Microwave Absorption Performance of $La_{0.9}Y_{0.1}MnO_3$ with Different Sintering Temperatures

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Abstract. $La_{0.9}Y_{0.1}MnO_3$ powders have been synthesized at different temperatures by the traditional solid state method. The crystal structures have been characterized by X-ray diffraction (XRD). The electromagnetic parameters were measured by vector network analyzer (VNA) within the frequency range of 8.2-12.4GHz. It's found that the pure perovskite structure has been obtained at the temperature of 1250˚C. The bandwidth for *R* <-10dB became thinner with the sintering temperature's increase from 1250˚C to 1350˚C, and the absorbing peak moves to the higher frequency first an low frequency then, the absorbing peak is enhanced and weakened then.

Introduction

Microwave absorbing material (MAM) is a kind of functional material that can absorb electromagnetic wave effectively and convert electromagnetic energy into heat or make electromagnetic wave disappear by interference [1]. They have attracted considerable attention for its use in industry, commerce and military [2]. $La_{1-x}Y_xMnO_3$ has colossal magnetoresistance and potential applications in sensors and microwave absorbers [3]. There have been a few of reports on the electromagnetic properties and microwave performance of $La_{1-x}Y_xMnO_3$, such as references [3-5]. However, the changes of microwave absorbing ability with different sintering temperatures have not been reported before.

In this paper $La_{0.9}Y_{0.1}MnO_3$ powder were fabricated at different sintering temperatures by the solid state reaction method. The crystal structures were characterized by XRD, and the electromagnetic parameters (complex permittivity $\varepsilon=\varepsilon'-j\varepsilon''$, complex permeability $\mu=\mu'-\mu''$) were measured by VNA. The influence of different sintering temperatures on microwave absorbing properties was investigated.

Experiment

$La_{0.9}Y_{0.1}MnO_3$ powders were fabricated by the solid state method. The starting materials La_2O_3,$MnCO_3$ and Y_2O_3 were mixed, ground and calcined at 950℃, 1050℃, 1150℃, 1250℃, 1350℃ respectively. Crystal structures were characterized by XRD, electromagnetic were measured using VNA within the frequency range of 8.2-12.4GHz respectively.

Results and discussion

XRD

Fig.1 shows the crystal structures of $La_{0.9}Y_{0.1}MnO_3$ powders sintered at different temperatures. It can be seen that pure perovskite structure has been formed at the temperature of 1250°C. When the calcined temperatures are 950°C, 1050°C and 1150°C, there are still some tiny impurity phases (La_2O_3, Y_2O_3).

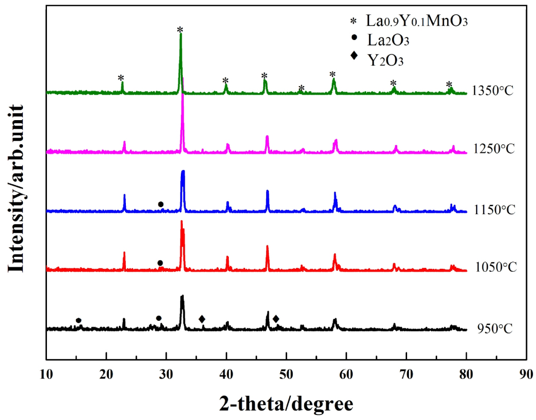

Fig.1. X-ray diffraction patterns of $La_{0.9}Y_{0.1}MnO_3$ powders sintered at different temperatures

Electromagnetic parameters

Fig.2 and 3 shows the permittivity and permeability of $La_{0.9}Y_{0.1}MnO_3$ powders calcined at different temperatures. The real parts of electromagnetic parameters imply the ability to store energy and the imaginary parts imply the microwave absorption ability. [6]

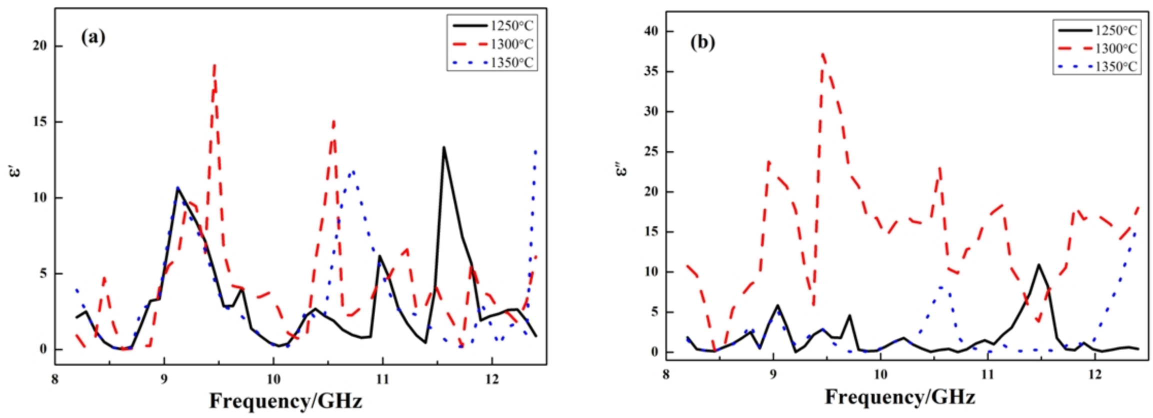

Fig.2. Real (a) and imaginary (b) parts of permittivity of $La_{0.9}Y_{0.1}MnO_3$ powders with different sintering temperatures

Fig.2(a) shows changes of the real part of permittivity ε′ with the sintering temperatures increase. It can be seen that ε′ increases with the calcined temperature's increase within the frequency range of 10.6-11GHz. However, ε′ decreases with the calcined temperature's increase within the frequency range of 10.5-11.8GHz, and it increases first and decreases then within the frequency of 9.3-10.6GHz and 11-11.5GHz. There were nearly no big changes of ε″ within other frequency. Fig.2(b) shows the imaginary part of permittivity ε″, ε″ increases first and decreases then with the calcined temperature within the frequency of 8.2-11.4GHz and 11.6-12.4GHz, and it decreases within the frequency of 11.4-11.6GHz. $La_{0.9}Y_{0.1}MnO_3$ powders calcined at 1300°C have the strongest peak .

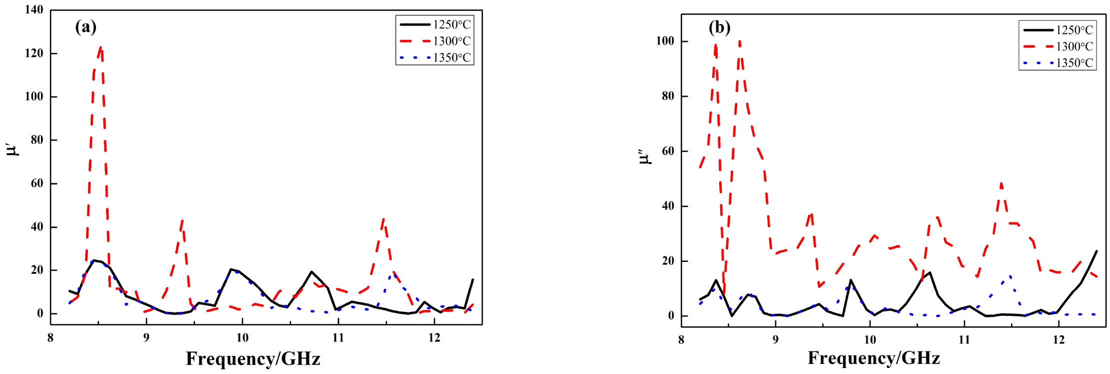

Fig.3. Real (a) and imaginary (b) parts of permeability of $La_{0.9}Y_{0.1}MnO_3$ powders with different sintering temperatures

Fig.3(a) shows the real part of permeability μ′ , μ′ increases first and decreases then with the calcined temperature's increase within the frequency range of 8.4-8.6GHz, 9.1-9.5GHz and 10.9-11.8GHz. But, there were nearly no big changes of ε″ within other frequency. Fig.3(b) shows the imaginary part of permeability μ″, μ″ of $La_{0.9}Y_{0.1}MnO_3$ powders calcined at 1300℃ is the strongest compared with others within the frequency of 8.2-12.4GHz. There are no big differences of μ″ of $La_{0.9}Y_{0.1}MnO_3$ powders calcined at 1250℃ and 1350℃ over the range of 8.2-12.4GHz.

Microwave absorbing properties

The reflection loss (*R*) usually implies microwave absorption properties. According to the transimission line theory [15], the normalized input impedance Z_{in} of a metal-backed microwave absorbing layer is given by

$$Z_{in}=(\mu/\varepsilon)^{1/2}\tanh(j2\pi fd(\mu\varepsilon)^{1/2}/c) \quad (1)$$

Where μ and ε are the relative complex permeability and permittivity, respectively, of the composite, c is the velocity of light, d is the thickness of the monolayer absorber, f is the frequency.

The reflection loss (*R*) could be obtained based on the following equation

$$R=20\log|(Z_{in}-1)/(Z_{in}+1)| \quad (2)$$

It is clear that the reflection loss of the composite medium were determined by the six parameters: the real and imaginary parts of the relative complex permittivity (ε=ε′- jε″) and permeability (μ=μ′-jμ″), the thickness of the absorber and the working frequency.

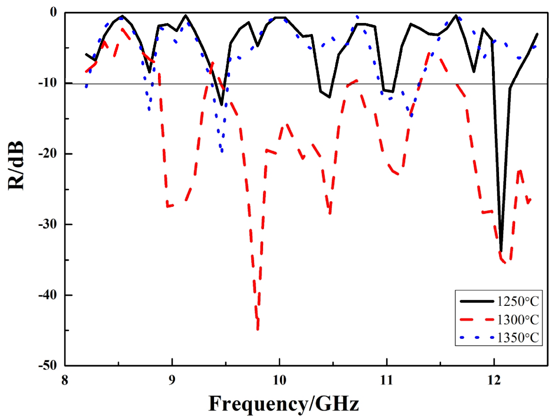

Fig.4. Reflectivity of $La_{0.9}Y_{0.1}MnO_3$ calcined at different temperatures

Fig.4 shows the microwave absorbing properties of the single layer absorber with the thickness d=0.8mm. It can be seen that $La_{0.9}Y_{0.1}MnO_3$ powders calcined at 1300℃ have best microwave absorption ability. Tab.1 shows the microwave absorbing performance of $La_{0.9}Y_{0.1}MnO_3$ powders calcined at different temperatures. It is clear that the effective absorption band for *R*<-10dB of $La_{0.9}Y_{0.1}MnO_3$ powders calcined at 1300℃ was up to 3GHz, and the absorption peak was the maximum, up to 45dB, which was far more than others within the frequency of 8.2-12.4GHz.

Tab.1 Changes of microwave absorbing properties of $La_{0.9}Y_{0.1}MnO_3$ powders with the calcined temperatures.

Samples	Sintering Temperature (˚C)	Bandwidth (R<-10dB)	Maximum reflectivity (dB)	Frequency (GHz)
	1250	0.35	-34.00	12.1
$La_{0.9}Y_{0.1}MnO_3$	1300	3.0	-45.00	9.79
	1350	0.3	-21.00	8.32

Conclusions

(1)$La_{0.9}Y_{0.1}MnO_3$ powders calcined at different temperatures have been fabricated by the solid state reaction. The pure provskite structure has been obtained when the temperature is 1250˚C.

(2)Both the real and imaginary parts of electromagnetic parameters of $La_{0.9}Y_{0.1}MnO_3$ calcined at 1300˚C had the maximum peaks within the frequency range of 8.2-12.4GHz

(3)Within the frequency range of 8.2-12.4GHz, $La_{0.9}Y_{0.1}MnO_3$ calcined at 1300˚C was a strong and wideband microwave absorbing material. The effective absorption bandwidth for *R*<-10dB was 3GHz and the maximum absorption peak was up to 45dB. The material could have a certain value as a microwave absorbing material.

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