Comprehensive Analysis for Calculating Extensive Elastic Compliance and Mechanical Loss from a Non-Electrode Sample

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Piezoelectric parameters and their corresponding losses are categorized into two groups of intensive and extensive ones. Extensive parameters, are the material properties measured under the constant condition that is dependent on the volume, such as dielectric displacement, D, and strain, x. On the other hand, intensive parameters are under the constant condition which is the ratio of the two extensive ones and therefore independent on the volume, such as electric field, E, and stress, X.

In previous methods, only the intensive parameters could be measured directly in lead-zirconate-titanate (PZT) k_{31} mode rectangular plate ceramics. Then the extensive parameters could be calculated indirectly from the coupling factor and the "K" matrix. For example, s_{11}^D was calculated indirectly from the measurable s_{11}^E in the equation of $s_{11}^D = s_{11}^E(1 - k_{31}^2)$. However, these methods did not have very accurate results, due to error propagation in indirect calculations, especially for extensive loss parameters.

We have introduced and verified an advanced method based on partial electrode samples, including full-electrode and non-electrode samples, which have the benefits of measuring both the intensive and extensive parameters directly and more precisely in k_{31} mode PZT plates. The full-electrode sample is a typical rectangular plate, and the measured parameters correspond to intensive condition, i.e., constant electric field. The non-electrode sample has electrodes only for a small portion of the surface area and at the middle of the sample, i.e. a=%10. Therefore, by neglecting the middle electrode part, it mostly contributes to the constant dielectric displacement (D) condition. The method uses a non-destructive approach, by applying electric field to the middle electrode, as a mechanical-excitation and actuating the whole sample. Furthermore, the impedance spectrum of the sample could be measured from the electrode part. We have verified that the extensive elastic compliance and the corresponding mechanical loss could be measured from the anti-resonance frequency and its mechanical quality factor of non-electrode sample. This result is achieved by neglecting the 10% difference of the center actuator part. The schematic views of the full-electrode and non-electrode samples, and their measured impedance spectrums are demonstrated in Fig. 1 and 2.

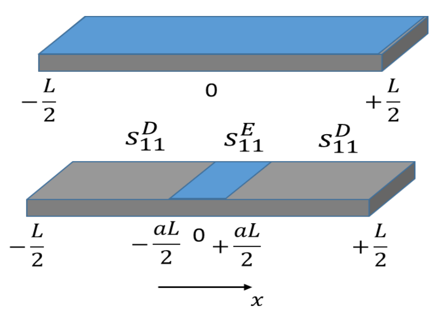

Figure 1. Schematic views of full electrode and non-electrode samples.

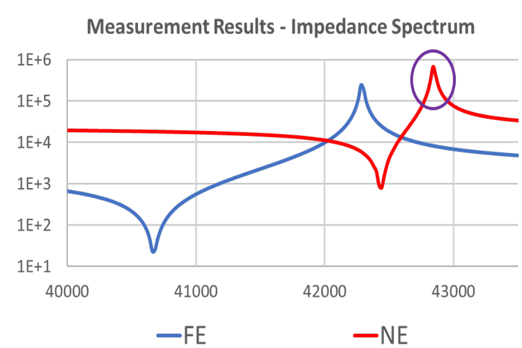

Figure 2. Impedance spectrum of full-electrode (FE), and non-electrode (NE) samples.

In this poster, we are going to present the analytical solution for calculating the exact amount of the extensive parameters in a non-electrode sample, with considering the actuator part contribution in final solution. We are going to solve the problem parametrically, with respect to "a", the portion of the middle electrode. The exact amount of the extensive parameters is the limit of this solution when "a" is approaching to zero.

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