TWO-DIMENSIONAL MICROTHRUSTER MATRIX USING GAP/AP SOLID PROPELLANT

K. Sathiyanathan[1], R. Lee[1], H. Chesser[1], C. Dubois[2], R.A. Stowe[3*], R. Farinaccio[3], S. Ringuette[3]

[1] *York University, Canada;* [2] *Ecole Polytechnique de Montréal, Canada;* [3] *DRDC Valcartier, Canada*

Robert.Stowe@drdc-rddc.gc.ca

A solid propellant microthruster (SPT) is a two-dimensional matrix of millimetre-sized rockets with each one being individually addressable to provide milliNewtons of thrust for precise course corrections. SPT arrays have the advantage of being extremely low power, low mass and low volume. Effectively, hundreds of thousands of miniature rockets can be placed on a single platform. York University's nanosatellite program, in collaboration with DRDC Valcartier, is developing a unique SPT design based on conventional inexpensive materials with future plans for MEMS fabrication. The prototype SPT consists of individual thrusters with chambers 1.5 mm in diameter and approximately 3 mm in depth. The entire SPT has a mass of approximately 30 grams and is 4 cm x 4 cm x 0.5 cm in dimension.

The propellant is a formulation of glycidyl azide polymer (GAP) and ammonium perchlorate (AP). The propellant formulation was customized to obtain a lower viscosity to enable easier filling of the miniature combustion chambers. The AP content was reduced from its traditional value to about 50% by mass with the remainder being composed of GAP polymer and GAP plasticizer. GAP is an active binder allowing for the small amount of propellant to be as energetic as possible. The use of an energetic plasticizer is aimed at lowering the glass transition temperature of the binder, an important characteristic if the propellant is to be used under space flight conditions. Highly energetic components, very small grain sizes and prevention of heat loss are critical considerations in making the microthruster fire successfully. At these small scales, the high surface area to volume ratio leading to chemical and thermal quenching, and the low Reynolds number affect the mechanics of combustion and fluid flow and must be taken into account.

In this poster, we present an overview of the SPT design and manufacturing, small scale considerations, test procedure, and results. Testing for the prototype thrusters was achieved using a very lightweight pendulum thrust stand with a high precision laser interferometer to measure displacement. Tests with no nozzle, sonic nozzle and supersonic nozzle have been performed. Pendulum deflection values are promising. The proposed SPT design will be demonstrated on-board the YuSEND-1 satellite, currently under development at York University.

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