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Application of Tribioelectric Nanogenerators

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Introduction

The rapid advancement of portable electronics and sensor networks necessitates the development of sustainable and dependable energy sources for them. Powering them exclusively with batteries has become more impractical and unattractive, owing to the short battery life, wide spread of these types of electronic gadgets, and significant health and environmental dangers. As a result, new technologies that can harvest energy from the surrounding environment as sustainable power sources are developing study topics known as nano-energy research, which focuses on the applications of nanomaterials and nanotechnology for harvesting energy for powering micro systems.

About the Study

Triboelectric nanogenerators based on contact electrification and electrostatic induction have recently emerged as a promising mechanical energy harvesting technology, offering unique benefits such as high output power, high efficiency, low weight and cost effective materials, and simple fabrication. After three years of research, TENGs' area power density has reached and their volume energy density has reached. The greatest mechanical energy conversion efficiency has currently reached roughly 85%. Triboelectric nanogenerators were utilised to charge a phone battery directly and as self-powered active sensors.

Even when the present TENG performance is highly high, there are still requirements for continuing to increase their output performance for more and more practical applications, which demands rational design and thorough optimization of both materials and structures. Furthermore, as with the development of CMOS integrated circuits and systems, TENGs, power management circuits, signal processing circuits, energy storage components, and/or load circuits are necessary for the actual usage of TENGs.

Theoretical simulation is required for understanding the working mechanism and evaluating overall system performance. Finally, because doing control experiments is often time-consuming and inefficient, simulation is always an essential element in the whole device design process. As a result, a good theoretical understanding of TENGs is essential throughout the whole research field. This knowledge can aid in the selection of the correct TENG structure and materials, the avoidance of designs that will dramatically impair output performance, and the selection of ideal systemlevel topologies for integrated energy harvesting systems.

The purpose of this paper is to present a summary of the fundamental theoretical research on triboelectric nanogenerators. We'll start with the governing equation and work our way up to the corresponding circuit model and simulation method. The basic output features of four fundamental TENG modes, including open-circuit voltage, short-circuit transferred charges, and intrinsic capacitance, are then thoroughly investigated. Additionally, resistive and capacitive load characteristics are shown. Finally, based on the aforementioned fundamental facts, we will present different advanced TENG structures and optimization methodologies for each fundamental TENG mode.

TENGs work by a mix of contact electrification and electrostatic induction. Contact electrification produces static polarised charges, whereas electrostatic induction is the principal method of transferring mechanical energy to electricity. TENG will have intrinsic capacitive behaviour since the most fundamental electrostatic device is a capacitor. The inherent capacitive behaviour of a random TENG is investigated. In any triboelectric generator, two materials face each other. Mechanical force can be used to change the gap between these two triboelectric layers. After being pressed into contact with each other, the contact surfaces of the two triboelectric layers will have opposing static charges as a result of contact electrification.

The triboelectric effect, which happens when two different materials come into contact, occurs frequently in our daily lives. It is frequently viewed negatively in industry because the electrostatic charges it generates can cause fires, dust explosions, dielectric breakdown, electronic damage, and other difficulties. When two triboelectric surfaces are separated, the electrostatic charges combine to produce a capacitive energy device, which led to the development of early electrostatic generators such as the "friction machine" and Van de Graaff generator.

Triboelectric activity is used in conjunction with electrostatic induction. Triboelectrification, in instance, creates static polarised charges on material surfaces in contact, whereas electrostatic induction drives mechanical energy conversion to electricity via an electrical potential change generated by mechanically agitated separation.

Aside from the many working modes, the TENG has a number of other benefits, including a wide range of material availability, light weight, cheap cost, and great efficiency even at low operation frequency. In theory, any material with discrete charge affinity may be used to create a TENG, resulting in a varied range of materials capable of exceptional performance at opposite ends of the triboelectric series.

Net negative triboelectric charges are commonly achieved with polytetrafluoroethylene and silicone, whereas net positive charges are obtained with nylon and metal. The majority of current TENGs are polymer-based and flexible, making them easy to manufacture, cost-effective, and portable, whereas high-temperature TENGs are built of durable ceramic materials to resist extreme operating conditions. In addition, the power density of a TENG.

The emerging nanogenerator technology, together with the piezoelectric nanogenerator, has been widely acknowledged as a revolution in the field of energy harvesting and sensing, earning around 195 patents. Its trends, impacts, and commercialization strategies have been studied using a variety of methods, including bibliometrics, patent analysis, technology mining, techno-economic lifetime assessment, and technology road-mapping, with the results indicating that nanogenerator development is becoming more interdisciplinary, necessitating efforts not only from materials science and nanotechnology, but also from computer science, information systems, and public policy. The international conference on nanogenerators and piezotronics was established in 2012 and has since been held every two years, with attendance growing from 50 in 2012.

The creator of TENGs established the prestigious peer-reviewed journal Nano Energy in 2012 to aid in the development of nanomaterials-related

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energy solutions, of which the nanogenerator is an important component. Currently, the TENG is advancing at a quick pace and has emerged as a growth indicator in the nanogenerator industry. TENG-related articles have expanded rapidly from 8 in 2012 to almost 400 in 2017, with authors from more than 40 countries. Several commercial TENG-based products, such as air filters and face masks, have been released in Chinese domestic markets, opening the door for widespread commercialization [1-5].

Conclusion

Contact electrification has been recognised as a prevalent phenomenon for about 2,000 years. CE is one of the most fundamental consequences of electricity production and is created by physical contact between two materials, as well as tribology and interfacial charge transfer. CE, on the other hand, has limited applications in contemporary industry and is often seen as a negative influence to be avoided since the produced electrostatic charges can cause fire, dust explosions, increased friction, and energy losses. The situation has changed as a result of the development of triboelectric nanogenerators as a new type of energy harvesting technology. TENGs may turn mechanical energy into electricity in our daily life by combining triboelectrification with electrostatic induction.

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