Research on Energy Supply System for Low-Power Devices Based on Temperature Difference and Piezoelectric Conversion

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For sensors deployed in shaded field environments, it is difficult to utilize solar energy as a sustainable long-term power supply. This paper proposes an energy storage system driven by diurnal temperature variation, a type of clean energy. Two-way shape memory alloy (SMA) springs are used to convert temperature variation into spring displacement, and multi-layer stacked piezoelectric ceramic (PZT) is utilized to transform mechanical energy into electric charge, which is then accumulated in a capacitor to serve as the power source for short-term wake-up of sensors. In this paper, five schemes are compared, which are: thermal expansion of solids, liquids, and gases, gas-liquid phase transition, and SMA phase transition. Among these, two-way SMA is selected as the primary energy storage device, and PZT is employed as the energy conversion device. Experimental results show that a single SMA spring can output 0.11 J of mechanical energy within one cycle in an appropriate temperature range, and the efficiency of PZT is about 30%. When three SMA springs are connected in parallel, they can output 0.15 J of electric energy per cycle. This is sufficient to support sensors to realize one daily "wake-up". The proposed scheme provides a feasible alternative power solution for long-term field research with scarce sunlight. Additionally, the device can be extended to other cases, like space stations, lunar surfaces and marine floating sensors, which can also utilize diurnal temperature differences. The harvested energy is clean, stable and sustainable, offering a continuous power supply for low-power devices that need to maintain low-frequency operation or short-term wake-up in shadowed areas.

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