1-1-2013

Modelling of polyaniline for wi-fi electromagnetic interference shielding

Whamid Al-Shabib
Edith Cowan University

Stefan W. Lachowicz
Edith Cowan University

10.1109/ICMSAO.2013.6552654
Al-Shabib, W., & Lachowicz, S.W. (2013). Modelling of polyaniline for wi-fi electromagnetic interference shielding . Proceedings of the 2013 International Conference on Modeling, Simulation and Applied Optimization (ICMSAO). Hammamet, Tunisia. IEEE.

Modelling of Polyaniline for Wi-Fi Electromagnetic Interference Shielding

Whamid Al-Shabib
Edith Cowan University
Joondalup, Australia
W.Al-shabib@ecu.edu.au

Dr. Stefan W. Lachowicz
Edith Cowan University
Joondalup, Australia
s.lachowicz@ecu.edu.au

***Abstract*— In this paper COMSOL model is used to model the s-parameters of the electromagnetic shielding of layer/layers of Polyaniline (PAni) for Wi-Fi Electromagnetic Interference (EMI) shielding. PAni has a good future for minimizing the problems with Electromagnetic Shielding (EMS), and will be increasingly be used to provide protection from Electromagnetic Radiation (EMR) and Electromagnetic Interference (EMI). With the increased development in Wi-Fi and telecommunications equipment, a simple model is required to test for transmission losses. In this paper the electromagnetic radiation from antenna, positioned 30cm from PAni shielding device is modelled using COMSOL 4.2. The paper predicts the radiation reduction after using PAni shielding device. The prediction of electromagnetic radiation distribution with PAni shielding device is simulated, the focus of the simulation is on the Wi-Fi microwave frequency of 2.45 GHz and the modelling of the PAni as an Intrinsic Conducting Polymer (ICP) for transmission losses that was obtained from the COMSOL simulation is compared with PAni shielding test data obtained from the experiential set up. The COMSOL model is used to predict both the electric field intensity around the PAni material and establish the plot of transmission losses.**

Keywords*— Electromagnetic shielding; Intrinsic Conducting Polymer; component; formatting; COMSOL modelling.

I. Introduction

The wireless communication channels have achieved wide-bandwidth, plus very power-efficient transmissions techniques and as Wi-Fi and mobile phone systems increase in speed and design complexity, EMI shielding showed no advances in term of the materials that are used for shielding despite emissions increase. The EMR needs to be directed to the selected area of the device, and the unwanted EMR emission absorbed, through use of appropriate coatings to enhance the performance of Wi-Fi and mobile phone devices. The EMI design affects the power consumption and the continuous use of the mobile system. There are also the environmental issues of how safe and disposable are these current coated materials are. [3] EMR comes from either unwanted conducted signals or via radiation from other devices. [5]

Electromagnetic (EM) radiation may cause symptoms such as insomnia, nervousness, languidness, and headaches. [6], [2] moreover, EMR fields can cause many diseases, such as leukemia, miscarriage and breast cancer, via continuous exposure to EM fields and pulses. Thus various EMI shielding methods have been developed, not only to reduce the probability of occurrence of the aforementioned hazards, but also to increase the lifetime and efficiency of electronic devices. [6], [1], [4]

978-1-4673-5814-9/13/$31.00©2013

The three interactive components of EMI emission are the transmitter and receiver sources of electromagnetic energy, and, the propagation path for this energy.

EMI shielding can be divided into four types depending on the frequency range and continuous or pulse. The first type, called EMI power spectrum shielding, is for the range 1 - 100 KHz. The second type of EMI shielding is the radio frequency range 100 KHz - 1 GHz. The third type is the microwave and beyond frequency band of the electromagnetic energy. The fourth type is the electromagnetic pulse (EMP), which has a broad band, with high intensity short duration bursts of electromagnetic energy, such as nuclear explosion and electric discharge. The basic model will be confined to the frequency range of the electromagnetic scattering measurements of 1-8 GHz. [8] The COMSOL model will be later applied to measurements that are made on free open air environment.

II. COMSOL Model

The model of EM shielding can be classified into two types broadband frequency that arises from high power transmission lines, motors, thermostats, switches etc. and the second type is narrow band shielding that protects from interference that normally arises from deliberate transmissions such as radio and TV stations, pager transmitters, cell phones, etc. The narrow band shielding COMSOL model would be dictated by the types of measurements anticipated, the device size, frequency ranges, cross section levels, the material properties and the surrounding EMI. The model uses Maxwell's Equation(1)

$$\Delta \times B = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial E}{\partial t} \qquad (1)$$

The model simulate the electromagnetic wave transmission loses and the EMR distribution between the transmitter and receiver for frequencies between 1-8 GHz. The COMSOL model depends on the dielectric properties of the PAni material inserted between the transmitter and receiver. The COMSOL model here assumes that the wave propagation delays and the magnetic field are neglected, the charges in the materials that are used is linear. The COMSOL model assumes that the main causes for phase shifts in the electromagnetic field is due to conducting polymer being capacitive. The COMSOL model shows the transmittance $S_{21}$of PAni shielding device for several frequencies between 1-8 GHz. The process of COMSOL modeling is divided into 7 parts, RF physics, frequency range, the geometry in Fig. 1, material properties, meshing, study of the selected frequency domain and displaying the results.
The first step is to create a 2D model in Fig.1, which is simple and is used here to include the geometry parameters of the experimental set up, the other steps that include the defining of the materials that are used in the experimental set up in Fig. 2. The electromagnetic PAni material properties that are needed to COMSOL model are: The electrical conductivity, relative permittivity, relative permeability and the refractive index. The use of electromagnetic Maxwell's equations and the electromagnetic wave is selected and the choice of frequency domain study with Electromagnetic Wave interface is used to simplify the model and assumed that all variations in time occur as a sinusoidal signals. Meshing and simulating of the materials under electromagnetic radiation of the experimental set up that includes a Yagi antenna transmitter and receiver positions 1, position 2 and the PAni shielding device position 3 in Fig. 1.

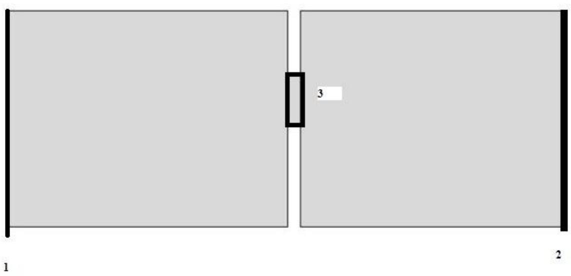

Fig. 1. COMSOL 2D model

III. OPEN AIR EXPERIMENTAL RESULTS

The PAni shielding device capability was tested and the experimental data obtained from the experiment in Fig 2. The PAni material for the shielding device was obtained from Sigma-Aldrich, and ordinary glass slides 15 cm width by 15 cm length were supplied from a local workshop. The shielding device is the ordinary glass slide that is used as a substrate for coating the liquid conducting polymer Polyaniline salt (PAni) [8] and was placed in the middle between the receiver and transmitter antennas (60cm apart). The PAni material and the substrate were fixed on a square hole of 15cm by 15cm on a rectangular shape Aluminium screen of 190cm by 115cm. Both transmitter and receiving antennas were connected to an E5071C Network Analyser (NA) in order to measure the transmission loss $S_{21,}$ for the PAni shielding device. Yagi antennas supplied by Manntel for both transmitting and receiving ports, the transmitter and receiving Yagi microstrip antennas have a resonance frequency at 2.45 GHz, with a dielectric constant of 4.7 and a loss tangent of 0.025.
Fig. 3 shows PAni in terms of its transmission loss parameter S_{21} in free space experiment. The result in Fig 3 indicates that the PAni and other Intrinsic Conducting Polymers (ICP)[8] materials have the future potential to replace the current metal and carbon based technology of providing a thin layer of coating to mobile phone and Wi-Fi devices for EMI shielding and achieved a variety of S_{21} shielding values.

In this case PAni has achieved a transmission loss from -30dB between 2-3 GHz. The current metallic material shields suffer from two problems; corrosion and weight. The use of carbon based shielding is becoming more attractive with microcarbon derived from carbon black, which is much cheaper than nanocarbon or carbon fibres; however carbon fillers in general still suffer from four problems; cost, sloughing, health and long term environmental issues. Carbon based shielding use has been reported in several research papers for use in EMI shielding.

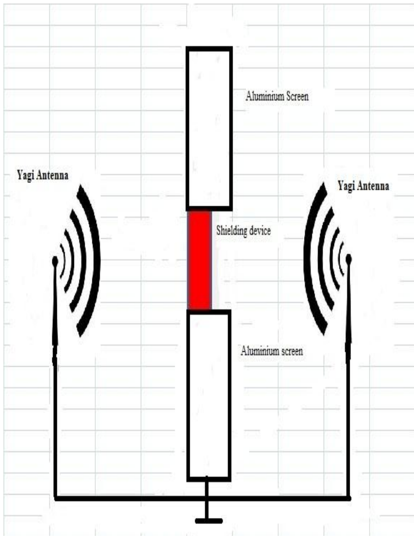

Fig. 2. Experimental set up

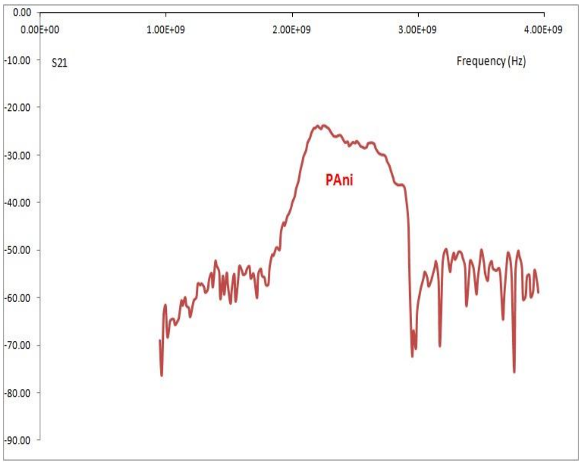

Fig. 3. PAni Transmission losses

PAni shielding material will be suitable for the new generation of EMI and EMR shielding for mobile phones and Wi-Fi devices because they are lightweight, and has no health or environmental issues that have been reported. It has also been demonstrated, that the PAni can cover a variety of range of frequencies between 1-8 GHz for transmission losses [1] and PAni shielding based devices could be used to enhance the shielding of the wireless devices.

IV. ACHIEVED SIMULATION GRAPHIC AND TRANSMISSION LOSS RESULTS

The COMSOL simulation is compared to a result obtained from the open air experiment in Fig. 2, Fig. 2, shows the EMR is transmitted from the antenna positioned on left hand side number (1) to the receiver positioned on the right hand side (2) and the PAni device is in the middle (3)as shown in Fig. 1 and Fig. 4. The maximum S_{21} is about -46 dB between 1-8 GHz as shown in Fig. 5.

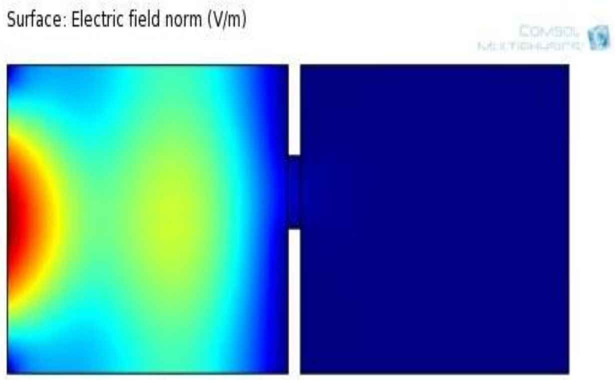

Fig. 4. Electric field density for PAni shielding device

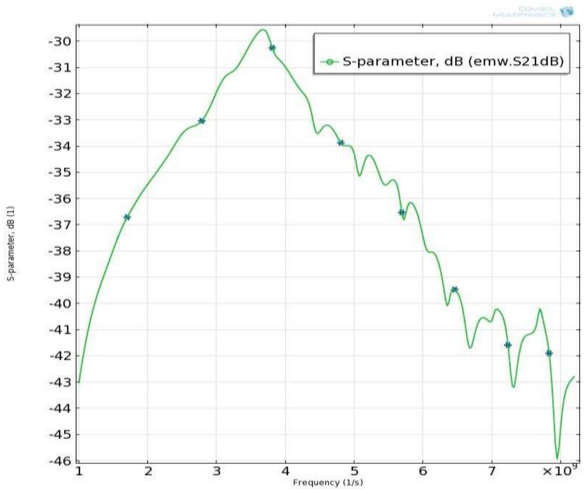

Fig. 5.Transmission loss S21 for PAni shielding device

V. CONCLUSIONS

The aim of this paper is to provide a basic electromagnetic scattering model that will be used to relate the actual PAni materials properties and EMR transmission loss open air measurements to the COMSOL model. The results showed a transmission loss averaged around -46 dB between 1-8 GHz. This model can be extended to other ICP materials, like PPy, PEDOT and the model is useful when the ICP material vary in percentage weight that in turn change the electrical conductivity.

VI. REFERENCES

[1] AA Al-Ghamdi, O.A. Al-Hartomy, F. Al-Solamy, F. Al-Hazmi, EH El-Mossalamy, and F. El-Tantawy. On the prospects of conducting polyaniline/natural rubber composites for electromagnetic shielding effectiveness applications. Journal of Thermoplastic Composite Materials, 2012.

[2] A.J. Bur. Dielectric properties of polymers at microwave frequencies: a review. Polymer, 26(7):963–977, 1985.

[3] YK Hong, CY Lee, CK Jeong, JH Sim, K. Kim, J. Joo, MS Kim, Y Lee, SH Jeong, and SW Byun. Electromagnetic interference shielding characteristics of fabric complexes coated with conductive polypyrrole and thermally evaporated ag 1. Current Applied Physics, 1(6):439–442, 2001.

[4] D.C. Trivedi and S.K. Dhawan. Shielding of electromagnetic interference using polyaniline. Synthetic metals, 59(2):267–272, 1993.

[5] J.L.N. Violette, D.R.J. White, and M.F. Violette. Electromagneticcompatibility handbook. Van Nostrand Reinhold Company, 1987.

[6] Y. Wang and X. Jing. Intrinsically conducting polymers forelectromagnetic interference shielding. Polymers for advanced technologies,16(4):344–351,2005.

[7] W. Zhong, J. Deng, Y. Wang, and W. Yang. Oxidative graft polymerizationof aniline on the modified surface of polypropylene films. Journal of applied polymer science, 103(4):2442–2450, 2007.

[8] W.Al-Shabib, D.Habibi, and Z.Xie Identifying smart conducting materials for Wi-Fi electromagnetic interference shielding, 10.1109/APEMC.2012.6238028