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Dielectric and electric proprieties of (1-x)(Pb($Fe_{2/3}W_{1/3}$)O_3)-xPT-yMnO_2 multiferroics ceramics at high temperatures

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Abstract – Dielectric and electric properties of multiferroics Pb($Fe_{2/3}W_{1/3}$)O_3 ceramics were evaluated over broad temperature and frequency ranges. Two Debye-type dielectric relaxations were observed at high temperatures (300K-600K). The low temperature relaxation was attributed to charge carrier hopping process between Fe^{3+} and Fe^{2+}.The high temperature dielectric dispersion was associated with oxygen vacancies related defect complex.

Single-phase multiferroics materials present the coexistence of three (or at least two) of the ferroic properties: ferroelectricity, ferromagnetism and ferroelasticity. Some multiferroics materials exhibits magnetoelectric coupling, which relates the influence of a magnetic (electric) field on the polarization (magnetization) of a material [1]. Pb($Fe_{2/3}W_{1/3}$)O_3 (PFW) is a ferroelectric and antiferromagnetic magnetoelectric multiferroic, showing a perovskite-type structure, in which the two kinds of cations (Fe^{3+} and W^{6+}) are randomly distributed at the octahedral B-site positions. The ferroelectric Curie temperature, T_C, for PFW was reported between 180 and 200 K. A broad maximum of the dielectric permittivity was attributed to a ferroelectric phase transition, but it is not related with structural changes: the perovskite material remains in a pseudocubic structure down at low temperatures. The magnetic Neèl temperature is reported to be around 340–380 K[2].

Multiferroics PFW ceramics samples were synthesized via a two-stage solid state reaction, which efficiently suppressed the formation of undesirable stable impurity phases. The complex dielectric permittivity was measured as a function of temperature (15K-800K) at frequencies between 100Hz and 10 MHz and electric conductivity was measured at same temperature interval. The influence of MnO_2 and $PbTiO_3$addition, up to (1-x)($PbFe_{2/3}W_{1/3}O_3$)-xPT-yMnO_2 x=0.10, 0.20 and 0.30; and y=0.5 and 1 %, in the electric and dielectric response was also investigated.

The results show that PT addition decrease the dielectric constant value while MnO_2 increased it at T_C.

Besides the ferroelectric–paraelectric phase transition, two distinct thermally activated dielectric dispertions were observed in the temperature range of 300–600K. The dielectric permittivity maximum of the second set of peaks decreases and shifts to higher temperatures as the frequency increases, while the loss factor maximum increases and also shifts to higher temperatures. From the electric conductivity measurements it was obtained 0.52-0.60 eV of activation energy for PFW and PFW-PT and ~0.90eV for MnO_2 doped samples.

The low temperature dispersion probably corresponds to charge carrier hopping process while the high temperature dispersion, which is strongly dependent of sample annealing, can be attributed to complex composed defects of oxygen vacancies and conducting charge carriers.

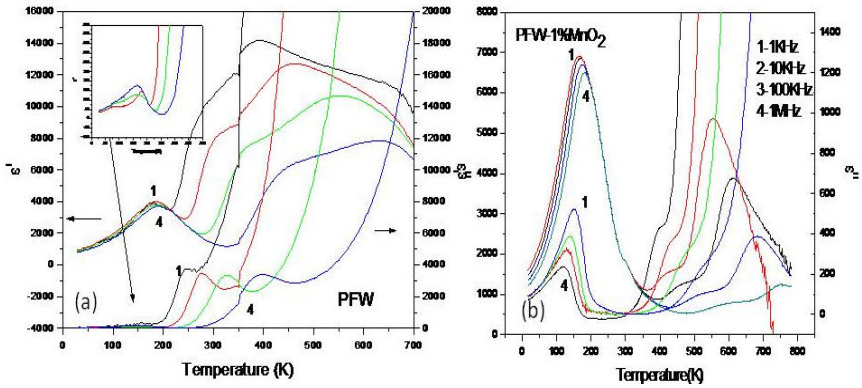

Figure 1: Temperature dependence of dielectric properties at various frequencies: (a) PFW and (b) PFW-MnO_2.

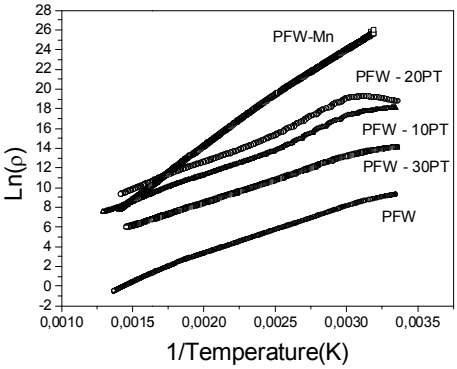

Figure 2: Temperature dependence of electric properties for PFW, PFW-PT series and PFW-MnO_2 ceramics

[1] EERENSTEIN W., MATHUR N.D., SCOTT J.F. **Nature**, v.05023, a.n.44217, (2006).
[2] IVANOV S.A. et all, **Materials Research Bulletin** 39 (2004) 2317–2328.