Microtechnology and Nanoscience

Master Thesis Project

Design and Manufacture of Piezoelectric Energy Harvesters for Applications in Autonomous Internet Wireless Sensors

Background:

Over the last decade, the interest for autonomous intelligent wireless sensors (AIWS) has increased substantially. Despite significant research effort, the biggest remaining challenge is substituting a conventional battery solution with a power source that does not need to be replaced. Energy harvesters show promise as alternative power sources. To be able to replace a conventional battery solution, an energy harvester needs to be able to deliver sufficient power. The primary problem for a piezoelectric energy harvester is the bandwidth, which is usually quite narrow and makes the harvester ineffective in most real-life applications.

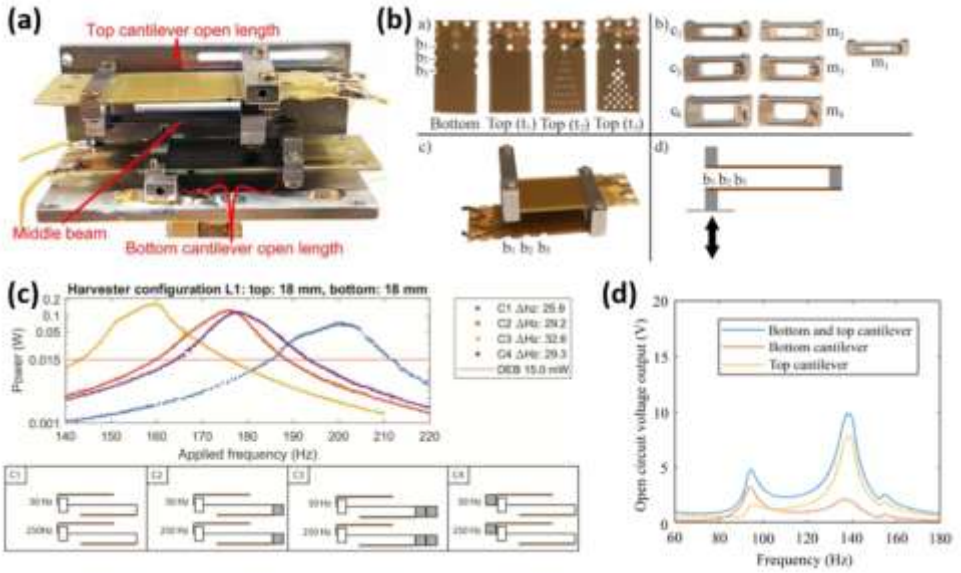

Figure 1: (a)Cantilever setup with a movable proof mass; (b) Several configurations of piezoelectric cantilevers for improving bandwidth; Open voltage outputs for (c) the movable proof mass harvester setup;(d) top cantilever (yellow line), bottom cantilever (red line) and total voltage output (blue line) for the −4 mm configuration. [1- 2]

Purpose and Project Description:

The objective of this thesis is to design, analyze and manufacture energy harvesting structures that can deliver a large bandwidth of output producing frequencies. This will include:

- Derive a 2D Finite Element (FE) model that enables prediction of 3dB bandwidth, energy and power outputs at different vibrational frequencies and accelerations.
- Analyze the structure using multi-objective optimization with respect to several objectives such as bandwidth and energy output.
- Conceptually describe the effects of different parameters (e.g. length, width, thickness, proof mass volume, piezoelectric material choice) have on final output.

- Manufacturing the design and integrating a piezoelectric stack
- Experimental characterization and analysis at RISE Smart Hardware and comparison with numerical results.

The FE code should be able to model the effects from the acceleration from the surroundings, influence of stress induced on the side-beams of the cantilever on the 3dB bandwidth, influence of material effects such as damping, etc. Recommended FE program is COMSOL Multiphysics, but others may also be used.

The project is suitable for 1-2 students from MPAME, MPPDE, MPSYS, MPSEB and master programs linked to MC2 or Engineering Physics.

Student Background:
This project is suitable for students who are interested in computational mechanics and the Finite Element Method. Students with strong interest and good experiences in programming are encouraged to apply. It is a good if the student(s) has some manufacturing knowledge/ experience. They will have an interaction with the microfabrication facility at MC2 Chalmers and be provided with experimental support from RISE Smart Hardware.

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About:
RISE Smart Hardware:
RISE Smart Hardware is a Swedish research institute within electronics, optics and communication technologies. As one of Europe's top research institutes, we provide cutting edge resources and knowledge within electronics, optics and communication technologies. We have the facilities and lab resources to offer advanced R&D as well as small scale production and prototyping. Our mission is to find new ICT-solutions for existing and future demands, creating sustainable growth in industry and society.

MC2:
The Department of Microtechnology and Nanoscience – MC2 – is a unique research department in the areas of micro- and nanotechnology, housing more than 200 researchers and PhD students. We focus our research on the areas of future nano- and quantum electronics, photonics, bio- and nanosystems.

References:
[1] Köhler, E., et al. "Impact of designed asymmetries on the effective bandwidth of a backfolded piezoelectric energy harvester." *Sensors and Actuators A: Physical* 292 (2019): 77-89.
[2] Staaf, L. G. H., et al. "Effective piezoelectric energy harvesting with bandwidth enhancement by assymetry augmented self-tuning of conjoined cantilevers." *International Journal of Mechanical Sciences* 150 (2019): 1-11.