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DESIGN AND FABRICATION OF MEMS THRUST MEASUREMENT SYSTEM FOR PERFORMANCE EVALUATION OF MEMS THRUSTER

Abstract

Nano satellites such as cubeSat have been attracted much attention due to its mass and size. These satellites need a micro propulsion system such as a micro thruster for expanding the missions and extending its lifetime. Various research of the micro thrusters have been reported, but the research of the thrust measurement system suitable for the testing of micro thruster is still insufficient. In this study, MEMS thrust measurement system suitable for the μN level thruster has been developed. The proposed MEMS thrust measurement system was based on piezoresistive sensor and consists of a membrane, microbeam, and piezoresistive sensor. The design range of the thrust measurement system is from 500 μN to 10 mN. Prior to the fabrication, the FEM analysis was conducted to verify the stability of the system and design the dimensions of a membrane, microbeam, and piezoresistive sensor. The size of the membrane and the microbeam were 15 mm x 15 mm, and 500 μm x 500 μm, respectively. The thickness of the membrane and microbeam was 20 μm. The numerical simulation results were calculated that the stress and strain of the microbeam in the thrust range of 500 μN to 10 mN were from 7 to 130 MPa and from 51 to 1018 $\mu\varepsilon$, respectively. The stability of the thrust measurement system was verified by comparing the yield strength(Silicon, 1 GPa) of the material with the maximum stress. The position of the piezoresistive sensor was located in the 20% section of the microbeam in order to achieve the high gauge factor. The MEMS thrust measurement system was fabricated with SOI wafer. The poly-silicon layer into which a boron ion with a concentration of 1.5E+15 cm-2 was implanted was used to form the piezoresistive sensor. The microbeam and membrane were fabricated by deep reactive ion etching method. The thin metal layer to form the electrode was deposited by using sputtering method. In order to investigate the static characteristics of the fabricated measurement system, the gauge factor, nonlinearity, and hysteresis were measured by using standard weight. The value of the gauge factor, which represents the sensitivity of piezoresistive sensor, is 34.0; this value is about 7-15 times higher than the gauge factor of a conventional metal-foil strain gauge. Further, nonlinearity and hysteresis were 0.21% and 0.17%, respectively. Based on these results, we established the μN level thrust measurement system based on MEMS technology.