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DESIGN AND ANALYSIS OF A MEMS BASED MICROVALVE FOR MICRO-PROPULSION SYSTEMS

Abstract

This paper will discuss the design of a piezoelectric actuated microvalve to modulate the flow in propulsion systems intended for space application. There has been a rising interest over the past decade to achieve high level of miniaturisation by developing small satellite components of sub-millimeter to sub-micron level to meet the mission requirements of nano and pico-satellites. Delft University of Technology is currently developing an innovative green propellant driven micro-propulsion systems based on micro-electro-mechanical (MEMS) technologies for its PocketQube called Delfi-PQ with a 5x5x5 cm form factor. While the actual thruster is developed, the interfacing and integration to other components is still under development.

Due to strict mass, volume and power limitations imposed by the PocketQube satellite requirements there arises a need for micro-scale components to develop a highly integrated propulsion system. TU Delft is focusing its research on the development of microvalves with minimum leak rates and integration in the same microchip as the actual thruster. The thrusters have a chip size of 17*7mm and specific impulse of 105-117s. In this paper a brief review of the challenges involved in the development of microvalves which are suitable for space applications will be provided. After evaluating the current microvalve actuation concepts, the paper will present the preliminary design of a MEMS-valve suitable for a flow rate of 4-5 g/hr, power consumption of 5 W and maximum operating pressure of 5 bars. The design is modelled as a normally closed valve consisting of three major parts: valve seat with inlet and outlet, flexible membrane and a piezoelectric actuator. The device will be fabricated from silicon-on-insulator wafer along with thin film deposition of the lead zirconate titanate (PZT) material on the micro-machined part. The MEMS fabrication process flow available at the TU Delft's Else Kooi Laboratory will be outlined for the device. This paper will also address the test procedure, the experimental results of five passive microvalve devices fabricated at Else Kooi along with the limitations in the technology available for the package assembly processes.