Toward the Development of a Proposal to Study the Effects of UV Radiation on some La(Sr/Ca)MnO Compounds

Logan Pyle[*], Matthew Kornfield[#], L. L. Henry[$] (Mentor)
*REU student SUBR (2013), Home University: Kansas State University, Manhattan, KS
*REU student SUBR (2012), Home University: Georgetown University, Washington DC
[$] Southern University and A&M College, Baton Rouge, LA

Abstract: The LaMnO based compounds exhibit interesting effects when exposed to ultraviolet radiation**.** This work is on development of a proposal to study the effects on the physical properties of some Ca/Sr doped LaMnO compounds (thin films and bulk material). It is anticipated that the full proposal will be ready for submission early in the upcoming academic year.

Keywords: UV Radiation, La(Sr/Ca)MnO

1. Introduction

This work is the second stage of preliminary work to prepare a proposal application for funding to support a study of the effects of ultraviolet radiation on some $LaMnO_3$ based compounds. We intend to study the effects that UV-A, B and C radiation have on micro- and nanometer sized $LaMnO_3$ particles as well as bulk nanostructured $LaMnO_3$ based materials. The first two stages of work have been accomplished by LA-SiGMA REU students.

The alkaline-earth doped LaMnO based perovskites that exhibit colossal magnetoresistance are a source of great interest to the field of "spintronics".[1] These materials also provide fertile grounds for research because of their magnetic properties. Possible applications include utilizing these magnetic properties in different temperature ranges.[2,3]

On the other hand, environmental conditions, such as exposure to ultraviolet radiation, impact the properties of these materials. In the electromagnetic spectrum, ultraviolet (UV) radiation includes electromagnetic waves of wavelengths between visible light and x-rays. This is further subdivided into UV-A (320-400nm), UV-B (wavelengths of 290-320nm), UV-C (wavelengths of 220-290nm), Far UV (wavelengths of 190-220nm) and Vacuum UV (wavelengths of 40-190nm)[4]. Our interest lies with the effects of interactions between the materials and UV-A, UV-B and UV-C light.

It has been shown that when thin films of some LaMnO based compounds are exposed to ultraviolet radiation, the electrical resistance drops significantly when continuously exposed to UV light for extended periods of time.[5] If the sample is kept at a sufficiently low temperature (below 100K), the persistent photo-induced conductive (PPC) properties remain, i.e., the semi-conductor remains in its conducting state even though it is not subject to any outside influences (except temperature). [5]

2. Experimental

Phase 1.

Several synthesis routes have been used by many groups to obtain micro- and nano-sized LaMnO particles:

1. Solid State- A process in which a binder solution is used to create the final product[6]
2. Sol-Gel- A process that creates gel samples by changing the pH of the solution[6]
3. Alkoxide Technique- A process that creates samples by spin-coating and annealing[7]
4. Acetate Technique with Nitrates used as a Precursor- A process that uses acetate to form the desired sample[7]

The solid state and sol-gel (#1 and #2) techniques create bulk samples while the alkoxide and acetate technique (#3 and #4) create thin films. Thin films can also be fabricated by a laser ablation technique.

Our emphasis for the first phase of the study was carried out by coauthor Matthew Kornfield during his REU stay at SUBR (See reference #6). He successfully used a sol-gel technique to synthesize micro- and near nano meter sized particles of LaMnO doped with strontium and calcium (LSCMO). This route was chosen because the process yields phase pure samples and is very easy to do. Results of Thermogravimetric Analysis/Differential Scanning Calorimetry (TGA/DSC) measurements indicated phase pure LSCMO. Composition and structure characterizations of the samples were by x-ray diffraction, scanning electron microscopy (SEM) and energy dispersive x-ray (EDX) techniques. SEM imaging shows that the material was an aggregate of smaller particles. Figure 1 represents SEM images of the microstructure of the samples. The clearly defined shapes are images of the solid microcrystals. As a result having some problems with the imaging, fine resolution at the higher magnifications was unattainable preventing a more accurate depiction of the size of the near nanometer sized particles (Fig. 1(b)).

Fig. 1 (a)

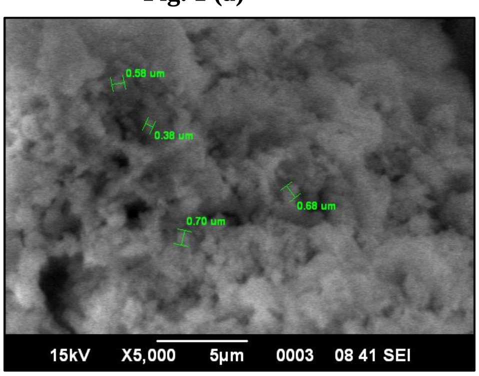
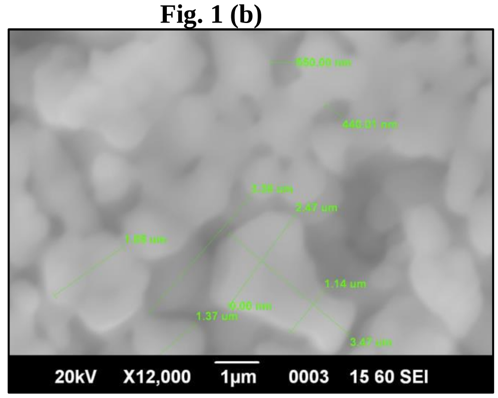


Fig. 1 (b)



Phase 2.

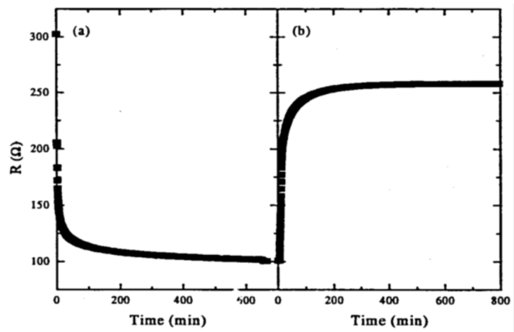


Fig. 2 *(a.) Resistance vs. Time under illumination at 95 Kelvin (b.) at 300K not under illumination*

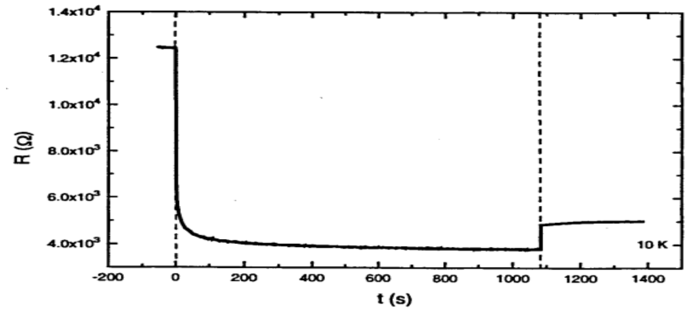


Fig. 3 *Resistance versus illumination time for* $La_{\frac{2}{3}}Sr_{\frac{1}{3}}MnO_{2.88}$*. The illumination time was from 0-1080 seconds. This graph shows PPC. The slight increase in resistance at 1080s is due to the heat of the lamp being shut off.*

The next phase of the study was carried out by another REU student, coauthor Logan Pyle. This phase undertook a study review of the literature to see what work had been previously done demonstrating effects of exposure to UV radiation on ceramic based materials, in particular LaMnO based materials. Of particular interest is a study by A. Gilabert, et al., "*Effects of illumination on the electrical properties of oxygen deficient cuprates and manganites.*"[5] This work describes the effects of UV light on strontium doped lanthanum manganite thin films. Figures 2 and 3 represent their results, which illustrate the effects on the material's resistance when the films are exposed to visible and ultraviolet light for extended periods of time. For Part (a), of Fig. 2, the graph shows the resistance vs. time under light illumination at 95 Kelvin, while for part (b) the resistance vs. time not under illumination at 300 Kelvin. This experiment strongly suggests that there is a connection between UV light and the behavior of the resistivity in the Lanthanum Manganites. Figure 3 shows resistance versus illumination time for $La_{\frac{2}{3}}Sr_{\frac{1}{3}}MnO_{2.88}$. The illumination time was from 0-1080 seconds. This graph shows PPC. The slight increase in resistance at 1080s is due to the loss of the heat of the lamp when it is turned off.

3. Future Direction

Having gained experience with successfully synthesizing micro- and near nano-sized LMnO based particles and having become aware of some of the effects that have been observed by other groups, it is our intent to develop a program to study the effects of UV radiation on the physical properties of those compounds. We would like to study specifically the transport properties (I-V and thermal), the magnetic properties and the magnetoresistance properties, of some doped lanthanum manganite compounds under UV illumination. To our knowledge, most of the work done to date has been done using thin films. Our study would extend the knowledge to include not only thin films but also bulk materials comprised of micro- and nano-sized particles as well.

Our results will have implications for fuel cell technology, including solar energy devices and propulsion devices and systems. It is expected that a proposal for funding to carry out the study will be submitted in the near future.

4. Acknowledgments

The current work is funded by the NSF EPSCoR LA-SiGMA project under award #EPS-1003897.

5. References

[1] Sebastian Anthony (2012). *Extreme Tech* [online]. Available from: <http://www.extremetech.com/computing/131230-cpus-of-the-future-amd-partners-with-arm-while-intel-designs-a-brain-on-a-chip>. [Accessed 7/19].

[2] M. Muroi, P. G. McCormick and R. Street (2003, June). *Surface spin disorder and exchange bias in $La_{0.7}Ca_{0.3}MnO_3$ nanoparticles synthesized by mechanochemical processing*. (Rev. Adv. Mater. Sci. 5). Advanced Nano Technologies and The University of Western Australia, Welshpool, Australia.

[3] B. Roy, A. Poddar, and S. Das (2006, May). *Electrical transport properties and magnetic cluster glass behavior of $Nd_{0.7}Sr_{0.3}MnO_3$ nanoparticles*. (Journal of Applied Physics 100). Saha Institute of Nuclear Physics, Kolkata, India.

[4] Zeman, G. (n.d.) *Ultraviolet Radiation*. (2011). Health Physics Society. Web

[5] A. Gilabert, R. Cauro, J.P. Contour, M.G. Medici, J.C. Grenet, R. Papiernik, Ivan K. Schuller. Effects of illumination on the electrical properties of oxygen-deficient cuprates and manganites. (2000). Journal Title: Superconducting and related oxides, physics and nanoengineering IV, 331-7, 4058.

[6] M.C. Kornfield, S. Wicker, L. L. Henry. Synthesis and Structural Characterization of La_0.5 Ca_.25 Sr_.25 Mn., (Unpublished). Southern University La-SIGMA REU 2012.

[7] R. Cauro, J.C Grenet, A. Gilabert, M. G. Medici. Persistent Photoconductivity in La_0.7 Ca_x Ba_(1-x) MnO_3 Thin Films. (1999). International Journal of Modern Physics Volume 13 (Numbers 29, 30 and 31).