Piezoelectric Vibrational Energy Scavengers Using Sol-gel-Derived PZT Thin Films

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Vision

Ubiquitous wireless sensor networks have extraordinary potential for use in applications such as demand response, environmental monitoring, manufacturing & medical devices. Realization of these networks for wide-spread market use requires that the sensor nodes be low-cost, non-intrusive, & maintenance free. A microscale energy scavenger addresses these needs by harnessing environmental vibrations to provide a replenishable source of power for the sensor node while simultaneously reducing the volume occupied by the power generator & the amount of raw materials required.

Methods

To improve sol-gel PZT film piezoelectricity:

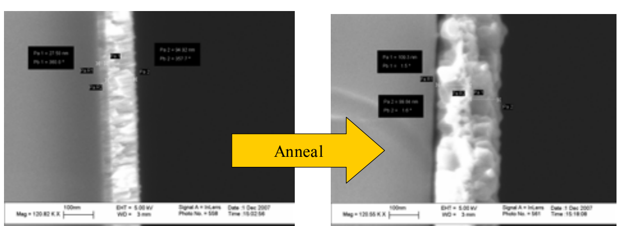
• Compare crystallinity and annealing characteristics of various bottom electrode/underlayer materials without PZT
• Explore impact of spin-coat parameters and anneal schedule on PZT piezoelectric response

To improve power output:

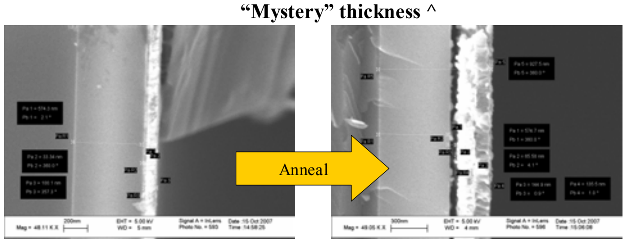
• Develop special geometries: ↓ resonant *f*, ↑ % material strained
• Improve piezoelectric constants of the sol-gel PZT film

To improve stability over lifetime:

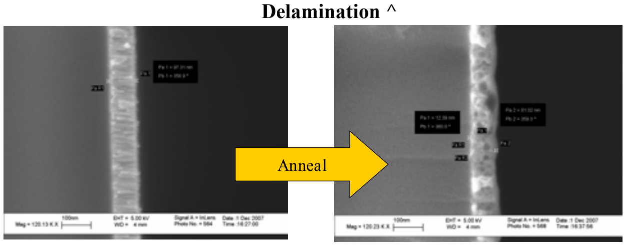
• Test PZT/top electrode plasma cleaning treatment
• Explore impact of thermal imprint on piezoelectric behavior
• Use strain engineering (biaxial tensile/compressive layers)



“Mystery” thickness ^



Delamination ^



Loss of grain orientation ^

Research Questions

What choice of parameters maximize PZT piezoelectricity?

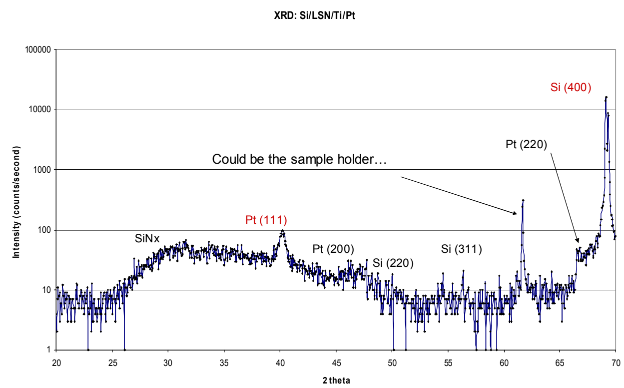
• What is the impact of bottom electrode materials on PZT morphology?
• How do the spin-coating and anneal schedules affect PZT piezo reponse?

How can power output be increased?

• How can high *f* MEMS & low *f* vibration sources be reconciled?
• How can % of material undergoing strain be maximized?

How can stability/robustness be ensured for lifetime?

• How can electromechanical domains be engineered to prevent fatigue?
• How can fabrication process be improved to prevent fatigue?



Findings

Film quality:

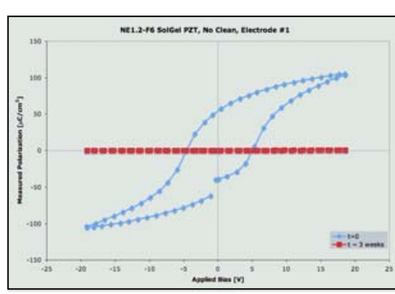
• Not highly dependent on underlayer and adhesion layers tested
• Poor film quality not solely due to PZT
• Expected to be strongly dependent on anneal scedule parameters

Power output

• ~ 20 µW/cm^3 predicted from sol-gel films, based on current d_{33} values
• Modeling shows alternate geometries can increase % strain

Stability/Robustness

• Cleaning step before electrode deposition improves stability



No Ionmill Clean

Ionmill Clean