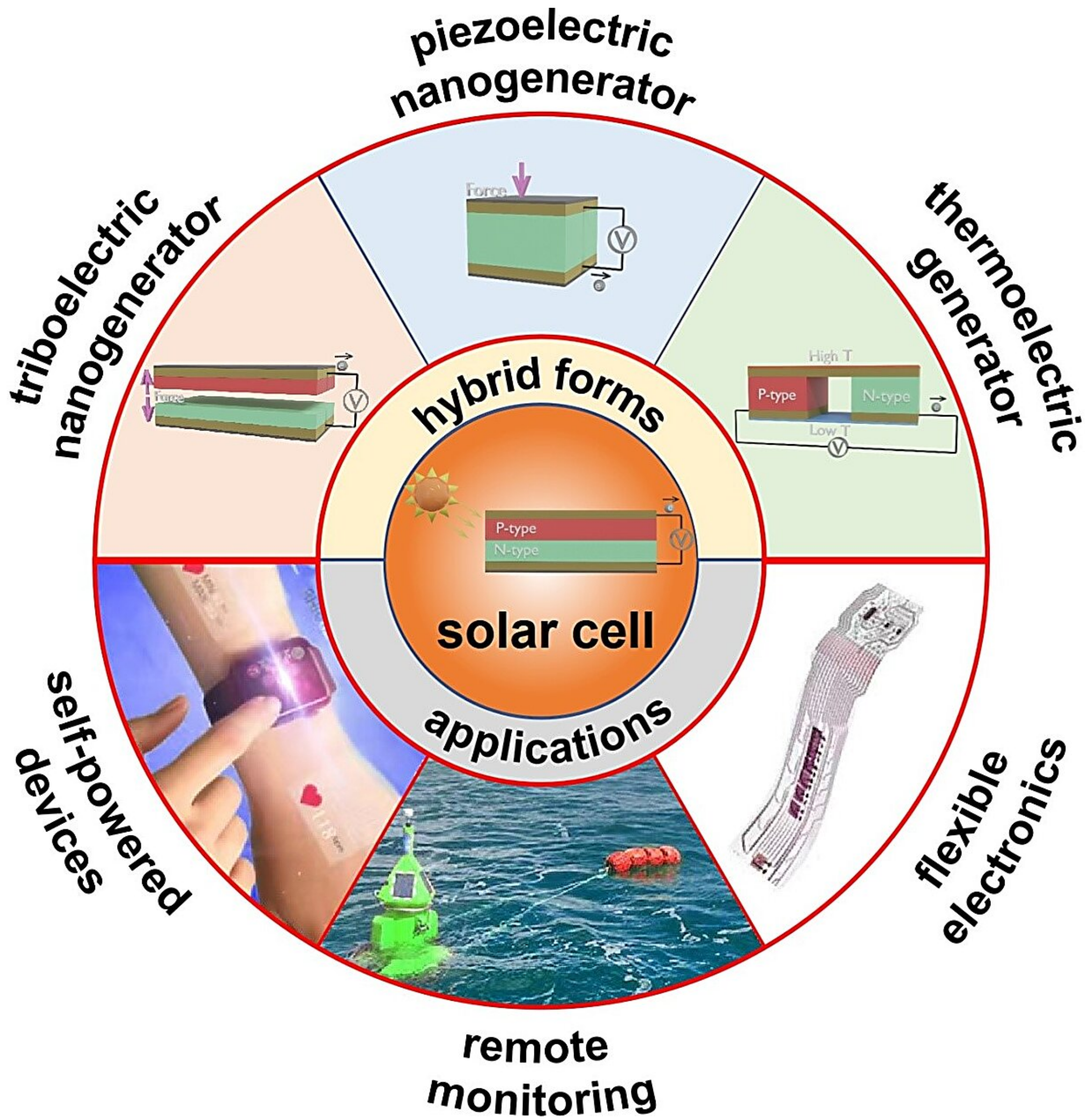
Scientists explore solar cell-based hybrid energy harvesters

September 15 2023



Credit: *Opto-Electronic Science* (2023). DOI: 10.29026/oes.2023.230011

Energy harvesting stands out as a vital player in our modern world. Solar energy, with its renewable and environmentally friendly characteristics, has gained immense popularity in various applications, ranging from small wearable electronics to powering large-scale systems. However, the challenge lies in making solar cells consistently reliable, as they are influenced by weather conditions.

This issue has sparked researchers to explore a novel solution: merging solar cells with other types of energy harvesters to create hybrid energy harvesters (HEHs). These hybrid systems use diverse mechanisms to capture energy from the surroundings. The work is published in the journal *Opto-Electronic Science*.

This review takes a closer look at four key types of energy harvesters: solar cells, triboelectric nanogenerators (TENGs), piezoelectric nanogenerators (PENGs), and thermoelectric generators (TEGs). It zooms in on the recent advancements in solar cell-based hybrid energy harvesters (SCHEHs), shedding light on their structures and practical applications.

The review outlines three specific designs that combine TENGs, PENGs, and TEGs with solar cells to create robust energy harvesters. Additionally, it addresses the challenges faced in developing these hybrid systems and offers insights into the directions of potential research of SCHEHs.

The driving force behind this research is the need to overcome the limitations of traditional energy sources and to make renewable energy technologies more dependable. By merging various energy harvesting methods, scientists aim to create more efficient and reliable energy solutions, contributing to a sustainable energy future.

The authors of this article review the progress of solar cell-based hybrid energy harvesters (SCHEHs) in recent years. It begins by explaining the principles and accomplishments of solar cells, triboelectric nanogenerators (TENGs), piezoelectric nanogenerators (PENGs), and thermoelectric generators (TEGs).

The review then involves the detailed structures of SCHEHs, explaining how they function and where they can be applied. Finally, the challenges faced in developing these hybrid systems are discussed, and the review concludes with insights into potential future advancements in this research field.

As we all know, the current energy challenges faced by society, including issues of availability, affordability, and sustainability, have spurred the need for a shift from fossil fuels to cleaner, renewable energy sources.

This transition has led to a focus on energy harvesting, a technology that has numerous benefits such as sustainability, reduced reliance on external power sources, cost savings, and environmental advantages. Energy harvesting plays a pivotal role in offering clean and dependable power solutions across various applications, contributing to a more sustainable future.

The motivation behind this review arises from the limitations of traditional energy sources and the growing concern for environmental preservation. Researchers have turned their attention to renewable energy sources, aiming to develop devices that can generate electricity without harmful pollution. These devices, known as renewable energy harvesters, tap into different environmental sources like wind, solar radiation, human motion, water waves, and waste heat.

Among these, solar cells have gained prominence due to their low maintenance costs, minimal carbon footprint, and abundant availability. While solar cells have seen substantial advancements in power conversion efficiency and stability, they are still reliant on sunlight, making them susceptible to weather conditions.

To address this challenge, scientists have been working on combining solar cells with other energy-harvesting technologies to create hybrid systems. These systems, like triboelectric nanogenerators (TENGs), piezoelectric nanogenerators (PENGs), and thermoelectric generators (TEGs), can harness energy from the environment via different mechanisms. By integrating these technologies, researchers aim to create more stable and continuous power supplies, ensuring reliable energy generation even when sunlight is limited.

Overall, SCHEHs offer a really hopeful way to make energy conversion better and improve how energy-gathering systems can be used. These systems blend the good parts of solar panels with other ways of collecting energy. This helps in making better ways to create power for many different uses, like making things work without needing to plug them in, watching things from far away, and having smart ways to get around.

Beyond this, these systems play a big role in helping the world use more types of energy that won't run out. This is really important as the world tries to move to using more energy sources that are good for the planet. In summary, the idea of blending different ways to make power in a hybrid system looks really promising and has been getting a lot of attention recently.

This review highlights recent breakthroughs in the realm of solar cell-based hybrid energy harvesters (SCHEHs), combining triboelectric, piezoelectric, and thermoelectric methods.

Solar energy, a leading contender in the energy landscape due to its clean and abundant nature, takes center stage. By teaming up solar cells with other energy harvesters, these hybrid setups can draw energy from multiple sources simultaneously, maximizing energy generation potential. Solar cells primarily depend on sunlight, which can be hindered by various factors.

Integrating alternative energy sources with solar energy ensures a consistent power supply. This strategic combination lets the system harvest energy from sources like mechanical vibrations and temperature differences, allowing continuous electricity generation even when sunlight is limited.

These hybrid systems capitalize on the unique strengths of each energy harvesting technique. For example, Solar cells shine in converting sunlight into electricity, while piezoelectric nanogenerators (PENGs) excel in converting mechanical vibrations into energy. By harmonizing these technologies, the hybrid system achieves optimal energy conversion efficiency and performance.

Furthermore, this integrated design increases power density, a significant advantage for space-constrained applications like wearables or small electronics. In cases where one component faces limitations, the others step in to maintain consistent power generation.

Overall, solar cell-based hybrid energy harvesters (SCHEHs) hold immense potential for improving energy conversion efficiency and expanding the versatility of energy harvesting systems.

Through their innovative combination of solar cells and diverse energy harvesting techniques, they pave the way for sustainable and efficient power generation across various applications. As research in this field advances, we can anticipate even more effective and adaptable energy solutions.

More information: Tianxiao Xiao et al, Solar cell-based hybrid energy harvesters towards sustainability, *Opto-Electronic Science* (2023). DOI: 10.29026/oes.2023.230011

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