MEMS Power Generator Based on Piezoelectric Conversion

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U N I V E R S I T Y O F M A R Y L A N D

Motivation

Aim:

To design a micro-scale power generator capable of harvesting energy from its surroundings to power a portable tracking beacon.

Constraints:

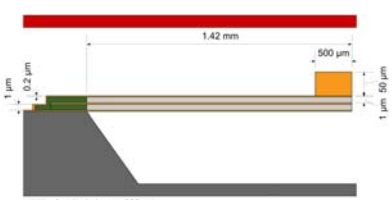
- accumulate 18 Joules needed for one RF impulse in a reasonable amount of time
- limit footprint of harvesting device to 0.5x0.5 mm²

Performance

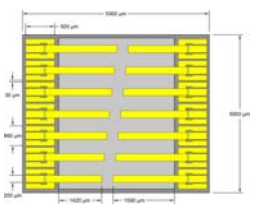
- Operational range: 170 to 200 Hz at 10 m/s² (found on car engines)
- Expected power output: 0.3 uW per beam at a damping factor of 0.1.

Geometry

- array of 14 cantilever beams, each comprised of two layers of PZT and three electrodes
- proof masses at the tip of each beam for generation of bending moment



Cross-sectional view of one beam



Top view of cantilever array

Novelty

- 14 cantilevers with 7 different resonant frequencies in the range from 170 to 200 Hz ensure that the device can work on a broader spectrum (at different engine speeds) and produces more energy
- the bilayer design eliminates the need for a structural layer as the neutral axis is moved to the middle electrode and at the same time increases the amount of active material without calling for thick layers

Fabrication

1 

Pattern lower gold electrode. Deposit oxide insulation by e-beam evaporation. Pattern it by RIE.

2 

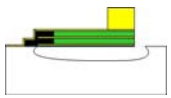
Spin-on PZT sol-gel (2a). Pattern it wet-chemically (2b).

3 

Deposit middle electrode by e-beam evaporation. E-beam and pattern second oxide insulation layer.

4 

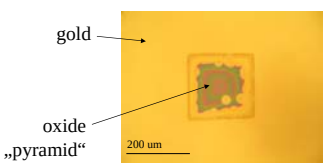
Electroplate gold proof mass using Loctite 3108 as a mold.

5 

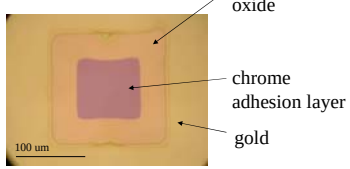
Remove mold in oxygen plasma. Release cantilever in isotropic RIE etch.

Results

1. Patterning E-beamed Oxide



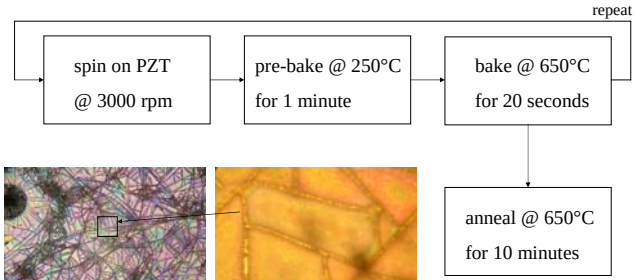
Large oxide undercutting after 20 minutes in BHF 50:1



Chrome undercutting after wet etching

2a. PZT Sol-Gel Deposition

PZT was deposited from its sol-gel state.

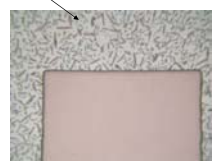


PZT grain structure after five deposition cycles

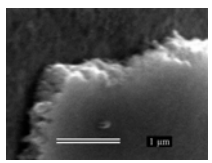
2b. PZT Wet Etching

Used recipe as proposed by Ezhilvalavan et al. [1]:

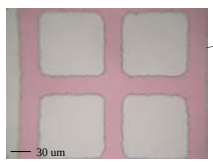
- 1 ml BOE(6:1)
- 6 ml 0.2 M acetic acid (arbitrary molarity)
- 6 ml nitric acid (65%)
- 6 ml hydrochloric acid (35%)
- 4 g ammonium chloride
- 2 g EDTA
- 75 ml DI water



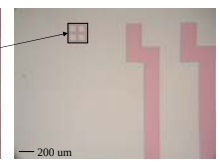
After 30 secs etch time, resist covers PZT



SEM picture of corner



Alignment mark from PZT



Total 1 min etched, resist removed

Acknowledgements

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References

[1] S. Ezhilvalavan and V. Samper, Ferroelectric properties of wet-chemical patterned PbZr0.52Ti0.48O3 films, *Applied Physics Letters*, vol. 86, no. 072901, 2005.