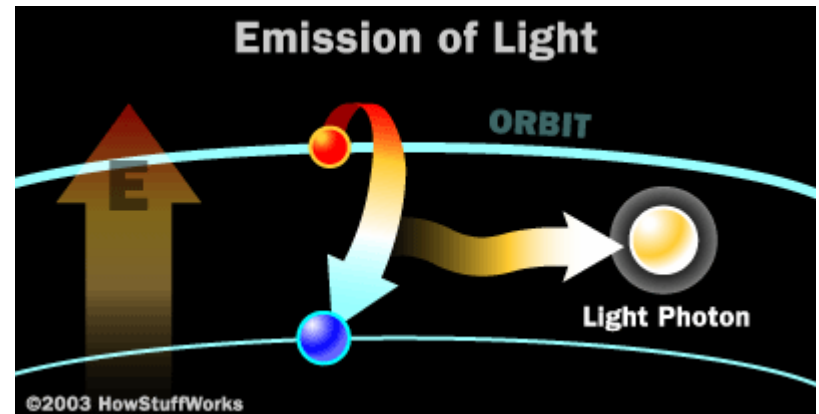
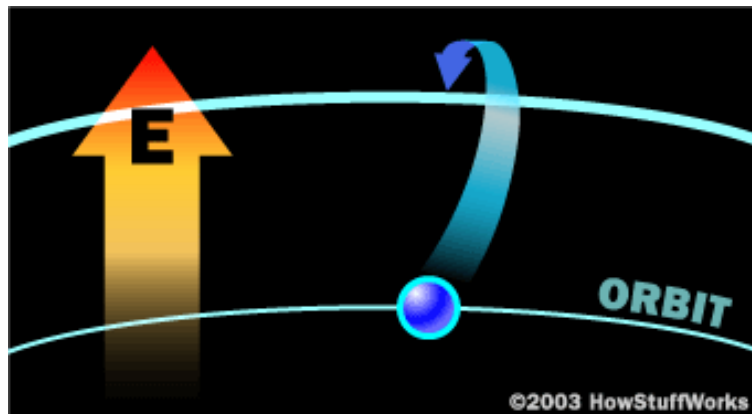


Anti-Reflective Coating of a Diode Laser System

Matt Lockwood
UC Physics Dept
Chad Orzel

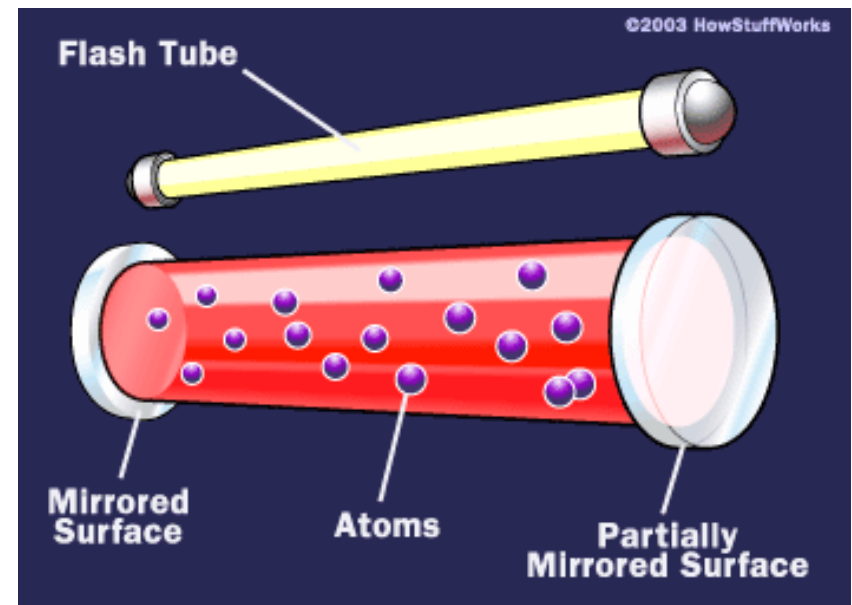
Laser Theory

- The fundamental process involved in laser emission is the absorption and emission of energy by electrons
- When electrons emit absorbed energy, a photon is released with a specific wavelength that corresponds to the amount of energy emitted



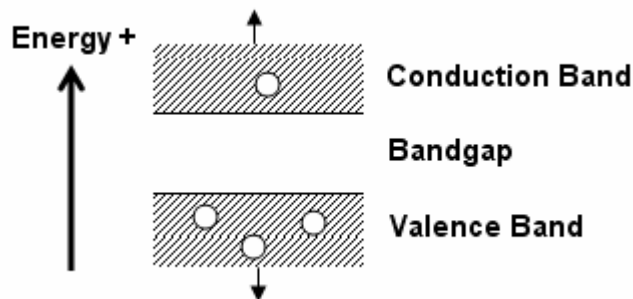
Laser Construction

- All lasers have three basic components – the pumping medium, pumping mechanism, and mirrors.
- For LD's, the pumping mechanism is electric current, medium is a computer chip, mirrors are the surface of the chip

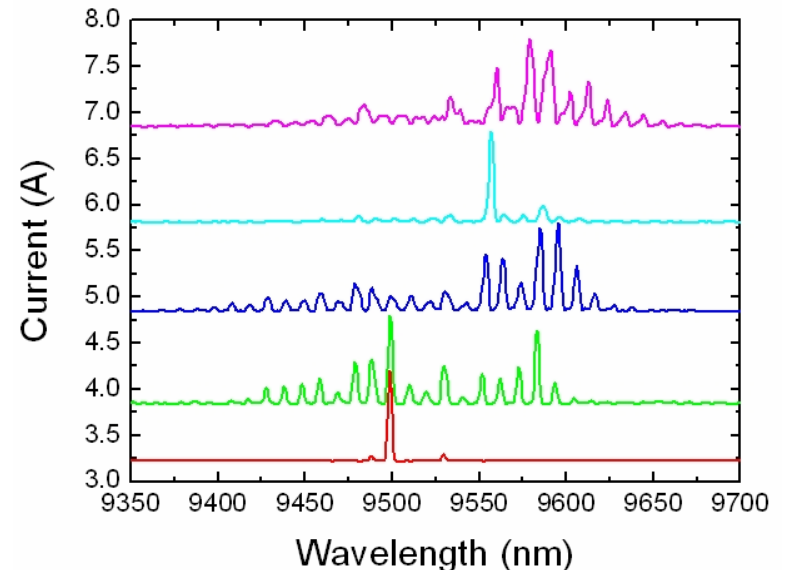


The Problem

- Laser diodes have energy bands, rather than defined energy levels



- This allows a LD to fluoresce at multiple wavelengths (multimode)
- For use in our lab, we need a very specific single wavelength (singlemode)



The Solution – Injection Locking

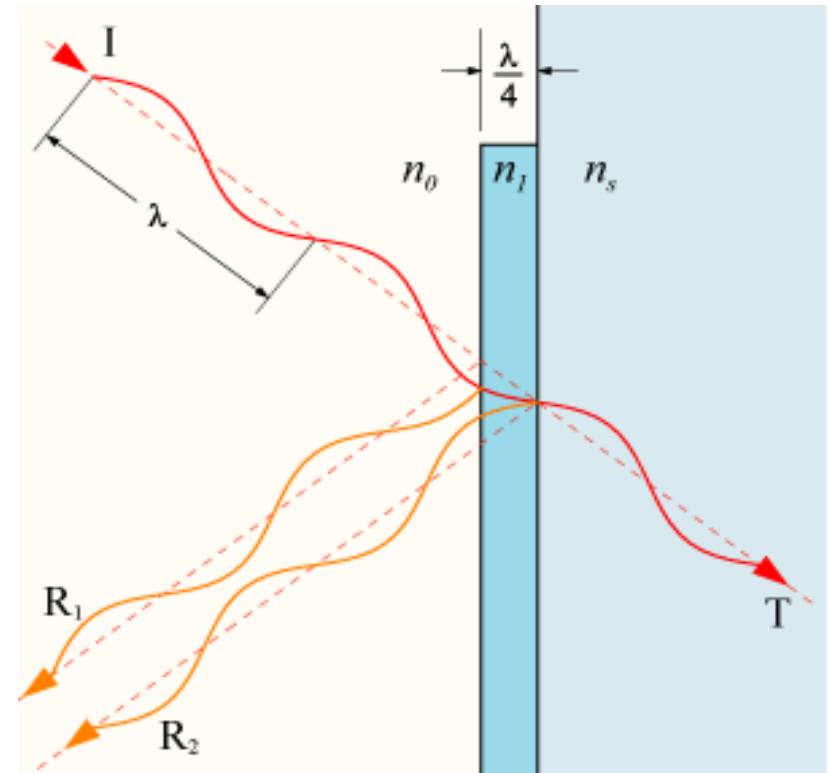
- Injection locking seeds a particular desired wavelength of light inside of a laser's pumping medium
- Seeds the laser with light from a low-power, single-mode laser
- Effectiveness of injecting locking limited by reflectivity of the LD surface
- Locks a laser into emitting at a specific wavelength, even if the laser normally runs in multimode

Anti-Reflective Coating

- An AR coating can be applied to reduce the reflectivity of a laser diode's surface (mirror) – this makes the injection lock more effective
- Capable of reducing a surface's reflection coefficient to less than 0.1%
- Used commonly in laser optics and with eyeglasses

How AR Coatings Work

- AR coatings exploit the interference effect of thin films
- By applying a coat exactly $\lambda/4$ thickness of film, one can ensure that a certain wavelength is transmitted
- The reflected waves from the back surface is half a wavelength out of phase with the wave reflected from the front – they interfere destructively
- Because all reflected waves are destructively interfered, all light passes through the film



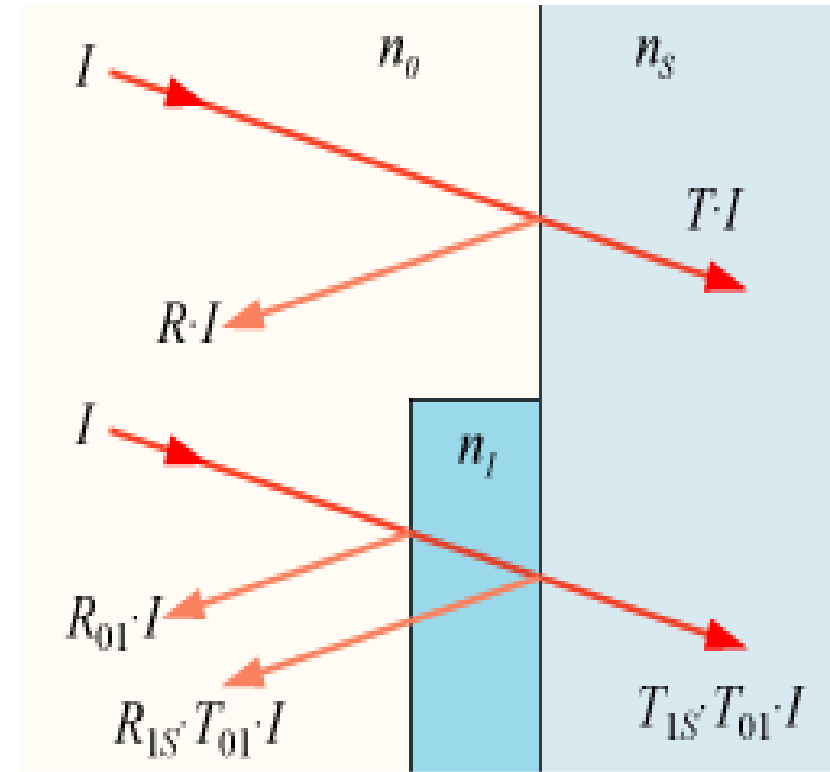
AR Coating, cont'd.

- Can also reduce reflection of incoming light off surface of LD
- Reflection coefficient:

$$R = \left(\frac{n_0 - n_S}{n_0 + n_S} \right)^2$$

- Optimal index of refraction:

$$n_1 = \sqrt{n_0 n_S}$$

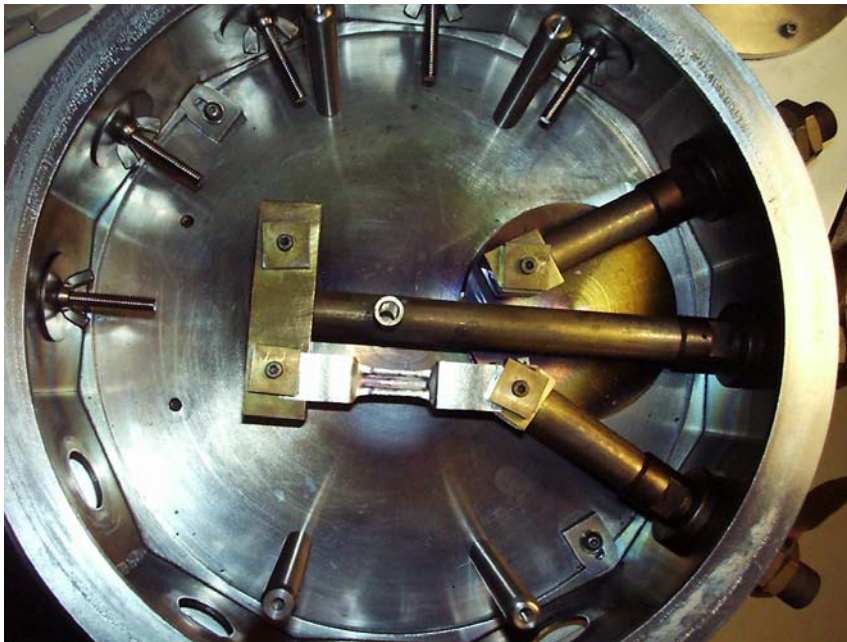


Applying an AR Coating

- In order to provide an accurate, even coating across the surface of the LD, it is necessary to evaporate the material onto the LD.
- Employ the use of a vacuum evaporator (pictured)



How a Vacuum Evaporator Works



- Current across the Molybdenum tray heats the AR material, which is evaporated to coat the surface of our LD (which is held above the tray)
- Vacuum $\sim 5 \times 10^{-6}$ Torr
- Use ~ 120 A current to heat the tray

AR Coating Deposition

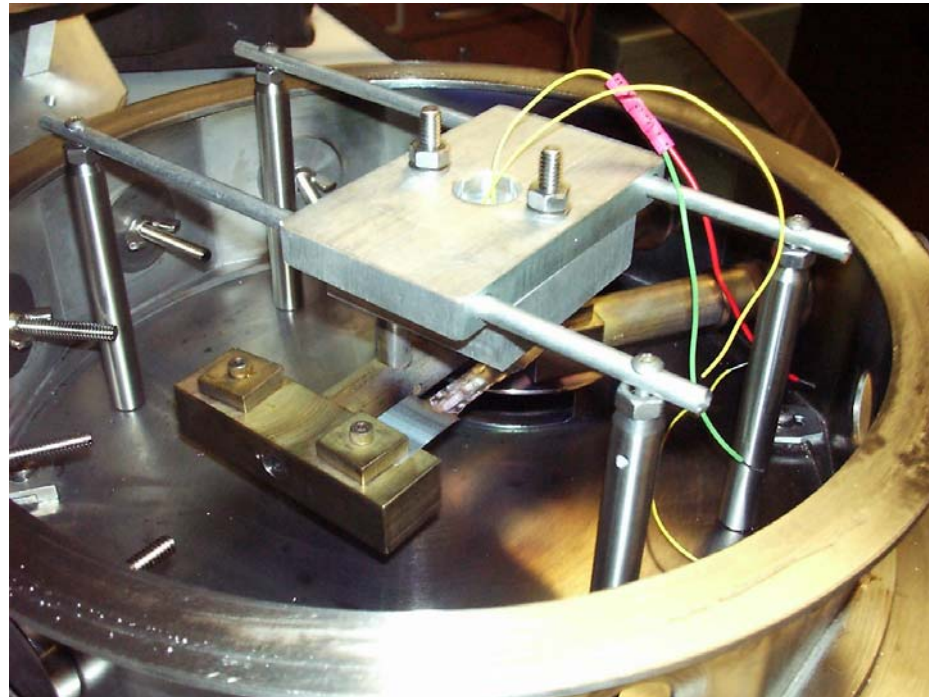
- Laser diodes have two primary components – laser diode and photodiode
- Use PD to measure the output of the LD
- Place LD near threshold, use current sweeps to find threshold current
- The threshold increases as the AR coating is applied
- When the threshold reaches a maxima, the coating has reduced the reflectivity of the LD surface as much as is possible

What Needs to be Done

- A method of mounting a laser diode above the Molybdenum tray
- Diodes are temperature sensitive – need temperature control
- Need power necessary to drive laser diode/temperature controllers

Progress Thus Far...

- First, had to design & produce a mount for the LD and its thermal coolers



Progress Continued

- Next, had to design feedthrough flanges for the vacuum chamber – required to be capable of passing an electric current through the vacuum chamber walls.



Coming Up...

- Begin applying AR coating to 'test' laser diodes
- Begin the end-goal of our project – applying AR coating to LD's for in-lab use

Thanks

- Chad Orzel
- John Sheehan
- Union College Physics Department