LED STATISTICAL MECHANICS

EXPERIMENT

- Measure I versus V (the diode curve) for each of the six super radiant LEDs.
- Record the emission spectrum of each LED. Use the multichannel optical analyzer (instructions below).
- For one LED, choose several currents and record the emission spectrum corresponding with each.

MULTICHANNEL OPTICAL ANALYZER

Finding the software

- If the computer is off, turn it on.
- Type CD LAMDA (or cd lamda).
- Type LS2000 (or ls2000).

Setting the baseline

- Reduce the ambient light entering the monochromator as much as possible.
- Make sure BASE is OFF.
- Use a 3" x 5" card to block off the light source (Hg or Na lamp, laser, or LED) so that ambient light is the only illumination entering the monochromator.
- CLEAR graph if necessary.
- Set the exposure time as desired.
- RUN.
- MARK AS Baseline.
- Turn BASE ON.
- The baseline must be reset whenever changing ambient light, exposure time, or central wavelength.

Calibrating the instrument

- If the x axis is WAVELENGTH, click to change WAVELENGTH to CHANNEL.
- Select the (approximate) central wavelength of the monochromator output by turning the crank on the monochromator.
- Illuminate with a laser or Hg, Na, He, or H lamp. The He and H tubes should not stay on for more than 30 s at a time.
- Major emission peaks (many additional peaks may be detected):
    - HeNe laser: 632.8 nm
    - Hg: 404.7 nm, 435.8 nm, 546.1 nm, 577.0 nm, 579.1 nm
    - Na: 589.0 nm, 589.6 nm
    - H: 410.2 nm, 434.1 nm, 486.1 nm, 656.3 nm (Balmer series)
    - He: 447.1 nm, 471.3 nm, 492.2 nm, 501.6 nm, 587.6 nm, 667.8 nm

- Pick two peaks at least 20 nm apart. Click on CHANNEL, choose WAVELENGTH, and enter the wavelengths and channels of the two peaks. Record the two pairs of channels and wavelengths; you will only be able to export raw data (counts vs. channel number). You will need to convert channel number to wavelength after exporting your data.
- Determine the range of channels that gives reliable, undistorted spectral information. Do this by studying a specified calibrating line at different channels by changing the mechanical wavelength setting of the monochromator.

Saving your data

- Under the file menu, SAVE your data as an *.ALL file to be able to reLOAD the wavelength calibration along with the data.
- To EXPORT data for use in graphing software such as Excel, Klaidagraph, Origin, or Sigmaplot, use the EXPORT command under the file menu. Your file will appear as a *.PRN file. This file will have a column of channel numbers and a tab-delimited column of counts. You will need to convert channel numbers to wavelength.

REPORT CONTENTS

- Read "Observing the Maxwell-Boltzmann distribution in LED emission spectra" and attempt to reproduce the results (Fig. 2, junction temperatures, and bandgap energies). It may be helpful to read one or more of the references therein.
- Specific points to consider include the following:
    - What determines the color of an LED? Why is its emission spectrum so much broader than a laser's?
    - It's not very instructive to merely copy the derivations of Eqs. (8) and (10). Instead, demonstrate that you understand the derivations. Fill in any missing steps, and clarify anything that's unclear.
    - The fits in Fig. 2 look great, but what happens when you graph your data on a log scale, as suggested by Eq. (9)?
- Since you apply a voltage V across the LED, each electron traveling through the power supply gains energy qV. Assuming that all this energy is converted into light energy, $qV = h\nu$, so you can determine Planck's constant by graphing ν as a function of V. Which ν should you use in the spectrum: the highest, the lowest, or the average? How does LED color depend on the V at which it turns on?
- The detector only absorbed a fraction of the photons emitted by the LED, so we can't determine the LED's total output power. However, we can calculate the total energy of all the photons in the detected spectrum. Compute this total energy for the LED whose spectrum you measured at several currents. How does this energy depend on current?

ADDITIONAL REFERENCE

C. Honsberg and S. Bowden, PVCDROM