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Development of MEMS Magnetic Type Micro Swing Generator

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Abstract: This paper presents the 10 mm square size MEMS (Micro Electro Mechanical Systems) magnetic type micro swing generator. Our proposal generator consists of silicon layer, base layer and magnet layer. The silicon layer has a coil, spring, and fin which was fabricated the silicon wafer by MEMS technology in the same process. The generator generates the micro swing which can apply to several applications. The MEMS magnetic type micro swing generator generates the movement by coils and magnet. As a result, our fabricated MEMS magnetic type micro swing generator generates the 1 μm micro swing.

1. Introduction

Many studies have intensively been done on micro actuator for several micro machines. Although the miniaturization of the actuator has conventionally been progressed by mechanical machining, assembles, and energy system. Some difficulty has appeared in order to achieve further miniaturizations. On the other hands, some advanced studies of micro actuator have been paid attention for PZT. However, PZT has hysteresis. Instead of conventional mechanical machining, MEMS (Micro Electro Mechanical System) technology based on the IC production lines has been studied for optical beam steering using magnetic field [1]. This devise has double degree-of-freedom by the coil made by cupper on the silicon wafer and magnetic field.

We are studying about the micro actuator. The coil, spring, and fin which was fabricated the silicon wafer by MEMS technology in the same process. The movement of MEMS magnetic type micro swing generator was generated by interaction of coil which flow electrical current and magnet. Therefore, the MEMS magnetic type micro swing generator has potential of the miniaturization of the swimming micro robot. This paper presents the system and movement of the MEMS magnetic type micro swing generator fabricated by MEMS technology.

2. Mechanism of MEMS magnetic type micro swing generator

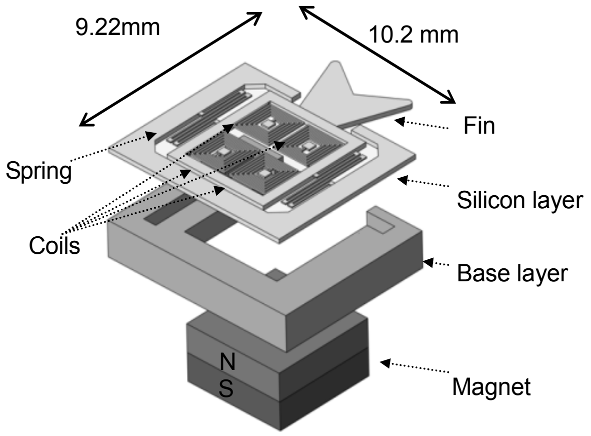

Figure 1. Design of the fabricated MEMS magnetic type micro swing generator.

Figuer1 shows Design of the fabricated MEMS magnetic type micro swing generator. The fin system was consisted of silicon layer, base layer and magnet. Silicon layer was consisted by coils, fin, frame, and springs. The peace of coils was 4. Each coil was consisted of two sinistrality coils and tow dextrality coils. The turns of coil were 5. The width of coil was 70μm. The coils were borne by springs. The springs were connected to frame. The size of spring was 120, 250, 4800 μm, width, thickness, length.

Schematic diagram of movement is shown in Fig.2. The movement of MEMS magnetic type micro swing generator was generated by interaction of coil which flow electrical current and magnet. Qualitative movement, the case of the magnetic field which is 1 dimension model only z-axis, Generative force *F(z)* of MEMS magnetic fin system describe as follows. *U(z)* is magnetic potential energy.

$$F(z) = \frac{\partial U(z)}{\partial z} \tag{1}$$

$$U(z) = \frac{1}{2}\left[m_m\left\{H_m(-t/2) + Hc(z + t/2)\right\}\right] + \frac{1}{2}\left[m_c\left\{H_m(z) + Hc(0) + \right\}\right] \tag{2}$$

z: Distance between surface of magnet and coil. m_m:

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[1]: Department of Precision Machinery Engineering

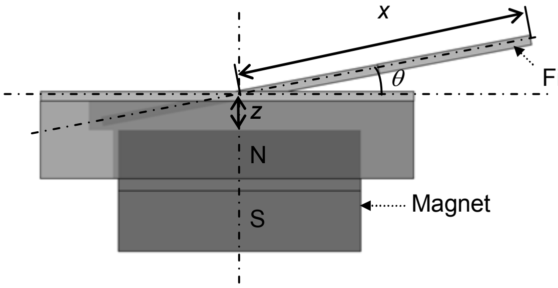

Figure 2. Schematic diagram of movement.

Magnetic moment of magnet. m_c: Magnetic moment of coil H_m: Intensity of magnetic field of magnet. H_c: Intensity of magnetic field of coil. t: thickness of magnet. Generative force $F(z)$ of MEMS magnetic fin system describe as follows.

$$F(z)=\frac{1}{2}\left[m_m\frac{\partial}{\partial z}H_c(z+t/2)+m_c\frac{\partial}{\partial z}H_m(z)\right] \quad (3)$$

The torsion direction of springs is out of consideration. The displacement angle of the cantilever describe as follows.

$$\theta=\frac{3l}{Ebh^3}Fy \quad (4)$$

l; length of a spring. E: Young's modulus. b: width of spring. h: Thickness of spring. x: Distance between surface of spring and fin. The displacement angle of the fin describe as follows.

$$\theta=\frac{3ly}{2Ebh^3}\left[m_m\frac{\partial}{\partial z}H_c(z+t/2)+m_c\frac{\partial}{\partial z}H_m(z)\right] \quad (5)$$

The displacement angle is depended on distance between surface of coil and magnet and figure of spring. In especial, the displacement angle is inversely relating the cubic of thickness of spring.

3. Result

The designed shape of silicon layer was formed by the photolithographic process. ICP dry etching process realized high aspect ratio machining. The base layer was fabricated by FR-4. The fabricated MEMS magnetic type micro swing generator was connected to the function generator (IWATSU SG-4105) and input the pulse ($V_{p\text{-}p}$: 20V, 1Hz).. The displacement was measured by laser displacement gauge (KEYENCE LK-H023) Figure 3 shows result. The displacement was 1 μm. The displacement has cycle length. Cycle length of displacement was shorter than input pulse. Cycle length of displacement and increase of displacement were needed more research.

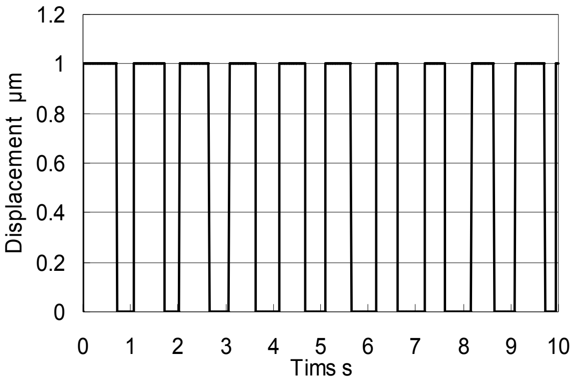

Figure 3. Temporal displacement of fin.

4. Conclusion

In this paper, we fabricated the MEMS magnetic type micro swing generator. The coil, spring, and fin simultaneously were fabricated all together by MEMS technology using silicon wafer. The displacement was measured by laser displacement gauge. The displacement was 1 μm. The displacement has cycle length. Cycle length of displacement and increase of displacement are need more research.

Acknowledgments

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Reference

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