Modelling the dielectrical properties of random heterogeneous materials (using COMSOL Multiphysics).

Introduction. Dielectric properties of heterogeneous materials have been the subject of considerable attention over several decades [1]. A heterogeneous material consists of domains of different materials or the same material in different states. The heterogeneity is characterized by a spatially dependent permittivity which takes different values in the different components and which may be random in some fashion. The size, shape, spatial arrangement and interactions between the different constituents of the material medium are the key to their dielectric properties. Understanding the effective permittivity of these materials is very important, as the permittivity of a material is a fundamental property, a knowledge of which is required for many applications [1].

The question is how the permittivity of random heterogeneous media, composed of different phases, depends on the randomness of its microstructure, permittivity and volume fraction of components? Except for a few special geometries, exact predictions of the effective permittivity are generally very difficult. However the computational techniques can be used to accurately characterize structure–dielectric property relationships of heterostructures [1-3].

Objective: Calculation of effective dielectric properties of a two-component random heterogeneous material in the quasistatic limit by using the numerical Finite Element Method (software Comsol Multiphysics).

Tasks:

- Read articles related to the subject, study the basic of the Finite Element Method and commercial software Comsol Multiphysics.
- Design and model the microstructure of the two-component random heterogeneous material.
- Carried out numerical studies of the effective permittivity as functions of volume fraction and (frequency-dependent) permittivity of components.

Requirements:

- Prior knowledge (undergraduate level) of Electromagnetic fields.
- Basic Matlab programming skills.

References:

[1] C. Brosseau, Modelling and simulation of dielectric heterostructures: a physical survey from an historical perspective, *J. Phys. D: Appl. Phys.* 39, pp.1277–1294, 2006.

[2] E. Tuncer, Y. V. Serdyuk, and S. M. Gubanski, Dielectric mixtures: electrical properties and modeling," *IEEE Trans. Dielect. Elect. Insul.*, vol. 9, no. 5, pp. 809-828, 2002.

[3] C. Brosseau and A. Beroual, Computational electromagnetics and the rational design of new dielectric heterostructures, *Progresses in Materials Science*, vol. 48, pp. 373-456, 2003.