

Semiconductor Laser Diodes

Presented by:

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Introduction

The background of the slide is dark blue with several concentric, light blue circles of varying sizes. A white horizontal arrow with arrowheads at both ends is positioned across the middle of the slide, passing behind the title.

- Why are we here today?
 - Overview of semiconductor laser diodes
 - Answer key questions
 - Learn
- Why do we care?
 - Take away knowledge to our future employers
 - To serve our scientific interests
 - To give me a good grade!

Questions to be Answered

- What is a semiconductor laser diode?
- What does it look like?
- How do they work?
- What are they made of?
- What are their properties?
- What are their uses?
- How much do they cost?
- Where can you get them?

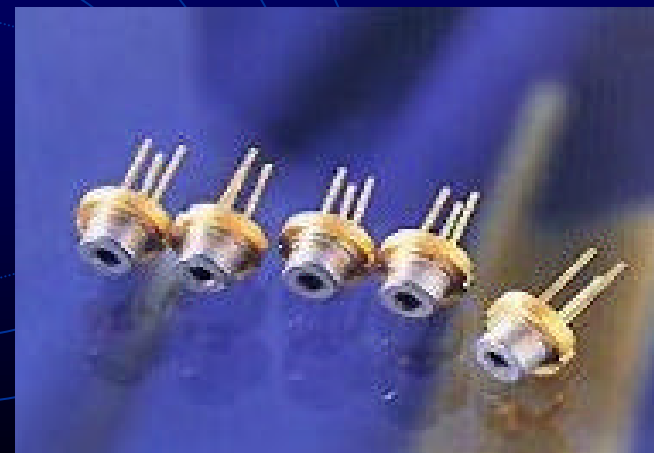


What is a semiconductor laser diode?

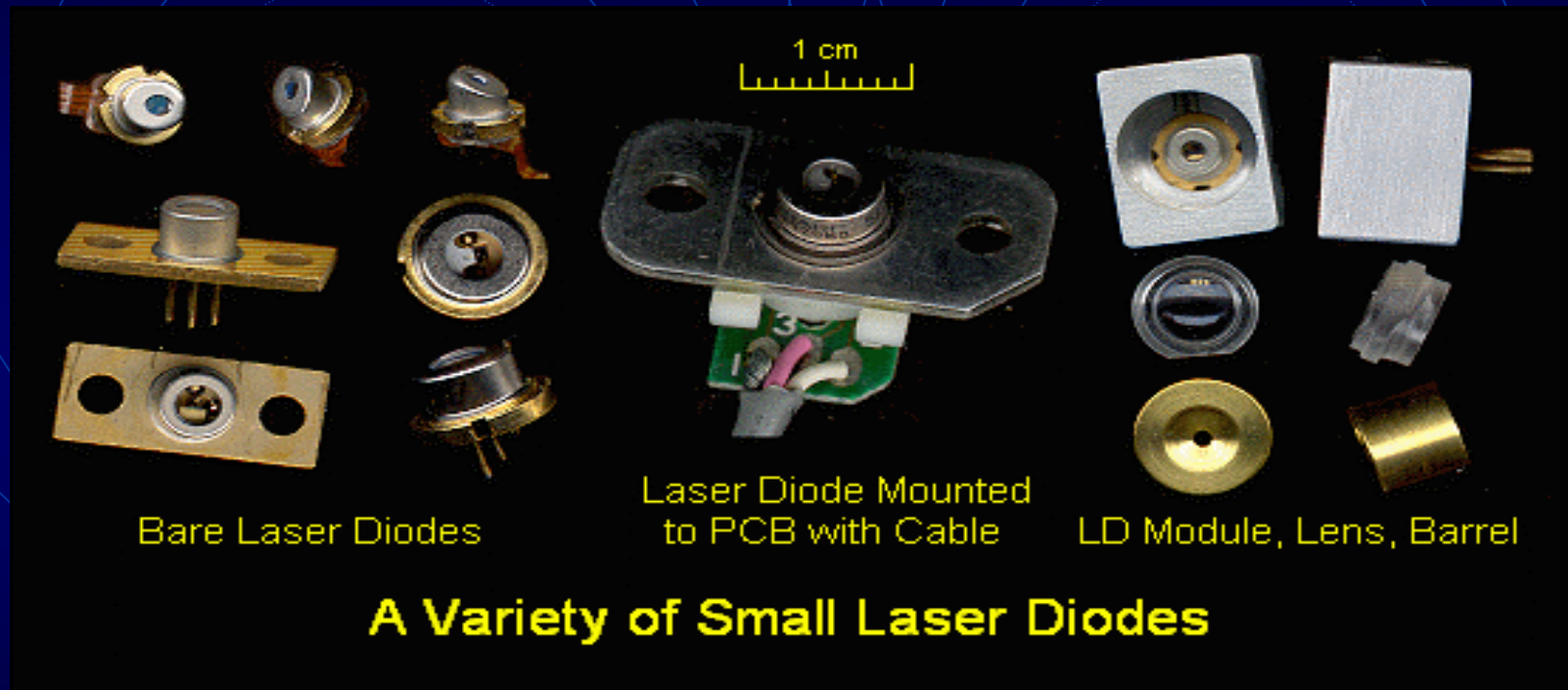
- A *semiconductor laser diode* is a device capable of producing a lasing action by applying a potential difference across a modified pn-junction. This modified pn-junction is heavily doped and contained within a cavity thus providing the gain medium for the laser. A feedback circuit is also implemented in order to control the amount of current sent to the laser diode.

What do they look like?

- Semiconductor laser diodes come in many shapes and sizes.
- They may be round, square, or rectangular, and have a few to many leads.
- There are many reasons for the different shapes including function, power output, specifications, etc.



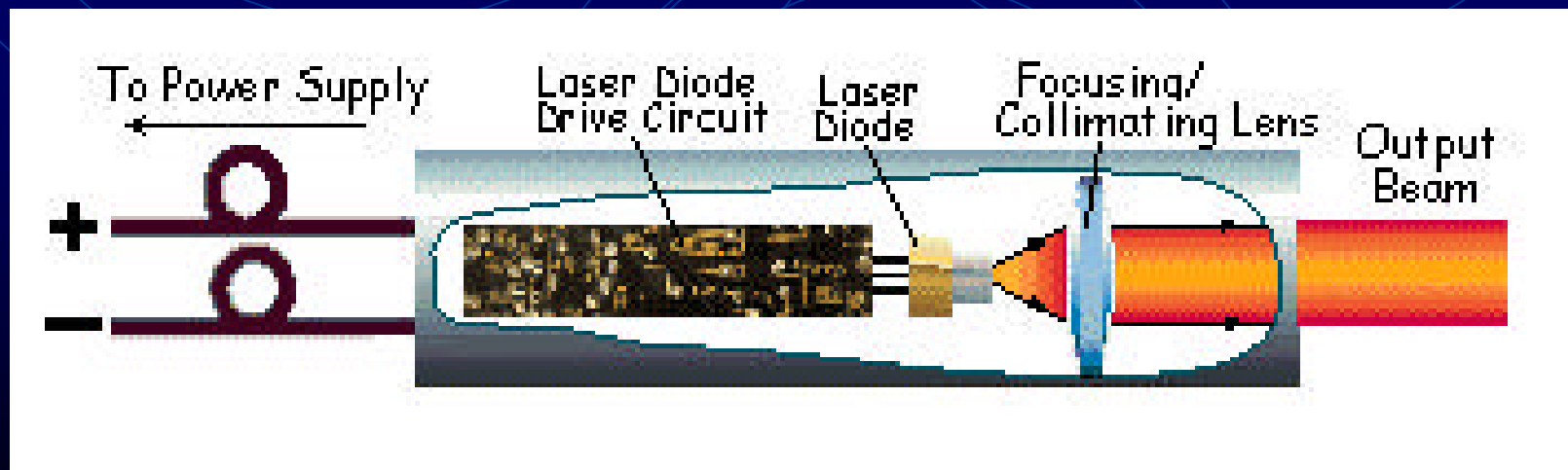
What do they look like?



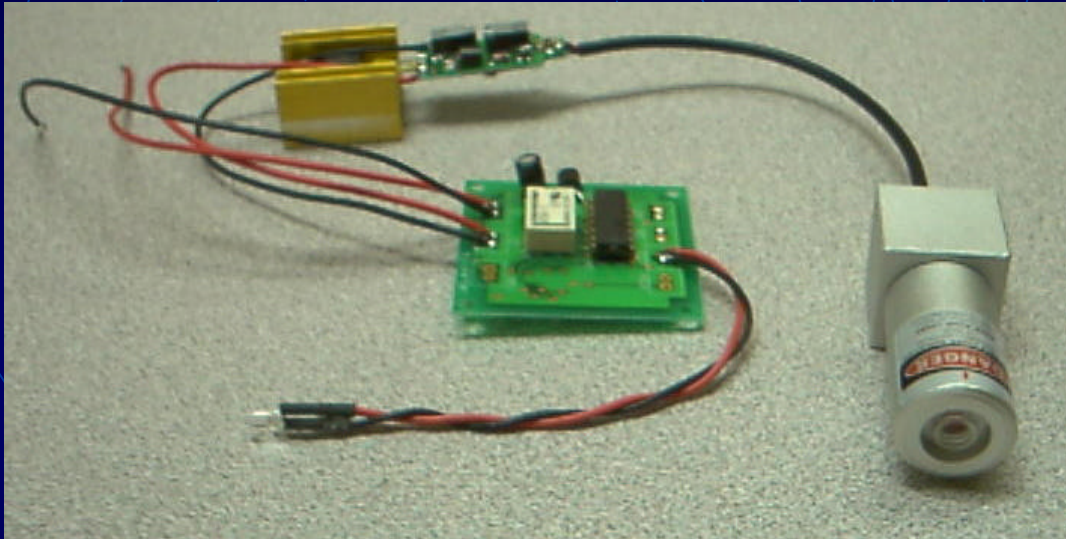
- The above photo shows a variety of low-power semiconductor laser diodes set in several different types of casings.

What do they look like?

- When in use, the S.L.D. is normally mounted in a laser diode module. The S.L.D. is driven and its current controlled by the drive circuit. A lens provides the desired beam shape.

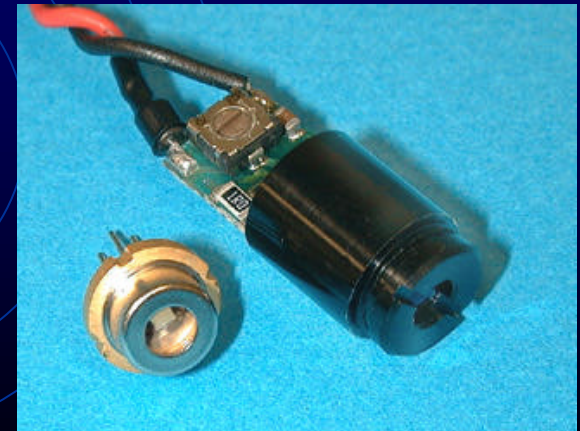


What do they look like?

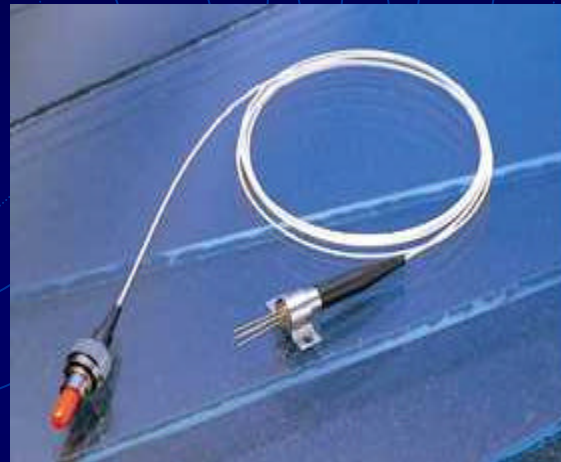
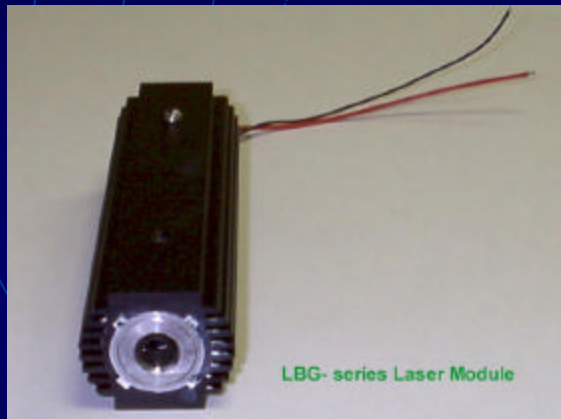


- The above photo shows a green semiconductor laser diode set in a module and with driver circuitry attached.

- The photo below shows a typical module-mounted S.L.D. with driver circuitry.



What do they look like?



- The left photo shows a high-power semiconductor laser diode set in a module. The middle shows a pigtailed S.L.D. module package for optical communication. The right photo shows a receptacle S.L.D. module package also for optical communication.

What do they look like?



- These S.L.D.s are examples of high-power “bar array diodes”.
- Clockwise from bottom left:

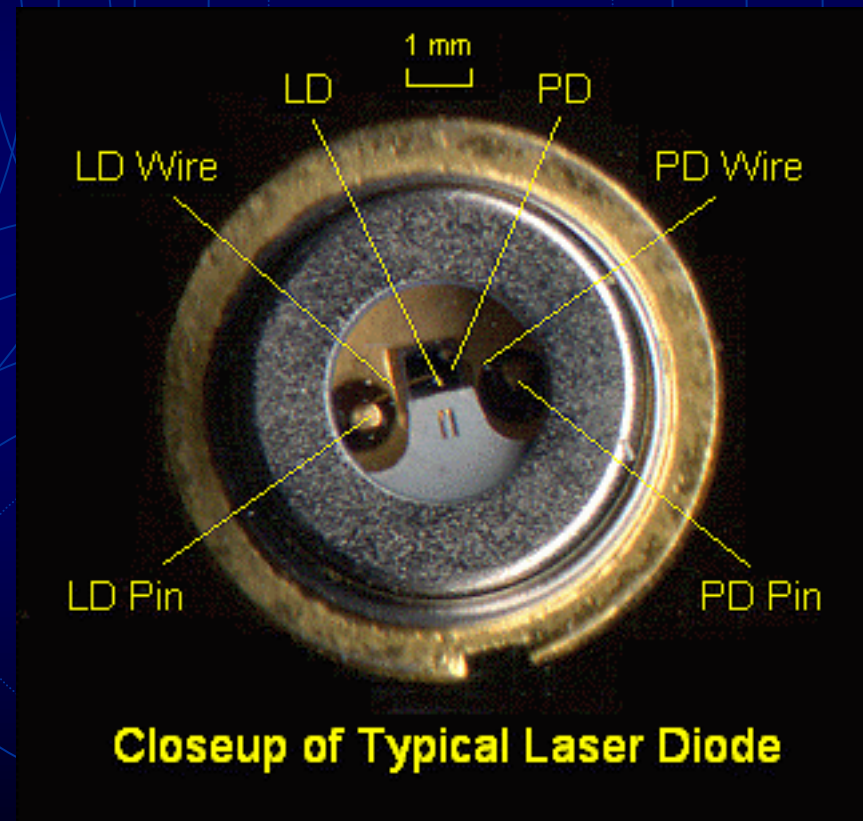


- 5 element CW array, 150W, actively cooled
- 60W QCW array, conductively cooled
- 30W CW array, conductively cooled
- 2500W QCW stacked array, actively cooled



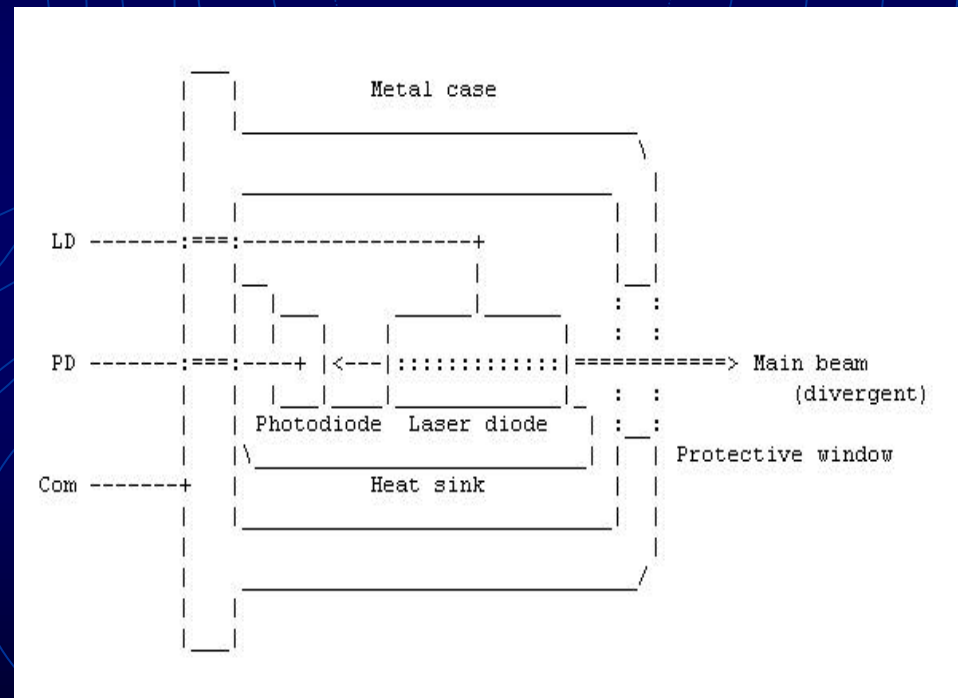
What do they look like?

- This diagram shows a close up view of a typical semiconductor laser diode.
- It can be seen that the S.L.D. consists of a laser diode, a photo diode, and connecting leads and pins.
- All of this is housed in a protective metal casing. A clear screen allows the beam to be emitted.



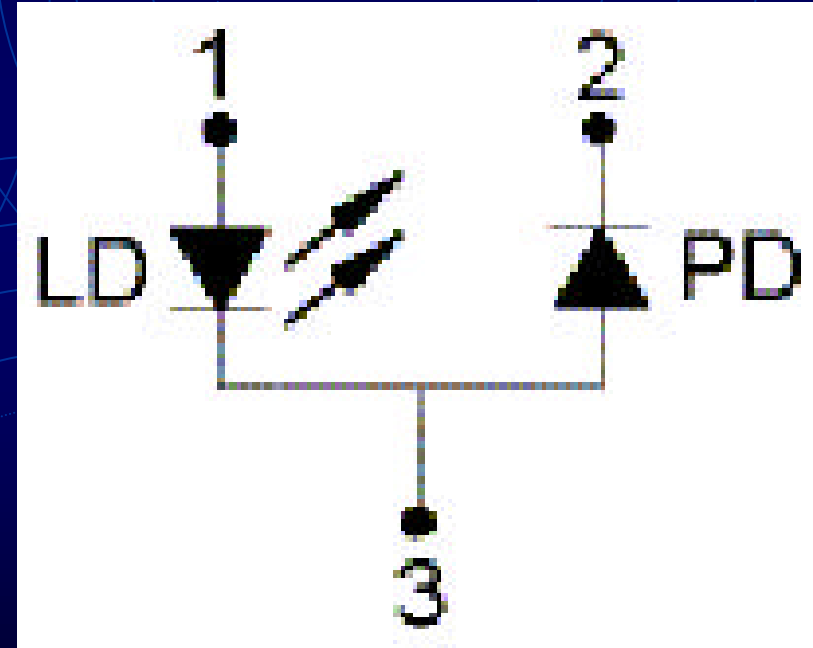
How do they work?

- This diagram shows the inside construction of the semiconductor laser diode.
- It can be seen that the laser diode emits in two directions, sending one as the output, and the other as a feedback to the photo diode.



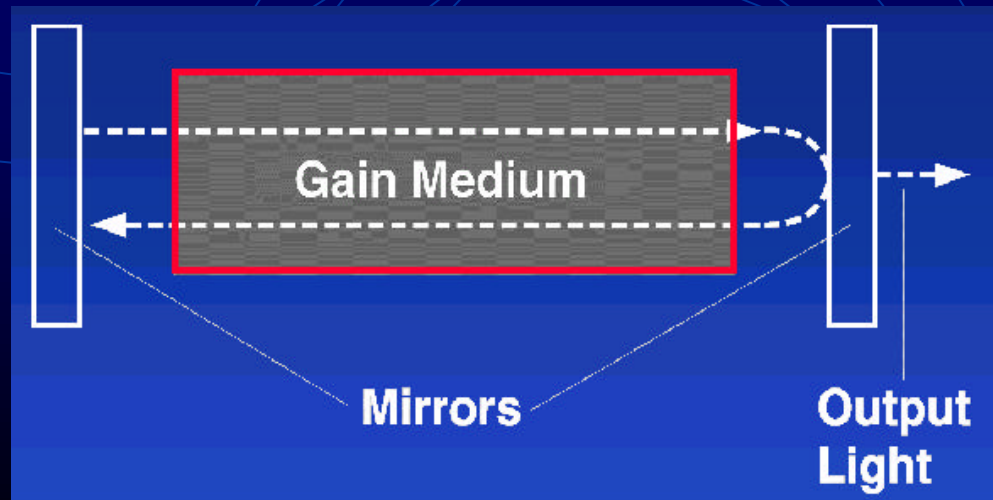
How do they work?

- This diagram shows how the LD and the PD are connected.
- The photo diode optically senses the amount of light sent from the laser diode, this is called feedback.
- This feedback is sent to a drive circuit which regulates the amount of current that the laser diode sees.
- The laser diode is very sensitive, and needs to be operated at 80% of its absolute maximum ratings.



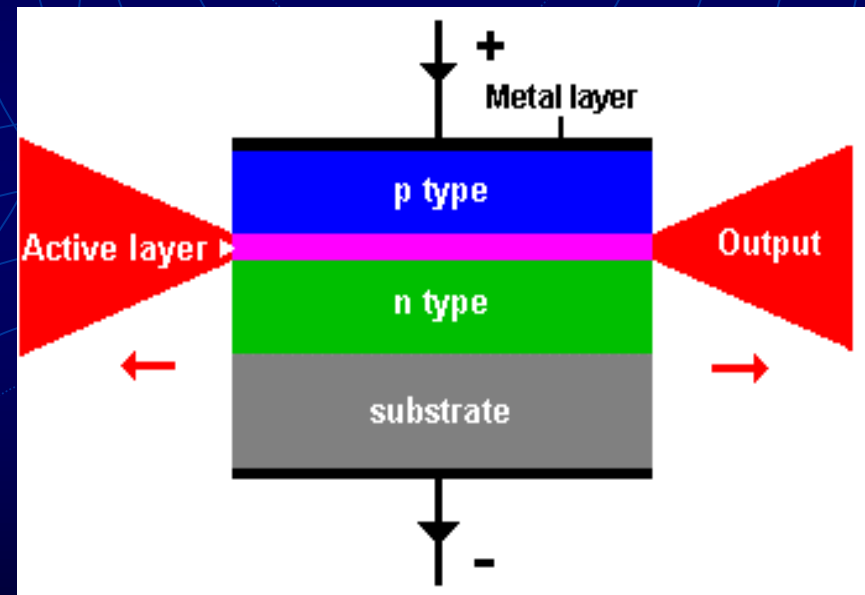
How do they work?

- A typical laser consists of three things:
 - a Pump, a Gain Medium, and a Cavity.
- The diagram below shows the gain medium and the cavity for a generic laser. The pump would send energy into the gain medium and this would excite the electrons and holes within it. This process then gets amplified within the cavity and lasing takes place.

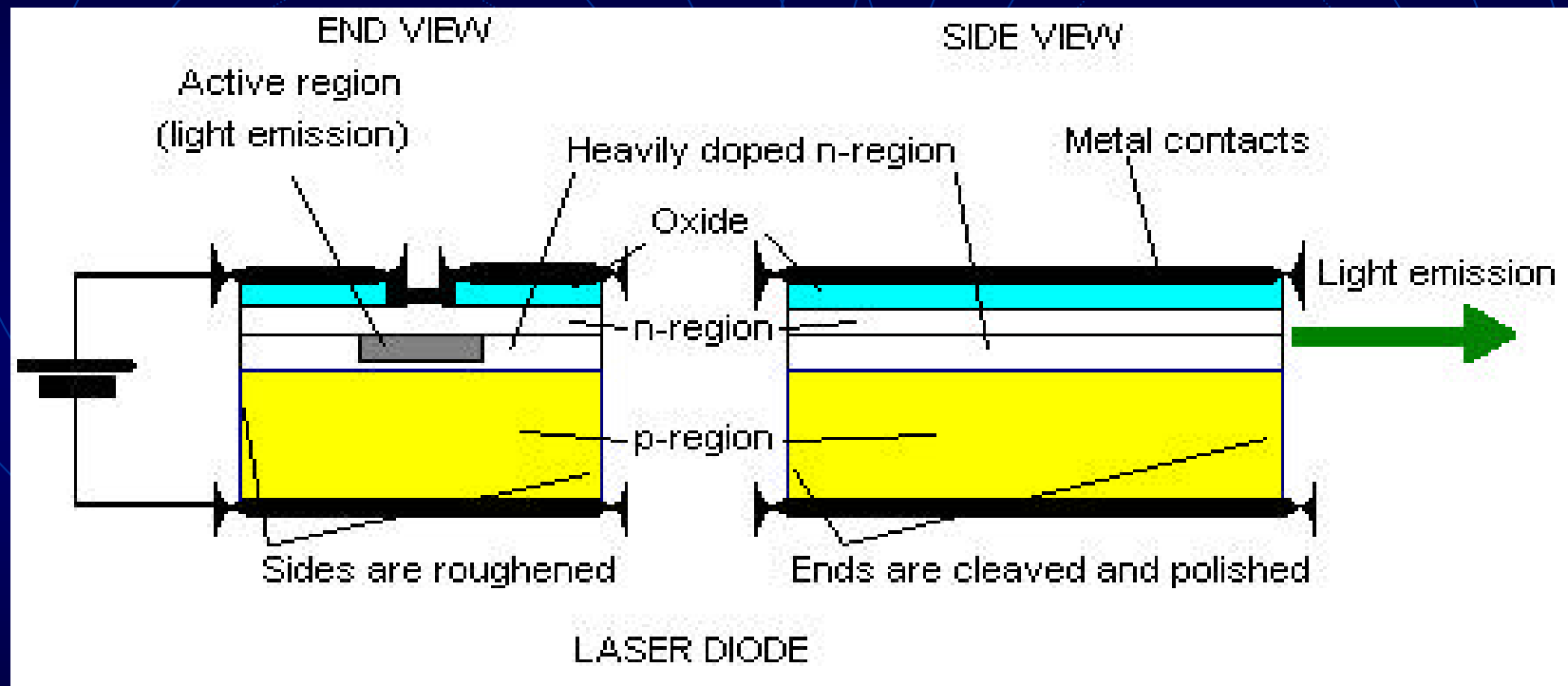


How do they work?

- This diagram shows a cross section of the inside of the laser diode.
- The L.D. consists mainly of a pn-junction separated by a thin active layer.
- The sides of the L.D. form the mirrors of the cavity and the beam is sent in the two opposite directions.
- A potential difference creates the pumping action and starts the lasing process.



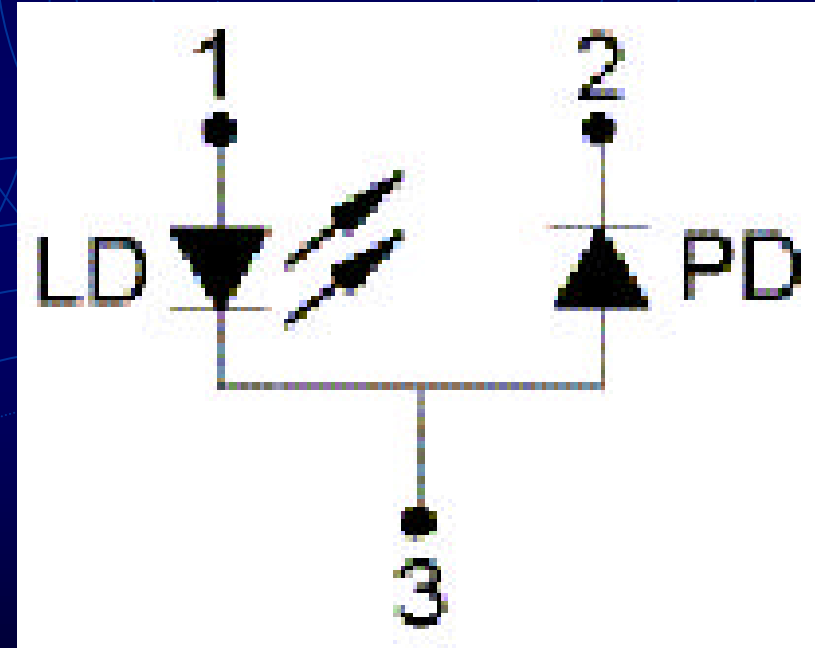
How do they work?



- Here is another look at how the laser diode creates the lasing action. This diagram clearly shows how the cavity is formed by cleaving and polishing the ends and roughening the sides.

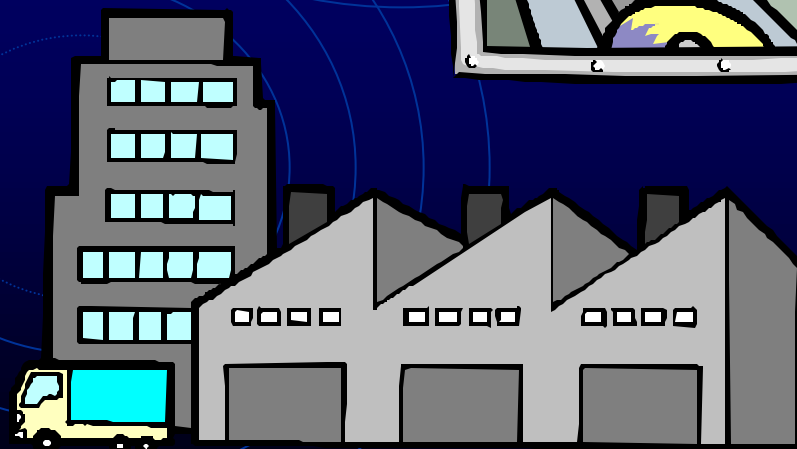
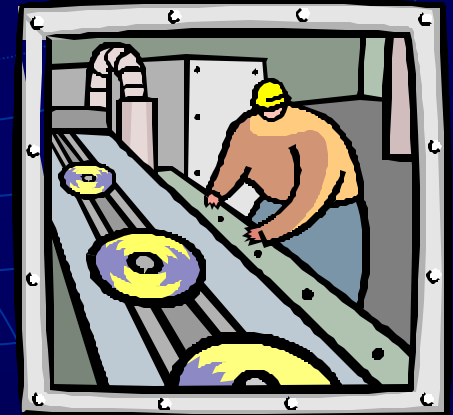
How do they work?

- Now looking back at the schematic of the S.L.D., we can see how the laser diode sends its output to the photo diode.
- The feedback mechanism is the most important feature of the S.L.D., without it, there would be no way to regulate the current and the device would burn itself out very quickly.

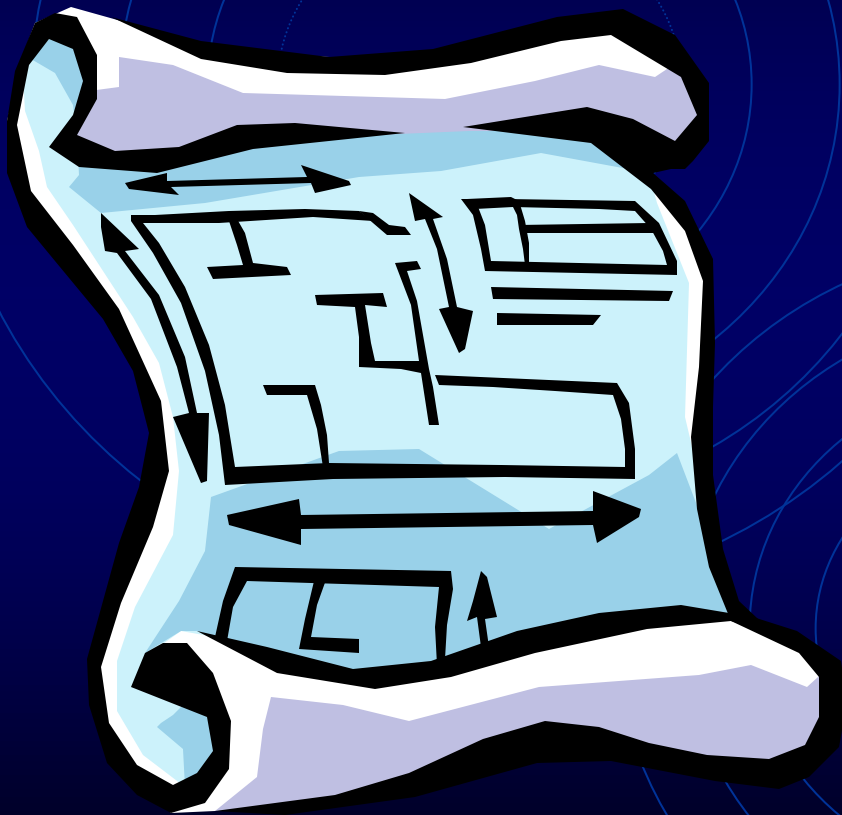


What are they made of?

- Semiconductor laser diodes can be made from many different types of semi-conducting materials including several elements found in groups III and V from the periodic table.
- A few examples of these materials include: GaAlAs, AlGaInP, InGaAsP.
- The major reasons for using one material over another are for the specifications needed, especially desired wavelength.



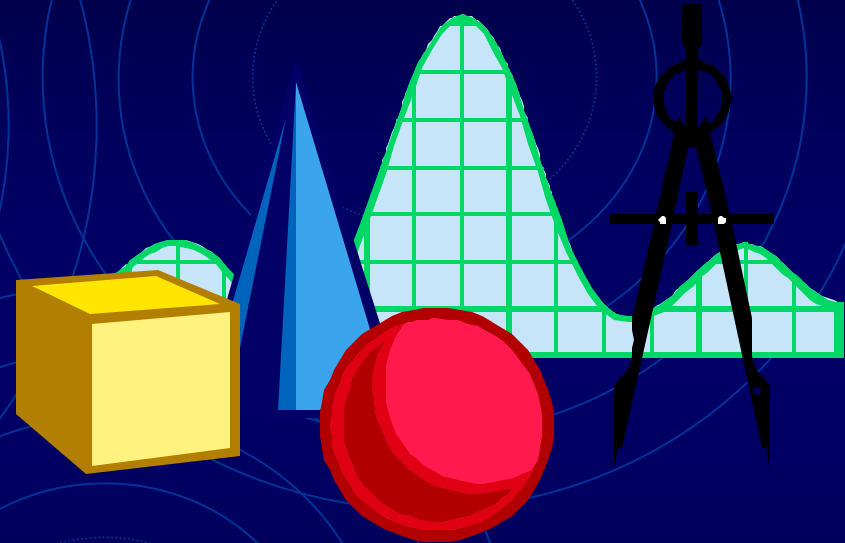
What are their properties?



- The properties of semiconductor laser diodes can be measured in various ways. The most common terms to describe them are given in the next two slides.
- These properties are used to place S.L.D.s in various classes such as: high/low power, wavelength, high temperature, etc.

What are their properties?

- Here is a list of the most important properties of semiconductor laser diodes.
- S.L.D. properties can be broken up into three general categories: *Electrical*, *Optical*, and *Temperature*.



- **Electrical:**

- Threshold current
- Operating current
- Operating Voltage

- **Optical:**

- Light output power
- Slope efficiency
- Beam Divergence
- Peak wavelength

- **Temperature:**

- Peak wavelength
- Laser threshold

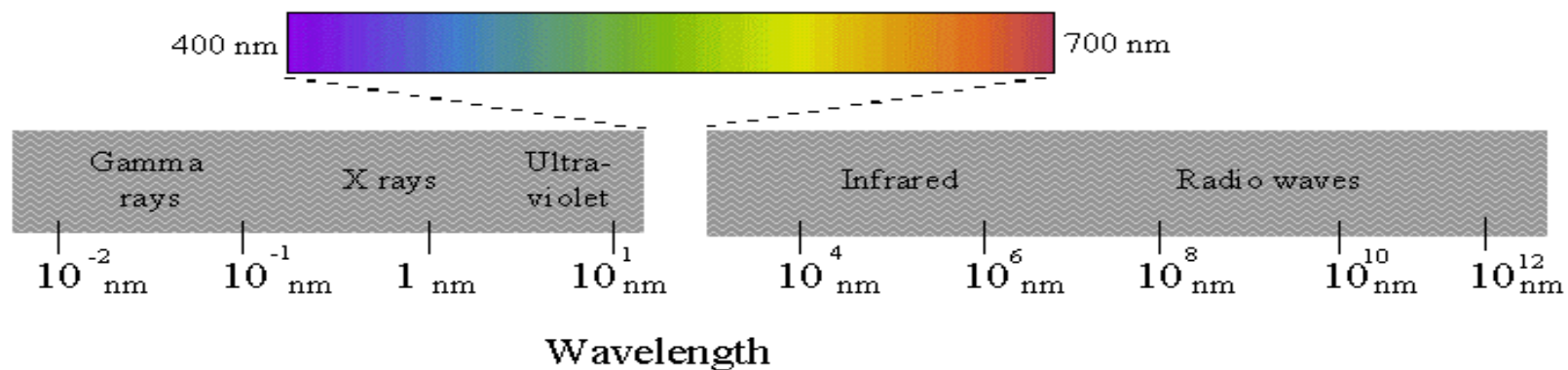
What are their properties?

- Electrical:
 - Wall-plug efficiency
 - Duty Cycle
 - Series resistance
- Optical:
 - Continuous/Pulsed Wave
 - Far field pattern
 - Fast axis
 - Slow axis
 - Spectral width
 - Near field pattern
 - Polarization ratio
- Temperature:
 - Active/Conductively cooling
 - Slope efficiency
 - Thermal impedance



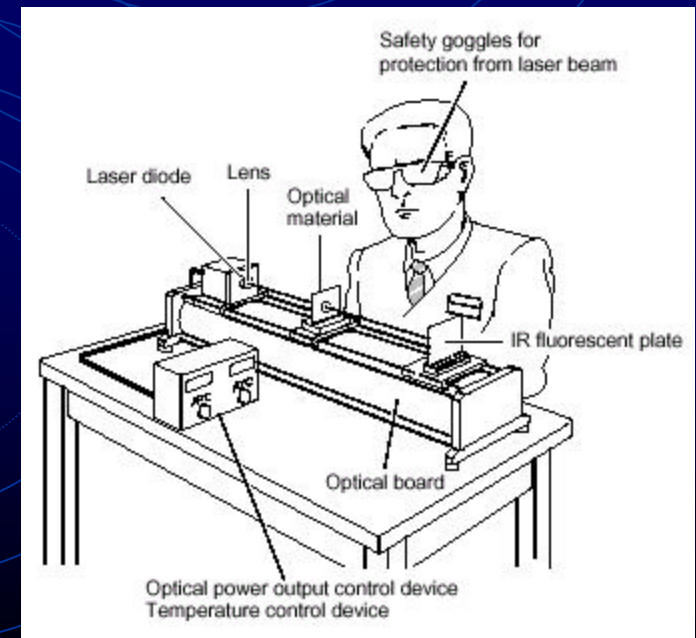
What are their properties?

- S.L.D.s can range in wavelengths such as Red (635-670 nm) and IR (780, 800, 900, 1,550 nm, etc). Green (~550 nm), blue (~450 nm), and violet (~400 nm) laser diodes have been produced in various research labs but until recently, only operated at liquid nitrogen temperatures, had very limited life (<100 hours), or both. Recent developments suggest that long lived room temp. green and blue S.L.D.s will be commercially available very soon.

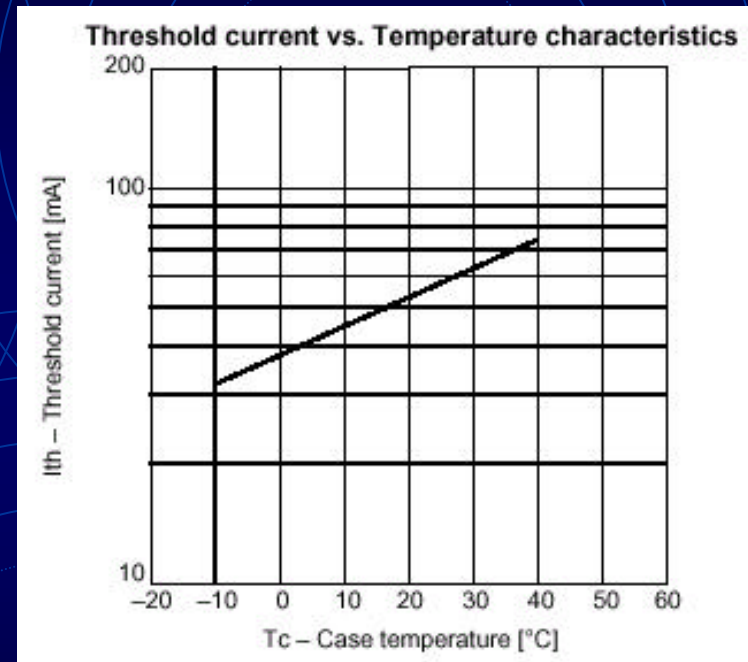
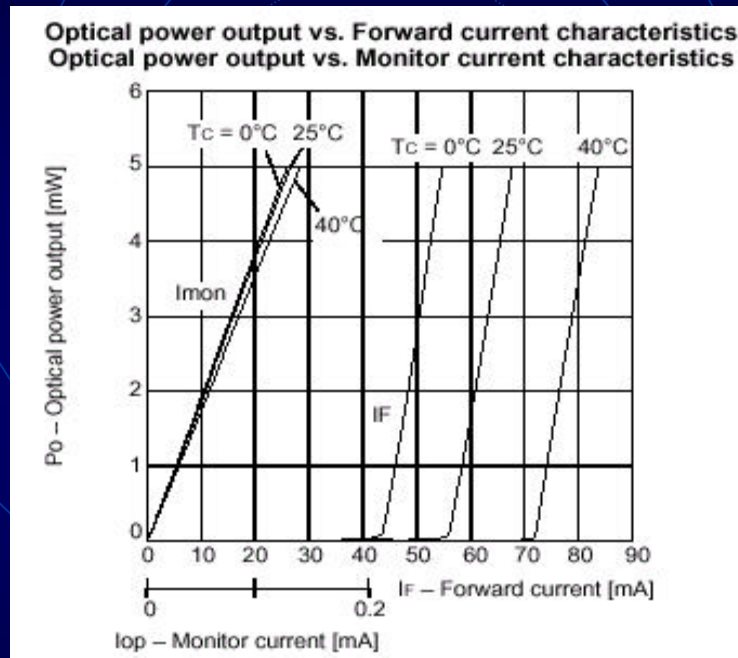


What are their properties?

- The beam quality of a semiconductor laser diode can be fair to high quality depending on design. The raw beam is elliptical or wedge shaped and also astigmatic. To make the proper correction requires additional optics (internal or external). Coherence length can be anywhere from a few mm to many meters.
- A typical S.L.D.'s output power ranges from approximately 0.1 mW to 5.0 mW, with up to 100W or more available. The highest power units are composed of arrays of laser diodes, not a single device. As power increases much more temperature and safety considerations are needed.



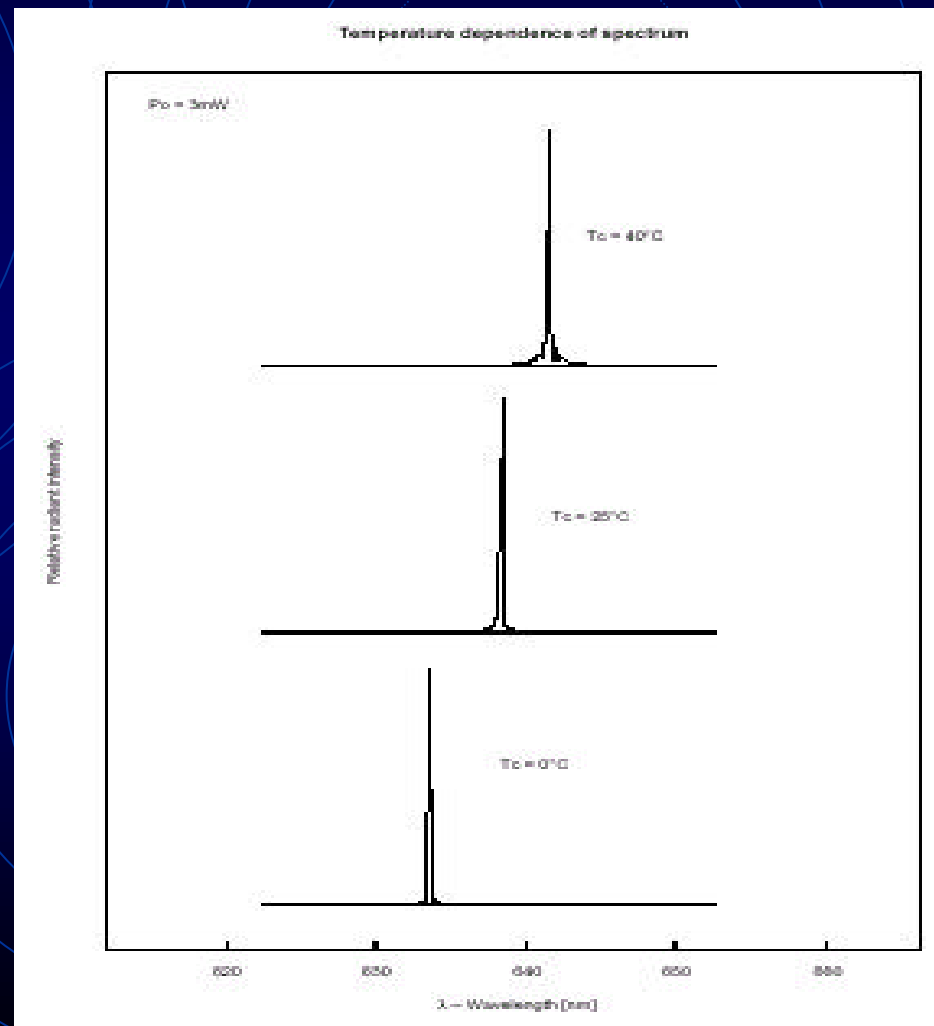
What are their properties?



- The graph on the left shows the slope efficiency of a typical low-power S.L.D.
- The graph on the right shows the effect of temperature on the threshold current.

What are their properties?

- This graph shows the change in the spectral wavelength due to a change in temperature.
- Temperature also is shown to have an effect on the relative radiant intensity.

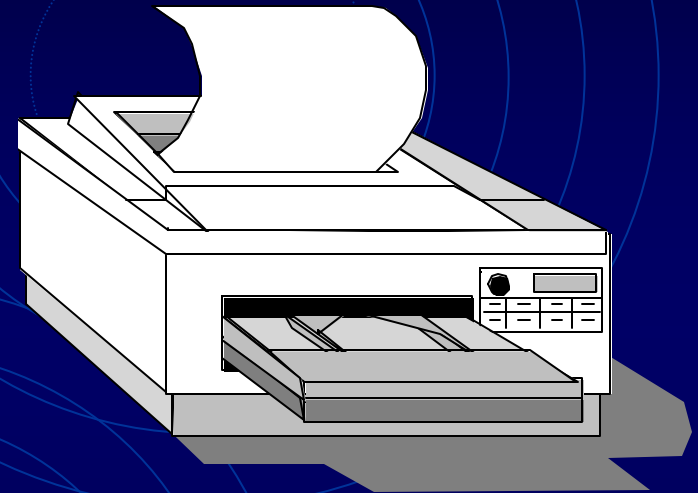
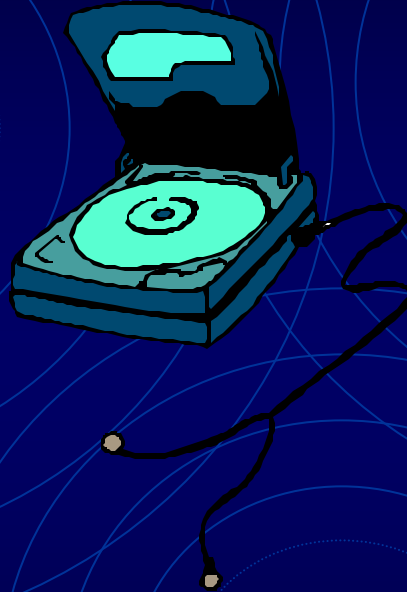
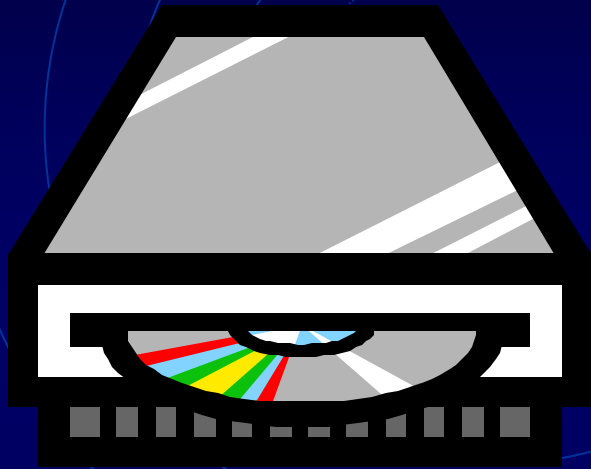


What are their uses?

- Semiconductor laser diodes can be used for many applications. The amount of products that can be developed using this simple type of device continues to grow all the time.
- Of course, the most easily thought of product of the S.L.D.s are lasers pointers, but it's what else they can be used for that makes them so special.

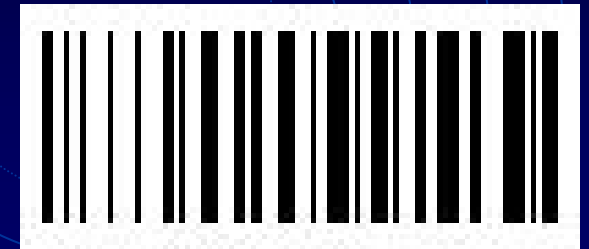
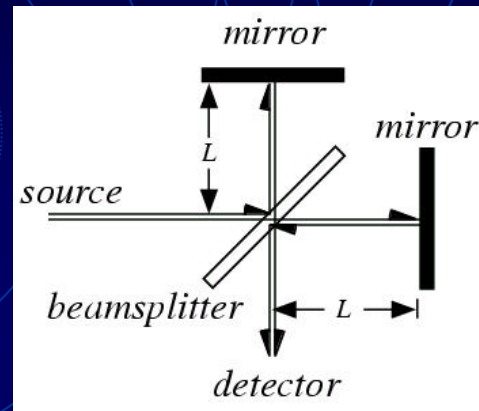
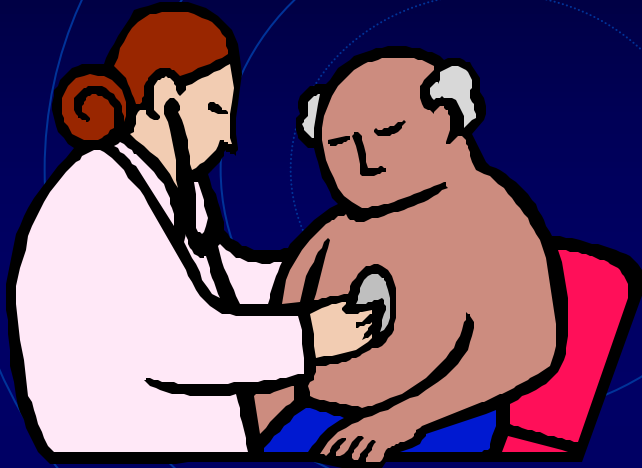


What are their uses?



- Some of the most common uses for semiconductor laser diodes are in everyday devices such as CD ROMs, CD players, LaserDisc and MiniDisc players, and also laser printers and laser fax machines.

What are their uses?



Bar Code Scanner

- Other uses might not seem so easily thought of, such as in medicine, interferometry, and bar code scanners, but are still used by many people everyday.
- S.LD.s can also be used for sighting and alignment scopes, measurement equipment, fiber optic and free space comm. systems, light shows, and as the pumping agent for other types of lasers as well.

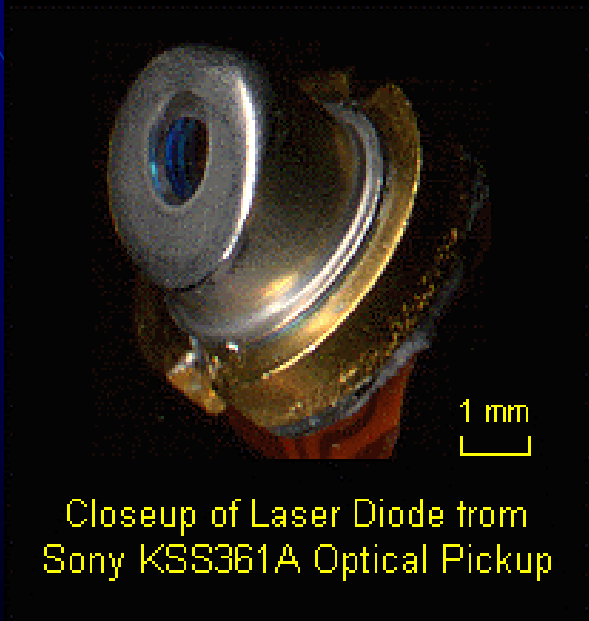
How much do they cost?

- Pricing always depends on the features that you include with a product. Semiconductor laser diodes are no different in this respect. Although they probably provide the cheapest form of lasers, they vary greatly in price from cheap to expensive. For a typical low power red S.L.D. you could pay as low as \$1, but for a highly scarce blue S.L.D. you could pay as much as \$10,000 or more.



Where can you get them?

- There are many business which sell semiconductor laser diodes, a few of which are hyperlinked below.
- Another easy way to get them is to take them out of old CD players and laser pointers.



Closeup of Laser Diode from
Sony KSS361A Optical Pickup

- <http://www.laser2000.co.uk/index.htm>
- <http://www.lasermate.com/diodes.htm>
- <http://www.optima-prec.com/index.htm>
- <http://www.sel.sony.com/semi/laserdio.htm>
- <http://www.slicorp.com/main/trade.html>
- <http://www.laser-diodes.thomson-csf.com/welcome.html.en>

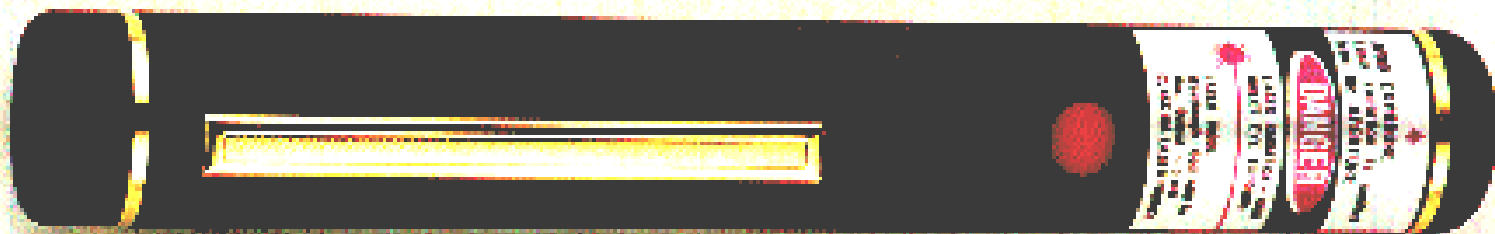
Key Points to Remember

- Semiconductor laser diodes are cheap and easy to use compared to other types of lasers.
- They can be used for many applications, and have the ability to be produced in a wide range of wavelengths and powers.
- The most important electronic consideration is the fact that a precisely controlled current source is needed to regulate the amount of current to the laser diode. Without this current protection, the diode will burnout quickly.

In Conclusion

- Semiconductor laser diodes have been around for about forty years now, but their possible uses continue to grow each day. We are at the new dawn of the millennium, and S.L.D.s will help bring about a new revolution in many fields of science; *the new optical solution revolution!*

LS-10 Laser Pointer



Bibliography

- Each of the following websites were used in the creation of this presentation:
 - <http://hp720.ceg.uiuc.edu/~fabiano/dc98/dc98.html>
 - <http://opel.ajou.ac.kr/frame1/ldiode.htm>
 - <http://vcs.abdn.ac.uk/ENGINEERING/lasers/lasers.html>
 - <http://www.ee.buffalo.edu/~camp/Modules/BarCode/index.html>
 - <http://www.laser2000.co.uk/index.htm>
 - <http://www.laser-diodes.thomson-csf.com/>
 - <http://www.lasermate.com/diodes.htm>
 - <http://www.misty.com/people/don/laserdon.html>
 - <http://www.optima-prec.com/index.htm>
 - <http://www.repairfaq.org/sam/lasersam.htm>
 - <http://www.sel.sony.com/semi/laserdio.html>
 - <http://www.slicorp.com/main/trade.html>



That's all Folks!!

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February 12, 2001

Consumer Optoelectronics

Dr. Alexander Cartwright