### University of Arizona

# Materials Science and Engineering

## MSE 110: Solid State Chemistry

##### Composition and Temperature Dependence of LEDs

Date Performed: September 20, 2022

Date Submitted: September 30, 2022

##### Cieran Wong

#### Composition and Temperature Dependence of LEDs

**Introduction**

The goals and purpose of the lab was to identify the potential rare-earth materials and/or compositions that make up the LEDs and various bulbs based on their band gap energies and intensity counts. The theory is that certain compositions will produce certain light colors as well as certain intensities. The various colors and types of bulbs also use different amounts of energy, while maybe producing the same amount and kind of light. We want to find out the energy efficiency of the lamps by obtaining data through a spectrometer to determine what the wavelengths and intensity counts of the respective bulbs are.

###### Experimental Procedure

Part I: Collecting the emission spectra for the LEDs at room temperature.

1. In the spectrometer placeholder, opposite there should be a space for the LEDs to go in. Place one of the LEDs in the placeholder spot and plug in the wire to the usb port in the computer. This will provide power to the LED and will turn it on.
2. Turn on the spectrometer which should be connected to the computer, and open up the respective software provided. Adjust the settings accordingly, this can be done through lowering the integration time so that the maximum intensity count is not way off the graph.
3. Save the data recorded as text data and export to an Excel file to graph.
4. Repeat for the other three LEDs, should have four graphs in total, measuring the intensity counts vs wavelength. The four LEDs are blue, green, red, and amber.

Part II: Emission spectra for the red and amber LEDs at 77K

1. Place the red LED in the liquid nitrogen provided. Wait approximately five minutes for the LED to reach the desired temperature.
2. Immediately after taking the LED out of the liquid nitrogen, place it in the placeholder opposite of the spectrometer. Plug the usb cable back into the port to turn it on, start a stopwatch, and begin recording data.
3. Every 30 seconds, for 4 minutes, record the emission spectra and collect the data in text form. Export the data to Excel.
4. In Excel, the data will be graph as a time vs the maximum intensity wavelength for each spectrum at the recorded time. Find a value for the wavelength at time = 0 or when the lamp is at 77 K.
5. Repeat for the amber LED

Part III: Emission spectra for the incandescent, fluorescent, and LED lamps.

1. Turn on the incandescent lamp and place the spectrometer about one foot away from it. You may need to angle the lamp so that it is in line with the spectrometer.
2. Adjust the integration time and the distance of the lamp from the spectrometer accordingly till the data on the graph is within a reasonable range and can be easily determined.
3. Save the data as text data and export to Excel. Repeat for the fluorescent and LED lamps.
4. Now turn on the Incandescent lamp and place the tip of the thermometer in the bulb. Wait until the temperature stabilizes or for 5 minutes. Record the temperature.
5. Repeat for the Fluorescent and LED.

###### Experimental Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Band Gap Energies at Room Temperature** | **Blue** | **Green** | **Red** | **Amber** |
| Energy | 4.34967E-19 | 3.85981E-19 | 2.99367E-19 | 3.24804E-19 |
| J to eV | 2.715150919 | 2.409366932 | 1.868710798 | 2.027490147 |
| wavelength | 457 | 515 | 664 | 612 |
| Estimated and Suggested Compositions | ZnSe because its band gap energy is also 2.7 | AlP because its band gap energy is also 2.4 | 50 - 50 AlAs and GaAs | 80 - 20 AlAs to GaAs |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | red vs time |  |  | amber vs time | |
| time | wavelength | | time | wavelength | |
| 1 | 640 |  | 0.5 | 588 |  |
| 1.5 | 643 |  | 1 | 592 |  |
| 2 | 645 |  | 1.5 | 594 |  |
| 2.5 | 647 |  | 2 | 597 |  |
| 3 | 649 |  | 2.5 | 599 |  |
| 3.5 | 651 |  | 3 | 600 |  |
| 4 | 653 |  | 3.5 | 602 |  |
| 4.5 | 654 | eV | 4 | 603 | eV |
|  | 3.12E-19 | 1.947918 |  | 3.38E-19 | 2.110245 |
| t=0 | 637 |  | t=0 | 588 |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | J | eV |  | Hypothesis on Rare-Earth element in the Fluorescent Light bulb |
| 1.9878E-25 | 3.24804E-19 | 2.0274901 | 612 | Erbium |

###### Discussion and Conclusions

Based on the Intensity vs. Wavelength graphs of the respective bulbs, we can see that Fluorescent uses the least amount of energy as it only has four peaks that have intensity counts greater than 20000 at 404 nm, 430 nm, 534 nm, and 612 nm, respectively; while the LED is less energy efficient as it ranges from about 436 nm to 776 nm. This gives reason to believe that the LED is using more energy since there is a wider range of peaks and intensity counts above 20000. For the Incandescent lamp, this would be the least energy efficient of the three as it has a range from 326 nm to 1054 nm. This uses the most energy as we can see that it has the greatest number of counts above 20000 as we get a range of 482 nm to 846 nm, a range where all the intensity counts are above 20000.

There may be some error in the data, for example, when collecting the data for the chilled LEDs, we may not have timed it correctly and our data collection might be off by a couple of seconds. While we did use a stopwatch to accurately measure the time, we did not start the clock till the LED was in the placeholder. We did not account for the travel time between the liquid nitrogen holder to the placeholder. Another example of potential error may arise from the lamps. We tried to angle the lamps as best as we could in front of the spectrometer, however, due to the size of the lamp in comparison with the spectrometer, we may have angled it incorrectly and gotten data that might be different from what a potential baseline might be. If the lamp were smaller and could go into the placeholder in front of the spectrometer, we could perhaps have collected data that was more precise and accurate.