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Design and Redesign of MEMS Piezoelectric Energy Harvesters

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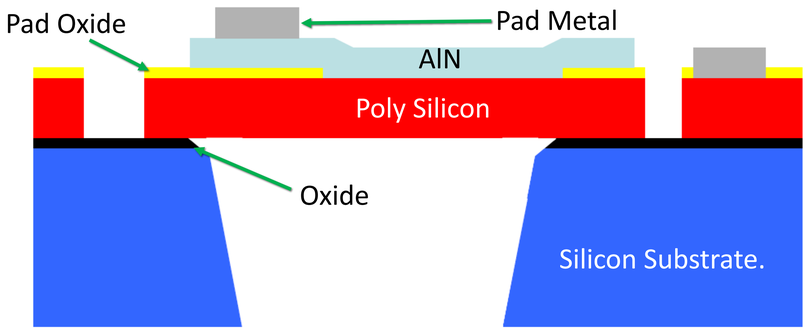
Design and Re-Design of Micro-Electro-Mechanical Systems (MEMS) Piezoelectric Energy Harvesters

Presenter: Shindano Singi Advisor: Prof. Mustafa Guvench
Electrical Engineering Department, Spring 2020

Abstract

The aim of this project was to redesign piezoelectric energy harvesters using Finite Elements Analysis (FEA) tools: ANSYS, SolidWorks, and L-Edit. The harvesters were designed in SolidWorks and simulated in ANSYS. L-Edit was utilized to design harvesters that will be sent to MEMSCAP for fabrication.

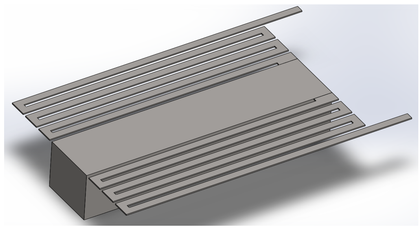


PiezoMUMPs layer deposition

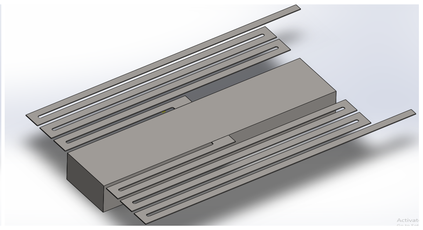
Introduction

Energy harvesters are based on the principle of piezoelectricity in which vibration energy is converted into electrical energy. When mixed with other circuitry, the harvester can power low-powered devices by avoiding bulky batteries. Usually such low power devices are employed to follow and control numerous physical parameters, store data, and wirelessly transfer it. Combining the circuitry with its power enables sensor placement in hard to access environments. Simulations of the three harvesters revealed the first resonant frequencies of 214, 298, and 357 Hz, and the maximum stress amplitudes of 8.063, 4.694 and 5.015 Mpa, respectively. Previous work on this type of device shows potential for practical application in naval, aerospace, and general industrial applications.

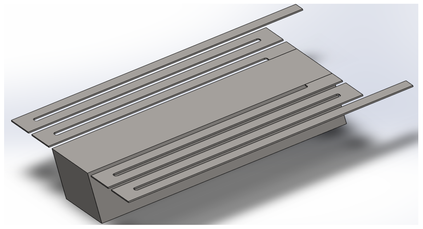
SolidWorks Designs



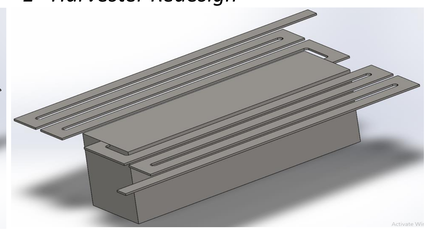
Original Harvester



1st Harvester Redesign

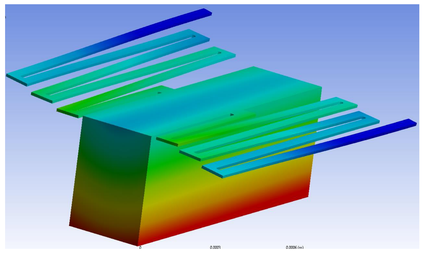


2nd Harvester Redesign

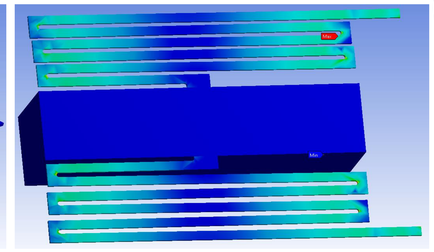


3rd Harvester Redesign

ANSYS Simulations

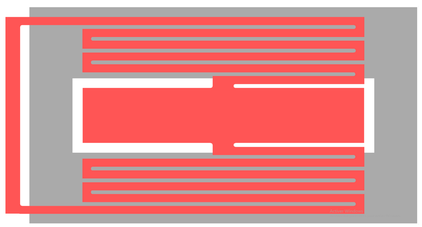


Modal Study: Frequency simulation

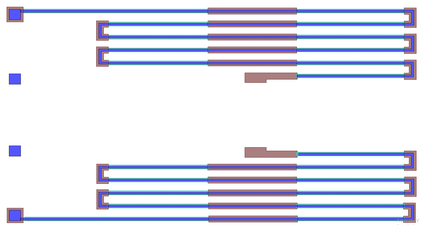


Structural Study: Stress Analysis

L-Edit Designs



1st Harvester Redesign



1st Harvester Redesign Skeleton

2nd Harvester Redesign

3rd Harvester Redesign

Design

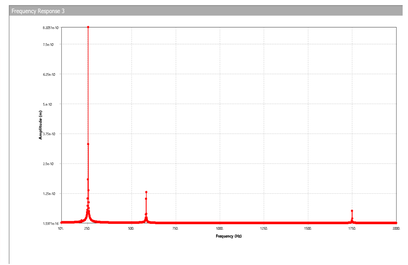
$$k = \frac{4}{N} * \frac{E w t^3}{L^3}$$

$$\omega_{n=} \sqrt{\frac{k}{m}}$$

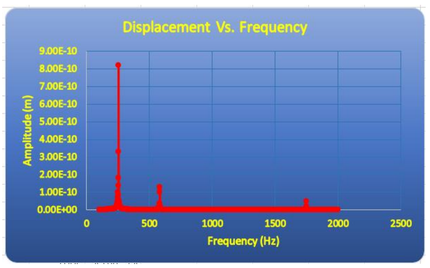
Harvester were designed in SolidWorks and simulated in ANSYS. 3 studies were performed: Modal study was used to visualize selected modes of frequency. Structural study was utilized to analyze the stress on the structure, and Harmonic study was employed to graph stress, displacement responses. Aluminum Nitride was deposited at places with more stress. The original harvester's shape was changed, fillets were added and tethers width were increased from 20 to 40 and 60 µm to ensure the springs can support the weight of the device. L-Edit software was used for design of harvesters that will be sent for fabrication. L-Edit was used for the design that was sent for fabrication (MEMSCAP).

Results

The modal simulation of the first, second and third harvesters showed frequencies ranging from 214 Hz to 3731 Hz, 298 to 4595 Hz, and 348 Hz to 4110, respectively. The gravitational acceleration (2gs = 19.6 m/s^2) was used in this simulation. Simulated maximum stress amplitudes for the 3 harvesters were 8.063, 4.694 and 5.015 Mpa, respectively. Graphs were plotted in ANSYS and their data were exported to excel for further analysis as shown below.



1st Harvester ANSYS frequency graph



1st Harvester Excel frequency graph