Journal of Physics: Conference Series

PAPER • OPEN ACCESS

A 3-way pushable electret-based energy harvester fabricated with 3d-printing and PDMS molding

To cite this article: Y. F. Chen *et al* 2018 *J. Phys.: Conf. Ser.* **1052** 012137

IOP Conf. Series: Journal of Physics: Conf. Series **1052** (2018) 012137 doi:10.1088/1742-6596/1052/1/012137

A 3-way pushable electret-based energy harvester fabricated with 3d-printing and PDMS molding

Y. F. Chen[1], H. Honma[2], and H. Toshiyoshi[2]

1 Graduate Institute of Photonics and Optoelectronics, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan
2 Institute of Industrial Science, The University of Tokyo, 4-6-1, Komaba, Meguro-ku, Tokyo, 153-8505, Japan

E-mail: d00941008@ntu.edu.tw

Abstract. An energy harvester device is developed with a PDMS chamber that contains upper and bottom electrodes (Al foil and electret) to form an air-dielectric variable capacitor, which can be pushed in three different manners to generate power through the up-and-down motion of the PDMS membrane. The 3-way mechanisms are experimentally compared..

1. Introduction

This paper reports the design, fabrication, and testing of a 3-way pushable energy harvester based on the three-dimensional (3D) printing and polydimethylsiloxane (PDMS) molding technology. The power is generated by the electrostatic inductance using the K^+-doping electret [1] due to the variance of the electrical capacitance between deformable electrodes. A similar device of PDMS-based flexible energy harvester with Parylene electret is reported in J. Micromech. Microeng. 2015 [2]. However, the method reported here is different from the prior work, and our device has better performance for power generation with the same effective active area of 1×1 cm^2.

2. Design and fabrication

Figure 1 shows a 3D model of the device structure, in which a 3D printed frame is used to create a PDMS mold. 3D printing has advantages such as low prototyping cost, fast, and clean, and PDMS device has characteristics of biocompatibility, non-reactivity, and mechanical flexibility. Containing all the properties of both technologies, a PDMS mold with a deformable thin membrane and a button-shaped chamber is created. Following the fabrication processes as shown in Fig. 2.

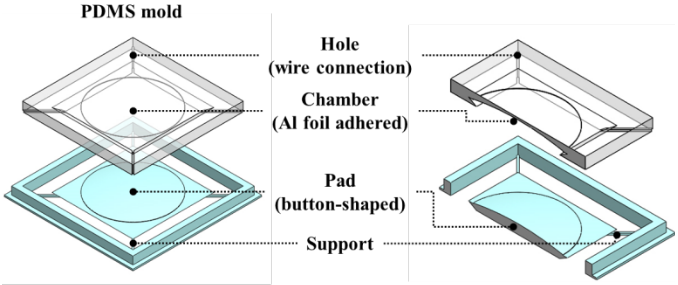
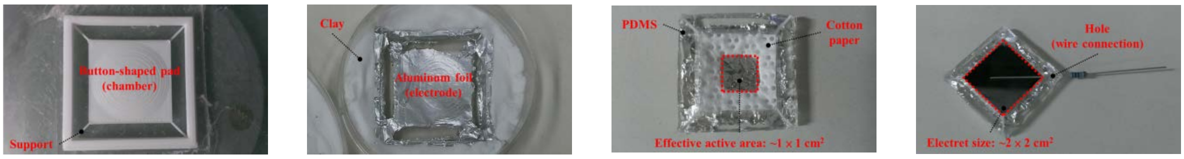


Figure 1. Illustration of 3D-printed frame and PDMS mold for fabricating device.

IOP Conf. Series: Journal of Physics: Conf. Series **1052** (2018) 012137 doi:10.1088/1742-6596/1052/1/012137



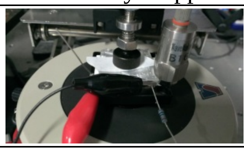
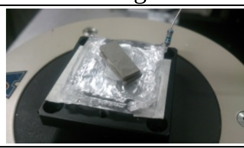
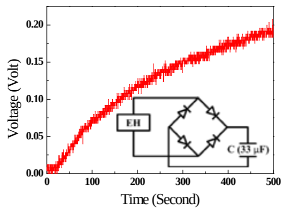
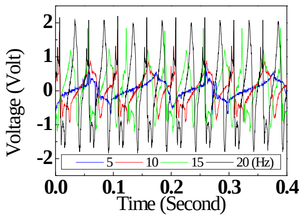
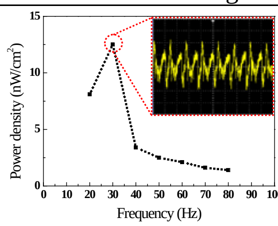
(a) (b) (c) (d)

Figure 2. The aluminum (Al) foil as an electrode layer was adhered onto the bottom side of the membrane during PDMS solidification, whereas a 2 × 2 cm^2 silicon electret is embedded into the chamber after PDMS molding. Also, a cotton paper is inserted as a spacer to form an air-dielectric variable capacitor; therefore, a 1 × 1 cm^2 effective active area of compact energy harvester device is created.

3. Power generation mechanisms and results of experiment

By using the identical energy harvester device, power can be generated due to capacitance changes through gap-closing, and three possible pushing mechanisms are used (Table 1). For Mechanism I (Finger tapping), the maximum output voltage of 15.6 V and the corresponding peak (rms) output power of 243.4 (54.0) μW/cm^2 with a 1 MΩ load of an internal resistance of the oscilloscope were obtained. This power may include triboelectric generation because the materials (PDMS, Al foil, and electret) may contact each other during pressing. For Mechanism II (Stationary stopper), the output voltages on the device at frequencies of 5, 10, 15, and 20 Hz were measured while the shaker was under controlled in the same displacement. The corresponding peak (rms) output power are 0.6 (0.1), 3.2 (0.4), 3.4 (0.6), and 4.8 (1.5) μW/cm^2. For Mechanism III (Vibrating mass), the output powers for the device loaded with a mass of 7.2 g at different frequencies were generated under the same acceleration of 1 m/s^2, and the peak (rms) output power of 12.5 (2.7) nW/cm^2 was measured at the frequency of 30 Hz. Compared with the above three mechanisms, the energy harvester device pushed by finger tapping can generate a much larger output power.

Table 1. Comparison of three possible ways to generate power.

Mechanism	Finger tapping	Stationary stopper	Vibrating mass
Photography of the device			
Purpose	Buttons of keyboard or phone	Reciprocating motions	Machines or bridges
Figure of experimental result	 Stored voltage of 208 mV was collected in about 8 min by finger tapping.	 Output voltage on the energy harvester device at 5, 10, 15, and 20 Hz by a shaker.	 Output power vs. frequency on the energy harvester device with a mass loaded on top.
Maximum power generation	$P_{\text{peak, output}} = 243.4\ \mu W/cm^2$ $P_{\text{rms, output}} = 54.0\ \mu W/cm^2$	$P_{\text{peak, output, 20 Hz}} = 4.8\ \mu W/cm^2$ $P_{\text{rms, output, 20 Hz}} = 1.5\ \mu W/cm^2$	$P_{\text{peak, output, 30 Hz}} = 12.5\ nW/cm^2$ $P_{\text{rms, output, 30 Hz}} = 2.7\ nW/cm^2$

References

[1] Hashiguchi G *et al* 2016 *AIP Adv.* **6** 035004
[2] Chiu Y *et al* 2015 *J. Micromech. Microeng.* **25(10)** 104007