07 LED-fortschrittliche Strukturen und Packaging

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Verschiedene Möglichkeiten um Strukturen und Effizienz von LEDs zu erhöhen:

- Doppelheterostrukturen (Urbachteil, Absorption)
- Form – Geometrie der LEDs
- Kontaktfomierung (Transparenz, effiziente Stromzuführung)
- Waferbonding – transparente Substrate

Das "Packaging" (Verpacken) der hat eine entscheidenden Einfluss auf:

- Lichtauskoppelung (Antireflexionsbeschichten)
- Abstrahlcharakteristik
- Stromzuführung
- Wärmeabführung (Verlustwärme)!
- ESD (electrostatic discharge) Elektrostatische Entladung

Urbachtail

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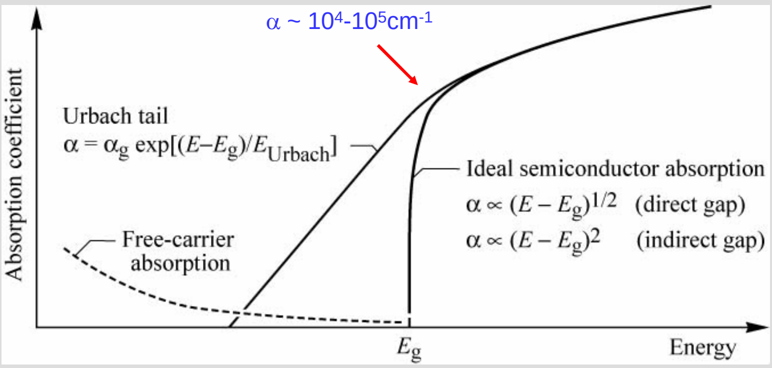
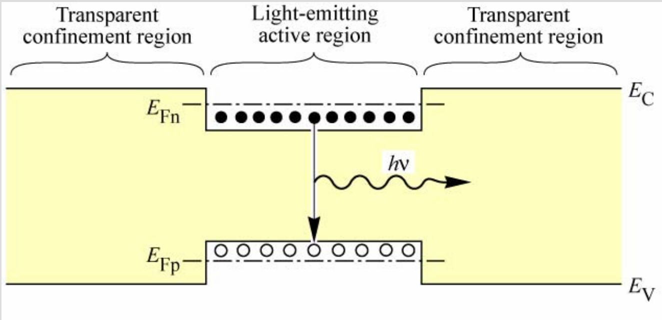


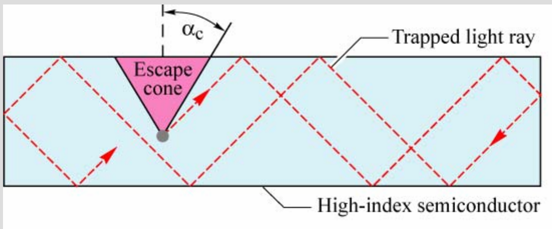
Absorptionskoeffizient eines Halleiters mit einer Bandlücke E_g versus Energie. Der "Urbach-tail" dominiert die Absorption knapp unterhalb der Bandlücke. Bei tieferen Energie ist die freie Ladungsträgerabsorption dominat.

DH-Struktur mit optisch transparenten Bereichen 3

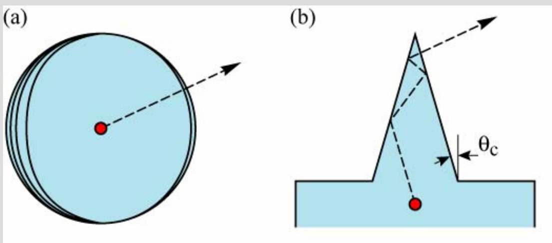


Doppelheterostruktur mit optisch tranparenten Confinementbereichen. Reabsorption ist in der aktiven Zone unwahrscheinlich, da in der aktiven Zone wegen der hohen Ladungsträgerkonzentration und der daraus resultierenden Burstein-Moss-Verschiebung der Absorptionskante.

verschiedene Lichtauskopplung 4



"Trapped light" in a rectangular-parallelepiped-shaped semiconductor unable to escape for emission angles greater than α_c due to total internal reflection.



Schematic illustration of different geometric shapes for LEDs with perfect extraction efficiency. (a) Spherical LED with a point-like light-emitting region at the center of the sphere. (b) A cone-shaped LED.

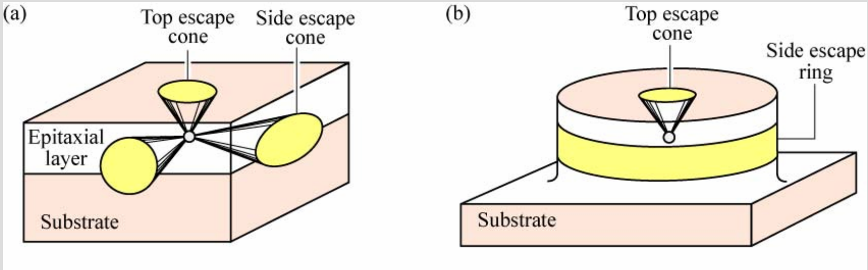
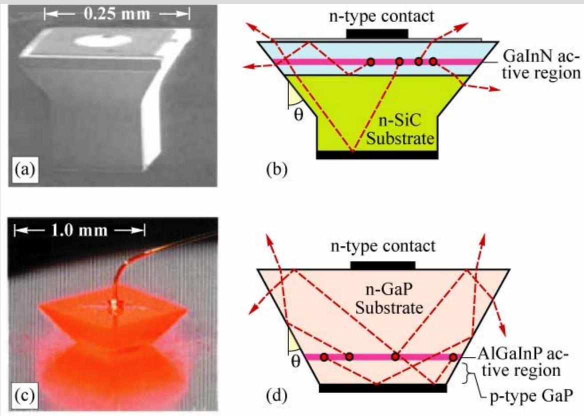
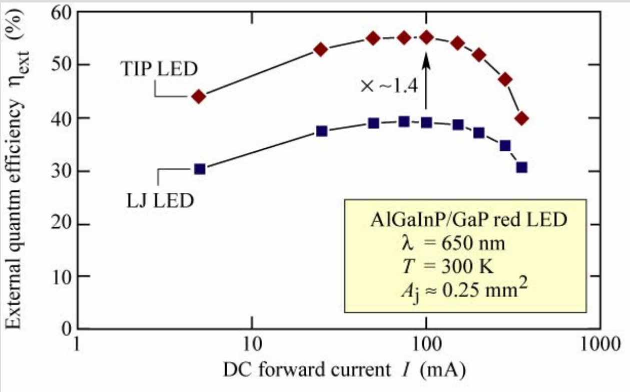


Illustration of different geometric shapes of LEDs. (a) Rectangular parallelepipedal LED die with a total of six escape cones. (b) Cylindrical LED die with a top escape cone and a side escape ring.



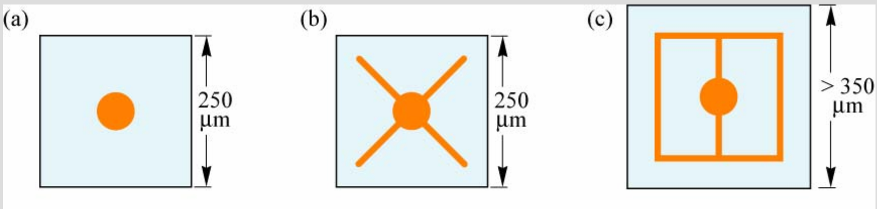
Die-shaped devices: (a) Blue GaInN emitter on SiC substrate with trade name “Aton”. (b) Schematic ray traces illustrating enhanced light extraction. (c) Micrograph of truncated inverted pyramid (TIP) AlGaInP/GaP LED. (d) Schematic diagram illustrating enhanced extraction (after Osram, 2001; Krames *et al.*, 1999).

Rote TIP und LJ LEDs



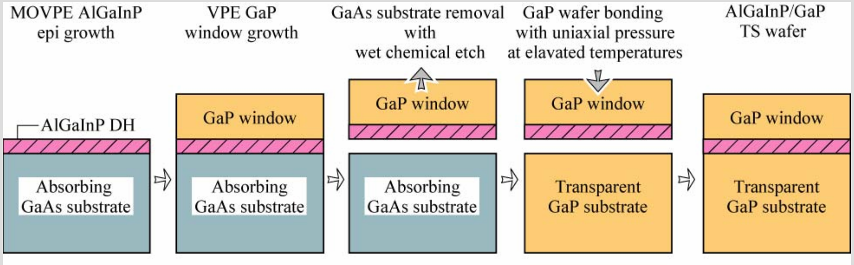
External efficiency vs. forward current for red-emitting (650 nm) truncated inverted pyramid (TIP) LEDs and large junction (LJ) LEDs mounted in power-lamp packages. The TIP LED exhibits a 1.4 times improvement in extraction efficiency compared with the LJ device, resulting in a peak external quantum efficiency of 55 % at 100 mA (after Krames *et al.*, 1999).

Verschiedene Kontaktformen



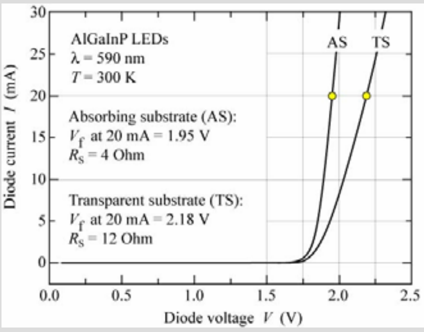
Top view on an LED die with (a) a circular contact also serving as a bond pad and (b) a cross-shaped contact with a circular bond pad. (c) Typical contact geometry used for larger LED dies.

Wafer-bonded transparentes Substrat 9

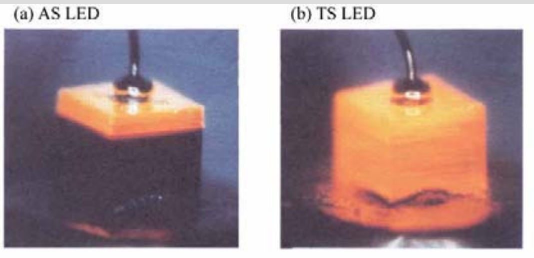


Schematic fabrication process for wafer-bonded transparent substrate (TS) AlGaInP/GaP LEDs. After the selective removal of the original GaAs substrate, elevated temperature and uniaxial pressure are applied, resulting in the formation of a single TS LED wafer (adopted from Kish *et al*., 1994).

Einfluss von einem transparenten Substrate auf IV und Abstrahlung 10

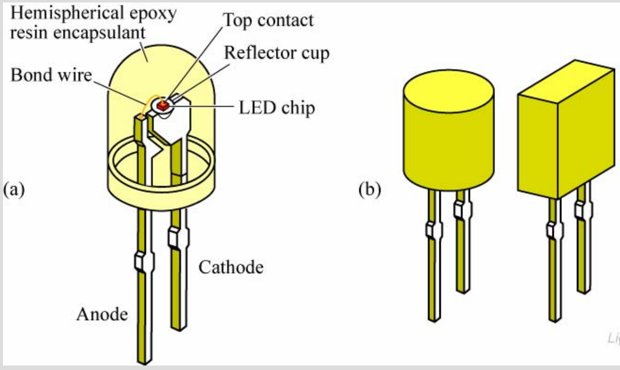


Current–voltage characteristic, forward voltage, and series resistance of absorbing-substrate (GaAs) and transparent-substrate (GaP) LEDs with AlGaInP active regions.



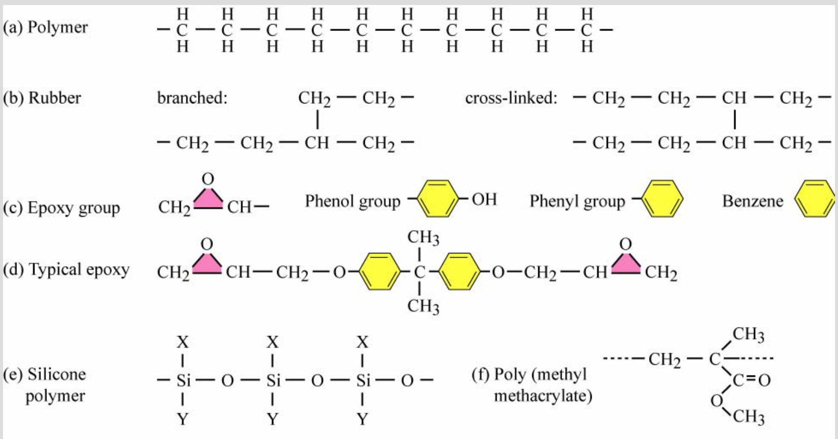
(a) Amber AlGaInP LED with a GaP window layer and absorbing GaAs substrate (AS). (b) Amber AlGaInP LED with a GaP window layer and a transparent GaP substrate (TS) fabricated by wafer bonding. Conductive Ag-loaded die-attach epoxy can be seen at bottom (after Kish and Fletcher, 1997).

Packaging



Typical packages; (a) LED with hemispherical encapsulant; (b) LEDs with cylindrical and rectangular encapsulant.

Chemische Struktur verschiedener Polymere



Chemical structures of polymers. Epoxy resins, silicone polymers, and poly methyl methacrylate (PMMA) are used as LED encapsulants. In the silicone structure, X and Y represent atoms or molecules such as H, CH_3 (methyl), C_6H_5 (phenyl).

Hochleistungsgehäuse - Querschitt

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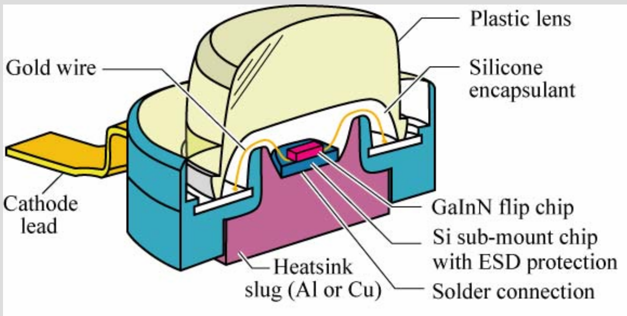

Cross section through high-power package. The heatsink slug can be soldered to a printed circuit board for efficient heat removal. This package is called *Barracuda package* which was introduced by Lumileds Corp. (adopted from Krames, 2003).

Hochleistungsgehäuse

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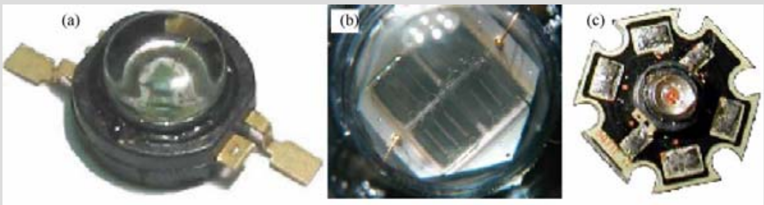
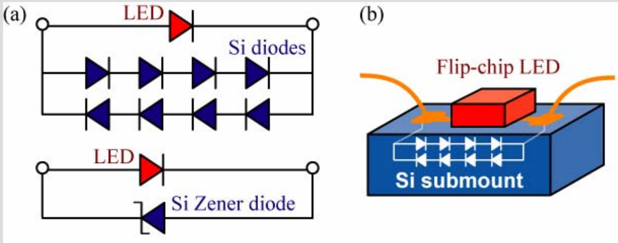


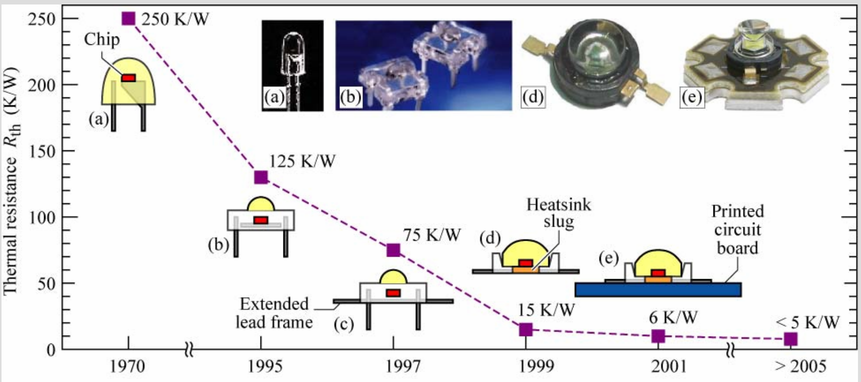
(a) High-power package; (b) LED die in package; (c) package on printed circuit board with high thermal conductivity. ((a) after Krames, 2003; (b), (c) after after LED Museum, 2003).

Elektrostatische Entladung



(a) Electrostatic discharge (ESD) protection circuits using multiple pn junctions or Zener diodes. (b) ESD protection incorporated in Si submount.

Wärmewiderstand von LED Gehäusen



Thermal resistance of LED packages: (a) 5mm (b) low-profile (c) low-profile with extended lead frame (d) heatsink slug (e) heatsink slug mounted on printed circuit board (PCB). Trade names for these packages are "Piranha" (b and c, Hewlett Packard Corp.), "Barracuda" (d and e, Lumileds Corp.), and "Dragon" (d and e, Osram Opto Semiconductors Corp.) (adopted from Arik *et al.*, 2002).