A SU-8 liquid cell for surface acoustic wave biosensors

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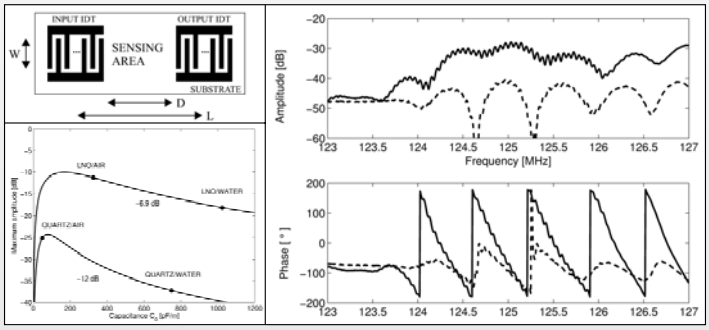


Top left – schematic top view of the SAW device showing the transducers and the sensing area
Down left – theoretical calculation of the maximum amplitude of the transfer function for quartz and lithium niobate
Right – transfer function of a quartz SAW device in air (solid line) and loaded with deionized water (dashed line)

INTRODUCTION

• Surface acoustic wave (SAW) devices, used as filters and delay lines in telecommunication, find application as biosensors for the detection of low amount of biomolecules in analytes, e.g. blood samples.

• The SAW is generated and received thanks to interdigital transducers (IDTs) that consist in a set of interdigitated electrodes patterned on a piezoelectric substrate such as quartz, lithium niobate or lithium tantalate.

• For biochemical recognition, the phase shift of the delay line is proportional to the amount of biomolecules adsorbed on the sensing area.

• Liquid loading of the IDT attenuates the transfer function, the net effect being stronger for substrates with a low electromechanical coupling constant.

RESEARCH

Objective: integrated packaging of SAW biosensors in the form of a liquid cell.

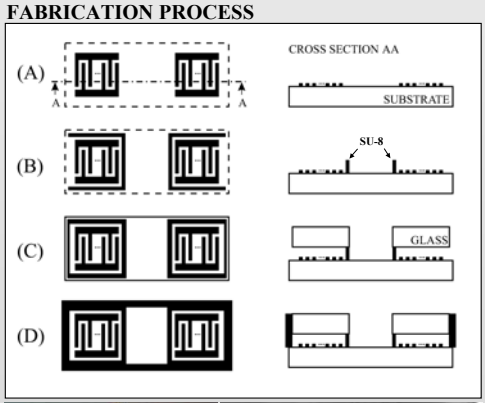
Characteristics:
• prevents the presence of liquids above the transducers;
• small disturbance effect on the propagation of the SAW;
• no interference with the biochemical sensing event;
• chemically inert materials resistant to surface cleaning treatment.

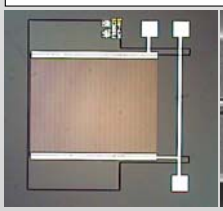
Fabrication process: ➔
• patterning of photosensitive epoxy SU-8 spacer around the IDTs;
• manual placement of a glass capping above the spacer.

The liquid cell defines a well of precise dimensions above the sensing area of the packaged sensor.

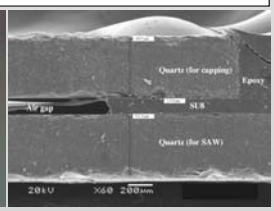
Microfabrication:
• reduce lateral dimensions of the SU-8 in order to minimize the acoustic absorption of the SAW signal;
• integrated packaging at the wafer processing level;
• address the micron-range scale of the sensor;
• liquid cell with reproducible characteristics compared to an external pre-molded liquid cell.

FABRICATION PROCESS



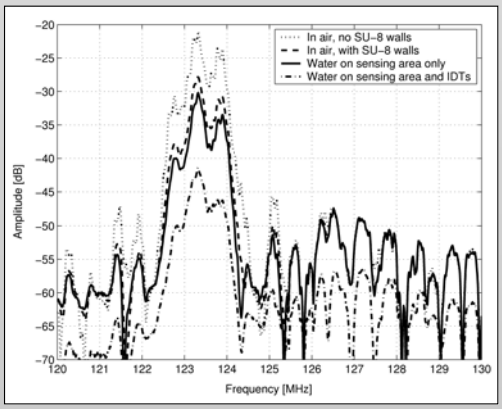


Optical microscope picture of the SU-8 spacer



SEM image of the cross section above the IDT

RESULTS



← Acoustic performances of the SAW device packaged with the SU-8 liquid cell

Effective protection against the liquid loading of the sensor.

SAW attenuation due to the epoxy loading about 1 dB per acoustic wavelength (1 dB/λ) covered on the acoustic path.

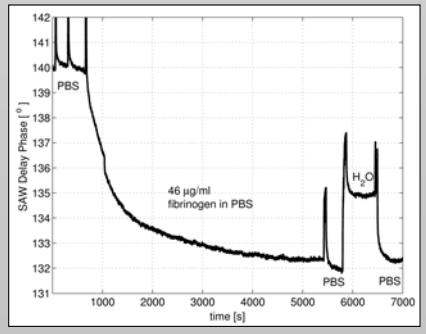
Packaged sensors were used, cleaned with UV/ozone, and re-used about 10 times before liquid leaks occurred.

Monitoring of protein adsorption with a fully packaged SAW biosensor ➔

Effectiveness of the packaging demonstrated by protein adsorption monitoring.

Experimental phase shift equal to a surface density of 675 ng/cm^2, a likely value for fibrinogen surface coverage.

No apparent interferences observed between the liquid cell materials and the biochemical solution.



CONCLUSIONS

The packaging of surface acoustic wave biosensors is successfully solved by the realization of a SU-8 based liquid cell.
The SU-8 assures the sealing of a capping layer above the transducers that prevents liquids to contact the electrodes of the transducers. Its materials have a good chemical resistance and are not interfering with the biochemical sensing event. The SU-8 liquid cell is an improvement compared to pre-molded liquid cells that must be pressed against the device in order to avoid leaks and is important for the reproducibility of experimental results.