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IONIC LIQUID FEEP: RECENT EXPERIMENTAL RESULTS

Abstract

The cesium-fed field emission thruster (FEEP) was developed for very demanding scientific missions in need of accurate micronewton level thrust, such as LISA Pathfinder. The ionic liquid FEEP (IL-FEEP) is new version of the field emission thruster where the alkali metal propellant is replaced by an ionic liquid. Ionic liquids are organic molten salts composed of a mixture of loosely bound cations and anions, liquid at or close to room temperature, developed by the chemical industry during the last 15 years as process fluids and solvents. In comparison to liquid metals, ionic liquid propellants have reduced specific impulse and mass efficiency; however, with respect to alkali metals, the use of ionic liquids for FEEP leads to considerable simplifications (i.e., cost savings) in space and ground operations and supporting equipment. Possibility of contamination to the host spacecraft, as well as danger of contamination of the thruster from the external environment, are much reduced. In comparison to other micro/nanosatellite propulsion systems, IL-FEEP performance is far superior in terms of specific impulse, controllability and power efficiency. The IL-FEEP system goal is to provide autonomous orbital maneuvering and lifetime extension capability through drag compensation (or de-orbiting) to micro- and nano-satellites, such as Cubesats, with limited impact on the onboard resources. Development of the IL-FEEP thruster is based on the heritage of the cesium FEEP and is currently funded by ESA and EU programmes.

This paper presents the results of a recent experimental campaign aimed at assessing the performance of linear slit FEEP emitters fed with a ionic liquid propellant. Tests were done on a standard 8-mm slit FEEP emitter fed with EMI-BF4. The test setup allowed for continuous monitoring of the thruster electrical parameters, as well as for direct scanning of the exhaust beam profiles using electrostatic wire probes. The test results essentially validate the possibility to operate the linear slit FEEP emitter with ionic liquid propellant in pure ionic mode. Results of the beam scanning show very regular and repeatable performance in positive mode, while operation in negative polarity showed some irregularities in beam profiles. Thruster performance in a later test in alternate polarity mode was remarkably stable over a very long period, in spite of the previous predominance of positive mode firing that could have affected the propellant composition in the reservoir due to electrochemical degradation. Alternate polarity is therefore regarded as a promising operating mode for the simplified FEEP thruster.