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Review Article

Comparison of LED and OLED

Askari Mohammad Bagher
Department of Physics, Payame Noor University, Tehran, Iran

***Corresponding author**
Askari Mohammad Bagher
Email: askarimohammadbagher@gmail.com

Abstract: LED stands for light-emitting diode. These are little solid-state devices that make light because of the movement of electrons through a semi-conductor. LEDs are relatively small compared to compact fluorescent and incandescent light bulbs, but they can get extremely bright. However, LEDs aren't small enough to be used as the pixels of a television – they're way too big for that. That's why LEDs are only used as the backlight for LCD televisions. OLED stands for organic light-emitting diode. Very simply put, an OLED is made with organic compounds that light up when fed electricity. That may not seem like a huge difference when compared to LED, but OLEDs can be made to be extremely thin, small and remarkably flexible. On an OLED TV, each pixel lights itself up independently of the others. In this article we will Compared OLED and LED.
Keywords: OLED, LED, LCD, LEC, PMOLED, AMOLED, PLED.

Introduction:

The first true LED television was initially developed in 1977 by James P. Mitchell. Eventually, LED technology was developed in conjunction with LCD TVs, backlighting the LCD screen pixels. OLED technology was initially developed by Eastman Kodak Company. The initial use of OLED technology was in wristwatches, car stereos, and MP3 players, among other devices. OLED TVs are now gaining in popularity, although they tend to cost more compared to LED-backlit LCD TVs[1]. In terms of picture quality, OLED TVs are superior to LED/LCD TVs in nearly every way. But picture quality isn't the only consideration at play. Let's do a point-by-point breakdown of how OLED and LED TVs stack up against each other [2].

How LED Technology Works:

Currently the LED lamp is popular due to its efficiency and many believe it is a 'new' technology. The LED as we know it has been around for over 50 years. The recent development of white LEDs is what has brought it into the public eye as a replacement for other white light sources. LEDs create light by electroluminescence in a semiconductor material. Electroluminescence is the phenomenon of a material emitting light when electric current or an electric field is passed through it - this happens when electrons are sent through the material and fill electron holes. An electron hole exists where an atom lacks electrons (negatively charged) and therefore has a positive charge. Semiconductor materials like germanium or silicon can be "doped" to create and control the number of electron holes. Doping is the adding of other elements to the semiconductor material to change its properties. By doping a semiconductor you can make two separate types of semiconductors in the same crystal. The boundary between the two types is called a p-n junction. The junction only allows current to pass through it one way, this is why they are used as diodes. LEDs are made using p-n junctions. As electrons pass through one crystal to the other they fill electron holes. They emit photons (light) [3].

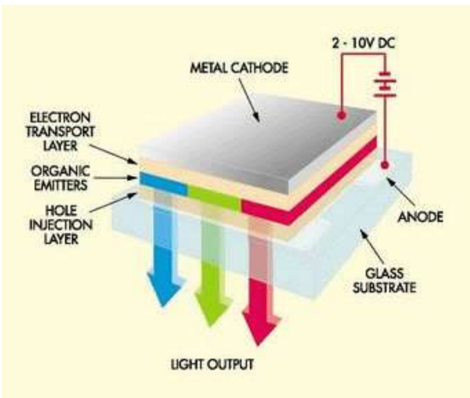

Fig 1: LED structure

LED TVs

Basically, LED TVs are LCD TVs with LEDs in place that backlight the pixels of an LCD, since they don't emit any illumination of their own. There are three types of LED technology primarily used by LED TV manufacturers, including white-edge LEDs, LED arrays, and dynamic LEDs. The below describes these three LED technologies:

1. White-Edge LEDs: Placed around the edge of the screen. They use a special panel, called a diffusion panel, to spread the light produced by the LEDs evenly behind the TV screen.
2. LED Arrays: Arranged behind the TV screen, the brightness cannot be controlled individually.
3. Dynamic LEDs: An array of LEDS controlled either individually or in clusters so that the LEDs can be dimmed locally to modulate the backlight light pattern.

How OLED Technology Works:

Early OLEDs had one layer of organic material between two electrodes. Modern OLEDs are bi-layer, they have an emissive layer and conductive layer sandwiched between two electrodes.

1. Electric current passes from the cathode to the anode. It passes through two layers of organic molecules.
2. The first layer the electrons pass into what is called the emissive layer. Electrons leave the conductive layer making 'holes' (positive charge). Meanwhile in the emissive layer there are excessive electrons (negative). The 'holes' jump to the emissive layer along the border of the two layers where they recombine with electrons (this place is the p/n junction). When the electrons join the holes light is emitted. Light color is dependent on the materials used in the organic or polymer layers.

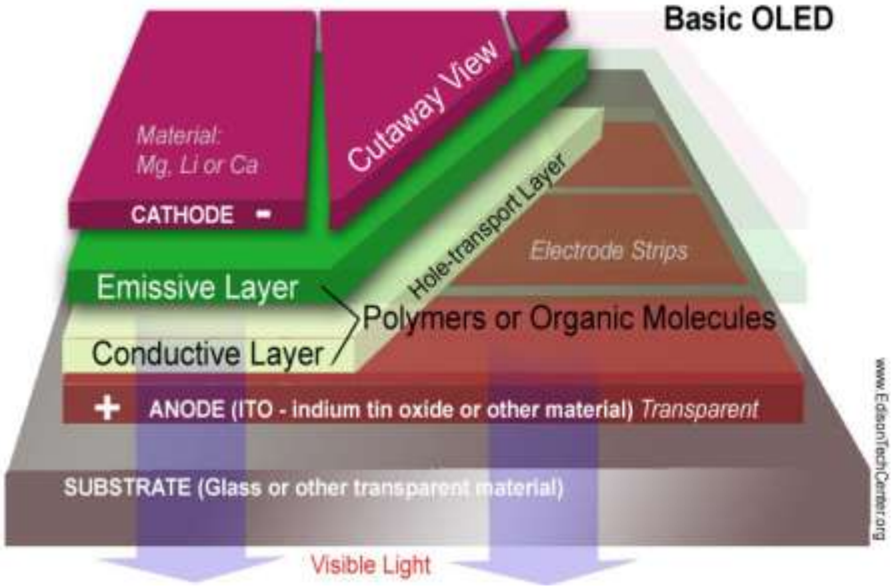

Fig 2: The figure is a simple modern OLED. There are a many new ways to construct the OLED using a variety of layer configurations. Displays will have additional layers such as an active matrix TFT (thin film transistor) which control pixel regions.

Types of OLEDs:

LEC (Electrochemical Cell):

In the scientific community, our liquid light concept is known as the Light-Emitting Electrochemical Cell (LEC). From a distance and a layman’s perspective, this technology is very similar to the Organic Light-Emitting Diode (OLED), as both technologies use a flat planar structure in which the light-emitting organic layer is sandwiched between two conductive electrodes.[4]

PMOLED (Passive-matrix OLED):

PMOLED stands for Passive-Matrix OLED, which relates to the way you control (or drive) the display. A PMOLED display uses a simple control scheme in which you control each row (or line) in the display sequentially (one at a time). PMOLED electronics do not contain a storage capacitor and so the pixels in each line are actually off most of the time. To compensate for this you need to use more voltage to make them brighter. So while PMOLEDs are easy (and cheap) to fabricate, they are not efficient and the OLED materials suffer from lower lifetime (due to the high voltage needed). PMOLED displays are also restricted in resolution and size (the more lines you have, the more voltage you have to use). PMOLED displays are usually small (up to 3" typically) and are used to display character data or small icons: they are being used in wearable devices, small gadgets and sub displays.

AMOLED (Active-matrix OLED):

There are two types of OLED displays - PMOLED and AMOLED. The difference is in the driving electronics - it can be either Passive Matrix (PM) or Active Matrix (AM). An AMOLED (Active-Matrix OLED) is driven by a TFT which contains a storage capacitor that maintains the line pixel states, and so enables large size (and large resolution) displays. AMOLEDs can be made much larger than PMOLED and have no restriction on size or resolution. The term AMOLED means Active-Matrix OLED. The 'active-matrix' part refers to the driving electronics, or the TFT layer. When you display an image, you actually display it line by line (sequentially) as you can only change one line at a time. An AMOLED uses a TFT which contains a storage capacitor which maintains the line pixel states, and so enables large size (and large resolution) displays. Used in displays, it has a switch built into it in the form of a thin film transistor backplane. The transistor allows the unit to be switched on and off. [5]

PLED (polymer LED):

PLED is short for polymer, or polymeric, light-emitting diode, a backlighting, illumination and display technology. Polymers are substances formed by a chemical reaction in which two or more molecules combine to form larger molecules. PLEDs are thin film displays that are created by sandwiching an undoped conjugated polymer between two proper electrodes at a short distance. The polymer emits light when exposed to electricity. PLEDs enable full-spectrum color displays and are relatively inexpensive compared to other display technologies such as LCD or OLED and require little power to emit a substantial amount of light. PLED displays are great for hand held instruments that will not be running all the time. Before designing in a PLED or OLED be aware the life span is from 8000 hr. to 2000 hrs. They are great for medical test instruments where the product is used and then turned off. They have a 160 degree viewing angle; 1000 times faster update speed that an LCD, in fact our 128 x 128 Full Colors is capable of full motion video at 40 frames per second. They achieve a brightness of 80 cd/m2. They come in full color 65K and 256K. Most of the OLED Graphics are area color. [6]

OLED TVs

OLED TVs use organic material, in the form of carbon, to provide a natural light source to light the display. This allows for OLED TV screens to be larger, lighter, and retain consistent color from even the widest of viewing angles. The table below describes two types of OLED technology available: RGB and white OLED.

RGB OLED:

In an RGB OLED display, the red, green, and blue pixels are sandwiched together. When a current passes through the pixels, a white light is created. This light, in turn, passes through a color filter dividing it into the respective variations of the colors of red, green, and blue that forms the picture.

White OLED:

The light produced starts out as a white color. It then passes through the color filter, which in turn produces the colors seen on the screen. This type of OLED display is thought to be superior to the RGB OLED displays due to the longer life of the white OLEDs and the less chance of color shift.

The Differences between LED and OLED TVs

The differences between LED and OLED TVs include illumination methods, price points, and energy efficiency levels. The list below documents these differences.

1. The main difference between an LED TV and an OLED TV is that the pixels of an OLED TV are self illuminating, whereas the LEDs in an LED TV are used to light an LCD display.
2. LED TVs are currently less expensive than OLED displays, though eventually experts expect OLED TVs to drop significantly in price.
3. OLED TVs feature a wider viewing angle than do LED TVs. With OLED, the colors do not get washed out when viewers watch from extreme angles.
4. OLED technology offers the ability to develop lighter and thinner displays than LED TVs do.
5. OLED TVs offer the deepest blacks of any type of flat-screen diode TV available.
6. OLED TVs have the ability to make a greater number of colors, though this advantage is miniscule when compared to the current level of HDTV technology, limiting the number of colors that can be utilized.
7. OLED TVs are more energy efficient when compared to their LED counterparts.

LED Advantages: [7]

1. Energy efficient - LED's are now capable of outputting 135 watt
2. Long Lifetime - 50,000 hours or more if properly engineered
3. Rugged - LED's are also called "Solid State Lighting (SSL) as they are made of solid material with no filament or tube or bulb to break
4. No warm-up period - LED's light instantly – in nanoseconds
5. Not affected by cold temperatures - LED's "like" low temperatures and will startup even in subzero weather
6. Directional - With LED's you can direct the light where you want it, thus no light is wasted
7. Excellent Color Rendering - LED's do not wash out colors like other light sources such as fluorescents, making them perfect for displays and retail applications
8. Environmentally friendly - LED's contain no mercury or other hazardous substances
9. Controllable - LED's can be controlled for brightness and color

LED Disadvantages: [7]

1. LEDs are currently more expensive, price per lumen, on an initial capital cost basis, than

more conventional lighting technologies. However, when considering the total cost of ownership (including energy and maintenance costs), LEDs far surpass incandescent or halogen sources and begin to threaten compact fluorescent lamps.

2. The Chart Below compares different light sources based upon the life of the bulb and the electrical cost at 10 cents per kWh (kilowatt hour). Note: fixture costs and installation costs are not included.

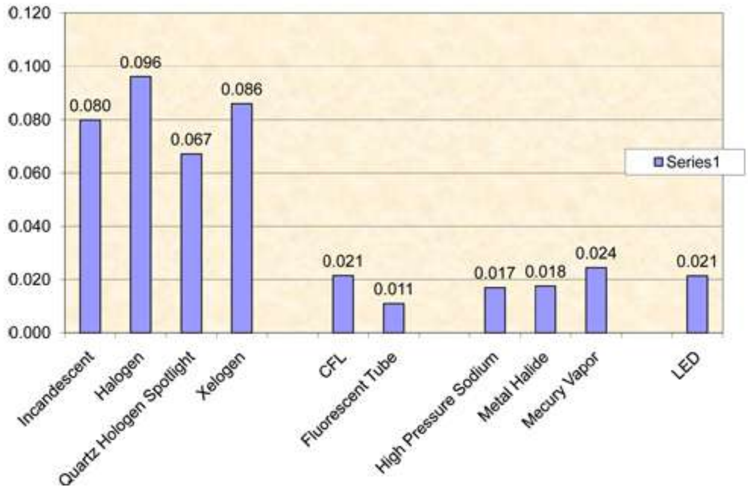

Chart: Different light sources based upon the life of the bulb and the electrical cost at 10 cents per kWh (kilowatt hour)

3. LED performance largely depends on correctly engineering the fixture to manage the heat generated by the LED, which causes deterioration of the LED chip itself. Over-driving the LED or not engineering the product to manage heat in high ambient temperatures may result in overheating of the LED package, eventually leading to device failure. Adequate heat-sinking is required to maintain long life. The most common design of a heat sink is a metal device with many fins, which conducts the heat away from the LED.
4. LEDs must be supplied with the correct voltage and current at a constant flow. This requires some electronics expertise to design the electronic drivers.
5. LED's can shift color due to age and temperature. Also two different white LED will have two different color characteristics, which affect how the light is perceived.

OLED Advantages: [8]

1. The plastic, organic layers of an OLED are thinner, lighter and more flexible than the crystalline layers in an LED.
2. Because the light-emitting layers of an OLED are lighter, the substrate of an OLED can be flexible instead of rigid. OLED substrates can be plastic rather than the glass used for LEDs.
3. OLEDs are brighter than LEDs. Because the organic layers of an OLED are much thinner than the corresponding inorganic crystal layers of an LED, the conductive and emissive layers of an OLED can be multi-layered. Also, LEDs and LCDs require glass for support, and glass absorbs some light. OLEDs do not require glass.
4. OLEDs do not require backlighting like LCDs. LCDs work by selectively blocking areas of the backlight to make the images that you sees, while OLEDs generate light themselves. Because OLEDs do not require backlighting, they consume much less power than LCDs. This is especially important for battery-operated devices such as cell phones.
5. OLEDs are easier to produce and can be made to larger sizes. Because OLEDs are essentially plastics, they can be made into large, thin sheets. It is much more difficult to grow and lay down so many liquid crystals.
6. OLEDs have large fields of view, about 170 degrees. Because LCDs work by blocking light, they have an inherent viewing obstacle from certain angles. OLEDs produce their own light, so they have a much wider viewing range.

OLED Disadvantages: [9]

1. Usually only with a lifespan of 5,000 hours; 10,000 hours lower than LCD at least.
2. Large quantity production of large-size screens is not available. It is therefore, only applied to those portable digital products.
3. Problems of color purity still remains: it is difficult to display fresh and rich colors.
4. Water can easily damage OLED.
5. Sunlight Effect: Another disadvantage of OLED display is that they are hard to see

in direct sunlight. So if you have open lobbies where sunlight reaches directly, you will not get benefit of viewing these screens.

6. Manufacturing - Manufacturing processes are expensive right now.

Result and discussion:

Before purchasing an LED or OLED TV, shoppers should know how both types of technology work, as well as the advantages and disadvantages of each option. This allows shoppers to make a more informed decision when deciding which TV type to select.

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