INVESTIGATION ON A NEW SHIELD BOARD

IN MRI MESUREMENT CIRCUMSTANCES

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ABSTRACT

A new shield board with the function of keeping a magnetic field stationary but possessing shield effect and a low absorbing characteristic for microwaves has been fundamentally investigated using non-magnetic but conductive materials. The new shield board consists of two parts, an EM wave absorber and a low conductive board with the function of EM wave shield.This paper focuses on the investigation of microwave absorbing characteristics. Matching characteristics more than -10 dB in reflection coefficient are obtained by only layering a thin absorber with printed conductive rings on the surface of a dielectric material.

INTRODUCTION

Recently, as one of promising method for hyperthermia temperature measurement, non-invasive technology using MRI has been developing. In this circumstance, the disturbance of magnetic field distribution is not allowed when setting up treatment devices such as an applicator systems, computers etc. Generally, most of these conventional devices are composed of iron based housing and frames that cause the disturbance of magnetic field distributions. In this paper, a new shield board with the function of keeping a magnetic field stationary but possessing shield effect and a low absorbing characteristic for an electric field has been fundamentally investigated using non-magnetic but low conductive materials. This shield board can be applied to electric device casing and other devices is needed in the medical treatment room, particularly in the room for MRI temperature measurement. When this shield board is used as the case of applicator system or oscillator and other devices in the hyperthermia treatment room when measuring a temperature by MRI system, this board works as a kind of absorber for the EM waves generated form inside the oscillator and prevents the incident EM waves from outside but the magnetic field disturbance is suppressed. Because this configuration is totally composed of a non-magnetic material, magnetic field distributions are suppressed compared to the other devices using an iron material as a casing. In the present paper, an EM wave-absorbing characteristic is principally discussed regarding this shield board.

CONSTRUCTION

One of the authors has proposed a metallic line pattern absorber (MELPA) [1][2]. As one of the application of these kinds of EM wave absorber, a new absorber consists of a thin dielectric substrate with printed metallic loops, as shown in Fig. 1. The back of the absorber is attached to a shorting plate. The principle of suppressing MRI magnetic field disturbance is based on the idea that a shorting plate attached to the back of absorber is composed of a low conductive material or a conductive plate coated witha lossy material like carbon-graphite. By adopting these kinds of shorting plate, the magnetic field disturbance caused by eddy current is suppressed. As the result, magnetic field distribution in MRI measurement circumstance can be kept stationary.

On the surface of the dielectric substrate, metallic loops are distributed with in-line periodicity. The same kinds of loop patterns have been used for microwave filter devices, or Frequency Selective Surface (FSS) [3]-[5]. In these filter application, there is no need to mount a conductive shorting plate on the back of FSS. Present shield board is constructed by piling up several dielectric substrates with the printed conductive loops that are gradually increasing in size along the EM wave propagation and attaching a non-magnetic but a low conductive plate to the end of pilling up the dielectric substrate. Fig.1 (a) and (b) illustrate a front and a side view, respectively. As a thin dielectric substrate with the conductive loops,

forming polystyrene or urethane foam etc. are used. Therefore, this absorber has a special feature of producing a light weight and low cost absorber compared to conventional EM wave absorbers.

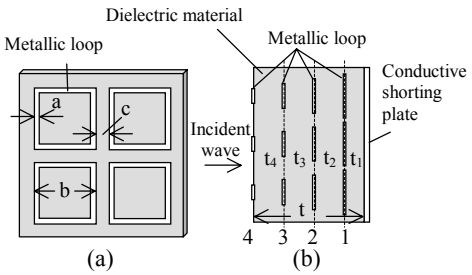

Fig .1 Fundamental construction of EM wave absorber

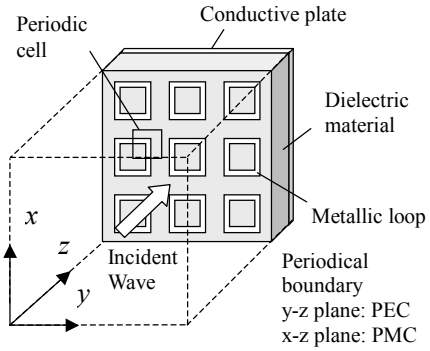

Fig.2 Model for Analysis

INVESTIGATION OF MATCHING CHARACTERISTICS OF ABSORBER

The present shield board has a special feature of an EM wave absorbing characteristic. Each EM wave-absorbing unit is composed of a thin dielectric substrate with printed conductive loops on its surface. These units are layered by gradually increasing the loop size along the EM wave propagation. By introducing this construction, multi-peak absorbing characteristics with the reflection coefficient more than -10 dB is obtained at the frequency region from 1.8GHz to 10 GHz. To investigate present fundamental matching characteristics, FDTD analysis is introduced. Since the present absorber has a periodical structure, periodical boundaries are introduced and at the opposite side of ferrite absorber, a 16 layer PML absorbing boundary is set up as shown in Fig. 2.

Fig. 3 shows the reflection coefficients or matching characteristics. The sizes of the square loop is tabulated in Table 1. Each substrates is 2.5 mm thick. On the surface of the substrate, thin metallic loops are mounted. Total thickness of the bsorber is 10.0 mm. A conductive plate is attached to the back of the absorber. In Fig. 3, a fine dotted line shows the case where only one substrate is mounted as an EM wave absorber. A solid line represents the case of layering four substrates. Each substrate gradually increases the loop size along the EM wave propagation as shown in Fig.1 (b). The thickness of absorber is 10 mm**.** The relative permittivity of the substrate is 5.0 and a slightly conductive nature with the value of 0.1 S/m is given. From this figure, it is found that EM wave absorbing characteristic is improved by mounting the conductive loops on the surface of the dielectric substrate.

Table 1. Sizes of metallic loop

Loop No.	Loop size: b	Adjacent loop space: c
1	11.0mm	1.0mm
2	10.0mm	2.0mm
3	9.0mm	3.0mm
4	8.0mm	4.0mm

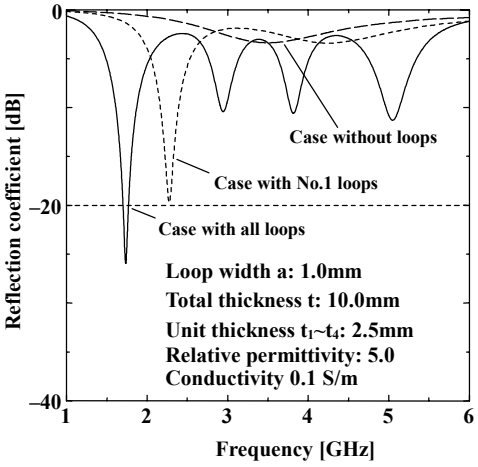

Fig 3. Matching characteristics with or without loops

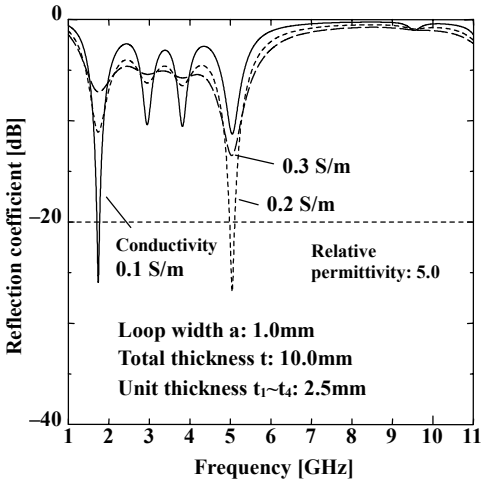

Fig 4. Matching characteristics
taking conductivity as a parameter

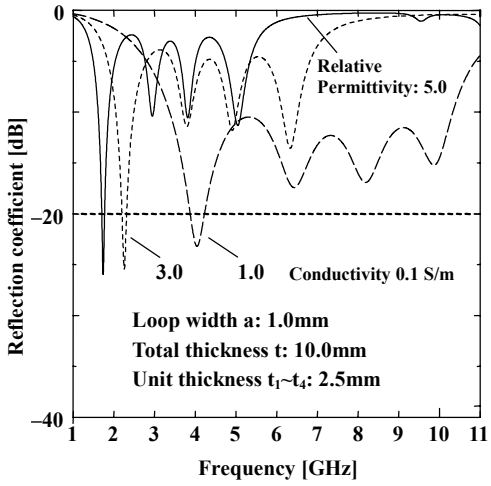

Fig 5. Matching characteristics
taking permittivity as a parameter

Fig. 4 shows the matching characteristic when the conductivity of substrate is changed from 0.1 to 0.3 S/m under the same condition of metallic loop sizes as Fig. 3. We find that change of conductivity of the substrate is not effective to improve the present matching characteristic. Fig. 5 shows the case where the value of permittivity is taken as a parameter when the other parameters are the same as Fig. 2. The matching characteristic is improved as the value of permittivity is decreased. It is found that a multi-peaks matching characteristic more than –10 dB is realized.

CONCLUSION

A new shield board with the function of keeping a magnetic field caused by MRI stationary and EM wave absorbing characteristic for microwave noise caused from the inside of electric devices has been fundamentally investigated. This paper focuses on the investigation of microwave absorbing characteristics for the present shield board. By piling up several dielectric substrates with printed metallic loops that are gradually increasing its size along the EM wave propagation, multi-peak absorbing characteristics of the reflection coefficient more than -10 dB were obtained at the frequency region from 1.8GHz to 10 GHz. In combination with a shorting plate composed of a low conductive material or a conductive plate coated a lossy material like a carbon-graphite, it is suggested that a new shield board with the function of suppressing magnetic field disturbance in MRI measurement circumstance and with absorbing characteristic for microwaves radiated by electric devices.

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