PERSPECTIVE

The Rise of Nanogenerators

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DOI: 10.54162/SD01-25201/14

The present article discusses the recent advancements in the field of self-powered systems that harness mechanical energy from vibrations in the environment to generate electrical power. It introduces the concept of nanogenerators, which can convert mechanical energy into electrical energy through piezoelectric or triboelectric effects. These nanogenerators are lightweight, flexible, and have a high energy density, making them suitable for integration into portable electronic devices and wearables. The article also highlights their potential application as biomedical sensors for monitoring human health by capturing bio-mechanical stimuli such as heartbeat and pulse. The choice of materials and device engineering are crucial in developing flexible and wearable nanogenerators, with various materials like semiconductors, transition metal dichalcogenides, and perovskites being explored for their piezoelectric and triboelectric properties. There is a need for further research to bring these technologies into everyday life, focusing on material selection, device engineering, and signal transmission technology to advance energy harvesting and health monitoring systems.

Key words: Energy harvesting, Triboelectric, Nanogenerators, Wearable electronics

In an recent times, the scientific community has delivered significant efforts to develop self-powered systems to meet the enormous requirement of power sources in modern life. Thus, scavenging mechanical energy from vibrations originating from surrounding sources is considered to be an alternative source for generating electrical power [1,2]. In fact, the vibration arising from any kind of transportation, environmental events (like wind, rain etc) or daily activities of human life (like walking, running etc) etc are the predominant sources of mechanical energy. In this context, the researchers have come up with the development of tiny power generators, called nanogenerators that can convert such mechanical energy into electrical energy. The nanogenerators working under the influence of piezoelectric or triboelectric effect (i.e. generation of electricity through mechanical stress or contact) have the potential for energy harvesting applications [3]. The piezoelectric or triboelectric nanogenerators (PENG or TENG) can act as the tiny power sources that can be integrated to various portable electronic devices. The exploitation of PENG or TENG is advantageous owing to their light weight, flexibility and high density of energy. In this regard, tremendous interest has been exhibited in developing PENG or TENG devices that can be attached to human body or wearable cloths. The suitable engineering of the device material and structure is the key factor to develop such flexible and wearable PENG or TENG devices. To be specific, textile based nanogenerators have demonstrated potential towards the application as energy harvesting system from human daily activities. Apart from power sources for portable gadgets, such nanogenerators may find the use as biomedical sensors to monitor human health status. Since such devices rely on the external mechanical pressure, the bio-mechanical stimuli such as heartbeat and pulse, respiratory action can trigger the devices. Recently, the potential ability of the nanogenerators to sense these actions have been demonstrated upon mounting the devices on the human skin or on wearables [4]. Further various health conditions such as body temperature, sweat etc. have been found to influence the nanogenerator output and thus may find the probable application of several healthcare devices [1]. With the advent of various fabrication and processing techniques, it has been possible to fabricate a wide range of materials of varying composition and morphology for the application in such nanogenerators. Beyond the conventional ceramic or polymeric materials, it has been possible to fabricate different semiconductors, transition metal dichalcogenides, perovskites materials that

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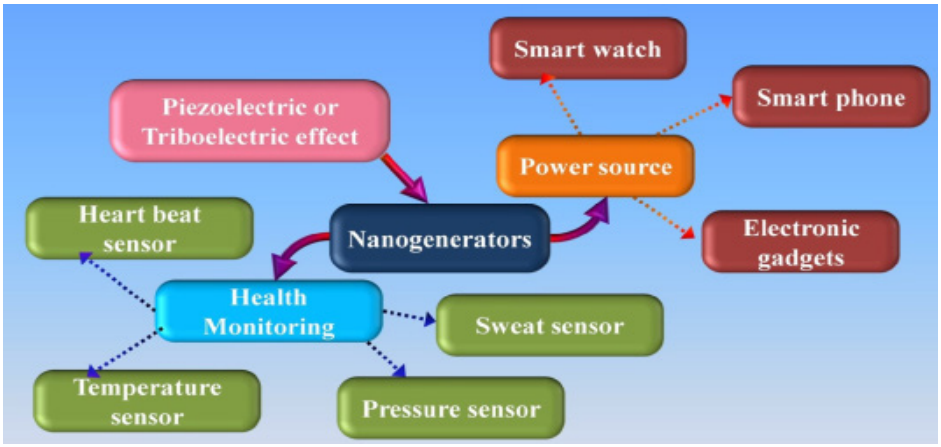

Schematic: Versatilie applications of Piezoelectric and Triboelectric nanogenerators.

exhibit triboelectric properties. The semiconductor materials such as GaN, ZnO, CdS etc. are advantageous to enhance or modify the nanogenerator properties by contributing their optoelectronic properties [5]. In addition, transition metal dichalcogenides, offer excellent flexibility due to their ultrathin layered morphology [3]. On the other hand, perovskite materials with excellent light harvesting capability have exhibited potential capability towards the application in nanogenerators [3]. In spite of these developments in material systems, the scientific community needs to go a lot to bring such technologies for daily life application. In this context, proper selection of active material and nanogenerator device engineering play crucial role and can open up the scopes for futuristic application. Hence, there are abundant scopes to explore the potential of piezoelectric and triboelectric nanogenerators through the investigation of the active material, device structure and signal transmission technology. Such exploration will definitely boost the requirement of energy harvesting technologies as well as health monitoring systems.

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