Effect of Zr Doping on Structural, Dielectric and Magnetic Properties of Fe_2TeO_6

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ABSTRACT

The polycrystalline FTO (Fe_2TeO_6) and FTZO ($Fe_2Te_{0.95}Zr_{0.05}O_6$) possessing tirutile tetragonal structure with $P4_2/mnm$ space group is prepared following solid state reaction route. We have studied the modification in structural, dielectric and magnetic properties of FTO due to 5% Zr doping. Phase confirmation is done by the Reitveld refinement of XRD data and the polycrystalline FESEM micrograph is obtained in both cases. Enhanced dielectric property in FTZO is found relative to FTO. The complex impedance analysis indicates the non-Debye type of relaxation implications and multiple transport mechanism present in both the materials. The room temperature magnetization study shows a typical paramagnetic nature in FTO while in case of FTZO minute opening in the M-H loop is found due to substitution of paramagnetic Zr^{4+} ion in place of diamagnetic Te^{6+} in lower field region.

Introduction

- The possibility of potential applicability of multifunctional magnetoelectric material for the fabrication of advanced next generation device[1,2] accentuates the scientific community of concerning fields with high priority over the past several decades.
- The Iron tellurate Fe_2TeO_6 (FTO) is a potential candidate that exhibits magnetoelectric (ME) coupling. Several reports have been published about Iron Tellurite (Fe_2TeO_6) as a ME materials. The magnetoelectric coupling in this compound was first reported by S. Buskphan et al. [3].
- Fe_2TeO_6 was first synthesized by Bayer via solid state reaction route and its magnetic structure was first determined by Kunnman et al. [4] and Montmory et al. [5].
- It has been also theoretically predicted that by substitution of larger atom in place of Tellurium such as Hf, Zr, Nb it is possible to enhance Néel temperature.[6]
- We have studied the structural dielectric and magnetic behavior of FTO (Fe_2TeO_6) and FTZO ($Fe_2Te_{0.95}Zr_{0.05}O_6$).

Conclusions

- The polycrystalline nature phase of FTO remain invariant under Zr substituition..
- Due to the 5% doping of Zr in place of Te dielectric constant is increased and loss is decreased in FTZO relative to FTO indicates the enhancement of dielectric property in FTZO.
- The impedance spectroscopy reveals the non-Debye type of relaxation mechanism and possibility of different conduction mechanisms present in both FTO and FTZO .
- A large variation in impedance from MΩ to kΩ is found in between the 50°C to 190°C.
- The room temperature magnetization variation with the magnetic field shows paramagnetic behavior in both FTO and FTZO.

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References

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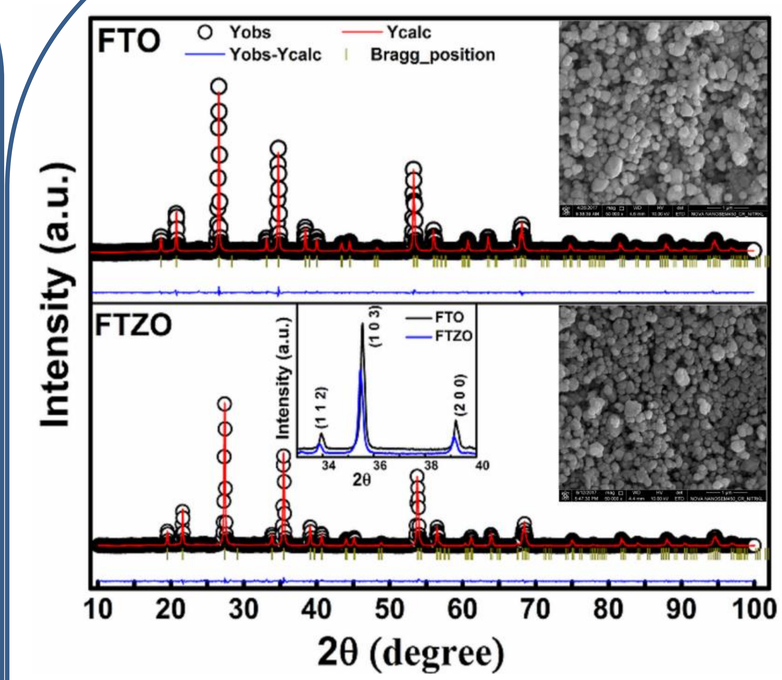
RESULTS

(a)



(b)

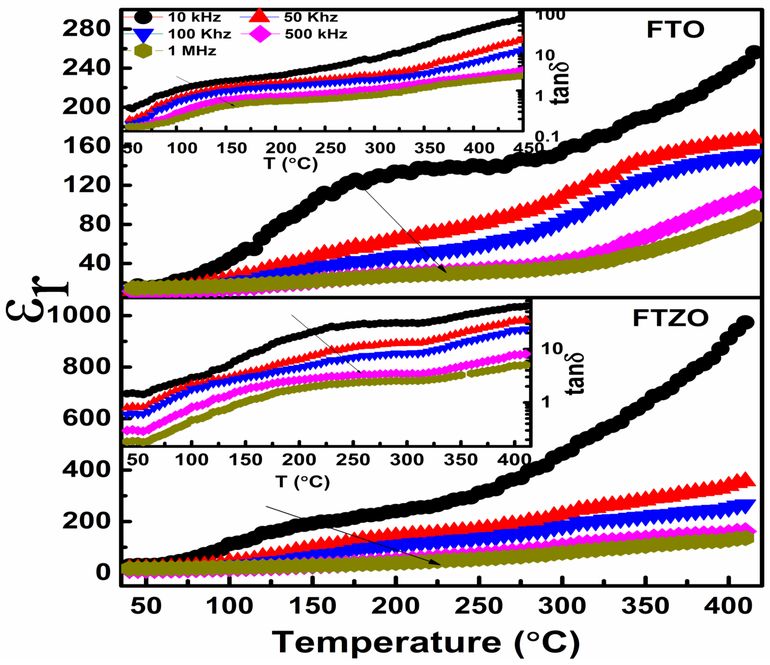
Parameters	Fe_2TeO_6	$Fe_2Te_{0.95}Zr_{0.05}O_6$
a (Å)	4.60430(2)	4.60469(3)
b (Å)	4.60430(2)	4.60469(3)
c (Å)	9.08799(8)	9.08838(9)
V (Å^3)	192.661(2)	192.702(2)
X^2	6.55	4.51

(a) Both FTO and FTZO are tetragonal tirutile phase with P 42/mnm pace group Symmetry. Substitution of larger Zr atom (0.72 Å)in Te atom (0.52 Å) XRD peaks are shifted towards lower angle and porosity is decreased due to substitution.

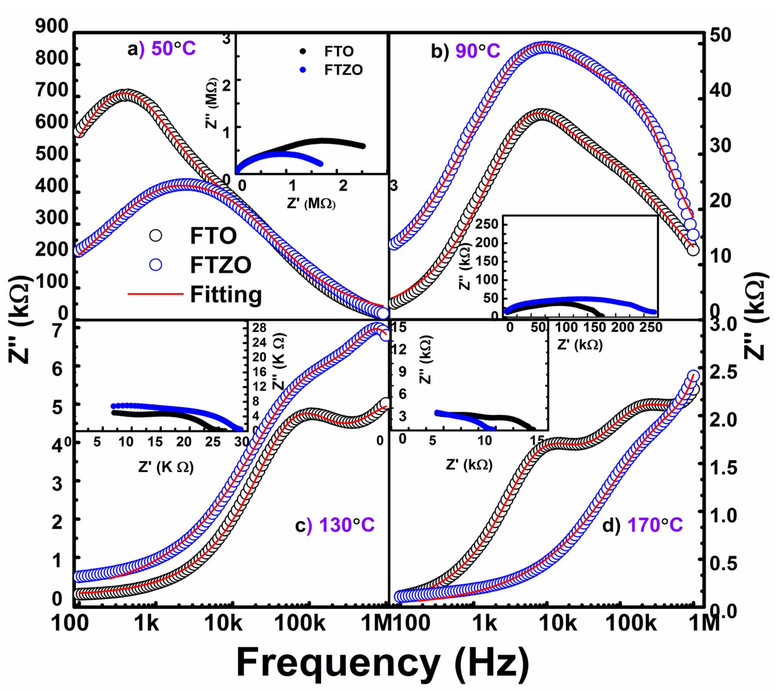
(b) The cell parameters and volume are increased due to the doping of Zr in place of Te.

(c) The enhancement of dielectric constant in FTZO compared to the FTO seen in the temperature variation from 50°C to 400°C. In both cases temperature dependent relaxation peaks are present which also imprinted on the inset loss versus temperature plot.

(c)



(d)



(d) The presence of double inflexion points in each Z'' versus frequency curves are well fitted with modified Cole-Cole function with Z'' fitting equation containing double terms as shown in equation shown below instead of Z'' part of the Cole-Cole [7] function.

$$Z'' = \frac{R_1(\beta_1 f)^{\alpha_1} cos(1-\alpha_1)\frac{\pi}{2}}{(1+(\beta_1 f)^{2\alpha_1})sin(1-\alpha_1)\frac{\pi}{2}} + \frac{R_2(\beta_2 f)^{\alpha_2} cos(1-\alpha_2)\frac{\pi}{2}}{(1+(\beta_2 f)^{2\alpha_2})sin(1-\alpha_2)\frac{\pi}{2}}$$

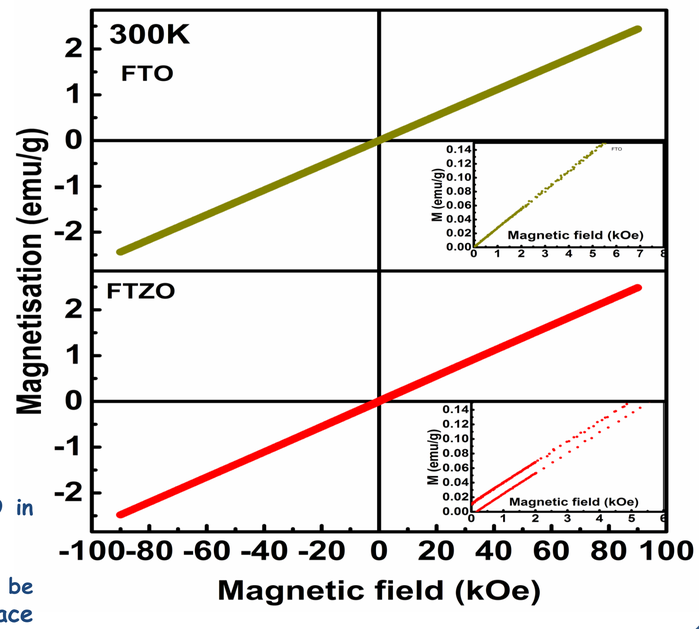
The α_1, α_2 ranging from 0.5-0.84 and 0.81-0.5 respectively in case of FTO and 0.489-0.521 and 0.65-0.89 in case of FTZO.

- The values of α_1, α_2 in between correspond to the presence of non-Debye like relaxation phenomenon .
- Two sets of relaxation time obtained from the fitting indicate the distribution of relaxation time and corresponds to the presence of different conduction mechanism present in the both material.

In the inset Z'' versus Z′ plot the presence of two suppressed semicircular arcs also indicates non Debye like relaxation phenomenon as in Z'' versus frequency curves, present in both FTO and FTZO.

(e) Typical paramagnetic behavior is seen in both FTO and FTZO in the shown isothermal magnetization curve.

Small loop opening in case of FTZO shown in the inset can be attributed to the effect of paramagnetic Zr^{4+} substitution in place of diamagnetic Te^{6+}



(e)