Linear Array of Electrospray Micro Thrusters
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Electrospray thrusters are electrostatic accelerators of charged particles that use the electrohydrodynamic effect known as Taylor cone as propulsive effect [1]. These particles could be charged droplets, solvated ions, or a mix of the two. Since the new advances in electrospray technology that occurred in the late 1980s [2], the field of electrospray propulsion has experienced a renaissance, specifically aiming to provide efficient high-tunable precision low-thrust engines for micro-satellites and high accuracy astrophysics missions [3]. The MIT Space Propulsion Laboratory and the Microsystems Technology Laboratories are currently pursuing the development of a micro-fabricated electrospray emitter array for space propulsion. The project is developing in parallel two radically different concepts, a pressure-fed engine, and a surface tension-fed engine. This abstract reports the design, fabrication, and experimental characterization of a micro-fabricated, internally-fed linear array of electrospray emitters (Figure 1). This work demonstrates the feasibility of high clustering of electrospray emitters. The linear array is composed of 1 plenum, 12 manifolds, and 240 emitters. The emitters are sharpened to reduce the startup voltage. The electrodes are micro-fabricated with conductive paths made of tungsten and electrical insulation provided by vacuum gaps 350 µm wide and 10 µm thick PECVD silicon oxide. The electrodes are hand-assembled to the engine using a novel technique that relies on clusters of micro-fabricated springs [4]. This assembly scheme allows us to have two independent process flows for the electrodes and the engine hydraulics. The emitter-to-emitter separation is 130 µm, and the hydraulic diameter is 12 µm. The length of each channel is 15 mm. The engine uses highly doped formamide as propellant, with electrical conductivity in the 0.3 – 3.0 S/m range. The electrospray array operates in the single Taylor cone droplet emission regime, and it requires about 2000 V to become activated. The engine implements the concept of hydraulic and electrodynamic flow rate matching to achieve electrical control. Current versus flowrate characteristics of the engine are in agreement with a well-established reduced order model (Figure 2). Experimental data, demonstrating the low divergence of electrospray emitter arrays operated in the single Taylor cone, is in qualitative agreement with a reduced order mode that assumes the absence of a thermalized tail in the plume.

REFERENCES: