【Grant-in-Aid for Scientific Research (S)】

Broad Section D

Title of Project : Development of a Wideband Microwave Absorber – Contributing to the Internet of Things Society Through Dual-phase Engineering

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【Purpose and Background of the Research】

In the Internet of Things (IoT) era, in which devices and appliances are now connected to the Internet, the number of information and communication technology (ICT) devices is expected to rapidly increase. To accommodate the transmission of large amounts of information at high speeds, the frequency band will be shifted from the current ultra-high frequency band to the higher super-high frequency band (0.7–6.0 GHz), which is called the early 5G band. However, as the noise emitted from many ICT devices affects communications using this band, reduction of this noise is vital.

Although electromagnetic wave absorbers absorb noise and are used to mitigate against this problem, conventional electromagnetic wave absorbers using soft magnetic materials, such as spinel ferrite and Fe-based materials, are not used in this frequency range because of the decrease in the imaginary part of their relative permeability (μ_r”). In addition, because ICT devices emit noise at many different frequencies, electromagnetic wave absorbers should function over a wide frequency range.

Therefore, in this research, modified dual-phase powders consisting of hard magnetic and soft magnetic phases will be prepared. The hard magnetic phase will increase the frequency range because of its high magnetic anisotropy and the soft magnetic phase will generate high permeability. By controlling the microstructure of the modified dual-phase powder, we will develop broadband electromagnetic wave absorbers that can function in the early 5G band.

【Research Methods】

The modified dual-phase powder will be based on a composite powder consisting of hard and soft magnetic phases (Table 1). This design is based on the difference in resonannce frequencies between the two phases. The powder will be prepared by heat treatment (e.g., hydrogen reduction), followed by mixing using a mechanofusion reaction or a coating method (e.g., arc plasma deposition). Furthermore, to obtain electromagnetic wave absorption over a wide frequency range, μ_r’ and μ_r” must be within a certain range (matching region), as shown in Fig. 1. To achieve this, the two-phase microstructure will be controlled by methods including the distribution of the two phases in the powders and the volume fraction of the powders in resin composites.

Table 1 Schematic illustration of modified dual-phase powders.

Method	Hard Magnetic Particles		Soft Magnetic Particles		Modified Dual Phase Particles	
Mixing	Coprecipi-tation		Hydrogen Reduction		Mechanofusion	
Coating	–	–	Hydrogen Plasma Metal Reaction (HPMR)		Metal Organic Decomposition	
Coating	Coprecipi-tation		–	–	Arc Plasma Deposition (APD)	
Heat Treat.	Coprecipi-tation		–	–	Hydrogen Reduction (Partial reduction)	

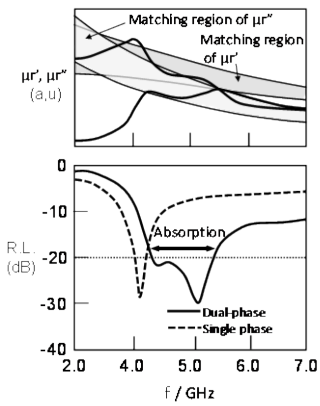

Fig. 1 Matching regions and reflection loss (RL).

【Expected Research Achievements and Scientific Significance】

In this research, a new type of microwave absorption material will be developed for use in microwave absorbers. The material will be based on a modified powder composed of a hard and soft magnetic phase. The results will contribute to the development of ICT devices and to the establishment of IoT and sustainable societies.

【Publications Relevant to the Project】

・S. Sugimoto, S. Kondo, K. Okayama, et al., “M-type ferrite composite as a microwave absorber with wide bandwidth in the GHz range”, *IEEE. Trans. Magn.*, **35**(5), 3154-3156, (1999).

・T. Maeda, S. Sugimoto, T. Kagotani, et al., “Effect of the soft/hard exchange interaction on natural resonance frequency and electromagnetic wave absorption of the rare earth-iron-boron compounds”, *J. Magn. Magn. Mater.*, **281**, 195-205, (2004).

【Term of Project】FY2019-2023

【Budget Allocation】122,600 Thousand Yen

【Homepage Address and Other Contact Information】

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