath region self-consistently by using a plasma-sheath equation [3]. However, their analysis is for the plasma which consists of positive ions and electrons.

Potential distribution near the extraction region for the plasma with the surface produced negative ions is studied analytically, where negative ions produced on the PG surface are considered in addition to positive ions and electrons. The negative ions produced on the PG surface that have the energy larger than $-q\phi_{\min}$ can reach and pass through the center of the plasma, where $-q$ is the charge of the negative ion and $\phi_{\min}$ is the minimum electric potential. It is shown that the negative potential peak is formed near the PG surface for the case of strong surface production, which is not appeared in the general sheath potential. This will come from that low energy negative ion cannot over the potential drop produced by negative ion itself and in result the negative peak appears in equilibrium state. Negative ions may be reflected by this negative potential peak near the PG and returned to the PG surface. This reflection mechanism by the negative potential peak possibly affects the negative ion extraction. It is also indicated that the potential difference between the plasma and the wall for the plasma with the surface produced negative ions becomes smaller than that for the plasma without negative ions. This potential distribution also has possibility to affect on the negative ion extraction.

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