PROPOSAL OF A MICRO LIQUID ROTOR OPERATED BY SURFACE-ACOUSTIC-WAVE
Tsunemasa Saiki\textsuperscript{1,2}, Katsuhide Okada\textsuperscript{2} and Yuichi Utsumi\textsuperscript{2}
\textsuperscript{1}Hyogo Prefectural Institute of Technology, JAPAN and
\textsuperscript{2}Laboratory of Advanced Science and Technology for Industry, University of Hyogo, JAPAN

ABSTRACT
A micro liquid rotor operated by surface acoustic waves (SAWs) was proposed and fabricated. The liquid rotor has two interdigital transducers (IDTs) that generate SAWs, in order to increase efficiency of rotating the liquid. The IDTs were fabricated by patterning Al/Cr on a LiNbO\textsubscript{3} substrate. A liquid pool in the rotor is a round shape of 4mm diameter, and its depth is 200µm. A sidewall of the liquid pool was made of SU-8 on the substrate. In the experiment, it was shown that the liquid rotation speed in the pool increases with increasing the electric power applied to the IDTs. When the fabricated liquid rotor was applied electric power of 2W, the liquid of 5µL rotated at 3,100rpm.

KEYWORDS: Surface-acoustic-wave, Liquid, Actuator, Rotation

INTRODUCTION
In µTAS, the manufacturing process for each component devices must be simplified in order to integrate multiple functional devices such as pumps, valves, reactors, sensors, etc. in one chip. Especially, pumping devices have limited the simplification of the whole structure of the system due to its structural complicacy. We have investigated the application of surface acoustic waves (SAWs) to the pumping for the continuous micro liquid flows. The SAW devices can be fabricated simply by the use of UV photolithography and wet etching processes, which leads to the integration of these as several functional components in µTAS.

In liquid flow actuators driven by SAWs, water droplet moving had been mainly reported [1, 2] and there had been no reports of continuous liquid flow actuators. However we succeeded in creating a continuous flow of liquid using the SAWs [3]. Based on the optimized design of the actuator, we propose and fabricated a novel micro liquid rotor driven by SAWs. We also evaluated its performance as a water rotor driven without mechanical movement.

DESIGN AND FABRICATION
Over view of our novel micro liquid rotor are shown in Figure 1. When high frequency voltage is applied to a interdigital transducer (IDT), SAWs are generated. The SAWs propagate in the surface layer of the substrate and pass through a sidewall to the plane of the liquid pool bottom. The liquid in the pool then is driven by longitudinal pressure wave radiation from the SAWs and rotated in a counterclockwise direction. Here, by using two IDTs, the rotor was fabricated base on optimized design to improve the rotation efficiency.

A photograph of the fabricated micro liquid rotor is shown in Figure 2. The IDTs (a pitch of 200µm, pairs of 20 and an aperture size of 2mm) were fabricated by
patterning Al on a LiNbO$_3$ substrate. A sidewall of the liquid pool (an inner diameter of 4mm and a depth of 200µm) was made of SU-8 on the substrate.

![Diagram of micro liquid rotor operated by SAWs](image1)

**Figure 1. Overview of micro liquid rotor operated by SAWs**

**Figure 2. Photograph of fabricated micro liquid rotor operated by SAWs.**

**EXPERIMENTAL**

As a rotational characteristic of the micro liquid rotor, we investigated angular velocity of the liquid. Our experimental setup is shown in Figure 3. In the experiment, we used 1kHz burst waveform consisted of 1,000 cycles of sine wave of 19.2MHz. For the flow visualization of the liquid, organic dye was dissolved by pure water and Al particles were added to the liquid.

![Experimental setup for measuring angular velocity of liquid](image2)

**Figure 3. Experimental setup for measuring angular velocity of liquid.**
RESULTS
The sequential photographs taken by the high-speed camera are shown in Figure 4. From sequential photographs the angular velocity of liquid rotation was measured using positions of tracers. The relationship between the electric power $P$ applied to the IDT and the angular velocity $\omega$ of liquid rotation is shown in Figure 5. Here, the measuring time $t$ is 3 seconds after the electric power was applied to the IDT. The angular velocity increased with an increase of the electric power, and the maximum angular velocity of our fabricated liquid rotor was about 330 rad/s (3,300 rpm) at 2W. We expect that the liquid rotor may be able to use such as mixer and separator for pretreatment in µTAS.

![Sequential photographs taken by high speed camera at liquid pool.](image)

Figure 4. Sequential photographs taken by high speed camera at liquid pool.

![Relationship between electric power applied to IDT and angular velocity of liquid rotation.](image)

Figure 5. Relationship between electric power applied to IDT and angular velocity of liquid rotation.

REFERENCES