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Critical behavior of $Zn_{0.6-x}Ni_xCu_{0.4}Fe_2O_4$ ferrite nanoparticles

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Abstract

We have investigated the critical behavior of $Zn_{0.6-x}Ni_xCu_{0.4}Fe_2O_4$ (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 (β= 0.386 ± 0.002, γ= 1.271 ± 0.012 and δ= 4.387 at T_C = 305 K). Whereas for a high amount of Ni, these exponents belong to a different universality class (β = 0.716 ± 0.063, γ= 0.807 ± 0.008 and δ= 2.010 at T_C = 565 K for x= 0.2 sample) and (β= 0.785 ± 0.004, γ= 0.797 ± 0.002 and δ= 2.061 at T_C = 705 K for x = 0.4 sample). This is due to the fact that the substitution of Zn^{2+} (non-magnetic ions) by 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 deducted from the critical exponents using the KF method.

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