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Abstract

A hybrid piezoelectric and reverse electrowetting energy harvester for wearable biosensors †

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Abstract: Wearable biosensors play a critical role for healthcare monitoring. However, reliance of biosensors on batteries has serious drawbacks. Although the human body energy can be converted into electricity with energy harvesters. Hybridization of multiple energy harvesters is a prominent trend to increase the power output. In this work a hybrid piezoelectric and reverse electrowetting (REWOD) energy harvester is proposed. The main principle of working is based on the presence of electrical double layer in REWOD component and the coupling with a piezoelectric nanogenerator via an electret. The proposed energy harvester design was tested numerically and in a series of experiments.

Keywords: energy human harvesting; reverse electrowetting on dielectric (REWOD); piezoelectric nanogenerator (PENG); electrostatic microgenerator; continuous monitoring biosensors; wearable biosensors; radial artery

1. Introduction

Modern healthcare widely employs implantable and wearable biosensors to continuously monitor patient's physiological data. Biosensors rely heavily on use of batteries in their design which has several drawbacks which can be addressed by using energy harvesters. There are multiple potential sources of energy on the human body that can be effectively exploited by various transducers [1]. As a single targeted energy type might be insufficient or suboptimal in terms of the power output and availability of energy, several energy generators are coupled in one hybrid energy harvester that can target multiple energy sources or scavenge energy from one energy source but with multiple generators. Biomechanical energy produced by the human cardiovascular system represents a reliable source of pulsations produced by the radial artery in particular, which were successfully used in numerous energies harvesting applications [2-3].

In the present work, a hybrid piezoelectric nanogenerator (PENG) and electrostatic energy harvester that scavenges energy from radial artery pressure variation is presented. Reverse electrowetting on dielectric (REWOD) is implemented through a bubble of conductive liquid which is squeezed in-between two electrodes, one of which is coated with a dielectric material [4]. By modulating the distance between the electrodes, the electrical double layer (EDL) formed at the fluid-electrode surface changes modifying the capacitance of the system thus allowing it to collect accumulated charge [5]. The working principle of the designed energy harvester is explained in Figure 1. The electret on the top of the shared electrode biases the REWOD component and therefore prevents ions and counter ions in EDL from changing their places [6]. EDL which forms on top of the electret increases overall capacitance of the system and maximum charge generation. When pressure is released and the harvester moves back to its initial state, the process repeats itself with electrons moving in the opposite direction.

2. Materials and Methods

In this project, the hybrid harvester consists of a commercially available piezoelectric disc and a customised printed circuit board (PCB) for the REWOD component. The piezoelectric disk harnesses PZT-5 ceramics that are deposited on top of a brass diaphragm (CuPbZn). The top part of the piezoelectric material is coated with silver (Ag). The REWOD component consists of the shared brass electrode coated with an electret and a counter electrode (Cu). NaCl was used as a conductive liquid.

3. Discussion

A concept of the hybrid piezoelectric/REWOD energy harvester was explored computationally through simulations with the Multiphysics software COMSOL, where finite element analysis was employed to better understand the physical behaviour in solid and liquid phases of the REWOD component. In addition, an experimental setup was designed and constructed. The piezoelectric component was experimentally assessed across the range of practically available frequencies (1-2.5 Hz). The effect of material and geometrical parameters were investigated (Figure 2).

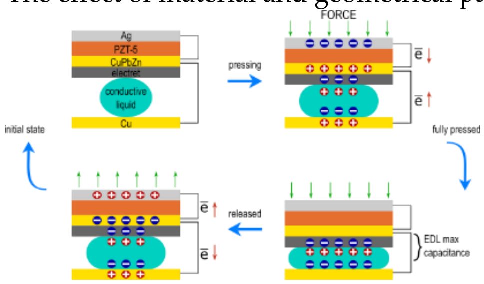

Figure 1. The hybrid harvester working principle

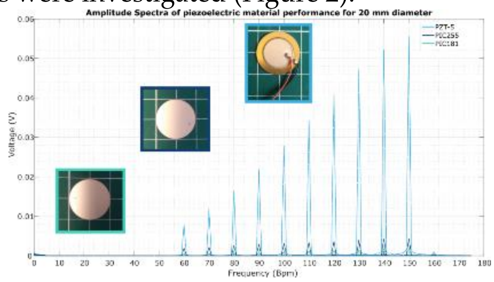

Figure 2. Empirical data on the influence of piezoelectric material on harvester output.

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