ICAM2009

11th International Conference on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

Complex permittivity and permeability of a Ni-Zn ferrite at different temperatures in the 50-1500-MHz range

A. C. C. Migliano(1)*, A. L. Côrtes(1), V. L. O. Brito(1) and R. T. Carvalho(1)

(1) Instituto de Estudos Avançados, Divisão de Física Aplicada. Rodovia dos Tamoios, km 5,5 – Putim – São José dos Campos – SP – Brazil – 12228-001. E-mail: migliano@ieav.cta.br; cortes@ieav.cta.br; vlobrito@ieav.cta.br; ricardo@ieav.cta.br.

* Corresponding author.

Abstract – Complex permeability and permittivity data of a Ni-Zn ferrite, under temperature variation, are presented in this work and the reflection loss and electric conductivity were derived. The real part of permittivity (ε') was nearly constant (≅15.8) in each temperature in frequencies between 500-900MHz. Above this frequency range, the permittivity was increasing. However, the loss factor (ε") versus temperature curves presented a flat behavior with increasing values within the temperature range studied, reflecting on the reflection loss and on the electric conductivity derived. Both real and imaginary parts of magnetic permeability, μ' and μ'', presented approximately unchanged behavior under temperature variation.

Because of their high resistivity and high magnetic permeability, magnetic ceramics have been studied in the last decades for several applications such as transducers for RF and pulse transformers [1-2]. These materials also allow the conception of composite materials and detectors with no distortions in frequency. Thus, the need of tailoring the electromagnetic properties of the material for the operational frequency range has become an important factor in the project of electromagnetic devices.

This work presents the study of the complex magnetic permeability and complex permittivity of a $Ni_{0.5}Zn_{0.5}Fe_2O_4$ ferrite for frequencies between 50MHz -1.5 GHz and temperatures between –40 ^{o}C and +40 ^{o}C. Reflectivity and resistivity data, derived from the measurements of permeability and permittivity, were also obtained.

The real part of permittivity (ε') results evidenced a thermal coefficient "α" (eq. 1) inversion after 500 MHz, approximately. Below this frequency, the thermal coefficient was positive and above it, it was negative. In the lowest temperature studied (-40 ^{o}C) an ε' minimum was defined, assuming the value of 12 in 250 MHz.

$$\alpha = \frac{\varepsilon' - \varepsilon'_{ref}}{\varepsilon'_{ref}\left(T - T_{ref}\right)} \quad (1)$$

(T_{ref} = reference temperature ; $\varepsilon_{ref} = \varepsilon$ at T_{ref})

The results shown on Fig. 1 indicate that the relationship between complex magnetic permeability and temperature may vary with frequency. In Fig. 2, one can observe that the permittivity varies with frequency and increases with temperature, presenting a steep increase in temperatures near 10^{o}C. Fig. 3 shows that the temperature coefficient of the complex permittivity is nearly null between 500 MHz and 900 MHz. A positive coefficient was observed for frequencies lower than 500 MHz. At frequencies higher than 900 MHz the coefficient was negative.

Data convergence of the reflectivity results was observed with the frequency increase. Below 500 MHz, the data tended to show a maximum as temperature decreased. This maximum was around 250 MHz. The values of the conductivity results increased with frequency and temperature.

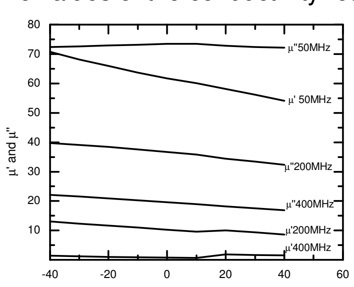

Figure 1: Variation of the complex magnetic permeability with temperature at some frequencies.

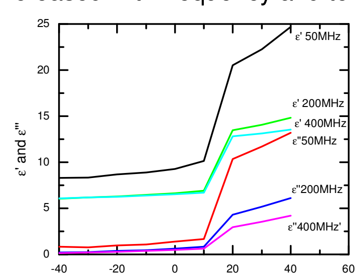

Figure 2: Variation of the complex permittivity with temperature at some frequencies.

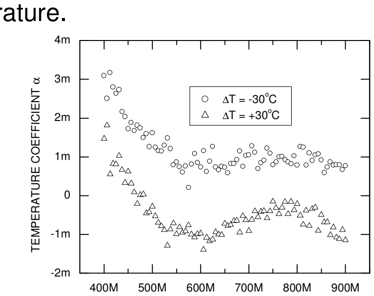

Figure 3: Thermal coefficient variation with frequency.

References

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