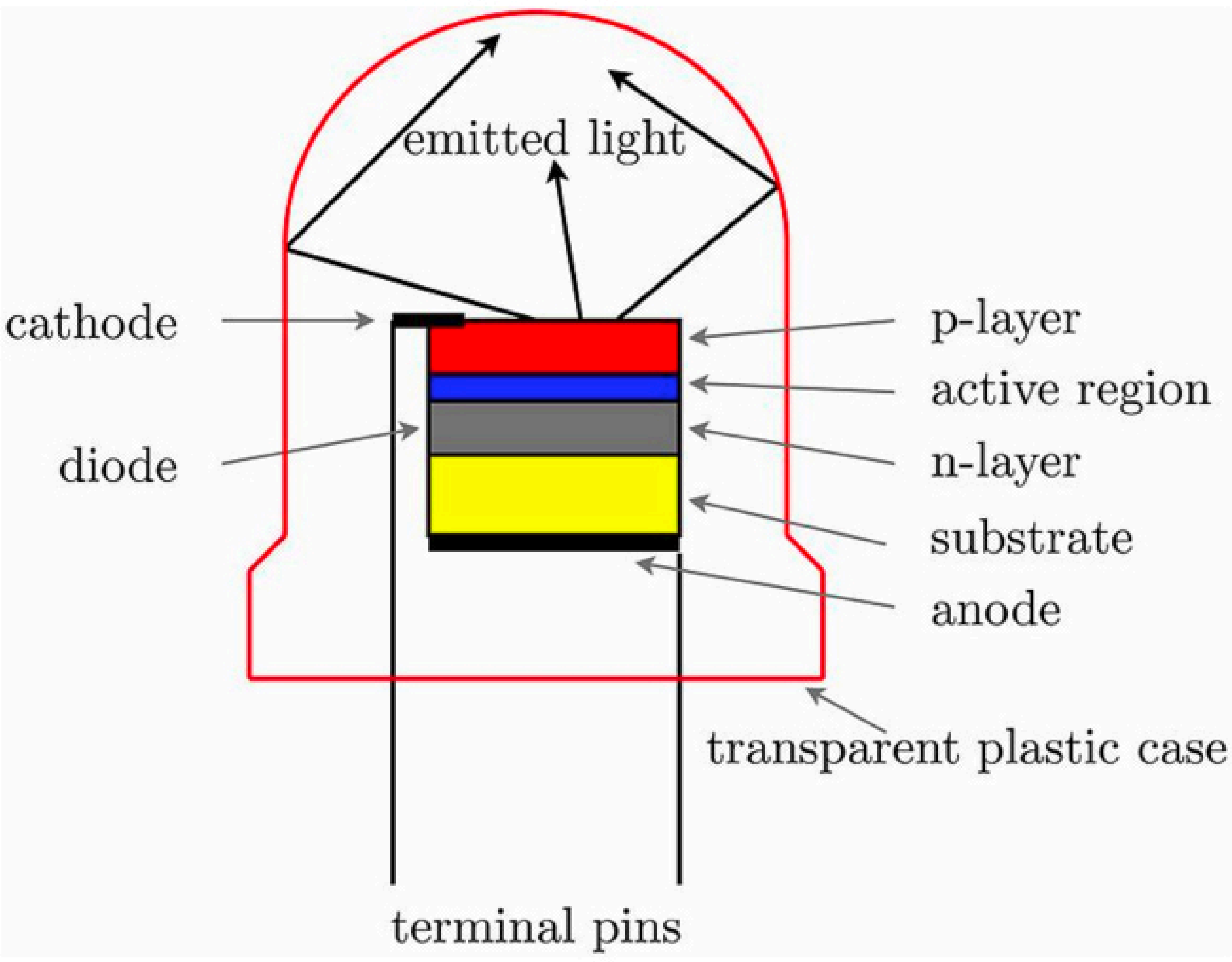
Posted in: General LED Information   Written by Gretchen Heber

How are LEDs Made?



Invented in the years after World War II, LEDs have revolutionized modern life. Ubiquitous in the electronics we use every day, LEDS are carefully and precisely fabricated in a complex and highly scientific process using highly specialized equipment.

LEDs are made from very thin layers of semiconductor material; one layer will have an excess of electrons (the n-layer), while the next will have a deficit of electrons (the p-layer). This difference causes electrons to move from one layer to another, thereby generating light.

Modern LEDs are manufactured using the metal organic chemical vapor deposition process. MOCVD is a technique for depositing thin layers of atoms onto a semiconductor wafer. Using MOCVD enables layers of precisely controlled thicknesses to be deposited, creating a material that has specific optical and electrical properties. Using this technique, it's possible to build a range of complex semiconductor structures, including LEDs.

Complex MOCVD-created semiconductors consist of not just one element, but rather of two or even more. They are therefore referred to as "compound semiconductors" (they're also called "III-V semiconductors" because they are made from elements of group III and V of the periodic table and can interact to form crystalline compounds.). The elements used in these semiconductors include gallium arsenic (GaAs), indium phosphide (InP), gallium nitride (GaN) and related alloys. Each element or combination of elements produces a particularly colored LED. For example, the use of indium gallium nitride ($In_xGa_{1-x}N$), made of a mix of gallium nitride (GaN) and indium nitride (InN), results in a blue LED. The application of elements can be precisely managed to further refine the exact wavelength, i.e. 415nm blue, of light emitted by the LED.

To produce these compound semiconductors, chemicals are vaporized, combined in a reactor with complex organic gas molecules and passed over a hot semiconductor wafer. The heat breaks up the molecules and deposits the desired atoms on the surface of the substrate (often sapphire), layer by layer. By varying the composition and dose of the ultra-pure gas, the properties of the crystal can be changed at an atomic scale. This method can grow high quality semiconductor layers (as thin as a millionth of a millimeter).

This precise deposition is critical for LED manufacture. The thinnest films required in an LED structure are less than one nanometer (0.000001mm) thick. Such thin film layers are usually deposited on substrates of four-inch size. Depending on the chip size, a 4-inch water can deliver between 4,000 and 120,000 LED chips.

The LEDs undergo multiple chemical etching processes, and multiple metal deposition operations on the n- and p-junctions create the anode and cathode electrons. At this point, the wafers are diced into pepper-flake-sized LEDs. Optical and electrical parts are added to the chips, resulting in an LED "package" or "array," which is used in a light fixture.

This is a simplified description of an extremely intricate and highly technical process — a process that has fundamentally changed the way we see the world.