LED Structures

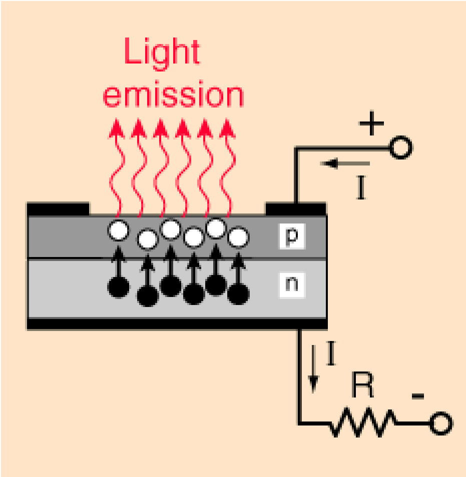
LED Structures

- Five major type:
- 1-Planar LED
- 2-Dome LED
- 3-Surface emitter LEDs
- 4-Edge Emitter LEDs
- 5-Superluminescent LEDs
- Only two have use in OFC(SLED and ELED)

Planar LED

- Simplest of the structures that are available.
- Fabricated by liquid or vapour phase epitaxial processes over GaAs surface.
- Lambertian emission.
- TIR limites the Radiance low.

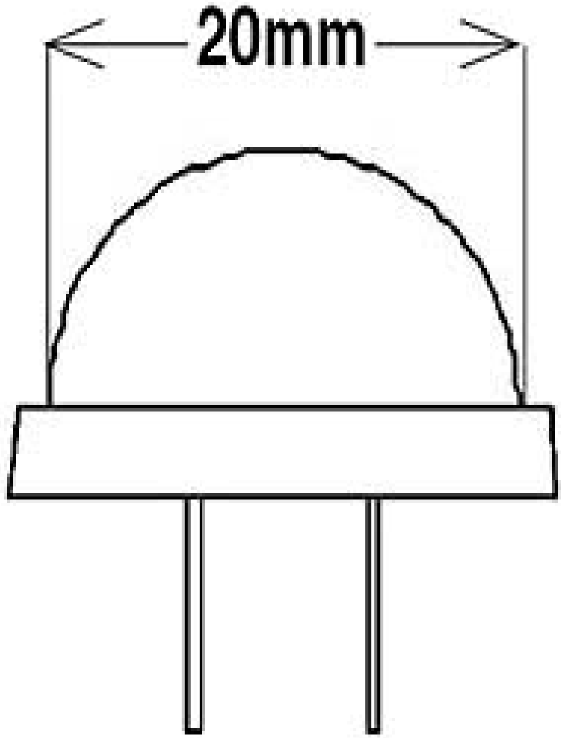
Figure of Planar LED



Dome LED

- A hemisphere of n-type GaAs around p-region.
- Higher external power efficiency than planar LED.

Figure of Dome LED

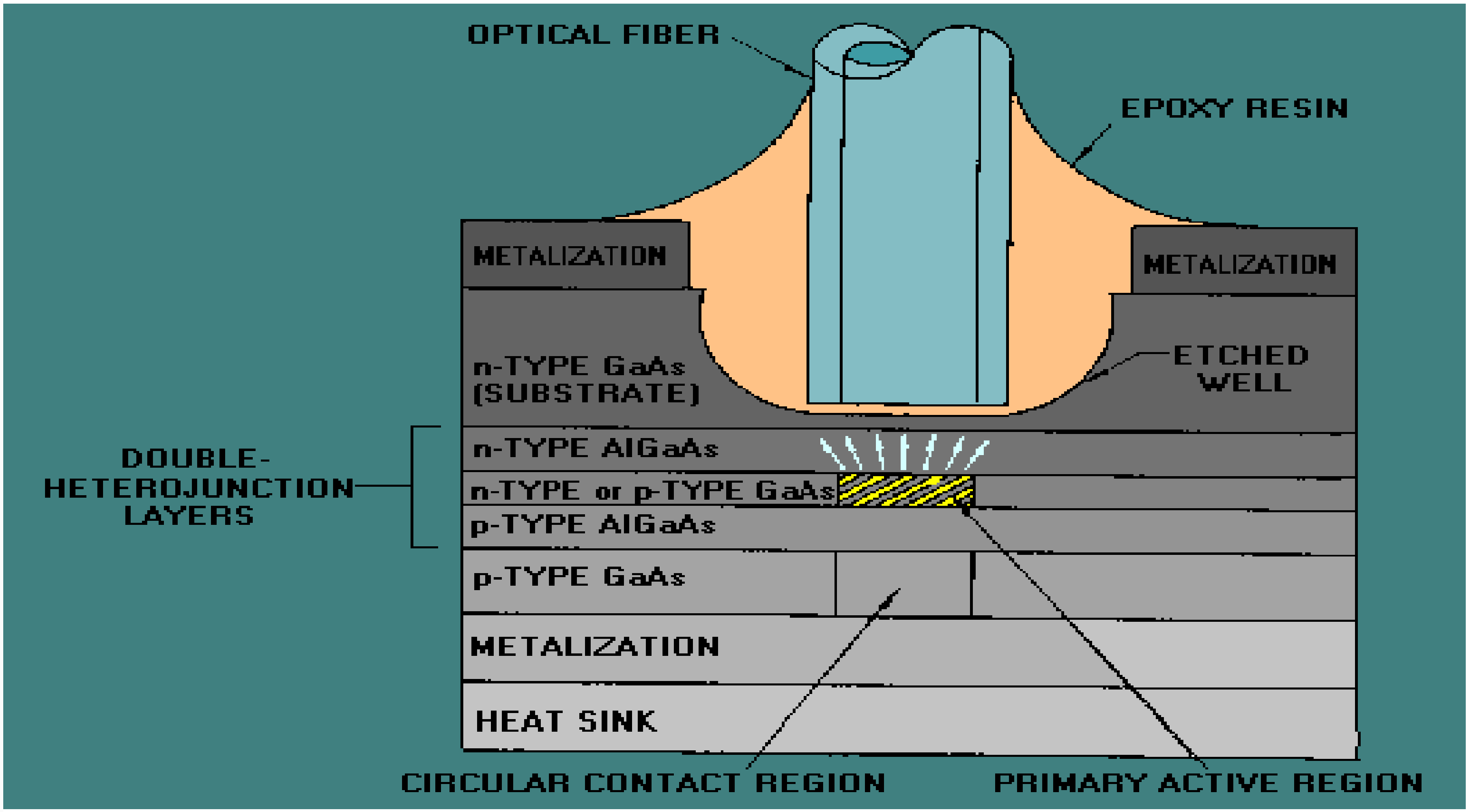


Surface Emitter LEDs

this form of LED structure emits light perpendicular to the plane of the PN junction.

- Method for obtaining high radiance is to restrict the emission to a small active region within device.
- Pioneered by **Burrus** and **Dawson.**
- Used an etched well in a GaAs substrat inorder to prevent heavy absorption of emitted radiation.
- Low **thermal impedance** in active region allowing high **current densities** and giving high **radiance emission** into optical fiber.

BURRUS-SLED


OPTICAL FIBER
EPOXY RESIN
METALIZATION
METALIZATION
n-TYPE GaAs
(SUBSTRATE)
ETCHED
WELL
DOUBLE-
HETEROJUNCTION
LAYERS
n-TYPE AlGaAs
n-TYPE or p-TYPE GaAs
p-TYPE AlGaAs
p-TYPE GaAs
METALIZATION
HEAT SINK
CIRCULAR CONTACT REGION
PRIMARY ACTIVE REGION

Explanation

- the size of the primary active region is limited to a small circular area of 20 μm to 50 μm in diameter.
- The active region is the portion of the LED where photons are emitted.
- The primary active region is below the surface of the semiconductor substrate perpendicular to the axis of the fiber.

Continue:

- A **well** is etched into the substrate to allow direct coupling of the emitted light to the optical fiber. The etched well allows the optical fiber to come into close contact with the emitting surface.
- In addition, the **epoxy resin** that binds the optical fiber to the SLED reduces the **refractive index mismatch, increasing coupling efficiency.**
- Typically, SLEDs operate efficiently for bit rates up to **250 megabits per second (Mb/s)**. Because SLEDs emit light over a wide area (wide far-field angle), they are almost exclusively used in **multimode systems**.

Characteristics of SLED

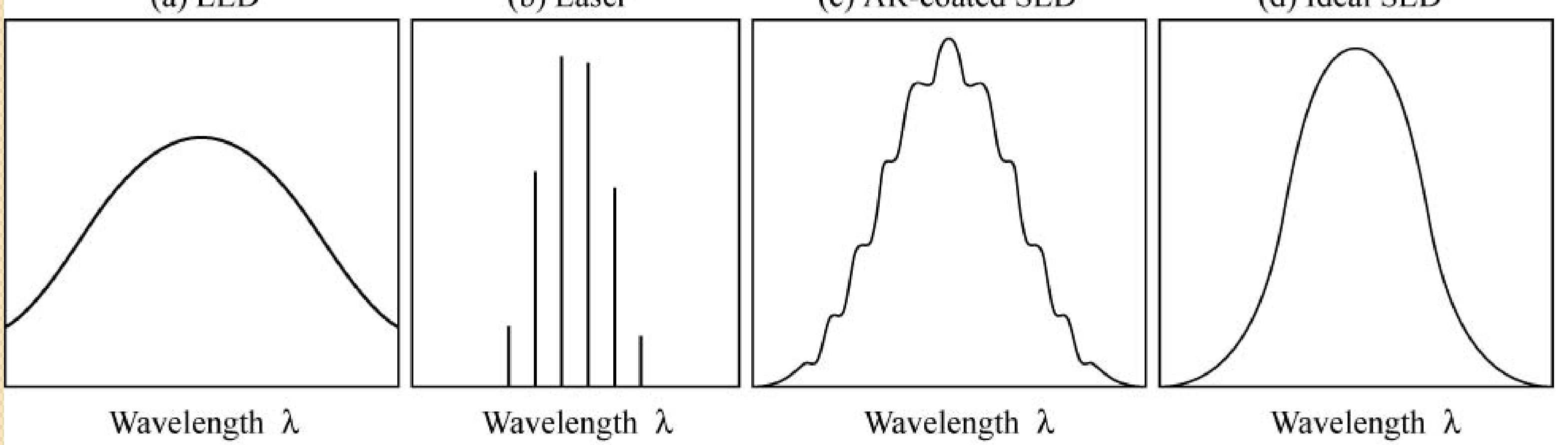
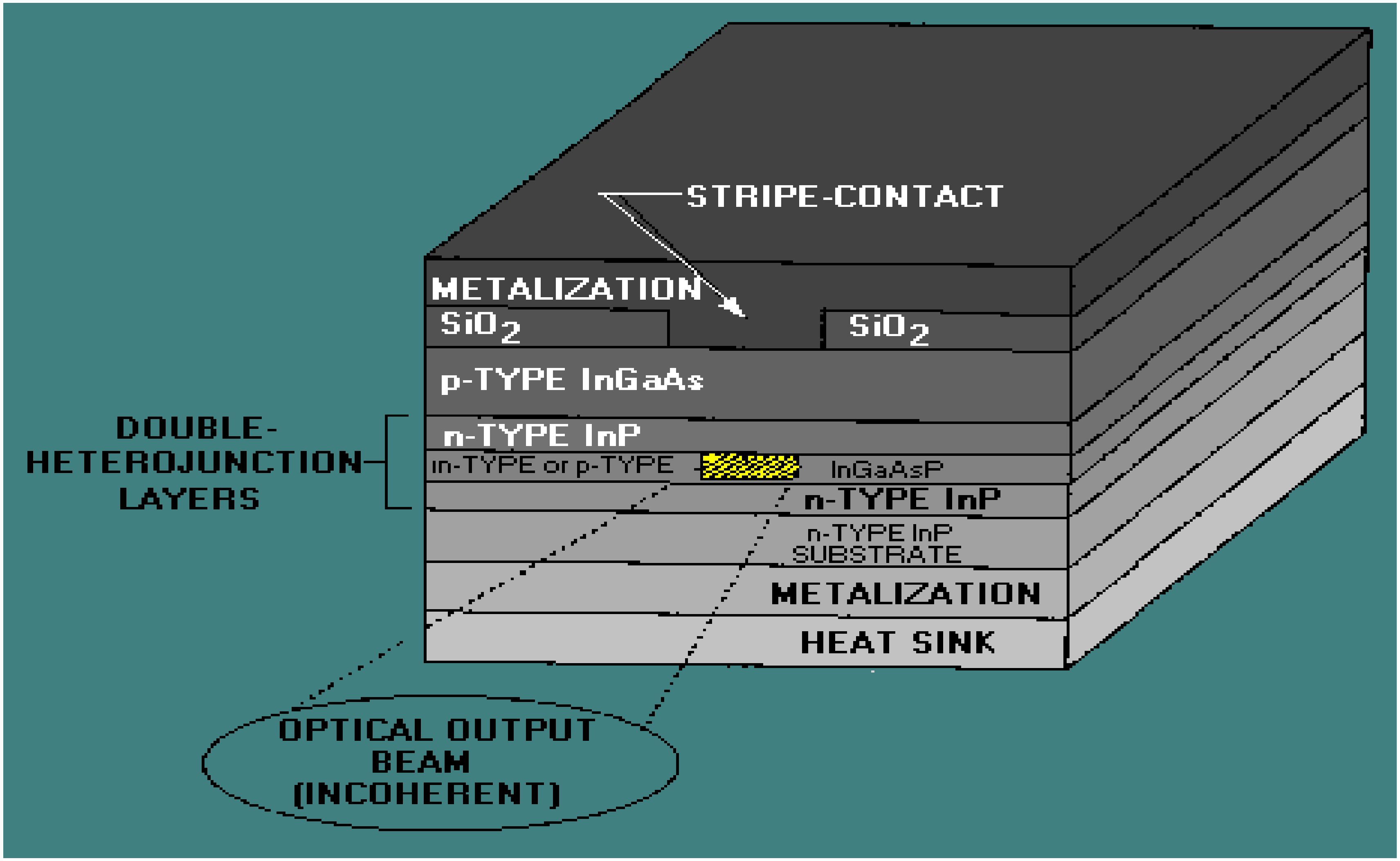


Fig. 23.10. Spectrum of (a) regular LED with a theoretical linewidth of 1.8 *kT*, (b) multi-mode semiconductor laser, (c) superluminescent diode (SLD) fabricated by AR coating of a multimode laser, (d) ideal SLD with linewidth less than *kT* (after Liu, 2000).

Edge Emitter LEDs

- High radiance structure currently used in optical communications is the **stripe geometry**
- Similar geometry to a conventional contact **stripe infection laser**
- Surface geometry allows very high **carrier injection densities** for given high current.
- This form of LED structure emits light in a plane **paralle**l to the junction of the PN junction.
- In this configuration the light can be confined to a **narrow angle**.

ELED structures



ELED

- It shows the different layers of semiconductor material used in the ELED.
- The primary active region of the ELED is a narrow stripe, which lies below the surface of the semiconductor substrate. The semiconductor substrate is cut or polished so that the stripe runs between the front and back of the device.
- The polished or cut surfaces at each end of the stripe are called facets.

spectrum

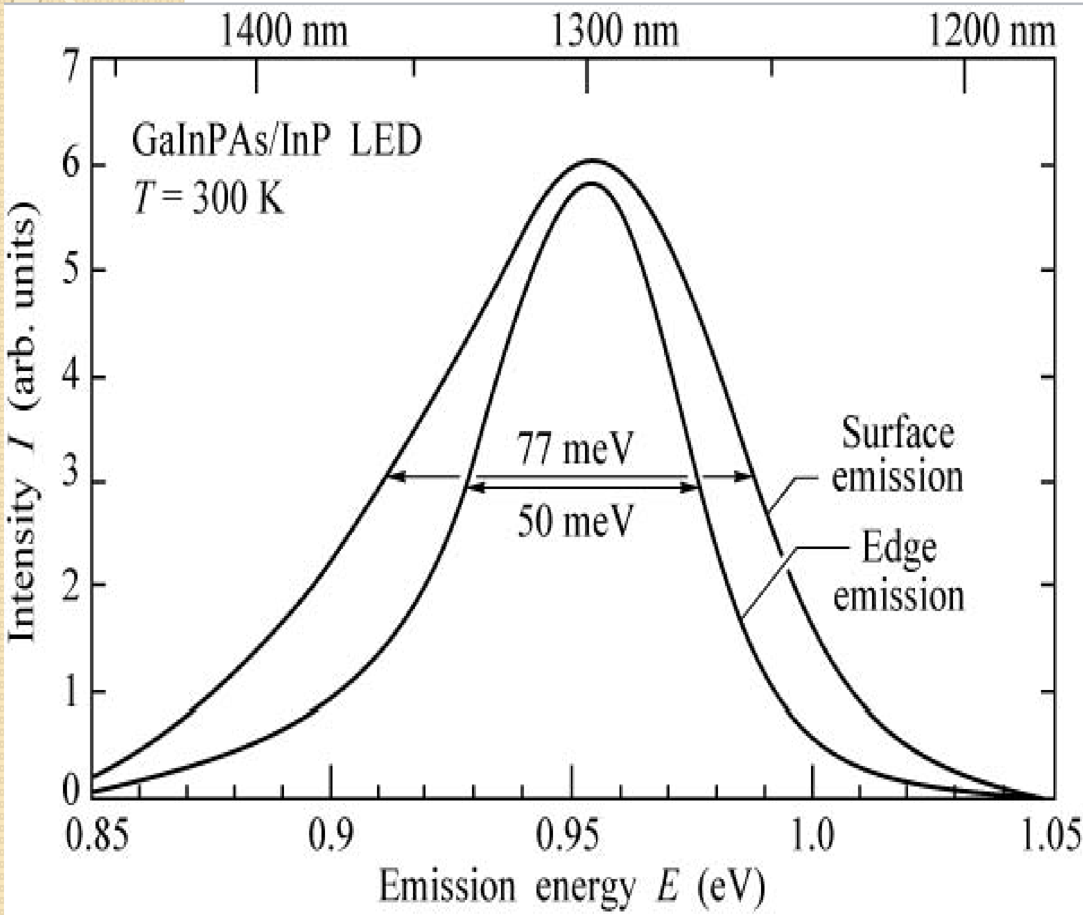


Fig. 23.3. Emission spectrum along the edge and surface of GaInPAs/InP communication LED emitting at 1300 nm. The spectrum emitted along the edge of the LED is narrower due to self-absorption.

APPLICATION

- In an ELED the rear facet is highly reflective and the front facet is antireflection-coated.
- ELEDs emit light only through the front facet.
- ELEDs emit light in a narrow emission angle allowing for better source-to-fiber coupling.
- They couple more power into small NA fibers than SLEDs.
- ELEDs can couple enough power into single mode fibers for some applications. ELEDs emit power over a narrower spectral range than SLEDs.
- However, ELEDs typically are more sensitive to temperature fluctuations than SLEDs.
- For medium-distance, medium-data-rate systems, ELEDs are preferred.
- ELEDs may be modulated at rates up to 400 Mb/s. ELEDs may be used for both single mode and multimode fiber systems.

Super luminescent LEDs

- Having advantages of both SLED and ELED-
- High output power
- A directional output beam
- A narrow spectral linewidth
- A super luminescent light emitting diode is, similar to a laser diode, based on an electrically driven **pn-junction** that, when biased in forward direction, becomes optically active and generates amplified spontaneous emission over a wide range of wavelengths.
- The peak wavelength and the intensity of the SLED depend on the active material composition and on the injection current level.
- SLEDs are designed to have high single pass amplification for the spontaneous emission generated along the waveguide but, unlike laser diodes, insufficient feedback to achieve lasing action.

diagram

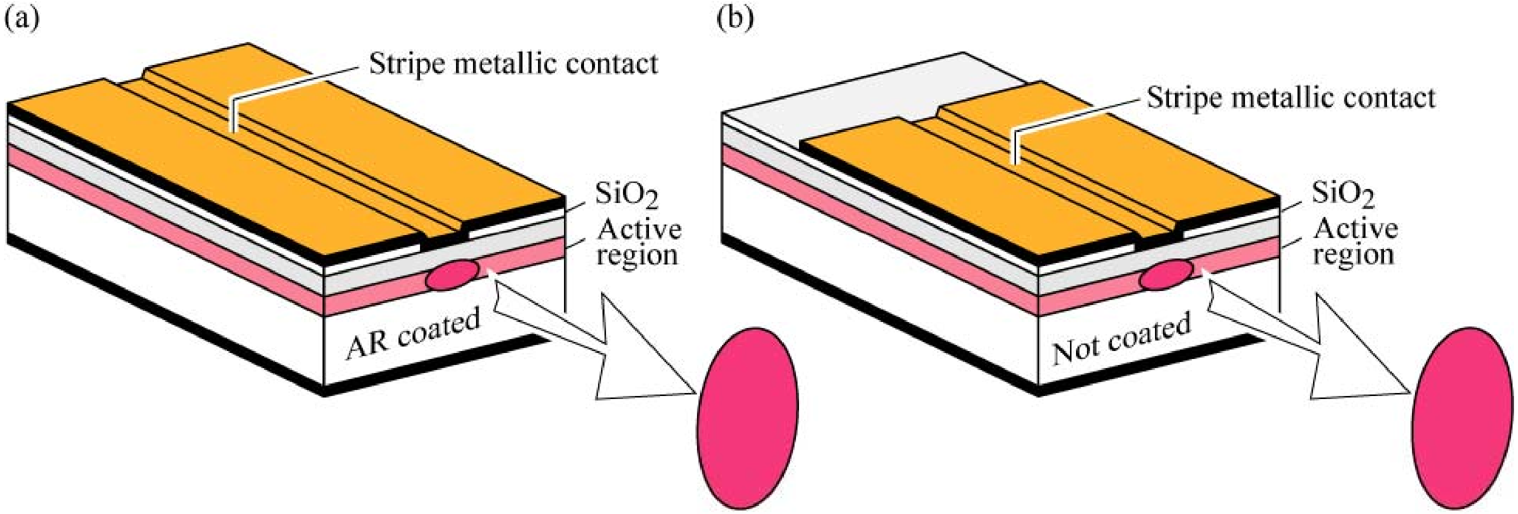


Fig. 23.9. Common structures of superluminescent diodes (SLDs). (a) SLD with cleaved facets coated with anti-reflection (AR) coatings. (b) SLD with cleaved, reflecting facets and stripe contact injecting current over the partial length of the device.

characteristics

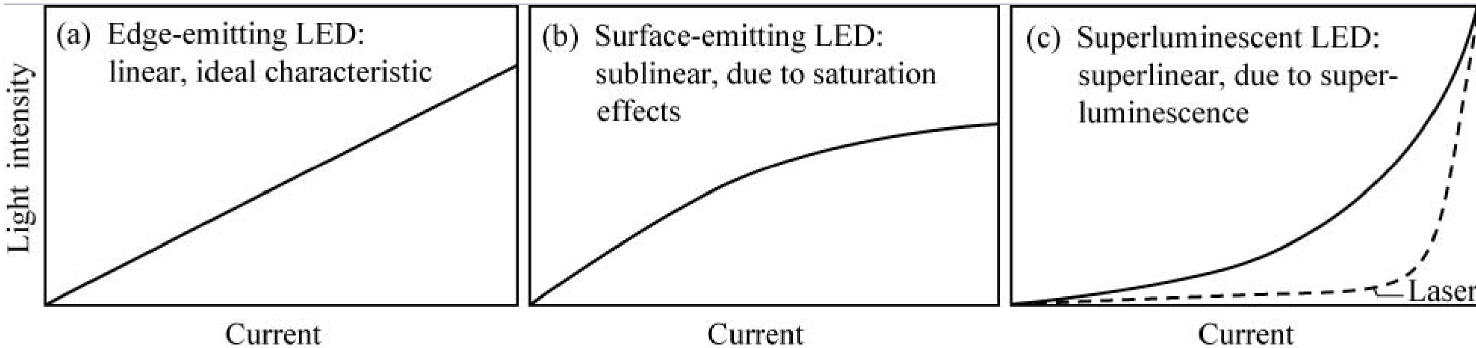


Fig. 23.11. Light-versus-current (*L–I*) characteristic of different LEDs. (a) Edge-emitting LED with little or no saturation effects. (b) Surface-emitting LED with small active area exhibiting saturation effects due to carrier overflow. (c) Superluminescent LED. Also shown is the *L–I* characteristic of a laser that exhibits a distinct threshold current.

characteristics

- The total optical power emitted by an SLED depends on the injected current (bias).
- Unlike laser diodes, the output intensity does not exhibit a sharp threshold but it gradually increases with current.
- A soft knee in the power vs. current curve defines a transition between a regime dominated by spontaneous emission (typical for surface emitting LEDs) and one that is dominated by amplified spontaneous emission (i.e. superluminescence)

laser to fiber coupling

- For greater coupling efficiencies ,lenses are used
- Power conversion efficiency(**η):**
- **Ratio of optical power coupled into fiber(Pc) to the electrical power applied at the terminals of device.**
- **$\eta = P_c/P$**
- **CONVEX lenses are used**

diagram

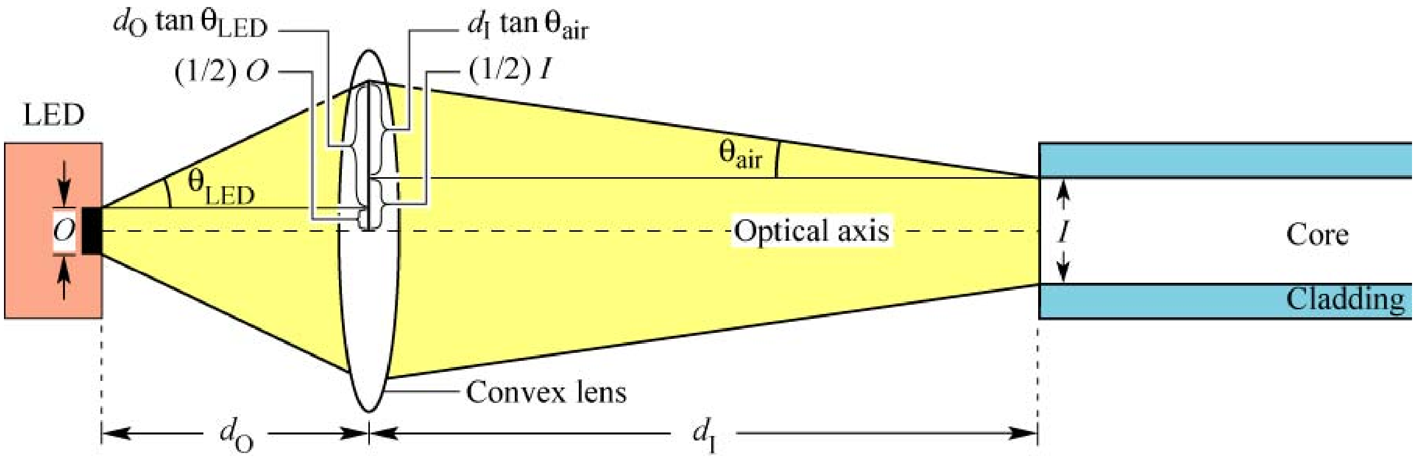


Fig. 22.7. Schematic illustration of coupling with a lens by imaging the light-emitting region of an LED onto the core of an optical fiber. The LED has a circular emission region with diameter O (Object). The emission region is imaged onto the fiber core with diameter I (Image) using a convex lens with focal length f.

Lenses

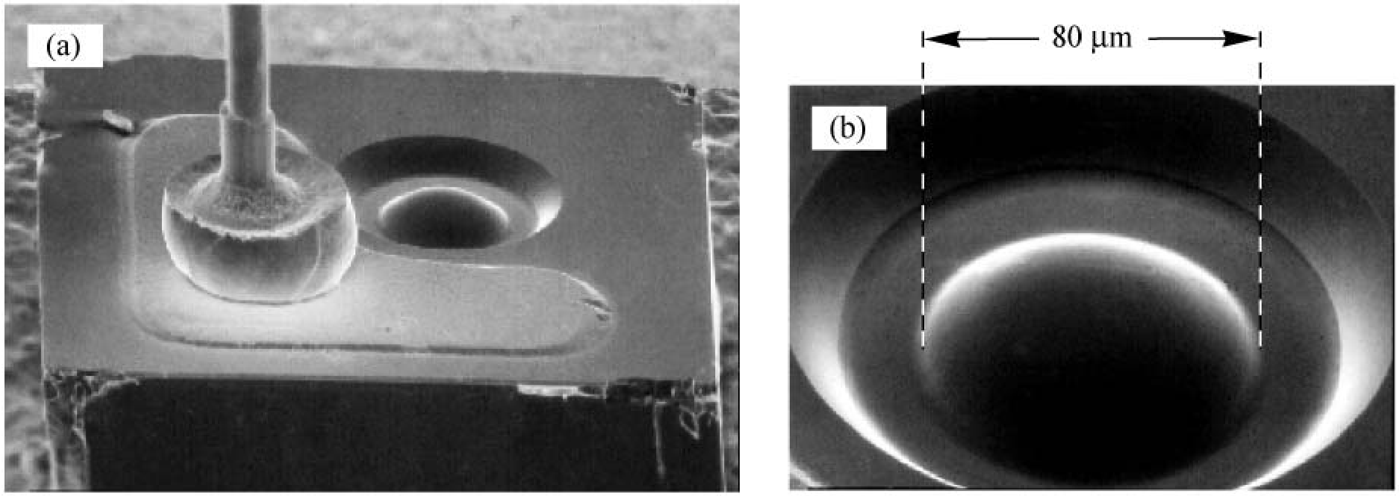


Fig. 22.8. (a) Commercial communication LED chip with integrated lens. (b) Detailed picture of the lens etched by a photochemical process into the GaAs substrate (AT&T ODL procuct line, 1995).