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DEVELOPMENT OF THE MEMS-BASED NOZZLE USING DRIE OF TAPERED HOLE TECHNOLOGY FOR CUBE SATELLITE

Abstract

With advances in micro-electro mechanical system (MEMS) technology, Microsystems are especially beneficial for small satellites. In these satellites, the MEMS thruster providing the micro propulsion is a key component to expand the missions and extend its lifetime. Several papers have reported MEMS nozzle such as 2D and hall type MEMS nozzle. In this paper we proposed a tapered MEMS nozzle using deep reactive ion etching (DRIE) to improve the performance of MEMS thruster. The design, fabrication, and performance evaluation of the proposed nozzle were presented. Prior to fabrication, CFD analyses were performed to predict the performance enhancement of the tapered nozzle compared with the hall type nozzle. The throat of the proposed nozzle was 100 μm, and the area ratio of the proposed nozzle was 2.2. The computation results gave that the thrust was 9.1 mN at a chamber pressure of 10 bar. The thrust of the tapered nozzle was higher 8.3 % than the hall type. Standard 150 mm <1 0 0> p-doped silicon wafers were used to fabricate the nozzle. A continuous SF6/O2 process at room temperature has been used to etch tapered MEMS nozzle using a DRIE-ICP tool. The measurement of the thrust was performed using a novel μN level MEMS thrust measurement system based on piezo-resistive sensor. As a result of thrust measurement, maximum thrust of tapered MEMS nozzle was about 7.7 mN. The measured average maximum thrust was approximately 15 % lower than that of CFD result. This study demonstrated that the fabrication of tapered MEMS nozzle is possible, and that the performance of the nozzle was improved by the tapered shape in micro scale.