On the Effect of Dielectric Relaxation Mechanisms on the Performance of a Multi-layered Triboelectric Nanogenerator

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Abstract: With the rapid development of the Internet of Things (IoTs), a growing number of mobile electronics are being connected to the internet and working in an environment without human interventions. Therefore, there is a crucial need for an alternative energy technology that can harvest energy from ambient environment to self-power devices, due to the inadequacy of conventional energy sources. Among the many energy harvesting technologies, triboelectric nanogenerators (TENGs) are attracting attention recently due to their flexibility, portability, cost-effectiveness and lightweight. TENGs utilize the triboelectric effect to generate electrical energy when two materials come in contact. The ubiquity of the triboelectric effect makes TENG a potential energy source for many applications, such as wearable electronics, smart buildings, and implantable medical devices. Previous studies have found that the performance of TENGs can be improved by employing a muti-layer material configuration where each layer contributes to a unique part in the charge generation and transport mechanisms. This improvement cannot be explained using theory since the theoretical calculations of the power output assume that the charges are confined at the contact surface. In this work, layered materials of Polydimethylsiloxane (PDMS) and P(VDF-TrFE) with different dipole orientations were investigated and assessed against single layered PDMS. The open-circuit voltage (V_{oc}) and short-circuit current (I_{sc}) of the samples contacting against Teflon, as well as the dielectric properties of the samples were measured. It is found that the V_{oc} increased by adding a layer of negatively poled P(VDF-TrFE) between PDMS and electrode, while the I_{sc} didn't show large difference among the samples. The change in V_{oc} is proposed to result from the accumulation of space charges at the interface of the layered materials. Simulation work was also carried out to support this hypothesis.