Iron Incorporation Into Ferroelectric Lead Titanate
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Introduction

Multiferroics are materials that exhibit a combination of ferromagnetic, ferroelectric, and piezoelectric properties. [1] The co-existence of both ferroelectric and ferromagnetic properties in one material provides fertile ground for fundamental research as well as technological applications.[2] There has been speculation that, owing to its large tetragonal distortion of (c/a = 1.064), lead titanate would be capable of retaining ferroelectric properties even at large magnetic B-cation concentrations. We have made series of PbTi₁₋ₓFeₓO₃₋₅ sample in the range 0 ≤ x ≤ 1, using wet chemical synthesis. No phase segregation into Ti-rich and Fe-rich phases. In this case ferroelectric and ferromagnetic properties may exist in two or more different phases.

Sample Preparation

Lead Subacetate Pb(CH₃COO)₂·2H₂O
Fe(III) Acetate Fe(C₂H₃O₂)₃
Titanium isopropoxide Ti[(CH₃)₂CHO]₄

Dissolution
Acetic Acid
Mixing
Polymerization
Drying
Sonication, 2 hrs

XRD, SEM and EDX

XAFS

XAFS Results

XRD values are low! Local structure is markedly different from XRD structure solution. Local structure preference of Ti and Fe are dissimilar and does not depend on the Fe concentration. Fe polyhedral tilt after x=0.3 resulting a short Fe-Fe scattering path. PbFeₓOₓ, powder diffraction pattern didn’t agree with XRD values.

Ferroelectric? Ferromagnetic?

High temperature (1000 °C) sintering causes phase segregation into Ti-rich and Fe-rich phases. In this case ferroelectric and ferromagnetic properties may exist in two or more different phases.

Summary

The solubility limit of Fe³⁺ in lead titanate host, according to Vegard’s law, is approximately 10%. Rapid reduction in c lattice parameter with x-composition suggests that uniform distribution of dopants has been achieved by sol-gel synthesis. No pyrochlore or iron oxide type phases have been observed. Ti and Fe local structures are significantly different. Ferromagnetic properties could be related to the tilting of Fe polyhedra and the formation of PbFe₁₋ₓO₁₋ₓ detected using XAFS.

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