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Effects of Mn and Co doping at different sites in $BaTiO_3$ thin films on crystal structure and magnetic properties

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$Ba_{1-x}Mn_xTiO_3$ (BMT), $BaTi_{1-x}Mn_xO_3$ (BTM), $Ba_{1-x}Co_xTiO_3$ (BCT) and $BaTi_{1-x}Co_xO_3$ (BTC) thin films with concentrations x = 0.02, 0.04, 0.08, 0.12, 0.16, and 0.20 were synthesized by sol-gel spin coating method on silicon substrates. The crystal structures were studied by XRD, and the magnetic properties were investigated by VSM. Tetragonal structure was observed in each sample except for BMT with x = 0.02, 0.16, and 0.20. The lattice parameter a increases, while c decreases with increasing concentrations x. The unit cell volume also enhances with higher Mn and Co-doping concentrations. The enhancement is greater in Mn-doped samples, whereas BMT and BCT exhibit larger unit cell volumes comparing to BTM and BTC, respectively. Ferromagnetic behavior is detected in all samples. The saturation magnetization per doping ion decreases with increasing x for BTM, BCT, and BTC. The ferromagnetic exchange interactions are believed to be double exchange Mn^{3+}-Mn^{4+} for Mn-substituted samples, and Co^{2+}-Co^{3+} for Co-substituted samples.

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