COMSOL Multiphysics® Software for Modeling STW Devices

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Abstract

INTRODUCTION
With fast development of computers, COMSOL Multiphysics software becomes attractive tool for simulation of Surface Acoustic Wave (SAW) and Surface Transverse Wave (STW) devices. Compared to other methods, such as Coupling-of-Modes (COM), [1], COMSOL does not demand phenomenological parameters extracted from experiments. More precise than COM simulators, FEM/BEM software packages [2] based on Green function description of wave motion in substrate, demand many efforts to be applied to a new material or, even, to a different crystal cut. COMSOL can easily be used for electrode structures including sub-layers, multilayered electrodes, dielectric layers, etc. on any piezoelectric substrate. It can deal also with 3D structures, not accessible for existing COM or FEM/BEM software packages. Therefore, we consider inevitable more wide spreading of COMSOL simulations of SAW/STW devices.

USE OF COMSOL MULTIPHYSICS
We use the Piezoelectric Devices interface of the Structural Mechanics Module. PML boundary conditions are applied to limit the simulated area/volume of substrate and to avoid reflections from artificial boundaries. We used manual mesh generation to find the trade-off between limited memory resources and accuracy of calculation. A specific combination of Eigen-frequency analysis and Frequency-domain analysis is applied over a primitive STW cell to study the waveguiding and resonant properties of STW resonators.

RESULTS: STW Resonant Characteristics
Here we give an example of COMSOL simulation of STW resonator [3] on rotated Y-cut of quartz. We determined the STW dispersion as function of incident wave angle, the harmonic STW admittance in 2D and the admittance of a finite STW resonator in 2D approximation. Fig.1 and Fig. 2 below shows the primitive STW cell and the 2D Harmonic admittance.
RESULTS: COMSOL simulation of 3D SAW structures
Another example is 3D simulation of periodic STW resonating structure with finite aperture. STW resonators in 2 GHz frequency range show excellent Q-factors of 4000 to 8000 [3]. COMSOL was used for finding parasitic transverse modes and optimization of the resonator (Fig. 3).

CONCLUSIONS

It is demonstrated that with a moderate workstation COMSOL can be used for simulation of real micro-acoustic devices, such as STW resonator. 3D periodic structures can be simulated and such important effect are modeled as radiation of energy in busbars by IDT, analysis of transverse modes, radiation of energy in busbars by IDT, optimization of "dummy fingers". The results are in excellent agreement with measured device performance. Stopband structure of periodic 3D phononic crystals can be found. Some limitations of COMSOL will be discussed.

Reference

[1] V.Plessky & J. Koskela, “Coupling-of-modes analysis of SAW devices”. International Journal of High Speed Electronics and Systems, 10 (04), 867-947, (2000).

[2] P. Ventura et al, « A new efficient combined FEM and periodic Green's function formalism for the analysis of periodic SAW structures”. Ultrasonics Symposium, 1995. Proceedings., Vol. 1, pp. 263-268, (1995).

[3] C. U.,Kim, et al. "High Q-factor STW-Resonators on AT-Cut of Quartz." 2007 Ultrasonics Symposium, pp. 2582-2585, (2007).

Figures used in the abstract

Figure 1: Displacements in the STW resonator.

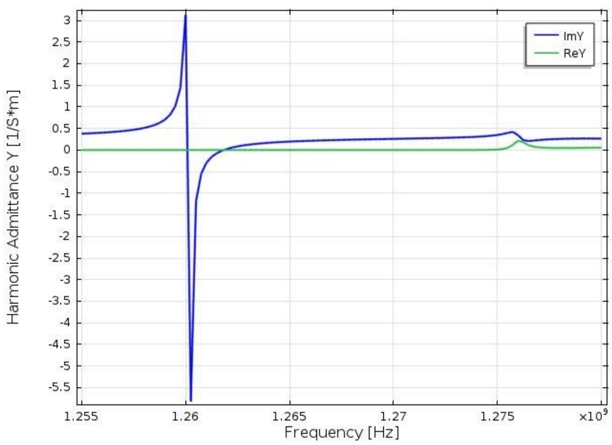

Figure 2: Harmonic admittance of the STW resonator.

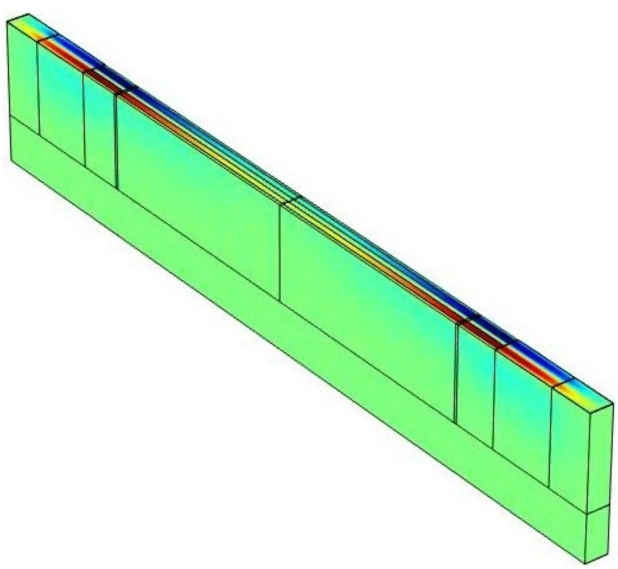

Figure 3: STW mode guided mainly by busbars.

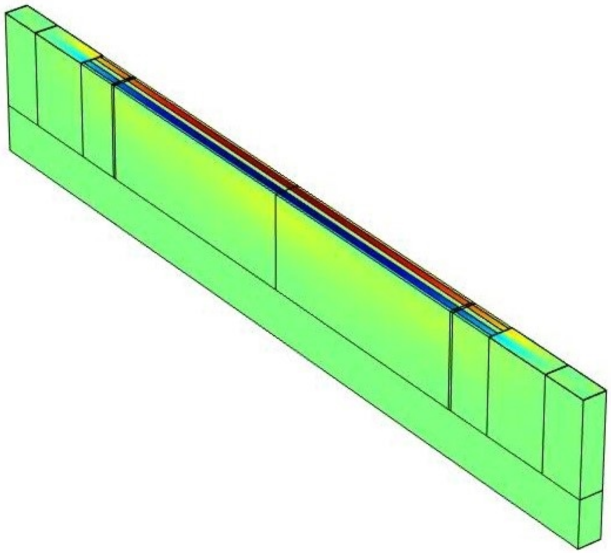

Figure 4: Well guided STW mode.