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A SILICON-BASED MEMS RESISTOJET FOR PROPELLING CUBESATS

Abstract

Over the last decade, the space community has been showing increased interest in cubesat projects, thereby aiming to provide small spacecraft with the same capabilities as now found on larger satellites. With this comes the challenge of providing cubesats with highly integrated and miniaturized sub-systems. Of these sub-systems the miniaturization of the propulsion system is a very challenging one, because of the relatively large volume occupied by the propellant and the limitations that come from conventional manufacturing.

Here, we present a novel resistojet, realized in silicon-based MEMS technology. A resistojet is intrinsically simple, requiring only a heater to heat up the propellant flow before it expands in the nozzle. It is considered the step to make after cold gas propulsion as it not only offers higher performance, but also a higher propellant density and hence reduced system mass. In the same time it enables an adequate safety level, and good performance in terms of specific impulse and electric power consumption.

Our MEMS resistojet thruster has an integrated thin-film heater capable of heating propellant gas flow of 1 mg/s to 350 C. Using nitrogen as propellant, the design should be capable of producing a thrust between 20 μN and 1 mN and a specific impulse about 1.5 times better than that of the cold propellant. However, it is also suitable for use with water or ammonia, which will increase volumetric specific impulse. Tests performed under vacuum conditions demonstrated good working of the thruster with chamber pressures and propellant flow rates in the range $1-5$ bars and $0.15-1.5$ mg/s, respectively and a maximum chamber temperature of 400 C. Analysis shows a discharge factor for the micro-nozzle of 0.8 at high flow rates and a factor 1.6 lower at low flow rates. Its small size (25 x 5 x 1 mm), low mass (162 mg) and low power consumption (< 1 W) are very attractive for application on cubesats.

This paper will describe the specification of requirements, the performed analysis and the designs generated and manufactured. We will also outline the fabrication steps, as well as the test setup, strategy and test results and discuss how well they compare with theory.