https://www.hella.com/techworld/us/technical/automotive-lighting/led-headlights-833/

LED HEADLIGHTS

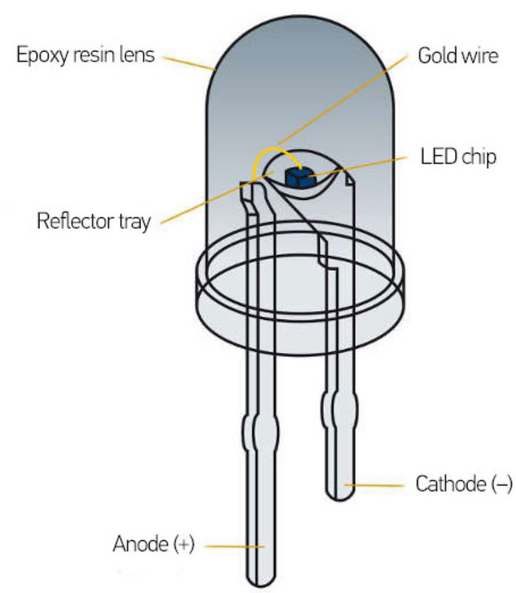
LEDs are currently in the process of replacing classic bulbs in modern vehicles. They not only provide high luminous efficiency and increased safety, but also more design freedom and a great level of savings potential.

BASIC PRINCIPLES OF LED CAR LIGHTS

LED stands for "light emitting diode", as it turns electrical energy into light. Physically, it is a cold-light source and an electronic semiconductor component part in optoelectronics.

Structure

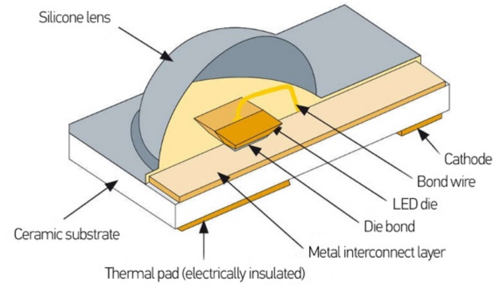
LEDs are available in the widest range of sizes, designs, and colours, depending on requirements. The classic variant (standard LED) has a cylindrical shape and is closed by a hemisphere at the spot where the light is emitted.



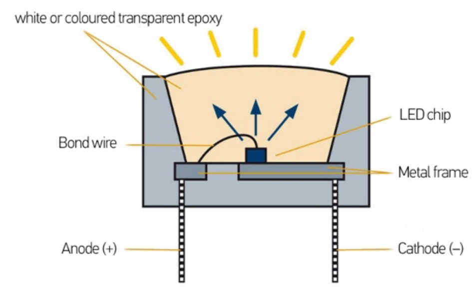
Simple LEDs consist of the following components

- LED chip
- Reflector tray (with contact to cathode)
- Gold wire (contact to anode)
- Plastic lens (combines and holds components)

Small and durable – The high-performance diode



High-performance diodes possess a large metal blank that allows for a better heat regulation. As the heat is dissipated more easily, more current can flow through the diode, the light emission covers more area, and the light output is higher. Compared to a simple 5 mm LED, the heat resistance is reduced tenfold. A high-performance diode has a square emission area of about 1 mm with a light output of 40-100 Lumen. The small, flat design of LEDs offers considerable leeway for ground-breaking product designs:



Designs

There are different types and designs of LEDs. According to their area of application, they differ in structure, power, and service life. Among the most important LEDs are:

Leaded LEDs

Leaded LEDs are the forerunners of all LEDs, and they are mainly used for control purposes. Nowadays they are used as a combination of several LEDs in LED spotlights, fluorescent tubes or modules. They are available in 3, 5 and 10 mm sizes. You recognise the cathode, the negative pole of a leaded LED, by the fact that it is shorter than the anode (positive pole) and that the plastic coating is flattened. The exit angle of the light is determined by the lens shape of the housing.

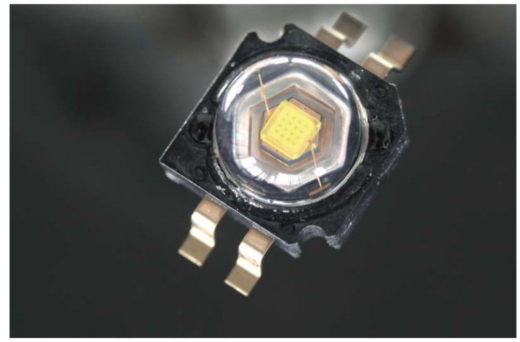
SuperFlux

SuperFlux LEDs are more powerful than regular leaded LEDs, and they have up to four chips (semiconductor crystals). They offer a broad beam angle and are particularly used for area lighting, as the light is emitted over an area. A good heat dissipation is achieved via four contacts, which can be individually controlled. The structure of the High Flux ensures a long service life and makes them an efficient light source that can be universally used.

SMD

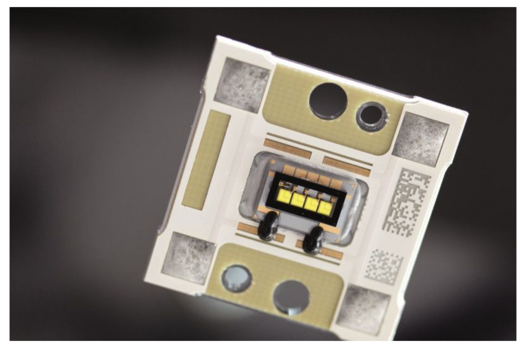
SMD stands for "Surface Mounted Device", which means that this diode is used surface-mounted. SMD LEDs usually consist of three to four chips and have solder contacts, which are soldered to the printed circuit board or connection surface. Regarding the current density, they are relatively insensitive and therefore can shine intensively. In the automotive industry, they are primarily used for direction indicators, stop lamps, or daytime running lights.

High Power



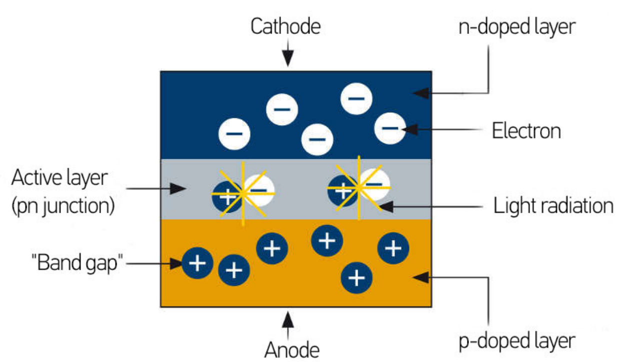
High-power LEDs are powerful and robust LEDs, which can be operated at currents of 1000 mA under ideal operating conditions. They are often used on metal-core PCBs. Their unusual design places increased demands on thermal management.

COB



The "Chip On Board" LED (COB) is the most advanced LED. It has this name because it is directly attached to the circuit board. This is achieved by so-called "bundling" which attaches chips though a fully automatic process on the gold-plated PCB. The contact to the opposite pole is achieved via a gold or aluminium wire. As COB LEDs do not use reflectors or lens optics, the beam angle of the emitted light is very wide. The greatest advantages of COB technology are the high illuminating power, the homogenous illumination and the numerous areas of application.

But what do LEDs consist of?



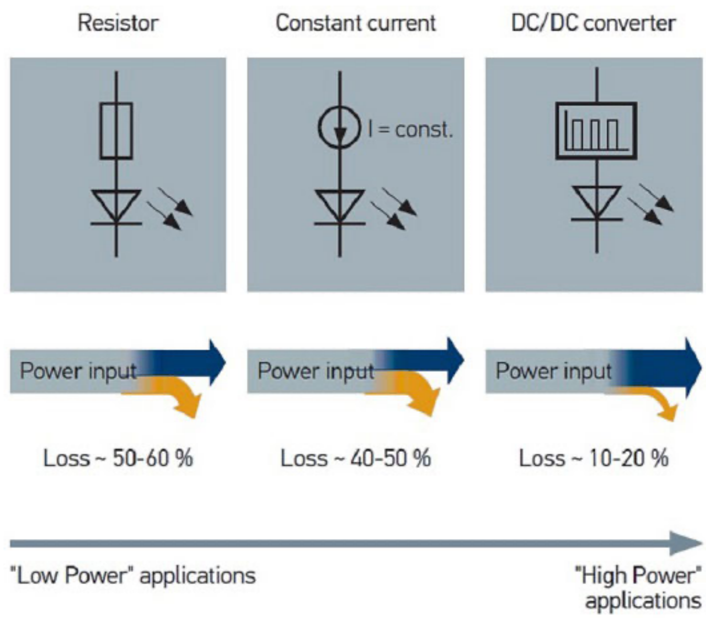
Basically, an LED consists of several layers of semiconductor compounds. Semiconductors, such as silicon, are materials whose electrical conductivity lies between that of conductors, such as the metals silver and copper, and non-conducting materials (insulators) such as PTFE or quartz glass. The conductivity of semiconductors can be greatly influenced by the specific introduction of electrically effective external substances (by means of a process known as doping). The different semiconductor layers together form the LED chip. The type of structure of these layers (various semiconductors) has a crucial bearing on the luminous yield (efficiency) and light colour of the LED.

If a current flows through the LED in the flow direction (from + to–), light is created (emitted).

The n-doped layer is prepared by the incorporation of foreign atoms so that there is a surplus of electrons. In the p-doped layer, there are only a small number of these charge-carriers. This produces so-called electron holes (band gaps). When a voltage (+) is applied across the p-doped layer and n-doped layer (-), the charge-carriers move towards each other. At the pn junction, recombination takes place (where oppositely-charged particles combine to form a neutral entity). This process releases energy in the form of light.

Electric properties – why too much current is damaging

If voltage is applied to an LED, the resistance falls to zero. LEDs are extremely sensitive components, and if the permissible current is exceeded even by a small quantity, they may be destroyed. Therefore **it is important never to connect LEDs directly to a voltage source**. They may only be connected if a current limiter or series resistor is built into the circuit. High-power LEDs are controlled via an electronic ballast that provides a constant current.



Service life

The service life greatly depends on the location and the provided current density. The higher the current flow, the more the diode heats up. This shortens the service life. The lower the temperature, the brighter and longer the LED shines. Appropriate cooling should therefore always be ensured. In addition to the heat produced by the LED, other sources of heat, such as heat from the engine or insolation, must also be taken into account. The intensity of the light radiation in LEDs continually decreases over time. This is an advantage, as unlike traditional lamps (incandescent bulb, halogen), an LED doesn't suddenly leave you standing in the dark. Even if the illuminating power is reduced, it normally does not suddenly fail. The plastic normally used in the lenses of LEDs gradually becomes hazy, which also affects the luminous efficiency negatively.

The future of the LED – optimal lighting conditions for vehicles

LEDs offer great functionality, technical performance, and optimal lighting results. They support saving energy resources and provide more safety in traffic. Furthermore, the daylight-like colour of the light allows for a pleasant and subjectively increased perception of the light.

LIGHTING AT THE HIGHEST STANDARD

Since 2010, the Audi A8 has been optionally available with a full LED headlamp. Ten projection lenses create a unique low beam. The daytime running light also offers unique features, as it was combined with both the direction indicator and the position light. The LED technology makes the structure of a headlamp very complex. Compared to previous headlamps, the number of component parts in a headlamp has increased significantly.

LED HEADLIGHTS ADVANTAGES: COMPARISON

LEDs are superior in several aspects. They might be more expensive to purchase than normal light bulbs or halogen bulbs, but their use pays for itself in a short time.

Light Source	Luminous flux [lm]	Efficiency [lm/W]	Colour temperature [K]	Luminance [Mcd/m²]
Conventional bulb W5W	~ 50	~ 8	~ 2700	~ 5
Halogen bulb H7	~ 1100	~ 25	~ 3200	~ 30
Gas discharge D2S	~ 3200	~ 90	~ 4000	~ 90
LED 2.5 Watts	~ 120 (2010) ~ 175 (2013)	~ 50 (2010) ~ 70 (2013)	~ 6500	~ 45 (2010) ~ 70 (2013)

Main advantages

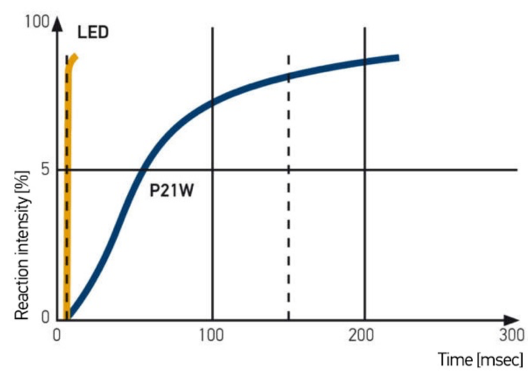
- Low energy consumption
- Long service life
- Impact and vibration-resistant
- Reduced heat build-up
- No maintenance or cleaning costs
- Mercury-free
- Good glare limitation
- Inertialess switching and modulation
- High-quality light projection
- Numerous designs (can be used almost everywhere)
- Individual light source configuration
- Light temperature remains during dimming
- Light colour can be regulated
- Low production costs
- Increased light output per chip
- Extremely few early failures
- Very compact dimensions
- No UV or IR radiation
- Low power consumption
- Directional light – Lambertian radiator with 120°beam angle
- High saturation

Fuel savings through combination of various light sources

Vehicle configuration (headlamp/rear light)	Fuel consumption [L/100 km]	CO_2 emission [kg/100 km]	Decrease
Halogen/conventional	~ 0.126	~ 0.297	-
Xenon/LED	~ 0.077	~ 0.182	39%
LED/LED	~ 0.051	~ 0.120	60%

Fuel consumption and CO_2 emission for an average operating time of the lighting system.

Reduced stopping distance – with the LED, you are on the safe side



The number of vehicles on the road is increasing worldwide. The increased traffic density on the roads leads to more frequent rear-end collisions. To avoid these, the driver must perceive light signals quickly. While a conventional incandescent bulb needs up to 0.2 seconds to light up, an LED reacts immediately. It does not require a warm-up phase and lights up immediately as soon as the brake pedal is depressed. The rear vehicle can thus react more quickly to the braking action of the vehicle in front.

Example: Two vehicles are driving in the same direction at a speed of 100 km/h (safety distance 50 m). The vehicle in front brakes, and the driver of the second vehicle reacts to the LEDs lighting up immediately and brakes at almost the same moment. This reduces the stopping distance by almost 5 m and represents an enormous increase in safety.

[At highway speeds, using LED taillights instead of incandescent taillights has the same effect as increasing the distance between vehicles by one car length.]