Particle-In-Cell simulations on active mitigation of spacecraft charging in the Earth's polar region

Hideyuki Usui[1]; kojiro Imasato[2]; Yoshiharu Omura[3]; Hitoshi Kuninaka[4]

[1] RISH, Kyoto Univ.; [2] RISH,Kyoto Univ.; [3] RISH, Kyoto Univ; [4] ISAS

By performing three-dimensional Particle-In-Cell simulations, we have been investigating the time-dependent process of spacecraft charging mitigation by plasma injection. We particularly focus on the differential charging occurring between solar panel and spacecraft conducting part of spacecraft in the polar environment. In the presence of aurora electron beam, the absolute charging of spacecraft becomes the order of KeV as the worst case and the differential charging between the conducting surface of the spacecraft and the dielectric material on the solar panel can become several hundreds volts[1]. To mitigate the charging, active plasma release from a plasma contactor onboard the spacecraft is proposed as one of the effective methods. In order to understand the charging mitigation process by the plasma release we started to examine the transient plasma process in terms of electron/ion flux to the spacecraft surface and the corresponding potential variation by performing 3D PIC simulations.

In the simulation space, we set a spacecraft which consists of conducting body and dielectric film on the solar panels. This spacecraft system is immersed in the isothermal magnetized plasma environment. We assume that the aurora beam energy is around 100 eV. We started a simulation with no plasma emission from the body in order for the spacecraft to achieve a floating potential. After achieving the floating potential, we start emitting plasma from the spacecraft surface from one side of the spacecraft.

Due to the aurora current, the conducting part of the spacecraft was negatively charged around -50 V while the dielectric surface of the solar panel is about -30 V because of ion flux impinging at the ram side. In this case, approximately 20V differential charging occurs at the dielectric surface. In such a situation, we started emitting electrons from the spacecraft surface. Because of negative charge emission, the spacecraft potential increases and approaches to the plasma potential. This implies the absolute charging of spacecraft has been mitigated. The dielectric surface potential also increases. However, it starts decreases again at the later time, which implies that the differential charging is not mitigated. When we inject ions as well as electrons from the contactor, we can mitigate the differential charging at the dielectric panel. In the present paper, we will describe the details of the mitigation process of the absolute as well as differential charging of spacecraft in the polar environment.

REFFERENCES

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