

Modeling and Simulation of Piezoelectric Materials for Comparison to Experimental Data

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Abstract

Introduction

Finite element analysis (FEA) is a modern tool for exploration of new horizons in science, technology and engineering. Different computer software such as ANSYS, ABACUS, PZFLEX and COMSOL Multiphysics® based on FEA is used for modeling and simulation of acoustic phenomena for design of new and optimization and improvement of existing acoustic engineering systems. This work presents application of FEA to modeling and simulation of different types of piezoelectric materials, including some new and promising such as piezo crystals PMN-PT and PIN-PMN-PT [1]. The work demonstrates "evolution" of modeling from a single piezoelectric element to a device design.

Use of COMSOL Multiphysics

COMSOL was applied for 2D and 3D modeling of materials and simulated many performance parameters [2], such as frequency response and electrical impedance. Figures 1 demonstrates the primary approach to modeling and simulation:

Results

Figure 2 and 3 shows frequency responses of two types of materials PIN-PMN-PT and PZT-8. Four bars of different heights are presented for each material.

Conclusions

This work gives a comparison between experimental and modeling data for different types of piezoelectric materials with analysis of their effectiveness and efficiency. Graphs demonstrate significant elevations of mechanical displacements for PIN-PMN-PT piezoelectric crystals.

Reference

1. Raffi Sahul, et al. , Complete set of elastic, dielectric, and piezoelectric constants of [011] C poled rhombohedral Pb (In_{0.5}Nb_{0.5})O₃-Pb(Mg_{1/3}Nb_{2/3})O₃-PbTiO₃:Mn single crystals, Journal of Applied Physics , Volume:113 , Issue: 7 , Feb 2013 , pp 074106 - 074106-5.;
2. E.Nesvijski, Nondestructive Evaluation of Composites Using Model Based Design, COMSOL Conference Proceedings, Boston, 2012, pp 1-5.

Figures used in the abstract

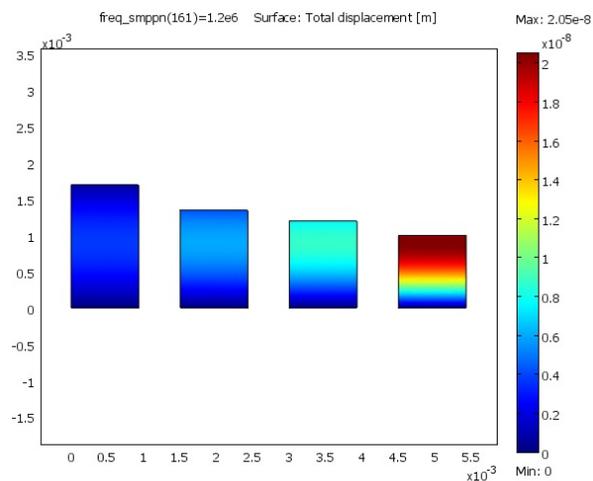


Figure 1: COMSOL model of piezoelectric elements used for frequency response analysis.

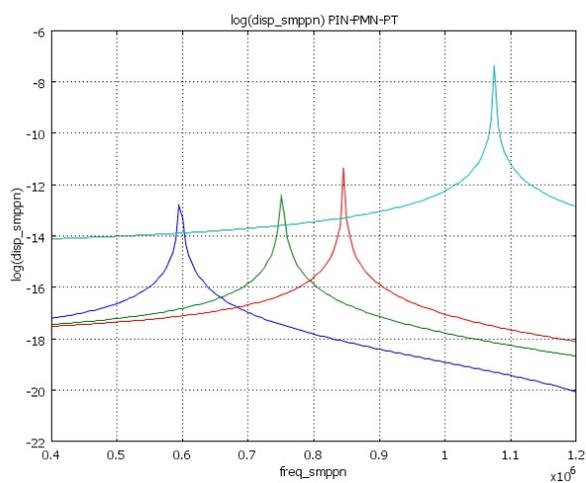


Figure 2: Mechanical resonance (displacement in log scale) of PIN-PMN-PT.

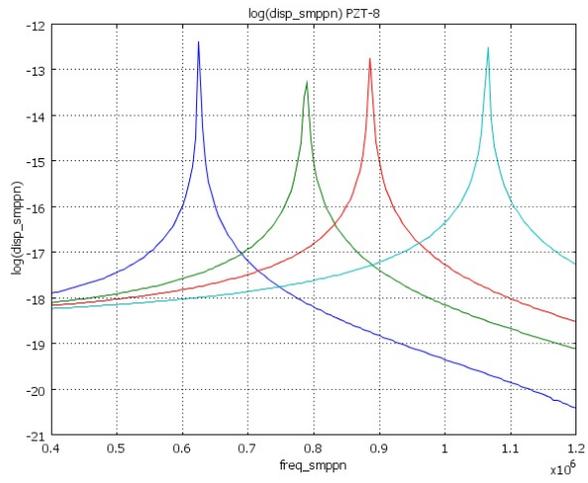


Figure 3: Mechanical resonance (displacement in log scale) of PZT-8.