International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Study Dielectrically Behavior of the (Ba TiO_3) and (Ba $TiO_3/Ni_{0.7}$ $Zn_{0.3}$ FeO_4) Nano Composites

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Abstract: ***In this research, nano composites were manufactured from (Ba TiO_3andNi$_{0.7}$ $Zn_{0.3}$ FeO_4) nano compound s. ($Ni_{0.7}$ $Zn_{0.3}$ FeO_4) Nano compound was added to Ba TiO_3 by 20% and 50%. These materials were mixed in a solid reaction and formed under pressure 5.4. MPa were treated at 1100 °C. It has been observed that the dielectric properties of Ba TiO_3 decreased with the addition of $Ni_{0.7}$ $Zn_{0.3}$ FeO_4) Nano compound in general, this is due to the generation of pores in the composite.***

Keyword: Ba TiO_3, Ba $TiO_3/Ni_{0.7}$ $Zn_{0.3}$ FeO_4, Nano composites

1. Introduction

$BaTiO_3$ is ones from of the dielectric materials, which has structure called Perovskite [1-4].Structure of Perovikite contain on several oxides, and it has the chemical formula ABO_3, where A refer to cat ion sites, which equal 12, while B has 6 sites, and oxygen take places in the center of the facial edges [5 & 6], as shown in (Fig. 1) [7].

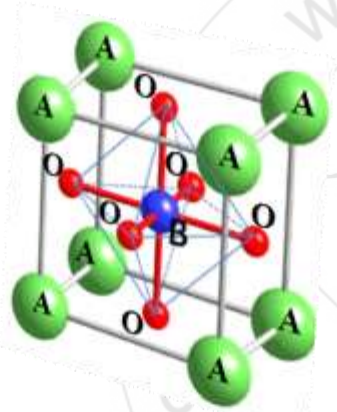

Figure 1: Structure of Perovikite [7]

It has been noted behavior of some transition for $BaTiO_3$ ions through of dopant processes depended on ionic radius [8], therefore determines the substitution site by ionic radius. In particular the phase changes that occur by replacing the ions of both sites (A) and (B) in the composition of the Perovikite (ABO_3), So there is a large number of elements that are acceptable and suitable for the replacement process in the Perovikite installation, including (Ba^{2+}, Ti^{4+}, Ca^{2+}) and so on [5&6]. A wide range of properties and applications can be improved as a result of the substitution process. Materials are divided according to their volume electrical resistivity ($0\text{-}10^{-3}$, $10^{-3}\text{-}10^{8}$, $10^{8}\text{-}10^{18}$) (Ω.cm) [9], conductor, semiconductor and insulator at room temperature. One of the outstanding characteristics of the ferroelectric ceramics is the high electrical insulation properties. These ceramics are composed of barium titanate, which has made this ferroelectric compound a distinctive material for electrical engineering, especially this property used in high-potential ceramic spaces as well as other electrical insulation properties, including the following properties [10]. Dielectric constant (ε_r), complex permittivity (ε_r''), dielectric loss ($\tan\delta$), AC conductivity ($\sigma_{a.c}$) and dielectric strength (E_{br}). These properties are calculated using the following equations [11-16].

$$\varepsilon_r = \frac{cd}{\varepsilon_o A} \quad (1)$$

$$\varepsilon_r'' = \tan\delta\, \varepsilon_r' \quad (2)$$

$$\sigma_{a.c} = \omega\, \varepsilon_o \varepsilon_r' \tan\delta \quad (3)$$

$$E_{br} = \frac{V_{br}}{t} \quad (4)$$

In this paper, the effect of dielectrically properties of (Ba TiO_3) and (Ba $TiO_3/Ni_{0.7}$ $Zn_{0.3}$ FeO_4) Nano composites is studied.

2. The Method of Work

$Ni_{0.7}$ $Zn_{0.3}$ FeO_4 Nanoparticle has been added to the Ba TiO_3 Nano compound with percentages is 20% and 50% to determine the effect of these compounds on the properties of the insulating compound ($BaTiO_3$). The semi-dry forming process of the models, the samples were pressed using a hydraulic piston and by stainless steel mold with a diameter 1.7 cm, thickness 0.85 cm and a pressure of 5.4 Mpa for 5 minutes. The samples are placed in furnace, (5°C /min) is heating rate, under atmospheric pressure, and sintered temperature 1100°C, for 4 hours, to measure the dielectrically properties of samples (LCR meter) used (50 Hz -1 MHz) GPIB, RS, 232, LRC -8105 (2050), where it is by this device measuring the amplitude (C_p) and loss angle (tan δ) as a function of frequency. Equations (1, 2, 3, 4) were applied to calculate Ɛ', Ɛ'', $\sigma_{a.c}$. As well as the breakdown voltage was measuredand application of the equation was calculated the dielectric strength of samples.

3. Conclusions

The electrical properties include, the frequencies special effects on the (ε_r'), (ε_r''), (tanδ), and ($\sigma_{a.c}$) at the range ($50\text{-}10^6$) Hz, in the (R.T), also involve Breakdown voltage and dielectric strength measurements

Figures (1) shows vary of (ε_r') values. The result of (ε_r') for the $BaTiO_3$=39.60, But when adding the ($Ni_{0.7}Zn_{0.3}Fe_2O_4$) compound by 20% and 50% to $BaTiO_3$,

(ε_r') equal (7.83), (4.48) at 1MHz.The (ε_r') values decreases with increasing incremental rates, but at low frequency (50Hz), the (ε_r') values decrease and increases with increased $Ni_{0.7}Zn_{0.3}Fe_2O_4$ addition ratios, due to the increase the gradual crystallization at heat treatment, this means increase the level of a chemical reaction and the decrease in the total pores, which leads to getting better properties.

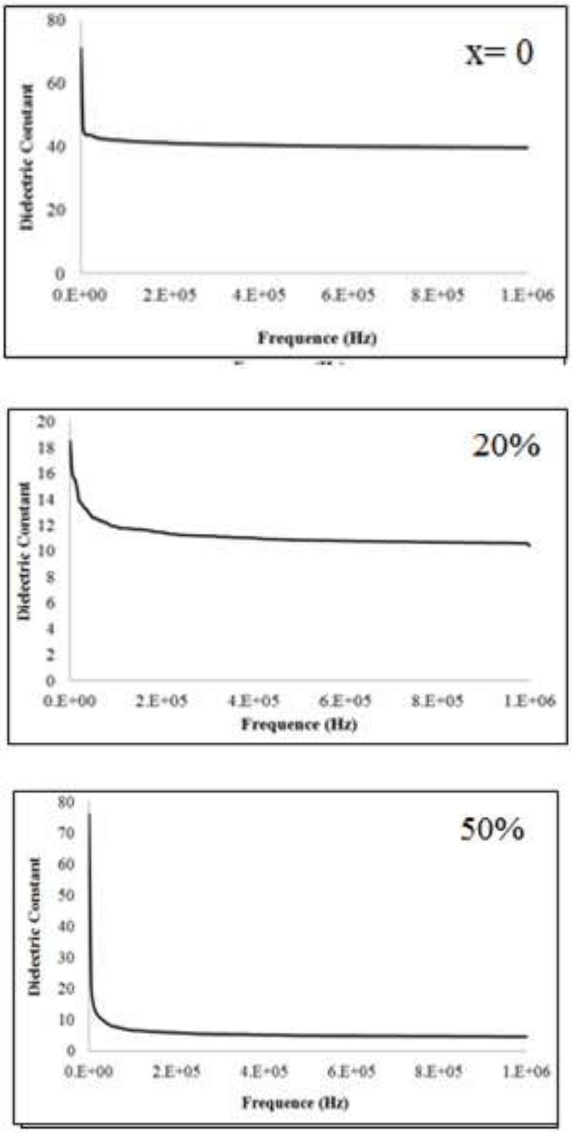

Figure 1: (ε_r') for pure $BaTiO_3$and (20and 50 $Ni_{0.7}Zn_{0.3}Fe_2O_4$) %addition ratios a specimens

Figures (2) refer to the optimum ratios required to obtain the low (ε_r'') values for ceramics composites at 20%, (ε_r'') = 0.56609 at (1MHz), and this due to one of the main advantages of ceramics as dielectrics is that (ε_r'') is small compared with each materials [15].

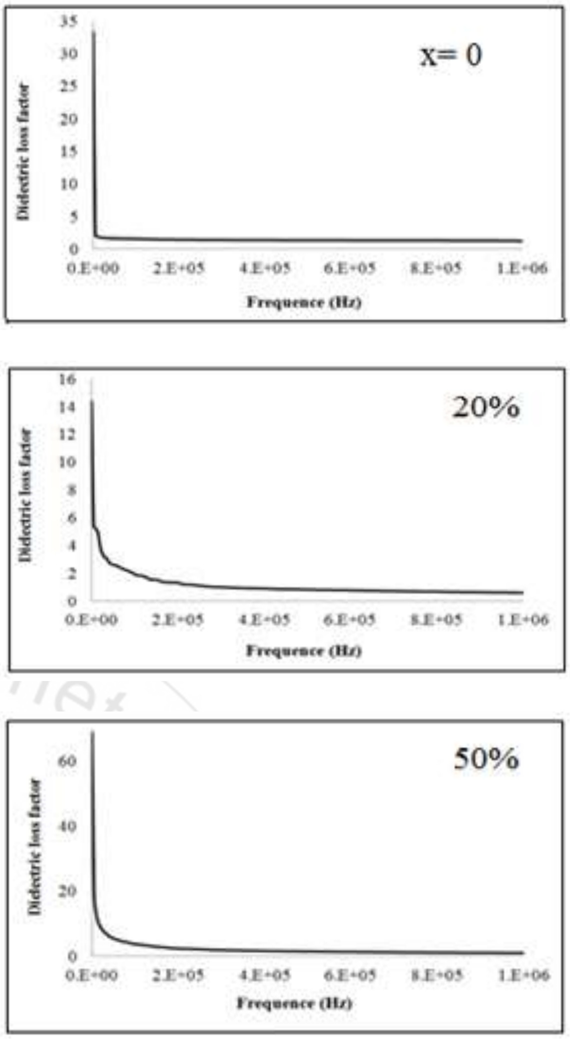

Figure 2: (ε_r'') for pure $BaTiO_3$ and (20 and 50 $Ni_{0.7}Zn_{0.3}Fe_2O_4$) % addition ratios a specimens

The results of the tangent and $\sigma_{a.c}$ at frequency at (50 and 1M) Hz are compiled in [Table 1] for all specimens. As it is clear in the table, at 50Hz that the lower $\sigma_{a.c}$ results for all samples are ($1.30*10^{-9}$ $(\Omega.cm)^{-1}$) for $BaTiO_3$ sample than with composites.

Table 1: The tangent loss (tanδ) and ($\sigma_{a.c}$) values at 50Hz and 1MHz for groups prepared at sintering temperature (1100°C)

Samples	*tangent loss* (tanδ) at		Alternating electrical conductivity ($\sigma_{a.c}$) $(\Omega.cm)^{-1}$	
	50Hz	1MHz	50 Hz	1MHz
$BaTiO_3$	0.469	0.03028	$1.30*10^{-9}$	$1.68*10^{-6}$
20%	0.7766	0.05473	$2.16*10^{-9}$	$3.04*10^{-6}$
50%	0.735	0.0461	$1.91*10^{-7}$	$4.9*10^{-5}$

Table 2: Exhibits that the dielectric strength values for samples decreases from (2.909 to 1.977) Kv/mm than with dielectric strength value for $BaTiO_3$ specimen (3.476Kv/mm), also shows that compositeshave the lower dielectric strength values than $BaTiO_3$ specimen due to the formation of porous structure.

Paper ID: ART20175952 DOI: 10.21275/ART20175952

Table 2: The Dielectric strength and breakdown voltage values for samples prepared at sintering temperature (1100°C).

Samples	Breakdown voltage (Kv)	Dielectric strength (Kv/mm)
$BaTiO_3$	27.6	3.476071
20%	25.4	2.909507
50%	15.7	1.97733

4. Conclusions

The crystallized composite samples compacted to 5.4 MPa and fired at 1100°C, the dielectric constant at low frequency (50Hz) is decrease and increases with the increases of ratios (20%and50%). The (ε'_r) values at 1MHz for specimens', decrease from (18.50124, 76.06546) to (7.83247, 4.48693) respectively. For the composites samples, the $\sigma_{a.c}$ has smaller values than that of the $BaTiO_3$ sample, due to the porosity. The results of the measurement of dielectric strength show that the break down voltage of the $BaTi_{O3}$ specimen is higher than the all specimens . The decreasing in the dielectric strength values for samples referred to the porosity and ($_{\sigma d.c}$) values, and vice versa.

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