2008 PhD Quals Questions
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1. (I have a LED demo with Red, Green & Blue LEDs which I show to the student) Can you first draw a band diagram for light emitting diode (LED) and describe how it works?

2. What is different about the 3 LEDs I showed you, what is important? Does the semiconductor have to be a direct bandgap semiconductor?

3. I then show a white LED and ask, how can I get white light from a LED?

4. Can you draw the I vs V characteristic for the 3 diodes and label R, G, B? How would the LEDs differ and what insight can you gain about the material from the I-V characteristic?

5. Can you draw the emission spectrum for one of the diodes and compare it to that of an incandescent light bulb and explain the key features of the LED?

6. If you now compare the emission spectrum with the I-V characteristic, it seems that I'm getting a "free lunch" since I am able to get 2.5eV photons out with about 2V of applied bias. How is this possible? What is missing in this picture?

7. If we thermally isolate the diode, but have a window in which the photons can escape, what will happen to the LED and how does this effect the I-V and emission characteristics of the LED as a function of time (temperature)?

8. (I now show the student a Red semiconductor laser pointer) The semiconductor parts of this laser and the red LED are quite similar, but not identical. How does this semiconductor laser differ from the LED and in particular, why is the light emission so strongly directional in the laser compared to the LED?

9. On your graph of the LED spectral output, draw a similar curve for the laser? What are the notable differences?

10. If I were to put both the laser and LED in my thermally isolated environment so the temperature decreases, would you expect the optical output of the LED and laser to behave differently as a function of temperature? Explain.