Electromechanical coupling properties of stretchable electret film and its applications: mechanical sensing, energy harvesting and actuation

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Abstract. Electrical and mechanical energy type converts around the nature. Among electromechanical coupling effects and materials, electrets are widely applied on microphones, earphones, and air filters. Stretchable electrets have been developed with elastomeric bases and nano-particle electrets to behave its mechanical stretchability and electrical activity simultaneously, and its electromechanical properties has been expanded on multiple applications such as mechanical sensing, energy harvesting and actuation. The electromechanical coupling properties of this energy-active material are analyzed in this work by four types of mechanical procedures: compression, vertical motion, stretch extension, and vertical pricking between electrode setup. It is found that the vertical pricking onto electret films induces ultra-high effective piezoelectric coefficients according to its mechanical-induced deformations. The electromechanical applications of mechanical sensing, energy harvesting and actuation with this mechanical procedure are demonstrated with this pricking type, showing its advantages of electromechanical coupling capabilities.

Keywords. Electret, Flexoelectricity, actuator

1. Introduction

Electromechanical coupling effects and materials are helping on solving multiple problems such as mechanical sensing, energy harvesting, and actuations, which are among the key procedures of industrial systems and bio-mimic robotics. Among various electromechanical coupling effects, electromagnet, triboelectricity, electret, piezoelectricity and flexoelectricity contribute on different conditions due to their advantages and restrictions. Among these effects and materials, electrets are considered as energy active materials because they "hold" net charges quasi-permanently and dipole moments inside materials, and then output high electromechanical coupling efficiencies than those dielectric materials without embedded net charges and dipole moments [1-2].

This approach enables different material couples, and its electromechanical properties are tremendously enhanced. In this work, several types of mechanical procedures are analyzed and discussed to find the electromechanical coupling advantages of stretchable electrets. Application demonstrations of mechanical sensing, energy harvesting, and actuation are demonstrated with this electromechanical setup.

2. Electromechanical coupling behavior

The application ranges of electrets have been extremely expanded by their mechanical stretchability. In this work, the stretchable electret is restricted by its boundary, and the upper and lower non-contact electrodes are set to generate the electromechanical procedure.

The free vibration frequency of the film is determined by the elastic modulus, thickness, and the pre-stretch level of the electret film. It is seen that the amplitudes of the outputted charge are averagely 7.1 nC, with a free vibration frequency 16.9 Hz. The vibration naturally decreases, and the equivalent capacitance is measured as 4.89 pF. The maximum power output is then calculated as 1.13×10^{-4} W at the frequency 20 Hz.

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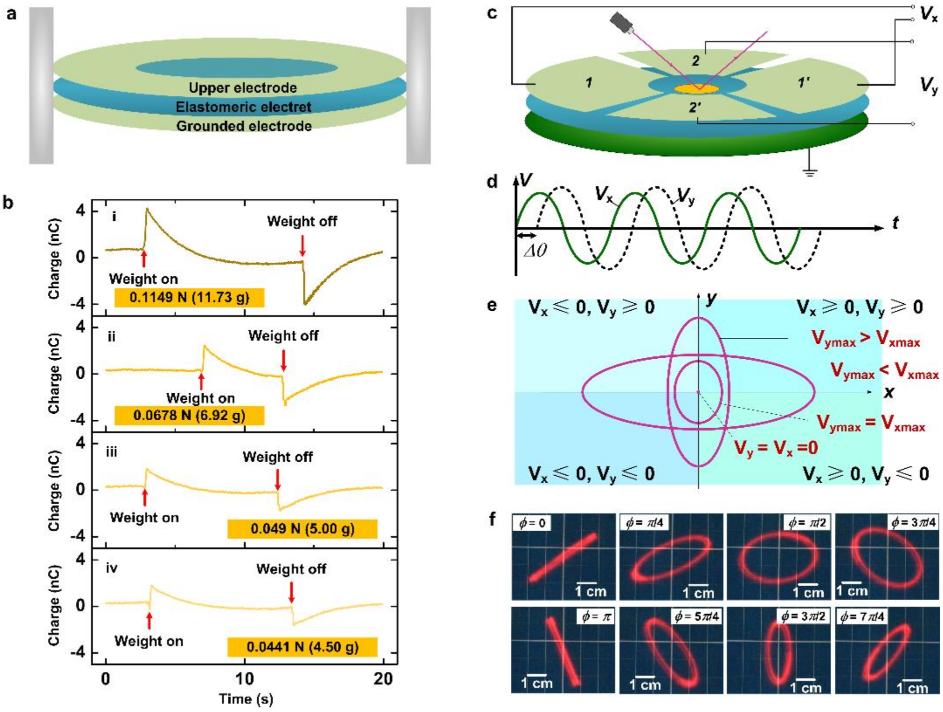

Figure 1. The electromechanical coupling behavior of the proposed design.

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