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NEW COMPOSITE MATERIALS USED IN ELECTROMAGNETIC FIELD SHIELDING

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Experimental studies and researches in this paper are dedicated to assessing health risks to EMF exposure. The presented studies aim to find new possible materials with shielding properties for EMF radiation, generated by different equipments. This paper presents an analysis of the results over field measurements based on the electromagnetic field theory. New composite materials, based on metallic powder from Cu and Fe metals and FeSi, AlNiCo, and Pyrite alloys are analyzed taking into account measurements of EMF attenuation in the range of 900 MHz – 4 GHz, finding the optimum shielding level of the new materials.

Keywords: EMF shielding, new composite materials, EMF health exposure

1. Introduction

This paper discusses an original topic, that of preparation of new composite materials for specific applications. The novelty of this work consists into the preparation of EMF shielding screens, which can be used for complex applications.

The chosen materials to be transformed in EMF shielding screens are among the softest magnetic materials and present outstanding peculiarities. Those with large and positive magnetostriction, exhibit bistable behavior with magnetization reversal through a giant Barkhausen jump originating in the propagation of a single-domain wall [1].

A number of outstanding magnetic properties, such as magnetic bistability, enhanced magnetic softness, and EMF shielding effect have been discovered recently in such materials [1–5].

The International Scientific Community had developed for many years studies on the EMF effects on human health. The scientific studies didn't prove a direct connection between mobile phone usage or the mobile phone stations proximity and health damage. This conclusion is sustained by studies of independent institution such as World Human Health Organisation. [7].

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2. Experimental

The experiments consisted in preparation of metallic powders, from different metalls, such as Fe, Cu, and alloys AlNiCo and Pyrite. Magnetic particulate size distribution was determined using a granulometer with sieves between 36 - to 160 μm.

The technological process of obtaining Fe, Cu, AlNiCo and Pyrite powders is made using a Retsch planetary mill, with two workstations, in which the metal is inserted in bulk condition into the ether oil and it's ground using metal balls at a speed of 120 rpm for 3 hours. The powder thus obtained is granulated with granulometer, obtaining 6 grits, as follows: 0 - 36 μm, 36-40 μm, 40-50 μm, 50-80 μm, 80-125 μm, 125-160 μm. The target concentrations to be used were: 0.5%, 2%, 4%, 8%, 10%, 16%. The work procedure used for obtaining the electromagnetic shielding screens is presented here (fig. 1) :

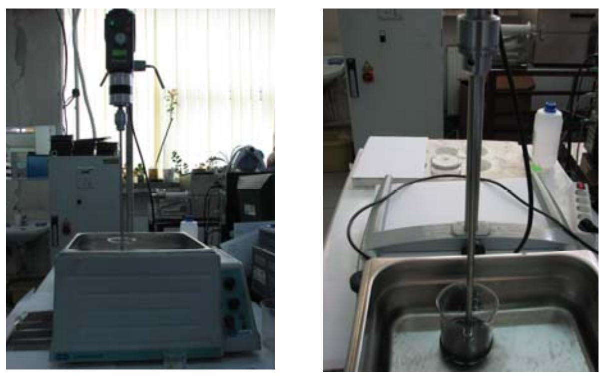

Fig. 1 Aspects during ultrasonic and mechanical treatment on the mixing composite material (metallic powder with resin and hardener)

- Calculate weights for resin and hardener for wanted concentration;
- Mix resin with increasing concentration of metal powder and placed in the ultrasonic bath for 5 minutes at a temperature of about 70^{o}C. During ultrasonic treatment, mechanical stirring is done;
- Mix only with mechanical agitation for another 10 min;
- Add the hardener and mix ultrasonic and mechanical for an additional 8 min;
- Pour the mixture obtained in the form (tray platelet)

The resulted samples sizes are 260 x 180 mm.

The resin used as embedding matrix is epoxy resins based on bisphenol A and epichlorohydrin, that have a molecular weight up to 900 and to a maximum of 0.2% epoxy, with the next advantages:

• Hydroxyl group ensure adhesion to the surface were are deposited;

• Aromatic rings influence the p-π conjugation effect whose free rotation around the C-O bond is reduced, giving them the necessary mechanical strength and heat;

• Large distance between glycidyl and hydroxyl groups, cross-linking of these resins enables a wide range of reactive agents, such as carboxylic acid compounds, hydroxyl compounds, amide, amine, or anhydride.

The structure and the magnetic properties of the prepared alloys and compounds, were investigated by XRD (using an X-ray Brucker's diffraction instrument, AXS D8 ADVANCE type), and magnetization measurements, performed on vibrating sample magnetometer, 7300 Lake Shore type.

3. Results and Discussion

Figs. 2 and 3 shows the diffraction patterns obtained for AlNiCo alloy and Fe, prepared by the technological process described above. It can be notice the appearance of peaks of different intensities, depending on the type of the alloy used for composing. The peak's intensity is higher, due to sufficient crystallization time for the appearance of a higher proportion of crystalline phase.

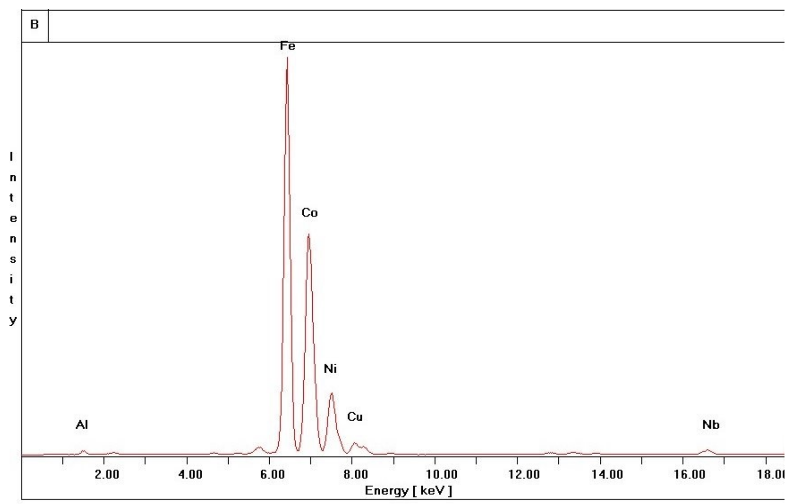

Fig. 2 XRD pattern for Al-Ni-Co alloy

The conclusion that emerges is clear: structural features of metallic powder can be tailored by adjusting their processing parameters. So, one can obtain composite materials with various structures of the metallic powder: amorphous or polycrystalline, characterised by different sizes of crystals.

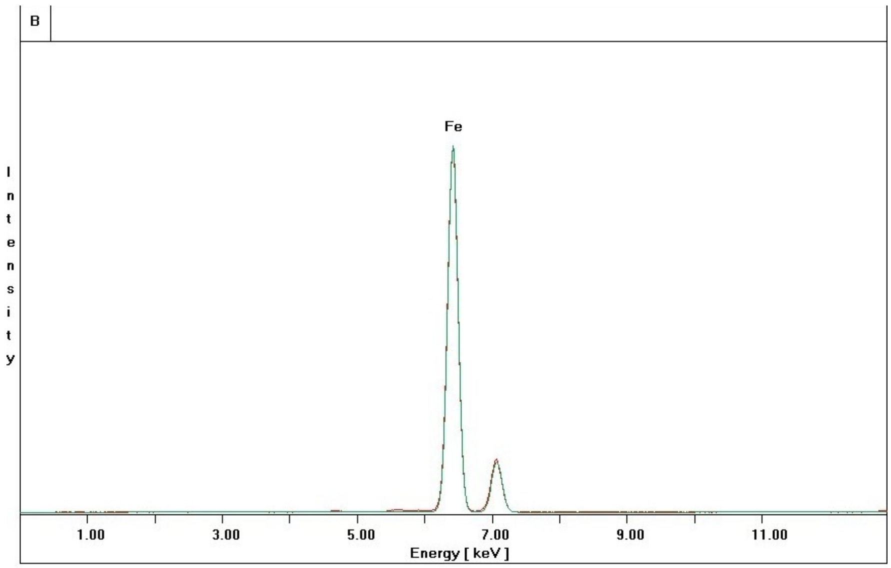

Fig. 3 XRD pattern for Fe

For magnetic characterization, it was necessary to plot the hysteresis cycles. This indicates the magnetic behaviour of alloys, the magnetic moment of each alloy and the saturation.

Measurement results with vibrating sample magnetometer were processed using Origin, hysteresis cycles resulting in Figs. 4 - 7.

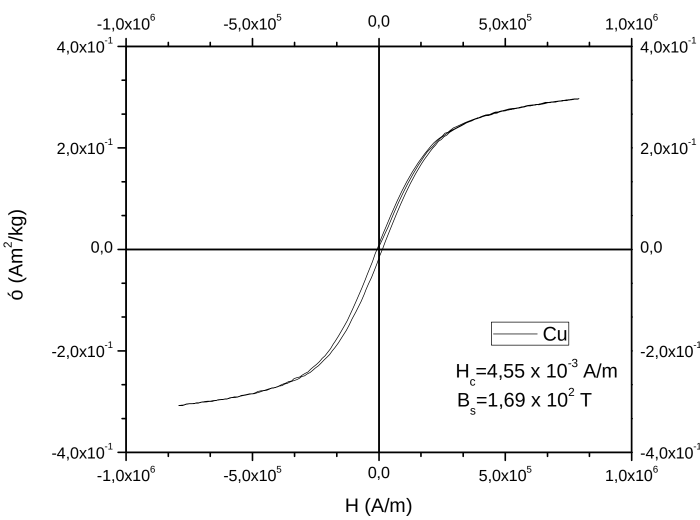

Fig.4 Hysteresis loops for Cu

Fig. 4 presents the hysteresis loop for Cu. Based on this loop we can determine the Cu main magnetic characteristics: $B_S = 1.69 \times 10^2$ T and $H_c = 4.55 \times 10^{-3}$ A/m.

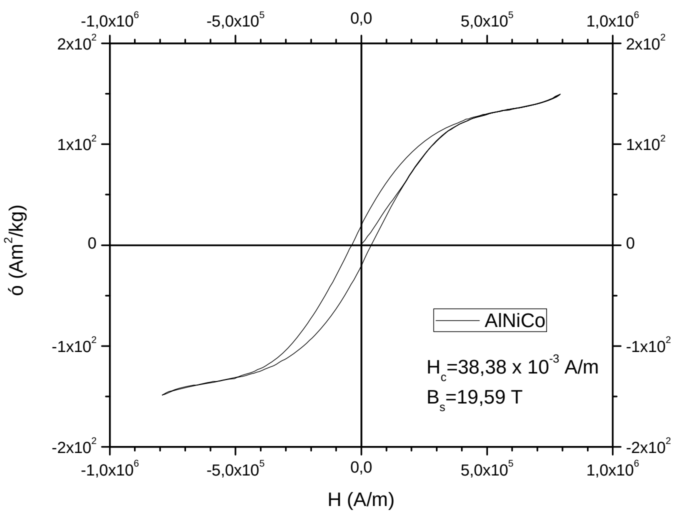

Fig. 5 Hysteresis loops for AlNiCo

Fig. 5 presents the hysteresis loop for AlNiCo. Based on this loop we can determine the main magnetic characteristics for this alloy: $B_S = 19.59$ T and $H_c = 38.38 \times 10^{-3}$ A/m.

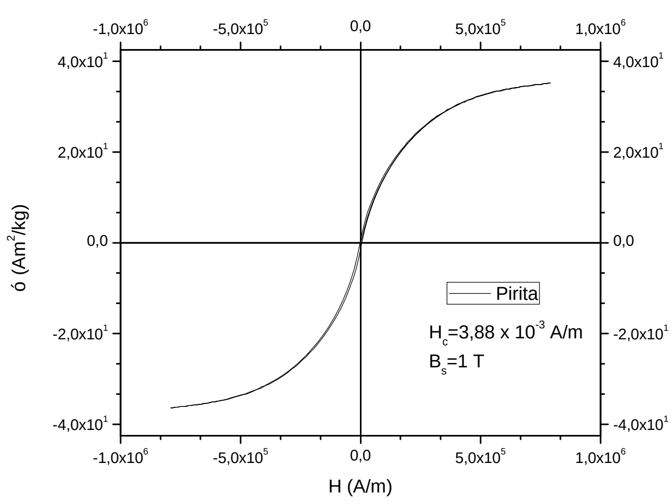

Fig. 6 Hysteresis loops for Pyrite

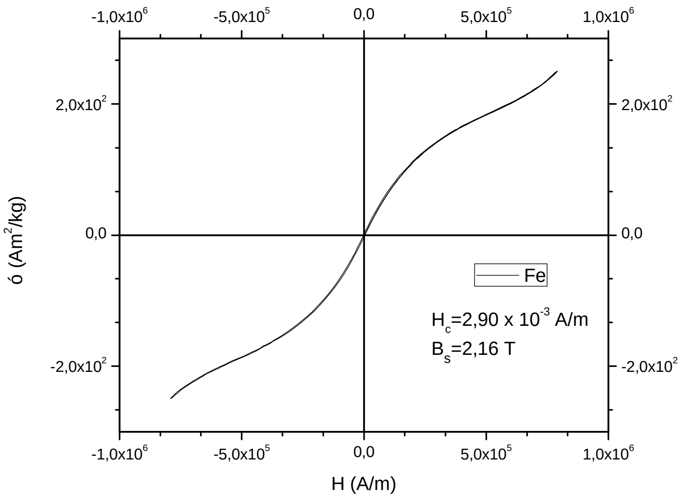

Fig. 7 Hysteresis loops for Fe

Fig. 7 presents the hysteresis loop for Fe. Based on this loop we can we see: B_S = 2.16 T and H_c = 2.90 x 10^{-3} A/m. As it can be seen from the hysteresis loop shape and from the values of the principal magnetic characteristics, all the chosen materials consists in soft magnetic material.

For electromagnetic characterization, all the electromagnetic screens were measured in the frequency range of 0,9 – 4 GHz, using Horn type antennas for emision – reception of signal, a signal generator and a spectrum analizer. The measurements took place in Anechoic Chamber, made by INCDIE ICPE-CA.

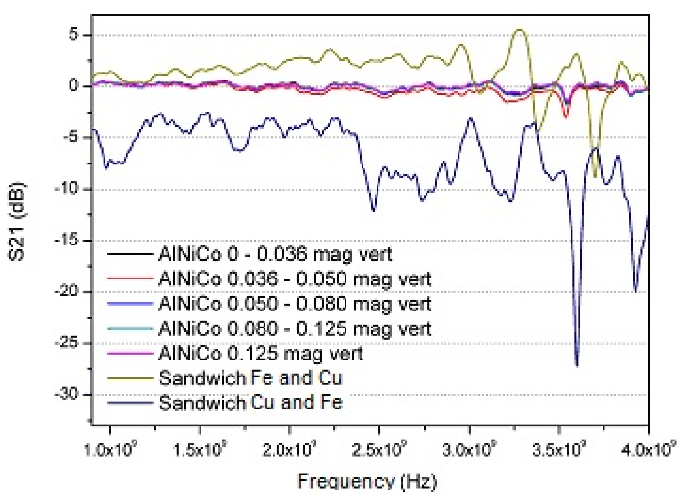

Fig. 8 Attenuation measurements for AlNiCo electromagnetic screens

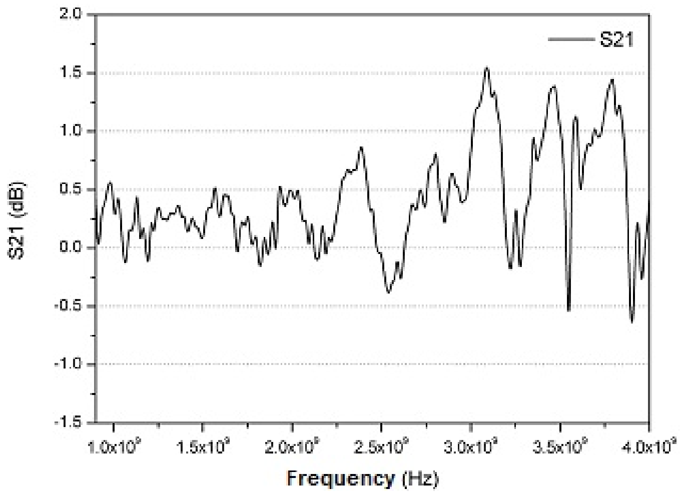

Fig. 9 Attenuation measurements for Pyrite electromagnetic screens

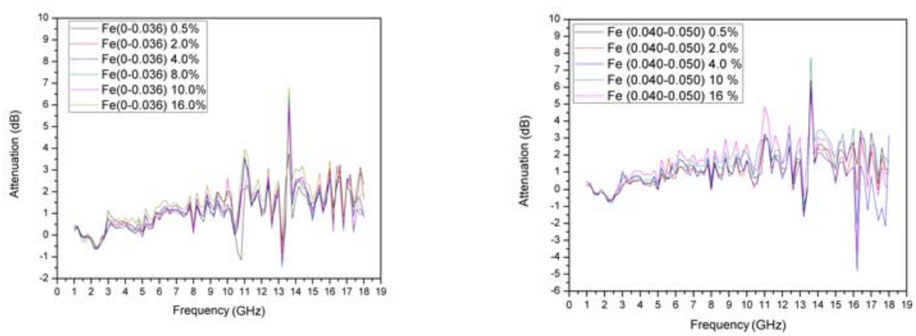

Fig. 10 Attenuation measurements for Fe electromagnetic screens:
a) for grain size between 0-0.036 mm and concentration of 0.5%, 2%, 4%, 10%, 16%; b) for grain size between de 0.040-0.050 mm and concentration of de 0.5%, 2%, 4%, 10%, 16%

In Fig. 10 it can be easily noticed that for the Fe screens are almost identical behavior of the samples, with a slight increase in attenuation with increasing the concentration. It was also a slight increase in attenuation observed on the Fe samples with grain 0.040-0.050 mm (maximum attenuation 7.77 dB for 13.6 GHz) than the one with grain of 0-0.036mm (maximum attenuation 6.78 dB to 13.6 GHz).

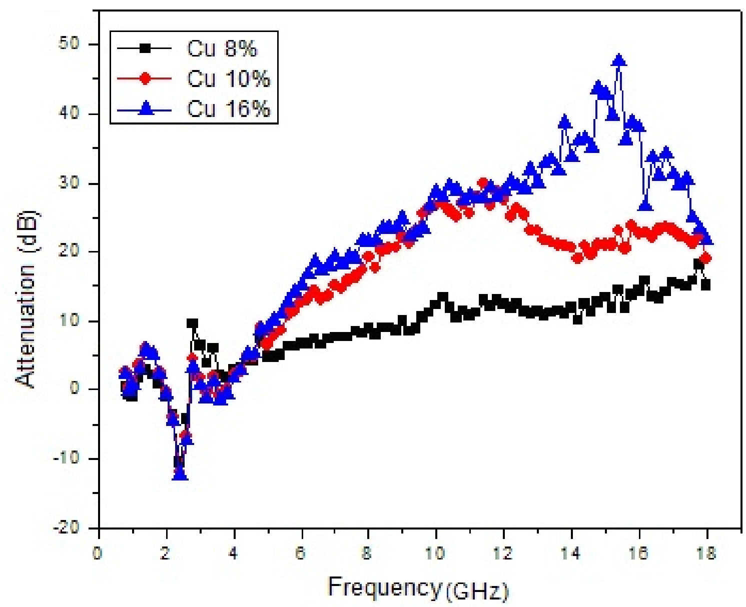

Fig. 11 Attenuation measurements for Cu electromagnetic screens

For frequency range between 0.9 to 4 GHz is observed in the slope of the attenuation curve that the maximum value for attenuation, of 48 dB, is for Cu electromagnetic screen with 16% concentration (fig. 11).

4. Applications

New composite materials have been introduced gradually in a laboratory level and proved to be very promising in many technological applications owing to their excellent magnetic and mechanical properties. [8 – 12]

There are many aplications for this electromagnetic screens, among them is the used for the absorption of electromagnetic radiation produced by various devices such as mobile phones, microwave ovens, GSM antennas. The main benefits of these new materials are:

- Absorption of electromagnetic radiation using Cu screens up to 45 dB (for the concentration of 16%) ;
- Obtaining shields with magnetic radiation protection;
- Optimizing working conditions in areas with electromagnetic radiation above average, leading to improving work levels and reducing the medical "stress"
- Increasing life quality and reduce the risk of illness to exposed personnel to electromagnetic radiation.

Fig. 12 Electromagnetic screens made from Cu powder with concentration of 4%, 8%,16%

Fig. 13 Electromagnetic screens made from Fe with concentration of 4%, 10%, 16%

5. Conclusions

The results obtained during the experimental research show that, through selection of the suitable alloys, one can prepare electromagnetic screens, characterized by special electric, magnetic, resistive, conductive properties.

The remarkable properties, conjugated with the fine size and the electromagnetic behavior, make the new composite material a potential candidate for key components in different fields: electromagnetic shielding, electronics and electrical engineering.

Acknowledgement

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