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Semiconductor Lasers

Introduction:

Semiconductor lasers are compact and efficient light sources that emit coherent and chromatic radiation. These devices operate based on electrical-to-optical energy conversion within a semi-conductor material.

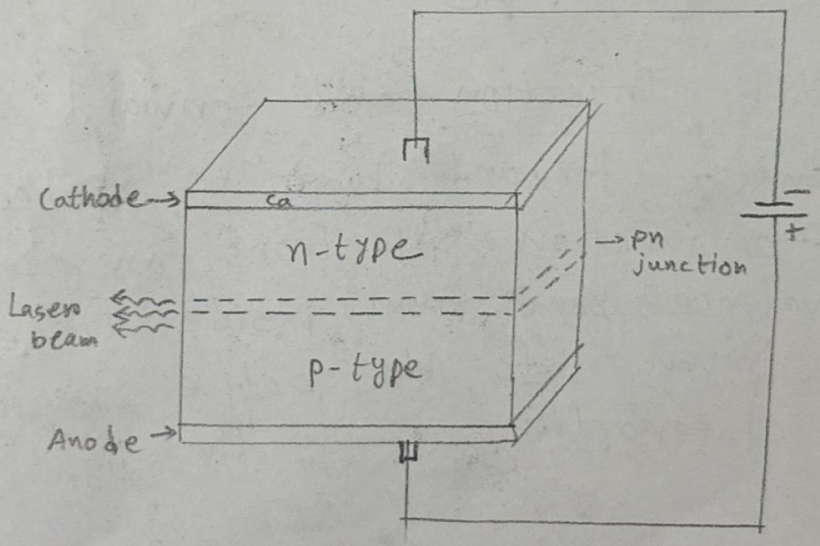

Fig: Semiconductor Laser

Construction:

The basic structure of a semiconductor laser consists of a direct bandgap semiconductor such as Gallium Arsenide (GaAs). The junction is enclosed within an optical cavity, typically formed by two parallel

- mirrors or cleaved crystal surfaces, It includes:

1] An active region, where electron-hole recombination occurs.

2] cladding layers, which confine both carriers and light.

3] One facet of the laser is partially reflective, allowing a portion of the amplified light to exit as the laser output.

Operation Principle:

Carrier Injection and forward bias:

When a forward bias is applied across the p-n junction electrons are injected into the valence band from p-side. These carriers are driven into the active region, where their interactions power the light emission.

Photon Generation

As electrons drop from the conduction band to fill holes in the valence band, they release energy in the form of photons.

Stimulated Emission

some emitted photons collide with other electrons. This stimulated emissions

of identical photons - same wavelength, phase and direction, which produces the coherent light.

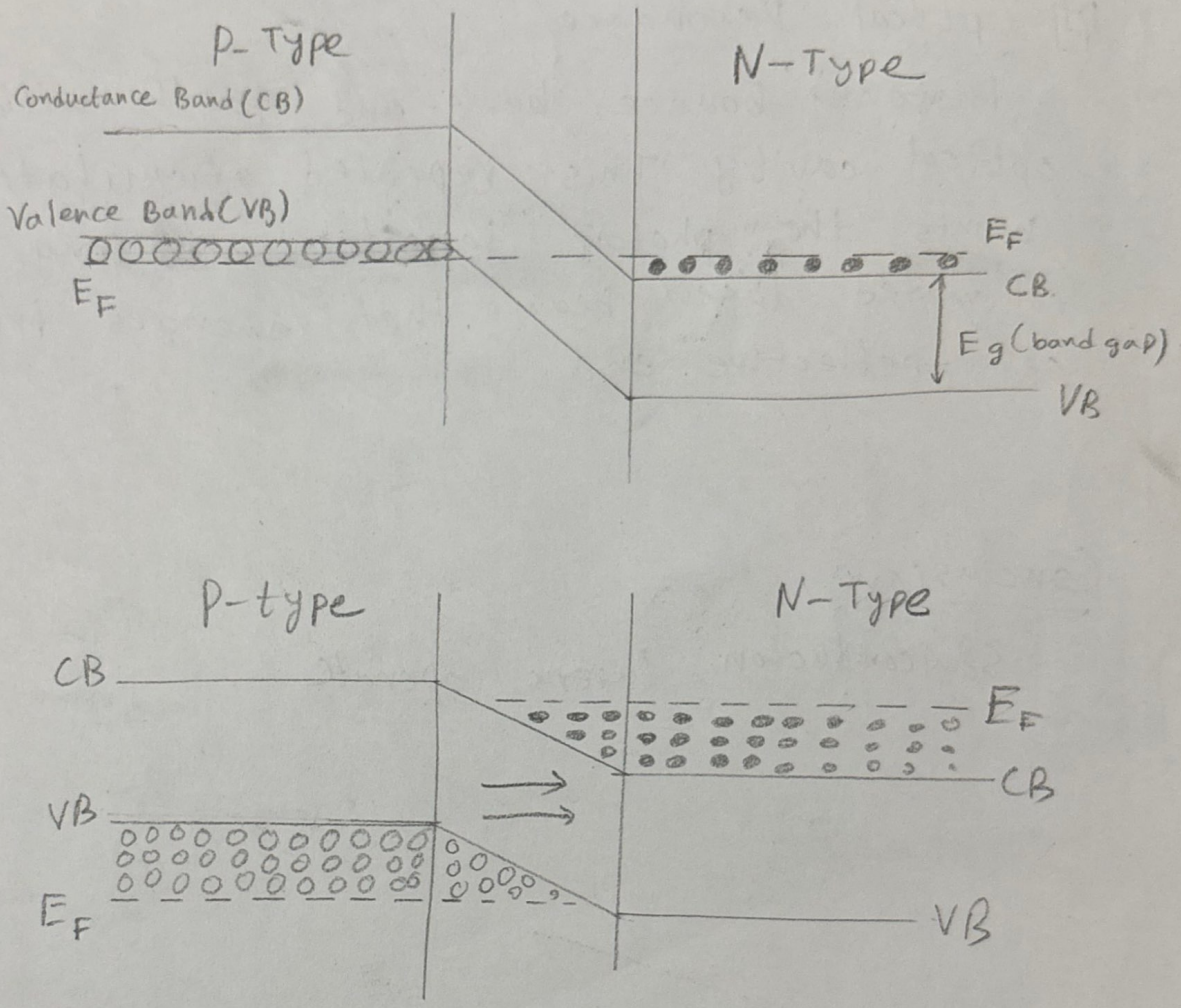

Fig: Light emission of semiconductor laser

Threshold Condition:

Lasing action begins only when the rate of stimulated emission surpasses internal optical losses. This occurs at a specific input current level known as the

threshold current. Below this, the device behaves like an LED.

Optical Resonance

Photons bounce back and forth within the optical cavity. This repeated stimulation boosts the photon density resulting in a collimated laser beam that emerges from the semi-reflective end.

Conclusion:

Semiconductor lasers operate on the principle of stimulated emission in a forward biased pn junction producing a beam of light coherent, monochromatic, and highly directional.

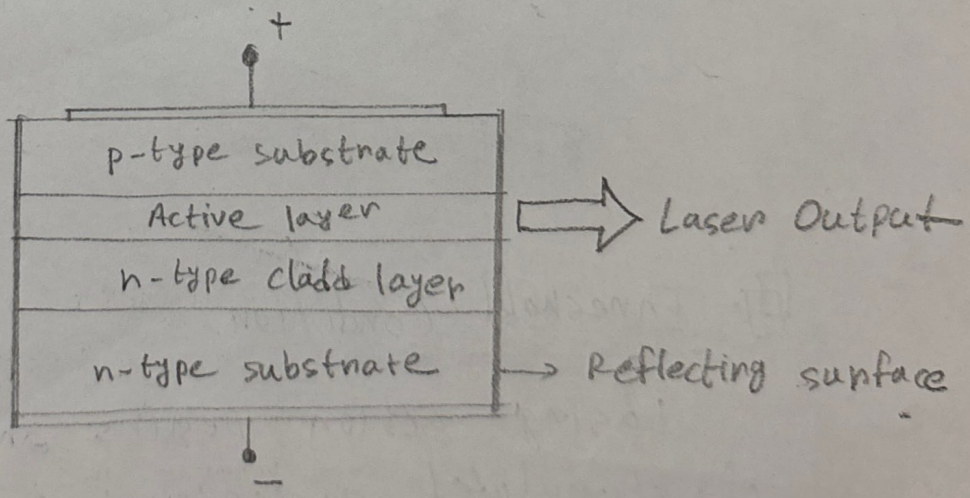

Fig: Overview of semiconductor laser