Ultrasound Pressure Field Of A Resonating Piezoelectric Membrane With Three Excitation Electrodes.

Vassil Tzanov

Universitat Autonoma de Barcelona
Department of Electronics Engineering
Electronic Circuits and Systems Group

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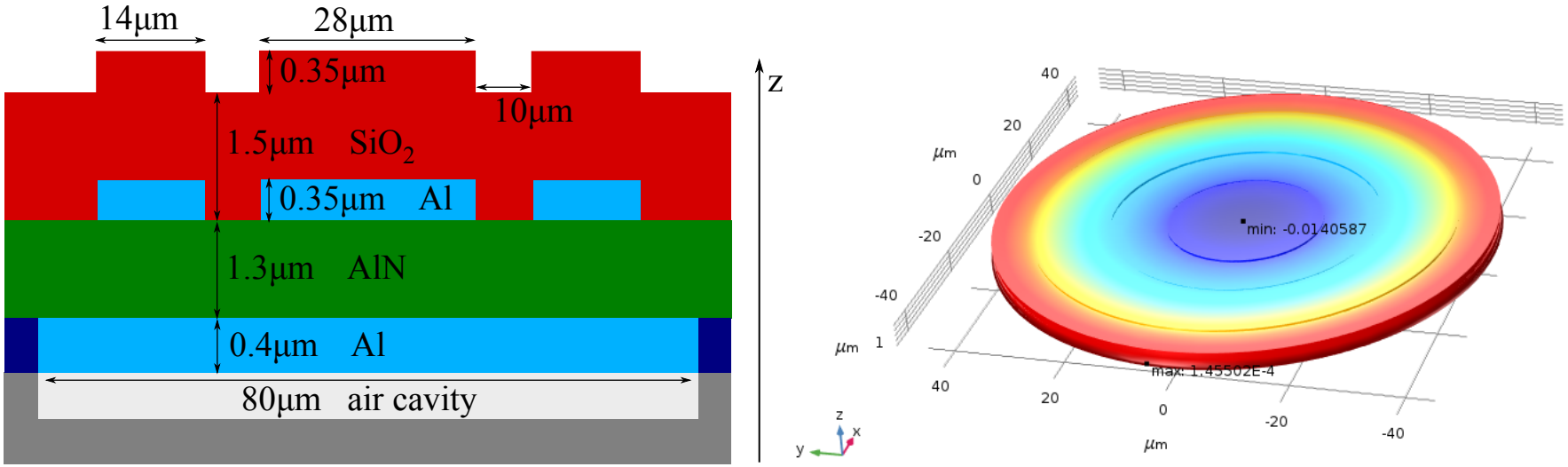
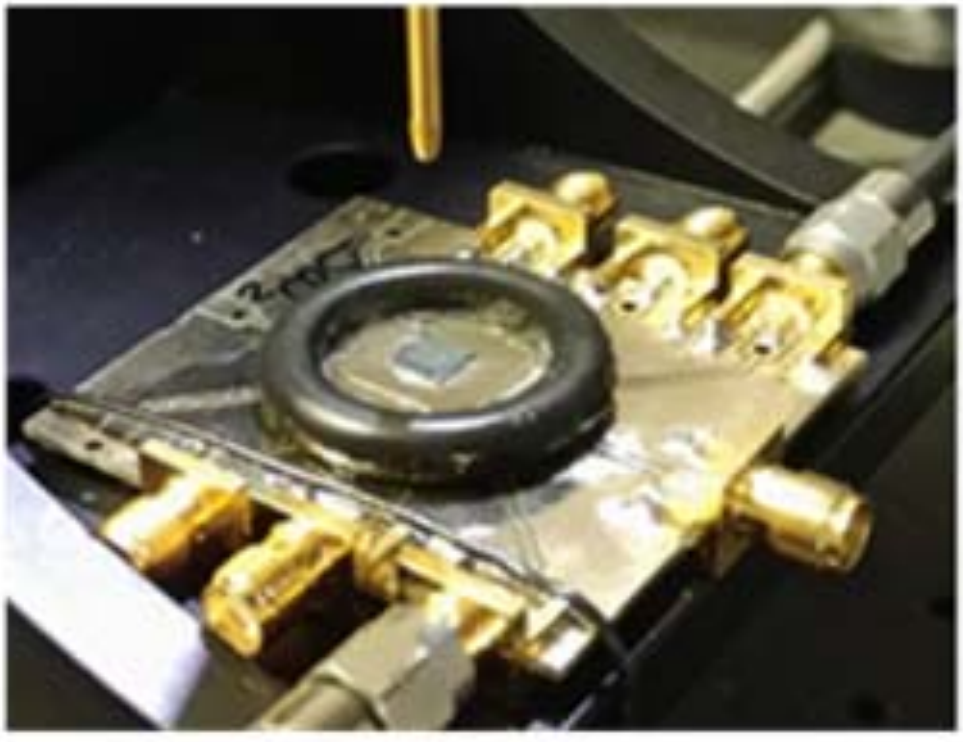
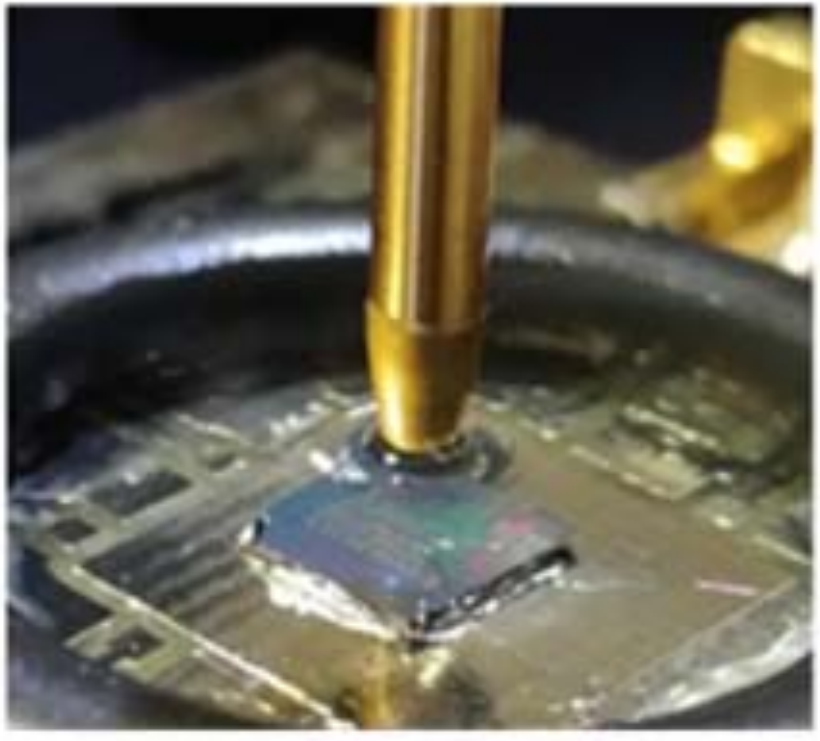
Al-AlN-Al-SiO_2 Piezolelctric Micromachined Ultrasound Transducer



COSMOL model of a clamped multi-layer membrane resonator.

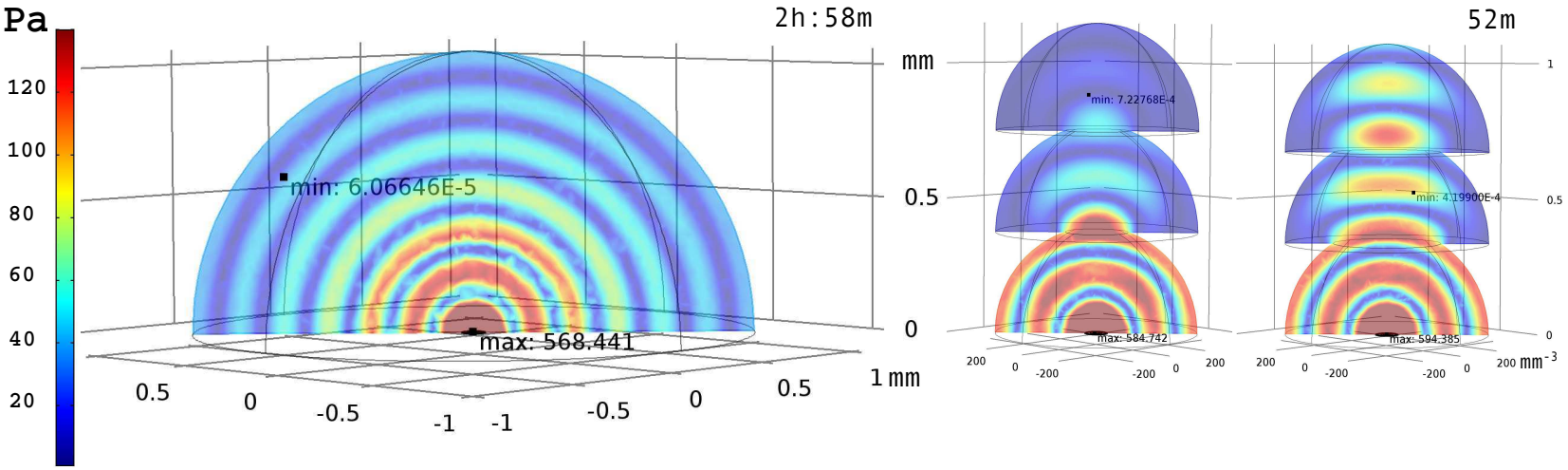
Measurements



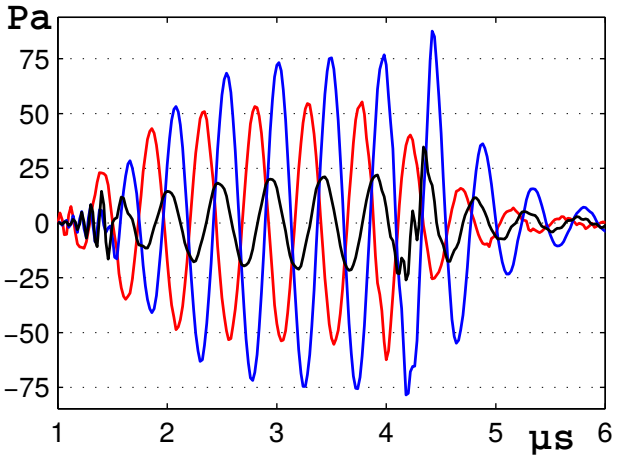


Output pressure measurements with a hydrophone (ONDA, HNC-1500) 3.8 mm away from the PMUT. The acoustic medium is Fluorinert FC-70 (ρ =1940 kg/m^3, c =687 m/s).

Pressure field in time domain



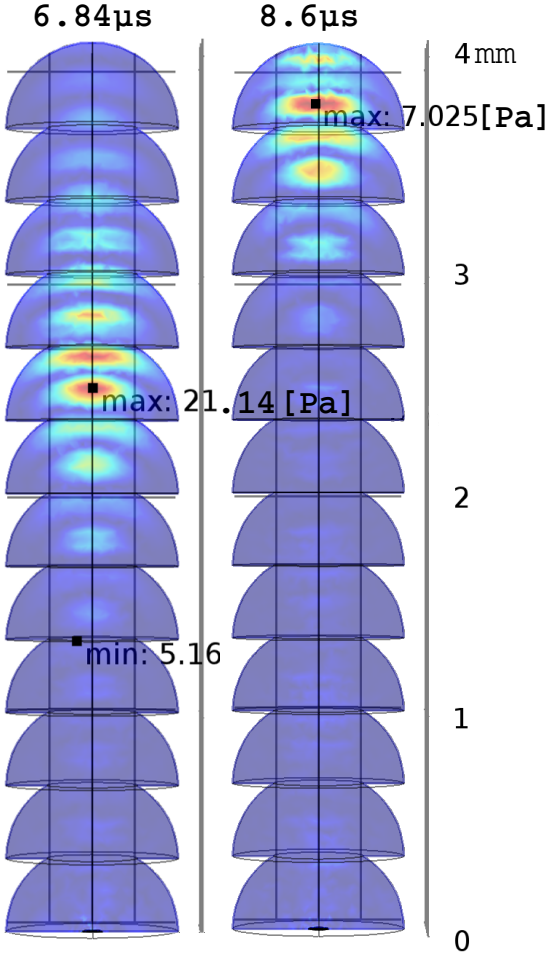
Pressure fields in Fluorinert: single-sphere (R = 1mm), three-hemispheres with 5% and 15% overlapping of their radii (R = 395μm); the simulations are stopped at 3.4 μs.

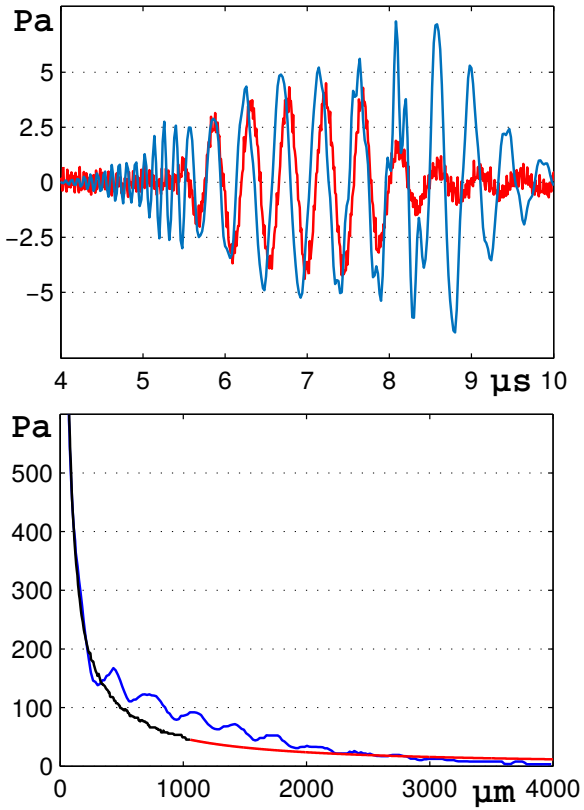


Comparison between the simulated wave-trains of the pressure field at 1mm:

red - single hemisphere,
black - 5% overlapped,
blue - 15% overlapped.

Results





Left: output pressure field. **Right top:** comparison with experiment (red) at 4mm.

Rgiht bottom: maximum pressure computed by multiple hemispheres (blue) versus computation by a hemisphere (black) with an extrapolation (red).

Results

mode media	0,1 Air	1,1 Air	2,1 Air	0,2 Air	0,1 Fluorinert
frequency Experiment [MHz]	5.64	11,3	18.06	20.34	2.2
frequency Simulation [MHz]	5.57	11.28	18.6	20.87	2.08

	Pressure peak-to-peak at 3.8 in/out/differential	Displacement peak-to-peak of the membrane in/out/differential
Experiment	0.8/2.7/4 [Pa/V_{pp}]	0.1/0.29/0.38 [nm/V_{pp}]
Freq.-domain simulation		0.07/0.12/0.18 [nm/V_{pp}]
Time-domain simulation	0.84/1.57/2.46 [Pa/V_{pp}]	0.07/0.12/0.18 [nm/V_{pp}]

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Summary

Our models allow different geometries and materials to be investigated and are well calibrated to fit with the conducted measurements. Hence, we have the ability to compare electrode designs, layers thicknesses and layers materials when aiming at an optimal ultrasound actuating performance.

By using specially designed boundaries we reduced the needed computational resources for the time-domain simulation of the pressure field. Still in a good agreement with the experiment at 3.8mm for the inner electrode actuation.

Future work on the boundaries of the acoustic media can further optimize the quality of the resulted pressure field in time domain.

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