Proceedings of Symposium on Ultrasonic Electronics, Vol. 33 (2012) pp. 73-74
13-15 November, 2012

Measuring of plasma clotting using shear horizontal surface acoustic wave sensor
横波型弾性表面波センサを用いたプラズマクロット計測

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1. Introduction

Anticoagulants are needed to prevent the blood clotting at heart bypass operation. It is important to know blood condition. Electrochemical sensors have been used to monitor blood coagulation [1]. When plasma is mixed with APTT (activated partial thromboplastin time) reagent and $CaCl_2$, plasma-clotting is caused (see **Fig. 1**). In this paper, a shear horizontal surface acoustic wave (SH-SAW) sensor [2] is applied to monitor the plasma-clotting.

Fig.1 Plasma-clotting

2. Experiment and methods

The SH-SAW sensor used is shown in **Fig. 2**. The SH-SAW sensor was fabricated on 36YX-$LiTaO_3$. Operating frequency was 51.5MHz. Propagation surface of one delay line is electrically shorted (short channel). The other has free surface area in the propagation surface (open channel). A mechanical perturbation of the adjacent media on the SAW sensor is obtained from the short channel. Mechanical and electrical perturbations on it are obtained from the open channel. If differential signal between two channels are monitored, the electrical perturbation is only obtained. A network analyzer was used to monitor the perturbations of phase.

Figs. 3 and **4** show experimental methods. For method 1 and 2 in Fig. 3, all samples were mixed on the SH-SAW sensor. For method 3 and 4 in Fig. 4, all samples were mixed in the vessel and added onto the SH-SAW sensor. Plasma-clotting did not occur for methods 2 and 4, because the APTT reagent was not included. Samples were injected into a pool on the sensor. Phase was measured at 30s intervals. Then phase shift from the phase at 0s was calculated. Measurement time is 600 seconds.

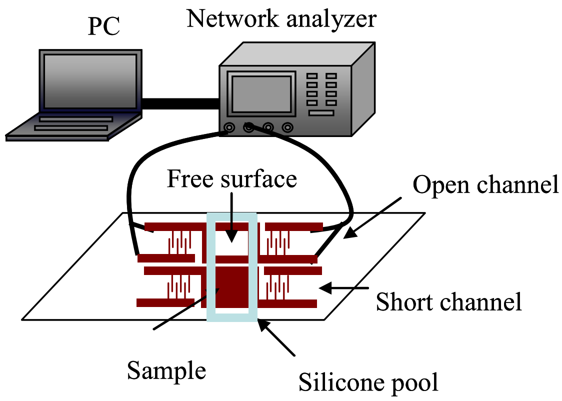

Fig. 2 Schematic diagram of measuring system

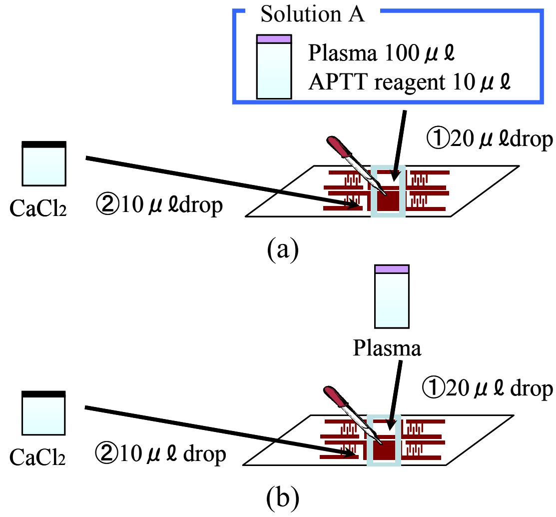

Fig. 3 (a) method 1 (b) method 2

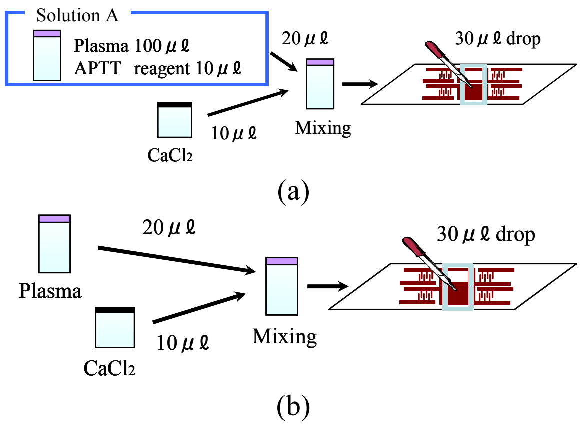

Fig. 4 (a) method 3 (b) method 4

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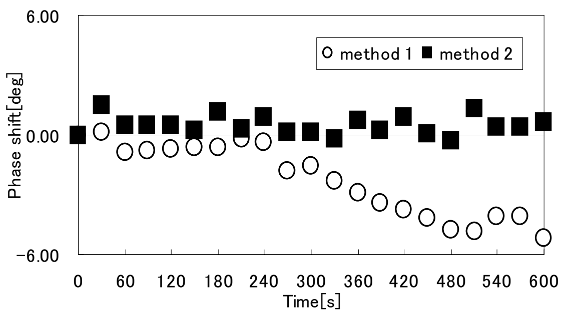
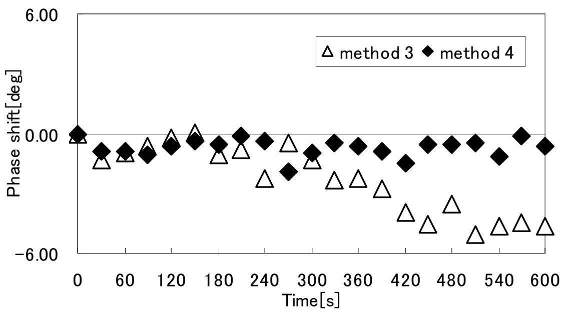
3. Results and discussion

Experimental results of four methods in Figs. 3 and 4 are plotted in **Figs. 5** and **6**. From Fig. 5, it is found that the phase shift of methods 1 and 3 decreases with time after 300s. As the gelation occur due to plasma-clotting, viscosity of the sample increased. Therefore obtained results are reasonable. Also, due to the gelation, shear modulus is also changed. To estimate viscosity and shear modules during plasma-clotting in future work. On the other hand, phase shifts of methods 2 and 4 are constant. As the APTT reagent is not involved, the clotting reaction does not occurred. Standard deviations of method 2 and 4 are about equal to those when distilled water is loaded on the SH-SAW sensor.

For Fig. 6 (a) and (b), the results agree well. Two methods are the each figure were prepared to confirm the plasma-clotting. Without the APTT reagent, the plasma clotting does not occur. As the results with and without the APTT reagent coincide with each other, the SH-SAW sensor for the electrical perturbation can not detect the plasma clotting. In other word, the SH-SAW sensor detects electrical property charge due to liquid mixing.

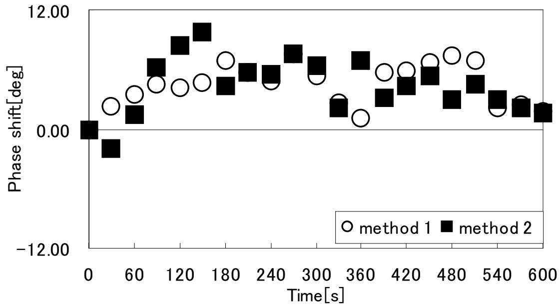


(a)

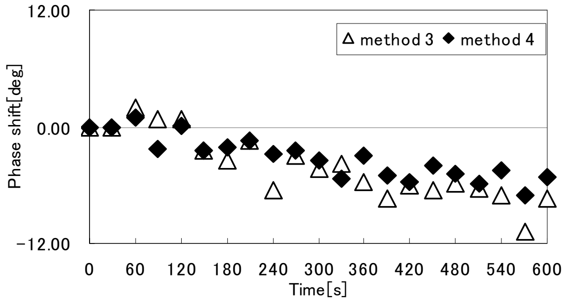


(b)

Fig. 5　Experimental results of short channel
(a) method 1 and 2 (b) method 3 and 4



(a)



(b)

Fig. 6　Experimental results of open channel
(a) method 1 and 2 (b) method 3 and 4

4. Conclusions

In this paper, the SH-SAW sensor is used to monitoring plasma clotting. The results suggest that the SH-SAW sensor for mechanical perturbation detection is able to apply for plasma clotting monitor.

As future work, it is necessary to compare performance with other sensors. As the sensitivity of mechanical perturbation of the SH-SAW sensor used is worse, we must select a piezoelectric substrate for high sensitive detection. Furthermore, since SH-SAW sensor used in this study is expensive, it is not suitable in this case to disposable after a measurement. Therefore, it is necessary to consider the sensor can be disposable and inexpensive.

References

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