# REPORT SHEET

| Name: Alex Leoh |         | Role in Experiment: |                 |  |  |
|-----------------|---------|---------------------|-----------------|--|--|
| Name:           |         | Role in Experiment: |                 |  |  |
| TA:             | Continu | Due Date:           | Data Submitted: |  |  |

**Report Sheets are to be turned in by the indicated due date.** Turn in **one** set of Report Sheets per group. Students caught bringing pre-answered Report Sheets into lab will receive a zero for that lab that cannot be replaced.

# **Bandgap Analysis**

| TABLE 11.1    | ABLE 11.1  |                                     |                               |  |                                      |  |  |  |
|---------------|--|-------------------------------------|-------------------------------|--|--------------------------------------|--|--|--|
| LED Color     | Intrinsic Band<br>Gap (E <sub>gi</sub> ) (eV) <sup>a</sup> | Peak Emission<br>Wavelength<br>(nm) | Optical Band Gap $(E_g)$ (eV) | Band Gap<br>Difference<br>$(E_{gi} - E_{g})$ | Chemical<br>Composition <sup>b</sup> |  |  |  |
| Blue          | 3.099  | 470.5                               | 2.6372                        | 6.4618                                       | 6.1685                               |  |  |  |
| Green         | 3,3981   | 527.2                               | 2.3536                        | 1.6445                                       | 0.2381                               |  |  |  |
| Yellow        | 2.4155   | 593.3                               | 2.6914                        | 0.3241                                       | 6.2974                               |  |  |  |
| Orange        | 23252  | 608.7                               | 2.0385                        | 6.2867                                       | 0.2106                               |  |  |  |
| Red           | 2.2434   | 6343                                | 1.9562                        | 0.2972                                       | 6.075-8                              |  |  |  |
| Silicon Diode | 1.1934   |                                     |                               |  |                                      |  |  |  |

<sup>&</sup>lt;sup>a</sup> From slope of Eq. (1).

### Sample Calculations:

Blue green 
$$2.6372 = 3.42 - 2.65 \times - \times (1-x)2.4$$
 (blue)
$$6 = 6.7828 - 2.65 \times - \times (2.4-2.4x)$$

$$0 = 0.7828 - 2.65 \times - \times (2.4-2.4x)$$

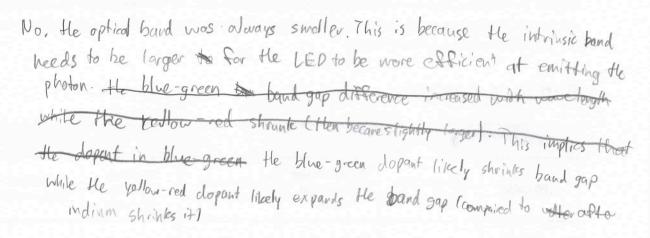
$$0 = 2.4 \times 2 - 5.05 \times + 0.7828$$

$$5.05 = 1.42.4 \times 2.41 \times 2.41$$

<sup>&</sup>lt;sup>b</sup>Use Eq. (2) for blue and green and Eq. (3) for red, orange, and yellow.

### Questions

1. Did your determined intrinsic bandgap value match your results from the optical measurement method? Comment on each specific LED result and provide an explanation for how well the two experimental results matched. Is there a consistent relationship between these values among the LEDs? Are you able to conclude anything about the intrinsic bandgap and/or the dopant bandgap energies?



**2.** Determine the ratio of aluminum to gallium content for each of the LEDs made from AlGaInP and the ratio of In to Ga in the LEDs that use GaInN. Can you draw any conclusions then about elements that increase or decrease the bandgap energy?

**3.** For a device to be a good conductor, there must be a significant electron population in the conduction band. When no energy is supplied to a semiconductor, the relative population of the conduction band follows Boltzmann's population law. In the case of a diode, the equation is:

$$\frac{\text{CB Population}}{\text{VB Population}} = e^{-E_{g}/kT}$$

Where CB and VB population are the respective electron populations in the conduction and valence bands,  $E_g$  is the intrinsic band gap in eV, k is Boltzmann's constant (8.617 × 10<sup>-5</sup> eV/K), and T is the temperature in kelvin.

**a.** Calculate the population ratio for the intrinsic silicon diode at room temperature. A general rule of thumb for a device to be considered a good conductor is that the population ratio should be around ½. Based on your calculations, is it a good conductor or semiconductor? If not, how is it made into a conductor or semiconductor?

$$= \frac{1.1934}{8.617.10^{5} \cdot 295} = 4.08 \cdot 10^{-21}$$

$$= \frac{1.1934}{1.1934}$$

$$= \frac{1.1934}{$$

**b.** Could temperature be used to make the intrinsic silicon conductive? Comment on the practicality of this method.

#### **TA Signature**

Ask your TA to review your work and sign your report. The TA will sign above once satisfied that the student has performed the entire procedure. The report will not be accepted or graded unless signed.