Modeling and Simulation of Piezoelectric Materials for Comparison to Experimental Data

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Introduction: This work presents application of FEA to modeling and simulation of device performance using of different types of piezoelectric materials, including some new and promising such as piezoelectric single crystals PMN-PT and PIN-PMN-PT

Property	PMN-32%PT
Free K_3	8000
Clamped K_3	3000
Loss	<0.01
Tc (?C)	166
Pr (pC/cm^2)	26
Ec (kV/cm)	3.2
d_{33} (pC/N)	1800-2000
d_{31} (pC/N)	-1000
k_{33}	0.91
k_{31}	-0.51
kp	N/A
kt	0.62
N_{33} (Hz-m)	599
N_{31} (Hz-m)	721
Np (Hz-m)	N/A
Nt (Hz-m)	2002
s_{33} (10^{-11} m^2/N)	8.65
s_{11} (10^{-11} m^2/N)	5.97
s_{12} (10^{-11} m^2/N)	-0.77
s_{13} (10^{-11} m^2/N	-4.53
c_{33} (GPa)	129
c_{11} (GPa)	114
c_{12} (GPa)	100
c_{13} (GPa)	112

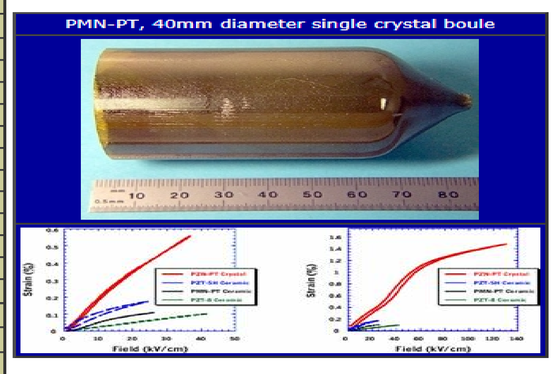

Figure 1. Piezoelectric single crystals

Computational Methods: piezoelectric component based on matrix coefficients of PMN-PT and PIN-PMN-PT, surrounded structural elements, symmetric side, roller bottom, 1-100 volts, ground bottom solve the equation for frequency responses:

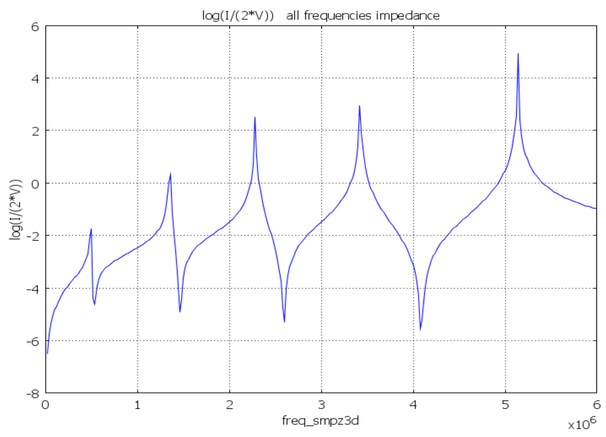

Figure 2. Impedance vs. frequency responses for multi-element transducer

High resolution, broadband transducers, compact and high power and MEMS applications:

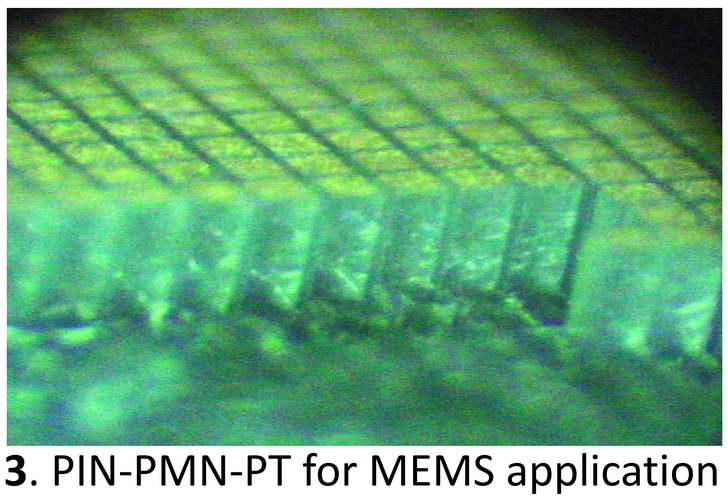

Figure 3. PIN-PMN-PT for MEMS application

Major fields of applications:

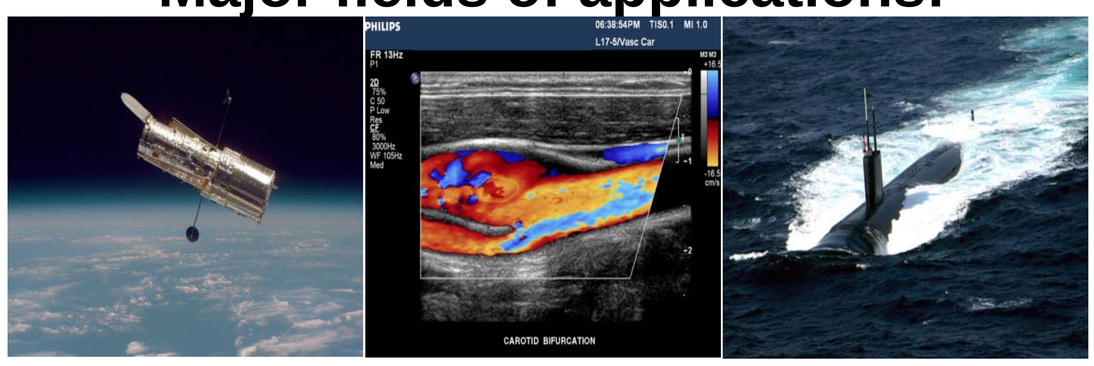

Figure 4. NASA, NAVY and medical diagnostics

Comparison of displacements of the PIN-PMN-PT and PZT-5H (ratio 8.5):

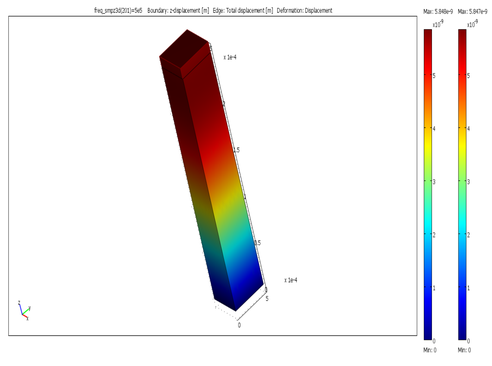

Figure 5 Single element

Figure 6. Composite transducers and MEMS

Conclusion: Comparison between experimental and modeling data for different types of piezoelectric materials with analysis of their effectiveness and efficiency and demonstrate significant elevations of mechanical displacements for PIN-PMN-PT piezoelectric crystals.

References:

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2. Ed Nesvijski, Nondestructive Evaluation of Composites Using Model Based Design, COMSOL Conference Proceedings, Boston, 2012, pp 1- 5.

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