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Proceedings of Symposium on Ultrasonic Electronics, Vol. 37 (2016)

16-18 November, 2016

Investigation interaction SH-SAW with managed electroinduced domain structures

Siarhei Barsukou[1, 2]†, Jun Kondoh[1], and Sergei Khakhomov [2] ([1] Shizuoka Univ., GSST, Gomel State Univ.; [2] Gomel State Univ.)

1. Introduction

The ultrasound interaction with induced domain structures in crystals was studied since 20 years ago. Sound managements are perhaps the most obvious application of phononic crystals. Now it has increased the interest in the phononic crystals because they are providing new device that offer the same physical effects in the light and sound [1, 2]. The development of super lenses for acoustic waves and sound mirror would be a major breakthrough for a difference of ultrasound techniques. Unfortunately development of the SAW device for high frequencies is needed using the expensive high resolution technique. However the velocity of ultrasound in a solid material is lower than the velocity of the light. The low velocity of transverse (SH) component of ultrasound wave may be lower than 1000 m/s. This knowledge is allowing sciences to increasing the physical size of the elements of the SAW device for obtaining investigated effects.

2. Theoretically and experimental studies

We studied the possibilities of creation of the electroinduced manage domain structure in 36° rotated Y-cut, X-propagating $LiTaO_3$ single crystal. The crystal thickness is 350μm. The domain structure was induced by crossing electrode structure on the surfaces of the crystal [3-5]. **Fig. 1** shows the dimensions of the SAW device and the main direction in the crystal.

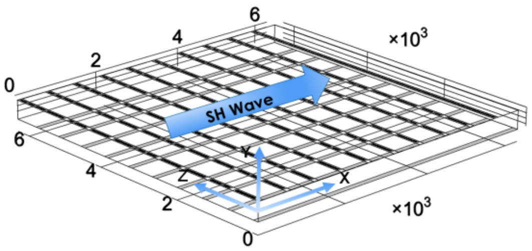


Fig. 1 Main view and dimensions of the SAW device (μm).

The SH-SAW propagates in X direction, the electric field was applied in Y direction of the crystal. The finite element methods (FEM) were used to investigate piezoelectric polarization and mechanical displacement for different crystal thickness. We studied the relationship between the pitch of electrodes and the thickness of the crystal. It was shown that the stable periodically domain structure can be obtain if the pitch between electrode fingers is equal or higher than the thickness of the crystal.

The **Fig. 2** is shown FEM calculated result of the electroinduced domain structures in the crystal. The electric field and displacement is distributed towards Y-axis. It is clear to see the areas with the expressed direction of displacement in a volume of the crystal.

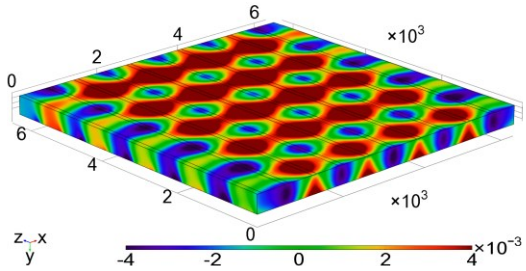


Fig. 2 The electroinduced domain structure in a crystal (total displacement in a $LiTaO_3$ crystal in μm)

The principal of the SH-SAW interaction with the electro induced domain structures is shown on **Fig. 3**.

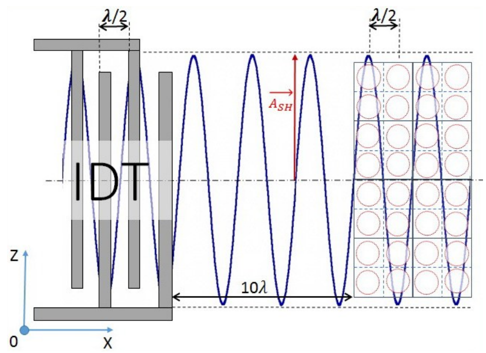


Fig. 3 The principal of the SAW device (IDT – inter digital transducer)

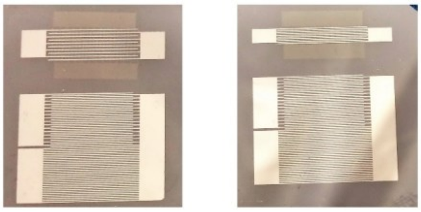
The transmitted SH-SAW by IDT is interact with domain structures. We developed SAW devices with distance between the transducer and domain structures is equal 10λ. The value and type of the interaction depend on the electroinduced

barsukou@mail.ru

domain structure features. Note that in our case we studied resonance conditions of the SH wave interaction.

We obtained theoretical and experimental results for two different types of the SAW device with different type interaction. It was studied electrode structures with pitch 0.5 and 0.25. This structure has different distance between domain clusters, which allows to get different interaction SH wave with domain structures. Described SAW devices have four crossed electrodes on two sides. That allows to control 16 different domain configurations for each SAW device. Note that for specific practical applications, some combinations may have the same value of interaction.

The photos of the two types developed of the 10MHz SAW device with calculated parameters are shown in **Fig. 4**.

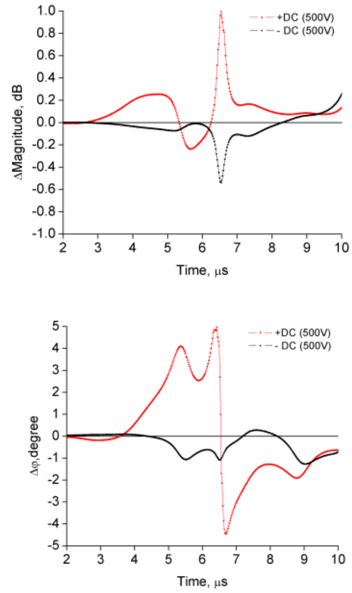


(1) (2)

Fig. 4 Photo of the developed two type SAW device (1–pitch equal 0.25; 2–pitch equal 0.5)

The described SAW devises has 5 pairs of the electrode structures with two different pitches between electrodes. The other parameters and dimensions of the electrodes was equal IDT. The IDT consist of SAW transducers and reflector, that allows transmit SH-SAW in one direction to the crosselectrodes structure. The interaction between SH-SAW and domain structure was observed using the reflection method. The electrical parameters and reflectance was measured by Network analyzer Agilent Technologies E5070B (300 kHz – 3 GHz).

The experimental results of the measuring parameters of reflectance of the SH-SAW on a time are shown in **Fig.5.** The parameters of the reflectance were measured for SAW devices with domain structure with pitch between electrodes is equal 0.5. The DC value is 500V. Reflected signal was measured for two different polarities of DC: the red one curve describes DC=+500V, the black one - DC=-500V. The absolute deviation of the reflected signal was measured as a difference between reflected signal when DC=0V and DC=±500V. From the figures it is easy to see that magnitude and phase of the reflected signal is changed on the DC polarity. The time from 6μs to 7μs is corresponds to reflect the area of the domain structures.



(1)

(2)

Fig. 5 The experimental results of measuring parameters of the reflected signal (1 – the absolute deviation of the magnitude reflected signal on a time, 2 – the absolute deviation of the phase reflected signal on a time)

3. Conclusion

In this paper possibilities of creating phononic crystals with periodic domain structures electroinduced by crossing electrodes was proposed. It was described of the main features of domain structures and capabilities of managing parameters of the domain structure by external electric field. We proposed the SAW device with the ability to manage of the parameter interaction by electroinduced domain structure. This gives great opportunities to develop managed SAW devices and phononic crystals.

References

1. Jia-Hong Sun, Tsung-Tsong Wu: Phys. Review, vol. 4 (2006).
2. Badreddine, M., Assouar, M., Oudich, M.: J. Appl. Phys. Letter, vol. 99 (2011).
3. Golenishtchev-Kutuzov, A.V., Kalimullin, R.I.: Progress in Physical Science, vol. 170, № 7 (2000). pp. 697-712. (In Russian)
4. Khakhomov, S.A., Barsukov, S.D., Semchenko, I.V.: Journal of Automation, Mobile Robotics and Intelligent Systems, vol.3, No.4 (2009).
5. Barsukov, S.D., Khakhomov, S.A., Semchenko, I.V.: Abstract of 14th International Conference on Global Research and Education (2015). p. 116.