Swiss-Lithuanian Ferroelectrics: From controlled internal fields to energy harvesting / medical diagnostics / microelectronic applications / SLIFE

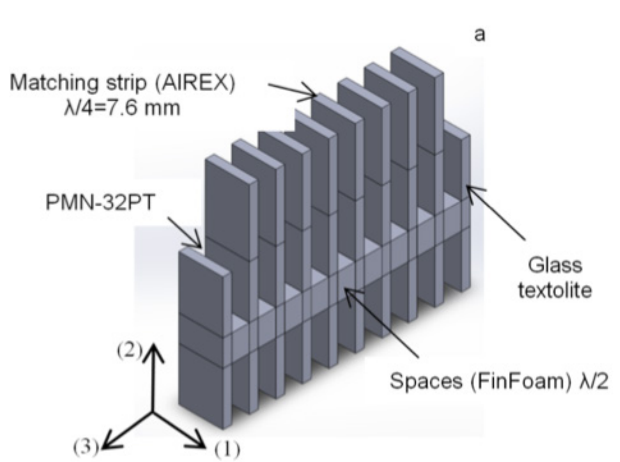
the objective of the project

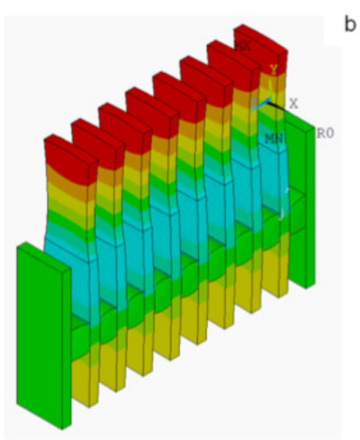
Ferroelectricity is the property of some polar materials to undergo polarization reorientation when subjected to external electric field. Ferroelectrics are ubiquitous materials in modern technology with substantial interest in further extending their functionality in components of medical-diagnostic equipment (using the piezoelectric effect), microelectronics and communications (ferroelectric switching and dielectric properties), and energy harvesting (piezo-, pyroelectric, and photovoltaic effects).

Real ferroelectric materials have internal electric fields due to finite size, charged defects, and inhomogeneities in the material. This is even more pronounced in thin films. These inevitable fields are often considered a hurdle, typically causing degradation of properties. Several recent studies showed strongly enhanced properties (piezoelectric, dielectric, photovoltaic) originating from internal fields, hinting that internal fields could be beneficial if properly addressed.

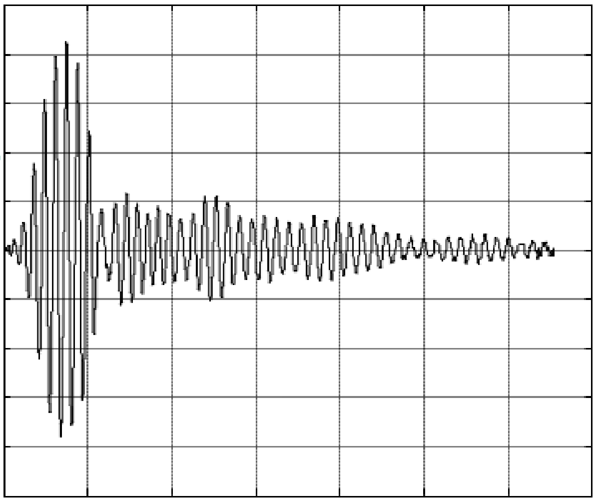
ultrasound institute

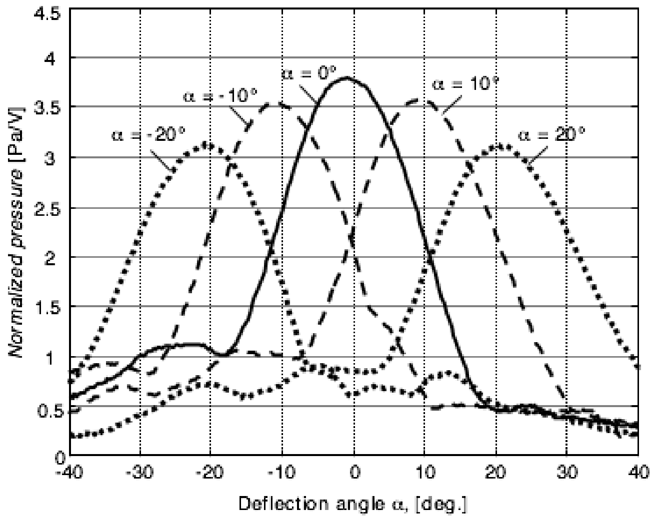
Performed ultrasonic characterisation of the BTO, PMN-PT crystals and developed the special transducers, which possesses in a transmission mode 10 times better efficiency than a conventional PZT composite ultrasonic transducer. The high piezoelectric properties of the lead magnesium niobate – lead titanate (PMN-32%PT crystals) allow development of a new type of air-coupled ultrasonic transducers. The high electromechanical factor of the transverse extension mode helps to achieve a good performance of air-coupled transducers. Performance of the ultrasonic array was improved by applying matching strips made of materials with low acoustic impedance. Theoretical and experimental investigations of the acoustic fields radiated by the 8 element ultrasonic array demonstrated not only a good performance of the array in a pulse mode, but very good possibilities to steer the ultrasonic beam in space electronically also.





Air – coupled ultrasonic array: (a) design; (b) spatial distributions of displacements at the resonant frequency





Acoustic pressure pulses in air at the distance 1 mm from the transducer measured by the Bruel&Kjaer wideband 1/8" microphone at PMN – 32 % PT single crystal transducer

Measured normalized acoustic pressure distributions across the ultrasonic beam at the distance 80 mm from the array at different beam deflections angles

project partners

Vilnius University (Lithuania), Ecole Polytechnique Federale de Lausanne EPFL (Switzerland), Institute of Ultrasound of Kaunas University of Technology (Lithuania).

related publications

1. **R. Kažys, R. Šliteris, J. Šeštokė.** Simultaneous monitoring of the electromechanical coupling coefficients and domain structural changes of the PMN–32%PT crystals during poling process. Ferroelectrics 2015, vol. 480, issue 1, P. 24-31.

2. **R. Kažys, R. Šliteris, J. Šeštokė, A. Vladišauskas.** Air – coupled Ultrasonic Transducers based on an Application of the PMN-32%PT Single Crystals. Publisher: Ferroelectrics. Abingdon: Taylor&Francis. ISSN 0015-0193. 2015, vol. 480, issue 1, p. 85-91. DOI: 10.1080/00150193.2015.1012458.

3. **R. Kažys, R. Šliteris, J. Šeštokė.** Application of PMN-32PT piezoelectric crystals for novel air-coupled ultrasonic transducers. Publisher: Physics procedia: proceedings of the 2015 ICU international congress on ultrasonics, Metz, France. ISSN 1875-3892. 2015, vol. 70, p. 896-900. DOI: 10.1016/j.phpro.2015.08.185.

4. **R. Kažys, R. Šliteris, J. Šeštokė.** Development of air-coupled low frequency ultrasonic transducers and arrays with PMN-32%PT piezoelectric crystals. Publisher: IEEE International Ultrasonics Symposium (IUS), 21-24 October 2015, Taipei, Taiwan. ISBN 9781479981823. p. [1-4]. DOI:10.1109/ULTSYM.2015.0214.