MEMS Piezoelectric Vibrational Energy Harvester – Characterisation for Mischief Platform Gen II

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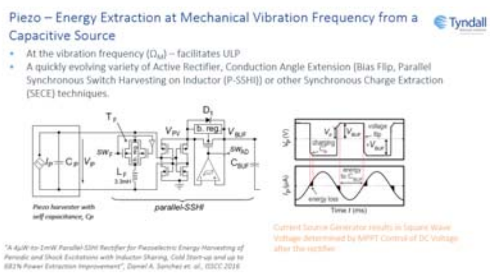
Introduction

Tyndall has a research trajectory in MEMs scale AlN Piezo transducers. There are numerous and quite disparate techniques for maximising power extraction from AC piezoelectric sources – AC MPPT. This work involves experimental characterisation and modelling of a high frequency (stiff) AlN on Silicon prototype transducer to create and validate dynamic electro-mechanical models for use in AC front end design in Mischief II. The key question is around the magnitude of the reverse piezo effect and how much adverse electrical damping will be created by the HF resonant bias flip, versus the gained increased rectifier conduction angle.



Device structure

- The piezoelectric material (AlN) is sandwiched between two metal thin films, as shown.
- The piezoelectric material dispenses positive and negative ions when external force is applied – adaptive energy harvester.

- 50um Si thickness (Dry Reactive Ion Etch)
- Piezoelectric material (AlN) a 5mm*2mm
- Device 5mmX8mm

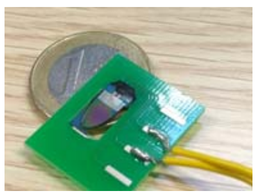


Figure 1 : *Actual device*

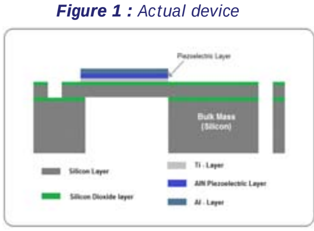


Figure 2 : *Device layer structure*

COMSOL and Electrical Model

- The model is flexible, meaning device geometries can be designed to compare the results of devices with different parameters.

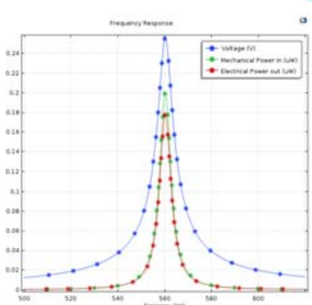


Figure 3: *COMSOL Model output graph*

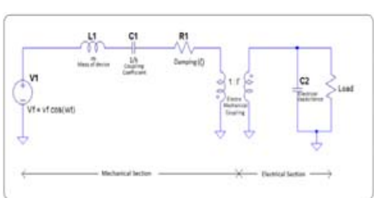


Figure 4: *Electro-Mechanical Model*

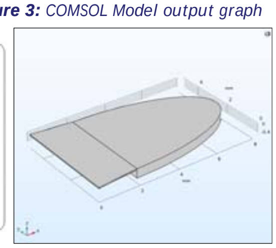


Figure 5: *COMSOL Model*

Experiment using the Electromechanical Shaker

- The shaker provides constant controlled vibration source with specific acceleration.
- For acceleration of 0.1g, the device generates 170 nW with load of 550 kΩ and resonance at 545 Hz.
- Mechanical displacements are determined by replication of generated voltages with loudspeaker system mounted under laser vibrometer (+/- 175um)

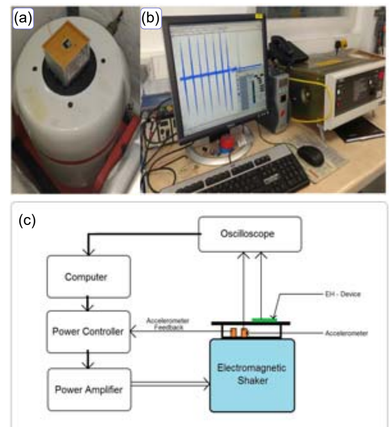


Figure 6: *(a) VTS V455/6-PA1000L Shaker, (b) Experimental setup and (c) Block diagram of setup*

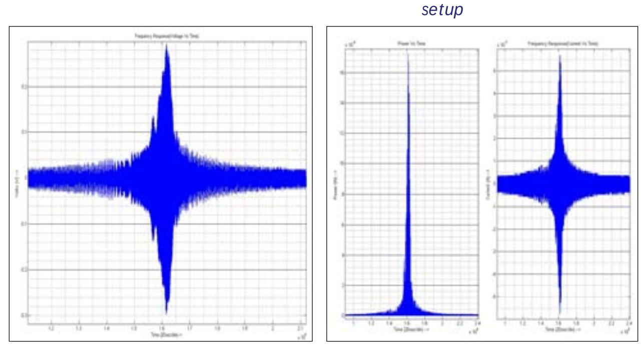


Figure 7: *Experiment results using Electromagnetic Shaker*

Future work

- Narrow bandwidth – implies constrained resonant frequency tuned applications and custom mechanical design per application
- Optimisation of piezoelectric and electrode materials required – enhanced power harvesting.
- Determination of practical power transductions in broadband and shock induced vibrational applications
- Further validation of key parameters such as mechanical damping coefficient and piezo constitutive forward and reverse coupling factor
- Design of low drop-out Active Rectifier for ULP and low voltage AC source in 180nm SOI
- Determination of power transfer increase with Bias Flip and SECE methods

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