

Characteristics of Semiconductor Laser Diodes

Article Overview

Semiconductor laser diodes are compact, electrically pumped lasers that generate coherent light through stimulated emission in a semiconductor p-n or p-i-n junction.

Structure and Operation

A semiconductor laser diode consists of a p-n junction or p-i-n structure where electrons and holes recombine to emit photons. This recombination can occur spontaneously or be stimulated by incident photons, producing coherent light. Optical feedback from a resonator allows the light to amplify and sustain laser oscillation. The choice of semiconductor material, such as GaAlAs, AlGaInP, or InGaAsP, determines the emission wavelength, which can range from ultraviolet (UV) to infrared (IR) spectra ().

Types and Packaging

Semiconductor laser diodes come in various forms, including edge-emitting diodes, vertical-cavity surface-emitting lasers (VCSELs), and bar array diodes. They may be packaged in TO-can modules, pigtailed modules for optical communication, or high-power arrays. Many modules include a photodiode for feedback, which monitors output power and stabilizes the laser ().

Electrical and Optical Properties

Laser diodes are electrically a PIN diode, driven by forward voltage. Key properties include:

- o Wavelengths: Red (635-670 nm), IR (780-1550 nm), Green (~550 nm)
- o Output power: From milliwatts to over 100 W in high-power arrays
- o Beam quality: Often astigmatic; coherence length varies from millimeters to meters
- o Temperature sensitivity: Performance depends on junction temperature and material properties ().

Physical Principles

The gain in a semiconductor laser arises from stimulated emission at interband transitions. Electrons excited into the conduction band recombine with holes in the valence band, emitting photons with energy near the bandgap. Direct bandgap semiconductors are preferred because indirect bandgap materials, like silicon, do not efficiently support optical transitions due to momentum mismatch ().

Applications

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Semiconductor laser diodes are widely used in:

- o Fiber-optic communications for high-speed data transmission
- o Optical storage such as CD, DVD, and Blu-ray reading/writing
- o Laser pointers, barcode scanners, and laser printing
- o Industrial and medical applications, including material processing and sensing
- o General illumination when combined with phosphors to produce white light ().

Advantages

They are compact, efficient, and capable of high modulation speeds, making them ideal for integrated optical systems. High-power diode arrays enable applications requiring intense light output, while single-mode diodes provide narrow linewidths for precision tasks (). In summary, semiconductor laser diodes are versatile, electrically driven lasers that combine compact size, tunable wavelength, and high efficiency, serving a broad range of technological and industrial applications.

Laser diodes are commonly used in devices such as barcode readers, laser printers, security systems, and fiber optic

A laser diode is a specialized semiconductor device that emits highly directional, coherent light through the process of stimulated

This section explains the basic characteristics of laser diodes along with the terms and symbols used in datasheets to

When laser diodes are used in electronic circuits, it is necessary to understand, not only the standard specifications that might be

Laser diodes have become the essential part of electro-optical systems used in different areas of human activity. To

The other topics covered in the chapter include: operational fundamentals, semiconductor materials used for making semiconductor

Key performance characteristics are thoroughly explored, including emission bandwidth, wavelength tuning via temperature or

Semiconductor or diode lasers, typically about the size of a grain of salt, are the smallest lasers yet devised.

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They consist of a p-n

A laser diode (semiconductor laser) is an electronic component that generates laser light by converting electric current

One of the key challenges facing the semiconductor laser diode industry is the ongoing pursuit of improved efficiency,

Laser diodes form a subset of the larger classification of semiconductor p - n junction diodes. Forward

Semiconductor lasers (520nm, 445nm, 635nm) Semiconductor lasers (638nm, 545nm, 488nm) Semiconductor lasers or laser diodes

Introduction to Semiconductor Lasers Semiconductor lasers, also known as laser diodes, are a type of semiconductor

A laser diode is a small semiconductor device that emits powerful and precise light using a process known as

A laser diode is a semiconductor device that is identical to a light-emitting diode (LED) and

What is a Laser Diode? A laser diode, similar to a light emitting diode (LED), is comprised of a junction between two

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