Effect of Interphase Region and Neighboring Particles on Electric Field Intensity within Nanocomposite Systems

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***Abstract*—Recent works show that the presence of the interphase surrounding nanoparticles can improve the dielectric properties of nanocomposites. Also, neighboring particles in the nanocomposites affect the electric field distribution. Therefore, the objective of this paper to model and analyze the effect of one-dimensional (1D) nanofillers towards the electric field distribution when the interphase and neighboring are taken into account inside the nanocomposite system. By using Finite Element Method Magnetics (FEMM) 4.2 software, a model of nanocomposites system consists of polymer matrix, nanoparticle filler with interphase and neighboring particles is modeled under the electrostatic problem module. Electric field intensity is observed with different distance between adjacent nanoparticles and interphase region permittivity values. The result obtained show that the presence of the interphase with various permittivity value will result in distorted electric field intensity surrounding a nanoparticle. Furthermore, the electric field intensity also affected when adjacent nanoparticles displaced between each other within nanocomposites.**

***Index Terms*—Electric Field Intensity; Interphase; Nanocomposites; Neighboring Particles; Permittivity.**

I. Introduction

Nanotechnology have grown in various applications such as in the field of electronics, electrical, bioengineering and material and mechanical engineering [1, 2]. The study of the nanostructure materials has been emerged for the past half century in terms of electrical, mechanical, thermal and other properties which can enhanced the polymer nanocomposite properties [1-5]. Polymer nanocomposites has been well known among researchers as it contains the combination of any nanofiller's shape with base polymer through blending process. The unique combinations of this materials promise the enhancement of the dielectrics properties on the electrical conductivity, breakdown behavior, treeing resistance, corona resistance, etc. All these have in [2-15] and this phenomena is now inviting interest among other researchers. Polymer nanocomposite also exhibits breakdown mechanism similar to pure polymer [16-18]. The presence of the interphases region (a layer between the polymers matrix and the nanofiller) and the neighboring nanoparticles are claimed can affect the material properties.

Many reports have been written on the properties of the interphase between nanoparticles and the polymer matrix that can influenced the nanocomposites system [6, 10, 11, 13, 19-23], however there are still lack of discussion and analyses that have yet to be revealed especially the effect of the neighboring particles in the polymer nanocomposite and the preposition of the interphase region. It is important to study the influence of the interphase and its affect towards the neighboring particles in the nanocomposite materials to the electric field distribution due to the interaction and interplay between nanoparticles remain unsatisfactory.

Therefore, this paper continuous to the previous work in [13] in order to clearly understand the role of the interphase in the nanocomposites study of the previous work focusing on the effects of the neighboring particles. The analysis of the effect of interphase and neighboring particles on the electric field distribution is achieved by modeling one-dimensional (1D) nanofiller as nanoparticle filler in polymer matrix by using Finite Element Method Magnetics (FEMM) 4.2 software.

II. Modeling and Parameters Description

The dimensions of the design in the FEMM 4.2 software under electrostatics model were initialized by using a simple polymer slab with thickness of 1 μm and width of 2 μm, placed between 10 kVdc High Voltage (HV) potential and 0 V ground potential, as shown in Figure 1.

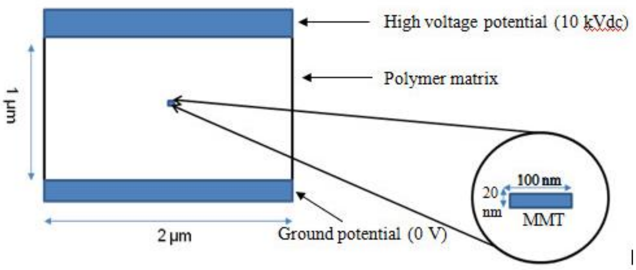

Figure 1: A two dimensional slab with thickness 1 μmand width 2 μm was placed between 10 kV DC high voltage (HV) potential and 0 V ground potential.

As a starting point, all of the designs were accomplished by using specific permittivity value for the polymer matrix and the nanoparticle filler. Based on the literature review, polyethene with dielectric permittivity, εr = 2.3 [9, 24, 25] was selected as the polymer matrix while the chosen (1D) nanofiller was montmorillonite nanoclay (MMT) with εr=5.5 [26]. For analyze the effect of the interphase region and neighboring nanoparticles, the information above was considered for all subsequent modeling. Meanwhile, the theoretical model of the spherical interphase region surrounding one-dimensional (1D) nanofiller with discrete thickness based on 'water shell' that has been emphasized and