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Development of MEMS Micro-Robot Using Piezo-Electric Impact-Type Actuator

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Abstract: This paper reports a MEMS micro-robot using piezo-electric impact-type actuator. This robot is composed of six legs, body flames, and an actuator. These components are fabricated by micro electro mechanical systems (MEMS) technology. The actuator realizes the rotational motion when the rotor impacted by vibration of the piezoelectric element. The rotational motion is transformed to the leg motion like an insect by link mechanisms. The robot was controlled by an electronic circuit of an artificial neuron model. The size of the robot was 4.0mm, 4.6mm, 3.6mm, width, length, height, respectively. The rotational speed was 60 rpm, and the speed was 180mm/min.

1. Introduction

Many micro-robots have been researched and developed intensively. Further miniturigation are required miniaturization to apply in the medical field such as health benefits of a blood vessel, and it can actuate in the precision machinery sector. Conventional robots are manufactured by mechanical machining. However, it is difficult to fabricate a small robot structures. To overcome this limitation, researchers have developed the micro electro mechanical systems (MEMS) technology, which is based on the IC production process[1-2].

On the other hand. In the control, the robots are conventionally controlled by digital systems based on microprocessors and software programs. However, it may not appropriately respond to unpredictable events. More flexible control is provided by artificial neural networks.

Previously, we have developed a MEMS micro-robot. The size of the fabricated robot was 4.0mm, 4.6mm, 3.6mm, and it has hexapod that mimics the insect[3]. This robot shows walking motion by artificial muscle wires controled by artificial neural networks. However, this robot is difficult to drive a long time because driving of the actuator is dependent on the heat. Moreover, this robot shows high power consumption.

In this study, the MEMS micro-robot with the impact-type actuator that does not depend on the heat and low power consumption is developed. This robot is controlled by artificial neuron model.

2. Design of MEMS Micro-Robot

Figure 1 shows a design of an impact-type actuator of MEMS micro-robot. MEMS micro-robot has six legs, and they are connected by a link mechanism. In this study, we uses a piezoelectric element to impact the rotor. Piezoelectric element is expands when a voltage is applied. Rotational motion of the rotor is realized by a hammer block impactimg the rotor. The hammer block is attached to the piezoelectric element. The leg in connected to the link mechanism and rotor.

Grooves is machined in the body for embedding piezoelectric element. The hammer block is held by the rim structure in the rotor. Therefore, the impact position of the hammer block is stabilised. Therefore, the hammer block is fixed and possible to strike the same location of the rotor at all times.

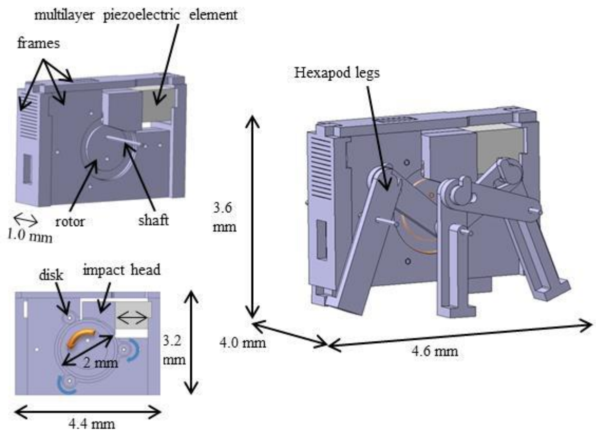

Figure1 Mechanism of the impact-type MEMS rotary actuator and robot.

Components of impact-type MEMS micro-robot was patterned on the silicon wafer by photolithography process. They were etched by Inductively Coupled Plasma (ICP) dry etching machine. All the constituent elements were produced by MEMS technology without

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the shaft. The Most accurate component is a hammer head. This hammer was assembled to contact into the rotor. As a result, the components were produced was sufficient accuracy to assemble the robot.

3. Control Circuit of Micro-Robot

Our micro robot is controlled by artificial neuron model. Figure 2 shows the circuit diagram of the pulse-type hardware neuron model (P-HNM). This circuit is mimicked the brain signal of the living organisms by an analog circuit. Driving pulses are generated by the P-HNM. The P-HNM circuit is characterized by a firing threshold and a refractory period, and produces a continuous pulse. The cell body model circuit is configured as a voltage-control negative resistance circuit, an equivalent inductance circuit, membrane capacitor C_M, and leak resistor R_1.

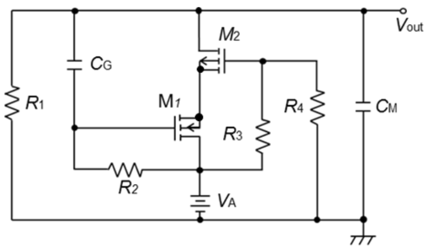

Figure 2. Circuit diagram of the P-HNM

4. Result

The output waveform by the fabricated circuit is shown in Fig 4. Since P-HNM could generate driving waveforms such as those shown in Fig 4, we have demonstrated that the fabricated AI circuit generates correct walking motion of the micro-robot. The rotational speed was 60 rpm, and the robot was walking on 180mm/min.

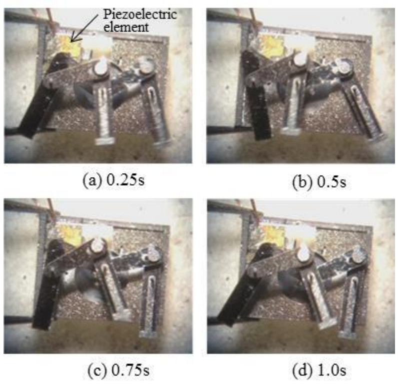

Figure 3. Motion of the micro robot.

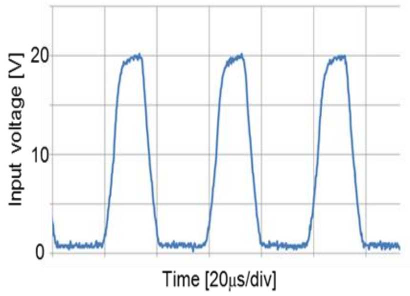

Figure 4. Input waveform for the piezoelectric element

5. Conclusion

In this study, we developed the MEMS micro-robot using the impact-type actuator. The size of the robot was 4.0mm, 4.6mm, 3.6mm, width, length, height, respectively.

The components were produced was sufficient accuracy to assemble the robot.The rotational speed was 60 rpm, and the speed was 180mm/min. Moreover, robot was controlled by P-HNM.

6. Acknowledgments

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