Synthesis and Investigation of Magnetic and Transport Properties of Some Half-Metallic Oxide Nanoparticles

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Introduction:

Looking at today's world from a technological view, it is changing rapidly. There is an ongoing race to develop faster, smaller and more efficient computing capabilities. These capabilities rest upon the materials they are made out of. As better materials are developed, the industry progresses.

This project's goal was to investigate the synthesis of $La_{0.5}Sr_{0.5}MnO_3$. This ceramic material displays some very interesting electrical properties and if harnessed correctly, it could make a valuable contribution to the materials market.

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Experimental:

- The goal, for sample #062011,was to obtain 2 grams of $La_{0.5}Sr_{0.5}MnO_3$. We started off with lanthanum (III) oxide, strontium carbonate and manganese (IV) oxide.
- The following equation was used to perform stoichiomtric calculations to obtain the correct amount of reactants:

$$2La_2O_3 + 4SrCO_3 + 8MnO_2 \rightarrow 8\ La_{0.5}Sr_{0.5}MnO_3 + 4CO_2 + O_2$$

- For the synthesis of sample #062011 we gather about 0.8 g of La_2O_3, 0.72 g of $SrCO_3$ and 0.85 g of MnO_2.
- Next decarbonization was performed by heating the sample for 12 hours at 1150°C. Following decarbonization, a pellet was pressed and put into the furnace to be sintered; it was sintered at 1250°C for 2 hours then at 1550°C for 24 hours.
- Another sample was also prepared, sample #062911. Only 2 grams of sample #062011 was prepared versus the 5 grams of sample #062911. The sintering process for sample #062011 consisted of two dwelling periods, the first at 1250°C for 2 hours and the second at 1550°C for 24 hours. Sample #062911 only had one dwelling period which was at 1562°C for 20 hours.

The reactants being ground together.

High Temperature Furnace

Results:

- After preparing the sample, it is necessary to verify the chemical composition through x-ray diffraction.

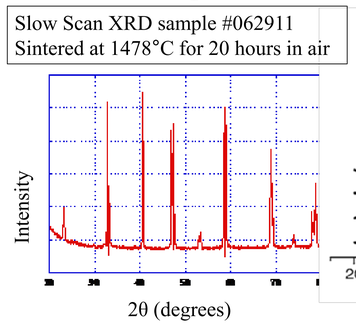


Figure 1

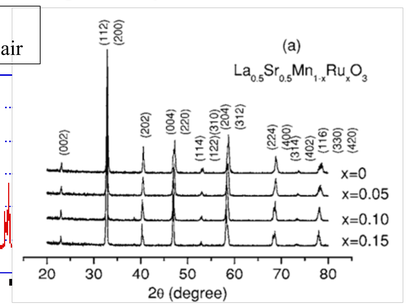
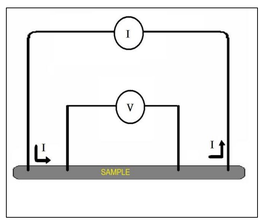


Figure 2

- If you compare figure 1 and figure 2 you can validate that the desired compound was produced. In figure 2 we are referring to the top line, when X=0.

- We also investigated the resistivity of our sample. Using a small piece of our sample the resistance was measured using a four-probe method. Four wires were connected to the sample, as illustrated in figure 3, using silver paste. A four probe device (Keithley 2010 multimeter) was used to determine the resistance. Figure 4 shows a sketch of the four probe method that was used to find the resistivity.

Figure 3



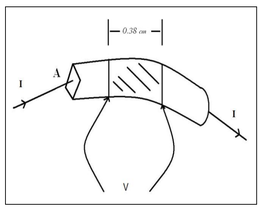


Figure 4

- The voltmeter gave a resistance value of 0.11 Ω for the sample. By using the resistance and the samples we can calculate the sample's resistivity using the following equation:

$$\rho = \frac{RA}{l}$$

where ρ= Resistivity, A = cross sectional area and ⌊ = length

- Following the sintering, the sample was examined. The sample was a dark grayish color. It seemed hard but also brittle. The sample also possessed some metallic properties. The sample seemed to have little resistance when it was measured with a voltmeter and it also displayed

- The odd thing about the substance displaying metallic properties is that the substance is a ceramic material. Ceramics are largely considered to be insulators; this being the case, the fact that the voltmeter was showing little resistance is quite bizarre.

- The starting compounds, La_2O_3, $SrCO_3$ and MnO_2, display no magnetic properties whatsoever. However, upon the decarbonization and sintering of our product, $La_{0.5}Sr_{0.5}MnO_3$, some magnetic properties were acquired. Paramagnetism means that the sample was attracted to the magnetic field of the magnet but in absence of the magnet, it did not display magnetic properties neither did it retain any of the magnetism after the magnet was removed.

Conclusion and Future Work:

This project is laying the foundation for a continuing research project. The main goal of the project was to develop a successful synthesis method that produces $La_{0.5}Sr_{0.5}MnO_3$.

Future work for this project includes the development of a suitable method to produce high quality half-metallic rare earth transition metal oxide nanoparticles and nanostructured materials. The principal investigator plans to investigate and modify the magnetic and charge transport properties of some half-metallic rare earth transition metal oxide nanoparticles.

References:

Ying, Yue, Jiyu Fan, Li Pi, Zhe Qu, Wenqin Wang, Bo Hong, Shun Tan, and Yuheng Zhang. "Effect of Ru Doping in $La_{0.5}Sr_{0.5}MnO_3$ and $La_{0.45}Sr_{0.55}MnO_3$." *Physical Review B* 74.14 (2006). Print.

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