Investigation on the Electrical Breakdown Strength of Soft Dielectrics

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Abstract

Soft dielectrics, as one category of electroactive materials, are capable of producing exceptionally large deformation under electrical stimuli [1]. Due to this unique property, soft dielectrics have extensive applications, such as artificial muscles, soft robots, actuators, oscillators and energy harvesters [2]. In these applications, soft dielectrics are subjected to an electric field, which can be realized by applying direct voltage or spraying charges on their surfaces. For safety reasons, one critical issue of using soft dielectrics lies in determining their electrical breakdown strength. However, as discussed in the literature, the electrical breakdown strength of soft dielectrics can be affected by various factors, such as elstic properties, deformation and original thickness of the material [3]. On the other hand, robust methods accounting for all these effects to predict the electrical breakdown strength of soft dielectrics are still lacking. Therefore, this work aims to develop a novel method to determine the electrical breakdown strength of various types of soft dielectrics. Among the existing studies on the cause of the electrical breakdown, the theories that attribute it to the evolution of instrinsic defects in the material have attracted much attention. When considering that the electrical breakdown of soft dielectrics is linked to the evolution of the intrinsic defects, configurational mechanics appears to be a suitable tool to determine the electrical breakdown strength. First proposed by Eshelby [4], configurational mechanics focuses on the evolution of the defects within the material. Based on the theory of configurational mechanics, this work presents a novel and universal method to predict the electrical breakdown strength of soft dielectrics. With the developed method, electrical breakdown data measured from different experiment set-ups can be well captured. Moreover, the developed method can be implemented in finite element simulation for soft dielectrics with different configurations. This work is expected to provide helpful solutions to the long-standing issue of using soft dielectrics and insights into imrpoving the electrical breakdown strength of soft dielectrics, which is also a significant topic for their applications.

References

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