Effect of Stretch-Dependent Permittivity of Dielectric Elastomers on Power Generation Performance

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Introduction

Dielectric elastomers (DEs) are suitable for ambient energy harvesting for Internet of Things (IoT) devices due to their high elongation at break, light weight, and high-energy density [1]. One of the key issues is that their permittivity decreases when stretched, and the effect of this stretch-dependent permittivity on power generation output was unclear. In this study, we investigate how stretch-dependent permittivity influences the power generation performance of dielectric elastomers, through both experimental measurements and analysis.

Experimental Procedures

Pure silicone rubber (Pure SR) and 2.5 vol% TiO_2-filled silicone rubber composites (SR@2.5 vol%TiO_2) sheets were fabricated. The stretch-dependent permittivity of these samples was evaluated using an LCR meter. Then, their power generation performance was evaluated using the quadrangular scheme as applied by Song et al. [2] under the same experimental setup. Furthermore, theoretical power generation output, with and without considering stretch-dependent permittivity, were calculated and compared with the experimental results.

Results and Discussion

The incorporation of TiO_2 particles increases the permittivity of silicone rubber sheets. Our previous studies have already demonstrated that the relative permittivity of SR@2.5 vol% TiO_2 and Pure SR decreases with increasing stretch ratio, and the decrease rate (stretch dependence) is roughly the same for the two materials. As shown in Figure 1, the power generation output of the SR@2.5 vol% TiO_2 was about 17% higher than that of the Pure SR. When the stretch-dependent permittivity was considered in theoretical calculations, the difference between theoretical and experimental output was reduced. Further analysis revealed that stretching reduces the permittivity, which decreases the input charge during DE's input–output cycle and thereby lowers its power generation output. In the future optimization of DE for energy harvesting, stretch-dependent permittivity should be considered a limiting factor. Therefore, achieving both high permittivity and low stretch dependence is essential for maximizing the power generation output of DE-based energy harvesters.

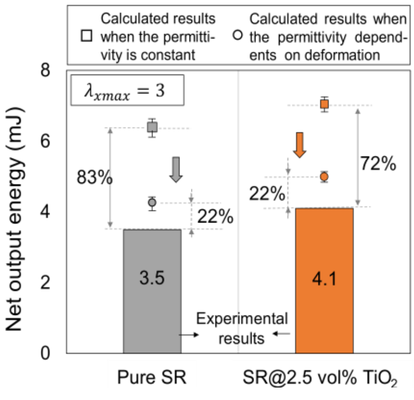

Figure 1 Experimental and theoretical results of the net generation output of Pure SR and SR@2.5 vol%TiO_2 [3]

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