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Structural, vibrational and dielectric behavior of $\text{Co}_{1-x}\text{M}_x\text{Cr}_2\text{O}_4$ (M = Zn, Mg, Cu and $x = 0.0, 0.5$) spinel chromites

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Abstract:

Low temperature sol-gel auto combustion method is used to synthesize the spinel chromites of $\text{Co}_{1-x}\text{M}_x\text{Cr}_2\text{O}_4$ (M = Zn, Mg {non-Jahn Teller (JT) ion}, Cu {JT ion}; $x = 0.0, 0.5$). Synchrotron, and lab x-ray diffraction pattern confirms the single-phase crystalline nature. Structural features from cubic (space group $Fd3m$) [CoCr_2O_4 , $\text{Co}_{0.5}\text{Mg}_{0.5}\text{Cr}_2\text{O}_4$ and $\text{Co}_{0.5}\text{Zn}_{0.5}\text{Cr}_2\text{O}_4$] to tetragonal (space group $I4_1/amd$) [$\text{Co}_{0.5}\text{Cu}_{0.5}\text{Cr}_2\text{O}_4$] are reported. SEM micrograph of sintered samples results in less porosity with average particle size distribution of $\sim 0.2 - 0.3 \mu\text{m}$. Shifting of Raman active phonon modes is seen with doping and an additional Raman active mode is seen at 666.45 cm^{-1} for $\text{Co}_{0.5}\text{Zn}_{0.5}\text{Cr}_2\text{O}_4$. Dielectric behavior as a function of frequency reveals that dispersion in all these chromites is attributed to hopping mechanism. Higher value of dielectric constant (ϵ') and minimum loss tangent ($\tan \delta$) for non-JT ion $\text{Co}_{0.5}\text{Zn}_{0.5}\text{Cr}_2\text{O}_4$ is measured inferring effective charge polarization in chromites as compare to doped JT ions. Both grains and grain boundaries are active in $\text{Co}_{0.5}\text{Zn}_{0.5}\text{Cr}_2\text{O}_4$ at lower frequencies as depicted from impedance analysis. Doping does not showed the presence of electric polarization in chromites.

Keywords: Spinel chromites, Synchrotron x-ray diffraction, Raman scattering, Dielectric properties.

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