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EM Wave Absorption of Sendust

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ABSTRACT : *In this study, we focused to develop EM wave absorbers with sendust for L-band. Without high temperature treatment, sendust was coated with $Al(OH)_3$ by very simple method. Prepared EM wave absorbers with 2 mm thickness showed absorption of 10 dB in center frequency of L-band . Sendust EM wave absorbers coated with $Al(OH)_3$ have advanced EM wave absorption.*

KEY WORDS : Sendust, Reflection coefficient, $Al(OH)_3$, Coating, Broad-band, Central frequency, Permeability

1. Introduction

There are so much unwanted EM (Electromagnetic) waves radiated from EM machines in spaces. The unwanted EM waves affect EM machines and humans. EM wave absorbers are used to protect EM machines and humans from the unwanted EM wave radiation. Magnetic materials, such as soft magnets (Mn-Zn, and Ni-Zn ferrites) and hard magnets (Ba, and Sr ferrites) are important materials as EM wave absorbers because of their high magnetic loss, which contributes to the EM wave absorption [1][2][3][4][5].

Even though, a lot of study have done to develop EM wave absorbers with broad-band absorption, almost of them have been focused on design [5] and almost materials for them were Mn-Zn, Ni-Zn, Ba, and Sr ferrites [1][2][3][4]. To increase absorption frequency band and absorption in a central frequency, it is very important to develop new materials.

Absorption frequency depends on resonance frequency of magnetic materials and thickness of an EM wave absorber [6], and, resonance frequency depends on their permeability.

This is a technical report. In this research, we interested in sendust as an EM wave absorbers for an L-band because of their high permeability.

2. Sample preparation and measurements

In this research, we used sendust powders as a starting material for preparing sheet-type EM wave absorbers. Usually, coating of materials with high resistivity, such as an Al(OH)3 on magnetic materials needs very high temperature over 1100℃. However, in this study, we coated samples by very simple method. Sendust powders were mixed with aqueous solution of carboxy methyl cellulous (CMC), and coated with Al(OH)3 by using a double screw mixer. The sendust coated with Al(OH)3 cured at 70℃ for 30 min in an oven, after that the cured powders were mixed with chloride poly ethylene(CPE) by using an open roller.

For the investigation of the EM wave absorption of the samples, the prepared sheet-type EM wave absorbers were punched into a toroidal shape with an inner diameter of 3.05 mm and an outer diameter of 6.95 mm. The absorption properties of the samples were investigated with a HP-8753D network analyzer. Figures 1 and 2 are diagrams of measurement system used for the reflection coefficient and the sample holder, respectively.

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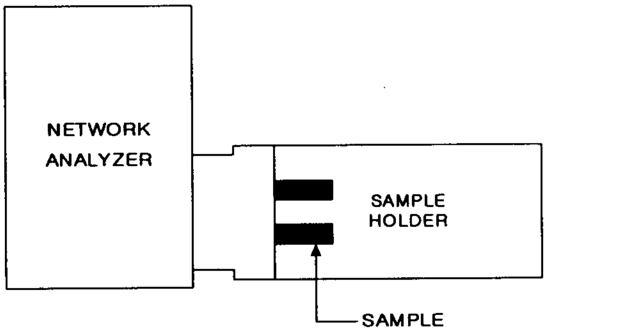


Fig. 1 Measurement system for the reflection coefficient.

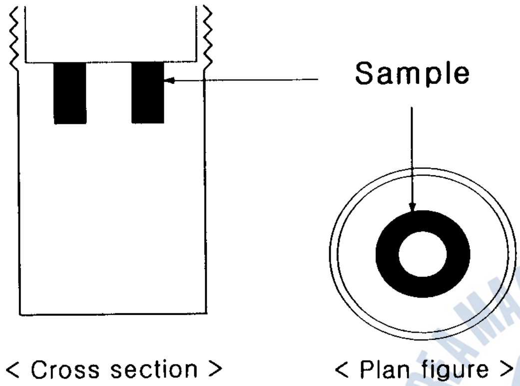
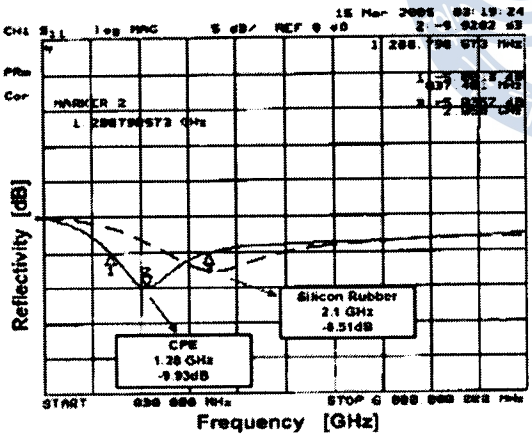


Fig. 2 Sample holder.



(thickness of 2 mm)

Fig. 3 Reflectivity as a function of frequency for samples prepared with silicone rubber and CPE.

3. Results and discussion

CPE and silicone rubbers are useful binders for EM wave absorbers. Thus, we prepared sendust EM wave absorbers with them and compared absorption. Figure 3 shows EM wave absorption as a function of frequency for

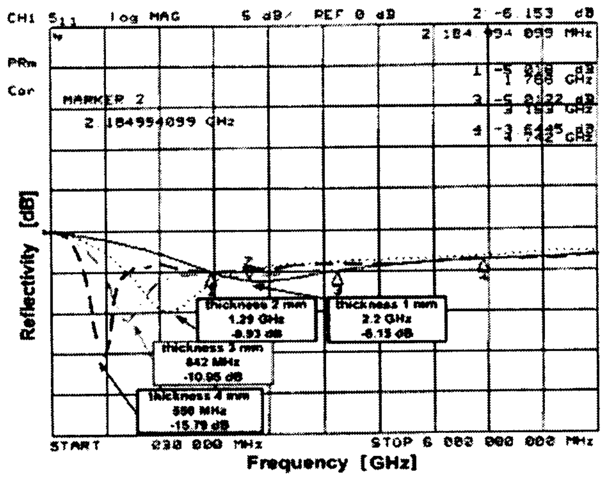


Fig. 4 Reflectivity as a function of frequency for samples of 1, 2, 3, and 4 mm.

samples of 2 mm. When we compare both, an EM wave absorber prepared with CPE shows better absorption than one prepared with silicone rubber. Thus, from now, we discuss about EM wave absorbers prepared with CPE.

As we mentioned before, central frequency of an EM wave absorber depends on their thickness like equa. (1).

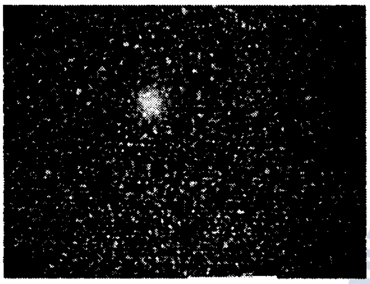
$$d=c/(2\pi\mu_r''f) \qquad (1)$$

where d, c, μ_r'', and f are sample thickness, light velocity, imaginary part of permeability, and central frequency of absorption, respectively [6].

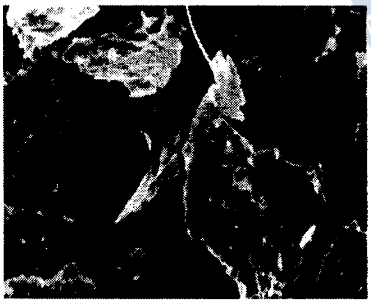
We investigated absorption for samples with different thickness and show the results in Fig. 4. Figure 4 shows that the sample of 2 mm has about 10 dB(90%) at 1.3 GHz which is center frequency of L-Band. Also, the central frequency decreases with increasing sample thickness, and this phenomenon satisfies equa. (1).

Exchange interactions between magnetic particles affect the absorption of an EM wave absorber prepared with magnetic materials. Thus, we coated sendust with $Al(OH)_3$ powders which have very high resistivity of about 1011Ω/cm to interrupt the interaction between magnetic particles. We thought that the coating of $Al(OH)_3$ on the surface of sendust will decrease the magnetic interaction between sendusts and increase resistivity loss. To confirm the being of $Al(OH)_3$ on the surface of sendust, we investigated SEM micrographs. Figure 5 shows a) $Al(OH)_3$ powders, b) sendusts without coating, and c) sendusts coated with $Al(OH)_3$. In Fig. 5 (c), we could confirm the surface of sendusts are coated with Al(OH)3.

Figure 6 shows that the band with of absorption increases and the central frequency shifts toward higher frequency with increasing coating amount. From this result, we can conclude that the Al(OH)3 coating on sendust is a useful method to increase absorption band and to control a central frequency. To illustrate this result, we investigated permeability for the samples and the result is shown in Fig. 7. In Fig. 7, (a) shows permeability as a function of frequency for a sendust EM wave absorber without coating, (b) shows permeability for one coated with Al(OH)3 of 10wt%, and (c) shows permeability for one coated with Al(OH)3 of 20wt%.



(a) Al(OH)3



(b) Sendust

(c) 20wt% Al(OH)

Fig. 5 SEM micrographs by 500, a) Al(OH)3 powders, b) sendusts without coating, and c) sendusts coated with Al(OH)3.

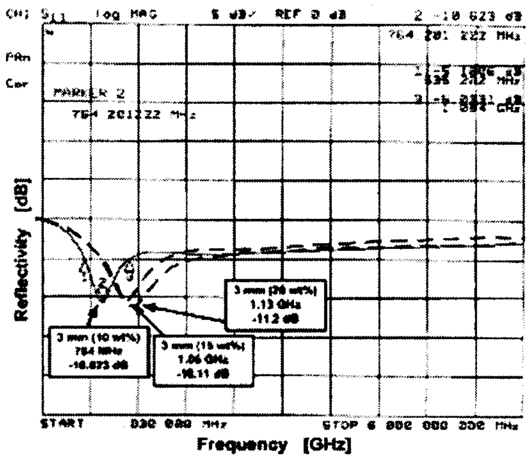
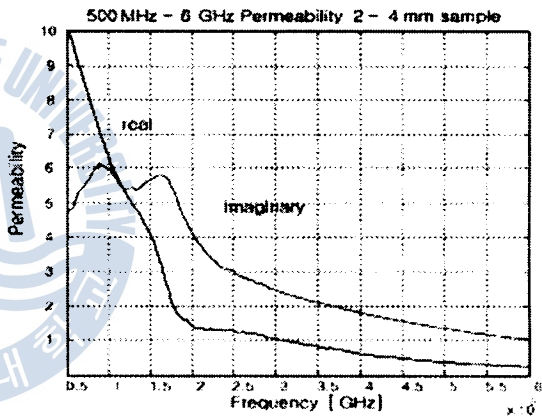
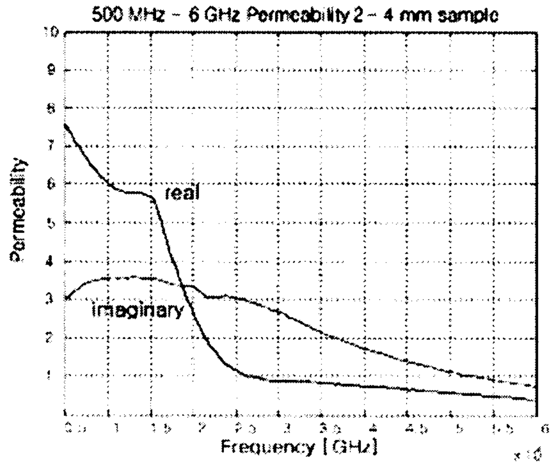


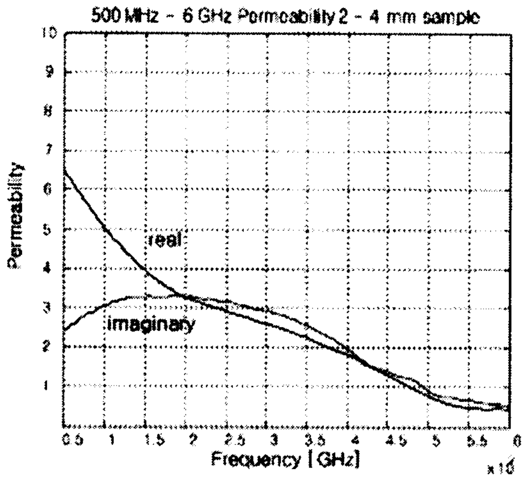
Fig. 6 Reflectivity as a function of frequency for samples with different coating amount of Al(OH)3.



(a)



(b)



(c)

Fig. 7 Permeability as a function of frequency for samples of (a) sendust without coating, (b) sendust coated with Al(OH)3 of 10wt%, and (c) sendust coated with Al(OH)3 of 20wt%.

The EM wave absorption of magnetic materials depends on magnetic loss, and magnetic loss is larger in the frequency of $\tan\delta>1$ than $\tan\delta<1$ ($\tan\delta=\mu''/\mu'$) [6]. In Fig. 7, the frequencies to show $\tan\delta=1$ are 1.2, 1.8, and 2 GHz for no coating, 10% coating, and 20% coating, respectively. The frequency of $\tan\delta=1$ increases with increasing coating amount. This phenomenon is in accord with the result of Fig. 6.

4. Conclusions

In this study, we suggested sendusts as a material for EM wave absorbers and investigated their EM wave absorption.

Prepared EM wave absorbers with 2 mm thickness showed good absorption in center frequency of L-band. Introduced simple method for coating is useful to coat sendust without high temperature. We showed coating of Al(OH)3 on sendust to increase absorption-band and absorption in central frequency. Suggested EM wave absorbers prepared with sendust can be a useful EM wave absorber for an L-Band.

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