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A MILLIMETER-SCALE REACTION WHEEL DESIGN USING THE MEMS MILLIMETER-SCALE TRAVELLING WAVE ULTRASONIC MOTOR

Abstract

The rapid development and application of Microelectromechanical Systems (MEMS) have been driving the miniaturization of the spacecraft. Small satellites, like CubeSats, and satellite-on-PCB have emerged as the MEMS technology advances. The reaction wheel commonly used for the Attitude Determination and Control System (ADCS) of the CubeSat generally includes a flywheel on a brushless DC motor. However, the development of miniaturization of the brushless motor has many restrictions, which also severely limits the miniaturization of the reaction wheel. In this paper, we present a millimeter-scale reaction wheel design based on the novel MEMS traveling wave ultrasonic motor technology. The traveling wave ultrasonic motor utilizes the piezoelectric effect to cause a vibration of a fixed stator and generates a traveling wave, which drives a rotor that is frictionally coupled with the stator to perform the required rotational motion. The structure of the traveling wave rotary ultrasonic motor will be discussed in this paper. The main components of the reaction wheel are a flywheel, a rotor and a stator with PZT films. This reaction wheel can produce a high torque output with generating a harsh noise, and another advantage is the quick response.

The magnitude and frequency of the excitation voltage are the keys to control of the ultrasonic motor, which will be discussed in detail in this paper. Actually, using the MEMS millimeter-scale traveling wave ultrasonic motor will push the limit of the small satellite to Femtosatellite, like the satellite-on-a-chip concept, which is under development at the University of Sydney. At the same time, this technology is also suitable for developing micro-actuators in aerospace and other applications.