Graphene based paint-like composites for electromagnetic shielding in the GHz frequency range

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Nowadays, wireless communication systems have resulted in an increased electromagnetic (EM) radiation background, which can influence biological systems as well as the operation of all electronic devices. This is known as electromagnetic interference (EMI), an effect that can cause malfunction of, as an example, sensitive medical devices and robotic systems or even become harmful to life. As a result, both systems and operators need protection in cases where they are close to EM radiation sources. Therefore, it is necessary to develop materials offering EM shielding at particular frequencies used in wireless systems.

Since the shielding materials must possess good electrical conductivity, metals such as aluminum, copper and steel are the most common and active materials used for EM shielding. However, there are several limitations in the applicability of metal in EM shielding applications since they are heavy, not easily handled/applied and they suffer from corrosion. As a result, the scientific community is trying to develop new EM shielding materials, a trial that has been significantly supported by the advances in materials science and nanotechnology. Among other materials, polymer composites containing carbon-based fillers (e.g., graphite, carbon black, carbon fibers, and carbon nanofibers) have been investigated for use in EM shielding applications[1] owing to their unique combination of electrical conduction, flexibility, light weight and corrosion resistance. However, so far the results did not allow yet an extensive use of composite materials in commercial applications and further research is required regarding materials, growth methods and understanding of the EM shielding mechanisms.

More recently, graphene has been suggested as an ideal candidate for the formation of polymer/graphene nanocomposites with improved mechanical and electrical properties[2] and its possible use in various applications including EM shielding[3] have been studied. It is the purpose of our work to investigate the applicability of graphene based paint-like composites in EM shielding for the frequency range of 2-24 GHz.

The samples used were based on paint-like compositions deposited on foam board. During preliminary tests, the composition was optimized regarding the polymeric binder employed, since some binders were observed to diminish both the conductivity and the EM shielding performance of the final coating. In all cases, water soluble binders were chosen in order to get an environmental friendly EM shielding material. Some binders were found suitable as dispersing agents but they were promoting foaming of composition. Poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (named PEDOT:PSS) was finally proved to be the most promising binder. Although it possesses barely acceptable binding properties, its remarkable conductivity allowed the use of fairly large amounts in order to compensate for the low binding capacity. In the present study compositions based on graphene flakes, HCl doped polyaniline and PEDOT:PSS dispersed in distilled water were examined. The dispersed solid phase was kept around 10% by mass in order to obtain a reasonably thin paste that can be deposited on foam board.

Regarding the transmission measurements, these were performed in free space, using a Hewlett-Packard 8722 ES vector network analyzer and four sets of microwave standard-gain horn antennas covering the range 3-24GHz. Prior to every measurement, an absorbing chamber was created using typical microwave absorbers (ECCOSORB AN-77, Emerson & Cuming Microwave Products, Inc., Randolph, MA) over all surfaces except the top, and each sample was placed in the middle of each set of horn antennas.

For the scopes of this work, graphene flakes/HCl doped polyaniline/PEDOT:PSS coatings of various concentrations and thicknesses deposited on foam board were tested regarding their EM shielding applicability. Their basic characteristics such as structural, morphological and electrical properties were also investigated and their correlation with the EM shielding performance was examined.

Acknowledgements: This project is implemented through the Operational Program "Education and Lifelong Learning" action Archimedes III and is co-financed by the European Union (European Social Fund) and Greek national funds (National Strategic Reference Framework 2007 - 2013).

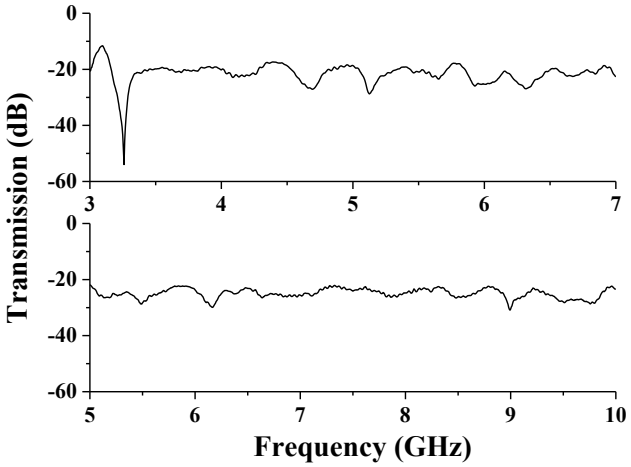
References

[1] Y. L. Yang, M. C. Gupta, K. L. Dudley, R. W. Lawrence, Nano Lett**, 5(11)** (2005) 2131.

[2] B. Shen,W. Zhai, D. Lu, W. Zheng and Q. Yan, Polym Int., **61** (2012) 1693.

[3] W. Song, M. Cao, M. Lu, S. Bi, C. Wang, J. Liu, J. Yuan, L. Fan, Carbon, **66** (2014) 67.

Figures



A typical example of GHz electromagnetic shielding in paint-like graphene composites