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Dependence on Preparation Temperature of the Microwave Absorption Properties in Absorbers for Mobile Phones

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Mn-Zn composite microwave absorbers mixed with silicone for mobile phones were prepared at different preparation temperatures of 10 °C, 30 °C, 50 °C, and 70 °C, and the effects of the preparation temperature of samples on the absorption were studied. The frequency that satisfies $\tan\delta > 1$ shifts toward lower frequency with increasing preparation temperature. We developed Mn-Zn composite microwave absorbers with an absorption of 3.8 dB at 1.8 GHz. These absorber should be very valuable for preventing unwanted microwave radiation from mobile phones. It is very important to consider preparation temperature in order to develop a composite microwave absorber with superior absorption.

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Keywords: Mobile phone, Composite absorber, Mn-Zn ferrite, Absorption ability, Preparation temperature

I. INTRODUCTION

Electromagnetic machines, such as personal communication and wireless lan systems, have become widespreaded in the world for human comfort. However, the spread of electromagnetic machines has caused new problems, such as TV ghosts and dangerous electromagnetic wave from microwave ovens. Especially, many researchers have reported that the microwave radiation from mobile phones may be a cause of cancer. Thus, it is very important to develop a protector that absorbs and/or shields the microwaves transmitted from mobile phones. Ferrite is a useful material for microwave absorption, and Mn-Zn ferrites are important materials as microwave absorbers because their magnetic loss contributes to microwave absorption [1,2].

Many studies were carried out on ferrites to investigate the effects of their volume percentages in composites, and particle sizes on the absorption of microwaves [3-6]. However, the effects of the preparation temperature on the absorption of microwaves have not been reported. In this contribution, we report the effects of the preparation temperature on microwave absorption properties to develop composite microwave absorbers with superior properties for mobile phones.

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II. PREPARATION AND MEASUREMENTS OF SAMPLES

1. Preparation of Samples

In this study, we used ferrite with the chemical composition $Fe_2O_3 : MnO : ZnO$ = 67.5 mol% : 24 mol% : 8.5 mol% as a starting material. We used a vibration mill to pulverize the ferrite into 1.3-μm and 20-μm powders were then mixed with silicone by using a roller. The surface temperature of the roller wheel was controlled to be 10 °C, 30 °C, 50 °C, and 70 °C which was the roller condition for investing the effect of the preparation temperature on microwave absorption. The thickness of samples was a uniform 1 mm. The detailed preparation conditions for the microwave absorbers are listed in Fig. 1.

2. Measurements of Samples

For the investigation of the microwave absorption properties, the prepared composite microwave absorbers were punched into toroidal shapes with inner diameters of 3.05 mm and outer diameters of 6.95 mm. The absorption properties of the samples were investigated with a HP-8753D network analyzer. Figures 2 and 3 are diagrams of the measurement method used for the reflection

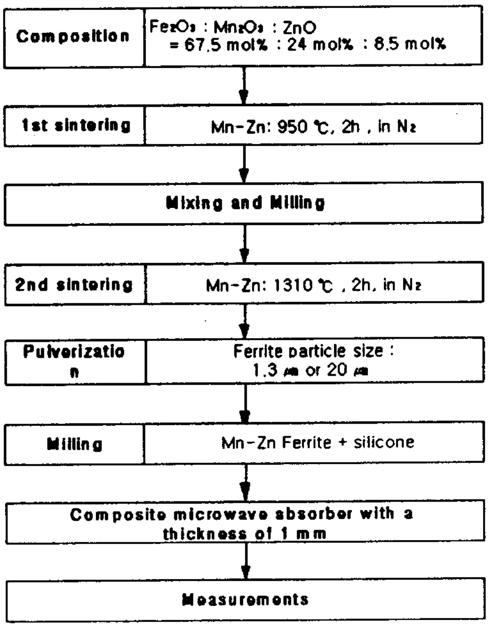

Fig. 1. Preparation of the composite ferrite absorber.

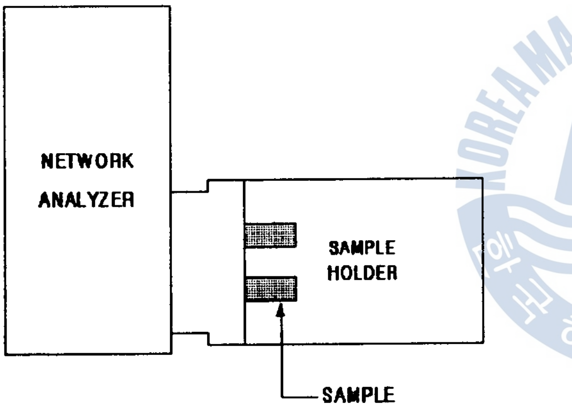

Fig. 2. Measurement method for the reflection coefficient.

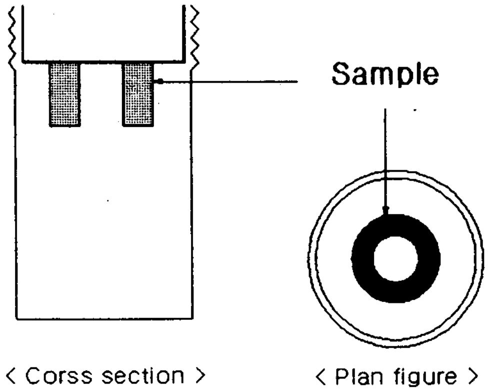

Fig. 3. Sample holder. (a) 10 °C (b) 30 °C (c) 50 °C (d) 70 °C

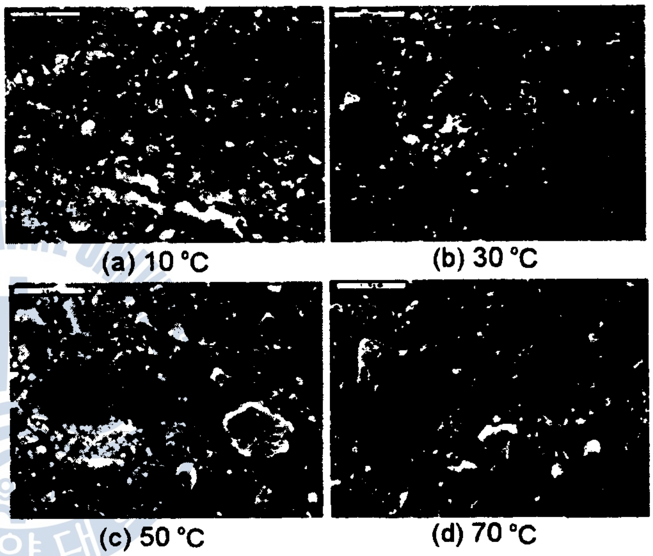

Fig. 4. SEM micrographs of specimens with a ferrite particle size of 1.3 μm prepared at (a) 10 °C, (b) 30 °C, (c) 50 °C, and 70 °C.

coefficient and of the sample holder, respectively.

III. MICROSTRUCTURE AND PROPERTIES OF SAMPLES

1. Microstructure of Samples

Surface micrographs of the specimens with a ferrite particle size of 1.3 μm prepared at 10 °C, 30 °C, 50 °C, and 70 °C are represented in Fig. 4, which shows that all ferrite particles were well mixed with the silicone and that no air holes were presented.

2. Dependence of the Microwave Absorption Properties on Preparation Temperature

Figure 5 shows the microwave absorption abilities as functions of the frequency for composite microwave absorbers with a ferrite particle size of 1.3 μm prepared at 10 °C, (b) 30 °C, (c) 50 °C, and 70 °C. The figures show that the microwave absorption abilities are, respectively, 2.0 dB, 2.8 dB, 3.0 dB, and 3.4 dB at 1.8 GHz which is the frequency used for mobile phones. The figures also show that the microwave absorption ability increased with increasing preparation temperature. In order to clarify the phenomenon, we investigated the permeability of the samples, and the results are shown in Fig. 6, which illustrates the permeability as a function of the frequency. The figures show that the real part of the permeability increased with increasing preparation temperature. Also, the resonance frequency is shifted toward lower frequency with increasing initial permeability and follows Snoek's law well [7].

The microwave absorption ability of ferrites is related

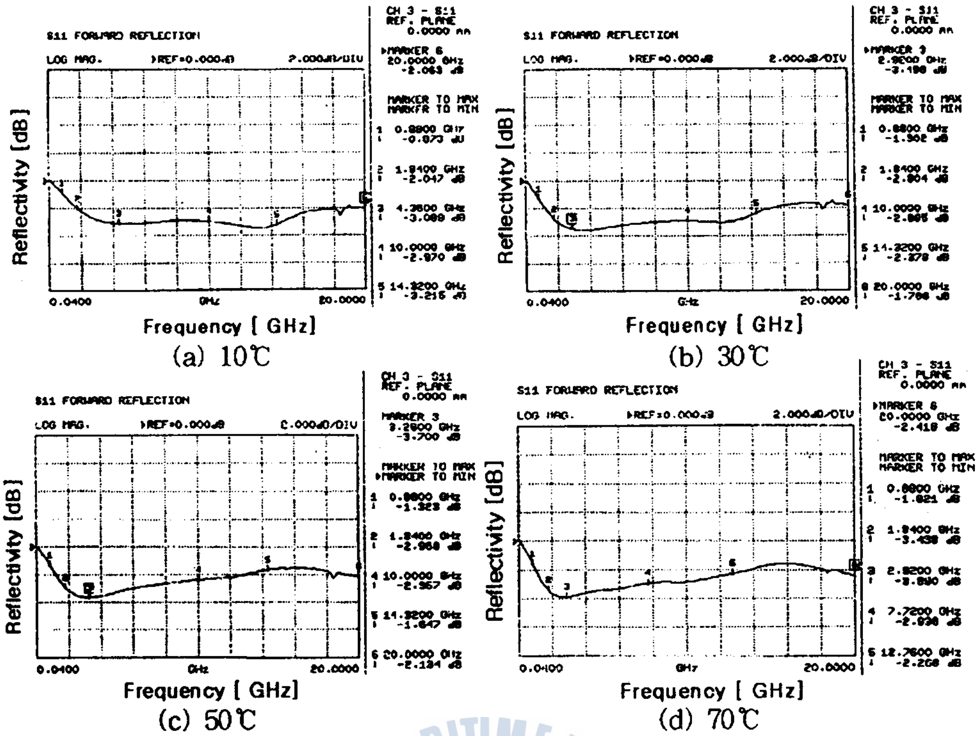

Fig. 5. Reflectivity as a function of frequency for specimens with a ferrite particle size of 1.3 μm prepared at (a) 10 °C, (b) 30 °C, (c) 50 °C, and (d) 70 °C.

with the magnetic loss $\tan\delta = (\mu''/\mu')$, and the magnetic loss is strong for $\tan\delta > 1$ [8]. In Fig. 6, the frequencies that satisfy the condition $\tan\delta > 1$ are 1.5 GHz, 800 MHz, 750 MHz, and 400 MHz for the samples prepared at 10 °C, 30 °C, 50 °C, and 70 °C, respectively.

We conclude that the increase in the microwave absorption at 1.8 GHz with increasing sample preparation temperature is related to the frequency for which show $\tan\delta > 1$. Also, the preparation temperature of microwave absorbers is very important for preparing microwave absorbers with superior properties for mobile phones.

We reported that the ferrite particle size affected the absorption ability of a composite microwave absorber; the absorption ability increased with increasing average particle size [5]. Thus, we prepared for a mobile phone a composite microwave absorber with a ferrite particle size

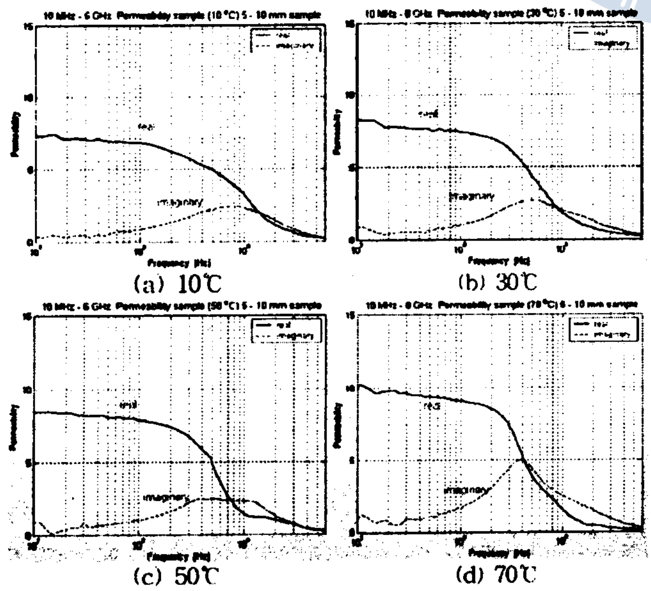

Fig. 6. Permeability as a function of frequency for specimens with a ferrite particle size of 1.3 μm prepared at (a) 10 °C, (b) 30 °C, (c) 50 °C, and (d) 70 °C.

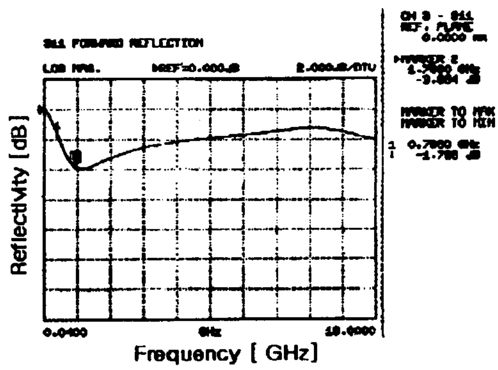

Fig. 7. Reflectivity as a function of frequency for a specimen prepared at 70 °C with a ferrite particle size of 20 μm.

of 20 μm at 70 °C with superior microwave absorption ability, and the absorption ability is shown in Fig. 7. The absorber shows a superior microwave absorption of 3.8 dB at 1.8 GHz. The figure clearly that a microwave absorber with the ferrite particle size of 20 μm has a larger value of microwave absorption than the absorber with ferrite particle size of 1.3 μm shown in Fig. 5(d). We conclude that the absorber with a ferrite particle size of 20 μm prepared at 70 °C is very valuable for preventing unwanted microwave radiation from mobile phones.

IV. CONCLUSIONS

In this study, we investigated the effect of the preparation temperature on the microwave absorption so as to develop a composite microwave absorber for mobile phones. The frequency for which $\tan\delta > 1$ shifted toward lower frequency with increasing sample preparation temperature. We developed a Mn-Zn composite microwave absorber with an absorption of 3.8 dB at 1.8 GHz. This absorber should be very valuable for preventing unwanted microwave radiation from mobile phones. Thus, it is very important to consider preparation temperature in order to develop a composite microwave absorber with superior absorption.

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