Thermoviscous Acoustics - Piezoelectric Modeling and Simulation of Surface Acoustic Wave Devices

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Introduction: Novel Proteins in high concentrations are expensive to produce. Solution properties specifically viscosity is very critical to the stability, processing, and delivery of such drugs.

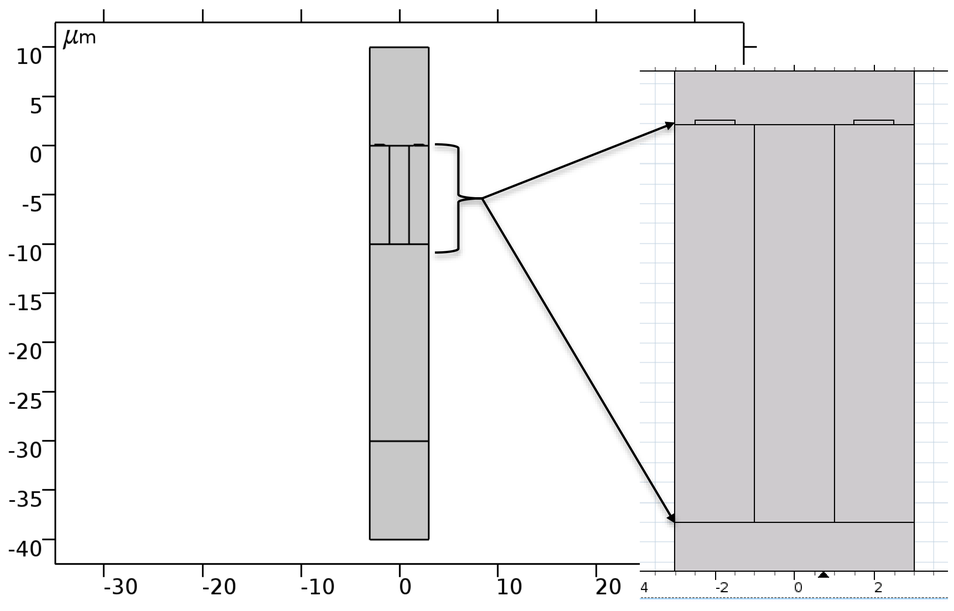

Figure 1. Geometry of SAW sensor

Device Geometry: We study the resonance frequencies of a SAW sensor consisting of an interdigitated transducer (IDT) etched onto an STQ 25YX Quartz substrate and covered with a layer of the 10μm thick air layer. The device unit cell is 6μm wide by 50μm deep. The groove between the electrodes is 2μm wide by 10μm deep. Metal electrodes are 1 μm wide by 1250μm thick. The zoomed in image shows 2 electrode and center groove. The presence of fluid causes a shift in resonance that slightly lowers the resonance frequency for the same SAW mode.

Simulation Details: The simulation uses thermoviscous acoustic - piezoelectric interactions. The model is meshed with “extra fine” parameters in the global domain to get denser mesh at the top where the electrodes and the groove lay, essential for achieving a high accuracy.

Results: Presence of fluid in the groove is detected using thermoviscous acoustic - piezoelectric interactions. The model accurately predicts the behavior of the SAW and fluid interactions.

Variable	Value	Units
T	25	° C
p	1	N/m^2
Liquid Switch	0 – 1	Off / On
vR	3488	m/s
f_0	900	MHz

Table 1. Table of parameters

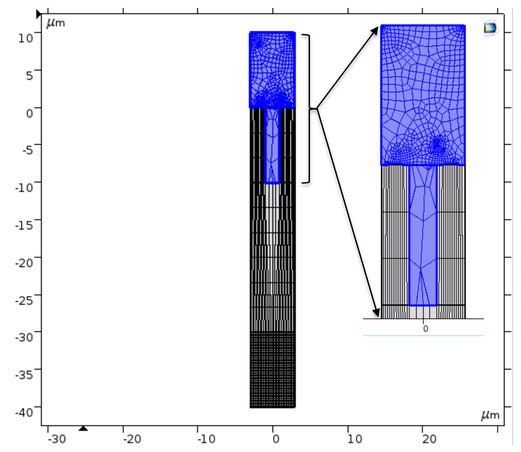

Figure 2. Meshed 2-D SAW sensor

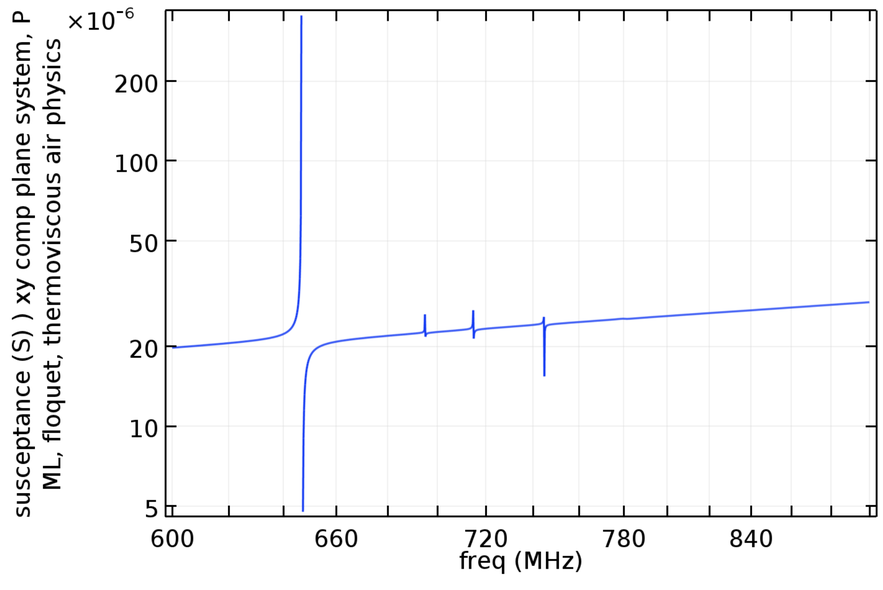

Figure 3. Susceptance (S) with floquet conditions under thermoviscous interactions.

Conclusions: Analysis of viscosity and resultant variations in conductance, susceptance, and admittance, as a function of Protein concentration and morphology, establish SAW sensors as significant characterization devices.

References:

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3. Muniraj, N. J. R., & Sathesh, K. (2011). 3D Modeling of a surface acoustic wave based sensor.