Magnetic Properties of Mn-Containing Aurivillius Oxides for Multiferroic Applications

S. Misture (Kazuo Inamori School of Engineering, Alfred University); J. Shi (Alfred University); V. Zapf (NHMFL-PFF)

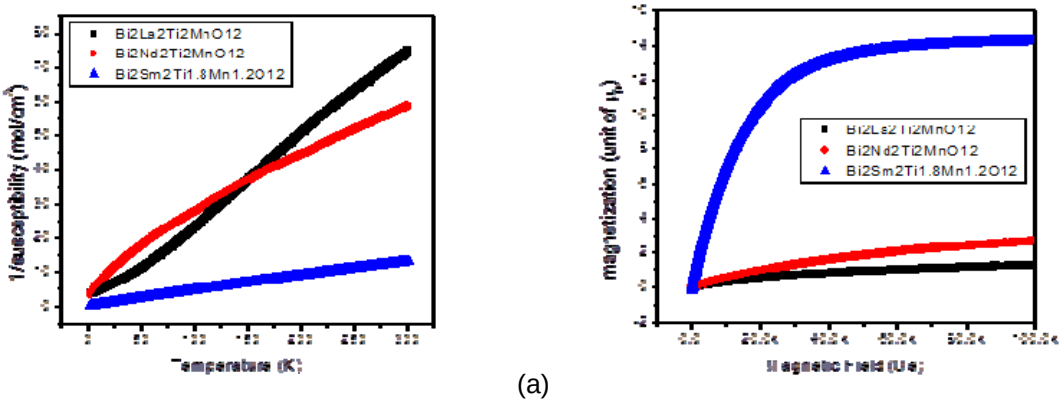
Introduction

Aurivillius phases are layered perovskite-derived materials of the form $Bi_2A_{n-1}B_nO_{3n+3}$ where perovskite-like layers, $[A_{n-1}B_nO_{3n+1}]^{2-}$ are interleaved with bismuth oxide $[Bi_2O_2]^{2+}$ sheets. The intense current interest in Aurivillius oxides stems from their rich crystal chemistry, enabling a broad range of applications including multiferroics, photocatalysts, low-fatigue lead-free ferroelectrics, and oxygen ion conductors.[1] Besides excellent ferroelectric properties, Aurivillius oxides have also been studied for their ferromagnetic/antiferromagnetic behaviors. Bulk $Bi_5Ti_3Fe_{0.5}Co_{0.5}O_{15}$ demonstrates clear multiferroic behavior above RT with a magnetic Curie temperature ~345°C ($2P_r$ = 13μC/cm^2 and $2M_r$ = 7.8 *m*emu/g).[1] In terms of broader impacts, we hope to more clearly define the structural origins of the multiferroic behavior in these layered oxides and link the structures from our neutron powder diffraction studies[2] with the magnetic behaviors.

Experimental

Measurements from about 2K up to 300K were obtained to study $Ln_2Bi_2Ti_{3-x}Mn_xO_{12}$ (Ln=La/Nd/Sm/Gd, x=0.6/1.0/1.2). Both temperature sweeps and field sweeps were measured on powder samples using a Quantum Design PPMS Vibrating Samples Magnetometer. For each sample, magnetic susceptibility from 2K up to 300K was measured, and field dependence of magnetization at ~2 to 3K was collected.

Results and Discussion



(a) (b)

Figure 1: (a) Temperature dependence of 1/magnetic susceptibility (b) M-H curves at 2-3K for Aurivillius oxides.

Both susceptibility and M-H plots show the paramagnetic behavior for all the Mn-doped Aurivillius ceramics, as seen in Fig. 1. Curie-Weiss temperature determined from the fitting of curves in Figure 1(a) varies from -50K to 23K as the Ln changes from Gd to La, indicating the existence of ferromagnetic and antiferromagnetic interactions. The effective magnetic moment likewise increases from 4.06μ_B for $Bi_2La_2Ti_{2.4}Mn_{0.6}O_{12}$ to 13.46μ_B for $Bi_2Sm_2Ti_{1.8}Mn_{1.2}O_{12}$.

Conclusions

In brief, we have studied both structural details and magnetic behavior of Mn-doped rare earth Aurivillius oxides. Additional work is in progress to determine the low temperature dielectric properties to complete the picture of the structural, electrical, and magnetic behaviors from ~2K to 1000K.

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References

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[2] E. Nichols, *et al*., J. Solid State Chem., **197**, 475 (2013).