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Ralaxation in interacting $NiFe_2O_4$ nanoparticles

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Abstract – The dynamical properties of $NiFe_2O_4$ nanoparticles were investigated by ac susceptibility (50 Hz $\leq f \leq 10^4$ hz) and Mössbauer spectroscopy measurements. The variation of the average blocking temperature as a function of the measuring time is satisfactorily described by a model that takes into account magnetic interactions of dipolar origin. We report the theory of relaxation, relevant to Mössbauer, maganetization and coercivity measurements.

During last few decades, ferrites have been studied extensively because of their importance in basic as well as in applied research [1]. We have studied the magnetic behavior of nickel ferrite nanoparticles with a mean diameter of 8.0 nm. AC susceptibility of nickel ferrite nanoparticles was measured as a function of temperature T from 2 to 300K under zero external DC field for frequencies ranging from f = 50 to 10,000 Hz. A prominent peak appears in both χ' and χ'' as a function of T. The peak temperature T_2 of χ'' depends on f following the Vogel–Fulcher law. The particles show superparamagnetic behavior at room temperature, with transition to a blocked state at T_B ~120K in ZFC and 124.2 K in AC susceptibility measurements (f =50hz) [Fig.1], respectively, which depends on the applied field. T_f decreases with increasing DC magnetic field as evidenced by zero-field,cooled susceptibility (ZFC) studies at 200 and 1000 Oe (T_f = 130 and 100 K respectively). As a typical superparamagnetic behavior, the zero-field-cooled and the field-cooled magnetizations diverge below T_f [Fig. 2]. The saturation magnetization and the coercivity measured at 4.2K are 24.2 emu/g and 15.7 kOe, respectively. The particle size distribution was determined by fitting a magnetization curve obtained at 295K assuming a log-normal size distribution. The interparticle interactions are found to influence the energy barriers yielding an enhancement of the estimated magnetic anisotropy, $K \sim 2 \times 10^5$ J/m^3. Mössbauer spectra obtained at higher temperatures show a gradual collapse of the magnetic hyperfine splitting typical for superparamagnetic relaxation. At 4.2 K, the Mössbauer spectrum was fitted with two magnetic subspectra with internal fields H_{int} of 486 and 522 kOe, corresponding to Fe^{3+} ions in A and B sites.

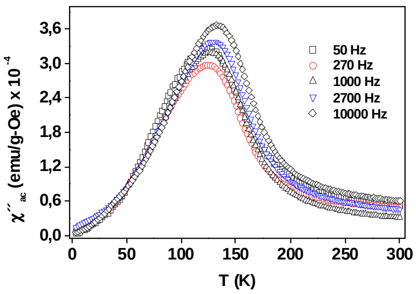

Figure 1: AC susceptibility (imag part).

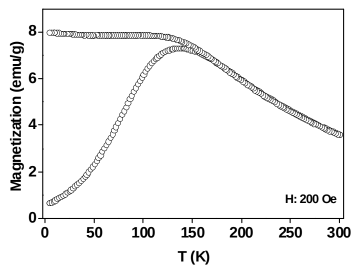

Figure 2: ZFC and FC curve .

References

[1] O. Masala and R. Seshadri, Chem. Phys. Lett 402 (2005) 160.