Modelling and Characterization of Piezoelectric Structures: From Bulk Material to Thin Film

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Abstract

With the development of micro and nanotechnologies, the research in the field of piezoelectric materials and new micro-electromechanical devices are getting much more inter-related. In this context, integrated structures based on the piezoelectric thin films are widely investigated and their characterizations become a crucial issue in development of new applications [1,2].

In the case of bulk material, resonance or out of resonance methods can be used to assess the material properties. The conventional static characterization methods use the direct piezoelectric effect. A static stress on the material generates a charge quantity on both faces of the material which is measured and the piezoelectric coefficient is determined. When applied to thin films, the method requires nano-positioning system to apply a uniform normal external stress on the sample. If not, the consequence can be a bending of the structure leading to an incorrect measurement and a possible fracture of the sample.

Inverse piezoelectric effect can also be used. In this case one has to measure the mechanical displacement for a given voltage. Today, laser based interferometer has sensitivity such that less than 1 nm measurements are achievable. Thin film characterizations are reported using this technique [3,4]. Previous works have addressed the development of a laser-based technique to characterize the mechanical response of a thin film laid down a substrate in a quasistatic regime [5,6].

To complete this experimental approach, a numerical study based on the finite element method is here carried out thanks to COMSOL Multiphysics® FEA software with the MEMS Module. We specifically model three piezoelectric samples in 3D: a PZ27 ceramic rod (with dimensions 2x2x15 mm), a PZ27 ceramic cylinder (20mm diameter, 2 mm thick) and a 240 nm PbZr0.52Ti0.48O3 film covered by a Pt electrode laid on a Si (100 oriented)/SiO2/TiO2/Pt structure. For each sample, a time dependant analysis is performed. We then obtain information on the effective d33 of the active electro-material

that are compared to experimental values.

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Reference

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