Accepted Manuscript

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PII: S0266-3538(16)30706-0

DOI: 10.1016/j.compscitech.2017.07.022

Reference: CSTE 6847

To appear in: *Composites Science and Technology*

Received Date: 11 July 2016

Revised Date: 1 July 2017

Accepted Date: 25 July 2017

Please cite this article as: Ji W, Deng H, Fu Q, Heterogeneous filler distribution in polymeric capacitor films: An efficient route to improve their dielectric properties, *Composites Science and Technology* (2017), doi: 10.1016/j.compscitech.2017.07.022.

Heterogeneous Filler Distribution in Polymeric Capacitor Films: an Efficient Route to Improve Their Dielectric Properties

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Abstract: High dielectric constant filler is often used to improve the dielectric properties of polymer. Most studies are focused on the uniform filler dispersion and interface between filler and polymer. Herein, multi-layered films containing $BaTiO_3$ and multi-wall carbon nanotubes (MWCNTs) as fillers, with different filler distributions were designed and prepared, including alternating distribution of layers with/without filler; core-shell distribution with filler concentrated at core or shell; and uniform distribution. The overall filler content in these films was kept constant. These films have almost the same dielectric loss. Interestingly, it was noted that the largest dielectric constant is achieved for sample with filler concentrated at the shell (around 50% higher than the rest at low frequency). Interfacial polarization and filler localization are thought to play important role. However, classic Series model does not take these issues into account. To understand this, a modified Series model was proposed to calculate the dielectric constant of multi-layered films by considering these issues. Such equation is much more accurate at describing experimental results from current study as well as some published literature than classic Series model. Our work demonstrates the importance of hierarchical structure in polymer composites for dielectric property and heterogeneous distribution of filler could be much better than uniform distribution.

Keywords: Nanocomposites, Dielectric, multi-layered, Energy density, Polymer

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1. Introduction

Dielectric capacitor has gained extensive interest due to its fast charge-discharge capability [1-3] which offers the highest power density among currently available electrical energy storage devices [4]. However, its low energy density has limited its application and needs to be further