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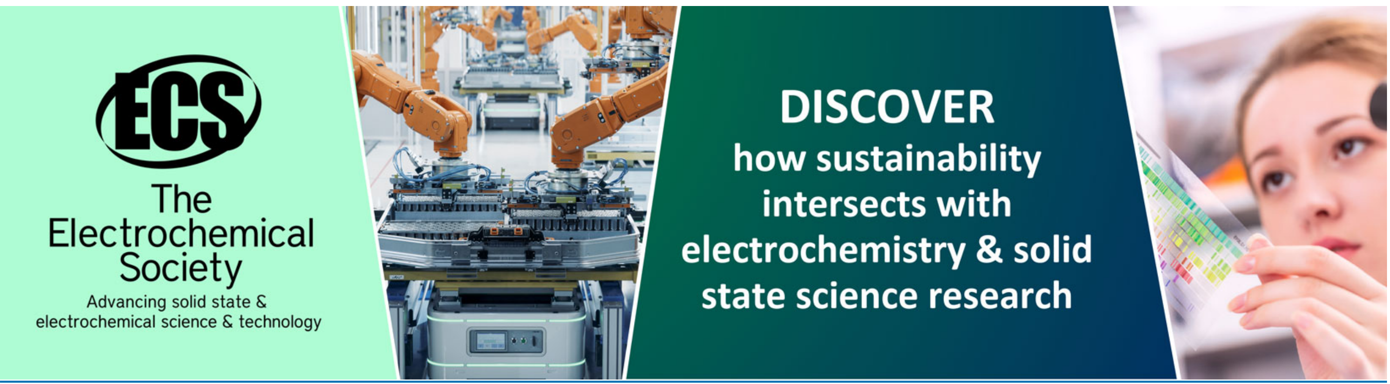

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Using graphene/styrene-isoprene-styrene copolymer composite thin film as a flexible microstrip antenna for the detection of heptane vapors

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Abstract. Most portable devices, such as mobile phones or tablets, use antennas made of copper. This paper demonstrates the possible use of antenna constructed from electrically conductive polymer composite materials for use in those applications. The method of preparation and the properties of the graphene/styrene-isoprene-styrene copolymer as flexible microstrip antenna are described in this contribution. Graphene/styrene-isoprene-styrene copolymer toluene solution was prepared by means of ultrasound and the PET substrate was dip coated to reach a fine thin film. The main advantages of using PET as a substrate are low weight and flexibility. The final size of the flexible microstrip antenna was 10 × 25 mm with thickness of 0.48 mm (PET substrate 0.25 mm) with a weight of 0.110 g. The resulting antenna operates at a frequency of 1.8 GHz and gain –40.02 dB.

1. Introduction
Nowadays, electronic devices use mainly copper based microstrip antenna for communication between each portable device in a network [1-3]. In many fields of science one of the most promising materials is graphene. There are ever increasing possibilities for the use of graphene in electronics. The main reasons for employing this material are their characteristics such are good conductivity and flexibility achieved by necessary adjustments, and a great potential for miniaturization. These composite materials can perform several functions simultaneously, they can be applied to a variety of products and active surfaces not only in the confines of ICT. This contribution is focused on the use of graphene in a passive antenna, which consists of a layer of graphene/styrene-isoprene-styrene copolymer, applied to a PET substrate.

The aim of this research is to produce a layer with the lowest possible resistivity, which ensures that the material used for the construction of the antenna is highly suitable. The specimen produced for the antenna contains graphene particles. In addition, the final price plays an important part when eventually incorporated into the applications and devices.

2. Experimental methods
Graphene/styrene-isoprene-styrene copolymer was used as a polymer with conductive filler base for the preparation of a conductive antenna layer. The flexibility and the mechanical properties of

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synthetic rubbers combined with the processing abilities of plastics, makes a great material. Low hardness and low viscosity are the primary advantages for easy thermoplastic processing as well as being of a soluble state. Styrene-isoprene-styrene copolymer was dissolved in toluene to reach a 16% wt polymer solution. Graphene particles sized 50 μm were treated using sonication in toluene by means of the sonication horn UZ Sonopuls HD 2070 kit for 15 minutes to disperse the graphene particles. The obtained dispersion was mixed together with a styrene-isoprene-styrene copolymer solution and stirred for two hours. The resulting solution contained 25% wt of graphene particles. The PET substrate was dipped into the graphene/styrene-isoprene-styrene copolymer and toluene solution for 10 s to attain the resulting active layer. The composite was kept at room temperature for 48 hours in order to dry completely [4-6].

The PET substrate strip (10 × 25 mm) was coated using the dip coating method. Figure 1 demonstrates the process of dip coating the PET substrate by graphene and styrene-isoprene-styrene copolymer solution. First step: Dip the specimen perpendicularly into the solution in order to dip coat it. Second step: Coating PET substrate by prepared copolymer dispersion. Third step: Gently raise the specimen vertically upwards. Fourth step: The film thickness is possible to control by the numbers of dipping of specimen and also on the speed of removal of the specimen.

The prepared microstrip antenna was measured by frequency analyzer for the measure of the resonant frequency. The antenna was located to the close chamber with was filled by saturated heptane vapors. The parameters of sample such are resonant frequency and gain was continuously measured in time. The resulting curves are visible in the figure 3.

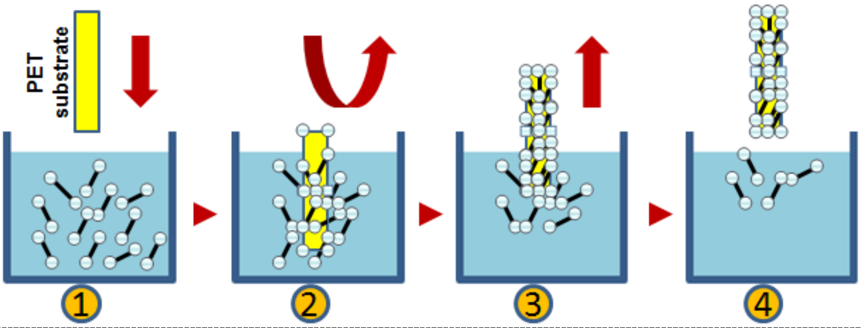

Figure 1. Preparation of electrically conductive layer using the dip coating method.

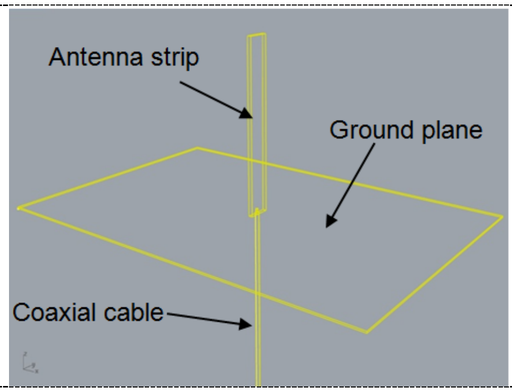

Figure 2. Construction of the antenna with antenna strip (coated PET), ground plane and coaxial cable.

3. Results

All measurements of the prepared antenna were performed in an anechoic chamber using the N9912A FieldFox Handheld RF spectrum analyzer with a measuring range between 2 MHz to 4 GHz. By means of this spectrum analyzer the parameter S11 was measured; this parameter determines the best frequencies of impedance matching for the antenna. The dimensions of the coated PET substrate are 10 × 25 mm. The total weight of the coated antenna is 0.402 g. The final size of flexible micro strip antenna was 5 x 50 mm with thickness of 0.110 g (PET substrate 0.25 mm). The ground plane of the antenna is made from FR-4 copper substrate sized 65 × 75 mm (Figure 2). All measured values (Figure 3) show that the PET substrate and graphene (styrene-isoprene-styrene copolymer) in combination with the dip coating technology proved to be very promising materials. By combining these materials a very efficient design of the microstrip antenna was achieved. Micrographs (Figure 4) obtained by scanning electron microscopy (FEI Nova NanoSEM 450) showed graphene (styrene-isoprene-styrene copolymer) conductive structure on the PET substrate.

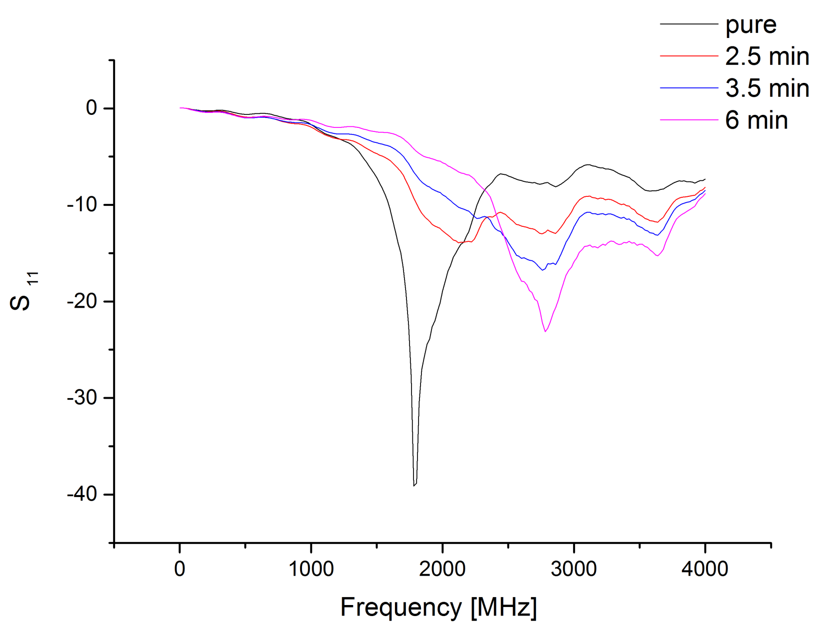

Figure 3. This graph represents the course of reflection coefficient "r" depending on the frequency in dB. (S11) for Heptane 1.8 GHz (-40.02 dB).

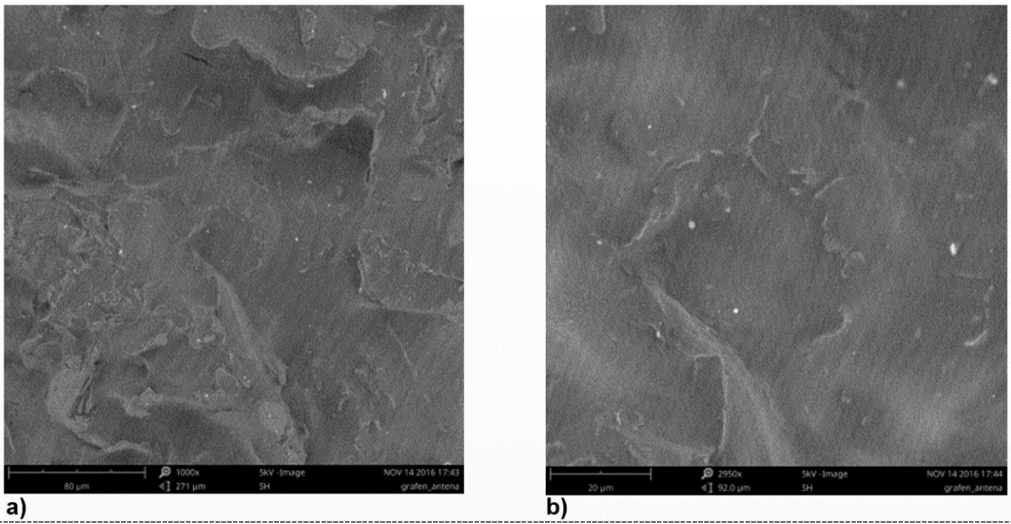

Figure 4. (a) SEM microscopy of the conductive structure on the PET substrate (scale of 80 μm), (b) SEM microscopy of the conductive structure on the PET substrate (scale of 20 μm).

4. Conclusion

Graphene particles and styrene-isoprene-styrene copolymer were used to prepare a conductive antenna layer. The antenna works at frequency 1.8 GHz (−40.02 dB) and can be used in the field of telecommunications. The main advantages are its light weight and the possibility for it to be incorporated into mobile phone covers. Additionally, the antennas could be applied to plastic covers used for portable telecommunication devices and also wearable electronics. The carbon graphene and styrene-isoprene-styrene copolymer network as an antenna could replace more commonly used materials in the future.

All portable telecommunication devices, such as mobile phones, used for communication purposes having antennas made of copper foils and strips, could be replaced in the future by the developed antenna. The majority of widespread technologies, e.g. LTE, GSM, UMTS operate at frequencies for which it is possible to produce a customized antenna using carbon nanotubes and styrene-isoprene-styrene copolymer deposited on the PET substrate because the PET substrate is frequently used for the next generation of the flexible antenna [7-15].

Acknowledgments

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