FEM Modeling in Robust Design for Graphene-Based Electromagnetic Shielding

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Abstract

Introduction
Electromagnetic shielding design is usually approached referring to nominal values of the main parameters. This could lead to malfunctioning devices and its performance differ widely from what was really aimed at or, worse, the final design product could even be physically unrealizable. This work presents a robust approach to the design of EM Shielding based on Graphene (Gph) layers. It is a two-dimensional sheet of carbon atoms, discovered in 2004. Since then, high-quality Gph proved to be surprisingly easy to isolate, giving birth to an exponentially increasing interest spreading from basic science to applications. In particular, as far as shielding is concerned, It must be highlighted that it is almost two hundred times stronger than steel, conducts heat and electricity with great efficiency and is nearly transparent and very flexible. Nevertheless Gph-based materials have technological fabrication processes still not assessed on well-known and defined standards as well as conduction mechanisms governing its EM behavior. A Robust Design approach is necessary and, an adequate analytic and simulation model to operate with.

USE OF COMSOL MULTIPHYSICS®
The implemented model uses "Port" settings for boundaries in AC/DC Module of COMSOL Multiphysics® software and refers to a thin layer representing Gph and a thicker bulk support of PMMA as reported in Figure 1. Port settings have proved to be crucial to implement the incident wave in AC/DC Module, which has been chosen instead of th RF one in order to be able to simulate nonlinearities and complex dependences in the future development of the model. Thickness of the Gph layer and its conductivity fall within a range for which it is possible to apply the thin-film approximation in FEM modeling.

RESULTS
A plane wave is simulated incident on a infinite electromagnetic shield as shown in Figure 1. Simulations are carried out varying two parameters: thickness of Gph layer (t) and conductivity (sigma). This work presents a robust approach to the project of an electromagnetic shield based on Gph. It is assumed that these two physical parameters of the device are characterized by measurement uncertainty (uncontrollable physical parameters) or variability given by technological processes (controllable physical parameters). Literature data are employed of an electromagnetic shield based on Gph in which it is shown the Shielding Effectiveness (SE) within the frequency range [20-40] GHz. A robust design of the device is realized with particular

attention to the central frequency. The commercial software COMSOL Multiphysics is adopted to simulate it. A combination of Montecarlo approach (MC) and vertex analysis (VA).

CONCLUSION

Robust design has proved to be crucial and fundamental to reliable implementation of Gph-based EM shielding. Moreover, comparison between simulation results and experimental measurements will be carried out in future development of our research, to implement a useful tool capable of modeling main shielding features and also possible non idealities and nonlinearities for future devices design. In particular further investigation can be imagined in the direction of multi-layer modeling and taking into account the possibility to substitute PMMA with newer and more performing materials.

Reference

[P. Khuzir, A.G.Paddubskaya, “Microwave absorption properties of pyrolitic carbon nanofilm”. Nanoscale research letters 8:60. 2013]

Figures used in the abstract

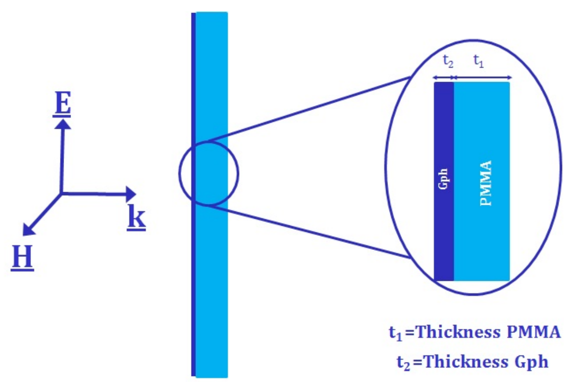

Figure 1: Transverse Section of the modeled structure and representation of the incident EM wave

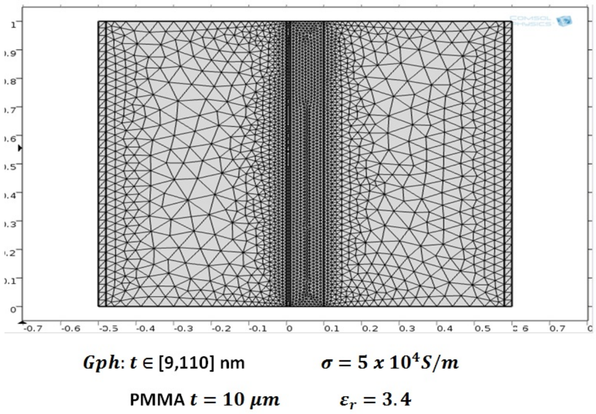

Figure 2: FEM Mesh for the simulated structure.

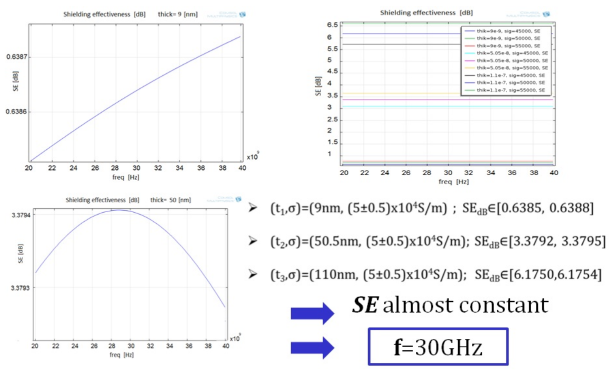

Figure 3: Central Frequency. Robust Solution found: (t,σ)=(110nm,5x104S/m)

Figure 4