Development of Transparent Electromagnetic Wave Absorption Wall

Satoshi SAKAKI, Yoshinobu OKANO
Musashi Institute of Technology
1-28-1, Tamazutsumi, Setagaya-Ku, Tokyo, Japan 158-8557

1. Introduction

Recently, the electromagnetic environment is deteriorated because of the emission from wireless equipments. Multi-pass fading and interference in the room are especially serious (see Fig.1) [1]. These phenomena cause deterioration in the wireless communication quality. The use of electromagnetic wave absorption wall (hereafter, it is described as EM-absorption wall) is thought as a suppression technique for these phenomena. As for EM-absorption wall for the room, $\lambda/4$ type EM-absorption wall (λ is wave length of the target electromagnetic wave) has been frequently used. Concretely, concentrated area of the microwave is generated by the resonance, and the microwave energy is absorbed with placing the lossy medium in that area. However, thickness of $\lambda/4$ type EM-absorption wall depend on wave length of the target electromagnetic wave. Additionally, because EM-absorption wall intercepts light, watching is obstructed. This property obstructs the safety securing and crime prevention. Accordingly, this report is described about the thickness suppression technology and the transparency improvement technology for the EM-absorption wall. 950MHz band used with UHF-RFID system is chosen as a target frequency. Generally, UHF-RFID system is used indoors, and influenced easily by electromagnetic interference. Therefore, EM-absorption wall is necessaries in UHF-RFID system.

2. System

Configuration of absorption wall

Fig. 2 shows the structure of EM-absorption wall where the thickness suppression technology is adopted. [2]. Patch elements layer is put on the reflection plate with the electro conductive sheet, and the resistance thin film layer is consisting on patch elements layer. The patch element layer loading is a kernel of the thickness suppression technology. Details of those effects are described in the following chapter. The absorbable microwave frequency can be controlled by the position of patch elements layer and the size of each patch element. Finite difference time domain method (FDTD-method) is used for this EM-absorption wall optimization as numerical analysis method. The size of the EM-absorption wall unit is assumed to be 600 mm x 600 mm shown in Fig.2. In FDTD-method, the unit that contains one patch element as shown under Fig.2 is periodically arranged and designed. The case where the size of the design unit is assumed to be 100 mm x 100 mm is shown in Fig. 2. Patch size is ***Pl* x *Pl*,** as for the distance from the resistance film to the patch is ***d1***, as for the distance from the patch to the reflection plate is ***d2*** and thickness of the whole is assumed to be ***d***.

3. Parametric analysis

3.1 Thickness suppress technology

In this chapter, an analytical result concerning the effect of the patch element layer loadings is described. Fig. 3 shows the microwave energy distribution of EM-absorption wall without the patch element layer [3]. Concentrated area of the microwave energy has been generated forward of reflection plate. This is due to the resonance, and the distance between the energy concentration area and reflection plate corresponds to quarter wavelength of an incident wave. If a resistance thin film is placed on this area the microwave energy is consumed, and does not reflect. However, when a resistance thin film is brought close to reflection plate, the electromagnetic absorption efficiency is rapidly deteriorated.

Fig. 5 shows the impedance of λ/4 type (thickness =78mm) EM absorption wall is shown with the Smith chart. The range of the frequency is 0.5GHz-1.5GHz. The absorption maximum point (950MHz) appears origin of Smith chart. But, thickness is very large. Next, when patch element layer loading type EM-absorption wall, the absorption keeps 10dB or more though thickness suppress 20mm (see Fig. 6). Fig. 6 is set to d=20mm as well as Fig. 5. It was proven that the the patch element layer loadings had the effect of thickness suppression for EM-absorption wall. Other shape parameters of the patch element layer loadings type EM-absorption wall are as follows. ***Pl***=90mm and ***d1***=***d2***=10mm.

3.2 Frequency adjustment.

The shape parameter analysis result for the patch element layer loading type EM-absorption wall optimization is shown in Fig. 7 and 8 respectively. Fig. 7 is the absorption transition when ***d1*** is changed (however, the size of the patch element and absorption wall thickness are fixed to ***Pl***=90 mm and ***d***=20mm respectively). Fig. 8 is the absorption transition when ***Pl*** is changed (however, the shape parameter of other absorption wall is fixed). The peak of the absorption shifts to the high region when the patch size is reduced. From these two results, the position where a patch element is inserted ***d1***=***d2***=10mm. The size is assumed to be ***Pl***=88mm. As a result, the frequency can be adjusted by changing the size and the position where a patch element is inserted.

4. Transparent materials

In manufacturing the patch element layer loading type EM-absorption wall, the following materials were selected for a transparency improvement of EM-absorption wall. A transparent shield sheet to use instead of metal reflection plate and the patch element is shown for Fig. 9. Optical permeability is 75% or more. The surface resistivity is about 0.2Ω/□ in UHF band. Fig. 10 is ITO (Indium-Tin-Oxide) thin film adopted for a resistance thin film. Optical permeability is 80% or more. In addition, the surface resistivity is about 370Ω/□. This is a material of best for a resistance thin film. Fig. 11 shows the structure of manufactured the patch element layer loadings type EM-absorption wall. Acrylic board of 2mm in thickness is used for the support of transparent electro conductive sheet and ITO thin film. The photograph of the transparent type electromagnetic wave absorption wall produced by using three materials is shown in Fig.12. The shape parameter of manufactured EM-absorption wall is enumerated in the following Tables 1.

5. Measurement

As for this chapter, the result of experimentally verifying a transparency improved thin type EM-absorption wall is described. The outline of the absorption measurement system is illustrated in Figure 13 [4]. Fig. 14 shows analytical results by FD-TD method with measured ones. θ is set to 0° in the measurement and the analysis. There is a difference in the transition of the absorption in the measurement and the analysis. This is thought the influence of supporter for the EM-absorption wall in the measurement. However, it was confirmed that the frequency that became an absorption maximum performance is adjacent with the measurement value and the design value. As a result, the analysis became a similar characteristic to the measurement.

6. Conclusion

In this report, result of inserting patch element, thickness is the entire ***d***=20mm and 1/4 thinned. Also, it is succeeded that transparency using three materials. The absorption was able to obtain 16dB. But the peak of the absorption is shifting 50MHz. There is a difference in the transition of the absorption in the measurement and the analysis. This is thought the influence of supporter for the EM-absorption wall in the measurement.

References

[1] S. Hashimoto, “Story of electromagnetic wave absorption wall,” (2001)
[2] Y. Okano, Y. Yasui, M. Abe, “development of a multi frequency electromagnetic wave absorption wall with metallic patch element loadings” Vol.J89-B No.10 pp.2022-2034, (2006)
[3] M. Shimamura, Y. Okano, M. Abe, “Development of Electromagnetic Wave Absorption Wall for Broadband with Metallic Patch Element Loadings” (2008)
[4] S. Hashimoto, “Measurement technique in micro wave and millimeter wave”, (1998)

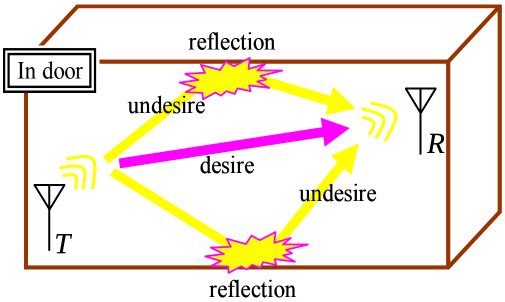

Fig.1 Multipass fading

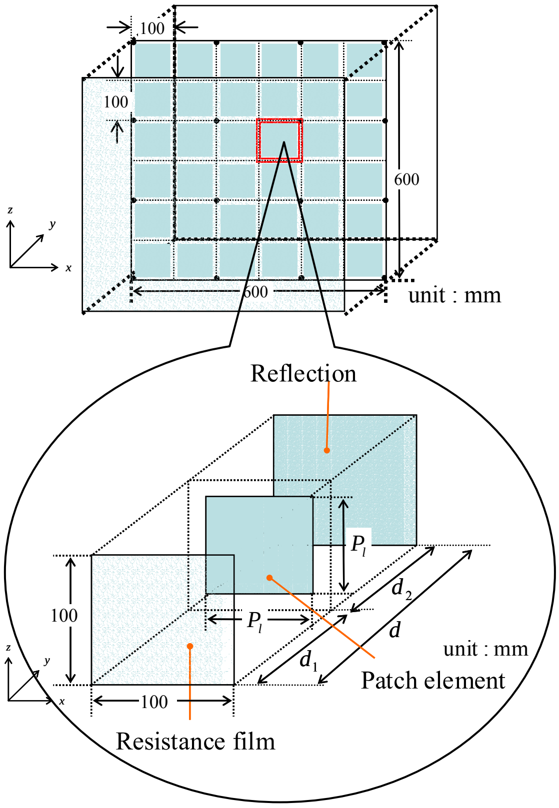

Fig.2 overall view and analytical model

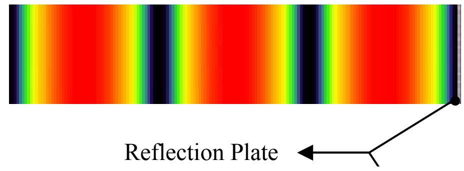

Fig.3 Electric field magnitude for λ/4 types

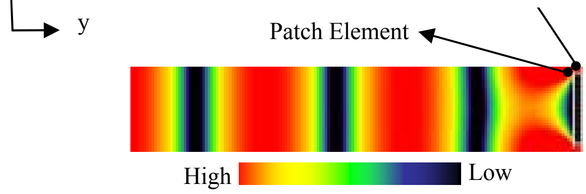

Fig.4 Electric field magnitude for patch element insertion

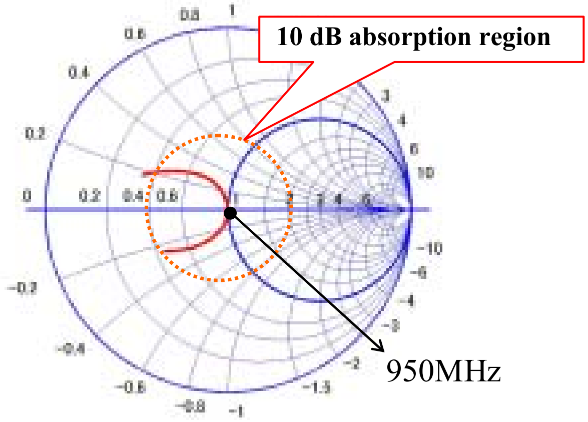

Fig.5 Impedance for λ/4 types

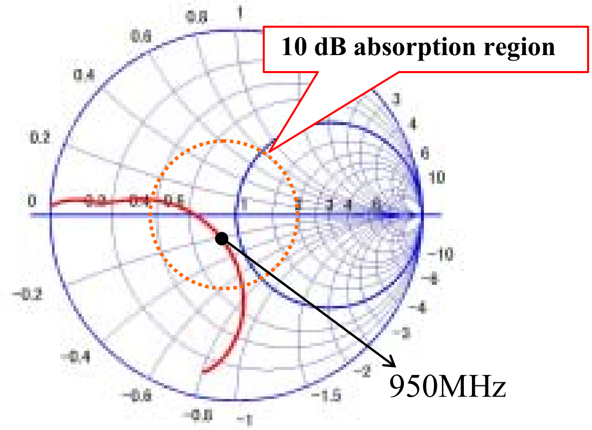

Fig.6 Impedance for patch element insertion

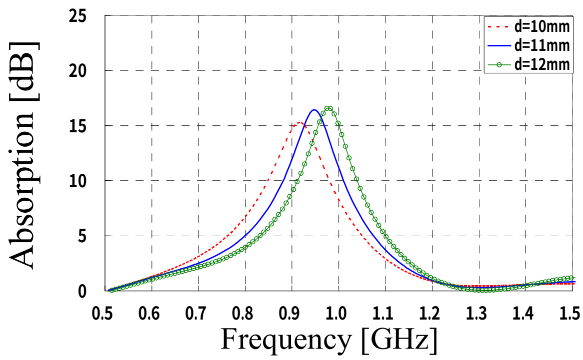

Fig.7 Insert position change of patch element

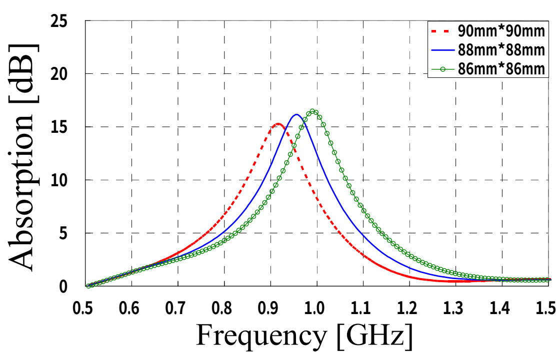

Fig.8 Change of size of patch size

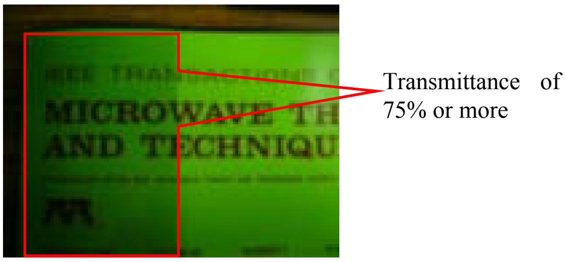

Fig.9 High transparent metallic mesh film

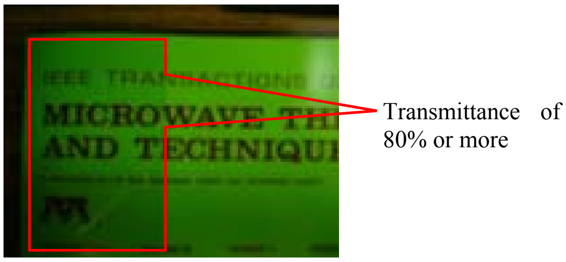

Fig.10 ITO film

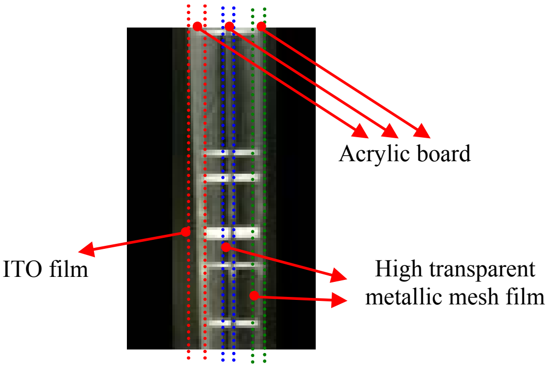

Fig.11 acrylic board

Fig.12 made the absorption wall

Table 1 Parameter

d	20mm
d1	10mm
d2	10mm
Pl	88mm
Acrylic board	2mm

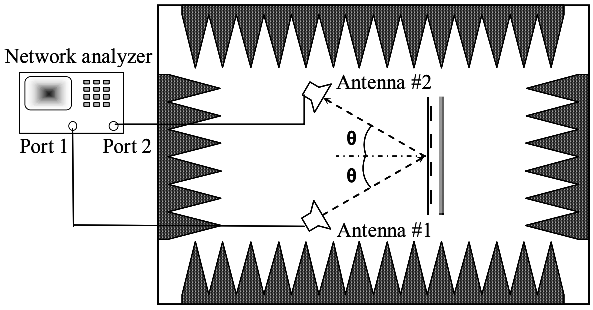

Fig.13 time domain method

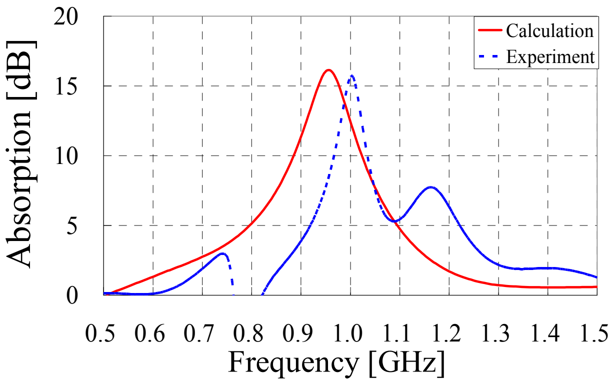

Fig.14 Comparison between analysis and measurement