Paper ID: 20142
oral

SPACE PROPULSION SYMPOSIUM (C4)
Electric Propulsion (4)

Author: Prof. Salvo Marcuccio
Sitael Spa, Italy

Dr. Nicola Giusti
Sitael Spa, Italy
Dr. Pierpaolo Pergola
Alta, Italy

IONIC LIQUID FEEP THRUSTER ION BEAM CHARACTERIZATION

Abstract

The Ionic Liquid FEEP (IL-FEEP) thruster is under development at Alta as a variant of the classical cesium FEEP thruster. In this application of the field emission electric thruster concept, the alkali metal propellant is replaced by a ionic liquid. Ionic liquids offer considerable advantages if compared with traditional FEEP propellants such as alkali metals (Cs, Rb) or other liquid metals and alloys (Ga, In, Bi), due to their negligible reactivity with air and water, extremely low vapour tension, low toxicity, and compatibility with a wide range of materials. These aspects lead to significant design simplifications and streamlined ground operations. In comparison with cesium, however, ionic liquids are expected to yield reduced specific impulse and mass efficiency.

The study here reported was aimed at the characterization of the thruster plume in terms of composition and velocity of the constituents, with the ultimate goal of getting a reliable estimate of the thruster specific impulse and mass efficiency. To this end, a large number of tests was carried out using a linear slit FEEP emitter fed with the EMI-BF4 ionic liquid. The thruster was fired in positive polarity and negative polarity to check the capability to extract anions and cations alone. Most of the testing was then carried out in alternate polarity mode, in order to avoid electrochemical poisoning of the propellant due to the unbalanced extraction of charged particles. Such operating mode is believed to be the most promising candidate for flight operation, as it would allow to get rid of an external neutralizer to maintain electrical neutrality of the spacecraft.

Ion beam composition was investigated with the Time-Of-Flight (TOF) mass spectrometry technique. The measurements show that the emitted beam is mostly composed of monomers (BF4)-, dimers (C6H11BF4N2) (BF4)- and polimers (C6H11BF4N2)n (BF4)-, with $100<n<200$ depending on the emitter voltage. Propellant consumption was evaluated indirectly by means of time integration of the emitted current, under the assumption of a certain beam composition, and independently verified by means of direct observation of the depletion of the propellant reservoir. The resulting specific impulse is around 1400 s at a working voltage of around 7.5 kV.