SPACE PROPULSION SYMPOSIUM (C4)
Propulsion concepts and studies (9)

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FIELD EMISSION CATHODES FOR ELECTRODYNAMIC TETHER SYSTEMS - EMISSION CURRENT STABILITY IN FLUCTUATING ELECTRIC POTENTIAL CONDITIONS -

Abstract

Increase in orbital debris around the earth has become a serious problem in this decade. Not only suppressing new debris generation but also removing existing on-orbit debris is necessary to remediate on-orbit environment. In the Japan Aerospace Exploration Agency (JAXA), the effort to develop an electrodynamic tether (EDT) system has been conducted to apply it as de-orbit propulsion of active debris removal systems. The EDT generates Lorentz force by the interaction between the geomagnetic field and an electric current through the tether.This drag force can be used for de-orbiting orbital debris.

The EDT system mainly consists of a long conductive bare tether for electron collection and an electron emitter. A field emission cathode (FECs) is an attractive candidate for the electron emitter because it possesses low electric power consumption, high mechanical robustness, and chemical stability. Our FECs feature the use of carbon nanotubes as electron emission material. Electron emission current from the FEC to surrounding plasma depends on various conditions such as the electric field on the emitter surface, electric potential difference between the FEC and space plasma, geometry of the FEC electrodes, and the location of the position of FEC on spacecraft.

We developed a current/voltage control algorithm for the FEC operation on EDT systems. The electric potential of the FEC with reference to space plasma fluctuates because the electromotive force of the EDT varies in time on orbit. Since the electron emission capability of the FEC is restricted by space charge limitation, which is determined by the relative potential conditions, the FEC operation parameters have to be controlled to emit appropriate electrons. In this algorithm, the electron extraction voltage was controlled to keep the internal "gate" current constant so that the FEC can operate stably in the fluctuated potential conditions. The control algorithm was tested using a laboratory-model FEC, which was operated in a space chamber. In this test, the electric potentials of the FEC were varied on the assumption that the EDT system orbits on sun synchronous or other low earth orbits. As a result, the "gate" current was almost kept constant in time-dependent potential conditions by selecting the appropriate amount of control-voltage change.

Our next steps are to simulate the influence of space charge limitation on the FEC operation by the

experiments, and then to evaluate the FEC characteristics dependence on the thickness of ion sheath, residual gas species, and vacuum pressure.