

Modeling of Nanocomposite Structures to Evaluate the Effect of Nanoplatelet Interphase Region on Electric Field Intensity

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Abstract—The effects of the nanoplatelet interphase region on the electric field intensity within a nanocomposite structures are presented in this paper. The modeling of the nanoplatelet and its interphases was performed by using the Finite Element Method Magnetics (FEMM) 4.2 software. Two possible structures of the nanoplatelet were simulated – with and without interphases. In addition, two different models of interphase structures surrounding the nanoplatelet were analyzed – one with rectangular-shaped interphase and the other with circularly-shaped interphase. Both sets of the model interphase were assumed to have different thicknesses and radii. The results showed that the presence of the nanoplatelet interphase affected the electric field intensity of the nanocomposite.

Index Terms—Interphase; Modeling; Nanocomposite; Permittivity.

I. INTRODUCTION

The development of polymer nanocomposites has led the boost of interest in evolving materials for the use in dielectrics and electrical insulation systems [1]. The combination of polymer and a small amount of nanofiller (i.e., polymer nanocomposite) has been found can enhance the thermal, electrical and mechanical properties of the materials compared to its microfiller-added counterpart [1]. The enhancement includes the dielectric properties such as the partial discharge (PD) resistivity, DC breakdown strength, high voltage arcing, and water treeing [2-4].

Polymer nanocomposites nevertheless will exhibit breakdown similar to many pure polymers [3, 5]. Recent researchers claimed that the interphase region, which is a layer between the polymer matrix and the nanofiller is an important region that could contribute not only to unique electrical properties such as increased the breakdown strength, but also it contributes to less favoured dielectric behavior [2, 6-13].

In order to clearly understand the effect of nanoplatelet interphase in nanocomposites, it is important to study the influence of the interphase behavior in nanocomposite materials. Therefore, in this paper, analysis on the effect of nanoplatelet interphase region on the electric field intensity is presented. By varying the structure and the permittivity values of the nanoplatelet's interphase, the results showed that the

presence of the interphase can reduce and increase the electric field intensity within the model nanocomposite depends on the structure development.

II. MODELING

A. Parameters

The electrostatic module in FEMM 4.2 was used to model a nanocomposite and analyse its subsequent electric field distribution. A unit cell model comprising a slab polymer with a nanoplatelet was assumed to be placed between two electrodes (high voltage vs. ground) (see Figure 1). The properties of the polymer, the nanoplatelet, and the interphase were assumed as in Table 1. The assumed permittivity values used in the analysis are shown in Table 2.

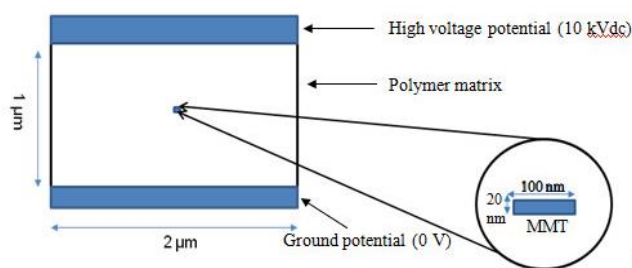


Figure 1: A two dimensional slab with 1 μm thickness and 2 μm width was placed between a 10 kV DC high voltage (HV) electrode and a 0 V ground electrode.

For the ease of simulation, several assumptions were made, such as [6-8]:

- The model contained a nanoplatelet uniform in size,
- The nanoplatelet had interphases which were uniform in size,
- The nanoplatelet were homogeneously dispersed within the polymer,
- The nanoplatelet interacted strongly with the polymer,
- The change in the electric field intensity was mainly affected by the variation in permittivity,