

# The Study of Disposable Substrates in Surface Acoustic Wave Devices

**Christine Truong**

Physics, Polytechnic Institute of New York University

NNIN REU Site: Penn State Nanofabrication Laboratory, The Pennsylvania State University, University Park, PA

NNIN REU Principal Investigator: Prof. Tony Jun Huang, Engineering Science and Mechanics, The Pennsylvania State University

NNIN REU Mentor: Dr. Xiaoyun Ding, Department of Engineering Science and Mechanics, The Pennsylvania State University

Contact: christinehtruong@nyu.edu, junhuang@psu.edu, xding@psu.edu

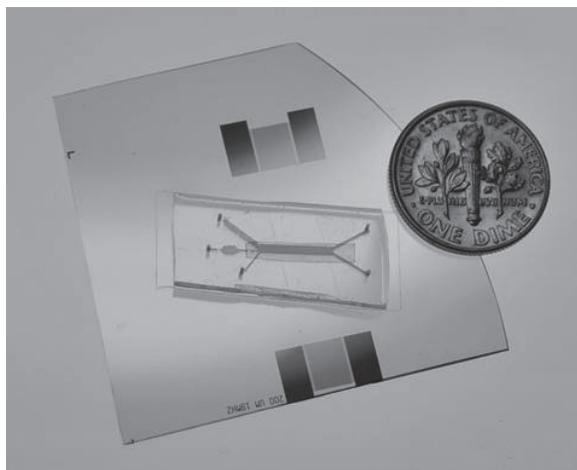


Figure 1: The SAW device, coupled with double-sided tape.

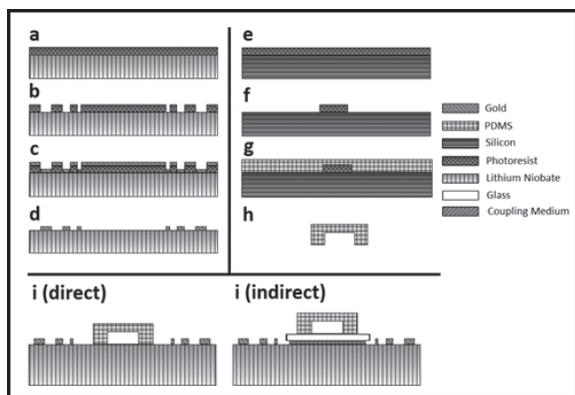


Figure 2: For the SAW device, the fabrication of the (a-d) IDTs (e-h) the channels, and (i) the difference between the traditional setup and the coupled setup.

## Abstract:

Surface acoustic wave (SAW) devices have been widely used in microfluidics to manipulate fluids and particles. Applications include single cell manipulation, particle focusing, particle patterning, cell separation and cell sorting. However, in typical SAW devices, if channels are defective or if channels become contaminated after use, the device cannot be reused because the channel component is directly bonded to the SAW device substrate.

Here we show that SAW devices, whose components were coupled through 25  $\mu\text{m}$  double-sided tape or petroleum jelly, can perform the same functions as a typical SAW device. Polydimethylsiloxane (PDMS) channels, which are normally directly bonded to a lithium niobate ( $\text{LiNbO}_3$ ) piezoelectric substrate with deposited gold interdigital transducers (IDTs), were instead bonded to glass slips and coupled to gold IDT-deposited  $\text{LiNbO}_3$ . The modified SAW device retained the ability to manipulate particles, given an increase of power. This study shows that coupled SAW devices can be as effective as typical devices, allowing more widespread use.

## Introduction:

SAWs are efficient cell and microparticle manipulators [1]. The concept behind particle manipulation is simple: A function generator sends an electrical signal to an IDT pair. The IDTs then convert that signal into SAWs on the surface of a  $\text{LiNbO}_3$  substrate. The two identical SAWs propagate toward each other and interfere to form a standing SAW within a PDMS channel between these two IDTs. The pressure nodes in the standing SAW apply an acoustic forces on particles, guiding them toward pressure nodes, allowing particles suspended in the PDMS channel to be manipulated [2]. Our approach is similar, except that SAWs will travel from  $\text{LiNbO}_3$  through a coupling agent and a glass slip before reaching the channel. The advantage is that the bonded channel and glass can easily be removed from  $\text{LiNbO}_3$ , allowing the device to be disposable and re-used.

## Experimental Procedure:

Standard lithography procedures were used to deposit IDTs on a  $\text{LiNbO}_3$  wafer. The wafer was spin-coated with SPR 3012 photoresist at 4000 rpm at 45 seconds (s) and then baked at 65°C, 95°C, and again at 65°C for 60 s each. Wafers were then exposed to ultraviolet light for 18 s and baked using the same parameters. The product was developed using a CD26 developer for approximately 60 s and cleaned using de-ionized water and nitrogen. The wafer was further cleaned using a plasma cleaner, with 1000 sccm  $\text{O}_2$ , and 50 sccm He after vacuum-down at 600 torr and 200 W for four minutes. After, a 5 nm adhesion layer of chrome and a 50 nm layer of gold were coated on the wafer to produce the IDTs.

The wafer-IDT composite was submerged in PG remover overnight; a sonicator was used with the IDT-wafer composite with isopropyl alcohol to remove excess gold.

The fabrication procedure for the PDMS channel was similar. Silicon wafers were coated with a SU-8-50 photoresist, spun at 2000 rpm for 45 s, and then baked at 65°C and 95°C for 5 min and 20 min, respectively. The wafer was exposed to ultraviolet light for 65 s and baked at the same temperatures for 2 min and 8 min. The product was developed by submerging in SU-8 developer for 3 min, and cleaned using isopropyl alcohol. The wafer was then baked at 150°C for 10 min. The PDMS channel was created by mixing one part elastomer curing agent to ten parts elastomer base, poured over the pattern, and incubated at 65°C for half an hour. Then channels were drilled to create inlets and outlets and bonded (via plasma induced bonding) to 250  $\mu\text{m}$  glass.

Coupling the wafer-IDT with the channel-glass composite was accomplished using either petroleum jelly or 25  $\mu\text{m}$  thick double-sided tape as a coupling agent. Figure 2 shows a schematic of each major step.

### Results:

Coupling results showed that our coupled SAW device retained the ability to pattern stationary particles. Four and ten micron polystyrene beads aligned along pressure nodes after the SAW was toggled, using a frequency of 24 MHz and a power of 17.0 dBm. Figures 3 and 4 show patterning results for each coupling agent. In addition, our device was also able to separate those 4 and 10  $\mu\text{m}$  diameter beads if the power was large enough; for tape coupling, the power (19.5 dBm = 89.1 mW) was nearly twice as large compared to the power needed to separate particles with petroleum jelly coupling (17.0 dBm = 50.1 mW).

### Conclusions and Future Work:

We have demonstrated that coupled SAW devices can pattern and separate particles and can be as effective as traditional

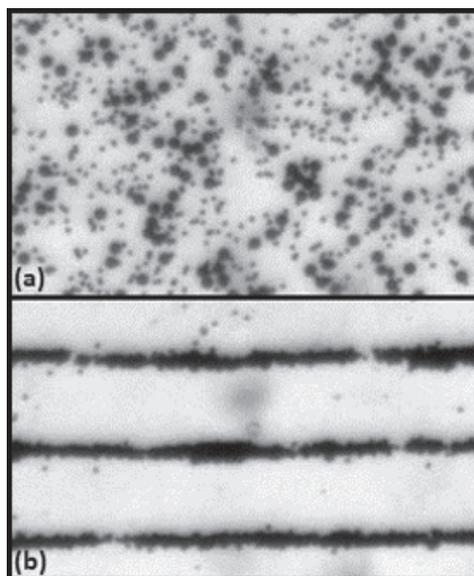


Figure 3: Patterning results using double-sided tape as the coupling agent, (a) before and (b) after toggling the SAW.

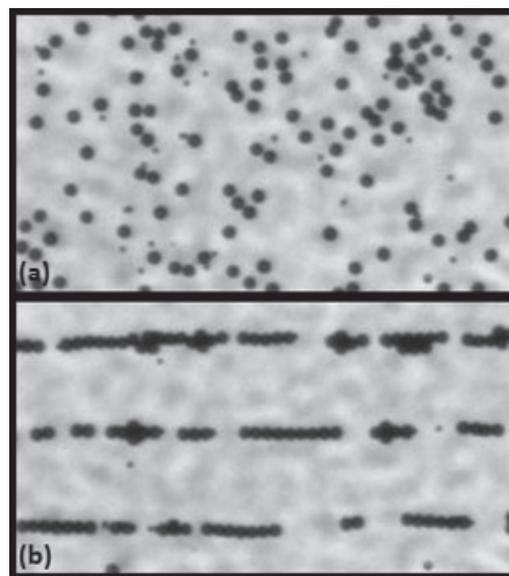


Figure 4: Patterning results using petroleum jelly as the coupling agent, (a) before and (b) after toggling the SAW.

SAW devices, despite needing a higher input power, and that petroleum jelly is a more efficient coupling agent than 25  $\mu\text{m}$  tape. In the future we hope to quantify the coupling efficiency (i.e. how much power is required to separate beads using coupling agents of varying density), examine different coupling agents, and expand the experiment by manipulating cells instead of beads.

### Acknowledgements:

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### References:

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- [2] Shi, J., et al. "Acoustic Tweezers: Patterning Cells and Microparticles using Standing Surface Acoustic Waves (SAW)." *Lab Chip*, 9, 2890-2895, 2009.