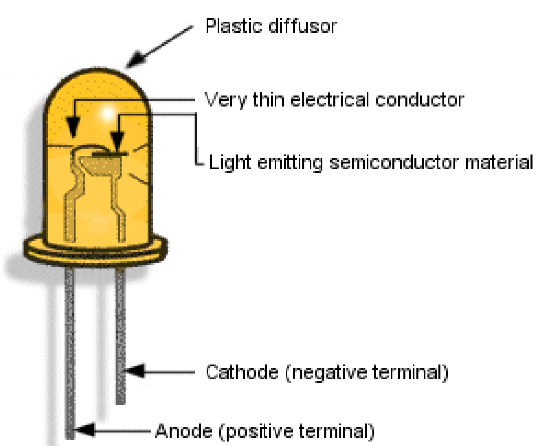
Light Emitting Diodes (LED) 101

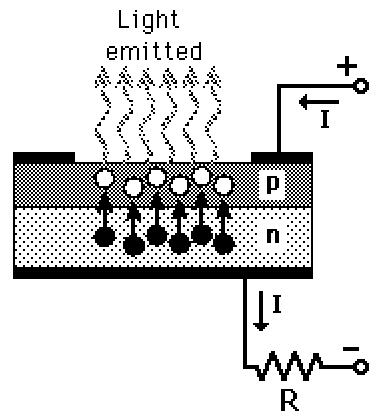
Everyone is familiar with light-emitting diodes (LEDs) from their use as indicator lights and numeric displays on consumer electronics devices. New LED materials and improved production processes have produced bright LEDs in colors throughout the visible spectrum, including white light, with efficacies grater that incandescent lamps. These brighter, more efficacious, and colorful LEDs move LED technology into a wider range of lighting applications.

Already a leading light source for exit signs and developing as a popular source for traffic signals, LEDs also appear in display, decorative, and transportation applications, with plenty of opportunity for expansion. Small, lightweight, durable, and with long life, LEDs have the long-term potential to be the source of choice in many applications, from automotive brake lights to indicator lights.

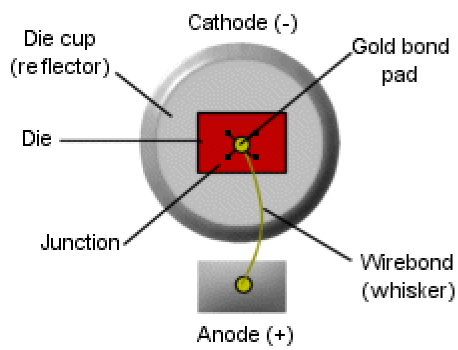
What are LEDs and how do they work?



LEDs are solid-state semiconductor devices that convert electrical energy directly into light. LED "cold" generation of light leads to high efficacy because most of the energy radiates in the visible spectrum. Incandescent, and to a lesser extent fluorescent, lamps radiate much energy in the non-visible spectrum, generating heat as well as light.



Light is generated inside the chip, a solid crystal material, when current flows across the junction of the different materials. The light-generating chip is quite small, typically 0.25 millimeters square. The plastic encapsulate and lead frame occupy most of the volume. Presently, the most commonly used LEDs is the 5 mm LED package (or T1-3/4).



Typical "ordinary" LED

Manufacturing LEDs involves a process known as epitaxy in which crystalline layers of different semiconductor materials are grown on top of one another. Advances in epitaxial crystal growth processes have enabled the use of LED materials for colors that previously could not be made with high enough purity and structural precision. The technique of chemical vapor deposition from metal organic precursors enables the cost-effective production of nitrides of the group-III metals from the periodic table, including aluminum gallium indium nitrides. Highly efficient indium gallium nitride (InGaN) blue LEDs result from this process.

LEDs emit energy in narrow wavelength bands of the electromagnetic spectrum. The composition of the materials in the semiconductor chip determines the wavelength and therefore the color of the light. A chip of aluminum gallium indium phosphide (AlGaInP) produces light in the red to amber range, while InGaN LEDs produce blue, green, and white light.

The first LEDs bright enough to use in outdoor applications were aluminum gallium arsenide (AlGaAs). These red LEDs appeared as high mount stop lights on automobiles and in a limited number of traffic lights. Today the US exit sign market has been almost completely transformed from incandescent sources to LEDs. A 1998 Lighting Research Center survey of exit sign sales representatives found that about 80 percent of exit signs being sold in the United States use LEDs as the primary light source. (In Europe, exit signs are green, which has made the transformation much more difficult, due to higher prices and the more recent development of ultra bright green LEDs.)

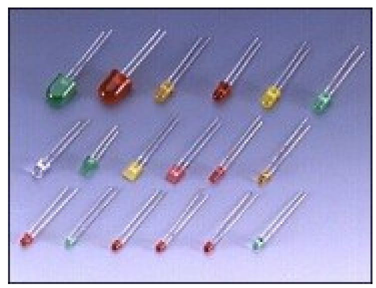
Similar transformations have occurred in roadway work zone safety lights used in the US and in some other countries, and variable message signs when AlGaInP LEDs became available. AlGaInP and InGaN LEDs have succeeded AlGaAs as the brightest available LEDs.[1]

Construction

Light Emitting Diodes (LEDs) typically consists of four components: a lead frame, a dice, and a fine wire bond, all encapsulated in an epoxy body. The light emitted by an LED is considered monochromatic, or having only one color. LEDs are offered in five colors: red, green, yellow, blue and white, although variations of these basic colors are available. The light emitted by an LED is always in a single color or wavelength.

When selecting an LED, the following key areas must be considered:

1. Package style and size
2. Color required
3. Intensity required
4. Viewing angle
5. Operating Voltage and current.



Terms and definitions

Lamp Sizes:

Typically the industry utilizes standard descriptive designations such as T1-3/4, T-1 and T-3/4. These refer specifically to the diameter of the lamp in 1/8 inch increments. (Example: T1-3/4 is 1 3/4 x .125" or .219" in diameter.)

Package Types:

Descriptive terms such as diffused, non-diffused, water clear and pale tint are typically used. Diffused lenses have an opaque appearance and are typically found on wider viewing angled LEDs. Non-diffused have a clear, unobstructed appearance to them and are typically tinted the color of the emitted light. Water clear is a term used to describe a non-diffused lens with no color tint. In the OFF state the LED appears clear like glass, yet in the ON state it emits its source color.

Package Styles:

Discrete LED- The term discrete is typically used to describe a single lamp utilizing a single dice as the source of light.

Circuit Board Indicator- C.B.I. is a term used to describe an LED that has been packaged in a plastic housing. Many are designed to position the LED at a right angle to the PCB allowing them to be used as panel indicators or status indicators.

Lamp Replacement Modules- is a term used to describe an LED or a cluster of LEDs that has been packaged and based to fit a standard incandescent or fluorescent socket.

Light Bars- Light bars are multiple LED dice mounted and encapsulated in a large rectangular package. Light bars are typically used in applications requiring large evenly illuminated areas.

Bar Graphs- Bar graphs are multiple LED dice mounted in a single housing. The segments are individual and can be addressed independently from one and another.

Seven Segments Displays- Are numeric characters made up of seven separate LED segments mounted in a single housing. Seven segment displays are available in various colors, character heights and in single and multiple digit configurations.

Sixteen Segment Displays- Are Alpha Numeric characters made up of sixteen separate LED segments mounted in a single housing. Allowing for both letters and numbers to be generated. Sixteen segment displays are available in various colors, character heights and in single and multiple digit configurations.

Dot Matrix Displays- Are blocks of discrete LEDs or dies encapsulated in a single module that allows each discrete "dot" to be addressed separately, allowing for full graphic capabilities. Dot Matrix displays are available in various heights and in single and multiple color configurations.

Indicator Lights-These indicator lights are typically discrete LEDs enclosed in an easily mounted plastic housing. Many configurations utilize lenses for enhanced viewing and built-in resistors for easy application at system voltages.

Cluster Lamps- This term describes a multi die or multi discrete LED module. This module can be produced in many different termination configurations to replace incandescent lamps in existing sockets allowing for cooler running and longer life at a reduced voltage cost.

Lens Color:

This is the color of the LED lens in the OFF state.

Emitted Color:

This is the color of the light emitted from the LED when it is energized. It is independent and unaffected by the lens color.

Luminous Intensity:

This term describes the light output of the LED and is typically expressed in millicandela at a defined current level. All LEDs have a minimum and typical luminous intensity rating. The intensity of an LED is always a function of forward current as expressed in milliamps.

Viewing Angle:

Is a representation of the typical light output pattern for the LED. It is measured by determining the angle between half intensity points on either side of the lamp axis. Typically the wider the viewing angle the lower the luminous intensity.

Peak Wavelength:

This is the wavelength at which the majority of the energy (light) is emitted by the LED. This measurement is typically expressed in nanometers.

Maximum Power Dissipation:

Expressed in milliwatts this is the maximum power rating for the LED.

Continuous Forward Current:

This is the maximum continuous operating current the LED can withstand without incurring life limiting damage.

Reverse Voltage:

Because and LED is a "diode," it is a polarized device having an anode and cathode connection. To energize the LED the voltage must flow in the correct direction. If the voltage is reversed, damage to the LED may result if this rating is exceeded.

---

1. Kathleen Daly, Andrew Bierman, Lighting Research Center in Troy, New York USA . The IAEEL newsletter 2/99, issue no. 23, Vol 8 www.jaeel.org