Strain Enhancement in Sol-gel PZT Energy Harvesting Devices

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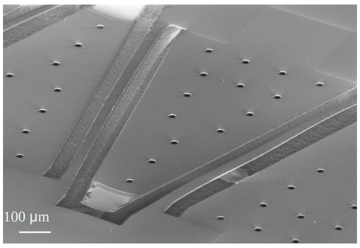
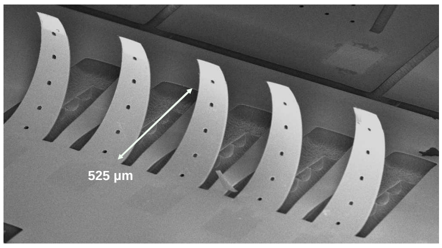
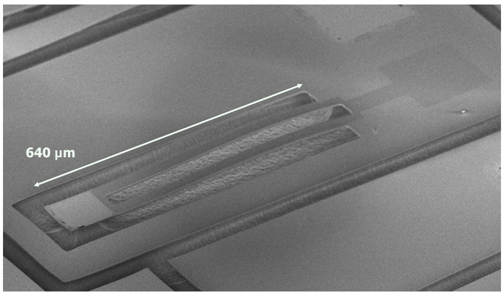
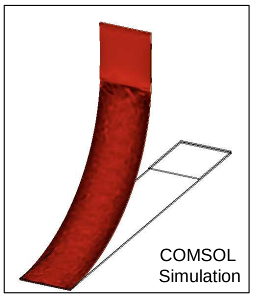


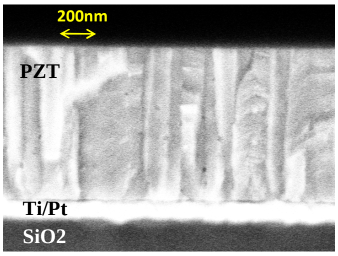


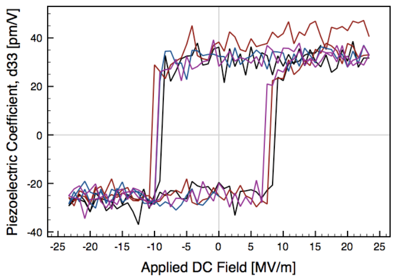




Vision

Ubiquitous wireless sensor networks provide an effective means for monitoring systemic environments with minimal invasiveness. Active monitoring of closed systems by such networks allows for directed, real-time automation, thereby improving system efficiency. Realization of these networks for wide-spread market use requires the sensor nodes be low-cost and require minimal maintenance. Local, renewable power supplies for each node, which convert ambient mechanical vibrations into electricity, are a critical technology for these networks. Our microscale energy scavenging devices are rapidly approaching sufficient generated power outputs through piezoelectric strain-to-charge conversion and clever design. These scavengers can power future nodes.





Research Questions

- ❑Can sol-gel PZT films achieve desirable piezoelectric properties and morphology?
- ❑Can released cantilevers be made from sol-gel PZT?
- ❑Will power output increase by changing geometry?
- ❑What is the optimized design for a microscale vibrational energy scavenger device?

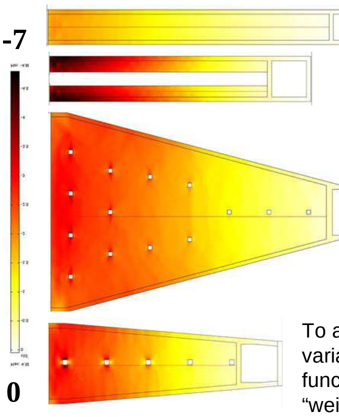
Methods

- ❑On Si substrates, deposit structural and bottom electrode layers with appropriately tailored stress.
- ❑Grow sol-gel PZT film by spin-coating.
- ❑Characterize PZT with XRD, polarization, & d_{33} measurements.
- ❑Use 4-mask microfabrication process to create released, cantilevered structures.
- ❑Select geometries that increase strained area.
- ❑Model mechanical response of cantilevers.

Findings

$\int \varepsilon(l)w(l)dl$

4.8 E -7



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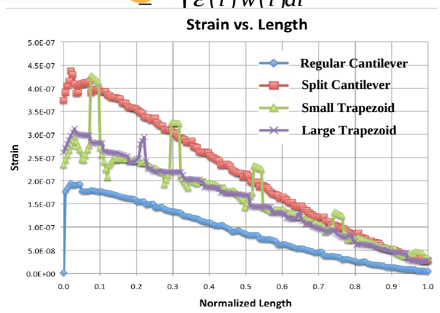

To account for shape, we weigh the variations of cantilever width as a function of its length *w(l)* into a "weighted strain" ε':

$$\varepsilon' = \frac{\int \varepsilon(l)w(l)dl}{\int w(l)dl}$$

Cantilever Geometry	Resonance Frequency [Hz]	ε', Weighted Strain [10^{-7}]
Rectangular	2588	0.9
Split	3747	2.2
Large Trapezoid	3506	1.8
Small Trapezoid	7233	1.7

Next Steps

- ❑Eliminate residual stress in cantilevers.
- ❑Test for power output.
- ❑Verify simulations experimentally.
- ❑Explore novel scavenger designs, including non-planar designs and multi-resonant designs.

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