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Experimental Performance of 1 mN-class FEEP Thrusters

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ABSTRACT

In FEEP emitters, ion emission occurs on a narrow slit wetted by a liquid metal, usually cesium, that is ionized and accelerated away by means of a strong electric field. Ions are created by field evaporation from a number of sites arising from self-sustained surface instabilities of the liquid metal meniscus, arranged in a linear fashion with a density of about 100 sites per mm. Neglecting secondary border effects at the edges of the slit, the total ion current extracted, and thus the total thrust produced, are directly proportional to the length of the emitting slit, with a typical linear thrust density of about 20 μN/mm.

Emitters with slits between 2 mm and 150 mm have been fabricated along the years, the only practical limit to slit length being ease of manufacture. While emitters at the lower end of the length range are suited for such applications as drag-free control of small scientific spacecraft (e.g., the Microscope small mission by CNES), longer devices can be used for commercial applications on microspacecraft or for accurate attitude control task like in the GOCE mission by ESA. In the latter case, a 1 mN maximum thrust level is needed to perform attitude control, along the axes transverse to orbital velocity, of a LEO spacecraft in the 1000 kg class. The propulsion requirements of this mission have been assumed as a reference for the design of a millinewton-level FEEP thruster by Alta / Centrospazio.

This paper reports on the experimental characterization of 50 mm slit FEEP thrusters. Recorded thrust was in the 1 μN to 1300 μN range with high controllability. Recorded beam profiles show divergency angles of about 20 deg and 40 deg in the plane of the slit and in a plane perpendicular to it, respectively. Power efficiency was always higher than 90% over a specific impulse range of 6000 s to 11000 s.