The Laser Diode

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Agenda

- **How a Laser Diode Works**
  - Laser Diode compared to Diode and LED
  - Homojunction vs. Heterojunction
  - Edge emitting lasers vs. VCSELs

- **Industrial Applications of the LD**
  - Laser Pointers
    - Red & Green lasers
  - CD/DVD-ROM
    - Blue, Violet, Ultra-Violet?
How a Laser Diode Works

- Operates similar to a Light Emitting Diode
  - Active medium is a semiconductor p-n junction
  - LED utilizes spontaneous emission of radiation
  - Fabry-Perot cavity produces stimulated emission of radiation
- Light is emitted diffracted
  - A collimator is needed to focus the beam
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Edge Emitting vs. Surface Emitting

- **Edge emitting laser:** light emission is through the cleaved edge of the laser. Edge emitters are difficult to integrate in large numbers.
- **Surface emitting laser:** much smaller and can be integrated in large numbers on a substrate wafer, much easier to test individually while still on the wafer.
VCSELs
Vertical Cavity Surface Emitting Lasers

- Very short optical cavity (1-3 \( \lambda \))

- Quantum wells are used to control optical properties

- Require highly reflective mirrors (99.9% vs. 30%)

- Metallic mirrors are replaced with Distributed Bragg Reflectors (DBRs)
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Buried Regrowth VCSEL
Comparison of Red and Green Laser Pointers

Typical Red Laser Pointer

Battery
LD Driver
LD Module

Typical Green Laser Pointer

Battery
Pump LD Driver
DPSS Laser Module

Comparison of Red and Green Laser Pointer Complexity
Typical Red Laser Pointer
Potassium titany phosphate (KTiOPO₄) nonlinear crystal

Neodymium doped yttrium orthovanadate

Edmund Scientific L54-101 Green DPSS Laser Pointer
Diffraction limits the size of a focused beam to a spot with a width on the order of the wavelength of the light emitted, therefore the wavelengths limits the density of data storage: shorter wavelengths enable higher storage density.

*This is actually an inaccurate representation of how the data would be arranged, optical devices use EFM, EFM+*
CD vs. DVD vs. Blu-ray Writing

**CD**
- 780-nm Red Laser
- Lens Aperture = 0.45
- One 1.2-mm polycarbonate layer
- Track pitch = 1.6\(\mu\)m

**DVD**
- 650-nm Red Laser
- Lens Aperture = 0.6
- Two 0.6-mm polycarbonate layers
- Track pitch = 0.74\(\mu\)m

**BD**
- 405-nm Blue Laser
- Lens Aperture = 0.8
- One 1.1-mm polycarbonate layer
- Track pitch = 0.30\(\mu\)m

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Typical CD-ROM Optical Pickup

Sony KSS361A Optical Pickup
Resources


