# Surface Acoustic Wave Scattering Matrix Evaluation Using COMSOL MultiphysicsÈ: Application to Surface Acoustic Wave Transmission Through 2D Surface Phononic Crystal

S. Yankin[1,2], A. Talbi[1], V. Preobrazhensky[1,3], P. Pernod[1], O. Bou Matar[1], A. Pavlova[1]

1. LICS/LEMAC, IEMN UMR CNRS 8520, EC Lille, B.P. 48, 59651, Villeneuve d'Ascq, France
2. Saratov State University, 83 Astrakhanskaya Street, 410012, Saratov, Russia
3. Wave Research Center, Russian Academy of Sciences, 38 Vavilova Sstreet,119991, Moscow, Russia

**Abstract:** This contribution is dedicated to numerical analysis of SAW propagation though 2D surface phononic crystal (PnC) and FE method is nowadays one of most common tool for such calculation. The device under investigation consists of two dispersive IDT and lattice of ferromagnetic pillars realized on 128˚ YX LiNbO3. In addition to dispersion curves calculations this work describes the results of original 3D FE modeling of the electrical properties of such SAW device via evaluation of SAW propagation through observed structure that give quantitative transmission characteristics. We demonstrated that this model permits to evaluate electrical response of PnC based devices. Obtained results show good agreement between band diagram and transmission computations.This model can be used for advance designing of PhC.

## Model:

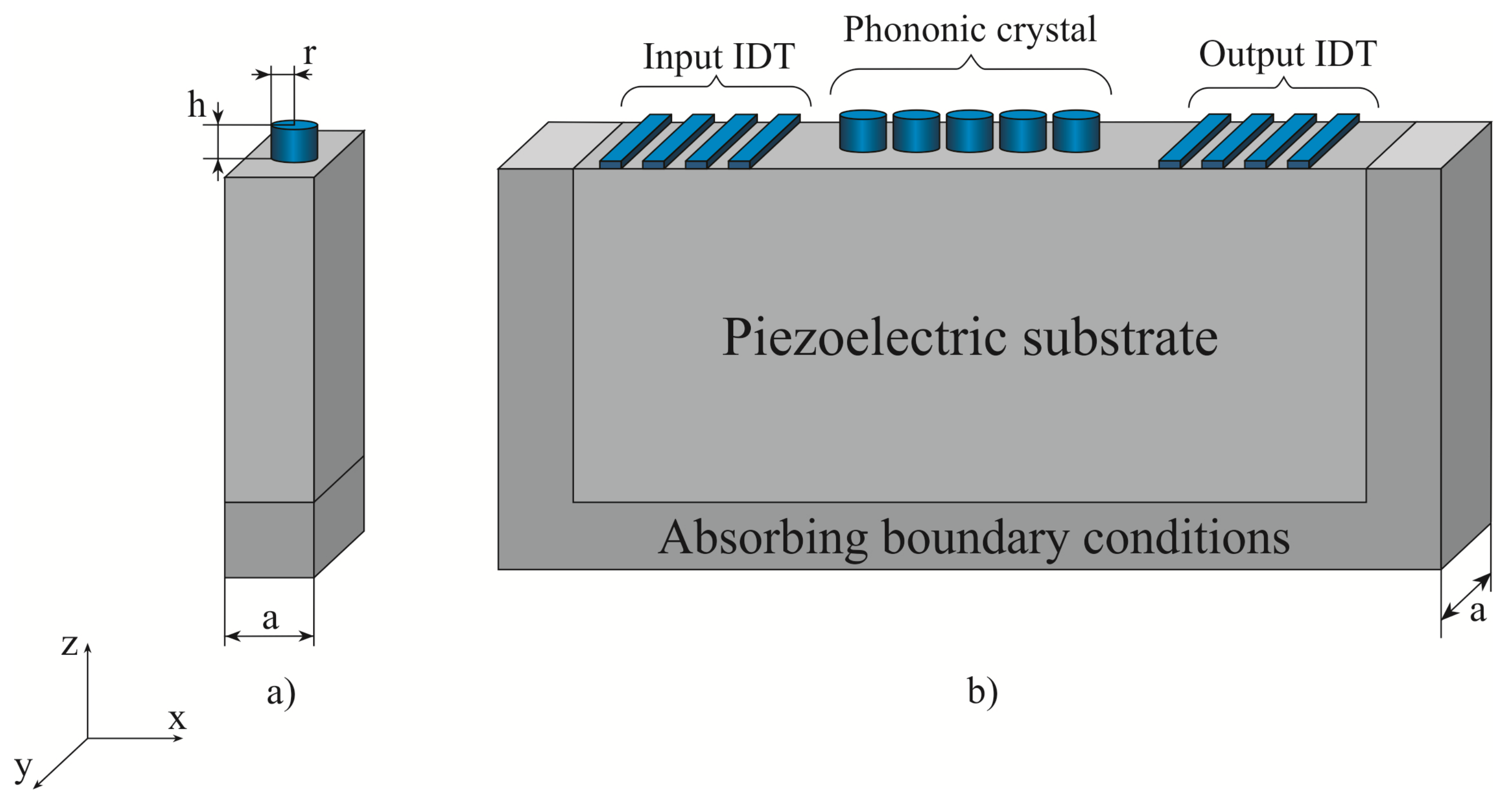


**Figure 1. a) Unit cell of the square periodic pillar based structure; b) The model of dispersive delay line with phononic crystal for transmission calculation.**

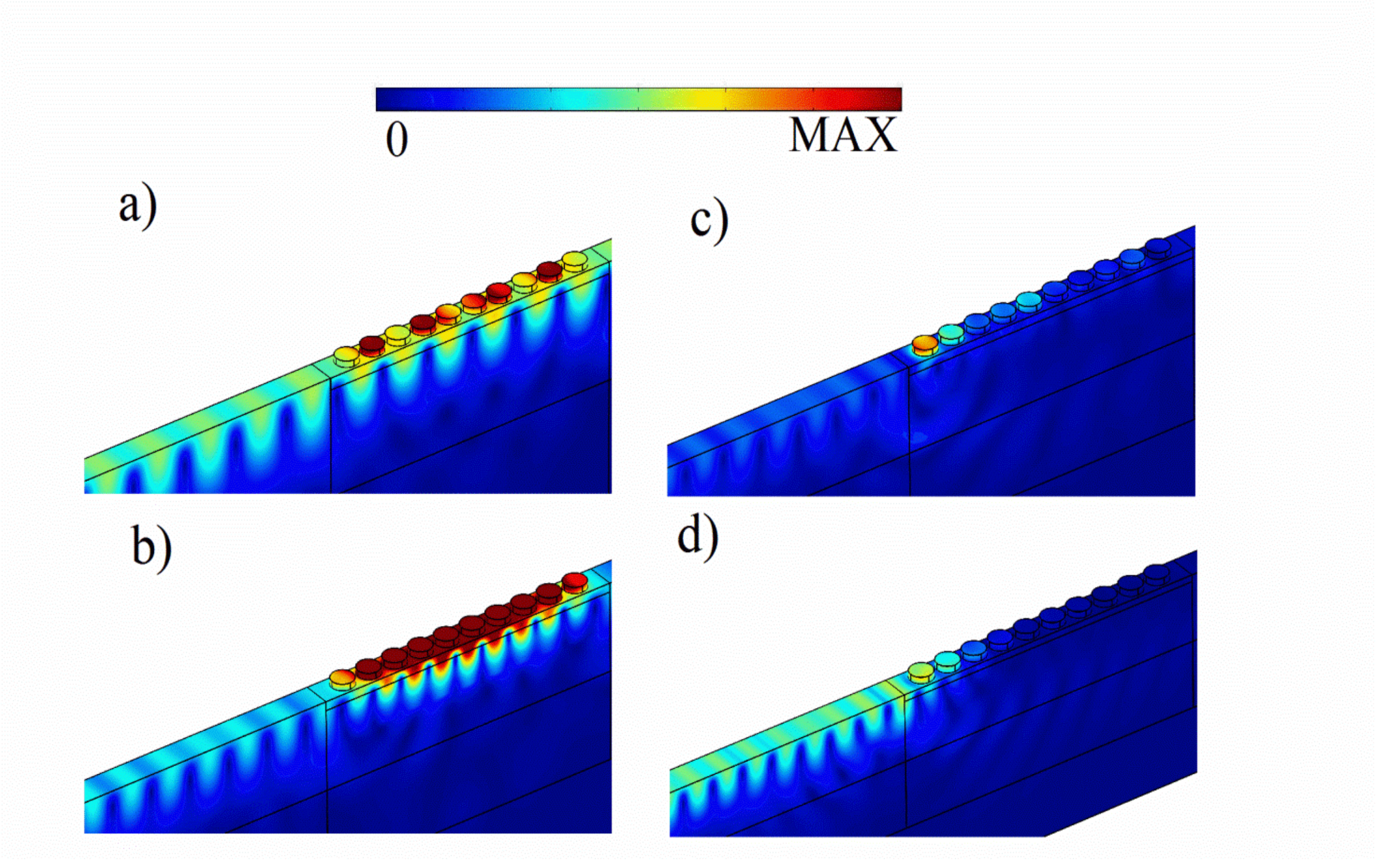
$$\text{Transmission spectra through PnC}: S_{21} = |S_{21}| \cdot e^{\,j\cdot\varphi}$$

$$\text{Reference}\quad \text{w/o}\ \ \text{PnC}: S_{21r} = |S_{21r}| \cdot e^{\,j\cdot\varphi_r}$$

$$\text{Relative transmission}: S_{21rel} = |S_{21r}| - |S_{21}|$$

$$\text{Accumulated phase difference}: APD = \varphi - \varphi_r$$

**Figure 5. Snapshots of total displacement for the four typical cases: a) f=78MHz-transmission; b)90MHz – resonance; c)92MHz – local gap; d)155MHz – Bragg gap. Color range is the same for all.**



## Results:

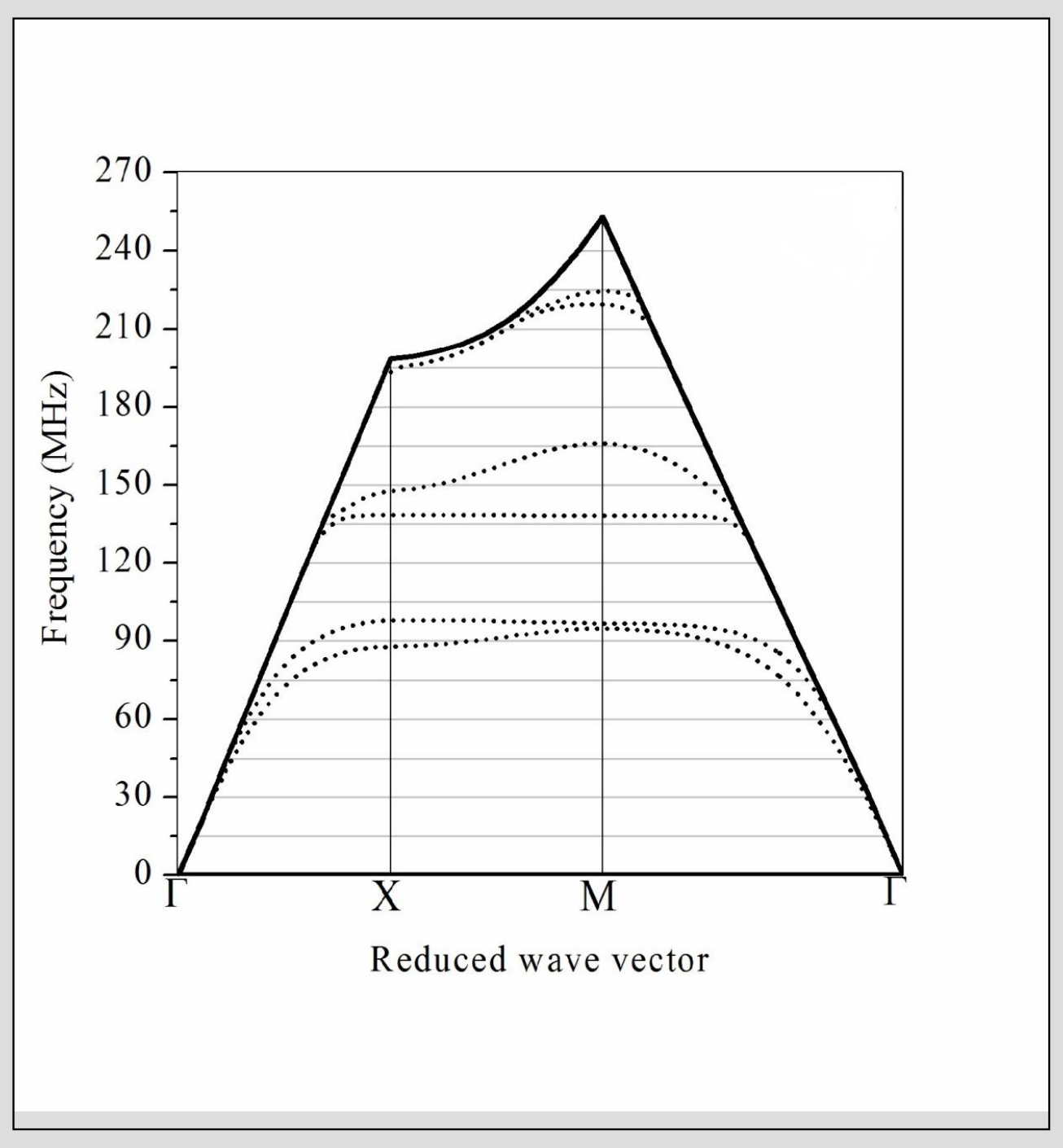


**Figure 2. Band diagram for a=10µm, r=4µm and h=4µm**

Pillar based nickel structure with period a=10Õm, radius r=4Õm and height h=4Õm.
SAW band gaps: after 88MHz and 140MHz

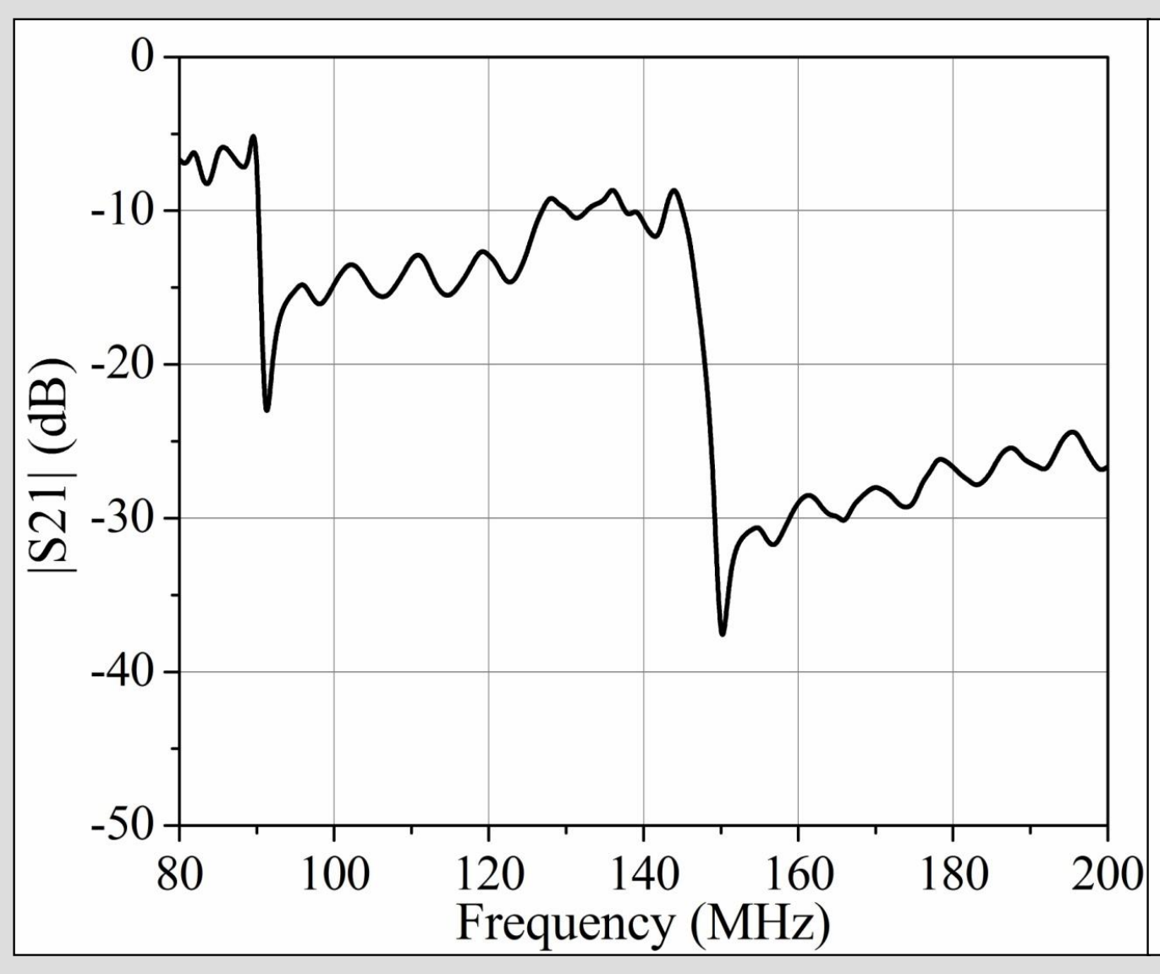


**Fig.3. Relative transmission through square array of N=10 Ni pillars with a=10µm, r=4µm and h=4 µm**

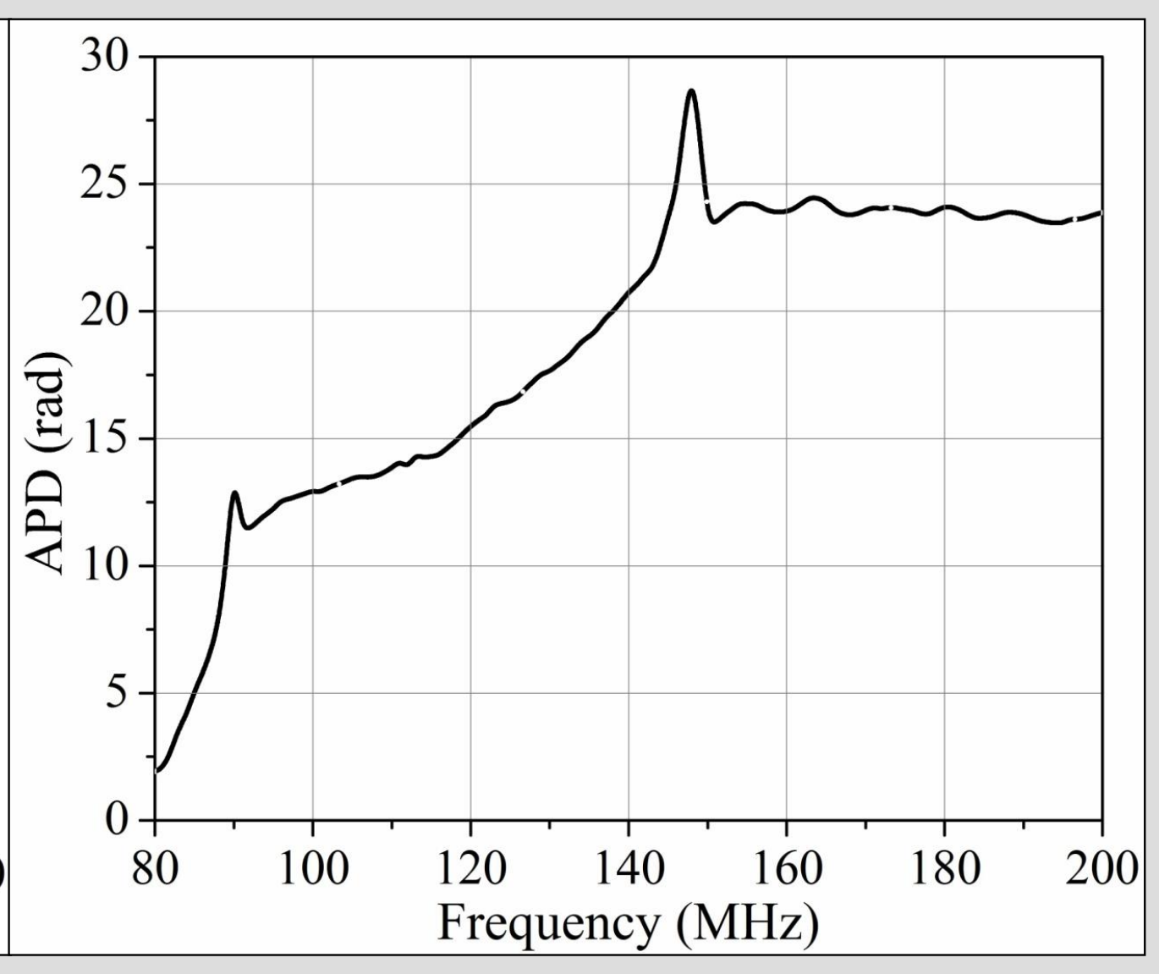


**Fig.4. APD through square array of N=10 Ni pillars with a=10µm, r=4µm and h=4 µm**

## Conclusions:

ÅThis FE model in COMSOL MultiphysicsÈ permits to evaluate electrical response of PnC based electro-acoustic devices.
ÅObtained results show a good agreement between band diagram and transmission computations.
ÅThe experimental validation on such structure was also performed (not shown in this contribution) and its results are close to calculations.
ÅThe model can be used for further advance designing of phononic structures.

## Acknowledgments:

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## Related publications:

1.A. Talbi, Y. Du, S. Yankin et al. Experimental investigation of surface acoustic wave interaction with 2D array PnC with various lattice symmetries. Proceedings of Joint UFFC, EFTF and PFM Symposium, 21ï 25 June, 2013, Prague, Czech Republic
2.A.Y.Pavlova, S.S.Yankin, Y.V,Hivintsev, et al. Feasibility investigation of phononic crystal development for surface acoustic waves of high frequencies using scanning probe microscopy. Proceedings of VIII Russian conference of young scientists, 3-5 september, 2013, Saratov, Russia.

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