SmartSole – Energy Generating Insole

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Problem Statement

In today's world, electrical energy is both an important commodity in North America and Europe and a fleeting resource in many parts of continents such as Africa, South America, and Asia. As the world becomes more globally integrated through technology, the need for reliable means of energy generation will increase. In order to satisfy both demographics, individuals must be armed with the ability to produce their own electricity that can be used for various scenarios.

Objectives

Design a shoe insole, compatible with various types of footwear that satisfies the following constraints:

- The energy harvesting components must not be thicker than ½" when fully assembled. This includes any/all piezoelectric and triboelectric (U-TENG) materials.
- Electrical outputs must be limited to a safe operating current: under 40 mA AC or 300 to 500 mA DC.
- The insole in its final form must generate an electrical output that can be used to power a DC load.

It is preferred that the device is lightweight, comfortable, durable, and affordable to ensure that it is practical for daily use.

Design Solution

Overview:

- Three (3) stacked triboelectric generators covering the heel and ball of foot area of the insole
- Three (3) stacked piezoelectric generators, optimized for maximum contact area at the heel and ball of foot area of the insole
- Internal circuit comprised of a 2.2 μF ceramic capacitor, twelve (12) half-wave rectifiers, and an output for a DC load

Specifications:

- Triboelectric generators are comprised of ITO coated PET (resistivity of 60Ω / sq in.), Kapton tape, and copper tape with conductive adhesive.
- Piezoelectric film sheets made from PVDF plastic, coated in silver for conductivity purposes.
- Half-wave rectifiers are made from 1N4007 Schottky diodes.

Future Work:

- Optimize circuitry to maximize electrical output, possibly by implementing AND gates, impedance-matching transducers, dual-capacitor configurations.
- Explore different triboelectric combinations, using various materials on the triboelectric scale such as Teflon and nylon or polyester and cotton.
- Explore other piezoelectric technologies better suited to the application (e.x. piezoelectric generator pads)

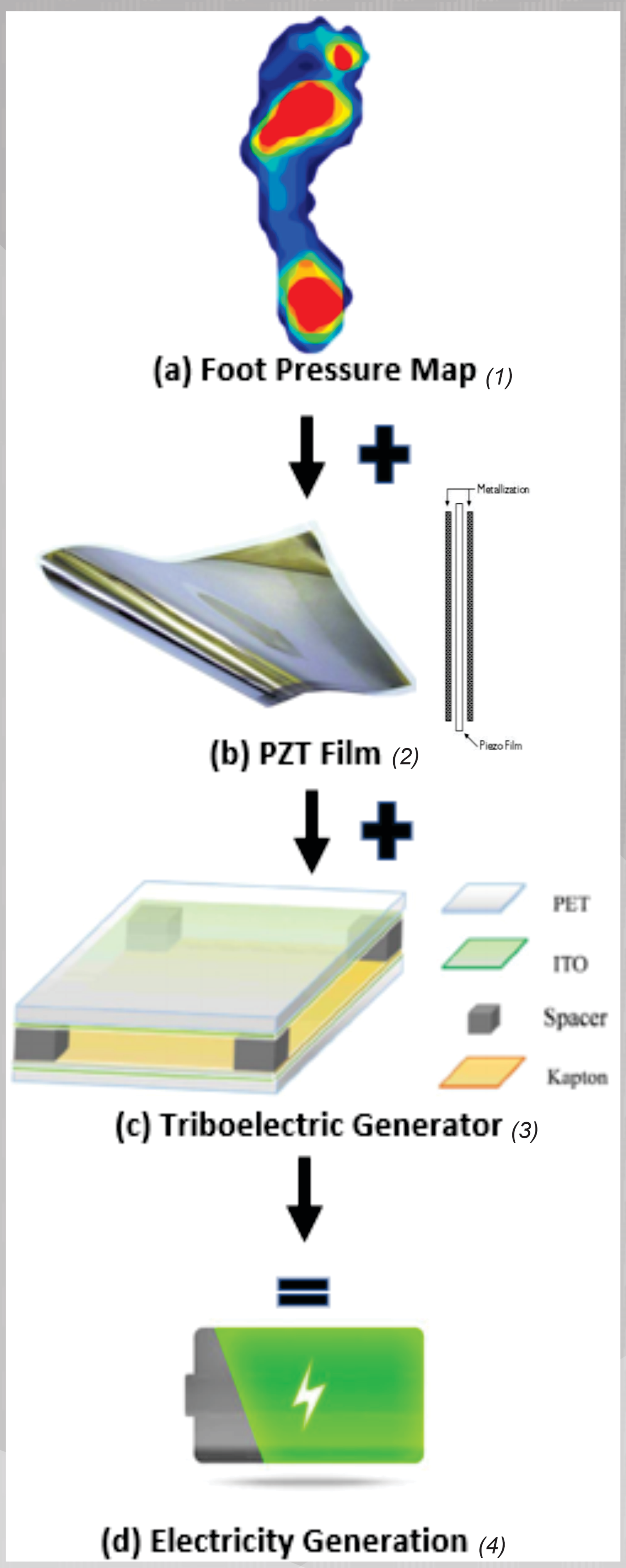

Figure 1: Conceptual flow diagram.

Triboelectric

Force:

- It can be seen that as force increases the output voltage decreased, possibly due to a testing error in which the lower force struck multiple times on contact.

Area:

- The results revealed that an optimal size of 3 x 3 inches provides the highest output.

Stacking:

- The more layers of triboelectric generators present the higher the peak voltage.

Piezoelectric

Force:

- As per the results from testing it can be seen that as increased force is applied, the output voltage increases.

Area:

- The results revealed that an optimal size of 2 x 2 inches provides the highest output.

Stacking:

- With three layers of the piezoelectric film the output voltage increased significantly.

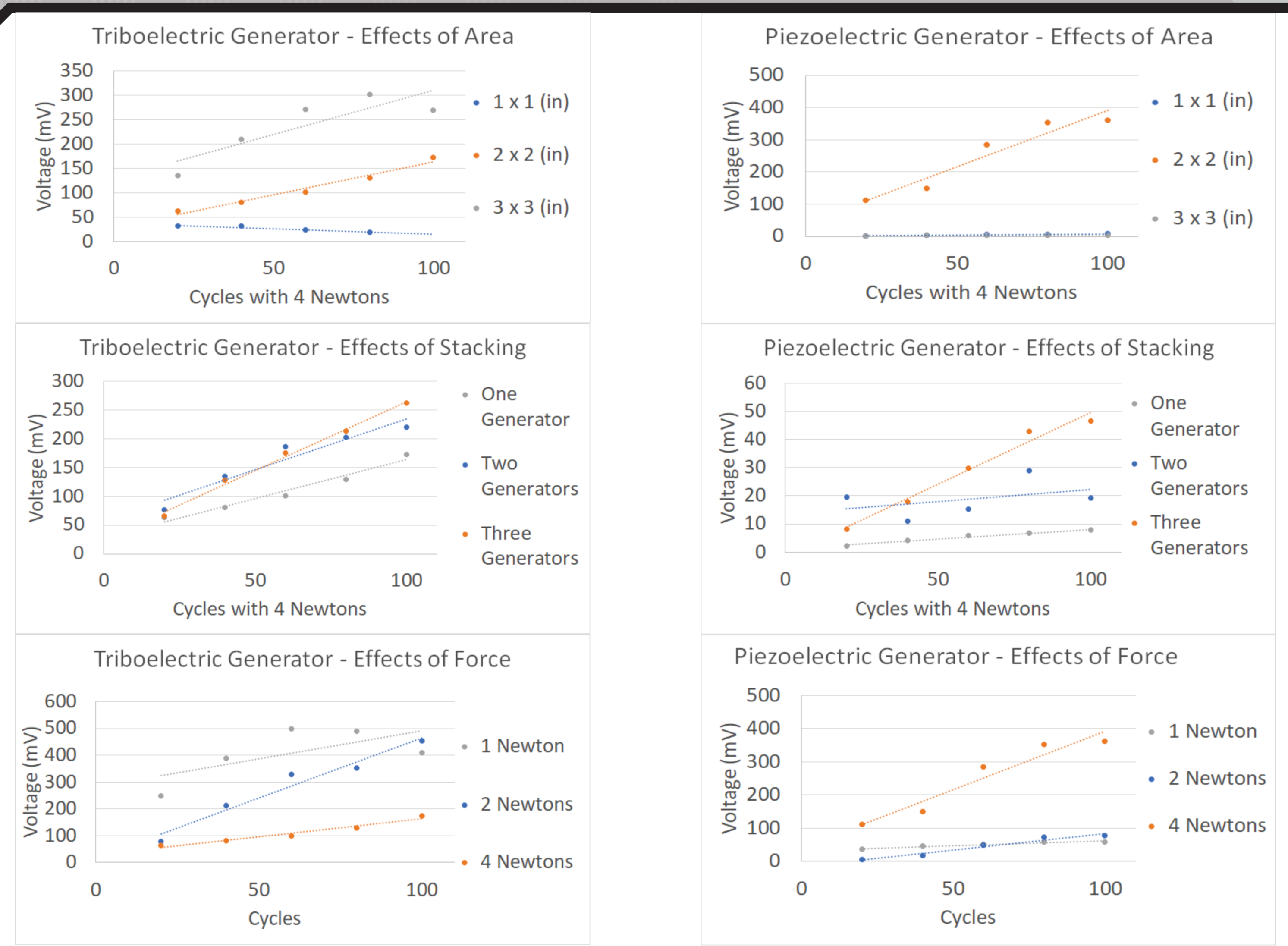

Figure 2: Results of Triboelectric and Piezoelectric Generator Testing.

Hybrid Testing

A hybrid generator was constructed using the most effective generators determined from individual testing. A piezoelectric film was placed in the air gap of the triboelectric generator. Results show that the technologies provide higher output voltage individually.

Force:

- With an increase in force the output voltage decreased likely due to decreased vibration

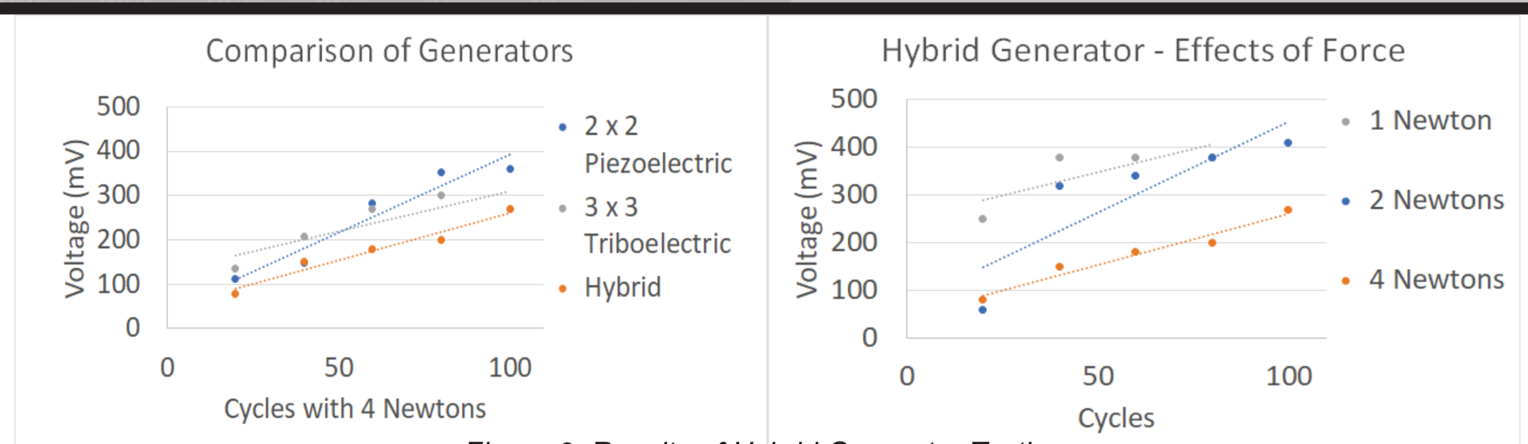

Figure 3: Results of Hybrid Generator Testing.

Conclusion

The SmartSole was successfully able to generate an electrical output capable of powering a small DC load by using piezoelectric and triboelectric generators. The optimal configuration of this technology was to have the generators stacked on-top of each other at the areas of the foot that experience the highest points of contact and pressure. Figures 2 and 3 above also show a correlation between the force applied to the generators and their electrical output. In order to optimize the electrical output, more complex circuitry is recommended to enhance the conversion of electrical current from AC to DC.

References:

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Biomedical

Mechanical