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A Brief Note on Light Emitting Diode

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Description

A laser diode is a semiconductor device that works similarly to a light-emitting diode in that a diode pumped directly with electrical current can produce lasing conditions at the junction. The doped p–n-transition, which is driven by voltage, permits an electron to recombine with a hole. Radiation in the form of an emitted photon is produced when an electron drops from a higher energy level to a lower one. This is what is known as spontaneous emission. When the process is repeated, light with the same phase, coherence, and wavelength can be created, which is known as stimulated emission. The wavelength of the emitted beam is determined by the semiconductor material used, which can range from infrared to ultraviolet in today's laser diodes. Fiber optic communications, barcode readers, laser pointers, CD/DVD/Blu-ray disc reading/recording, laser printing, laser scanning, and light beam illumination are all applications for laser diodes, which are the most common type of laser.

Electrically, a laser diode is a PIN diode. The laser diode's active zone lays in the intrinsic region, with carriers pumped in from the N and P regions, respectively. While early studies on diode lasers used simple P–N diodes, all modern lasers use a double-hetero-structure implementation, in which the carriers and photons are restricted to enhance their chances of recombination and light emission. A laser diode, unlike a conventional diode, is designed to recombine all carriers in the I region and produce light. As a result, direct band-gap semiconductors are used to make laser diodes. The epitaxial structure of a laser diode is produced using one of the crystal growth processes, often starting with a N doped substrate and growing the I doped active layer, then the P doped cladding, and finally the contact layer. Quantum wells are commonly used in the active layer, as they provide a lower threshold current and higher efficiency.

Laser diodes are a subset of the larger category of p–n junction semiconductor diodes. The two kinds of charge carriers, holes and electrons, are "injected" into the depletion area from opposing sides of the p–n junction by applying forward electrical bias across the laser diode. The p-doped semiconductor injects holes, while the n-doped semiconductor injects electrons. (The difference in electrical potential between n- and p-type semiconductors causes a depletion area, which is empty of charge carriers, to occur whenever they are in physical touch). Because most diode lasers are powered by charge injection, this type of lasers is frequently referred to as "injection lasers" or "Injection Laser Diode" (ILD). Diode lasers are categorized as semiconductor lasers since they are semiconductor devices. Diode lasers are distinguished from solid-state lasers by either nomenclature.

Optical pumping is another method of powering some diode lasers. Optically Pumped Semiconductor Lasers (OPSLs) use a III-V semiconductor chip as the gain medium and a pump source (usually another diode laser). In comparison to ILDs, OPSLs have various advantages, including wavelength selection and the absence of interference from internal electrode structures. The invariance of the beam parameters - divergence, shape, and pointing - as pump power (and hence output power) is adjusted, even above a 10:1 output power ratio, is another advantage of OPSLs.

When an electron and a hole are in the same region, they can recombine or "annihilate," resulting in spontaneous emission, in which the electron re-occupies the energy state of the hole and emits a photon with the energy difference between the electrons initial state and the whole's state. (The energy released from the recombination of electrons and holes in a normal semiconductor junction diode is carried away as phonons, or lattice vibrations, rather than photons.) Below the lasing threshold, the characteristics of spontaneous emission are comparable to those of an LED. Although spontaneous emission is essential to start a laser oscillation, it is one of the reasons for the laser's inefficiency once it has started to oscillate.

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