SPIN-GLASS MAGNETIC BEHAVIOR ON NANOSTRUCTURED ZINC FERRITE

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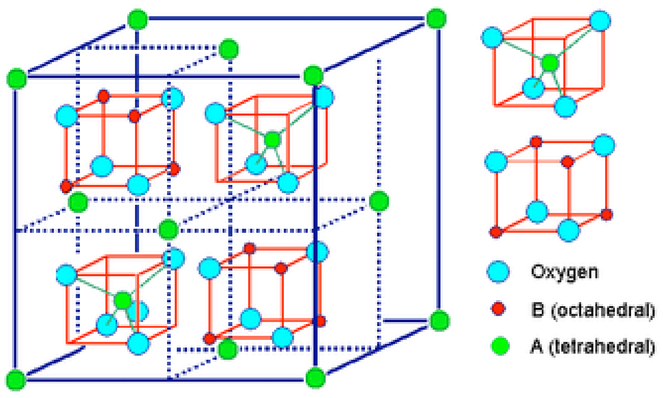
Abstract: Spin-Glass is a magnetic behavior where spin moments weakly interact due to magnetic frustration. Spin-glass behavior has been largely investigated from solid state physics in materials with magnetic or structural disorder. At present, the spin glass behavior is, for analogy, a model for other complex systems beyond the material, like model of cancer cells or neural works. In this work the spin glass behavior of Zn ferrite synthesized by ball-milling is investigated as a function of cation inversion, and the inversion degree is tuned by thermal annealing of the samples .

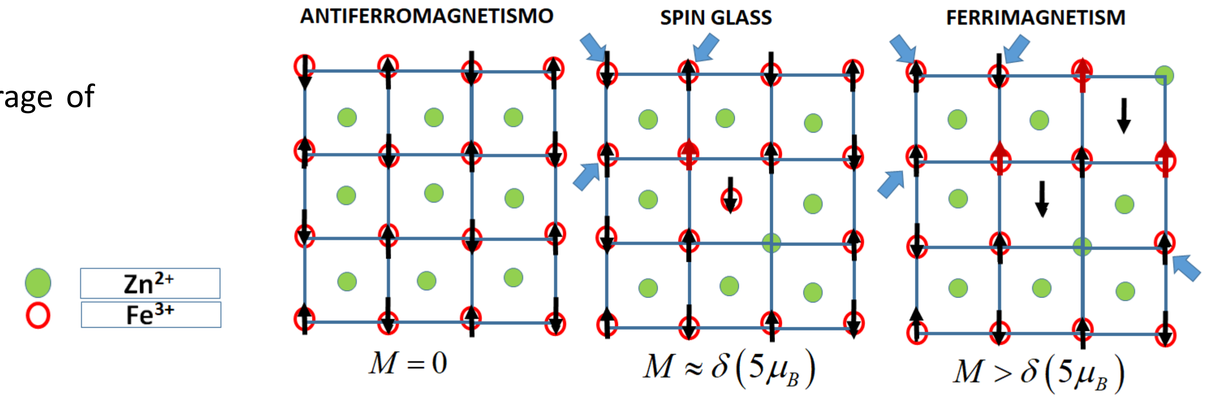
1. Spin-Glass. Magnetic frustration behavior and relation to inversion cationic on Zinc Ferrite

Spin Glass is due to a Magnetic Frustration of spin orientation caused by moving some Fe^{+++} cations to tetrahedral sites (A).



Zinc Ferrite ($ZnFe_2O_4$) is a normal spinel where divalent cations Zn^{++} are in A tetrahedral sites and Fe^{+++} in B octahedral ones

Inversion parameter (δ) is the average of Fe^{+++} cations placed in A sites.

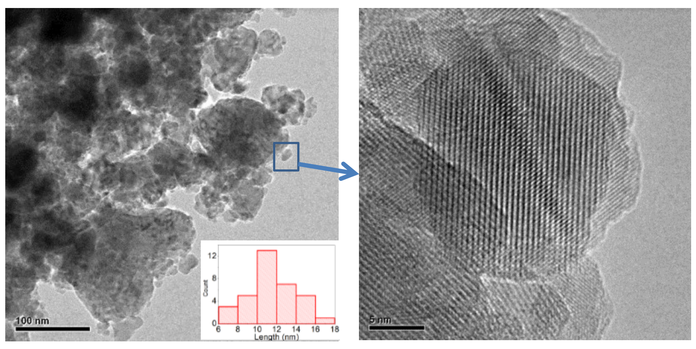


Square spin ordering scheme. Magnetic order depends on cationic inversion. If Zn cations are in A sites, the Zn ferrite is AFM. When Zn^{2+} and Fe^{3+} exchange their sites spin frustration or even ferrimagnetism can appear, depending on the inversion degree.

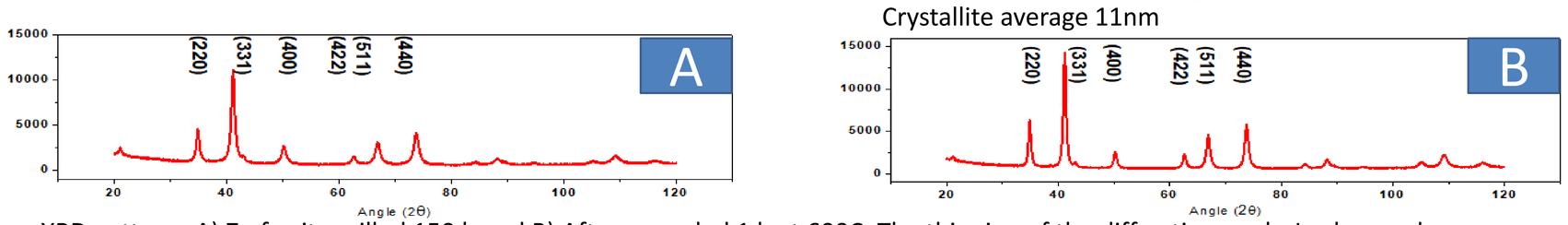
2. How do we get cationic inversion on zinc ferrite

2.1 CATIONIC DISORDER. Zn ferrite is synthesized by milling in a phase with maximum cationic disorder determined by Rietveld

High energy ball milling hematite and zincite powder

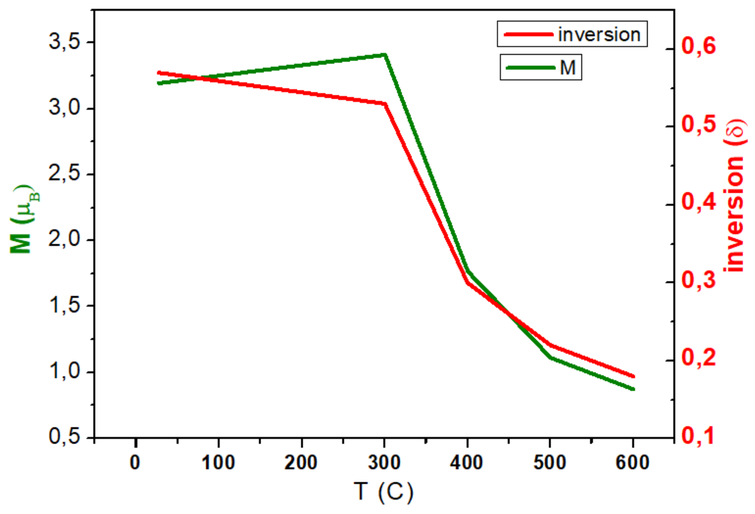


TEM of nanostructure $ZnFe_2O_4$ annealing 1 h at 300C. Crystallite average 11nm



XRD patterns A) Zn ferrite milled 150 h and B) After annealed 1 h at 600C. The thinning of the diffraction peaks Is observed

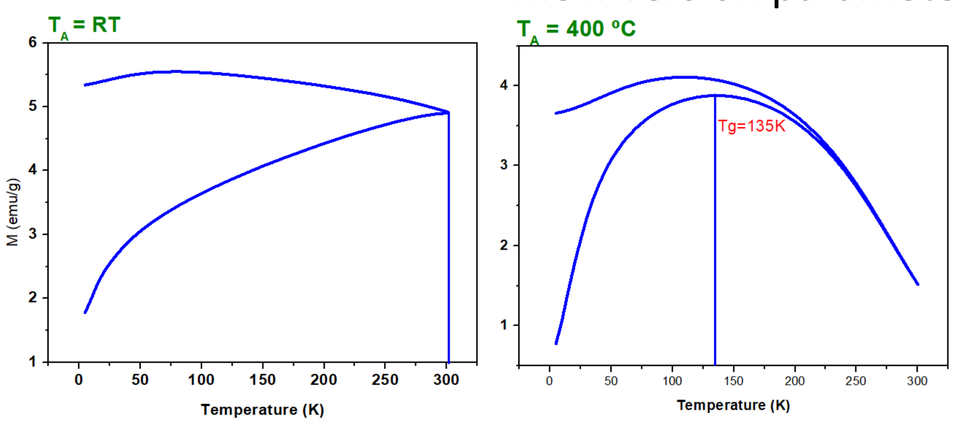
2.2 CATIONIC ORDER. By annealing, cationic order is recovered



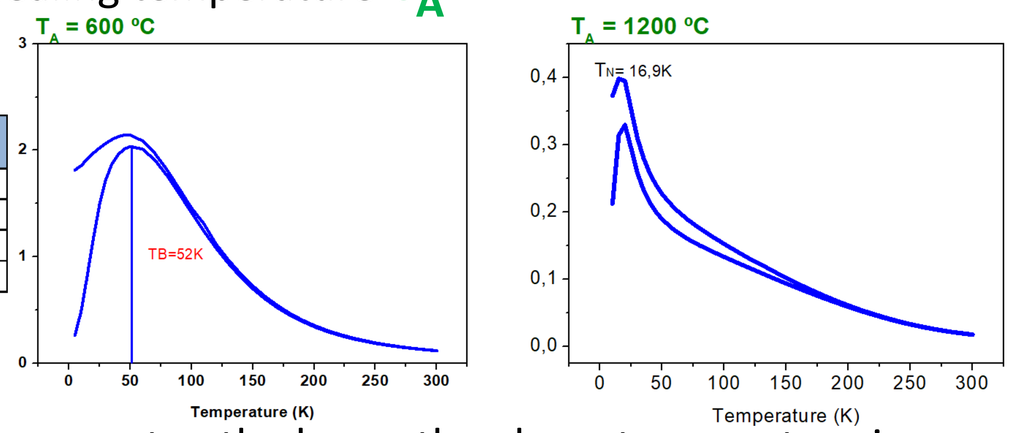
Inversion parameter δ and Ms (5K) as a function of annealing temperature

3. Magnetic behavior at low temperatures from maximum cationic disorder to order

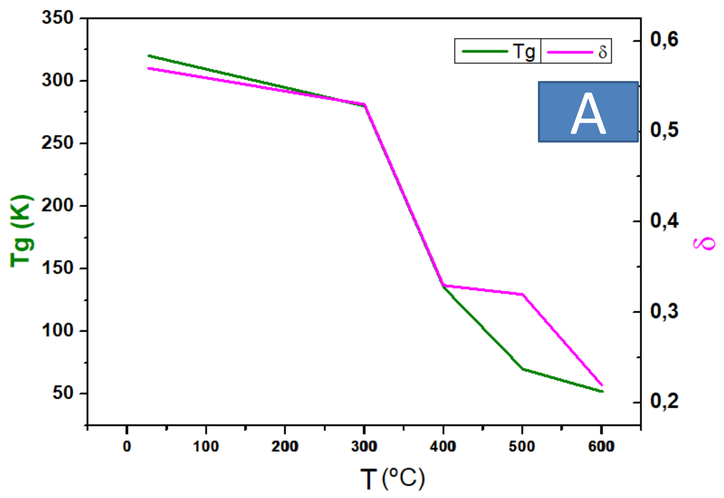
The inversion parameter δ can be tuned by the annealing temperature T_A



Annealing T (ºC)	δ	D (nm)	T_g (K)
27	0.57	11	300
400	0.33	12	135
600	0.22	16	52
1200	0.14	>200	

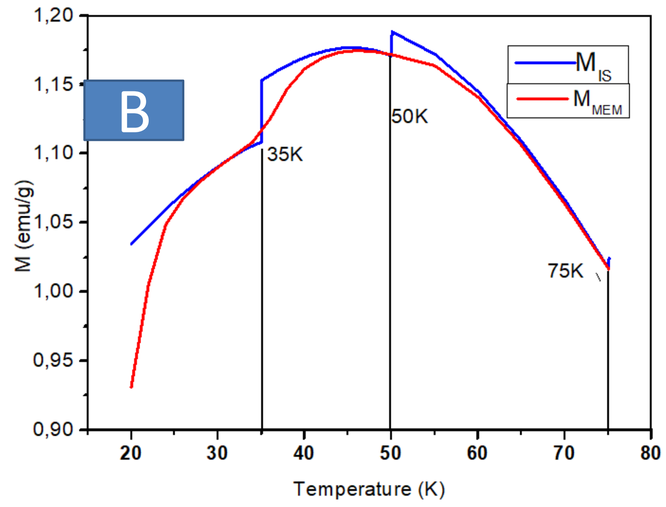


ZFC-FC plots at different annealing temperatures. The smaller the inversion parameter, the lower the glassy temperature is



A) Parallel behavior between the inversion parameter and the glassy temperature

B) Aging (M_{IS}) and memory magnetic (M_{MEM}) FC measurement, to verify Spin-Glass behavior at low temperature (sample at 600C)



Conclusions: We present here a systematic study on gradual structural order processing, starting from maximum inversion cationic distribution by mechanical alloying synthesis, to induce spin-glass on Zn-ferrite by annealing temperature. Glassy temperature is directly proportional to inversion parameter that can be tuned by the annealing temperature. Thus, how the spin glass order and transition differ from the standard ordered state and the standard phase transition is an important fundamental question to condensed matter physics