The Effect of Mn Doping on the Dielectric Properties of Lead Strontium Titanate (PST)

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Abstract
A modified sol-gel method was used to fabricate (Pb0.5Sr0.5)(Mn0.1Ti0.9)O3 (Mn doped PST) thin films with x = 0, 0.01, 0.03, and 0.05 on Pt/Ti coated SiO2/Si substrates. The structure, surface morphologies, dielectric and tunable properties of these films were investigated as a function of Mn content (x). X-ray diffraction, scanning electron microscopy and atomic force microscopy analysis showed that all the films were well crystallised with random orientation. It was found that the grain size/roughness, dielectric constant, loss, tunability and figure of merit (FOM) are affected by the Mn doping level. Further it was found that the ferroelectricity increases with Mn content. The dielectric constant reached a maximum of 1100 with 3 mol% Mn; whereas the maximum value of the tunability was 76.72% at 10 V with 1 mol% Mn.

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The Reason for the Increase of the Dielectric Constant for x < 0.03
1. Oxygen vacancies are generated by heat treatment under non-oxidizing atmosphere
2. Mn is a “freakish”, multivalence ion – it can appear as Mn2+, Mn3+, and Mn4+. Electron hopping between Mn sites begins in 5 mol% doped films.

Comparison
x < 0.02: Mn2+ doping consumes oxygen vacancies, thus providing a larger polarisation path. The dielectric constant increases.

Comparison
x > 0.02: Electron hopping between Mn2+, Mn3+ and Mn4+ begins. The hopping conduction due to the hopping of the charge carriers between Mn sites begins to occur in 2 mol% Mn doped PST, and then becomes distinct in 5 mol% doped films. This lowers in the end the dielectric constant and increases the loss in PST thin films

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