Temperature and Stress-dependent Single Crystal Properties for High Power SONAR Applications

Raphaël Lardat[1*], Thomas Leissing[1], and Thomas Pastureaud[1]
[1]Thales Underwater Systems, Sophia Antipolis 06903, France
* Raphaël Lardat: raphael.lardat@fr.thalesgroup.com

Deep-water SONAR projectors are subjected to high hydrostatic pressure and high input power. Hence, it is important to characterize the properties of the piezoelectric material with respect to stress and temperature, so that designers are able to predict electroacoustic performances of the transducer under different operating conditions. In this paper, we develop and demonstrate a methodology to identify the properties of a <001> poled mode 33 PIN-PMN-PT single crystal. A dumbbell transducer associated to a finite element model is used. The design of the dumbbell transducer is first detailed. Dimensions and passive materials are chosen so as to minimize the effect of inactive components on the effective coupling coefficient of the device. The dumbbell transducer allows measuring the complex admittance around resonance, capacitance and electrical dissipation factor at low frequencies, for different stress and temperature conditions. In a second section, the inverse method that allows identification of the single crystal properties is described. It uses a finite-element modeling of the dumbbell transducer and a multi-objective, multi-variable optimization algorithm. The chosen optimization algorithm is a genetic algorithm; it is shown to allow fast and precise identification of the single crystal properties. A Tonpilz projector using this same piezoelectric material was designed, prototyped, and its electroacoustic performances were measured in a pressure- and temperature-controlled water tank. We compare in the next section the electroacoustic performances of the measured Tonpilz projector with the ones calculated with a finite element model using the single crystal properties identified with the help of the dumbbell transducer. Two cases are considered: (i) low input power/duty cycle and (ii) high input power/duty cycle. In the second case the time-dependent thermal behavior of the piezoelectric material is accounted for. In both cases, simulation results are shown to be in good agreement with measured values under different operating conditions. The dumbbell transducer and the proposed identification method can hence be used to obtain an a priori estimate of the electroacoustic performances of the projector under different operating conditions, at lower costs and faster implementation than a Tonpilz prototype.