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Heterostructured ceramic materials based on PZTN-CFO compounds

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Abstract

Multiferroic composites are currently one of the hot research topics [1]. A great research effort is in progress to improve the fabrication of PZT–CoFe2O4 (PZT–CFO) composites due to the excellent piezoelectric properties showed by the PZT material class and the large magnetostrictive coefficient of the CFO. Unfortunately, unwanted reactions occur during densification of PZT–CFO materials at 1100–1200 °C. They are promoted by initial PbO loss that is calculated through XRD analysis, considering the amount of ZrO2 and variation of perovskite’s tetragonality. The resulting titania reacts with CFO to form cobalt titanate [2]. The microstructure of the composites at 26-81 mol% CFO content was thoroughly investigated; the CFO grain size distribution can be mono- or bi-modal and limited grain growth (240 nm). It has been demonstrated that twin boundaries on CFO (111) planes act as the effective pinning centers for the hindrance of domain wall movement [2, 3].

Experimental

• CONVENTIONAL SINTERING
  • Heating rate = 300 °C/h
  • Sintering temperature = 70% Tm
  • Soaking time = 0.5 h
  • Natural cooling

• QUITE-FAST SINTERING [2]
  • Heating rate = 300 °C/h
  • Sintering temperature < 70% Tm
  • Soaking time < 0.5 h
  • Cooling rate > 30 °C/min

Results

• PbO loss: 11%
• Bi-modal CoFe2O4 grain size distribution
• CoFe2O4 overgrowth by multiple parallel twinning [3]
• Coercivity: 239 Oe
• Reduced remnant magnetisation $M_r/M_{sat} = 0.17$

• PbO loss: 0.2%
• Euhedral CoFe2O4 grains: 250 nm
• Coercivity: 789 Oe
• Reduced remnant magnetisation $M_r/M_{sat} = 0.38$

Discussion

Reactions due to the PbO loss at the PZT/CFO interfaces [2]

\[ \begin{align*}
1^\circ) \text{ Pb}(Zr_{0.52}Ti_{0.48})O_3 \rightarrow f\text{PbO}_{0.5} + (1-f)\text{Pb}(Zr_{0.52}Ti_{0.48})O_3 + \\
\quad + 0.52(1-y+f)\text{ZrO}_2 + 0.48(1-z+f)\text{Ti}_2\text{O}_3 \\
2^\circ) \text{TIO}_2 + \text{CoFe}_2\text{O}_4 \rightarrow \text{CoTiO}_3 + \text{Fe}_2\text{O}_3
\end{align*} \]

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References