K6-21

Design of MEMS Rotary Type Actuator Using Piezoelectric Elements

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Abstract: Previously, we constructed the 4.0×4.0×3.5 mm size micro robot using MEMS technology. However, rotary type actuator using artificial muscle wires was difficult to actuate for long periods because thermal generation of the artificial muscle wires is larger than the radiation. In this paper, millimeter size piezoelectric actuator mechanism for MEMS micro robot has been proposed. The piezoelectric element actuator generates the rotational movement by tapping the gear by vibrations. As the result, MEMS rotary type actuator could be fabricated by 4.08×2.50×3.55 mm size by using MEMS technology.

1. Introduction

Many studies have been done on micro robots for several applications such as precise manipulations, medical fields, and so on. However, mechanical machining is difficult to fabricate the component which is less than 1mm size. Therefore, MEMS (Micro Electro Mechanical Systems) technology which is the micro fabrication technology based on the IC production lines have been studied for fabricate the components of the micro robot [1].

We are studying about millimeter size micro robot based on MEMS technology. Previously, we constructed the 4.0×4.0×3.5 mm size micro robot using MEMS technology [2]. The micro robot consisted of frame parts, rotary type actuators and link mechanisms. The rotary type actuator was composed by rotor and 4 pieces of artificial muscle wires. The rotary type actuator generated the locomotion of the robot by applying the electrical current to the artificial muscle wires. The wire shrunk at high temperature and extended at low temperature. However, rotary type actuator using artificial muscle wires was difficult to actuate for long periods because thermal generation of the artificial muscle wires is larger than the radiation.

In this paper, millimeter size piezoelectric actuator mechanism for MEMS micro robot has been proposed.

2. MEMS rotary type actuator

Figure 1 shows the schematic diagram of MEMS rotary type actuator. The MEMS rotary type actuator was connected of gear, ankle, piezoelectric elements, and frame.

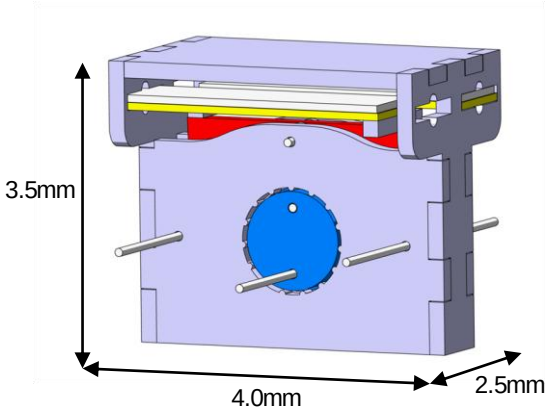

Figure 1. Schematic diagram of the rotary type actuator.

The components of the actuator were made from silicon wafer. We use the 100, 200, 500, μm thickness silicon wafer to construct the 4.0×2.5×3.5 mm size MEMS rotary type actuator. The micro fabrication of the silicon wafer was done by the MEMS technology. The shapes were machined by photolithography based ICP dry etching.

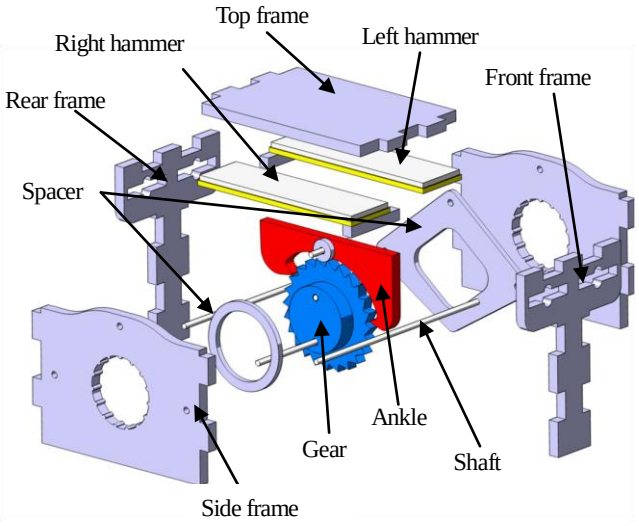

Figure 2. Structure of the rotary type actuator.

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Figure 2 shows the structure of the rotary type actuator. Each frames were bonded by cyanoacrylate. The side frame and ankle was connected by shaft which is cemented carbide round bar. The diameter of shaft was 0.1 mm.

In addition, sandwiched the spacers in order to reduce the gap between the ankle and gear.

3. Rotational mechanism of the MEMS rotary type actuator

The actuator was unimorph piezoelectric elements using a PZT was affixed to the brass plate by TDK PS1720. Piezoelectric elements were cut to 3.5×1.0 mm by dicing machine. Bonding a rod-shaped blocks to the tip of piezoelectric elements Bonding a rod-shaped blocks to the tip of piezoelectric elements as a hammer.

Figure 3 shows the rotational mechanism of the MEMS rotary type actuator. Structure that was turning the gear by tapping alternating ankle two vibrating hammer connected to the top of the rotary type actuator. Vibration of the hammer was driven piezoelectric element by function generator. And two hammers were tapping alternating waveforms shifted by 180 degreed phase flow in the other hammer. In addition, when tapping gear ankle rotate in a predetermined direction because gear was similar shape to the escape wheel.

4. Conclusion

As the result, MEMS rotary type actuator could be fabricated by 4.05×2.50×3.55 mm size by using MEMS technology.

In The future, we will study about using proposed MEMS rotary type actuator as a locomotion actuator of MEMS micro robots.

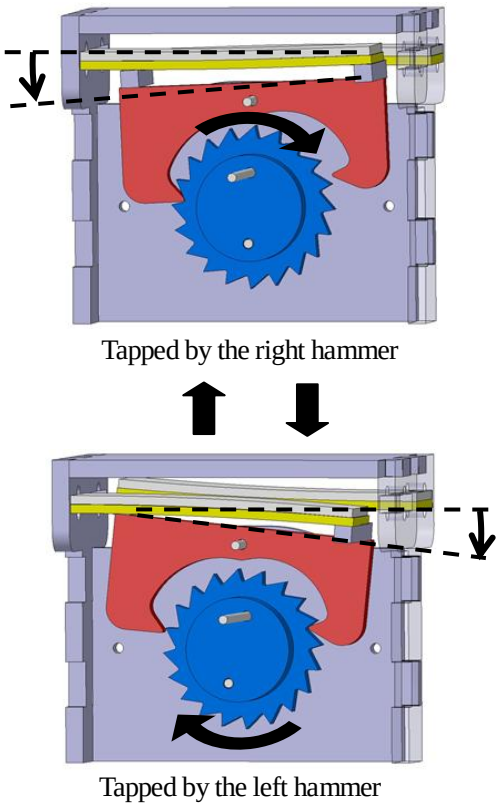

Figure 3. Schematic diagram of the rotational mechanism

Acknowledgments

This study was supported by Research Center for Micro Functional Devices, Nihon University.

This study was suppoted by Nihon University Academic Resarch Grant (Total resarch, "11-002").

This work was supported by JSPS KAKENHI 237602437.

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