Electromagnetic Wave Absorption Properties of α-Fe/$Nd_2Fe_{14}B$ Nanocomposites

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Abstract: The α-Fe/$Nd_2Fe_{14}B$ nanocomposites were prepared using a melt spinning method and subsequent annealing treatment. The complex permittivity permeability of composites was measured in the 0.5~18 GHz frequency range. The permeability spectra exhibits relaxation type characteristic. The α-Fe/$Nd_2Fe_{14}B$ composites shows an excellent microwave absorption property (reflection loss: RL$\leq$ -20 dB) in 9~17 GHz with thin matching thickness 1.6~2.5 mm due to the cooperate effect of magnetic loss and dielectric loss.

Key words: Electromagnetic wave absorber; Nanocomposite; $Nd_2Fe_{14}B$; Microwave electromagnetic properties
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Recently, the number of communication devices that utilize gigahertz range microwave radiation, such as mobile phones and LAN systems, has greatly increased[1]. However, electromagnetic interference (EMI) has become serious[2]. One promising technique to prevent EMI is the use of microwave absorption materials.

α-Fe/$Nd_2Fe_{14}B$ composites is composed of soft magnetic α-Fe phase with high M_S and hard magnetic $Nd_2Fe_{14}B$ phase with large H_A, consequently their natural resonance frequency are at a high frequency range and permeability still remains as a large value in high frequency range. Furthermore, the electric resistivity of $Nd_2Fe_{14}B$ is higher than that of metallic soft magnetic material[3], which can restrain the eddy current loss. Thus, it is possible to be a good candidate for thinner microwave absorbers in the GHz range.

1 Experimental procedure

The $Nd_8Fe_{91}B_3$ alloy was prepared by a melt-spun technique and subsequent annealing method. The phases and microstructure of samples are determined by XRD. The magnetic hysteresis loops were measured using a vibrating sample magnetometer (VSM). Microwave electromagnetic properties of samples (the weight ratio of magnetic powder: 80%) are measured using vector network analyzer in the range of 0.5—18 GHz by an Agilent 8720ET vector network analyzer. The reflection loss (RL) curves were calculated from the complex permeability (μ_r) and permittivity (ε_r) with a given frequency range and a given absorber thickness (d) by the formulas described in reference[4].

2 Results and discussion

Fig. 1 shows the frequency dependence of relative permeability permittivity. For $Nd_8Fe_{91}B_3$ composites, the real part μ_r' and imaginary part μ_r'' of relative permeability shows two dispersion peaks, and the first peak may induced by the size resonance due to the inhomogeneous of composites. The permeability spectra of $Nd_2Fe_{14}B$/α-Fe nanocomposites varies very slowly and exhibits relaxation type characteristic in the 0.5—18 GHz frequency range, and the second peak value of imaginary part μ_r'' obtains at 13 GHz. The imaginary part of permittivity for the composites exhibits a peak at 9 GHz. The dielectric properties of the composites arise mainly from the interfacial polarization. Consequently, microwave absorption properties of α-Fe/$Nd_2Fe_{14}B$ composites depend on cooperate effect of magnetic loss and dielectric loss.

This nanocomposite shows an excellent microwave absorption property (reflection loss: RL$\leq$ -20 dB) in 9~17 GHz with thin matching thickness 1.6~2.5 mm as shown in Fig. 2.

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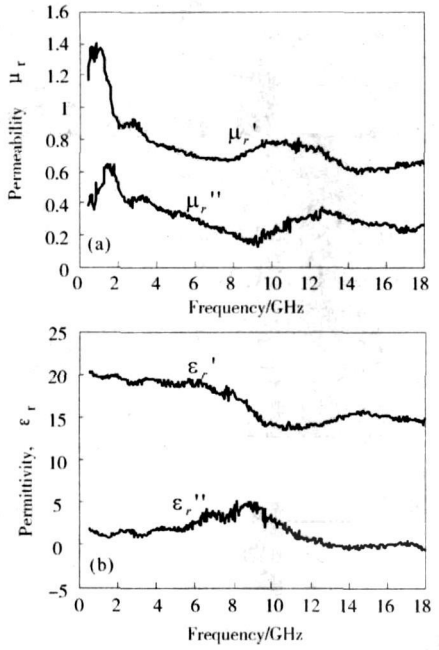

Fig. 1　Frequency dependence of relative complex permeability (a), permittivity (b) of Nd6Fe91B3 compositions

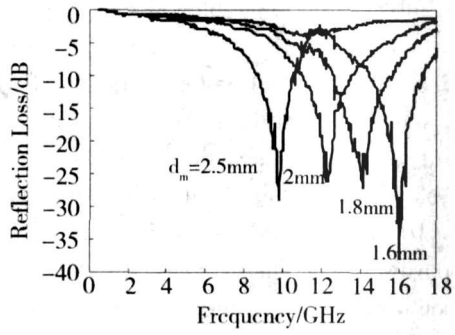

Fig. 2　Frequency dependence of reflection loss for $Nd_6Fe_{91}B_3$ compositions with different matching thickness

3　Conclusions

The permeability spectra of $Nd_2Fe_{14}B/\alpha$-Fe nanocomposites exhibits relaxation type characteristic in the 0.5～18 GHz frequency range. Microwave absorption properties of this composites depend on cooperate effect of magnetic loss and dielectric loss. A minimum RL of −37 dB is observed at 16 GHz with an absorber thickness of 1.6 mm. $Nd_2Fe_{14}B/\alpha$-Fe nanocomposites are promising microwave absorbers in GHz frequency range.

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纳米复相 α-Fe/$Nd_2Fe_{14}B$材料电磁波吸收性能研究

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摘　要：采用熔体快淬及晶化退火工艺制备了 $Nd_2Fe_{14}B/\alpha$-Fe纳米晶双相材料，对该材料在 0.5～18 GHz频段的复介电常数、复磁导率进行了测试，其磁谱表现为驰豫型特征。由于磁损耗和介电损耗的共同作用，纳米复相 $Nd_2Fe_{14}B/\alpha$-Fe吸波材料在 9～17 GHz具有良好的吸波性能，其匹配厚度为 1.6～2.5 mm。

关键词：吸波；纳米复相；$Nd_2Fe_{14}B$；微波电磁性能

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