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Effect of structural phase transition of GdCrO_4 to GdCrO_3 on magnetism

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Rare-earth orthochromites (RCrO_3) with orthorhombically distorted perovskite (ABO_3) structure exhibit a wealth of magnetic phenomena such as temperature-induced magnetization reversal (TMR), spin-reorientation (SR), spin-flipping (SF), and exchange-bias (EB). These occur as a result of magnetic interactions among the cations such as $\text{Cr}^{3+}-\text{Cr}^{3+}$, $\text{Cr}^{3+}-\text{R}^{3+}$ and $\text{R}^{3+}-\text{R}^{3+}$, where R is the rare earth element, such as Gd, Sm, Tm [1]. Rare-earth orthochromites also form a class of magnetoelectric multiferroics which exhibit the coexistence of ferroelectric and magnetic orders [1]. Some of these materials, such as single crystalline GdCrO_3 , exhibit a giant magnetic entropy change (ΔS_m) at a reasonable magnetic field, making it a potential candidate for the application in magnetic refrigeration [2]. TMR and EB have been reported in several RCrO_3 compounds due to the competition between the R^{3+} moment and the canted weak ferromagnetic (FM) component of Cr^{3+} ions [3]. In the present work, GdCrO_4 samples were obtained using sol-gel technique [4]. X-ray diffraction technique was used to identify the phase of the samples. The as synthesized samples were amorphous in nature showing a broad hump. Calcination of the samples at 630°C led to GdCrO_4 phase formation [5]. Further calcination of the samples at 1030°C for 1 hour led to the decomposition of GdCrO_4 into GdCrO_3 . Upon heat treatment, the Cr^{5+} oxidation state in the GdCrO_4 -zircon phase reduces to the relatively stable Cr^{3+} together with oxygen loss to stabilize the GdCrO_3 perovskite-structure [5]. The role of thermal decomposition of GdCrO_4 to GdCrO_3 on crystal structure and magnetic transitions, studied using XRD and vibrating sample magnetometer (VSM), will be discussed. Magnetization measurements as a function of temperature (M-T) with different probing magnetic fields were carried out to locate the various magnetic transitions in the samples under different measurement protocols such as zero field cooled (ZFC), field cool cooling (FCC) and field cool warming (FCW). Anomalies in the M-T curves observed at $T \approx 10\text{ K}$ and $T \approx 170\text{ K}$ correspond to spin - flip and Néel transitions, respectively. This is in agreement with previously reported values [1]. The hysteresis loops measured across the transition temperatures validate the magnetic transitions as observed in the M-T curves.

References

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