Triboelectric-Electromagnetic Hybrid Generator for Wind Energy Harvesting

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1. Abstract

Herein, we have reported a flutter based hybrid generator (F-HNG) composed of triboelectric nanogenerator (TENG) and electromagnetic generator (EMG) components. The triboelectric component is composed of a contact and separation mode using a roughness created fluorinated ethylene polymer (FEP) as a negative material and aluminum as a positive triboelectric material. Similarly, the EMG component is made of coil wounded in a horizontal way and attached on the other side of FEP. Both the components were housed inside a small rectangular wind tunnel structure. A neodymium magnet is placed on the acrylic on the top side of the structure. The contact and separation and electromagnetic actuation work simultaneously upon the same wind force and actuation leads to the generation of electrical output from both the TENG and EMG components independently. The TENG component generates a maximum voltage and current of 60 V and 700 μA. Similarly, the EMG component generates a maximum voltage of 200 mV and 20 mA. The generated energy can be utilized by lighting up low power electronic devices and can also be used for charging commercial capacitors.

2. Introduction

Nowadays, the energy required for our life is derived from the fossil fuels. But these fossil fuels create many issues like global warming and also this energy source will run out soon. The challenges are to find an alternative energy source from nature for save mother earth. These days, many scientist and engineers focus this issue and try solving this, and they developed many ideas and items [1, 2, 3]. But now, we suggest new type of hybrid generator, using triboelectric and electromagnetic generator for harvest wind energy. The triboelectric and electromagnetic generator had previously been reported for many applications such as water wave energy harvesting, self-powered active sensors, wind energy harvesting, and seismic detectors. The main reason for hybridizing the triboelectric and electromagnetic components in the single structure is to enhance the power and power density of the device and could easily been used for high power applications. Among that the hybrid generator made of TENG (voltage source, low operating frequency) and EMG (current source, high frequency) had attracted considerable interest due to easy construction, enabling TENG component in EMG structure itself (reducing device area), and extending the operating bandwidth of device with same mechanical stimuli.

3. Results and Discussions

The device fabrication is composed of an acrylic casing which houses the TENG and EMG components are assembled in a way that they can actuate simultaneously upon impact by wind. The TENG component is made of a contact separation way using Aluminum and FEP, whereas the EMG component works with the front and back motion of coil towards magnet upon wind direction as shown in Figure 1.

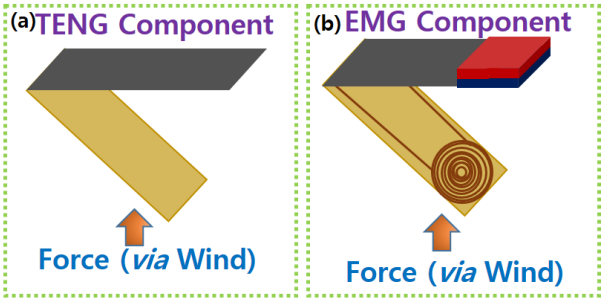

Fig. 1 (a) Schematic diagram of TENG component and (b) Schematic diagram of EMG component

Figure 2 shows the arrangement of the whole hybrid device inside a mini wind tunnel setup with the lateral wind direction. Figure2 shows the arrangement of the device inside the mini acrylic homemade wind tunnel with the wind actuation direction.

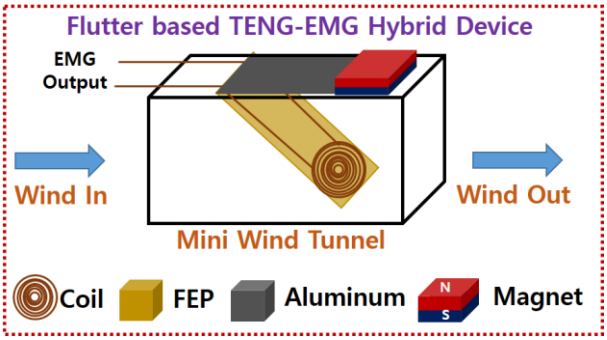

Fig. 2 schematic arrangement of flutter based TENG-EMG hybrid generator

This mechanism involves interaction between the surface-modified FEP film and the Al electrode with a combination of the triboelectric effect and electrostatic induction. Initially, the top Al electrode layer is in contact with the FEP layer. Next, because of the mechanical motion through wind force, the top layer separates from the FEP layer, and a charge difference occurs across the electrodes. This process induces a flow of electrons from the top electrode to the bottom electrode through an externally connected circuit, as shown in until an equilibrium state is reached This action contributes to the first half-cycle of the alternating current (AC) signal; the second half-cycle is achieved when the top electrode layer approaches the FEP film, inducing a flow of electrons in the opposite direction. The device is then placed in a linear motor and the electrical output of both TENG and EMG were measured. The TENG device generates a maximum voltage and current of 60 V and 700 μA. Similarly, the EMG component generates a maximum voltage of 200 mV and 20 mA. This shows that the flutter based device is capable of generating electricity from wind energy as shown in Figure 3.

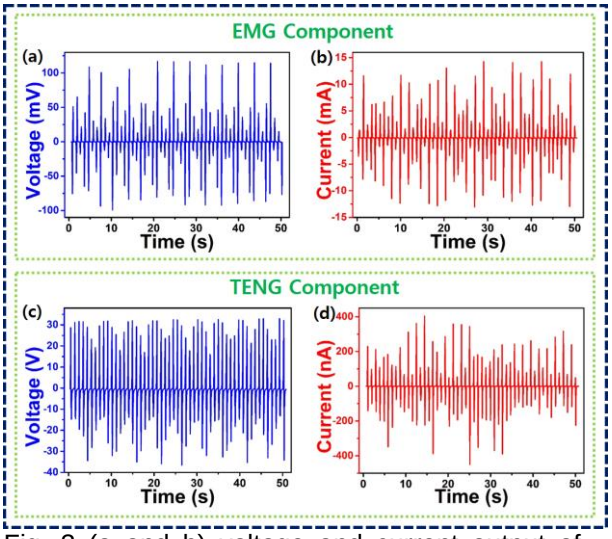

Fig. 3 (a and b) voltage and current output of EMG component. (c and d) electrical output of TENG component.

Further, the device is used for analyzing the instantaneous power density, switching polarity test for the confirmation of electrical output, demonstration of lighting up low power electronics such as glowing LEDs, charging commercial capacitors. Then the device output under various accelerating frequencies, which can be used for analyzing the energy harvesting capability under various wind speeds. Finally, four devices were used in the top of the building connected in parallel to harvest wind energy and been successfully utilized with the help of an electronic power management circuit.

Conclusions

In summary, a flutter based wind energy harvesting device was made using TENG and EMG components housed inside a small wind tunnel which can harvest energy upon simultaneous wind motion and generates electricity independently. The triboelectric component is composed of a contact and separation mode using a roughness created fluorinated ethylene polymer (FEP) as a negative material and aluminum as a positive triboelectric material. Similarly, the EMG component is made of coil wounded in a horizontal way and attached on the other side of FEP. The TENG component generates a maximum voltage and current of 60 V and 700 μA. Similarly, the EMG component generates a maximum voltage of 200 mV and 20 mA. The device is then used to study and analyze its maximum area power density, force analysis and operating commercial electronic devices. Finally, four devices were used in the top of the building connected in parallel to harvest wind energy and been successfully utilized with the help of an electronic power management circuit.

Acknowledgment

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