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Experimental evaluation of impact based flexible piezoelectric P(VDF-TrFE) thick-film

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ABSTRACT – This paper discusses on the evaluation of an impact based energy harvesting material using poly(vinylidene fluoride) trifluoroethylene P(VDF-TrFE) in the form of thick film on a flexible substrate. When an impact force from free-fall of 0.2N was applied to the film, as an energy harvester, a maximum peak-to-peak voltage of about 3.0V was generated which derived a maximum output power of 4.36 µW at an external load of 1kΩ.

1. INTRODUCTION

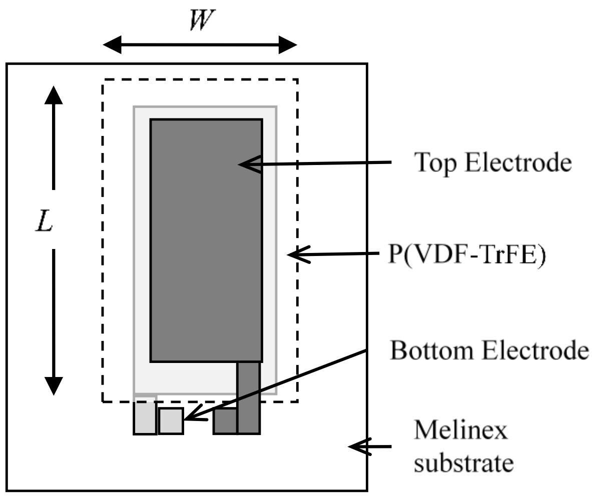
Piezoelectric materials have been widely used for biomedical engineering, smart sensor detection, structural health monitoring applications and are usually in the form of resonant based sensing devices [1-2]. After the discovery of PZT in the 50s, it has been developed as energy harvester [3]. However, PZT has a high brittleness and low compliance therefore it is not applicable to be fabricated on flexible structure. In most cases for optimum energy harvesting from impact based application, flexible structure is desirable. P(VDF-TRFE) thick film have advantages such as higher elastic compliance and acoustic impedance matching than the PZT counterpart. Furthermore, P(VDF-TrFE) has a better bonding layer on a flexible structure compared to piezoceramic material [4-5].

This paper reports a voltage generation from the P(VDF-TrFE) thick film and the maximum electric power when it underwent a free-fall drop impact test.

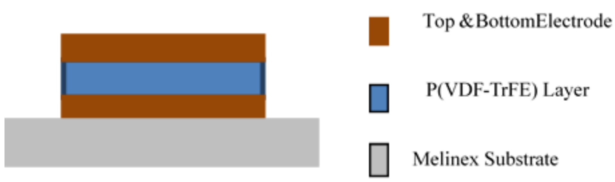
2. EXPERIMENTAL SETUP

Figure 1 shows the layout of the piezoelectric P(VDF-TrFE) thick film device. The P(VDF-TrFE) layer was sandwiched between top and bottom electrodes on a flexible Melinex substrate. Its dimension is shown in Table 1. The details of the fabrication process of the P(VDF-TrFE) thick film had been described in our previous paper [6]. A free-fall drop impact test was conducted on the device by dropping a known mass of plasticine with varying weights from 0.03 N to 1 N (refrains from falling out of the traget by using a plastic cylinder as shown in Figure 2) at a fixed height of 20cm.

The output voltage from the piezoelectric P(VDF-TrFE) thick film was measured using digital oscilloscope (Agilent Technologies: DSO-X2012A, Figure 3). The result shows the instantaneous of electrical voltage when the plasticine is released to be free-fall onto piezoelectric P(VDF-TrFE) thick film.



(a)



(b)

Figure 1 (a) Plan view and (b) side view of the schematic diagram of the sandwiched thick film.

Table 1 Dimension of Fabricated sensor device.

Layer	Dimension (mm) *L x W*
P(VDF-TrFE)	2.5 x 2.0
Top electrode	3.4 x 1.0
Bottom electrode	3.4 x 0.8

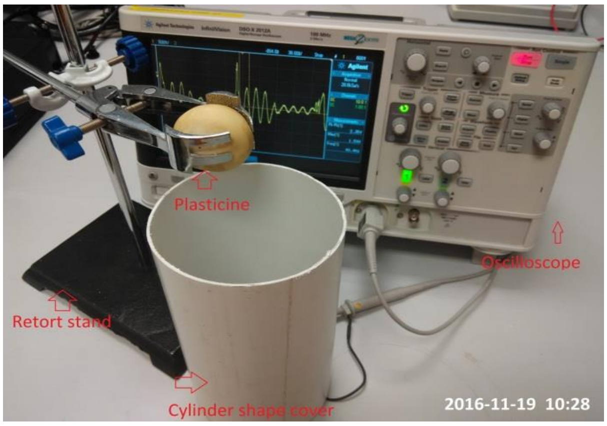


Figure 2 Experiment setup.

3. RESULTS AND DISCUSSION

Figure 3 shows an AC voltage of waveform was generated when an impact force applied onto the piezoelectric P (VDF-TrFE) material.

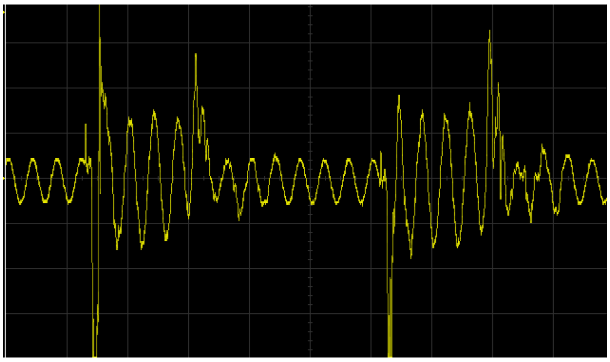


Figure 3 Output AC voltage peak when impact force.

The peak-to-peak AC voltage versus the free-fall impact force shows a saturation at about 3V when a impact force of 0.2N is applied (see Figure 4) A highest output voltage of 3.06V was generated at 0.2N load. When the force exceeding 0.7 N, the average output voltage settled down to 2.70V.

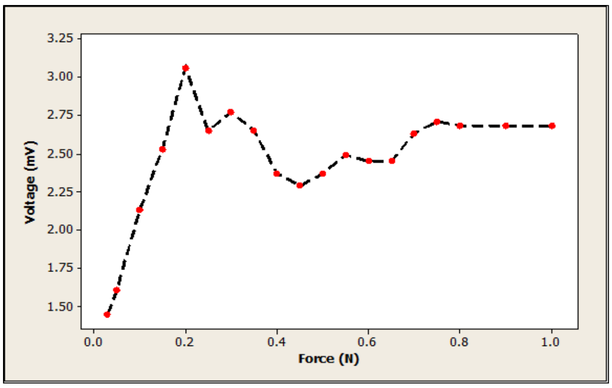


Figure 4 Voltage output vs force.

Figure 5 shows the electrical output power of piezoelectric P(VDF-TrFE) thick film when the output terminal of the film is connected to external resistive load varied from 700Ω to 5 kΩ. This was after the impact force was fixed at 0.2N. A maximum output power of 4.36 µW is being measured across an optimum external load of 1kΩ.

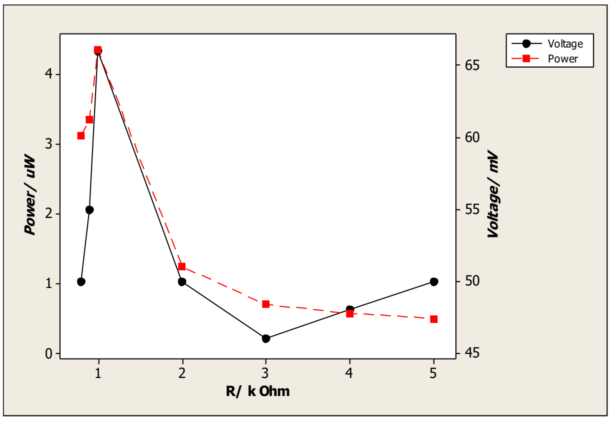


Figure 5 Power and Voltage vs Resistive load.

4. CONCLUSION

The piezoelectric P(VDF-TrFE) thick film which has been developed in this project exhibited a consistent electric voltage and power output when exerted a range of free-fall impact force. The output volage achieved a maximum of about 3V with an impact force of 0.2N which derived a power of 4.36 µW when connected with 1kΩ external resistive load.

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