Electroelastic modulus of 1-3 piezocomposite using Lamb waves propagation

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Background, Motivation and Objective

Due to their enhanced electromechanical properties with respect to conventional piezoelectric ceramics, 1-3 piezocomposite (1-3PC) materials are predominant in high performance ultrasonic array. Their complete effective electroelastic modulus (EEM) has a significant importance for numerical simulations to study undesired effects that almost depend on the transverse characteristics of the 1-3PC, such as mechanical cross-talks caused by Lamb waves. To determine the effective elastic, piezoelectric and dielectric tensors, theoretical homogenization models are available in literature. However, complete and accurate databases of each phase are required. In this work, a new method, based on direct measurements of propagative Lamb waves, is proposed to determine a complete 1-3PC EEM under operating conditions.

Statement of Contribution/Methods

First, in order to determine the 1-3PC EEM, experimental dispersion curves of the low-order Lamb waves are necessary. Then, experimental data are fitted using a recursive method that combines the theoretical curves obtained with Finite Element method and a fitting process based on a genetic algorithm. The cost function of this method intends to minimize the distance in the (w,k)-space between the three first symmetric and antisymmetric theoretical Lamb modes and those which were measured. A 1-3PC made of Pz27/Epoxy resin (70% volume fraction) with a pitch of 610µm was used to perform the measurements. Mass electrode covers the whole bottom surface while a thin rectangular electrode (15x1.11 mm²) was deposited on the top surface. Fig1.a) shows the top electrode aligned with the pillars of the 1-3PC to favor an x-propagation direction. Several electrode patterns were tested to change the propagation direction and the modes excited. Finally, a scanning laser vibrometer was used to measure normal displacements at the sample surface.

Results/Discussion

Complete EEM was obtained for the sample. On Fig1.b), the solution fits well the case of the x-propagation direction for the modes highlighted by the specific electric conditions shown in Fig1.a). These first results enable to demonstrate the efficiency and the robustness of this method for determining EEM experimentally. Other propagation directions were used to increase the solution's accuracy.

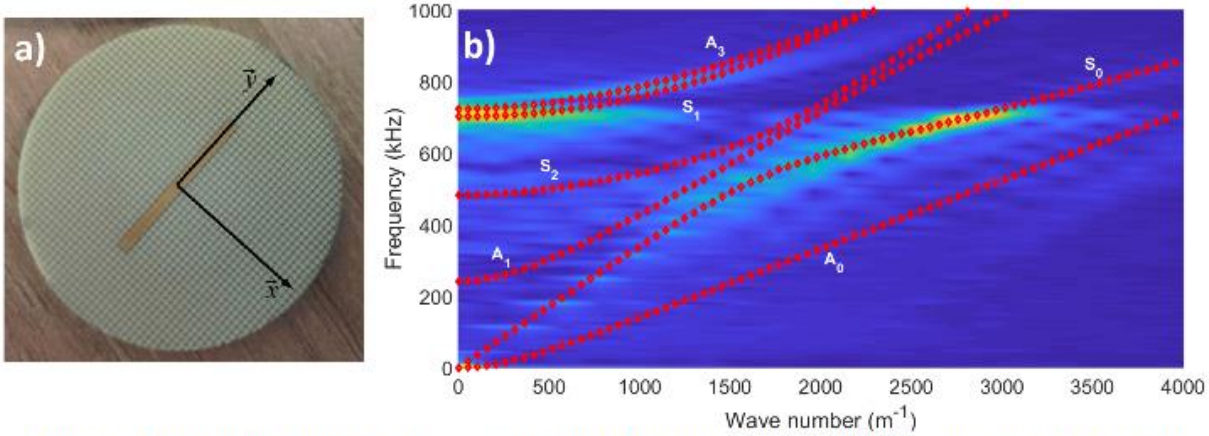

Figure1: ***a)*** Photography of the 1-3 piezocomposite used for measurements and ***b)*** dispersion curves of the first Lamb waves measured (color map) and calculated with the FEM solution (red dot line).