Supplementary Material of Manuscript

# Conductive Liquid-Based Surface Acoustic Wave Device

Jeonghun Nam[a,*] and Chaeseung Lim[a,*]

[a] Department of Laboratory Medicine, College of Medicine, Korea University, Korea University Guro Hospital, Guro 2-dong, Guro-gu, Seoul 152-703, Korea.

[*]Corresponding author:

**Jeonghun Nam, PhD**

jhnam77@gmail.com

Department of Laboratory Medicine, College of Medicine, Korea University,

226 Gamasan-ro, Guro-gu, Seoul, Korea, 08307

**Chae Seung Lim, MD, PhD**

malarim@korea.ac.kr

Department of Laboratory Medicine, College of Medicine, Korea University,

226 Gamasan-ro, Guro-gu, Seoul, Korea, 08307

**Supplementary movie 1.** Filling process for the electrode microchannel with eutectic gallium indium (EGaIn) as the conductive liquid metal. The playback speed of the movie is 1x.

**Supplementary movie 2.** Acoustic mixing of DI water (0.3 μL) with purple food dye mixed with 25% glycerin (5 μL) at an RF input power of 578 mW. The playback speed of the movie is 1x.

The measurement of the scattering parameters (S-parameters) is important to characterize the surface acoustic wave (SAW) devices. The SAW propagation can be evaluated by analyzing the S-parameters, including the transmission ($S_{21}$) and reflection ($S_{11}$), using a network analyzer (8753ET, Agilent). $S_{11}$ is the input reflection coefficient with the output port, and $S_{21}$ is the forward transmission gain with the output port.[1,2]

In the conductive liquid (CL)-SAW device, various parameters (including the width and the height of the electrode channel, the shape of the electrode channel, and the number of electrode pairs) can affect the device performance. However, we used the CL-SAW device with a fixed dimension and shape because we conducted a proof-of-concept for the proposed device. Figure S1 (a) shows the schematic of the experimental setup for measuring the S-parameters. To measure $S_{21}$, we used a pair of CL-based electrodes facing each other. In Figure S1 (b), the transmission ($S_{21}$) illustrates two well-defined resonant peaks in the frequency ranges of 9.5-10.5 MHz and 19.5-20.5 MHz, which included the calculated value.

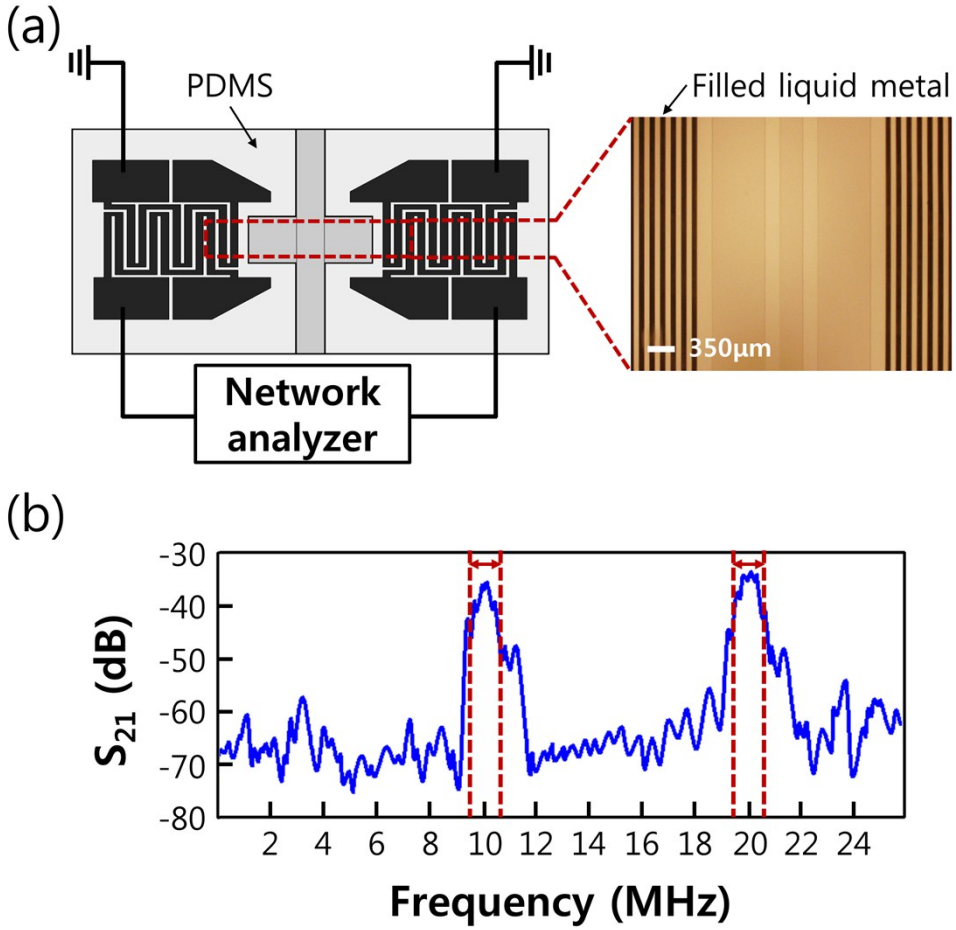


**Figure S1**. Evaluation of the scattering parameters (S-parameters) for electrode characterization. (a) Schematic of the experimental setup for measuring the S-parameters, and (b) transmission spectrum of the CL-SAW device within the frequency range from 0 to 26 MHz.

While the input power was applied to the CL-SAW substrates, the temperature of the substrates increased because of the mechanical vibration. The high temperature that resulted from acoustic heating may affect the properties of the sample liquid and biological objects in the liquid. To evaluate the temperature increase, the temperature in the SAW working region of the CL-SAW device was measured with a thermocouple and thermometer (TES-1303 k-type, TES Electric Electronic Corp.) for the RF input power ranging from 200 mW to 600 mW at an interval of 100 mW. We used clay to adhere the thermocouple in the SAW working region on the piezoelectric substrate. At each RF input power, the digitalized value of the temperature was read from the thermometer after being saturated from applying the input power 5 times at each condition. Within the applied input power range (200-600 mW), the temperature did not increase drastically and remained below 35 °C. It is compatible for applications on variable biological samples in this temperature range.[3-5]

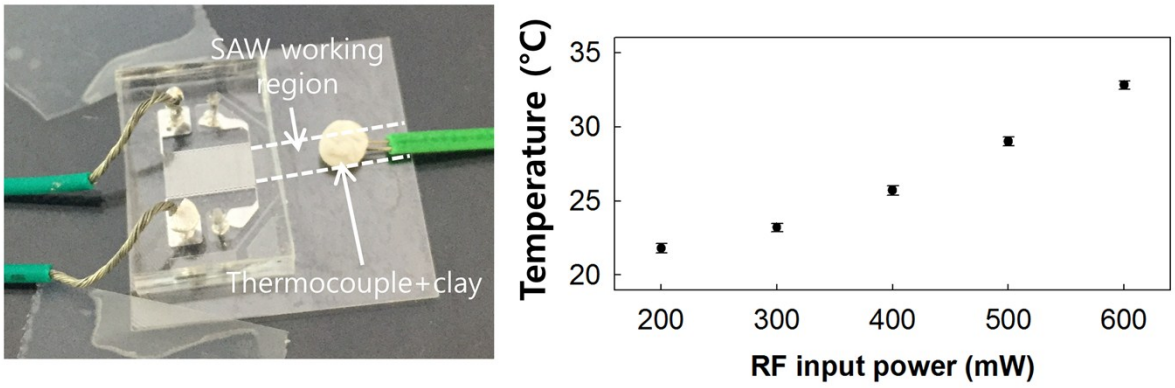


**Figure S2.** Effect of the RF input power on the temperature at the CL-SAW working region, and the experimental setup for the temperature measurements. The error bars show the standard deviation from the 5-time repetitive measurement for each RF input power.

**References**


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