

SPACE PROPULSION SYMPOSIUM (C4)
Electric Propulsion (4)

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PERFORMANCE IMPROVEMENT OF A CARBON NANOTUBE FIELD EMISSION CATHODE

Abstract

A field emission cathode (FEC) is an attractive electron source for various space applications such as electric propulsion, electrodynamic tethers, charging control of spacecraft, and scientific instruments. The FECs are especially suitable for small-sized space systems because the devices can be small, simple, and low-powered. In the Japan Aerospace Exploration Agency (JAXA), we have been developing carbon nanotube (CNT) cathodes, in which CNTs are used as electron emission materials.

Performance of a CNT cathode is specified by the extraction voltage, emission current density, electron extraction efficiency, emission stability, and durability. While some laboratory-model cathodes have been fabricated in JAXA, the characteristics have not been sufficient to apply the cathodes to practical applications. The purpose of this study is to improve these fundamental characteristics of the CNT cathode.

A new laboratory-model cathode was designed and fabricated based on our previous models. One of the major design changes was the treatment of the CNT emitter surface. In order to suppress the high-voltage-breakdowns between the emitter surface and the extraction grid, variation of the height of the nanotubes on the emitter surface was controlled below 10 micro-meters. Another major change was the insertion of a high resistance material between the emitter and the extraction grid to keep the close gap more stably. The nominal emission current was designed as 3.0 mA based on the electric field calculation.

Tentative results of the operation tests showed that the cathode can emit electrons stably up to 4.0 mA without fatal breakdowns. In this case, the current densities were approximately 0.125 mA/cm² for the assembly and 0.5 mA/cm² for the emission area. The extraction voltage was below 500 V and the extraction efficiency was around 90

As conclusion, a new laboratory model of a carbon nanotube cathode was designed and fabricated, and the characteristics were better than ones of our previous models. Detailed discussion including the endurance performance will be shown in the paper.