REPORT SHEET

Name: Alex Keoh Role in Experiment: ____________

Name: ____________ Role in Experiment: ____________

TA: ____________ Section: ____________ Due Date: ____________ Date 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

LED Color	Intrinsic Band Gap (E_{gi}) (eV)[a]	Peak Emission Wavelength (nm)	Optical Band Gap (E_g) (eV)	Band Gap Difference ($E_{gi} - E_g$)	Chemical Composition[b]
Blue	3.099	470.5	2.6372	0.4618	0.1685
Green	3.3981	527.2	2.3536	1.0445	0.2381
Yellow	2.4155	593.3	2.0914	0.3241	0.2974
Orange	2.3252	608.7	2.0385	0.2867	0.2106
Red	2.2434	634.3	1.9562	0.2872	0.0758
Silicon Diode	1.1934				

[a] From slope of Eq. (1).

[b] Use Eq. (2) for blue and green and Eq. (3) for red, orange, and yellow.

Sample Calculations:

$E = \frac{hc}{\lambda}$ $1\,eV = 1.602 \cdot 10^{-19}\,J$

Blue $\frac{(6.626 \cdot 10^{-34})(3.0 \cdot 10^{8})}{(470.5)(1 \cdot 10^{-9})} = \frac{4.22 \cdot 10^{-19}\,J}{} \cdot \frac{1\,eV}{1.602 \cdot 10^{-19}\,J} = 2.637\,eV$

Blue-green $2.6372 = 3.42 - 2.65x - x(1-x)2.4$ (blue)

$0 = 6.7828 - 2.65x - x(2.4 - 2.4x)$

$0 = 0.7828 - 2.65x - 2.4x + 2.4x^2$

$0 = 2.4x^2 - 5.05x + 0.7828$

$\frac{5.05 \pm \sqrt{(-5.05)^2 - 4(2.4)(0.7828)}}{2(2.4)} = 1.9356,\ 0.1685$

Yellow - red

(Yellow)

$2.0914 = 0.61x + 1.91$

$0.61x = 0.1814$

$x = 0.2974$

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?

No, the optical band was always smaller. This is because the intrinsic band needs to be larger ~~to~~ for the LED to be more efficient at emitting the photon. ~~the blue-green band gap difference increased with wavelength while the yellow-red shrunk (then became slightly larger). This implies that the dopant in blue-green~~ the blue-green dopant likely shrinks band gap while the yellow-red dopant likely expands the band gap (compaired to ~~other~~ after indium shrinks it)

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?

$In_xGa_{1-x}N$

B 0.17 $In_{0.17}Ga_{0.83}N$

G 0.24 $In_{0.24}Ga_{0.76}N$

] In ~~increase~~ decreases band gap

$(Al_xGa_{1-x})_{0.5}In_{0.5}P$

Y 0.30 $(Al_{0.3}Ga_{0.7})_{0.5}In_{0.5}P$

O 0.21 $(Al_{0.21}Ga_{0.79})_{0.5}In_{0.5}P$

R 0.08 $(Al_{0.08}Ga_{0.92})_{0.5}In_{0.5}P$

] Al increases band gap

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:

$$\frac{\textbf{CB Population}}{\textbf{VB Population}} = e^{-E_g/kT}$$

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^{-5} 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 ⅓. Based on your calculations, is it a good conductor or semiconductor? If not, how is it made into a conductor or semiconductor?

$e^{-1.1934/((8.617\cdot10^{-5}\cdot295)} = 4.08\cdot10^{-21}$

No

$\frac{1}{3} = e^{-1.1934/kx}$

$\frac{-1.1934}{\ln(\frac{1}{3})\cdot8.617\cdot10^{-5}} = x = 12666\text{ K}$ by heating it over 12000°C

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

Yes, but it is impractical as it could risk many other components of the device failing or breaking down faster from heat

also it would require temperature to increase by multiple orders of magnitude

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.