Finite Element Evaluation of Surface Acoustic Wave Reflection and Scattering from Topographic Iregularities Comparable with the Wavelength

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Abstract: Design of SAW devices needs the accurate study of the scattering fields, arising from the interaction of SAW with topographic irregularities. To solve this problem FE methods very perspective, because with its help one can take into account the actual geometry of the electrodes and reflectors. This work describes results of original time domain calculation of 2D SAW scattering fields in delay line made on 128˚ YX LiNbO3 substrate. Reflection, transmission and scattering coefficients are numerically evaluated as functions of the reflector's thickness.Calculations of SAW scattering field's picture clearly show that the intense SAW energy scattering into volume occurs for certain parameters of the reflectors, while for some other configuration SAW pass through irregularities practically without scattering.

Model:

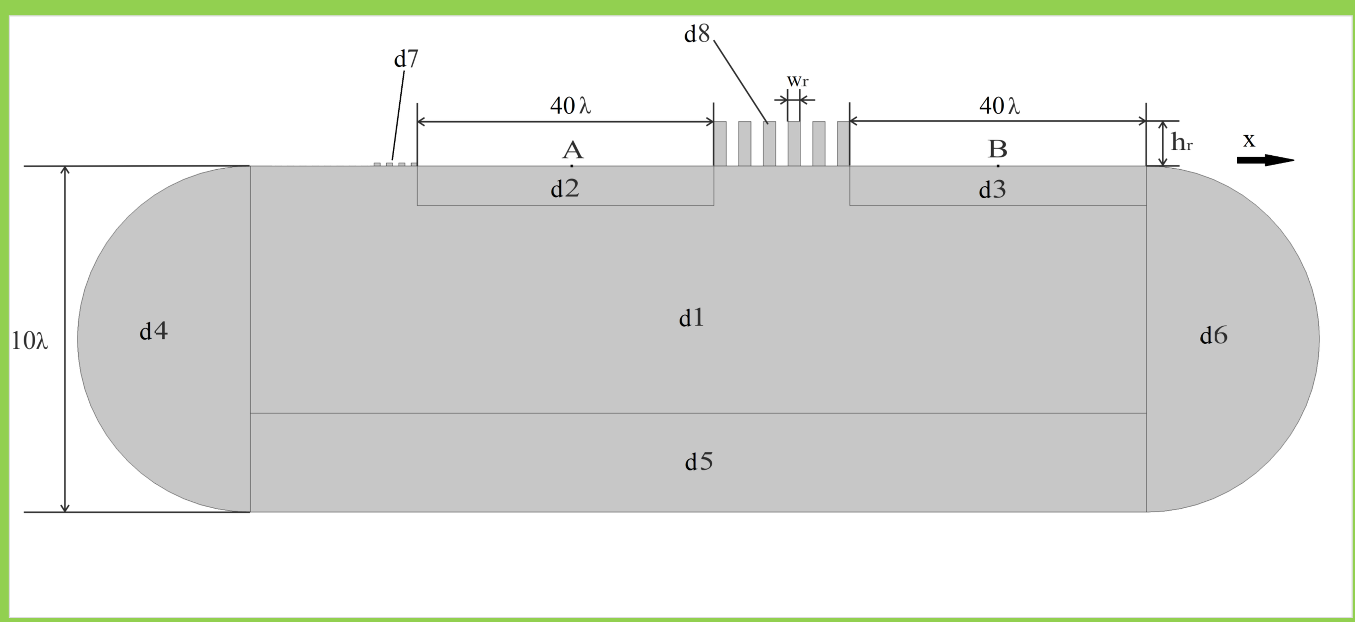

Figure 1. Model's geometry.
Domains d1-d6 represent 128˚ YX $LiNbO_3$. Domains d4-d6 are used to eliminate SAW reflections from boundaries of device and bulk reflection from the bottom of the substrate by introducing gradient of attenuation. No propagation loss in domains d1-d3.
IDT (d7) generates RF pulse with center frequency f0=2.44 GHz and duration of 25/f0.
Point "A" was used to detect of incident and reflected pulses from reflectors (d8), point "B" – to detect transmitted pulse. .

Applied method

Total energy:

$$E_d(t) = \frac{1}{2}\left(\int_d TS + ED\right) dV$$

$$E_{SAW} = E_{d2}(t_1),$$
$$E_{refl} = E_{d2}(t_2),$$
$$E_{trans} = E_{d3}(t_2).$$

Reflection, transmission and scattering coefficients:

$$Cr = \frac{E_{refl}}{E_{SAW}}; Ct = \frac{E_{trans}}{E_{SAW}};$$
$$Cb = 1 - Cr - Ct.$$

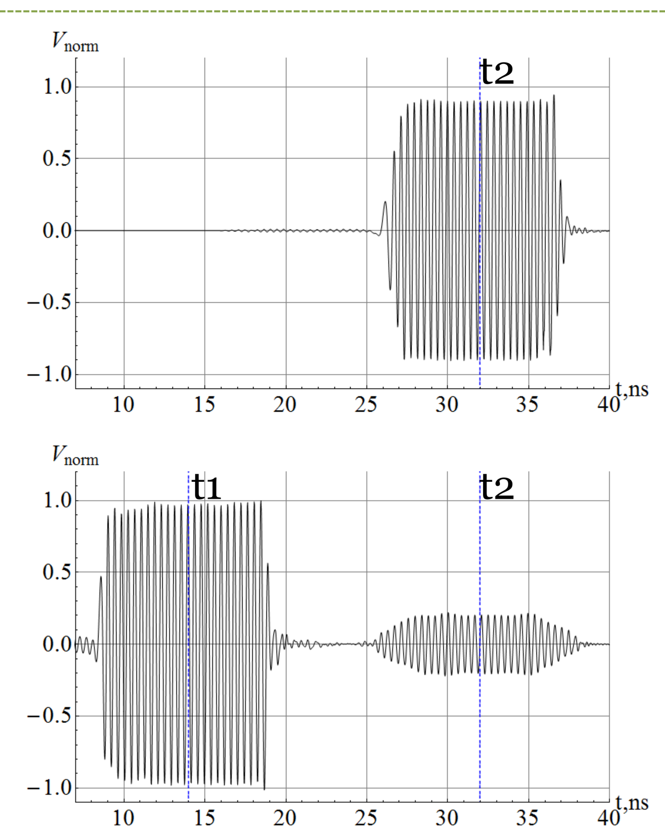

Figure 2. Normalized electric potential versus time at point "A" (a) and "B" (b). Blue dashed lines correspond to $t_1 \approx 14ns$ and $t_2 \approx 32ns$.

Acknowledgments:

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Related publications:

1. S.Suchkov, S.Yankin, I.Shatrova et al. Propagation and reflection of surface acoustic waves in the system of topographic irregularities comparable with the wavelength. Proceedings of the ICU 2013, 2-5 may 2013, Singapore.
2. S.Yankin. Modeling of surface acoustic wave scattering from the system of topographic irregularities comparable with the wavelength. Proceedings of 16émes Journées Nationales du Réseau Doctoral en Micro-nanoélectronique.
3. S.S.Yankin, I.A.Shatrova. Modelling of radiofrequency identification surface acoustic wave tags in 6GHz frequency band. Proceedings of VIII Russian conference of young scientists, 3-5 september, 2013, Saratov.

Results:

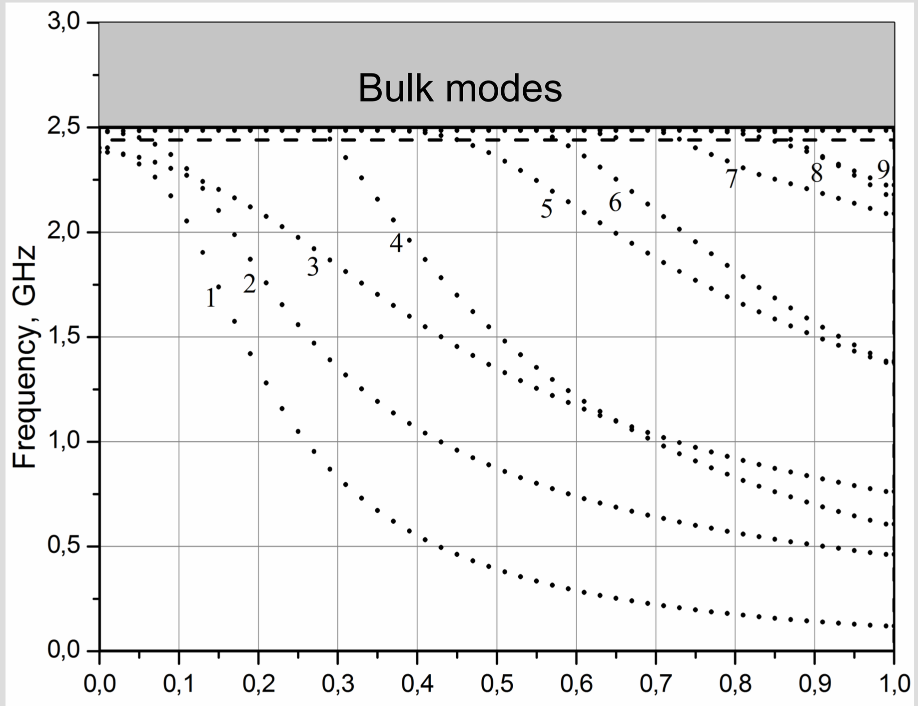

Figure 3. Dispersion curves for such Bragg reflector. Modes 3,6,9 correspond to shear polarization and don't influence on SAW. Maximums of transmission coefficient dependences correlate with existation of 2,5,7 modes, while 3 and 8 mode cause intensive scattering into volume.

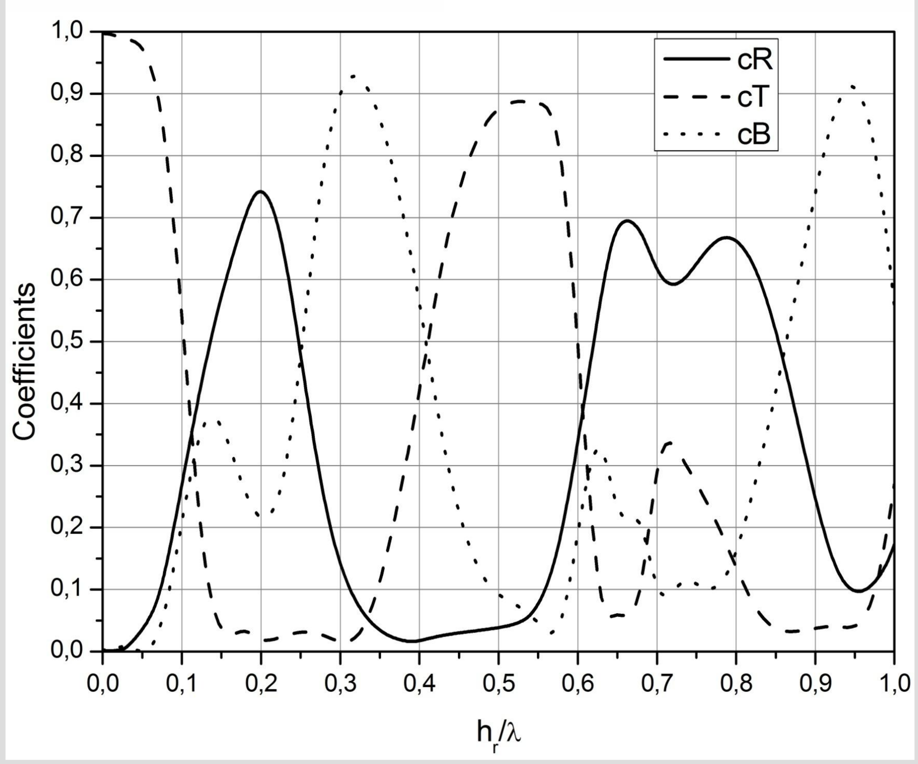

Figure 4. Reflection Cr, transmission Ct and scattering Cb coefficients for aluminum.

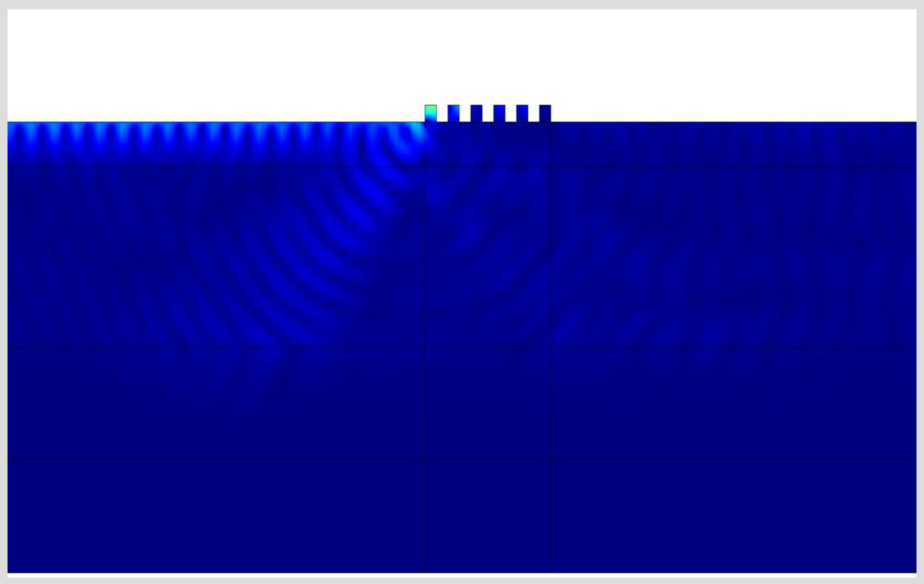

Figure 5. Total displacement at t=24.72ns for h_r/λ=0.28. Notable scattering into volume is detected.

Conclusions:

•Calculations of two-dimensional picture of SAW scattering fields clearly show that the intense SAW energy scattering into volume occurs for certain parameters of the reflectors
•while for some other their configuration a SAW beam can pass through topographic irregularities practically without scattering.
•This method should be applied for further detailed analysis of reflective structures to synthesize properly the modern SAW tags.