Improved Biosensors Through Advanced Designs: Experimental and Theoretical Study of SAW Transducers and Delay Paths

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We present an experimental and theoretical study of surface acoustic wave (SAW) interdigitated transducer (IDT) and delay path designs used for biosensor applications. IDT designs were created on 36° YX $LiTaO_3$ selected for its high electro-mechanical coupling and shear-horizontal (SH) wave generation capabilities. Based on literature reviews of IDT and delay path designs for improved electrical characteristics of SAW communication applications we have simulated and experimentally tested a number of designs. A comparison of experimental data collected using a network analyzer with time domain measurement capabilities and theoretical results calculated using a 3D finite element (FE) model will be presented.

Previous studies have shown sensitivity of SH-SAW biosensors can be significantly increased through the addition of a waveguide to generate Love-mode waves instead of SH.[1] For the Love-mode generation to occur: 1) the waveguide material should have a lower acoustic velocity than the substrate, and 2) the waveguide material should be of lower density than the substrate. In previous studies, many materials have been shown to be efficient waveguides. The most used materials are silicon dioxide, poly(methylmeth acrylate), polyimide, and polystyrene. In this study, we have utilized polystyrene as the waveguide material to allow for comparison with previous studies.[2] Parameters studied in this portion of the work were the attenuation and velocity changes of the acoustic wave due to the addition of varying thicknesses of polystyrene. Additionally a sensitivity studied was conducted through the use of an ideal mass to the center to the delay paths. One such comparison is shown in Figure 1 for the sensitivity of bare and optimized thicknesses for three IDT designs.

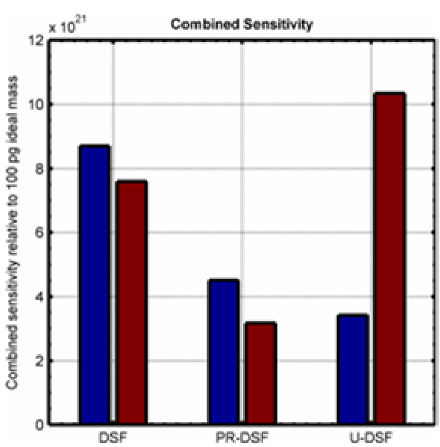

Figure 1. Sensitivity comparison of three in-house developed IDT designs.

Additional methods improve electrical characteristics commonly used, not particularly for sensors, include reflective gratings[3], grooves and corrugated gratings[4-6], and wave-guides. The reoccurring principle in these three primary schemes to improve the SAW device power loss is the conversion of bulk waves into surface waves and entrapment of energy near the surface that would otherwise be lost to bulk waves.[3,7] These solutions specifically address the power loss of sensors for personal and remote sensing applications. Ideal SAW delay line sensors have an insertion loss of 7 dB and it is not uncommon to work with insertion losses of 20 dB our simulated devices had insertion losses of 33.28 dB and where improved to 14.03 dB with our designed delay path structures. One such comparison is shown in Figure 2 for the sensitivity of bare, Love-wave, grooved, and our designed delay path using a fourth IDT design.

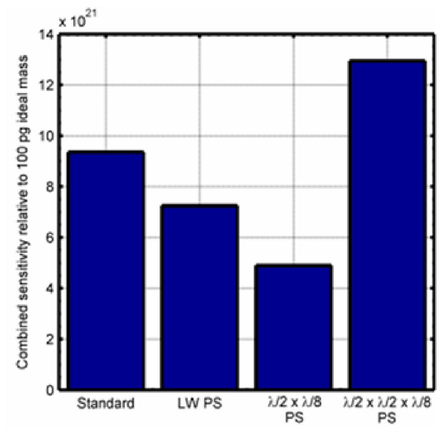

Figure 2. Comparison of sensitivities of four delay path designs including our own.

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