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DEVELOPMENT OF A NOVEL AMBIPOLAR PLASMA THRUSTER FOR NANOSATELLITES AND AIR BREATHING APPLICATIONS

Abstract

Miniaturized satellites have become increasingly popular in recent years due to their low development costs. In order to cover different mission profiles and to exploit the capabilities of miniature satellites, efficient and cost-effective propulsion systems are required.

The presented propulsion concept uses RF power and a novel antenna to ionize the propellant. The particles are accelerated by a magnetic nozzle. This eliminates the need for a grid, and the concept has a number of other advantages. The simple structure, consisting of a magnetic field generator, the antenna and a discharge chamber, is robust and does not require high DC voltages on board the spacecraft. Due to the ambipolar acceleration, no electrodes are exposed to the plasma. This extends the lifetime and allows the use of many alternative and novel propellants, which is an additional advantage for the use on micro- and nanosatellites. The presented propulsion concept can also be used as an air-breathing engine, since it can operate on gas mixtures similar to the Earth's atmosphere and does not require a neutralizer, which often cannot use the same gas mixture as an air-breathing engine due to atmospheric oxygen.

The presented thruster concept also addresses a point that is often neglected when using conventional antenna designs in RF thrusters: high coupling efficiency even without the need for automatic matching and at low powers of less than 100W. Since it does not rely on multimode resonances like a helicon plasma source, it is much less susceptible to instabilities and inefficient coupling if not operated under optimal conditions.

We present the development of a first prototype using this propulsion concept. The design and optimization were performed using a one-dimensional semi-empirical model for RF propulsion. The power target was 10-50W with a maximum Isp of 1000s and 1mN thrust at 50W. During the characterization of the thruster, different antenna configurations are tested and the results are discussed.

The obtained performance data are compared with the results of the computational model and an outlook for optimization is given. In addition to the performance analysis, the use of non-corrosive alternatives to iodine as a solid propellant for small spacecraft is discussed. These alternatives offer distinct advantages over conventional gaseous propellants such as xenon. In particular, they offer high density without the need for a pressurized tank and low propellant cost.