Effect of Rare Earth Ions on the Electric and Magnetic Properties of

Co-Zn Ferrite

Thesis

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تأثير أيونات العناصر الأرضية النادرة على الخواص الكهربية والمغناطيسية لفرايت الكوبلت زنك

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Summary

In the present work we have studied of rare earth ions and the preparation condition such as (sintering temperature and rate of heating) on the electric and magnetic properties of $Co_{0.5}Zn_{0.5}R_yFe_{2-y}O_4$.The samples were prepared by using standard ceramic technique. The used metal oxides are of analar BHD they are mixed together homogeneously with stoichiometric ratio and then grinding using agate mortar for two hours and then transferred into electrical shaker for anther two hour. The powder was then pressed and prefired (prisintering) at 850 ^{0}C for 30 hours in order to bring about the initial chemical reaction between the constitution. Then the prifired samples were sintered at 1100^{0}C for 90 hours.

Three groups were prepared as follows:

The first one is $Co_{0.5}Zn_{0.5}La_yFe_{2-y}O_4$ where $0.05 \leq y \leq 0.175$,sintered at 1100^{0}C with different heating rate (2,4,6 and 8^{0}C/min).

The second group is $Co_{0.5}Zn_{0.5}Ce_yFe_{2-y}O_4$ where $0.05 \leq y \leq 0.175$, sintered at (1100, 1150, and 1200^{0}C) using of heating rate 4^{0}C/min.

The third group is $Co_{0.5}Zn_{0.5}R_yFe_{2-y}O_4$ (R=La,Ce,Nd andGd) where$0.05 \leq y \leq 0.175$, sintered at 1100^{0}C with the rate of heating 4 ^{0}C/min.

The X-ray, IR, ac-conductivity, thermoelectric power (Seebeck voltage coefficient) and magnetic susceptibility for all groups were measured.

The temperature dependence of the real part of the dielectric have the same trend where ε' gives three regions. In the first region, the dielectric constant was slightly varies with temperature and frequency this region extended up to 400K. In this region the thermal energy is not sufficient to free the localized dipoles to be oriented in the field direction and the electronic polarization play a significant role.

In the second region up to 600k the thermal energy is sufficient to liberate more of frozen dipoles and the field accompanied with the applied frequency aligned them in its direction.

In the third region the high thermal energy , lattice vibration increasing entropy (randomness) increasing the friction between dipoles as well as the energy dissipation so the dielectric constant decreases and reaches a minimum value after which after which another type of polarization such as Maxwell Wagner polarization participate in polarization process leading to a sudden increase in ε'.

Taking into consideration the effect of rate of heating it was found that ε' decrease from rate 2^{0}C/min. up to rate 4^{0}C/min. after which ε' increased suddenly. This means that rate 4^{0}C/min. is the critical rate at which the grain growth reaches a value of drastically increasing polarization. We can say that the heating rate controlled all of the electrical characteristics inside the samples due to the changing of the grain size .In the region separating the grains the variation of the Maxwell Wagner polarization changes both ε' and ε''.

From the ac conductivity data, it was found that, nearly the same trend was obtained for the different La content .Three different regions were obtained; the first one is called the metallic like behavior at which nearly no variation in the conductivity with temperature but it varies with the applied frequency. The second region at which the conductivity is temperature and frequency dependent. This part of conductivity is called the ac part, where the applied frequency gives clear variation in the conductivity values. The third region at which the conductivity is frequency independent and temperature dependent this part is called the dc part. In general more than one straight line was obtained at each separate frequency. The activation energy in the high temperature region (E_{II}) is greater than that in the low temperature region (E_{I}).

The increase of the electrical conductivity in the investigated sample as in the most mixed ferrite materials is due to thermally activated mobility and not to thermally activated generation of charge carriers.

The dependence of real dielectric constant (ε') and absolute temperature (T) for $Co_{0.5}Zn_{0.5}Ce_yFe_{2-y}O_4$ sintered at 1100^0C with the rate of heating 4 $^0C/min$ $0.05 \leq y \leq 0.175$ as a function of applied frequency indicates that the general trend of all samples with different rare earth concentration (Ce) are the same except the sample with y=0.175 which explained on the basis of the assumption that, the mechanism of dielectric polarization and conduction are the same origin.

The dependence of the dielectric constant on sintering temperature of the ferrite $Co_{0.5}Zn_{0.5}Ce_{0.05}Fe_{1.95}O_4$ at 100kHz and 1MHz indicates that as the sintering temperature increase up to 1150 ^0C the polarizability increase after that it decrease and reaches its lower values at 1200^0C.

When comparing the conductivity behavior for the rare earth element of different ionic radii at 100kHz and at room temperature one can find that the Ce ions gives the lowest conductivity values. By increasing the radius of rare earth ions or increasing their concentration, the probability of their entering the spinel lattice.

The variation of Seebeck coefficient with average absolute temperature for $Co_{0.5}Zn_{0.5}$ $La_yFe_{2-y}O_4$ $0.05 \leq y \leq 0.175$ sintered at 1100^0C with the rate of heating 4 $^0C/min$. show that different trends were obtained for different La concentration. While the Seebeck transition is nearly the same for the first three concentration and differ for the last three concentrations 0.125, 0.15, 0.175. The sign of the Seebeck voltage coefficient was varied between positive and negative at different temperature range this indicates the participation of both electron and holes in conduction mechanism. It is also clear that the values of Seebeck coefficient varies depending on the amount of La ions in the ferrite samples, this was correlated to the ratio of Fe^{2+} / Fe^{3+} because the La^{3+} if it enter the spinel lattice replace Fe^{3+} ions on the octahedral site.

The variation of the molar magnetic susceptibility (χ_M) with the absoluter temperature as a functions of the magnetic field intensity for $Co_{0.5}Zn_{0.5}$ $La_yFe_{2-y}O_4$ $0.05 \leq y \leq 0.175$. Same trend was obtained at all La content with small shift in T_c depending on both the magnetic field intensity and the value of y. A dramatic decrease in (χ_M) with increasing temperature up to near (T_c) after which a slow decreases takes place. From point of view of the magnetic field intensity one can find that, by increasing the magnetic field intensity, the magnetic susceptibility (χ_M) decreases.