Magnetic and structural characteristics of Ni-Zn ferrite prepared by hydroxide precipitation method

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Introduction: Fast growing automotive, aerospace, telecommunication, robotics industries show great demand for electronic components, in which soft ferrites play important roles as core in inductors, transformers, as material for antenna rods, sensors, phase shifters and in many other applications. Ni-Zn ferrites [1] represent class of soft spinel ferrites with superior magnetic permeability, ultralow electric losses and excellent corrosion resistivity. The hydroxide precipitation method [2] was adopted for preparation of bulk polycrystalline Ni-Zn ferrite compounds with low Fe content. Iron deficiency decreases eddy current losses and improves performance of these ferrites. The XRD and magnetic methods were employed for characterization of sintered specimens.

Methods: Synthesis by hydroxide precipitation

$Fe(OH)_3$, $Zn(OH)_2$, $Ni(OH)_2$ water solutions → Ageing of precipitates+ thermal treatment at 800 ^{0}C → Planetary ball milling → Compaction + thermal treatment at 1380 ^{0}C → $Zn_{0.87}Ni_{1.57}Fe_{1.11}O_4$

XRD analysis

Magnetization measurements

Results:

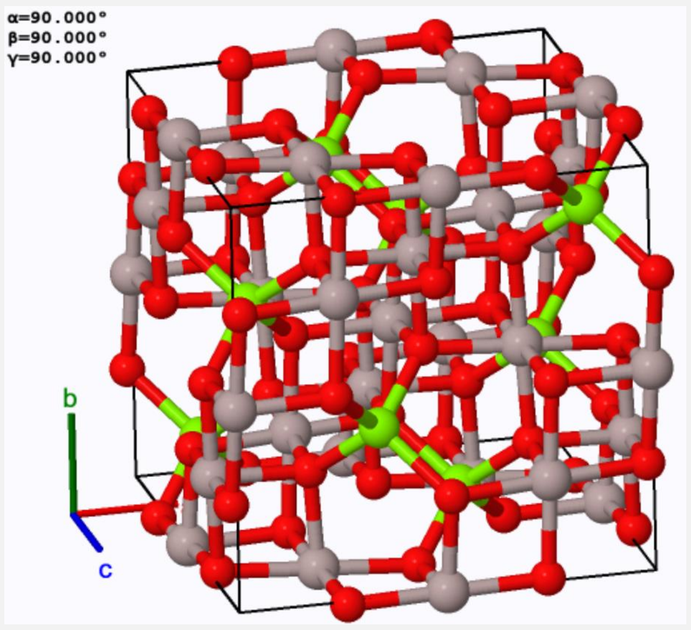


Figure 1. Unit cell of a Ni-Zn ferrite spinel. Grey circles are Ni, Fe atoms in octahedral positions, green circles are Fe, Zn ones in tetrahedral positions, and red circles are oxygen atoms.

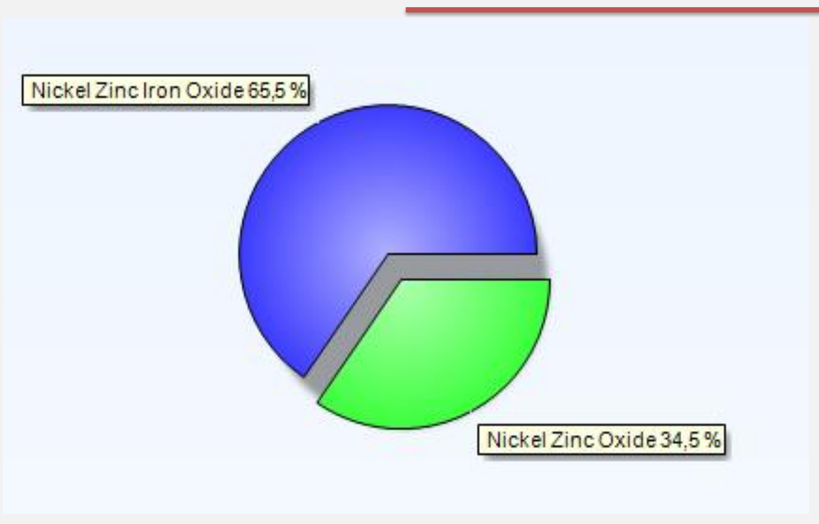


Figure 2. Phase content of $Zn_{0.87}Ni_{1.57}Fe_{1.11}O_4$ ferrite.

Ferrite $Ni_{0.6}Zn_{0.4}Fe_2O_4$ =65.5%

Ferrimagnetic (FM)

Crystal size =85.5 nm

Halite $Ni_{0.7}Zn_{0.3}O$ = 34.5%

non-magnetic

Crystal size =208 nm

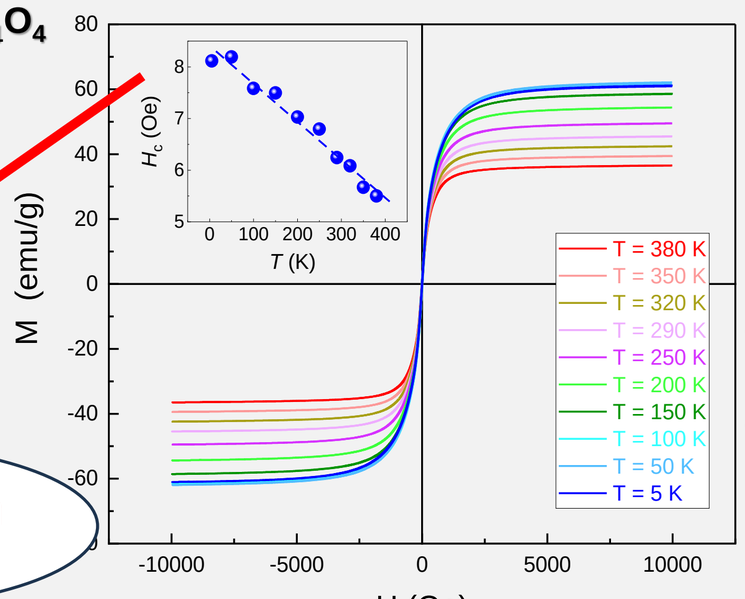


Figure 3. Field dependence of magnetization. The inset shows temperature dependence of coercivity H_C.

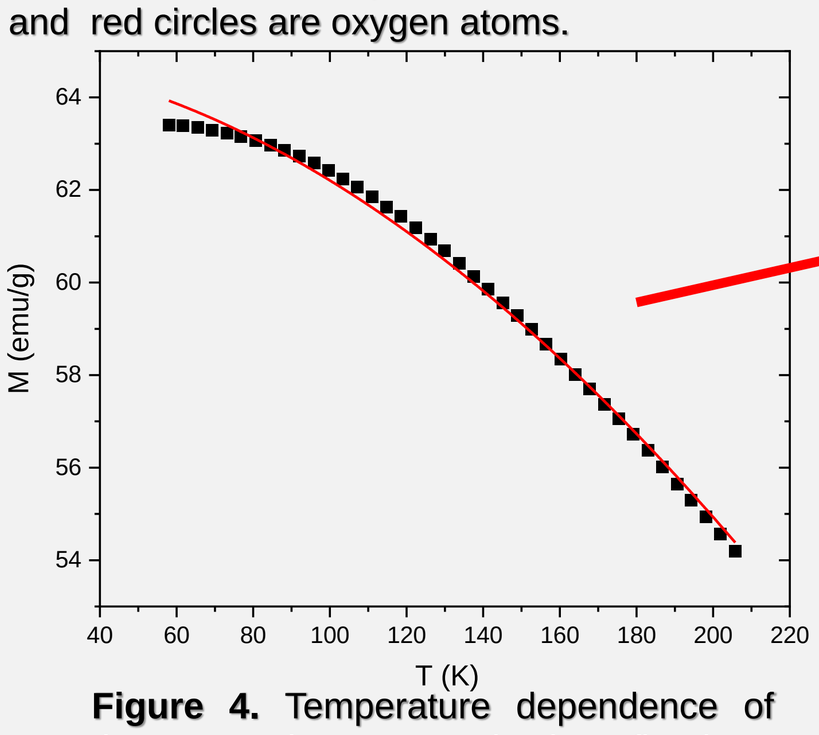


Figure 4. Temperature dependence of the saturation magnetization fitted to Bloch's law.

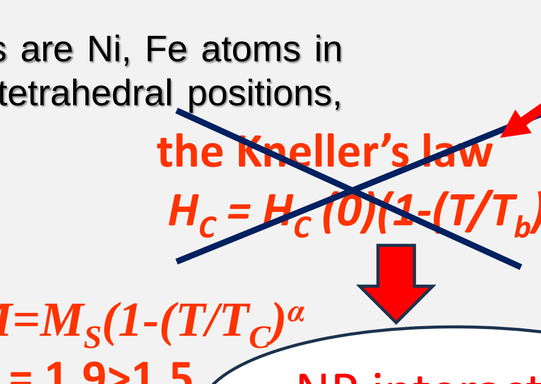
the Kneller's law $H_C = H_C(0)(1-(T/T_b)^{0.5}$

$M=M_S(1-(T/T_C)^{\alpha}$

α = 1.9>1.5

NP interaction + FM phase

Magnetic Nanoparticles (NP)



non-magnetic $Ni_{0.7}Zn_{0.3}O$

magnetic $Ni_{0.6}Zn_{0.4}Fe_2O_4$

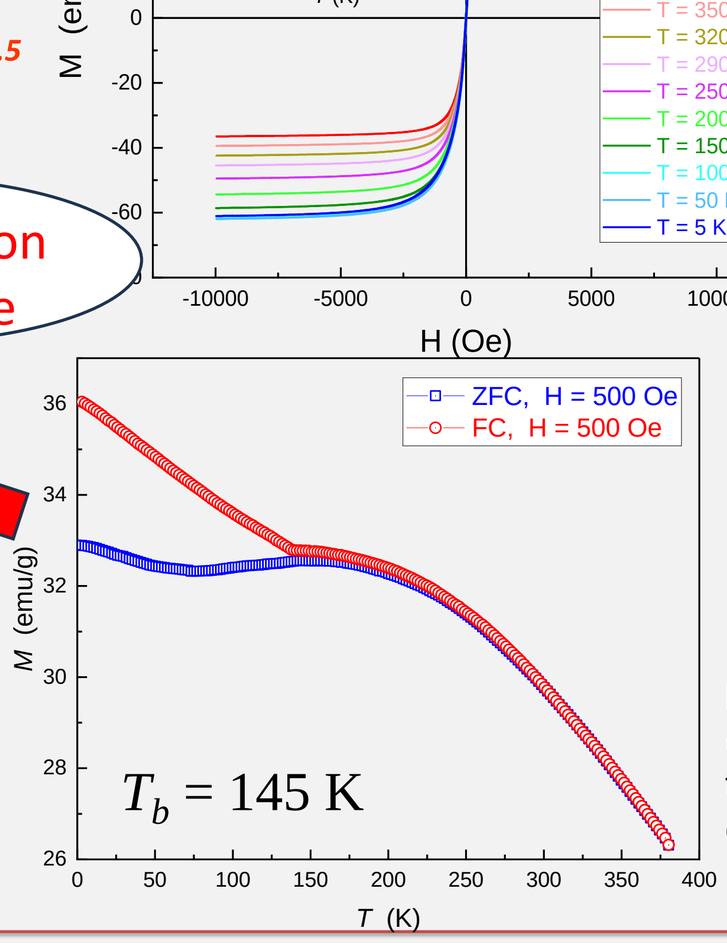


Figure 5. ZFC (blue) and FC (red) thermomagnetic curves.

Conclusions:

- **In $Zn_{0.87}Ni_{1.57}Fe_{1.11}O_4$ iron deficient spinel ferrite prepared by hydroxide precipitation method, two-phase structure consisted of magnetic $Ni_{0.6}Zn_{0.4}Fe_2O_4$ spinel ferrite and non-magnetic $Ni_{0.7}Zn_{0.3}O$ halite is formed.**
- **Deviation of temperature dependent saturation magnetization from Bloch's law, occurrence of the blocking temperature and bifurcation of the ZFC-FC curves indicate superparamagnetic system formed by Ni-Zn ferrite crystals embedded in halite shells.**
- **The features of temperature dependent coercivity and magnetic hysteresis above blocking temperature reveal also the presence of ferrimagnetic $Ni_{0.6}Zn_{0.4}Fe_2O_4$ phase in addition to superparamagnetic one.**