

# Accepted Manuscript

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PII: S0925-8388(15)31253-6

DOI: [10.1016/j.jallcom.2015.09.269](https://doi.org/10.1016/j.jallcom.2015.09.269)

Reference: JALCOM 35544

To appear in: *Journal of Alloys and Compounds*

Received Date: 25 July 2015

Revised Date: 6 September 2015

Accepted Date: 30 September 2015

Please cite this article as: E. Oumezzine, S. Hcini, M. Baazaoui, E.-K. Hlil, M. Oumezzine, Critical behavior of  $Zn_{0.6-x}Ni_xCu_{0.4}Fe_2O_4$  ferrite nanoparticles, *Journal of Alloys and Compounds* (2015), doi: 10.1016/j.jallcom.2015.09.269.

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## Critical behavior of $\text{Zn}_{0.6-x}\text{Ni}_x\text{Cu}_{0.4}\text{Fe}_2\text{O}_4$ ferrite nanoparticles

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### Abstract

We have investigated the critical behavior of  $\text{Zn}_{0.6-x}\text{Ni}_x\text{Cu}_{0.4}\text{Fe}_2\text{O}_4$  ( $x=0, 0.2$  and  $0.4$ ) ferrite nanoparticles near the ferromagnetic-paramagnetic (FM- PM) phase-transition temperature ( $T_C$ ). Experimental results reveal that all samples undergo a second-order phase transition. Through various techniques such as modified Arrott plot, Kouvel-Fisher method and critical isotherm analysis, the estimated critical exponents are close to those expected for three-dimensional Heisenberg class for  $x=0$  ( $\beta=0.386 \pm 0.002$ ,  $\gamma=1.271 \pm 0.012$  and  $\delta=4.387$  at  $T_C=305$  K). Whereas for a high amount of Ni, these exponents belong to a different universality class ( $\beta=0.716 \pm 0.063$ ,  $\gamma=0.807 \pm 0.008$  and  $\delta=2.010$  at  $T_C=565$  K for  $x=0.2$  sample) and ( $\beta=0.785 \pm 0.004$ ,  $\gamma=0.797 \pm 0.002$  and  $\delta=2.061$  at  $T_C=705$  K for  $x=0.4$  sample). This is due to the fact that the substitution of  $\text{Zn}^{2+}$  (non-magnetic ions) by  $\text{Ni}^{2+}$  (magnetic ions) increases the  $A$ - $B$  interaction sites of  $AB_2O_4$  spinel ferrite which in turn increases the magnetic disorder when increasing Ni content. Using the magnetic entropy change equation:  $|\Delta S_M^{max}| = a(H)^n$ , we have studied the relationship between the exponent  $n$  and the critical exponents of our samples. The obtained  $n$  value are 0.641, 0.843 and 0.873 for  $x=0, 0.2$  and  $0.4$ , respectively. These values are in good agreement with those deduced from the critical exponents using the KF method.

**Keywords:** Ferrite nanoparticles; Second order phase transition; Critical behavior.

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