Using triboelectric nano-generator for high-frequency vibration monitoring

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Abstract

Triboelectricity is the phenomenon of generating surface contact electrification (when two dissimilar material brought in physical contact) and electrostatic induction (electron flow due to potential drop when the charged surface separate). A triboelectric nanogenerator (TENG) utilizes a triboelectricity mechanism to convert mechanical energy into electrical energy, and the performance is significantly influenced by the mode of operation, material properties, and surface contact area. Promising results have been achieved by improving the performance of TENG-based vibration energy harvesters by modifying these parameters. However, their function is limited to low frequencies. This work presents an optimized TENG-based vibration energy harvester for higher frequencies and a broad range of frequencies through structural design supported by numerical simulations. Two alternative structures are developed. One spring-assisted, and one freestanding ball in plate design, with the aim to study the effect of structural design on TENG output. The experimental results show that the developed TENG based samples can successfully harvest vibration energy within the frequency range of 0-1200Hz. Due to the optimized structural symmetry, larger surface contact area, and effective spring stiffness, the two spring-assisted (TS) structures generate higher electric signal output (up to 200V and 0.9μA). The application of developed TENG extended for TENG-based vibration sensor to monitor machine condition. The sensors generate uniform and stable signals when compared to the commercial vibration sensor and demonstrate promising potential to detect bearing defect.

Keywords; Triboelectric, structure design, vibration frequency, sensor, bearing defect.