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Application and Development of TENG Technology from Multiple Perspectives

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Abstract: As a new type of energy conversion equipment, triboelectric nanogenerator (TENG) has attracted wide attention from researchers. This paper will discuss the basic principle, charge transfer mechanism, structure and material research methods, simulation and simulation methods, experimental design and scheme, test technology and instrument, advantages and limitations of TENG.
Keywords: TENG; Energy harvesting; Convergence

1. Introduction

TENG technology uses triboelectric effect to efficiently convert mechanical energy into electrical energy, which brings broad application possibilities for intelligent sensors, environmental monitoring and medical care.

Previous studies have shown that vibration frequency, material type, contact surface size and separation speed have a profound impact on the performance of triboelectric nanogenerators. At the same time, the research needs to be extended to new application scenarios such as smart sensors, environmental monitoring, and medical health. New materials and improved technical design should be used to solve current problems. In addition, the performance of triboelectric nanogenerators under extreme conditions should also be studied in depth. And develop new materials that can withstand high temperatures and are compatible with the human body, promoting the application and development of technology in a wider range of fields.

2. Text

2.1 Basic principle of triboelectric nanogenerator

TENG uses the relative movement between two materials with different electronegativity properties to generate electrical energy. These materials rely on friction and electrostatic induction to generate charge exchange during contact and separation, thus forming a potential difference on their contact surface and realizing the conversion of mechanical energy to electrical energy.

Zhang's team pointed out[3] that the working principle of TENG also involves the utilization of Maxwell displacement current, which has a key influence on energy conversion efficiency. Through the fine design of the internal structure of TENG, such as friction material layer, electrode and conductive wire, this device can effectively generate electricity in various working modes according to different environments and application requirements. The commonly used working modes include vertical contact-separation mode. In this mode, periodic current is generated through periodic contact and separation of materials. The horizontal sliding mode uses the continuous sliding of materials to realize the continuous flow of charges. In order to better adapt to the needs of specific applications, the design of TENG can be optimized. For example, the independent layer mode provides greater flexibility in component layout, which is especially suitable for occasions with special needs for structural design.

2.2 Research methods

2.2.1 Simulation methods

In the field of nano-energy technology, TENG has been extensively studied and explored as an emerging technology. Researchers use models and simulation tools, such as COMSOL software, to deeply analyze the working principle of TENG and its design improvements. Through detailed analysis of the charge distribution, potential changes, and the interaction with factors such as the distance between the electrodes of TENG under different working conditions, the research has improved our understanding of the factors affecting its performance. Wu's team studied the operation of contact and separation TENG in detail and discussed the external conditions. These studies enable scientists to better predict and adjust the performance of TENG to adapt to different operating parameters and lay the foundation for its future improvement and wide application. The application of this simulation technology not only deepens the understanding of the physical behavior of TENG. It also provides an effective way to test the performance of the equipment under different design parameters, which is helpful to promote the development and innovation of this technology.

Han 's team[3] studied to enhance the efficiency and power output of TENG by optimizing structural design and selecting specific materials and using nano-modification technology to improve surface performance. They tried different mechanical energy conversion experiments to verify the practical effects and feasibility of these new materials and improved designs in enhancing TENG performance. These research results have deepened our understanding of the development potential of TENG technology and provided important empirical support and new perspectives for the future progress of material science and energy collection technology [4].

In general, the use of simulation tools to simulate the electromagnetic field and charge distribution is very important for mastering the operation mechanism and optimal design of TENG.

2.2.2 Experimental design and scheme

Scientists have adopted a comprehensive method including theoretical analysis, computational simulation and experimental testing to construct a systematic research framework. According to the research objectives and the characteristics of the materials used, the research team has developed a variety of experimental schemes. The diversity of these schemes ensures that the research work can be carried out comprehensively and deeply. This methodology not only improves the quality of research, but also broadens the research horizon.

Wu's team developed a new type of contact-separated TENG device [1], and conducted in-depth mathematical derivation of the voltage of the device, the amount of charge transfer and its relationship with the distance between the plates (V-Q-x). Through field tests and simulation of electric potential and surface charge density using COMSOL software, the research group compared the experimental data with the simulation results. This comparison not only verifies the accuracy of TENG design, but also confirms its performance stability. This research result provides an important perspective for further understanding and further optimizing the performance of TENG equipment.

Guo's team have carried out a project to study polymer-based composite materials[5]. They have successfully created a new type of composite material by incorporating inorganic functional materials into polymers. This material is designed to improve its performance in energy conversion, power output density and triboelectric properties. Through extensive experimental investigations, the team explored the role of various fillers in improving the surface and electrical properties of composite materials. This research provides a new perspective and possibility for the development and application prospects of TENG.

Many scientific studies have focused on the exploration of triboelectric nanogenerators, and the experimental methods and design strategies are different. These studies have deepened people 's understanding of its working principle and increased the potential for use in practical applications.

In the process of exploring TENG, the method of experiment and simulation plays a core role. The correct selection of testing technology and tools not only helps to comprehensively analyze and evaluate the performance of TENG, but also provides reliable data support for its design optimization, which ensures that scientific judgment and improvement can be made based on accurate experimental data when developing TENG technology.

2.3 The application of TENG

TENG greatly enhances the possibility of sustainable energy utilization. This technology is particularly suitable for small electronic devices and self-powered vibration induction systems. It has been applied in many fields such as industrial automation, health care and environmental monitoring. In addition, friction nanogenerators based on paper and cellulose also show broad application prospects in the fields of self-powered sensors, wearable devices and medical devices.

TENG technology has shown its strong potential in a variety of application scenarios. For example, in intelligent transportation systems, TENG can be used as a self-powered sensor to effectively detect oral exhaled gases in traffic and harmful gases in industrial production. In addition, TENG materials reinforced with inorganic fillers have also been applied in flexible sensors and wearable devices. The research of TENG technology has further deepened into frontier scientific and technological fields such as light detection, photoelectrocatalysis and the Internet of Things. Through these studies, it not only improves the effective use of energy, but also opens up new ways and strategies for the development of renewable energy technologies.

2.4 Advantages and disadvantages

In recent years, TENG has received extensive attention due to its efficient energy conversion capability and wide application prospects. Studies have pointed out that TENG has shown its remarkable advantages in many industries. It uses a variety of materials and has a simple design [1]. These characteristics make TENG very suitable for use in a variety of energy harvesting devices that convert mechanical energy into electrical energy. In addition, the technology also uses paper-based cellulose materials, which enhances its environmental protection and sustainability characteristics, making it particularly important in eco-friendly electronic products. [2]

Acomposite film process with inorganic fillers was used to improve the performance of TENG. This method not only proves the diversity of material selection and the ease of operation of the production process, but also provides advantages in terms of safety. The improvement of this technology enhances the function of TENG and expands its potential in various application scenarios, especially in the use of mobile electronic devices and automatic drive sensors, which greatly improves its ability to integrate multi-functions.

3. Future development direction

Future research can also focus on the application of TENG in extreme environments, develop new materials with high temperature resistance and biocompatibility, and expand their use in more harsh environmental conditions.

References

[1] Wu Yesheng, Liu Qi, Cao Jie, Li Kai, Cheng Guanggui, Zhang Zhongqiang, Ding Jianning, Jiang Shiyu to collect the vibration energy of the friction nanogenerator design and output performance [J]. Journal of Physics, 2019, 68 (19).

[2] Li Ming Qin Aimiao Lian Peng Hejin. Research progress of paper cellulose-based triboelectric nanogenerator [J]. Progress of Materials in China, 2021, 40(4).

[3] Han Chang Bao, Wang Manqi, Huang Jianhua, Zheng Jiayu, Zhao Wenkang, Zhang Hao, Zhang Yongzhe, friction and nano-power generation technology research progress and its potential application [J]. Journal of Beijing University of Technology, 2020, 46 (10).

[4] Zhou Long Tang, Jia Yijing, Li Xiaomin and Deng Yingnan.Research progress on performance optimization strategy and application of triboelectric nanogenerator [J].Petrochemical industry, 2023, 52 (12).

[5] Guo Yin Chen Zixi Wang Hongzhi, Zhang Qinghong, research progress on friction nanogenerator based on inorganic filler composite film [J]. Journal of Inorganic Materials, 2021, 36 (9)

[6] Wang Xiaoli, Niu Zhihao, Yang Weixu.Performance study of triboelectric nanogenerator based on hyperelastic PDMS [J].Journal of Beijing University of Technology, 2020, 40 (3).