Periodic 3D Leaky SAW Simulations with 42 Y-cut Lithium Tantalate

S. Yandrapalli[1], V. Plessky[1]

[1]GVR Trade SA, Gorgier, Neuchatel, Switzerland

Abstract

Introduction
Leaky Surface Acoustic Wave (LSAW) resonators in rotated Y-X cut Lithium Tantalate (LiTaO3) are widely used for resonator based ladder filters in telecommunication applications. These devices make use of quasi- shear waves confined to the surface of the piezoelectric layer device for resonance. However, they are prone to losses due to some wave radiation to the busbar and coupling of slow shear bulk acoustic waves to the main SAW mode above resonance frequency[1]. Therefore, it is necessary to perform FEM simulations in order to quantify these losses and minimize them for designing low insertion loss devices.
A LSAW finite aperture device with 42o YX-cut LiTaO3 substrate was simulated in COMSOL Multiphysics®. The resonance frequency was at 1.97GHz with transducer period λ_0=2p = 2µm and Al electrode thickness h/λ_0=8%.

Method
The simulations are performed for a periodic resonator on 42o YX-cut LiTaO3 substrate. The device for modeling has a wavelength〖 2*p=λ〗_0=2µm, an aperture of W=20λ_0=40µm, aluminium electrodes with metallization of 50% and electrode metal thickness of h/λ_0=8% (160nm). Other features included in the design are busbars 3λ_0 wide and gap between the electrode tips and the busbars equal to 0.25λ_0.
The model uses a Piezoelectric multiphysics coupling node with Solid Mechanics and Electrostatics interfaces. The model consists of a single unit cell of width 2µm with LiTaO3 substrate, two electrodes (, +0.5V and -0.5V AC applied), vacuum of height 2λ_0(4µm) above the piezoelectric surface and solid Perfectly Matched Layer surrounding the unit cell laterally and at the bottom. The material properties of the PML are LiTaO3 or Al for the surface of the device in contact with piezoelectric or electrodes respectively. The two lateral sides perpendicular to the aperture have periodic Boundary Condition (BC) imposed on them in order to emulate an infinitely long resonator with infinite number of electrodes. The periodic BC used in this case is Floquet Periodicity where the displacement of the left side or source and destination are equal i.e. u_l=u_r with k_(x,y,z)=0. The periodic boundary condition is applied both in solid mechanics, whereas in the electrostatics module, continuity BC is applied where the potentials on both faces are equal i.e. V_L=V_R.

Results
After meshing, a frequency sweep was performed between 1.95-2.15GHz to study the Admittance response and field distribution of the resonator. As predicted from coupling of

modes(COM) model, resonance peak is seen at 1.97 GHz. Radiation to the busbar is observed from 1.977GHz and onset of bulk radiation to the substrate from 2.11GHz. Difficulties with applying PML are discussed.

[1] J. Koskela, J. V. Knuuttila, T. Makkonen, V. P. Plessky, and M. M. Salomaa, "Acoustic loss mechanisms in leaky SAW resonators on lithium tantalate", IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control,Vol. 48, No. 6, pp. 1517-1526, November 2001.

Figures used in the abstract

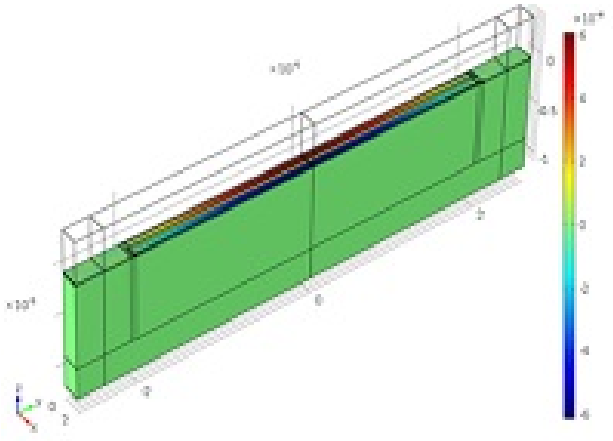

Figure 1: LSAW Shear Displacement in Y-direction at resonance.