2P-34

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 357-358
6-8 December, 2010

Acoustic Streaming on Micro-laboratory which Consists of Sensor plate/ Matching layer/ Piezoelectric Substrate

センサプレート/マッチング層/圧電結晶から構成されるマイクロ実験室上の音響流

Jun Kondoh[1†], and Yutaro Nakayama[2] ([1]Grad. School of Sci. & Tech., Shizuoka Univ.; [2]Grad. School of Eng., Shizuoka Univ.)
近藤淳 [1‡]，中山　祐太郎 [2] ([1] 静岡大 創造科学技術院; [2] 静岡大 院工)

1. Introduction

A miro-laboratory is investigated for a norvel application using a surface acoustic wave (SAW) device [1]. The micro-laboratory which is also called a digital microfluidic system is a integrated system with droplet manipulators using the SAW and sensors. Applications of the micro-laboratory are biosensors for detecting immunoreactions and enzyme reactions. To reduce influence of contaminants after measuring a bioreaction, it is preferred that a micro-laboratory is disposable. Therefore, three-layer structure of sensor plate/ matching layer/ piezoelectric substrate was proposed for the disposable micro-laboratory. Droplets were manipulated and measured on the sensor plate [1, 2]. After measurements, only sensor plate is changed. In the sensor plate, a bulk acoustic wave (BAW) is exited in the sensor plate. As a longitudinal wave is radiated from the BAW at droplet and sensor plate interface, the droplet is manipulated. It is important to know anacoustic streaming, namely radiated longitudinal wave profile. In this paper, observation results of an acoustic streaming is discussed. Aoustic streming on the three-layer structure is compared with it on 128YX-$LiNbO_3$. Also, phase velocity of the BAW in the sensor plate is estimated.

2. Experimental setup

An experimental setup is illustrated in **Fig. 1**. An interdigital transducer (IDT) was fabricated on 128YX-$LiNbO_3$. A part of the SAW device was dipped into a water tank. A cover glass which is the sensor plate was kept in parallel with the SAW device. Distance of the water layer was 40 µm, so three-layer configuration was realized in the water tank. Silver coated hollow glass spheres were mixed in a water tank. Sheet laser of 532 nm was used for observing the acoustic streaming. Light scattered by the spheres were monitored by using a high speed camera. Observed results were calculated with particle image velocimetry (PIV) method (Dipp-Flow).

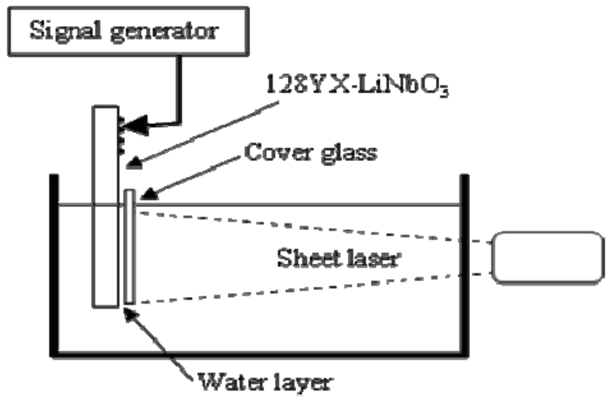


Figure 1. Schematic illustration of the acoustic streaming observation system.

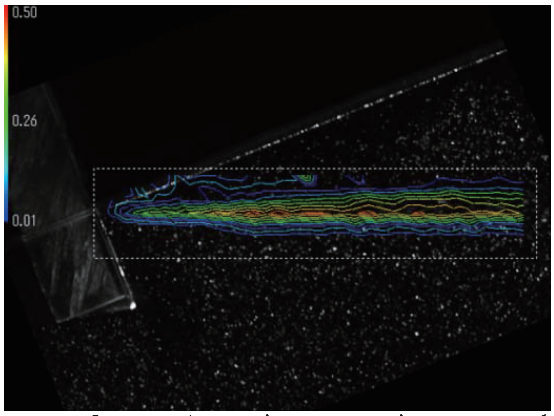


Figure 2. Acoustic streaming on the 128YX-$LiNbO_3$ surface.

3. Results and discussion

First, the acoustic streaming on the 128YX-$LiNbO_3$ was observed. The result is shown in **Fig. 2**. The streaming occurs from the water and 128YX-$LiNbO_3$ interface. Radiation angle of 22 ° agrees with the Rayleigh angle. Then, an acoustic streaming on the tree-layer structure was observed. **Figure 3** shows result. Compared Fig. 3 with Fig. 2, the beam width on the three-layer structure is wider than it on the 128YX-$LiNbO_3$. The result indicates that the acoustic streaming occurs from the whole surface

----

j-kondoh@sys.eng.shizuoka.ac.jp

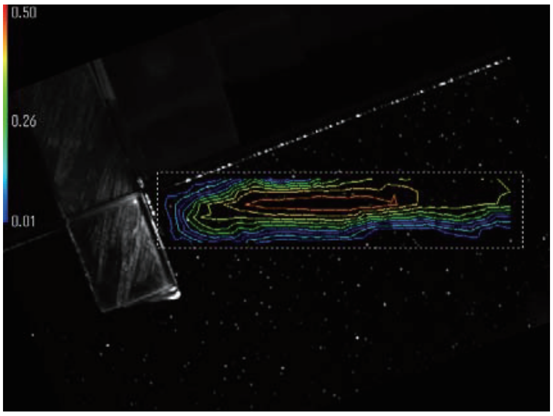


Figure 3. Acoustic streaming on the three-layer structure.

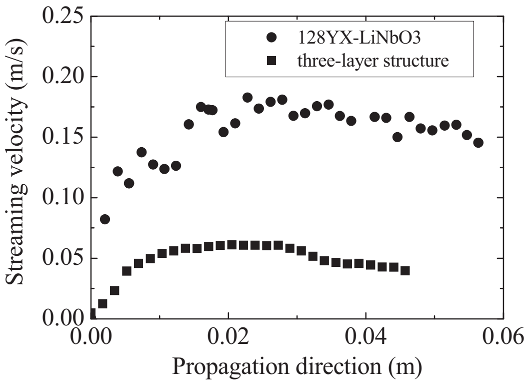
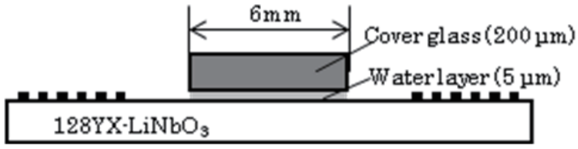


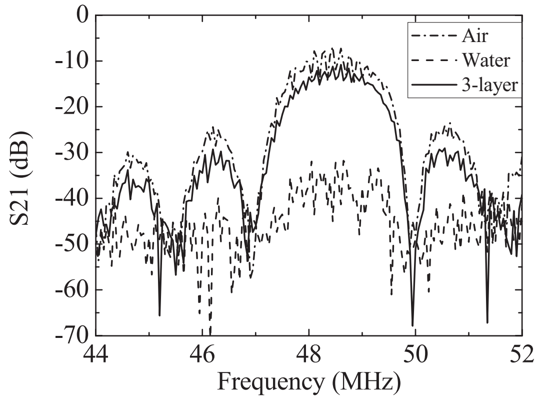
Figure 4. Comparison of streaming velocity on the 128YX-$LiNbO_3$ and three-layer structure.

of the cover glass. Values of maximum streaming velocities were extracted from Figs. 2 and 3, and plotted on **Fig. 4**. The streaming velocity for the three-layer structure is lower than it for the 128YX-$LiNbO_3$. The streaming velocity also depends on the machining layer thickness. When the matching layer thickness was 100 μm, the streaming velocity is lower than the thickness of 40 μm. This means that the streaming velocity approaches to it for 128YX-$LiNbO_3$ with decreasing matching layer thickness.

The acoustic streaming on the three-layer structure occurs from the whole surfaces of the cover glass. To experimentally explain, frequency responses of the three-layer structure were measured by using a network analyser (Agilent E4991A). Three-layer structure was fabricated between the IDTs as shown in **Fig. 5**(a). Figure 5(b) shows the measured results. For comparison, frequency responses for air and water loaded cases are also plotted. When the water is loaded on the surface, output signal decreases due to radiation of the longitudinal wave in to the water. When three-layer structure is formed between IDTs, the loss is improved. From the



(a)



(b)

Figure 5. (a) Configuration of the SAW device with three-layer structure for measuring frequency responses. (b) Frequency responses.

results, wave propagation is estimated that the longitudinal wave is reflected between the glass and the 128YX-$LiNbO_3$ with generating BAW into the cover glass. Therefore, the streaming generated from the whole surfaces of the cover glass. As difference of loss between air and three-layer structure is 5 dB, it is used to generate the BAW into the cover glass. Improvement of the value would promise to effective generation of the BAW.

From radiation angle in Fig. 3, the phase velocity of the BAW was estimated at 4180 m/s. We calculated the BAW in the glass plate. Calculated velocity almost agrees with the estimated values.

4. Conclusions

A novel digital microfluidic system which is called the micro-laboratory has been proposed. In this paper, acoustic streaming on the three-layer structure was observed and compared with it on the 128YX-$LiNbO_3$. Acoustic streaming profile from the 128YX-$LiNbO_3$ is narrow. In contrast to this, it from the three-layer structure is wide. Therefore, investigation to make use of the characteristic is necessary, such as droplets manipulation.

References

1. N. Yasuda, et al.: Jpn. J. Appl. Phys. **48** (2009) 07GG14.
2. T. Sugita, J. Kondoh: Proc. IEEE Sensors 2010 Conf. (accepted for presentation).