Advanced Materials Research *Online: 2014-04-09*
ISSN: 1662-8985, Vols. 915-916, pp 694-697
doi:10.4028/www.scientific.net/AMR.915-916.694

Investigation on microwave property of Fe/Co mixed powders

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Keywords: microwave absorption, permittivity, permeability, matching effect

Abstract. For the purse of improving the microwave absorption ability of carbonyl iron, Co power was chosen as additions to add into the sample. Both analyze and measurement proved that the addition of Co power effectively decreased the conductivity, while not obviously destroyed the magnetic property of the sample. In this way, the addition of Co power improved the sample surface matching effect, and correspondingly, the absorption ability is increased.

Introduction

As an important kind of microwave absorber, carbonyl iron always attracts the attention of many researchers [1,2]. As carbonyl iron combines magnetic and conductive dissipation mechanism, an important task of research is adjusting the conductivity and the magnetism of carbonyl iron, aiming to optimize microwave matching property of this material. Doping carbonyl iron with some additions has been proved an effective method for adjusting property. As Co atom has similar magnetic property as Fe atom, doping iron with Co addition can decreases the conductivity without damaging the magnetism of carbonyl iron. How exactly can Co additions affect the property of carbonyl iron? The purpose of this paper is to answer this question.

Sample Fabrication

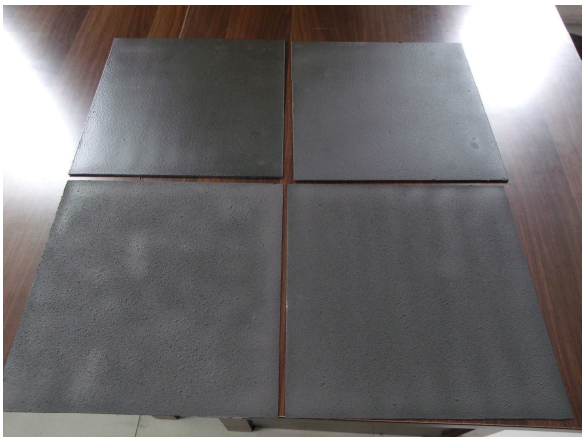


Fig.1 Samples containing Fe/Co mixed powder as absorbers.

The raw materials used includes: urethane resin, carbonyl iron powder, Co powder, ketone, two methyl polyamide, titanate coupling agent and cellulose acetate butyrate. The sample fabrication process is: At first putting mixture proportion of ketone, two methyl polyamide and titanate coupling agent into container, stirring three minutes with speed of 1500 r/min; Then adding

quantified carbonyl iron and Co powders into the mixture, stirring 15 to 20 minutes with speed of 3600 r/min; After that, adding corresponding firming agent, dispersing two minutes. Finally, putting the disperse mixture into airbrush and spraying it onto aluminum sheet. The aluminum sheet with pain was put into oven to dry. Four of the samples produced in this way are shown in Fig.1.

Property Measurement

The microstructure of the iron and Co powder were observed by SEM, and some of the pictures are shown in Fig.2. It can be seen that most of the iron powders are bulbar, part of them are onion-like. The powder size is about 0.3~4, with glossy surface. The distribution of the iron powders in the sample is uniform and no agglomeration is observed. The Co powders are also bulbar with grain size 50~200nm. Relatively, the Co powders are smaller and are not dispersed well. Agglomeration of Co powders in the sample can easily be seen.

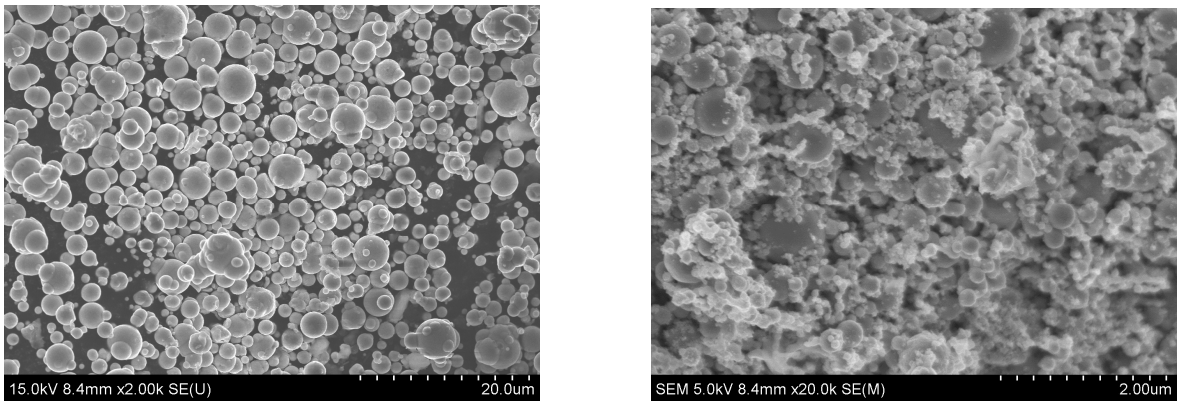
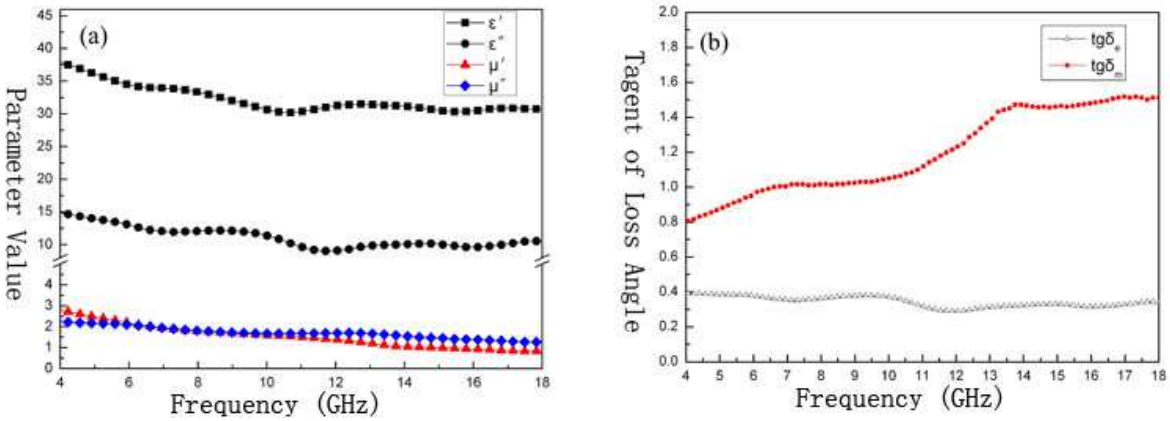


Fig.2 The microstructure picture for Fe powder (left) and Co powder (right).

For the purpose of measuring the electromagnetic parameter, iron and Co powders were mixed with paraffin according to certain proportion. Then the mixture was used to make a coaxial ring with size 2mm thickness, 30.4mm internal diameter, and 7mm outer diameter. The coaxial ring were used to measure the material parameter by a HP-8722ES network analyzer. All measured data are shown in Fig.3 and Fig.4.



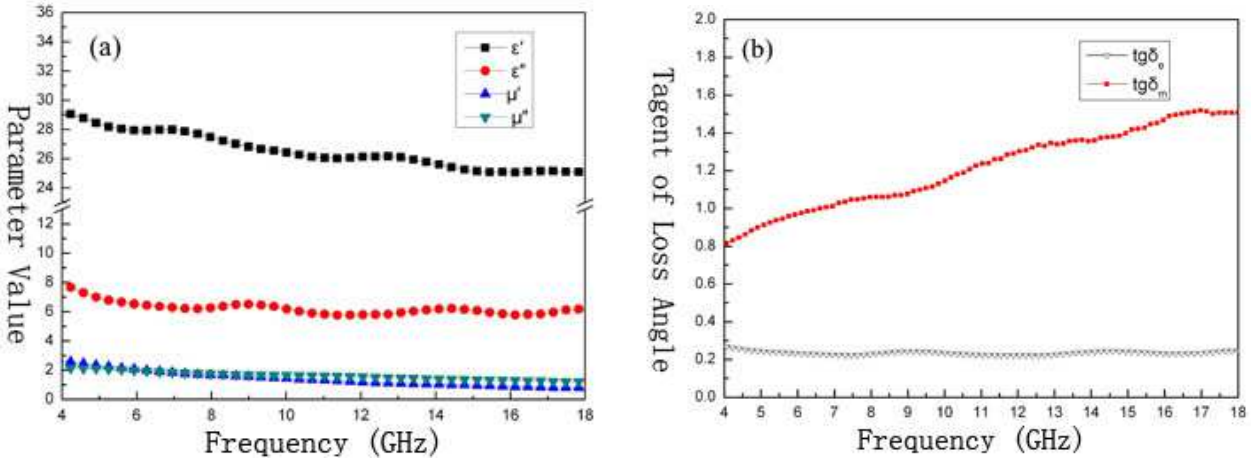
(a) (b)

Fig.3 The frequency dependence of electromagnetic parameters (a) and tangent of loss angle for carbonyl iron powder.

Influence of Co Addition

Generally speaking, electromagnetic parameters of microwave absorbers are in the form of complex. The ratio between the real and imaginary part of these parameters is called loss angle tangent. From Fig.3 (a) , it can be seen that the imaginary permittivity of the carbonyl iron powder is between 9~15, the imaginary permeability is between 1.5~2.5. The tangent of loss angle for permittivity is between 0.3~0.4, while for the permeability the value is 0.8~1.6。These data mean relatively strong magnetic dissipation and certain conductive dissipation.

According to the impedance matching theory, although the decreases of permittivity results in attenuation constant, lower surface reflection may also be resulted [3,4,5]. For microwave absorption, entering sample of microwave is first to be considered. In order to decrease permittivity while remain the permeability, Co powers were used as additions in our sample. Fig.4 (a) shows the parameters of the sample with Co additions. Comparing with the curves in Fig.3 (a), the change of permittivity is obvious, while the change of permeability is much less. The difference between magnetic loss angle and dielectric loss angle is also much smaller. Thus, the present of Co addition in the sample improves the matching effect obviously.



(a) (b)

Fig.4 The frequency dependence of the electromagnetic parameters and tangent of loss angle for Fe/Co mixed powders.

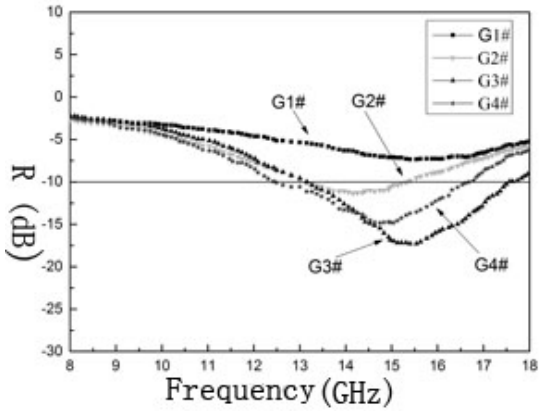


Fig.5 The absorption curves for sample with different Co mass ratio.

Shown inFig.5 is the reflection curves for sample with different Co mass ratio. The curve G1# is for the sample without Co addition. The Co mass ratio for curve G2# to curve G4# is 2.5%, 5%, 7.5%, respectively. It can be seen that, with the increase of Co mass ratio, sample reflection rate at first decreases gradually, but then increases gradually. The bandwidth with -10dB reflection is 2.25GHz for sample G2#, while the value for sample G3# increases to 4.23 GHz. It is true that there is a best value for the Co mass ratio, too much or too small value for the mass ratio is harmful for the sample absorption ability.

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