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Microwave reflectance and transmittance properties of conductive composite materials

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Abstract

This study investigates the microwave electromagnetic shielding properties of secondary use composite materials used as ingredients in shielding materials. Materials investigated include: waste tire crumb rubber (CR), metallurgical slag (MS) and commercial lightweight expanded clay aggregate (LECA). These materials were tested in a powder form in bulk conditions. The investigation also included core-shell type spheres – expanded polystyrene (EPS) coated by MS (MS@EPS), diameter 4.0–5.0 mm and coating thickness 150 μm. A setup of radiofrequency generating and metering instruments were utilized to measure the reflective and transmission properties of the innovative material. The radiofrequency field tests were done at 2.4 GHz frequency (WiFi network frequency). Reflection and transmission characteristics of the material were measured by free space method. Reflection and transmission coefficients (from 0 to 1) were calculated to each tested sample. The measurements results show full transmission properties for CR and MS@EPS. In case of LECA 91 % of the radiation passed through the material while 15 % of reflection was measured. The applications of prospective shielding materials innovative material may include shielding smart electrical systems and smart meters from an unwanted electromagnetic interference that may affect the work of the meters or the nearby electronic equipment.

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1. Introduction

Spurious electromagnetic fields could affect the wireless communications by smart networks and smart devices in power systems. Electromagnetic interference may be created by other devices in the same frequency bands. If the interfering radiation hits the smart devices or the operator's receiver with the sufficient amplitude, as described in top part of Fig. 1, it may affect the network health. The interference may inhibit the operation of smart systems and therefore affect the proper transmission of the information transmitted wirelessly. If no other technical means is available, the use of shielding materials could guarantee the operability of smart devices and networks. Where common building materials would allow interfering signals to penetrate into the premises where smart networks are installed, shielding materials would shield the premises from such spurious signals.

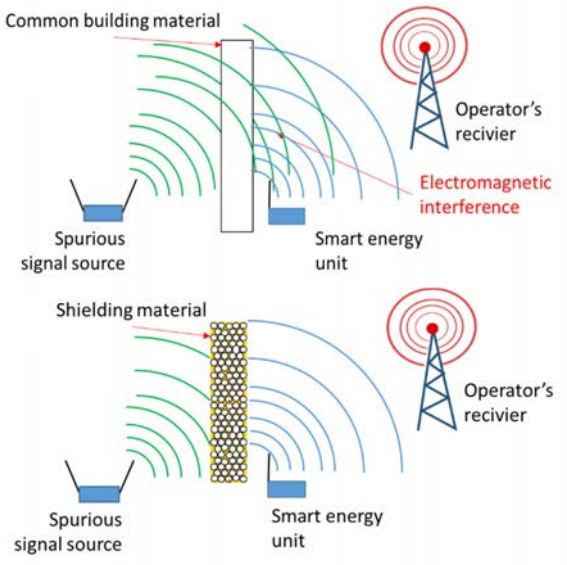

Fig. 1. Shielding materials guarantee the operability of smart devices.

The electromagnetic fields are an inherent component of the modern environment – also called as the electroclimate. The electromagnetic aspect of the environment has lately gained more attention as new wireless technologies and industrial processes have been developed. With the widespread use of these technologies the exposure levels of electromagnetic fields have raised rapidly and the need for environmental management of this risk factor is becoming more relevant. An option of environmental technology is to control these fields by certain materials.

Having an adequate shielding from radiofrequency (RF) electromagnetic fields (EMFs) may serve many causes. In case of sensitive electronic equipment is used, interference from environmental RF EMFs may hinder the functioning of these devices. Microwaves can cause electronic interference [1, 2]. Electromagnetic compatibility (EMC) is most important e.g. in hospitals where critical systems are in work. A review study by Boyle looked at electromagnetic interference (EMI) effects of devices on medical electronic instrumentation and found the highest risk of interference to be with two-way radios used by emergency crews, followed by mobile phones [3].

Shielding measures against electromagnetic fields may also serve human safety. In recent time more attention has been paid on the safety from RF EMFs exposure [4]. Strong RF EMFs are encountered in an occupational setting, where processes such as radiofrequency welding, industrial microwave ovens, mobile communication with high power transceivers etc. are done. Strong RF EMF exposure may be titled also to workers at plastic sealers and glue dyers, also with operating or servicing radio/TV transmission equipment and radars [5].