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Structural and photoluminescent properties of lead zirconate powders

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Abstract – Lead zirconate powders were obtained by the polymeric precursor method and were annealed at temperature from 300 to 800 ºC for 2 h. These powders were analyzed by X-ray diffraction (XRD) and photoluminescence (PL) measurements. XRD analyses revealed that the $PbZrO_3$ powders are free of secondary phases and crystallize in a orthorhombic structure. $PbZrO_3$ exhibit an intense PL emission at room temperature with maximum peak at 580 nm (green region) when excited by 488 nm wavelength of an argon laser.

Considerable interest has been recently focused on the study of the active optical properties, such as photoluminescence (PL) and non-linear optics, at room temperature of amorphous materials, such as the zirconate type perovskite. Lead zirconate, ($PbZrO_3$ or PZ), is an antiferroelectric (AFE) ceramic with a Curie temperature of ≈ 230 ºC. It is reported that PbZrO3 has an orthorhombic crystal structure at room temperature with lattice parameters of *a* = 5.87 Å, *b* = 11.74 Å, *c* = 8.20 Å [1]. Practically, this material is a potential candidate for energy storage applications for DC fields and low loss linear capacitor, owing to its AFE nature.

In this work we present measurements of broad PL as a function of heat treatment in $PbZrO_3$ powders prepared by the polymeric precursor method. Initially, zirconium citrate was formed by the dissolution of zirconium (IV) n-propoxide in an aqueous solution of citric acid (60–70 ℃). Stoichiometric amounts of lead acetate trihydrate (>99% purity, Aldrich) were added to this zirconium citrate solution. After the solution became homogeneous, ethylene glycol (99.5% purity, J.T. Baker) was added to promote mixed citrate polymerization by the polyesterification reaction. The citric acid/ethylene glycol ratio was fixed at 60/40 wt.%. This resin was then placed in a furnace and heat treated at 300 ºC for 2 h, causing their pulverization and forming the powder. This powder thus was calcined for 2 h in crucible at different temperatures, i.e., 400, 500, 600, 700 and 800 ºC, to obtain the $PbZrO_3$ ceramic powders.

The X-ray diffraction patterns of ceramic powders are illustrated in Figure 1. The orthorhombic perovskite phase was index with the space group *Pbam* and lattice parameters *a* = 5.9 Å, *b* = 11.9 Å, *c* = 7,99 Å, in agreement with the respective JCPDS (Joint Committee on Powder Diffraction Standards) card nº 49-0011. No secondary or intermediary crystalline phases where identified, indicating that the $PbZrO_3$ ceramic was successfully synthesized. The Figure 2 presents the PL spectra recorded at room temperature for the $PbZrO_3$ powders heat treated at 300, 400, 500, 600, 700 and 800 ºC. They were excited by the 488 nm (≈2.54 eV) line of an argon-ion laser. They emit in the visible spectra region (green emission) with a maximum at about 580 nm. The PL emission bands are broad and intense, mainly for the disordered powder annealed at 300 ºC. As observed in Figure 2(d-f) the heat treatment at 600, 700 and 800ºC for 2 h results in a material that did not present any PL at room temperature. This behavior is observed in the material that present a structure order. The structural organization to PZ can be confirmed by XRD results.

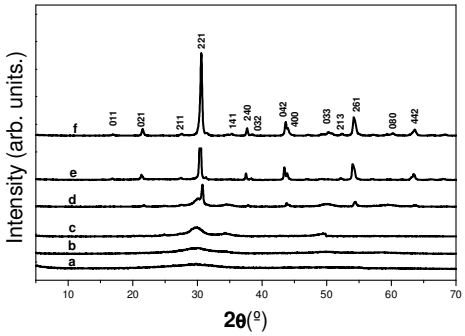

Figure 1. XRD patterns for the PZ powders heat treated at various temperatures: 300 - 800℃ (a-f).

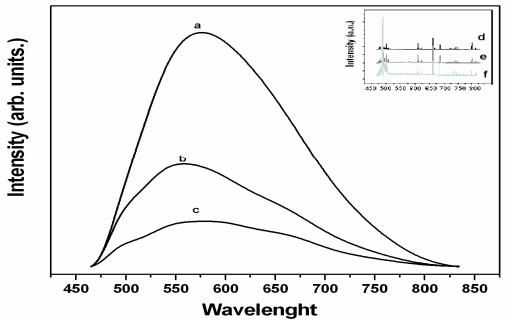

Figure 2. Photolumiscence spectra at room temperature of the PZ powders heat treated at (a) 300, (b) 400, (c) 500, (d) 600, (e) 700 and (f) 800℃ for 2 h.

References

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