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INSIGHT INTO ENDURANCE ENHANCEMENT OF ECR MICROWAVE DISCHARGE NEUTRALIZER

Abstract

Japanese deep space spacecraft Hayabusa is the first spacecraft using an electron cyclotron resonance (ECR) microwave discharge ion thruster as the primary propulsion system. A discharge cathode to generate primary electrons to generate plasma is not necessary for the microwave discharge ion thruster. Hence the cathode erosion is not able to occur, which is one of a typical breakdown of ion thruster. In fact, the total accumulated operation time of Hayabusa's four ion thrusters named "μ10" thruster almost reached 40,000 hours, setting the world record. However, μ10 experienced an autonomous stop in the final phase of Hayabusa project by the degradation of the neutralizer. It was shown that the neutralizer is a critical element that limited the thruster lifetime. Therefore it is necessary to enhance the endurance of neutralizer to make the lifetime of the spacecraft longer. To understand the mechanism of performance degradation, we presupposed a degradation mechanism by studying the neutralizer which had gone through a 20,000-hour endurance test and whose degradation had already occurred. According to this mechanism, degradation is triggered off by divalent ion sputtering against walls of inside neutralizer. To prevent the degradation, to decrease sputtering voltage which related to applied neutralizer voltage to emit electrons and to decrease numbers of the ions are effective. The objective of this study is to evaluate degradation in quantitative form by measuring current distribution of the neutralizer and find out the method to improve endurance of the neutralizer. When ECR neutralizer emits electrons, the same charge of xenon ions hit inside of the neutralizer as a counterpart. This hit is necessary to emits electrons but also it triggers off the performance degradation. Therefore measuring the charge of the xenon ions is proper for improving endurance of the neutralizer. This positive charge flows to the earth ground in laboratory experiment on the ground. We measured this current by insulating each parts of the neutralizer and investigated current distribution when running the neutralizer. We found out that there are parts which the ions hit dominantly and the parts which the electrons hit dominantly. This knowledge enable us to understand what part is intimately related to decreasing numbers of ions which sputter inside neutralizer and what part is intimately related to decreasing sputtering voltage. We will report the results and clarify the method to improve endurance of the neutralizer.