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SPACE PROPULSION SYMPOSIUM (C4)
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A NOVEL DESIGN OF MEMS BASED MICROPROPULSION SYSTEM FOR A NANOSATELLITE

Abstract

Development of Nanosatellites featuring masses from 1-10Kg resulted in the requirement of specialized onboard propulsion systems. There has been more emphasis on increasing the specific impulse, lowering volume and power consumption for the past one decade. Miniaturization is one of the solutions to this. Microelectromechanical Systems (MEMS) offers specialized techniques for the development of these propulsion devices known as Microthrusters. Main functions of these devices include Attitude control, Orbit adjust, Drag compensation, Station keeping, counteraction of gravity well distortions and counteraction of solar pressure disturbances. Among them Solid Propellant Micropropulsion systems drew so much attention because of minimized complexity, no moving parts, very low propellent leakage possibility. The number of solid propellant types that can be used is low which is considered to be a disadvantage. This paper aims to design an innovative micropropulsion system which efficiently overcome the disadvantages of previous designs. Bombardier Beetles of Kingdom Animalia are ground beetles which are known for their defense mechanism. When disturbed they eject a hot noxious chemical spray from the tip of their abdomen with a popping sound. There are two reservoirs in the beetle's abdomen that store Hydroquinone and Hydrogen peroxide. The two chemical are allowed to mix in a third chamber with water in the presence of catalysts such as peroxidases and catalases when needed. The catalysts rapidly break down the hydrogen peroxide, releasing free oxygen and catalyzing the oxidation of the hydroquinones into p-quinones. The reaction is very exothermic, and the released energy raises the temperature of the mixture to near 100 C, vaporizing about a fifth of it. The boiling, foul-smelling liquid partially becomes a gas by flash evaporation and is expelled explosively through an outlet valve, with a loud popping sound. The whole sequence of events takes only a fraction of a second.

The Bombardier beetle mechanism proves to be an efficient mechanism that can be used for Micropropulsion systems. The present device named as Bombardier beetle Microthruster uses a similar mechanism by storing Hydrogen peroxide in the first chamber and Hydroquinone with catalysts [which is solid] in the other chamber of MEMS device. When triggered Hydrogen Peroxide is allowed to enter the second chamber which thereby produces thrust. The hot substance is allowed to escape through the micronozzle. The exact design, thermal and flow simulations of the device have been formulated and presented in the paper. In addition thrust efficiency of the device is improved.