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Bilayered polydimethylsiloxane (PDMS) composite for dielectric elastomer applications

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ABSTRACT

Dielectric elastomers (DE) are used in various applications, such as actuator, generator and sensor. Despite its many advantages, DE also has limitation in its performance which is low relative permittivity. Many approaches that have been reported to increase the relative permittivity of DEs such as incorporated with permittivity enhancing fillers to PDMS films, however, it leads a drawback to other parameters (high Young's modulus and low breakdown strength). In this study, PDMS films were incorporated with high permittivity fillers which are hard filler (Titanium dioxide) and soft fillers (silicone oil and glycerol) and the synergistic effect of soft and hard filler through bilayer hybridization technique was investigated. The bilayered technique showed that there was an increase of relative permittivity of PDMS films without affecting the other parameters severely; the breakdown strength and Young's modulus of the PDMS films were kept on the acceptable level therefore, the figure of merit (FOM) of the bilayered PDMS films are higher than that in single layered.

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1. Introduction

Discovered in the early 1990 s, dielectric elastomer (DE) can be defined as soft insulating material that has potential to produce large strain with the present of the voltage. Because of DE is soft and can produce large strain, therefore DE are often referred for artificial muscle application [1]. Not only it has large strain, others advantages of DE include low cost [2], very low noise [3], light weight [4] and fast response [3]. The structure of DEs are based on an elastomer film sandwiched between thin and compliant electrodes. This advanced technology can be used for actuators, transducer and sensor.

Polydimethylsiloxane (PDMS) elastomers were chosen as DE in this study. This is because according to [5], PDMS have excellent properties such as high in efficiency, fast response times, can operated at broader temperature and lower viscous loss than other elastomers (e.g., acrylic elastomers). Lower viscous loss means that PDMS can maintain the mechanical stability of the elastomer even at higher frequencies. However, PDMS also have disadvantages such as low tear [6], tensile strength [2], and relative permittivity [7].

Therefore, in order to get better performances, the relative permittivity of PDMS should be improved. As many researchers reported, to improve one parameter of DE will normally affecting other parameters in negative way[8,9]. Thus, the other parameters should be carefully considered during parameter optimization to ensure all positive attributes can be achieved. In this research, Young's modulus and breakdown strength are the parameter that also should be considered to not affecting the DE negatively.

There are various techniques to produce high relative permittivity of the PDMS elastomers by adding various type of fillers to the PDMS is the one of the prominent techniques [10–16]. In this research, fillers for elastomer can be categorized into two types, which is hard filler such as adding several amounts of metal oxide for the example titanium dioxide or zinc oxide into PDMS matrix (compositing technique) and soft filler that refer to the addition of liquid type of fillers such as silicone oils (blending in of high-permittivity oils)[12].

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