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SPACE PROPULSION SYMPOSIUM (C4)
New Missions Enabled by New Propulsion Technology and Systems (6)

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DEVELOPMENT OF A LOW PRESSURE FREE MOLECULAR MICRO-RESISTOJET FOR CUBESAT APPLICATIONS

Abstract

The present and future generation of CubeSats and nano-satellites require low mass propulsion systems of intrinsic safety with a sufficiently long operational time. This is particularly true when formation flying maneuvers, orbit change maneuvers or station keeping of constellations is required. Typical corrosive, flammable, and/or toxic propellants cannot be used in this class of very small satellites; even cold gas thrusters, although they use intrinsically safe propellants such as inert gases, require to store them at a very high tank pressure and do not usually provide sufficient performance for tasks such as orbital maneuvering or drag compensation. One potentially promising "green" and safe propellant for future micro-propulsion concepts is water, which has, in liquid state, a high mass density and can eventually be stored also in its solid state as ice.

This paper presents the development status at Delft University of Technology of the Free Molecular Micro-Resistojet (FMMR) concept. In this particular type of electro-thermal thruster water, or another intrinsically safe propellant, is stored as a solid and operated at very low pressure, under sublimation conditions. The water vapor is then expelled at high Knudsen numbers, through micro-channels with resistance and sensors integrated, which are produced at Delft University of Technology using Micro-ElectroMechanical Systems (MEMS) technology. The complete manufacturing procedure, starting from a silicon substrate, is described in the paper.

The particle velocity is increased in the micro-channels not by geometrical expansion as in conventional propulsion concepts, but by thermal energy of the walls, transferred to the particles through collisions. The Direct Simulation Monte Carlo (DSMC) numerical simulations presented in the paper shows that it is theoretically possible to achieve a thrust level in the order of some N up to a few mN with a plenum pressure of 50 to 300 Pa and a micro-channel wall temperature of up to 700 K. The simulations show that plenum pressure, wall temperature, micro-channel shape and dimensions influence to a different extent the physics of the collisions phenomena involved. Thus the thruster performance, opens the way to a better understanding of the operational principle of this concept and to its possible use in future demonstration missions. Several design challenges at system level, that remain to be solved to make this demonstration possible, are also discussed in the paper.