### University of Arizona

# Materials Science and Engineering

## MSE 110: Solid State Chemistry

##### Measurement of Optical Properties of Materials

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#### Measurement of Optical Properties of Materials

**Introduction**

This experiment aims to examine the phenomenon of light, as light is able to be reflected, transmitted, scattered, or absorbed. Through the emission of light, we can find the refractive index of a material based on how much light goes through. Our experimental setup aims to look at the phenomenon of light, by utilizing different materials to examine how much light passes through if a voltage is kept constant. We also aim to understand how the varying thickness of a material controls the transmittance of light, and if there is such a thing as a fully transparent metal. The refractive index of light allows for us to gain an understanding of its connection with the medium and the level of transmittance.

###### Experimental Procedure

Materials:

* Small light bulb connected to power source and light detector
* 10 glass slides
* 1 thick glass slide
* 3 nickel-coated glass slides
* 9V battery

Procedure for glass slides:

1. Connect a digital voltmeter to the light detector by pushing probes into the connectors. The light detector contains a photo detector that generates a voltage proportional to the intensity of light hitting the detector. Set the voltmeter to an appropriate DC setting given that the readings will be less than 3 V DC. Turn on the switch for the detector (single switch) and allow the detector to warm up for about a minute. Read the voltage of the detector with ambient light.
2. Connect the light to the Textronix power supply and set the voltage to 5 V. Make sure the current limit dial is at a maximum. If the current limit switch comes on, decrease the voltage. Turn on the power supply (one switch in the front and back), and the light on the detector board will come on. Do not change the voltage powering the light during the rest of the experiment. If changed, the experiment will need start over from scratch.
3. Measure the voltage of the detector with the light on. Allow the detector to reach a steady state reading after the light comes on (it will take roughly a minute). Do not turn the light off or change the voltage powering the light for the rest of the experiment.
4. Obtain glass slides and make sure they are clean by rubbing them with a Kimwipe (look through slide to see if it’s clean). Place a clean slide in front of the detector with the light on and obtain the detector reading. The slide can be held in place with a binder clip. Clean a second glass slide and measure the voltage of the detector with a stack of two slides. Continues cleaning, stacking slides, one at a time, and measuring the voltage until you have measured the voltage for a stack of twelve slides. The last couple of slides can be held with fingers rather than the binder clip.
5. Clean the thick glass sample and measure the voltage of the detector. Note how the transmission of the thick piece of glass compares with the stack of twelve slides which is approximately the same thickness.

Procedure for nickel slides:

1. Steps 1and 2 are the same as the glass slides procedure.
2. Repeat Step 3, just re-measure the voltage for the bulb.
3. Obtain three nickel slides. Each slide has a different thickness. No not touch the surface of the slides as it may rub off the nickel coating. Handle the slides only by the edges and be careful not to drop them. The slides are labeled with roman numerals I to III scribed on the surfaces that do not have nickel on them. Carefully place each slide between the light and the detector. Hold the slide in place with a small binder clip. Obtain the voltage reading of the detector for each side.

###### Experimental Results

Refractive Index

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Slide** | **V1 (V)** | **VN/V0** | **Ln(VN/V0)** | **Tn** | **Ln(Tn)** |
| 0 | 1.304 | 1 | 0 | 1 | 0 |
| 1 | 1.237 | 0.94861963 | -0.05274737 | 0.9216 | -0.08164399 |
| 2 | 1.178 | 0.90337423 | -0.10161838 | 0.84934656 | -0.16328798 |
| 3 | 1.124 | 0.86196319 | -0.14854271 | 0.78275779 | -0.24493197 |
| 4 | 1.077 | 0.82592025 | -0.19125707 | 0.72138958 | -0.32657596 |
| 5 | 1.034 | 0.79294479 | -0.23200169 | 0.66483264 | -0.40821995 |
| 6 | 0.994 | 0.76226994 | -0.27145454 | 0.61270976 | -0.48986393 |
| 7 | 0.956 | 0.73312883 | -0.31043383 | 0.56467331 | -0.57150792 |
| 8 | 0.921 | 0.70628834 | -0.34773171 | 0.52040292 | -0.65315191 |
| 9 | 0.887 | 0.68021472 | -0.38534676 | 0.47603335 | -0.74226736 |
| 10 | 0.857 | 0.65720859 | -0.41975382 | 0.44200243 | -0.81643989 |
| Block | 1.155 | 0.904463587 | -0.100413233 | 0.9216 | -0.08164399 |

|  |  |
| --- | --- |
| B | 0.200306958 |
| n | 1.500959612 |
| %error | 0.064% |

Ni coated Slides

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Slide** | **V1 (V)** | **Vn/V0 = Ix/I0** | **Ln(Ix/I0)** | **X (nm)** | **N Al** | **N lambda** |
| 0 | 1.267 | 1 | 0 | 0 | 0 | 10471975.5 |
| I | 0.806 | 0.636148382 | -0.45232344 | 4.52323438 | 12.8968133 | 10471975.5 |
| II | 0.589 | 0.464877664 | -0.765981 | 7.65980997 | 21.8399337 | 10471975.5 |
| III | 0.307 | 0.242304657 | -1.41755943 | 14.1755943 | 40.4179793 | 10471975.5 |

###### Discussion and Conclusions

For the glass slides, the calculated n value had a percent error of 0.064% indicating that the data was relatively good, and all the calculations made were correct. The error may arise from numbers used during the calculations, perhaps rounding them too early or using too little decimal places. To refine the numbers further, we could potentially use a volt reader that has more than two decimal places as it will give a far more accurate reading and our percent error would be a little smaller. Based on the calculations we have done and the percent error we have derived, it is plausible to conclude that the refractive index of glass is indeed 1.5 and we have successfully proved that.

From the VN/V0 column for the glass slides, we can see that the thick glass slide had a transmittance of 0.9045 and the stack of ten thin glass slides had a transmittance of 0.6572. It is possible to conclude that the ten slides have a lower transmittance level as there is a constant break and form, where the light passes through, stops, and then starts again; this constant start and stop may affect the constant beam of light being passed through. And due to glass being slightly reflective, not all the light may pass through and by the time the light reaches past the tenth slide, not all of the light would have passed and thus we get a lower transmittance level. The thick slide on the other hand does not have this break and form and in this case, only has to consider the reflectiveness of glass.

Comparing one thick glass slide with one normal glass slide, we see the normal glass slide has a higher transmittance level than the thick glass slide. This could be due to the fact that the thick glass slide provides a larger medium for the light to travel through, making it take longer and reducing the amount of light that passes through. The thinner slide has less of a medium and decreases the amount of light that it loses when it passes through.

Nickel slides were slightly different compared with the glass slides as they had varying layers of thickness as opposed to how many slides were being stacked. From the data we obtained, we can see that the thicker the layer of nickel, the lower the transmittance. It is difficult to conclude that there is such a thing as a transparent nickel, as there is always going to be a minimum level of reflectiveness, refractiveness, and absorption of the nickel. We may, however, have a kind of nickel that is almost transparent but not quite there yet, a nickel that will allow as much light as physically possible to pass through.

Works Cited

MSE 110 Lab Manual for Lab7: Measurement of Optical Properties of Materials.