



## Development of Love wave resonators for biological sensing

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# LOVE WAVE RESONATORS FOR BIOLOGICAL SENSING

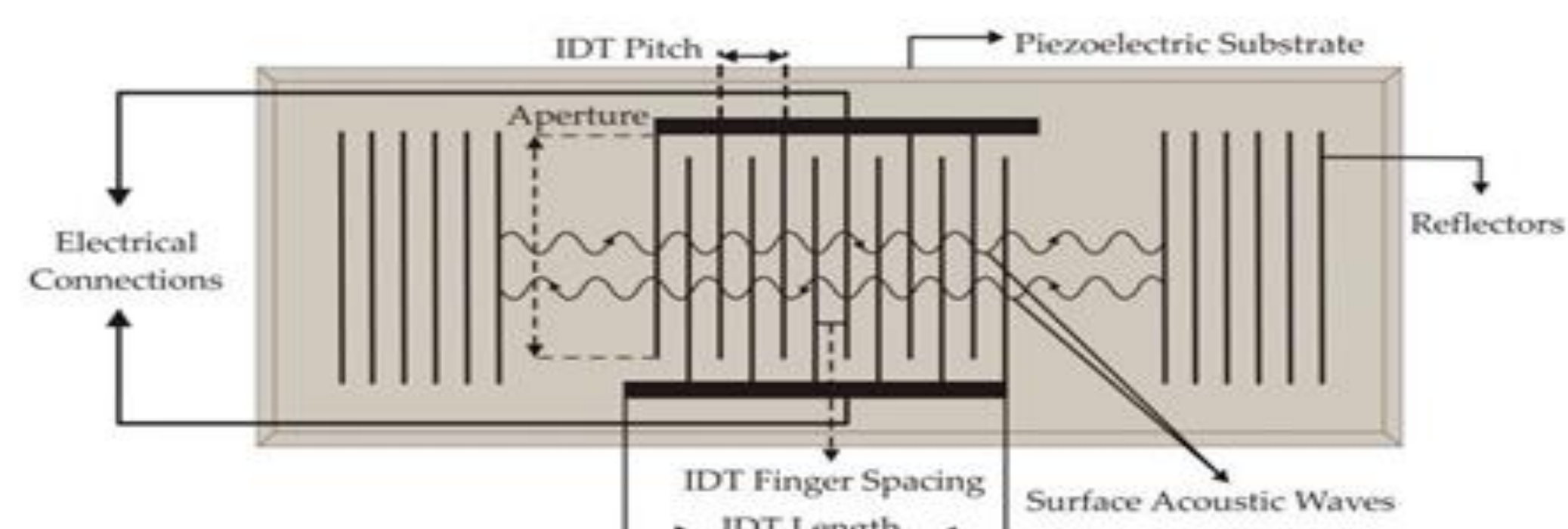
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## INTRODUCTION

The development of a biosensor can be challenging. Notably, the transducer must operate in a water-based complex media that often introduce system losses. Good performance in liquid media is however required for biological applications. This work focuses on the development of a transducer aimed to be used as a biosensor.

## TRANSDUCER

- Surface acoustic wave device
  - More sensitive to surface perturbations
- Resonator architecture
  - Better electrical performance<sup>2</sup>
  - Smaller size



- Avoid acoustic radiation into water → Love wave (shear horizontal polarization)

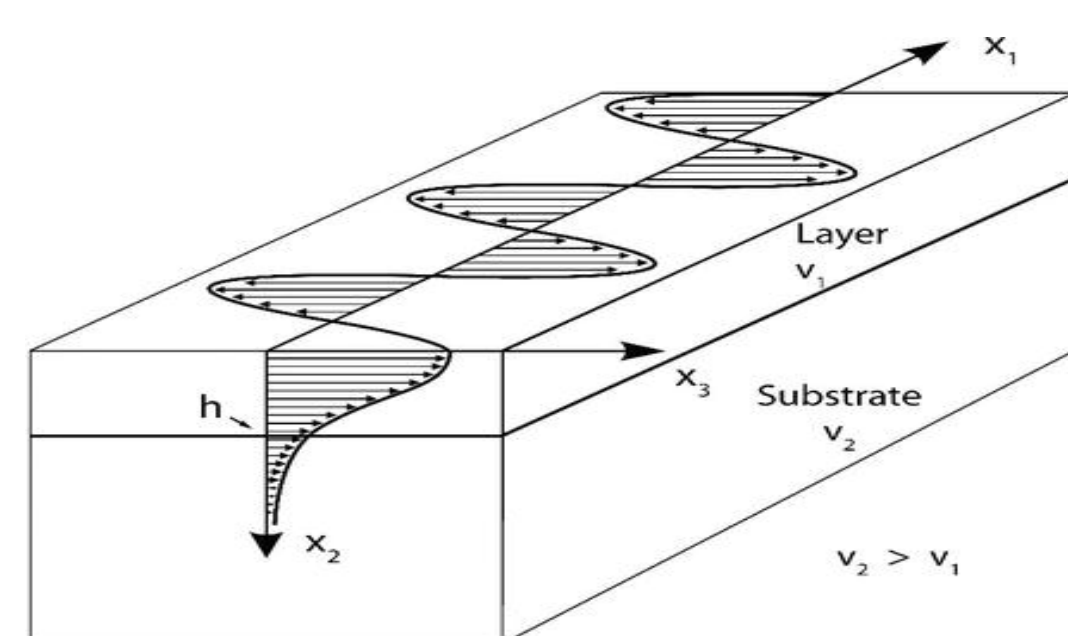
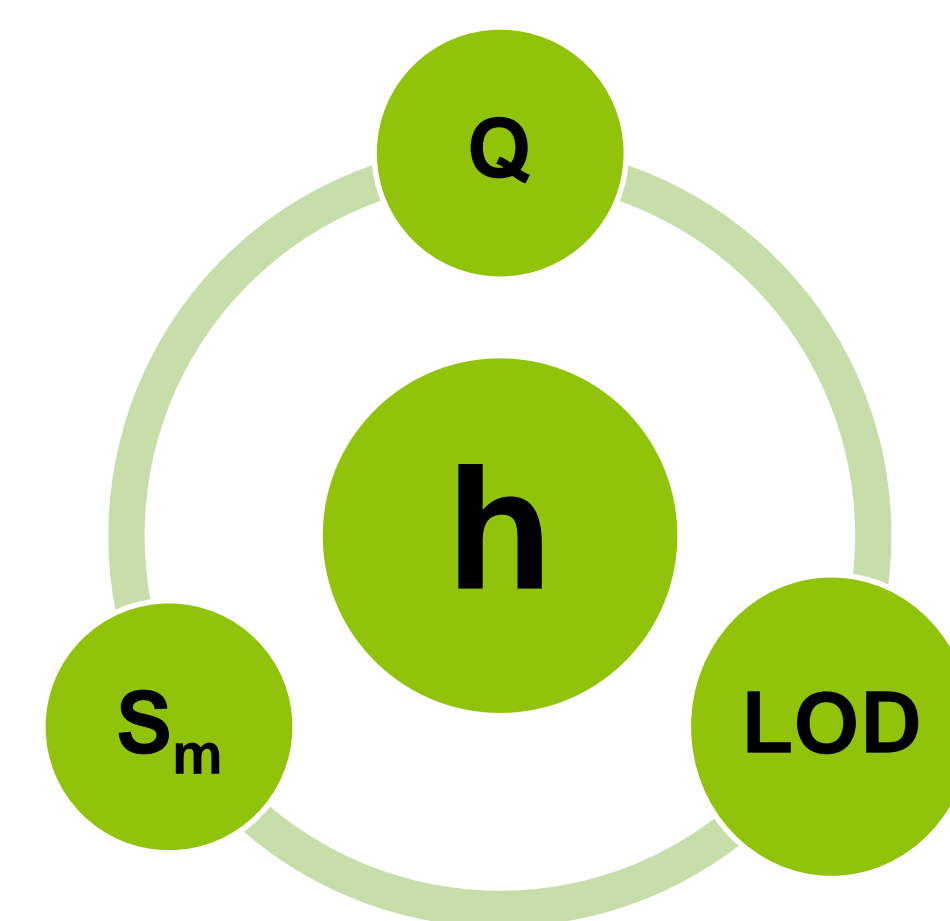


Figure 1: (top) Schematic of a surface acoustic wave device. (bottom) Love wave displacement field. The structure considered has a layer of thickness  $h$  on top of a semi-infinite substrate.

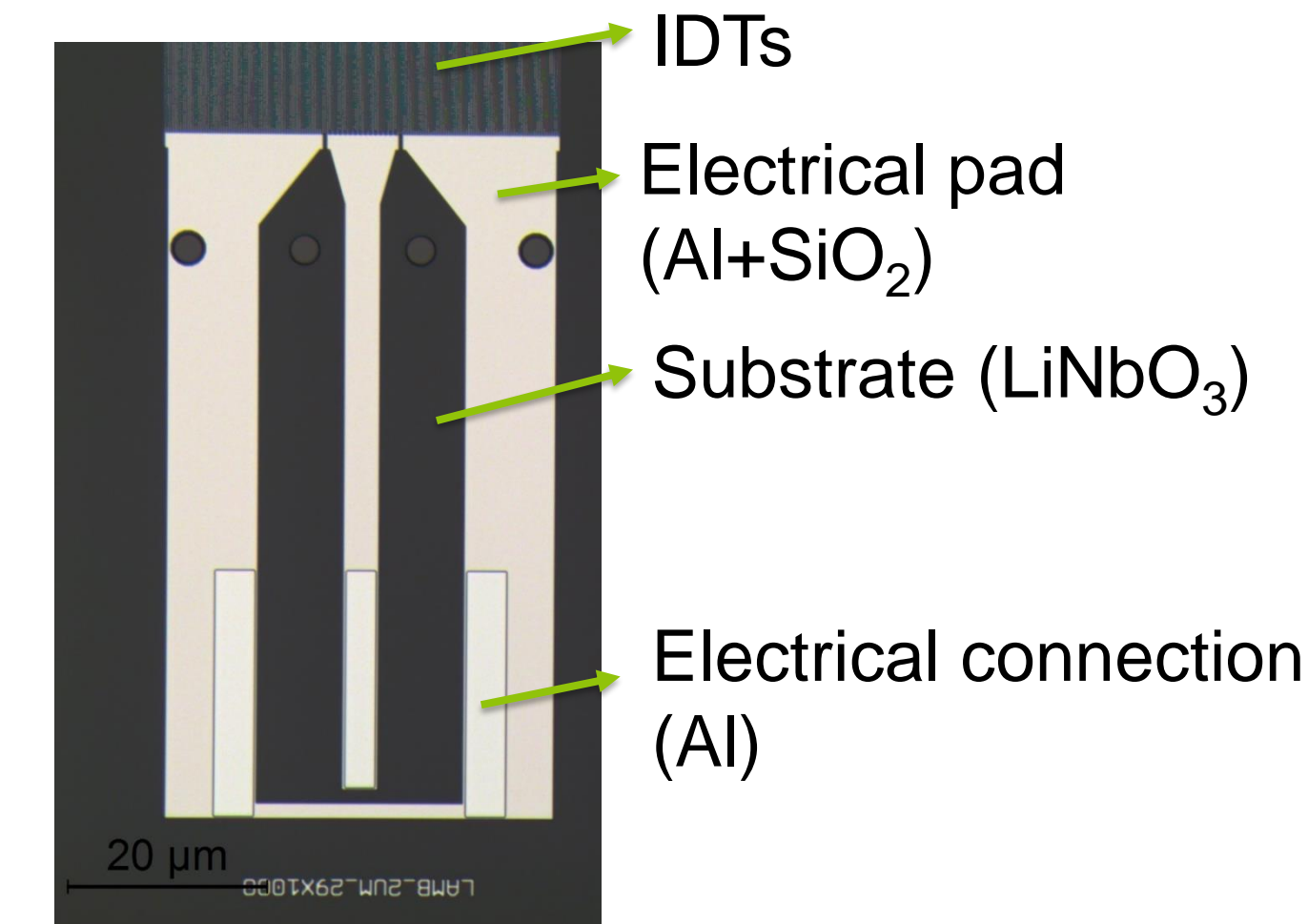
## FIGURES OF MERIT

Performance parameters:

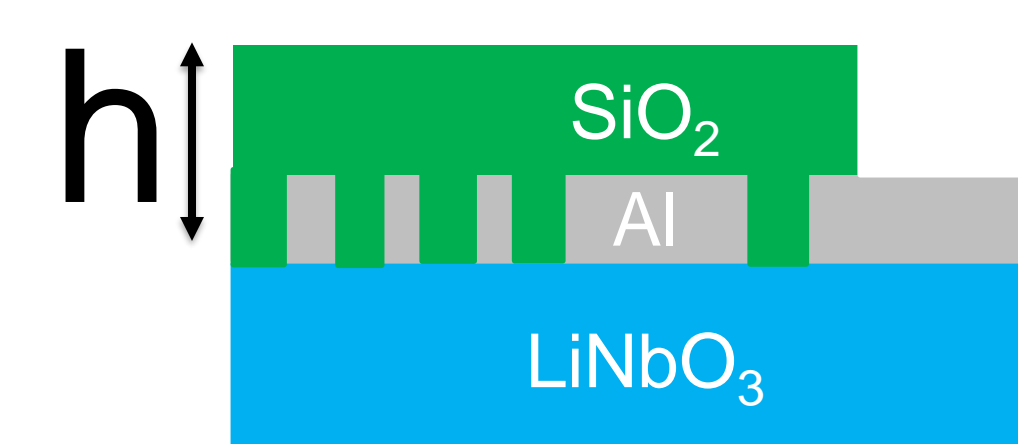
- Mass sensitivity  $S_m = \frac{\delta f}{\delta m} = \frac{f_0}{m_{eff}}$
- Limit of detection  $LOD \propto \frac{m_{eff}}{Q}$



Top view of the device



Resonator cross section



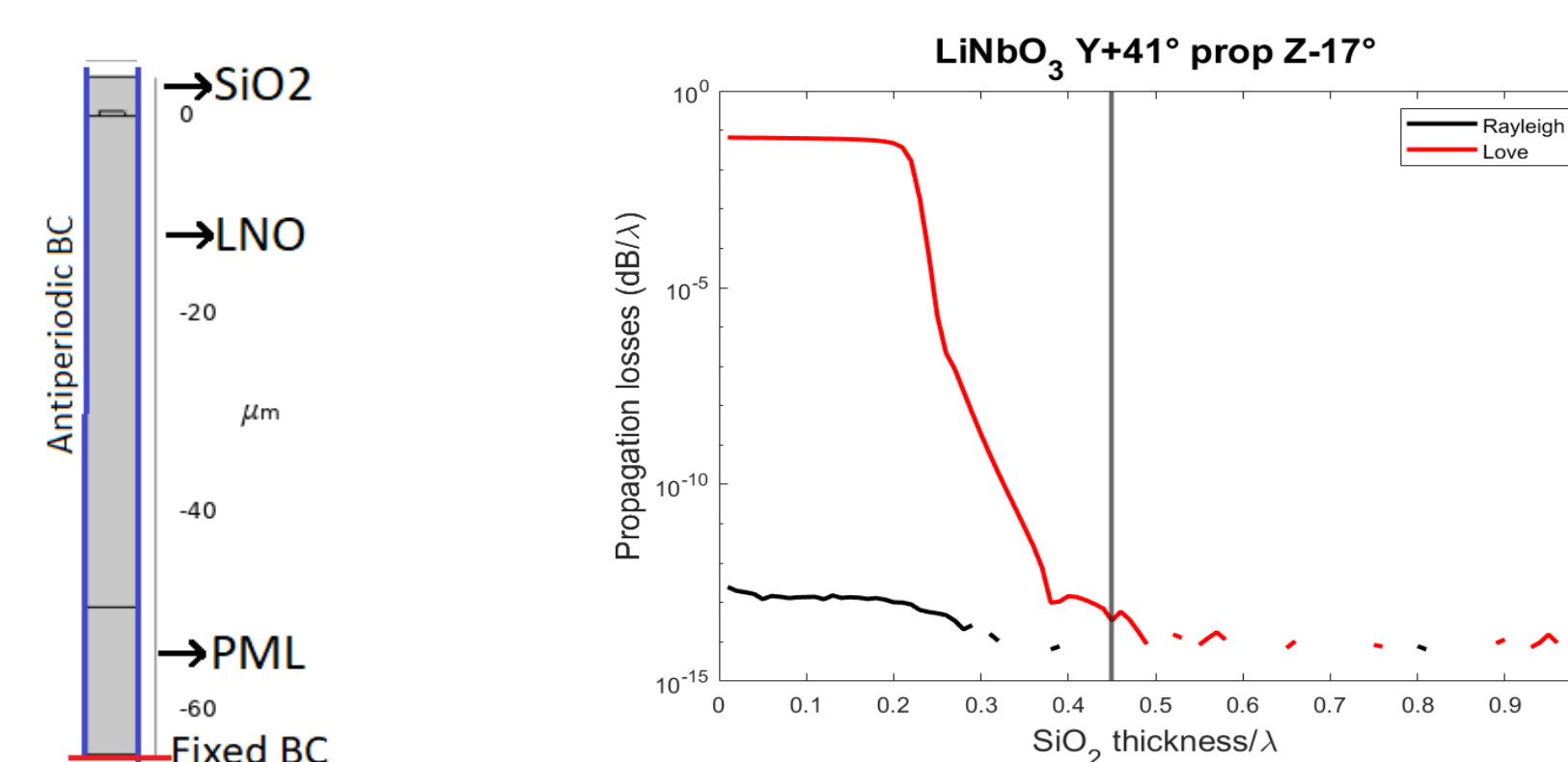
SiO<sub>2</sub> film thickness controls confinement of the mode in the vicinity of the surface → affects all performance parameters<sup>4</sup>

- Reduces radiation in the substrate → improves quality factor (Q)
- Brings acoustic energy closer to the surface → reduces  $m_{eff}$

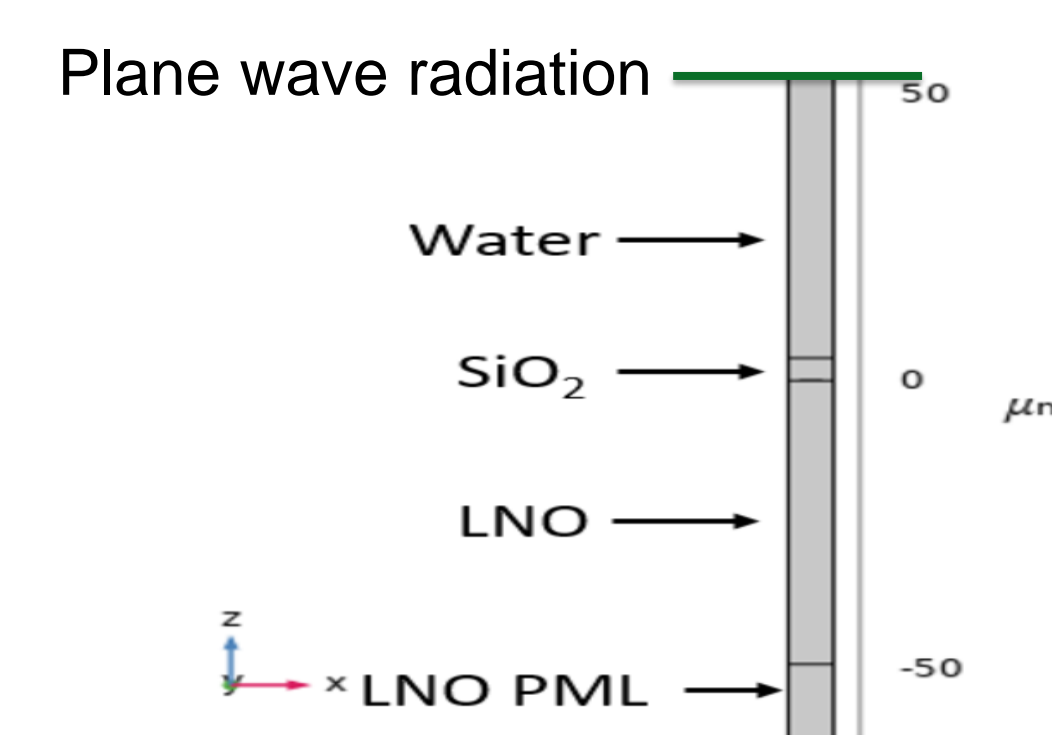
## TRANSDUCER DESIGN

Love wave propagation properties evaluated using periodic models:

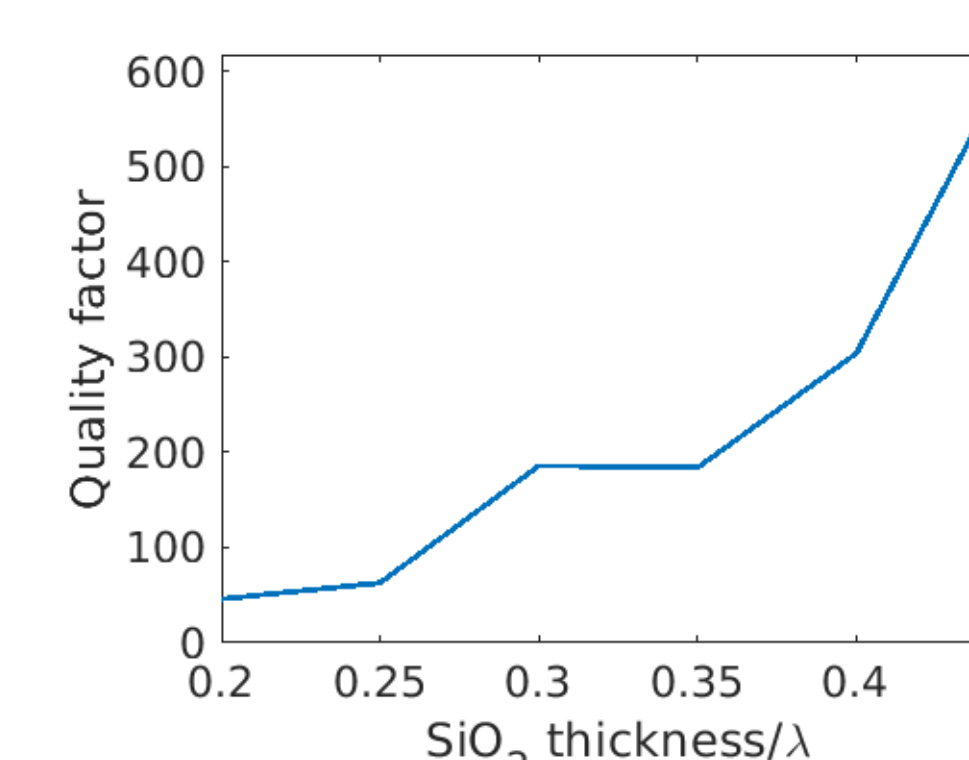
- Calculate propagation
  - Evaluate Love wave radiation into the substrate



$h/\lambda > 0.4$  to fully confine wave into the layer

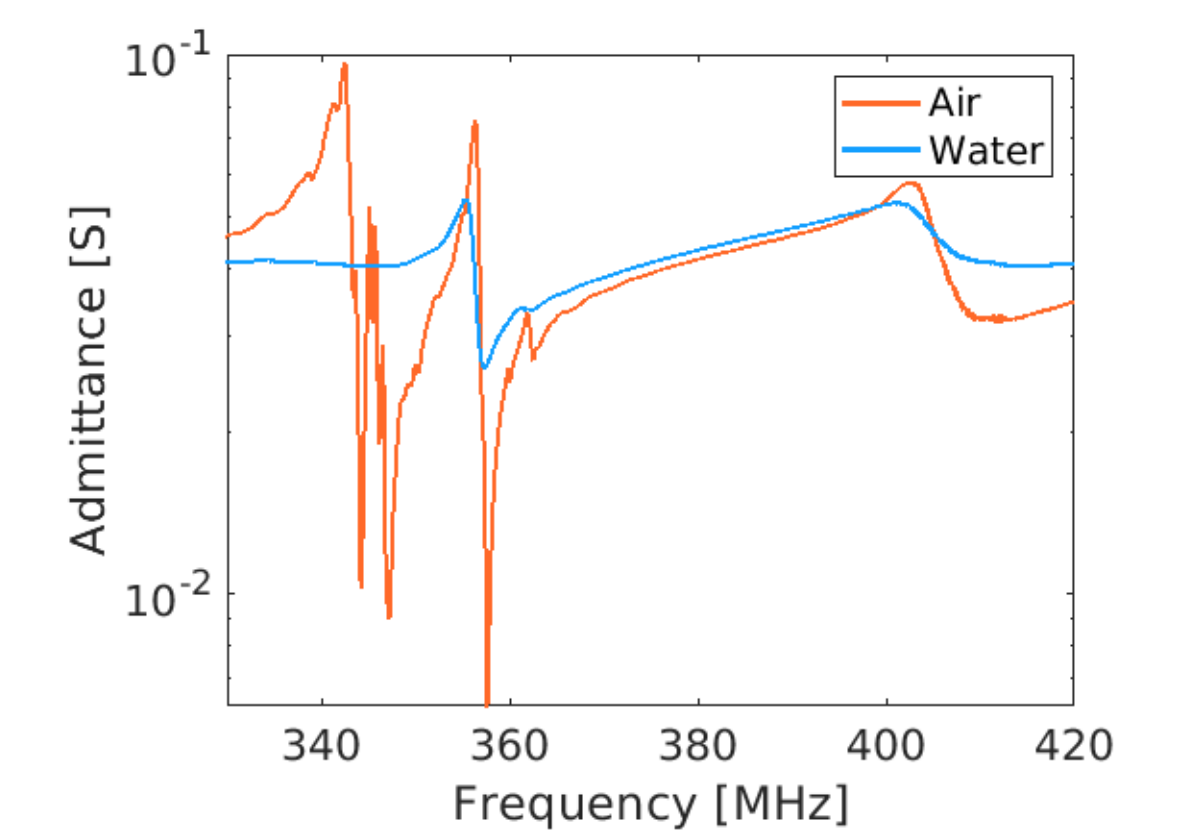
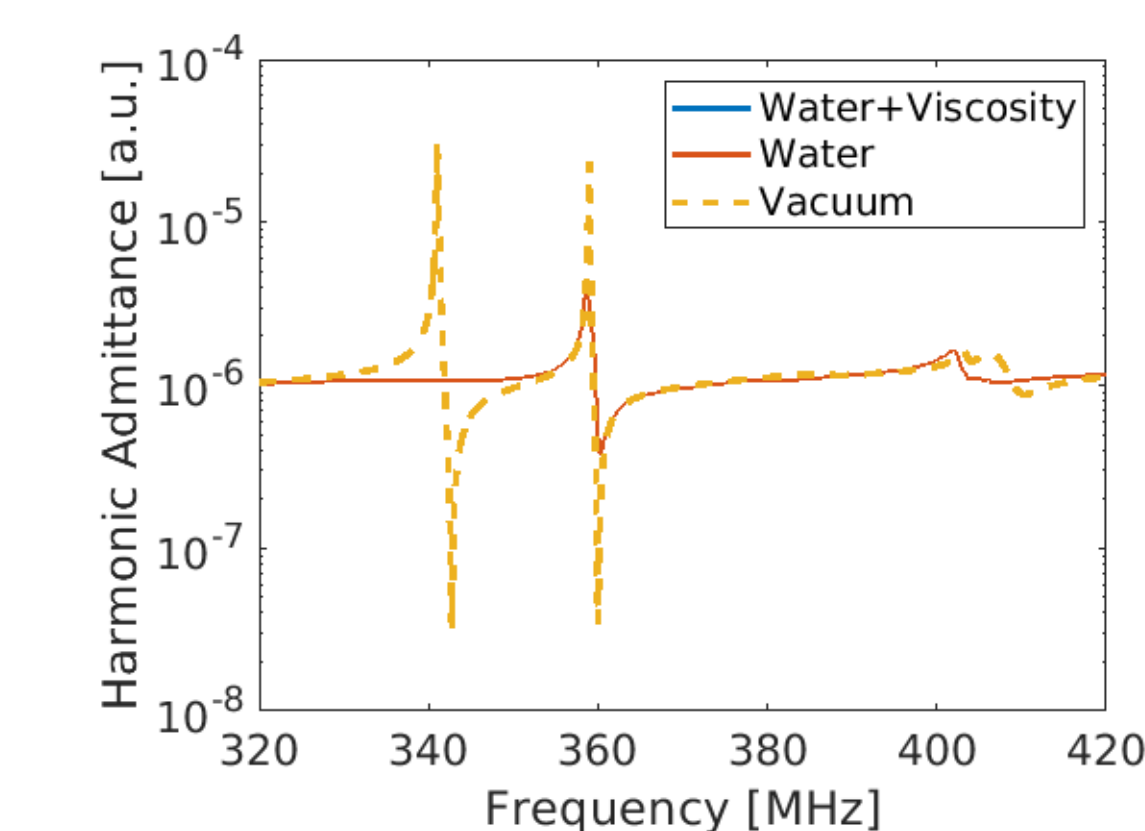


Love wave Q in water vs. h



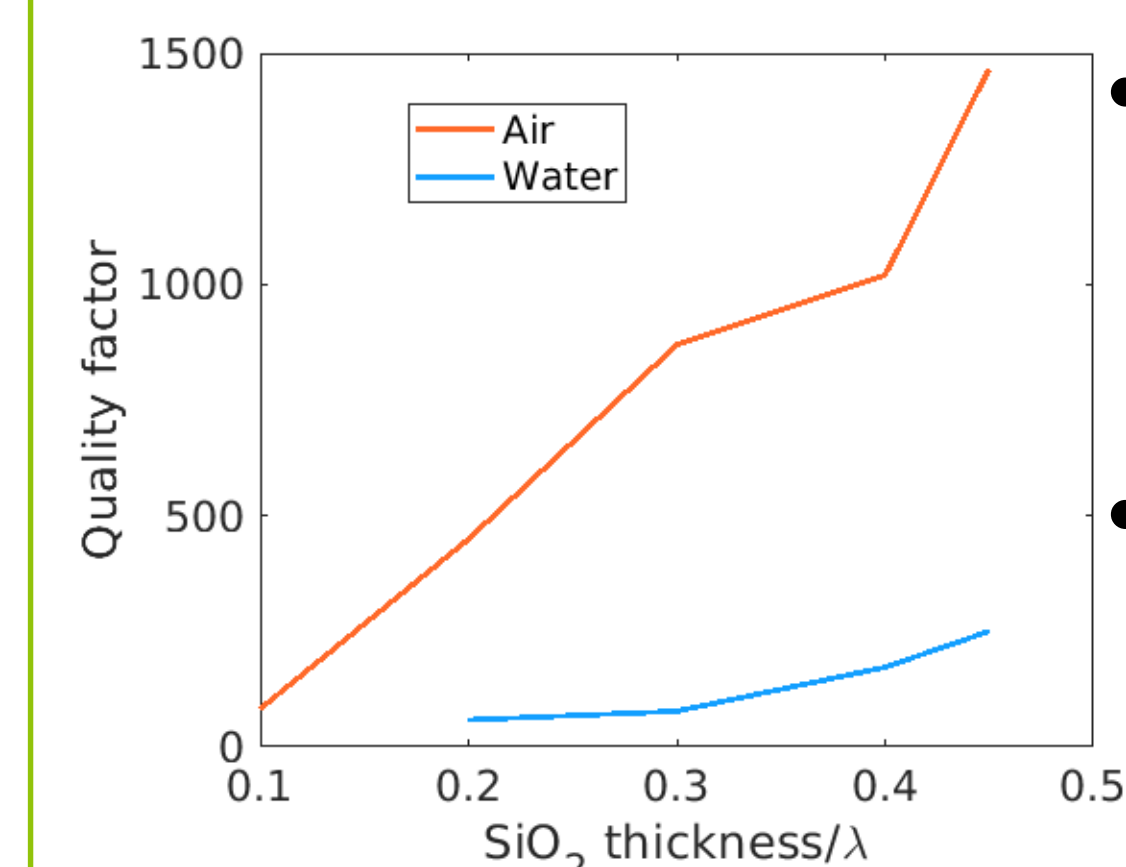
## RESULTS

### Love Resonator electric response



Comparison of the calculated harmonic admittance with the electric response of Love wave resonators when operating in air/water. Rayleigh wave heavily attenuated in liquid environment, as expected, given its vertical displacement at the fluid/structure interface.

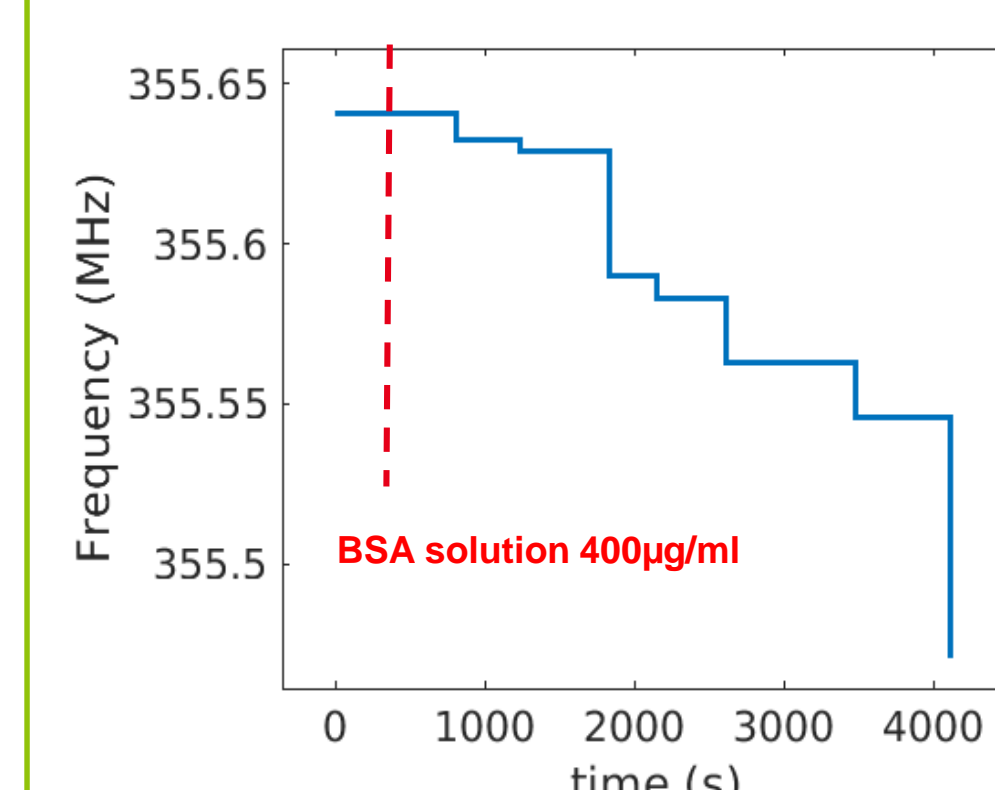
### Love wave Q vs. h



- Q reduces by a factor of 10 from air to water because of viscosity
- Confirmed positive influence of increasing the SiO<sub>2</sub> thickness on Q-factor.

## CONCLUSIONS AND PERSPECTIVES

We evaluated the electric response of the resonator in water, which heavily affects the Rayleigh wave and has a smaller impact on the Love wave. A protein detection experiment (Figure below) is in development to evaluate if the increase in Q yields better mass sensitivity/LOD. Next steps towards the biosensor are the implementation of a microfluidic channel passing over the active surface.



Biodetection experiment. Tracking the resonance frequency change during exposition to a BSA+PBS solution of 400 μg/ml

