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Effect of Rare Earth Size On Structural, Magnetic And Transport Properties Of $RBaCo_2O_{5.5}$

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Abstract. Oxygen deficient double perovskites $RBaCo_2O_{5.5}$ (R=Pr, Nd, Sm, Gd and Y) has been studied by XRD, magnetization and resistivity measurements. It has been found that the as rare earth size decreases, the distortions in structure give rise to fascinating magnetic and transport properties of such perovskites.

Keywords: Layered Perovskites, Magnetic oxides.
PACS: 75.47.Lx; 78.30.-j

INTRODUCTION

Double layered perovskites of type $RBaCo_2O_{5+\delta}$ (R=rare earth) are known for strongly correlated systems which shows specific behaviour of physical properties. These properties are associated with complicated magnetic phase diagram of these compounds. Among the various members of this family, the most interesting member is $\delta = 0.5$. In this system Co^{3+} ions are alternately located within square pyramids and octahedral oxygen environment. These compounds undergo a sequence of phase transition with decrease in temperature [1]. $RBaCo_2O_{5+\delta}$ are derivative of $RCoO_3$ systems where Co^{3+} is in low state(LS) which undergoes intermediate state (IS) and high spin(HS) with increase in temperatures[2]. Similar transitions can occur in $RBaCo_2O_{5+\delta}$ systems, but the controversy results of spin state transitions [3,4] demands more complex mechanism responsible for magnetic properties of these materials.

We have investigated the effect of rare earth size on structural, magnetic and transport properties of $RBaCo_2O_{5.5}$ samples.

EXPERIMENTAL

Polycrystalline samples of $RBaCo_2O_{5.5}$ (R=Pr, Nd, Sm, Gd and Y) was prepared by sol-gel method. The oxygen content of as synthesized sample was tailored by annealing in air, oxygen and argon atmosphere followed by ice quenching. The oxygen content was confirmed by iodometric titrations. X-ray diffraction (XRD) pattern was recorded in the range of $20° \leq \theta \leq 80°$ using Cu Kα radiation. Low temperature (10K – 320K) resistivity measurements were carried out using four-probe method. The magnetization measurements were carried out as a function of temperature M(T) using a Quantum Design SQUID magnetometer in the temperature range of 10 K to 300 K.

RESULTS AND DISCUSSION

Rietveld refinement of XRD pattern confirmed the formation of single phase samples with 122 type orthorhombic unit cell belonging to *Pmmm* space group. The variation of cell parameters and unit cell volume with R is plotted in Figure 1. Expectedly the cell volume decreases with decrease in ionic radius of rare earth ion. A small anomaly can be seen for R=Sm which is mainly due to a sudden contraction in lattice parameter "*a*".

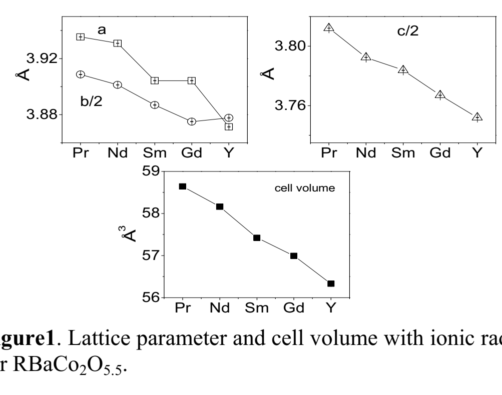

Figure1. Lattice parameter and cell volume with ionic radius for $RBaCo_2O_{5.5}$.

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M(T) at 1000 Oe for all compounds are depicted in the Figure 2. Except for Y a difference between zero field cooled (ZFC) and field cooled (FC) curves is noticed indicating complex magnetic ground state. At least two transitions from paramagnetic (PM) to ferromagnetic (FM) at T_C followed by a FM to antiferromagnetic (AFM) at T_N are visible in the plots. Apart from these two, the compound with Sm shows another antiferromagnetic transition at about 150K. Similar transitions are also seen in other rare-earths on closer examination of the magnetization curves [5].

It is very clear from Figure 4 that T_C and T_N increase with decrease in ionic radii of rare earth except Sm. This is perhaps related to the crystal structure. It may be noted that the lattice parameter *a,* for the compound with Sm shown an unusual contraction (Figure1).

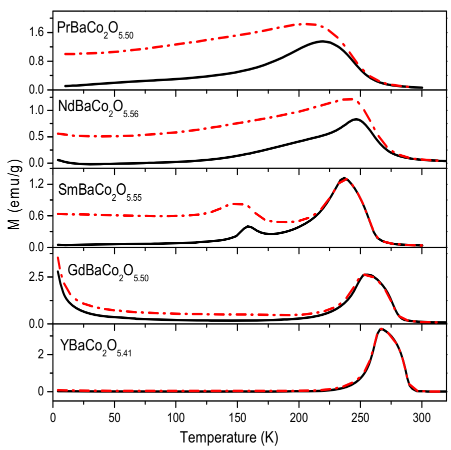

Figure 2. Magnetization as function of temperature M(T) registered at 1000Oe. Solid and dotted line shows ZFC and FC curves respectively.

Resistivity exhibits a semiconducting behaviour as can be seen in Figure 3. Here too the compound with Sm has resistivity lower by more than an order of magnitude compared to all other samples. It seems that a lower value of *a* leads to a greater overlap of Co – O bands and hence a greater mobility of the charge carriers.

In order to understand the transport mechanism and its relation with structure ln ρ v/s $T^{-1/4}$ in the temperature range 300K – 100K is plotted in Figure 4. It can be seen that the sample with Y has highest slope or characteristic hopping temperature while the other compounds have nearly the same values. This is in accordance with strong FM-AFM competition seen in these compounds. It may be noted that $YBaCo_2O_{5.5}$ has an AFM ground state. Further the plot of compound with Sm shows a broad feature at around 256K. This temperature is very close to its T_C. This indicates that the ferromagnetism in Sm compound arises due to inter octahedral Co-O-Co exchange interactions.

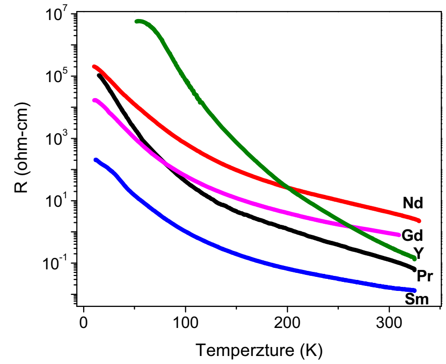

Figure 3. Resistivity as a function of temperature for $RBaCo_2O_{5.5}$

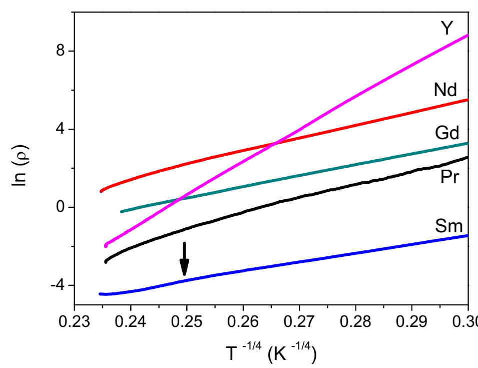

Figure 4. Plot of resistivity versus $T^{-1/4}$ for $RBaCo_2O_{5.5}$.

Therefore it can be concluded that the structure plays an important role in magnetic and transport properties of oxygen deficient $RBaCo_2O_{5.5}$.

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