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VERIFICATION OF A SIMULATION MODEL BASED ON BEAM DIAGNOSTICS MEASUREMENTS OF THE IFM NANO THRUSTER

Abstract

The mN-FEEP thruster developed at FOTEC has a high mass efficiency and due to its low thrust range, it is ideal for precision control of spacecrafts. The thruster is based on the liquid metal ion source (LMIS) concept, where liquid metal is used as propellant. The emitter consists of a porous tungsten needle crown wetted with liquid indium. A high voltage is applied between a needle-shaped emitter and an accelerator electrode, which leads to a strong electric field. Ions are extracted from the cone tip and are accelerated in the direction of the extractor electrode thereby generating the thrust. An example is the IFM Nano thruster developed at FOTEC and sold by ENPULSION, which is a thruster module designed for nanosatellites (CubeSats). Main drivers for precision control are the beam divergence angle, thrust vector and the propellant mass efficiency. Another aspect to consider is the interaction of the beam with components of the spacecraft. Due to such interactions, solar panels or electrical instruments on board the spacecraft could be damaged by coating with liquid indium or sputtering effects. So far, there are only a few studies on the structure and behaviour of the thruster beam of a FEEP thruster. For the experimental investigation of the thruster ion beam, a beam diagnostic system was set up at FOTEC. With this system the spatial ion current density and the ion energy distribution of the beam of a single needle as well as an entire crown emitter was observed. Based on these analyses, a particle tracing simulation model was developed, to determine the theoretical ion current density and energy distribution. The verification of the model shows that the thrust vector and divergence angle correspond to the experimental results, which means that the experimentally measured beam profile of a single needle can be covered by the simulation. In addition, a matching behaviour of the beam is achieved for various thruster parameters, such as electrode voltages or beam currents. This simulation model will lead to a better understanding of the thruster technology and will be used to optimise the thrust vector and the divergence angle of the thruster beam. For this purpose, a variety of parameters could be adjusted, such as the geometry of the thruster electrodes. With this, it would be possible to use the developed simulation model for various missions to adapt the thruster properties to the mission requirements.