Modeling, Simulation and Optimization of Piezoelectric Bimorph Transducer For Broadband Vibration Energy Harvesting

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**Introduction:** The objective of this research is to design a millimeter scale broadband energy harvester device through the use of a polycrystalline piezoelectric single bimorph beam. In this research, we use COMSOL finite element analysis software to design, simulate and analyze the voltage and power characteristics under mechanical vibrations of a piezoelectric cantilever beam.

![Fig. 1. Polarization vector of bimorph cantilever bending downward simulation (3-1 mode)](image1)

**Results:** when the resistance reached $5 \times 10^5 \Omega$, the power reached maximum value 0.4mW. A fixed length of the beam was set at 60mm as it is shown in Figure 6.

![Fig. 3. PZT-PZN Samples](image2)

**Modeling idea:** Our main contributions in this research are using newly developed PZT-PZN material and converting its piezoelectric material properties to the “language” which COMSOL can understand in multi-physics simulation. Optimization idea is expressed in a flow chart shown in Fig. 2.

![Fig. 4. Bimorph connected in series](image3)

**Table 1. Output Power comparison between samples**

<table>
<thead>
<tr>
<th>Name</th>
<th>Power(mW)</th>
<th>Optimal resistance(MΩ)</th>
<th>Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>0.404</td>
<td>4.9</td>
<td>44.5</td>
</tr>
<tr>
<td>Sample 2</td>
<td>0.394</td>
<td>5.4</td>
<td>46.2</td>
</tr>
<tr>
<td>PZT5A</td>
<td>0.206</td>
<td>3.5</td>
<td>26.9</td>
</tr>
<tr>
<td>PZT5H</td>
<td>0.144</td>
<td>1.8</td>
<td>16.1</td>
</tr>
</tbody>
</table>

![Fig. 5. Power vs. geometry](image4)

**Conclusions:** It is seen that power and voltage results in TABLE 1, are results of simulations showing a promising method to design energy harvesters to provide power for small-scale sensors of piezoelectric materials. Voltage and power of piezoelectric cantilever beams using composition of two samples is better than traditional PZT5A and PZT5H.

![Fig. 6. Voltage vs. geometry](image5)

**References:**