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EMI shielding using composite materials with two sources magnetron sputtering

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Abstract. In this study, the preparation composite materials for electromagnetic shields using two sources magnetron sputtering DC-M is presented. A composite material was prepared by coating a nonwoven polypropylene metallic layer in sputtering process of targets Ti (purity 99%) and brass alloy MO_{58} (58%Cu, 40%Zn, 2%Pb) and ϕ diameter targets = 50 mm, under argon atmosphere. The system with magnetron sputtering sources was powered using switch-mode power supply DPS (Dora Power System) with a maximum power of 16 kW and a maximum voltage of 1.2 kV with group frequency from 50 Hz to 5 kHz. The influence of sputtering time of individual targets on the value of the EM field attenuation *SE* [dB] was investigated for the following supply conditions: pressure $p_p = 2x10^{-3}$ Torr, sputtering power $P = 750$ W, the time of applying a layer $t = 5$ min, group frequency $f_g = 2$ kHz, the frequency of switching between targets $f_p = 1$ Hz.

1. Introduction

Due to the rapid increase of sources generating the electromagnetic fields (radio broadcasting, television, radio communication, mobile networks) and power generated by PEM sources, the shielding design is getting more and more challenging. Materials used in the technique of EMI shielding must have a suitably high coefficient of the shielding effectiveness *SE*, be resistant to influence of external environment (corrosion, oxidation) and mechanical impact. Materials must be also easy to form the shield and must have low production costs. Shields made as metal sheets, foil and mesh are characterised by good EM filed shielding effectiveness coefficient. However they are characterised by low resistance to influence of external environment (especially corrosion) and relatively high weight. The alternative to metal shields is the use of composite shield. The engineering of materials used for electromagnetic shielding is one of the most widely developing field of applications of composite materials [1-3]. One of the group composite materials based on laminar systems. Typical laminar system consists of a nonwoven fabrics with conductive layers deposited or laminates with pressed in conductive layers. Conductive layers may be put on by using the following methods: silk-screen printing [4], vacuum evaporation, or magnetron sputtering [5-7]. They are characterised by high shielding efficiency coefficient. However not every materials is suitable for conductive coating. The most often used method of the obtaining conductive layers is magnetron sputtering. Additionally during a process of magnetron sputtering, plasma cleans and activates surface of substrates [8,9]. Therefore magnetron methods allow to do metallization of materials such as PTFE or PP, which can not by transformed by metallization with other methods, because of their surface properties. Previous studies have shown that metallic layers (Zn) deposited on polypropylene nonwoven fabric allow effective electric field shielding (above 50 dB) [10]. To increase the resistant to influence of external environment and mechanical impact the two sources magnetron sputtering was proposed.

2. The two sources magnetron sputtering system

The processes of sputtering of two sources (targets): titanium (purity 99%) and brass alloy (58%Cu, 40%Zn, 2%Pb) were realised by magnetron launchers WMK-50 with the magnetic system of diameter ϕ=50 mm. The argon was used as a working gas. The pressure in the vacuum chamber was p_p = 2x10^{-3} Torr. The distance between the target and nonwoven fabrics has been set to 100 mm. The magnetron launcher was powered by impulse current source type DPS (Dora Power System) witch works in DC-M mode controlling power up to 16 kW with a maximum voltage up to 1.2 kV. This power supply can control group frequency f_g in the range of 50Hz to 5kHz and frequency of switching between targets f_p in the range of 0,1 Hz to 50 Hz.

3. Composites materials PP/brass alloy/Ti

Titanium and brass alloy layers were deposited on polypropylene nonwoven fabric of the base weight of 180g/m^2. The power P emitted by the gun was 750 W and the time of depositing t was 5 minutes. The frequency of switching between targets f_p was 1Hz. The PP nonwoven fabric were deposited only on A side or B side (5 samples – A side, 5 samples B side) for the different ratios of the time sputtering targets of titanium and alloy brass. A side was significantly less expanded surface area relative to the B side. The values of the surface resistivity of the coated samples are shown in Table 1. In figure 1 and figure 2 nonwoven fabric surface (sample A4 and B4) after the magnetron sputtering process were shown.

Table 1. Composites materials PP/brass alloy/Ti.

	Titanium (%)	Brass alloy (%)	Surface resistivity ρ_s (Ω)
A1	100	0	160k
A2	75	25	3,2k
A3	50	50	700
A4	25	75	270
A5	0	100	250
B1	100	0	4,9k
B2	75	25	1k
B3	50	50	98
B4	25	75	33
B5	0	100	24

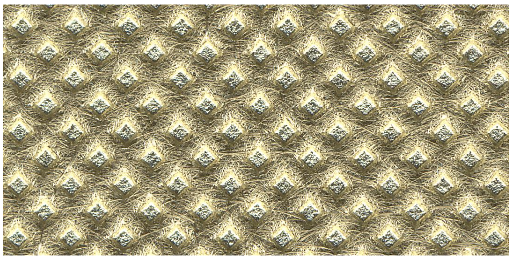

Figure 1. Textile surface after deposition of the brass alloy (75%) and titanium (25%) layer. Coated A site – A4 sample.

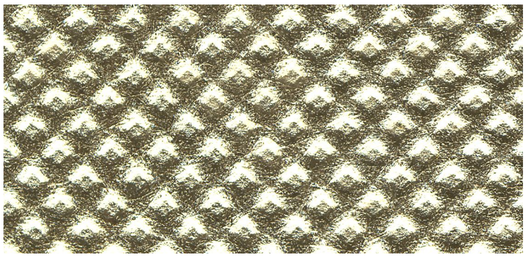

Figure 2. Textile surface after deposition of the brass alloy (75%) and titanium (25%) layer. Coated B site – B4 sample.

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4. Shielding properties of PP/brass alloy/Ti composites.

Measurements of shielding attenuation were realised on the test setup prepared in the Institute of Telecommunications, Teleinformatics and Acoustics of Wrocław University of Technology in accordance with the method of ASTM D4935-99. Measuring uncertainty was approximately 2 dB.
The study have shown an influence of different ratios of the time sputtering targets of titanium and alloy brass on a value of shielding attenuation. The highest value of SE was obtained for nonwoven fabric coated only by brass alloy (sample A5 and B5). It should be noted that the addition of titanium below 25% did not decrease value of *SE* (sample A4 and B4). A significant impact on the value of *SE* had surface structure. B side was more expanded surface, therefore the value of *SE* was almost two times higher. Dependence of the *SE* on frequency electromagnetic field for A side and B side was shown in figure 3 and figure 4. The frequency of electromagnetic field was in the range of 10 MHz to 2 GHz.

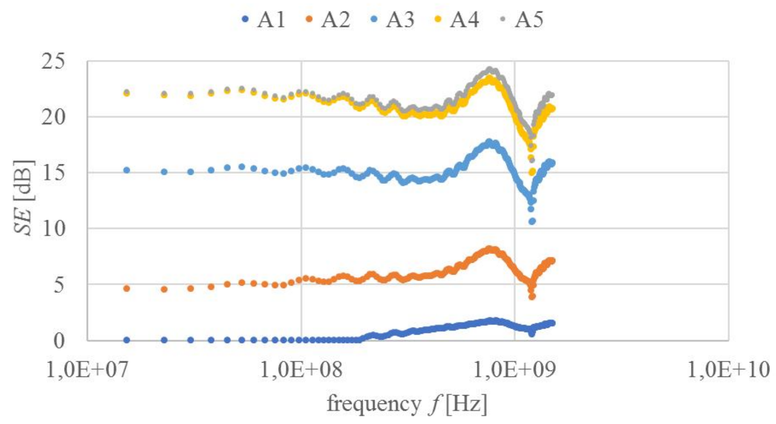

Figure 3. Dependence of the coefficient of shielding efficiency *SE* on frequency *f*. Coated A side.

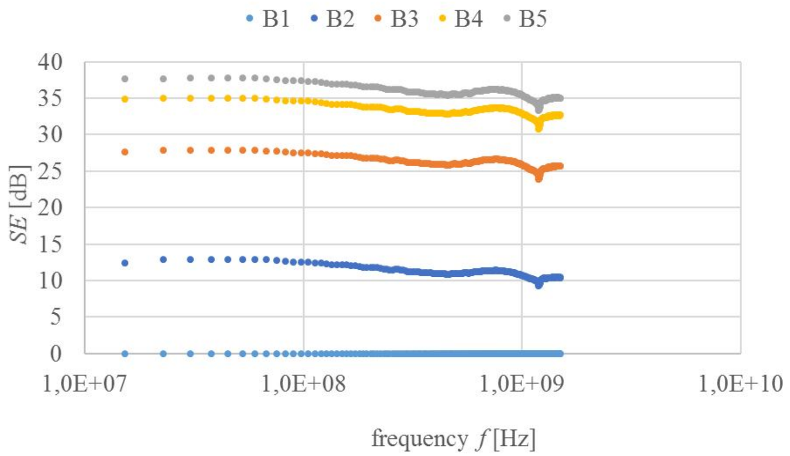

Figure 4. Dependence of the coefficient of shielding efficiency *SE* on frequency *f*. Coated B side.

In figure 5 dependence of the coefficient of shielding efficiency *SE* on surface resistivity ρ_s. was shown. The observed dependence in figure 5 was a linear in a log scale.

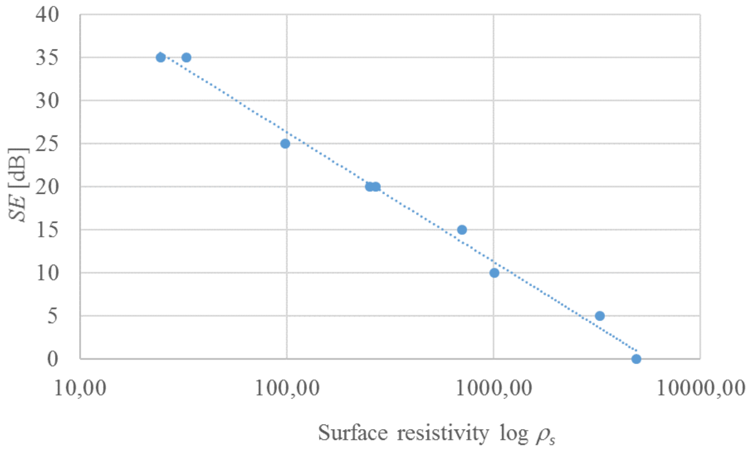

Figure 5. Dependence of the coefficient of shielding efficiency *SE* on surface resistivity ρ_s. Coated A or B side.

5. Conclusion

The possibility of industrial fabrication of the composite shielding materials with the coefficient of shielding efficiency exceeding 40 dB was confirmed by obtained results. The addition of titanium below 25% did not decrease value of *SE*. The addition of Ti could increase the resistant to influence of external environment and mechanical impact. The metallization of polypropylene nonwoven fabric with very good adhesion was realized using magnetron sputtering methods. Using the method of two sources magnetron sputtering allowed to speed up of technological process in the preparation of multilayer structures.

Acknowledgements

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References

[1] Jaroszewski M, Pospieszna J and Ziaja J **2010** *J. Non-Cryst. Solids* vol. 365(11-17) 625-628
[2] Bula K, Koprowska J and Janukiewicz J **2006** *Fibres & Textiles in EE* vol. 14(5) 75-79
[3] Koprowska J, Pietraniak M and Stawski W **2004** *Fibres & Textiles in EE* vol. 12(3) 39-42
[4] Wang Li-Li, et al. **2009** *Carbon* vol. 47 1905-1910
[5] Ziaja J, **2007** *Electrical Review* vol. 83(11) 235-239
[6] Ziaja J, Ozimek M and Janukiewicz J **2010** *Electrical Review* vol. 86(5) 222-224
[7] Ozimek M, Sikora A, Wilczyński W The study of magnetic domain development in shielding films using MFM technique, *Przegląd Elektrotechniczny* 89(8) **2013** 208-210
[8] Szubzda B, Szmaja A, Ozimek M and Mazurkiewicz S **2014** *Applied Physics A* vol. 117(4) 1801-1809
[9] Żyłka P **2012** *Electrical Review* vol. 88(5) 128-131
[10] Ziaja J, Koprowska J and Janukiewicz J **2008** *Fibres & Textiles in EE* vol. 16(5) 64-66