Effects of Ultraviolet Radiation on the electrical transport in some La(Ca/Sr)MnO compounds

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LA-SiGMA
Louisiana Alliance for Simulation-Guided Materials Applications

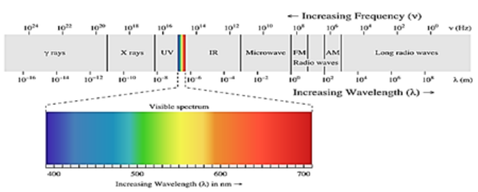
Abstract

The study investigated the effects of ultraviolet (UV) radiation exposure on the electrical properties of some La(Ca/Sr)MnO (perovskite crystal structure) compounds. In order to do that, it was necessary to calibrate the UV radiation sources. The calibration process required measurement of the UV intensity of the light source(s). Photodiodes were used to detect the UV light. The detection of UV radiation by the photodiodes is caused by the photoelectric effect. Our hypothesis involved measuring the electrical resistance of the La(Ca/Sr)MnO samples under normal (i.e. no UV exposure) conditions, and then again while under exposure to UV radiation, in order to demonstrate any changes in the electrical properties of the samples. Our results did not show any changes; thus, our conclusion did not support our hypothesis.

Motivation

The reemergence of interest in materials exhibiting the perovskite crystal structure, such as Lanthanum Manganite based compounds, is rapidly becoming widespread. Applications in photovoltaics and fuel cell technology demonstrate that the use of these materials has great potential importance to industrial use.
Hypothesis: The irradiation of the La(Ca/Sr)MnO materials with UV light will likely cause a movement of electrons, due to the photoelectric effect, at least on the surface; moreover, this change will likely cause a change in the electromagnetic properties of the material.

Electromagnetic Spectrum



- The known Electromagnetic Spectrum is composed of discrete energy packets, known as *Photons*.
- All Electromagnetic radiation carries both electrical and magnetic energy, and does not need a medium to travel through.

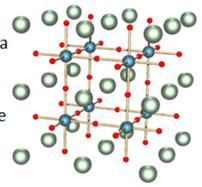
La(Ca/Sr)MnO Composition

- Based on data and experimentation from previous trials on LaMnO materials.
- Doping of LaMnO with Ca and Sr to produce materials not previously created.

Base Chemical Equation ↓	Dopant Variance (x value) →	x = 0.3 (Sample Number 270614A)	x = 0.4 (Sample Number 010714A)
$La_{0.5}Ca_{0.5-x}Sr_xMnO_3$		$La_{0.5}Ca_{0.2}Sr_{0.3}MnO_3$	$La_{0.5}Ca_{0.1}Sr_{0.4}MnO_3$

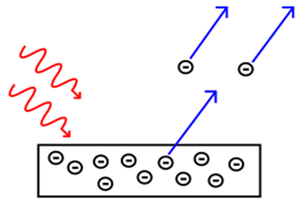
Perovskites

- Crystalline atomic structures which exhibit a variety of characteristics.
- La(Ca/Sr)MnO materials can vary in both structure and electromagnetic properties.



Work Function/The Photoelectric Effect

- The minimum energy required to remove an electron from the surface of a solid.
- The photoelectric effect is created by photon energy which exceeds the work function of the solid.
- Occurs when light energy strikes the surface of a solid material.
- If the wavelength of the light energy meets or exceeds the work function of the solid, electrons in that material are emitted.



Calculating Photon Energy

- **Planck's relation is defined as:** $E = hf$
  1. *E is energy*
  2. *f is frequency*
  3. *h is Planck's constant*
- **Frequency can be defined as:** $f = \frac{c}{\lambda}$
  1. *c is the speed of light*
  2. *λ is wavelength*
- **Thus, we can conclude that:** $E = \frac{hc}{\lambda}$

Calculating Electrical Resistivity

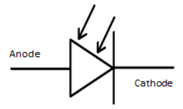
- Calculations of the Electrical Resistivity of the La(Ca/Sr)MnO specimens will establish a baseline.
- We are using the following formula:

$$\rho = R\frac{A}{l}$$

- **Where:**
1. *ρ is Electrical Resistivity*
2. *R is Electrical Resistance*
3. *A is the cross-sectional Area*
4. *l is the length*

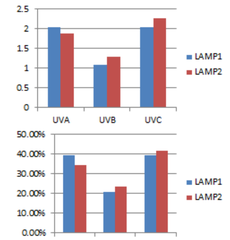
Photodiodes

- Photodiodes are semiconductor devices used to convert light energy into voltage.
- A surface contained within the diode is composed of Silicon, doped with impurities to facilitate electron movement.



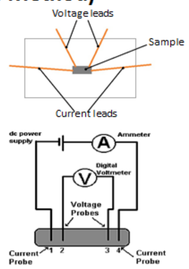
UV Lamp Data

- The voltages displayed in graph 1 read as negative values (polarity).
- From the values in graph 1, the compositional percentages of the lamps was determined (graph 2).



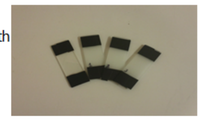
Electrical Resistance Measurement (Four Probe Method)

- Sample is affixed to the 3" x 5" index card.
- Four leads are attached to sample with silver conductive paint.
- Leads can be connected to multi-meter, or separate current source and voltmeter.

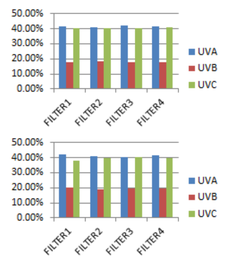


UV Filters

- The photodiode test procedure was employed while photographic optical filters were utilized.
- By applying a thin film of sunscreen to a clear material, we made filters.
- Isolating specific wavelength ranges was the focus of using filters.

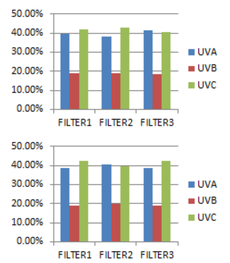


UV Lamp Data with Filters



- Lamp compositions with photographic optical filters.
- Lamp 1 data (top) and lamp 2 data (bottom) show similar compositions.

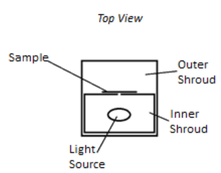
UV Lamp Data with Filters

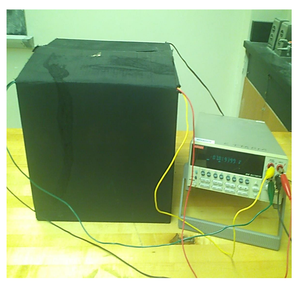


- Lamp compositions with created sunscreen filters.
- Lamp 1 data (top) and lamp 2 data (bottom) display similar compositions.

Experimental Setup

- Sample is mounted to a 3"x 5" index card.
- Inner shroud minimizes heat energy.
- Outer shroud prevents light pollution from other sources.





Experimental Data

Sample Number ↓	Properties Found →	h (height)	w (width)	l (length)	R (electrical resistance)	ρ (electrical resistivity)
270614A		2.11 mm	3.34 mm	4.425mm	$5.6375\times10^{-2}\,\Omega$	$8.978\times10^{-2}\,\Omega m$
010714A		1.788 mm	3.86 mm	4.89 mm	$7.8675\times10^{-3}\,\Omega$	$1.1101\times10^{-3}\,\Omega m$

- Samples were measured, and their electrical resistance was tested.
- Calculation of electrical resistivity was included in the compiled data.

Resources

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Conclusion

We concluded that there were no discernable electrical property changes in the LaMnO samples using Ultraviolet Radiation in the UV-a, UV-b, and UV-c ranges as a catalyst at room temperature. However; this finding does raise additional questions about the sample materials, including the utilization of the same experimentation processes while introducing new independent variables, such as temperature variances.

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