ELEC 413 Semiconductor Lasers

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Laser Characterization Lab

Caution: Laser light is dangerous. Do not look directly at the beam of light.

1 Laboratory Procedure

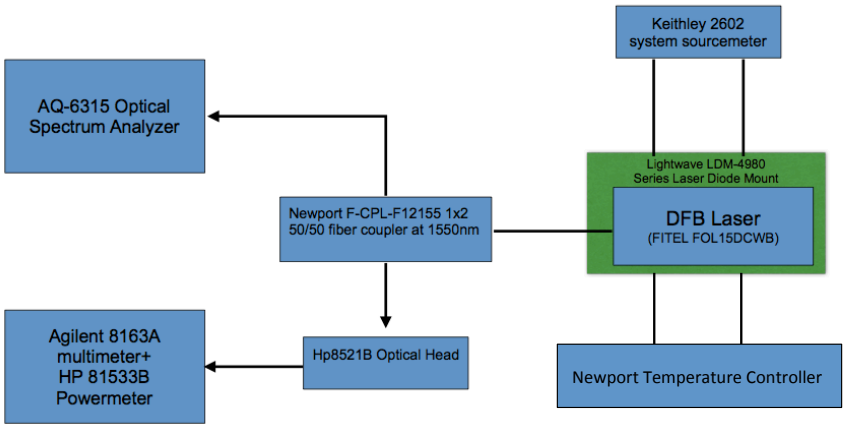

Figure 1: Diagram of the experimental apparatus

1.1 Turning on the Laser

1. Connect the setup as shown in Fig. 1.
2. Turn on the power of Keithley source meter [2602 SYSTEM Sourcemeter], shown in Figure 2.
3. Use channel A for the biasing of the DFB laser.
4. Set current limit and voltage limit for channel A using the LIMIT button in channel A.
5. Press MEAS to switch between different display modes.
6. Press SRC in Channel A to select "current" as the source.
7. Use the scroll button for editing and change position: Press for edit and scroll for changing position.
8. Set the initial current 1 mA for the current source in Channel A.
9. Turn on the current source of Channel A by pressing ON/OFF.
10. Check the lasers output power on the detector, shown in Figure 3. Record the value. Check the Voltage on the laser displayed on the Keithley. Record the value.

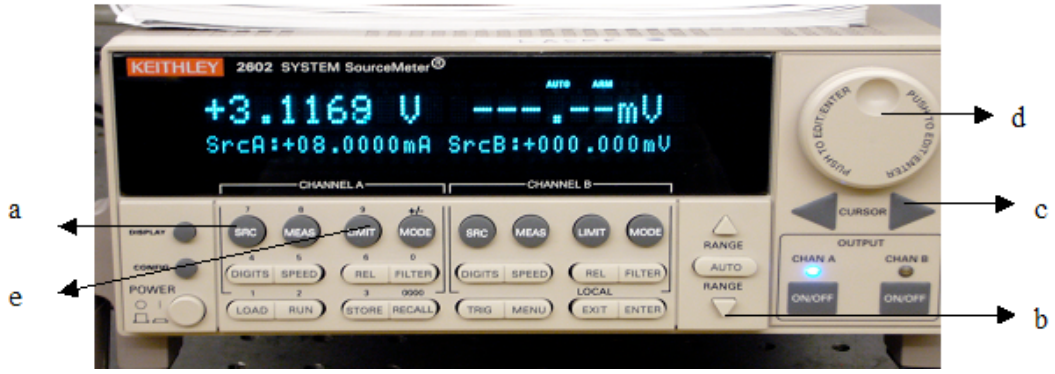

Figure 2: Keithley Source Meter

11. Increase the input current value by 1mA per step and observe the differences from the power meter and optical spectrum analyzer.
12. Turn off the Channel A of the Keithley.
13. Hold the optical fiber to point directly at the Infrared card.
14. Turn on Channel A of the Keithley. Observe the laser light on the card.

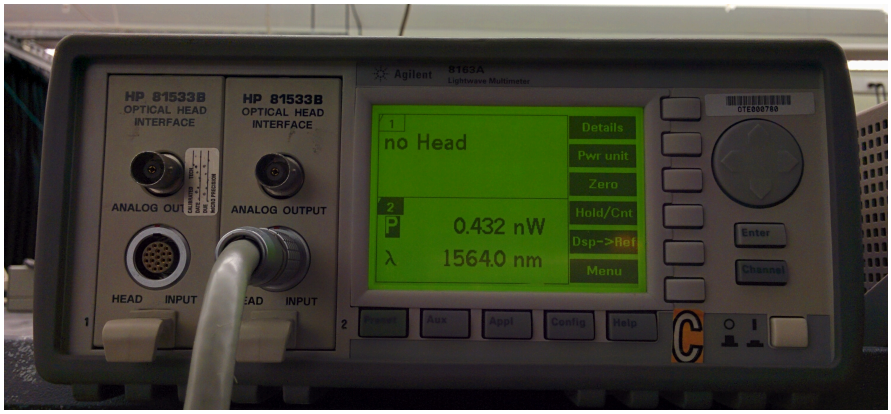

Figure 3: HP optical power meter

1.2 Measuring the Light-Output versus Current

1. Run the Matlab program (LIVdownloader.m).
2. You will get 2 curves: one is L vs I,the other is V vs I.
3. Estimate the threshold current.
4. The data will be saved, using the dlmwrite command, in a matrix with the following columns: Current, Voltage, Optical power.

1.3 Measuring the Optical Spectrum

In this experiment, we will investigate the behaviour of the laser's optical spectrum for varied bias conditions, and temperature.

1. Connect the laser output to the optical spectrum analyzer (OSA).

Figure 4: Optical spectrum analyzer

2. Measure the optical spectrum of the laser for the following bias conditions:
   (a) below threshold (3-5 different values)
   (b) near threshold (3-5 different values)
   (c) above threshold (5 different values)
   (d) above threshold (fixed current), but changing the temperature (3-5 different values) by the temperature controller.
3. To configure the OSA, adjust the necessary parameters (centre wavelenth approximately 1564 nm; span: a) 100-150 nm, b) 1-2 nm (record two spectra for each case, one zoomed in, one zoomed out); resolution bandwidth 1 nm for zoomed out, 0.1 nm for zoomed in; reference level, etc.).
4. Save the spectra to the computer, using OSAdownloader.m

2 Laboratory Report

2.1 Laser

1. Why is an infra-red card needed to observe the laser light?

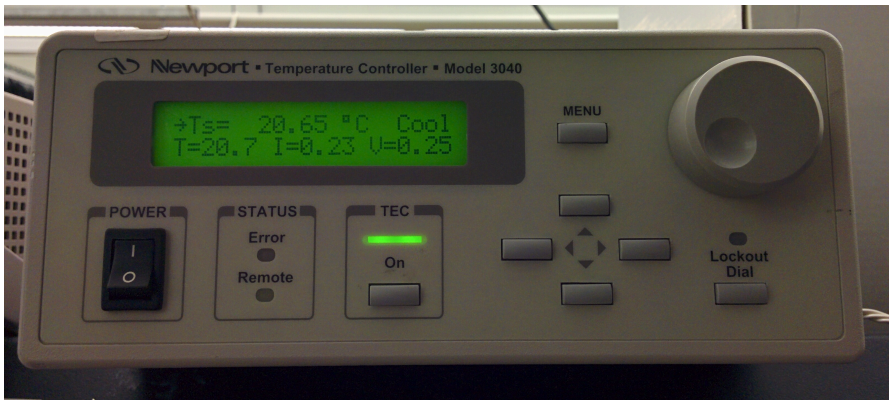

Figure 5: Temperature controller

2.2 Light-Output versus Current

1. Plot the Light output vs. Current (L vs. I).
2. What is the threshold current?
3. Plot the derivative of the L vs. I curve (i.e. dL/dI) What is the maximum slope efficiency of this laser?
4. Plot the 2nd derivative of the L vs. I curve (i.e. d^2L/dI^2). How is the threshold determined from this plot?
5. Plot the Voltage vs. Current (V vs. I)
6. Plot the derivative of the V vs. I curve (i.e. dV/dI). What is the differential resistance of the device, a) at threshold, b) at 2X threshold current?
7. Plot the $I\frac{dV}{dI}$. How is this plot used to identify the threshold?
8. What is the power consumed by the device, at the 2X threshold? What is the wall-plug efficiency of this laser? (i.e. light output power divided by power consumed, in %).
9. The LI curve you obtain likely deviates from a perfect LI curve (i.e. no light below threshold, and a straight line above threshold). Provide possible explanations for the deviations observed.

2.3 Optical Spectrum

1. Plot the optical spectra on the same graph.
2. What is the effect of the bias current on the emission spectrum, below threshold?
3. Estimate the 3dB bandwidth of the gain for each condition.
4. Does the amplitude of the gain spectrum vary with bias current? Is it different above vs. below threshold, and why?
5. What is the effect of the bias current on the lasing wavelength? Why? What is the tuning coefficient (in nm/mA)?