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Mechanism Study of Phase-transformed Single Crystal-driven Transducers

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Abstract : The Tonpilz transducers consisting of relaxor ferroelectric single crystal possess numerous advantages, such as small size, broad bandwidth, and high voltage response, which makes them widely used in the underwater acoustics field. The single crystal vibrators are inevitably subjected to uniaxial stress owing to prestress or hydrostatic pressure. Herein, the compressive stress will result in the changes of the elastic, dielectric, and piezoelectric properties, and deteriorate transducer's performance. However, few studies have been conducted to characterize the performance of single crystal under uniaxial stress. Besides, it indicates that the uniaxial compressive stress with an appropriate amplitude can induce phase transition of singe crystal from the rhombohedral phase to the orthorhombic phase (R-O) in [011]c oriented PIN-PMN-PT single crystals, leading to a nearly twofold increase in the piezoelectric strain constant d32. Therefore, it triggers the idea that the transducers can be driven by the phase-transformed single crystal under appropriate stress, which will significantly enhance its performance. Therefore, this study aims to investigate the novel mechanism of phase-transformed single crystal-driven transducers. A home-built setup was developed to measure the material's performance under uniaxial stress. Meanwhile, the performance of the Tonpliz transducer driven by a d32 vibrators was measured under uniaxial stress ranging from 0 to 5 MPa. An impedance analyzer was used to monitor the impedance and capacitance curves. For the piezoelectric coefficient measurement, the vibration displacement cl of the acoustic radiation surface of the transducer was measured by a laser vibrometer. The results illustrate that the amplitude of the conductivity increases around 10% under 2.5-3 MPa of uniaxial stress, which indicates the occurrence of a single crystal phase transition. Finally, a new transducer driven by phase-transformed single crystal vibrators is proposed, which provides innovative ideas for the design of hydroacoustic transducer with small volume and high sound source level.

Keywords : relaxation-mode ferroelectric single crystal, longitudinal vibration transducer, uniaxial stress, phase transition
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