# Biosensing System Modeling Using Phononic Pillars

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## Abstract

We present a design of a biosensing system based on an array of phononic pillars interacting with Love surface acoustic waves (L-SAW). The pillar is made up of alternating layers of silicon dioxide (SiO2) and Tungsten (W) which have different elastic and density parameters. The pillar structure was designed and optimized based on the targeted band diagrams obtained by calculating the eigenfrequencies by varying the wave number. A wide band gap was obtained, corresponding to a band of frequency where no wave can exist in the pillar. By variating the thickness of the layers, it was possible to include some specific modes into the band gap which were fully decoupled from other modes.
The modeled system consisted of a pilar between a delay line of interdigitated electrodes (IDTs) defined on top of a ST cut quartz piezoelectric substrate (Fig.) covered with a silicon dioxide (SiO2) thin film used as guiding layer to confine a surface wave created by applying a voltage to the piezoelectric substrate and obtain a Love wave.
The MEMs module was used to create a piezoelectric material, which was electrostatically actuated via the IDTs using AC/DC module. The resulting wave displacements were analyzed using the solid mechanics module. We placed continuity periodic conditions on the side of the delay line and the frequency domain solver was used for the analysis.
A normalized transmission parameter defined as the ratio of the delay line output to input point displacements v was introduced for the analysis. A sharp attenuation dip was observed on the normalized transmission curve which corresponds to two modes, which have been placed inside the band gap.
To estimate the mass sensitivity of the system, a weak mass perturbation was applied on top of the pillar (point load with F= δ_m ω²u and δ_m=1.15 fg). A downward shift of the resonant frequencies due to mass loading was observed. The shift was dependent on the displacement of the pillar. By placing the mass on the maximum point of displacement of the torsional mode, a frequency shift of 2.7 kHz was obtained for a single mass displacement.
The simulations of this work are being used to implement experimentally a L-SAW based biosensing sensor using phononic pillars for mass detection.

## Figures used in the abstract

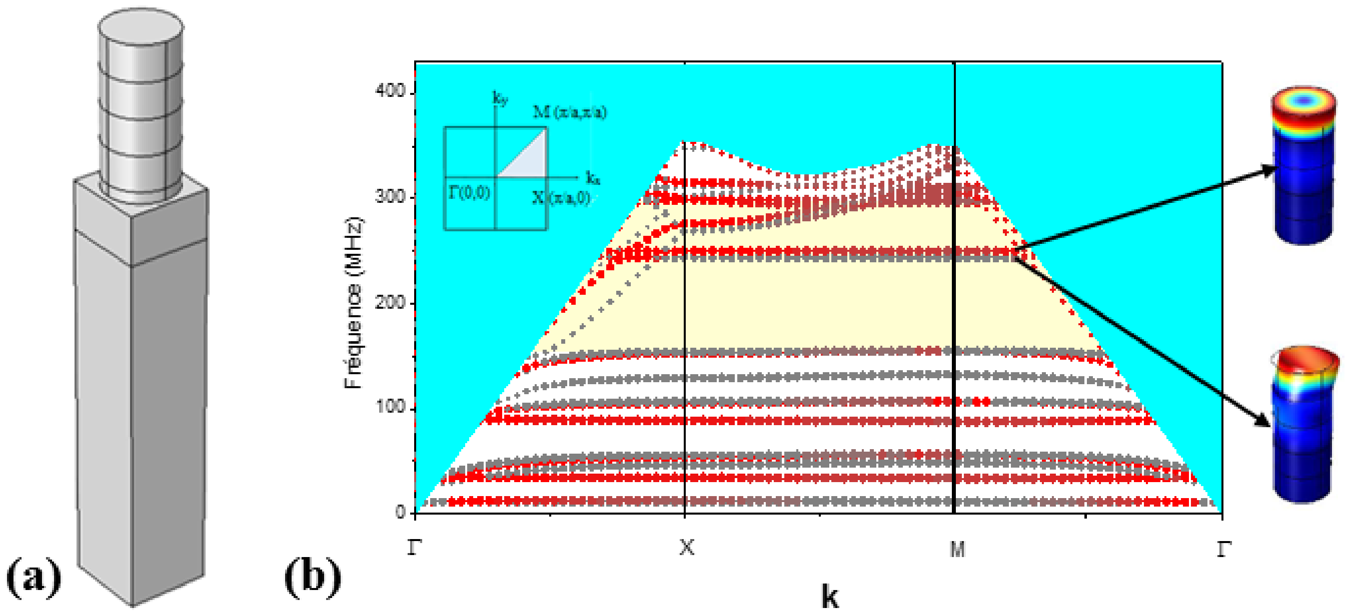


**Figure 1** : Unit cell used in the modeling which includes the Quartz substrate, the SiO2 guiding layer and the multilayered pillar (a), and the corresponding band structure with the positions of two interesting modes (b)

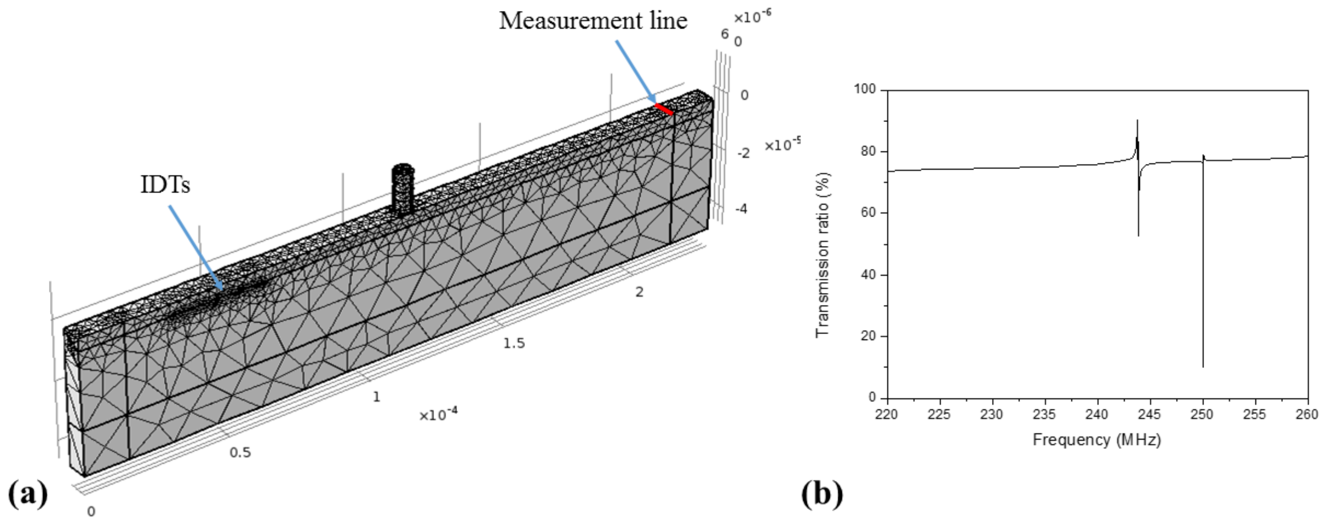


**Figure 2** : Delay line structure and transmissions (a) Example of a normalized transmission curve showing two attenuations/dips corresponding to resonant frequencies of the pillar (b)

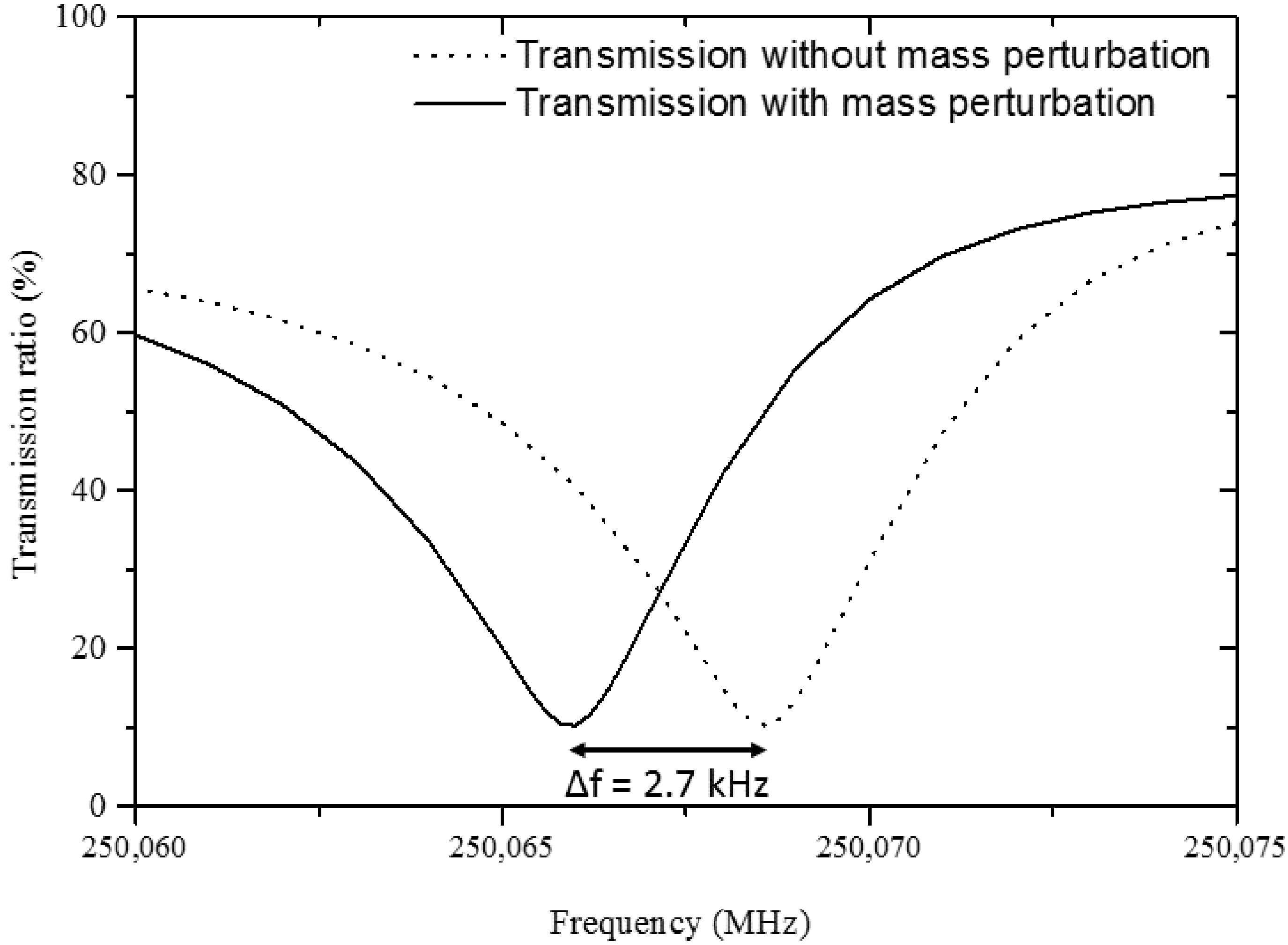


**Figure 3** : Single mass perturbation effect normalized transmission