Dependence of double layer potential on the properties of anode spot plasma

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The anode spot is successfully utilized to plasma ion source because of its high power efficiency with generating high plasma density near to aperture. It is important to figure out how to control the anode spot size at plasma ion source so as to enhance ion beam current. In this paper, we investigate the relationship among the anode spot size, bias current and operating parameters such as operating pressure and bias voltage. We find that properties of anode spot including its size is closely correlated with the double layer potential between the anode and the ambient plasma. The experimentally measured anode spot size show good agreements with the estimated one using particle balance between the production and loss of ions inside the anode spot.

1. Introduction

An anode spot plasma is localized high density plasma, generated in front of a small electrode biased positively with respect to the plasma potential of ambient plasma and distinguished with ambient plasma by a potential difference, called as double layer. We have proposed a new approach to produce high ion beam current using localized characteristics of anode spot plasma near the extraction aperture [1]. Recently, we found that the anode spot plasma size should be comparable to bias electrode in order to enhance the ion beam current with stable operation [2]. Song [3] proposed that the size of anode spot is proportional to the reciprocal of pressure and electron-impact ionization cross section of ionization potential. However, we experimentally observed that the length of anode spot is expanded by increasing the bias voltage even if operated at fixed pressure. In the present work, it is figured out that the relationship between changes of anode spot size and operating parameters such as operating pressure and bias voltage is explained in terms of double layer potential.

2. Experimental setup

The basic structure is the same as that used in our previous work [4]. The ambient plasma (argon, 10-100mTorr) is generated by inductive coupling with fixed RF power of 150 W at the frequency of 13. 56 MHz. The anode spot is generated in front of a planar electrode of 6 mm in diameter. A DC P/S drives the positive voltage in range of 0-100 V on the bias probe through a limiting resistor of 100 Ω. An axially movable Langmuir probe (D : 0.1 mm, L : 2.5 mm) is used to measure the plasma properties. Shapes and sizes of anode spot plasmas are recorded by a commercial digital camera.

3. Experimental Results and discussion

Measured plasma properties of ambient plasma and anode spot show that the anode spot expands with decreasing the double layer potential or increasing the operating pressure. Based on the experimental result, the length of anode spot is derived from the particle balance between ion production inside the anode spot and ion loss through the surface of anode spot. The estimated size of anode spot using the particle balance is comparable to the experimentally measured one which is determined by double layer potential variation with increasing bias voltage.

4. Conclusion

It is confirmed that not only the operating pressure but also the double layer potential has an influence on the determination of anode spot size. The present work is helpful to understand the relationship among the bias current, anode spot size and extracted beam current and also give an information about the operating parameters ranges of anode spot plasma ion source with stable operation

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6. References

[1] Y. J. Kim, D. H. Park, H. S. Jeong and Y. S. Hwang, Rev. Sci. Instrum. 77 (2006) 03B507.

[2] Yuna Lee, Kyoung-Jae Chung and Y. S. Hwang, Cur. Appl. Phys. 15 (2015) pp.1599-1605.

[3] B. Song, N. D. Angelo and R. L. Merlino, J. Phys. D: Appl. Phys. 24 (1991) 1789.

[4] Yeong-Shin Park, Yuna Lee, J. J. Dang, Kyoung-Jae Chung and Y. S. Hwang, Rev. Sci. Instrum.85 (2014).02A508.