Fabrication and test of SAW-based micro-force sensor

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***Abstract*—SAW devices are widely used as pressure, force measurement sensors. Because of their easy integrability, less space requirement, low cost fabrication and ability to remote wireless interrogate, we have studied the utilization of SAW device in our bio-device of cultured fibroblast collagen lattices. In this paper, we present the fabrication of SAW device using the lift-off process.**

I. INTRODUCTION

Previously, we have demonstrated a silicon based bio-device that made for collagen lattice culture [1][2]. In this paper, we studie Surface Acoustic Wave (SAW) based sensor for microforce measurement. Some similar researches were made in this context [3][4][5]. The aim is to find, at the first time, the relation between force and frequency shift and test it on the LiNbO3 substrate. The last step is to integrate the piezoelectric saw-based sensor into the silicon cantilever.

The force measuring principle based on the distortion of the received SAW by force or pressure. Intercorrelation is one of the methods used to evaluate the similarity ratio between two signals (transmit and received). The advantage of this type of evaluation is its robustness in the case of a low signal-to-noise ratio of one of the two signals.

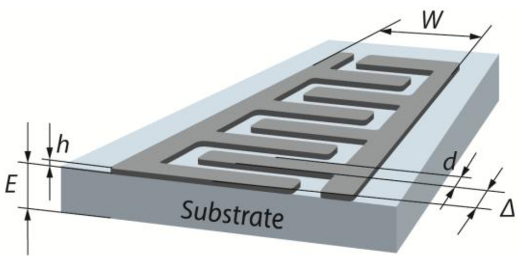

Figure 1. 3D perspective view of the SAW device.

II. MODELING

Analytical and 3D finite element method (FEM) analysis using Comsol software has been performed to find the IDT deformation corresponding to the frequency shift under the isometric forces applied by the equivalent dermis. The central frequency of the pass-band, the bandwidth and the number of transducers are the initial data for design calculations. MatLab is used to calculate the optimal values of this parameters. The goal of the calculations is to determine the main dimensions (metal thickness (h), the width of the IDT finger (d), the step (Δ) of IDT fingers, IDT network length (W), distance between the IDT ports, etc.) of IDT (figure 1).

III. MICROFABRICATION

Some more technics are known for IDT patterning on piezoelectric substrate such as wet and dry etching [6], lift-off [7] and printing [8]. A lift-off is widely used procedure that has less process steps and more efficient. A 128°YX cut lithium niobate (LiNbO(3)) wafer has been chosen as piezoelectric substrate because of its high coupling coefficient (5.5%) [9].

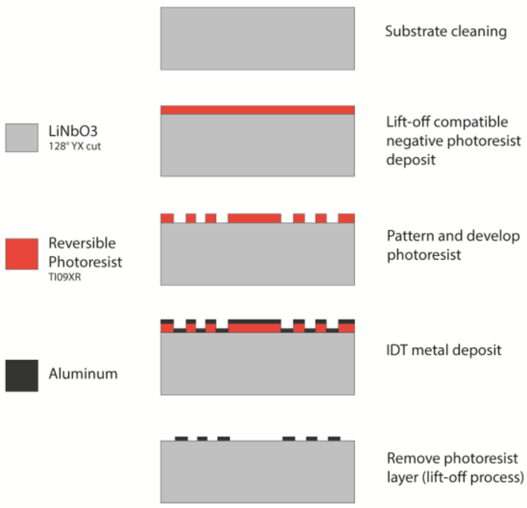

Figure 2. Flow chart

The process flow of the IDT deposit is briefly explained in figure 2. After cleaning the wafer using acetone, an TI09XR reversible photoresist is spin coated at 1100rpm for 30s with 4000rpm/s acceleration. Then, the substrate is baked at 100°C for 80s. Firstly, the wafer is exposed to the UV light of 90 mW/cm2 with a photomask. The exposed resist areas will remain on the substrate after development. After the reversal baking at 130°C for 80s, we proceed to flood exposure without mask such that all the regions of the resist that are exposed become soluble to the developer. The development of the resist around 1 min is the last step of the lithography.

Because of its low cost, good substrate adherence and low electrical resistivity [9] an 300nm thick aluminum metal mask layer is patterned using electron beam evaporation machine (Alliance Concept) according to the SAW structure designed in MEMS designing software (Layout Editor). Lift-off process is carried out to remove unwanted metal using acetone and ultrasound.

After cleanroom process, the wafer was cut and mounted on a printed circuit board. A gold wire bonding has been used to connect the IDT to the printed circuits (figure 3).

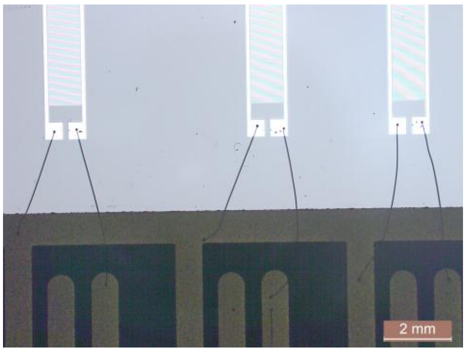

Figure 3. IDT patterns on LiNbO3 wafer connected to printed circuits by wirebonding.

Figure 4 shows the final device photo. Each IDT can be accessed using in/out pin jumpers.

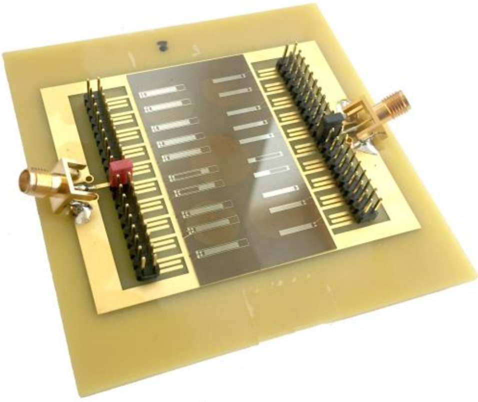

Figure 4. Photography of the test ready final device with in/out SMA connectors.

We have used an arbitrary wave generator (Euvis Inc AWG801) to generate the SAW and a DAC (ADQ108) to detect the wave by the receiver IDT port. The sent and received waves are presented on figure 5.

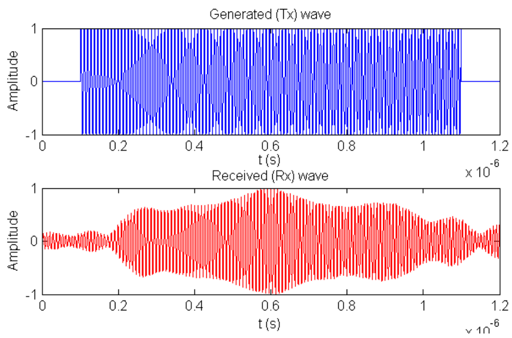

Figure 5. Temporal spectrum of transmitted (bleu) and received (red) acoustic wave. The signal amplitudes are normalized.

The S21 frequency response of each IDT port is also tested in order to characterize the power transmission between IDT ports (figure 6). The attenuation is -17dB that is better performance.

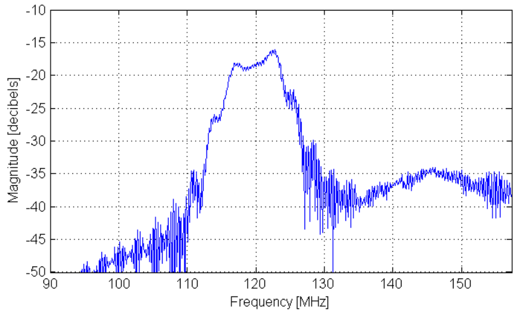

Figure 6. The S21 frequency response of the IDT (120MHz central frequency and 10MHz Bandwidth).

IV. Conclusion

The microfabrication of SAW-based force measurement sensor is presented in this paper. The final test results show that the chosen fabrication technics are well adapted to our case. The choice of the piezoelectric material and electrode metal is justified and made the device to show a high performance. Not any frequency shift due to microfabrication defect have been detected.

Acknowledgment

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