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OLED: Innovative Display Technology

Akhilesh Kumar Prajapati[1], Neha Lautre[2], Garima Malviya[3], Sanskar Shrivastava[4], Prof. K. Uma[5]

Electronics and Telecommunications Department, BIT, Durg, India[1,2,3,4,5]

Abstract: Tremendous progress has been made in the development of organic light-emitting diode OLED science and technology. Active matrix OLED with its superb overall display image quality, response time, viewing angle, contrast ratio, power efficiency, lightweight, and thin and flexible form factor is positioned to become a viable and successful commercial technology and one of the next mainstream displays in the marketplace. In addition, differing from LED, white OLED lighting has many advantages in that it is an area/surface, thin/lightweight luminaire capable of delivering uniform, warm (almost sun-like) illumination without noise/glare nor much heat dissipation problem. But, most of all, future OLED lighting can also be transparent and flexible – a feature that is unrivaled by any other competing solid-state lighting technology. This paper attempts to provide the reader with as complete a story as possible covering the past, present, and future trends of technology and product development of OLED.

Keywords: OLED, Burn-In, ImageRetention, HOMO-LUMO, Light Emitting Diode (LED), AMOLED, PMOLED.

I. INTRODUCTION

OLED, like LED, is a Solid-State Lighting (SSL) technology. OLED lighting is composed of thin organic layers (carbon based) sandwiched between two electrodes. When DC current is applied, charge carriers from the anode and cathode are injected into the organic layers, electroluminescence occurs and visible light is emitted. An OLED lighting panel starts with a transparent substrate that provides mechanical structure as well as desired optical properties. The substrate includes a patterned transparent conductor layer, usually Indium Tin Oxide (ITO) which serves as the bottom electrode, or anode. Very thin layers of organic materials are deposited onto the anode surface followed by a metallic cathode, or second electrode. These layers are very thin and each layer may contain several materials.
The choice of organic dopants determines the wavelength, or color, of the emitted light. The organic layers are unordered, which means, unlike LED, they do not require a crystalline substrate. Therefore, OLED lighting can be built on a wide variety of low cost substrates and across wide areas, making them ideal for large-area light sources.

II. BASICS OF OLED

OLEDs are a class of devices comprised entirely or almost entirely out of organic semiconducting materials. The term organic refers to the fact that significant portion of the chemical makeup is made up of carbon and hydrogen atoms. Unlike traditional crystalline semiconductors, free charge transport does not occur in energy bands arising from repetitive crystal structure. Rather, charge transport occurs in molecular orbitals; charge is often transferred through conjugated molecular structures. For example, the carbon ring structure of naphthalene is illustrated below. The 3 different configurations for the carbon-carbon bonds are shown with a single line representing a bond with 1 electron and a double line representing a bond containing 2 electrons. These 3 resonant forms of naphthalene are all equivalent and allow for the delocalized electron (called the sigma bond) to "hop" from left to right. Resonant Forms of Napthalene. Organic semiconductors can transport charge through conjugated molecular bonds.
Organic semiconductors are simply LEDs constructed from organic semiconductors instead of inorganic crystalline materials with much of the operating principles and performance metrics. The wavelength of emission is determined by the HOMO-LUMO energy gap. The Highest Occupied Molecular Orbital (HOMO) is analogous to the valence band, as the Lowest Unoccupied Molecular Orbital (LUMO) is to the valence band. Because the charge mobilities are much smaller in OLEDs compared to crystalline materials, OLED devices are usually extremely thin (with active device thicknesses often under 500 nm). Coupling this with the intrinsic properties of the molecular and polymer bonds of organic materials results in intrinsically flexible devices, especially when fabricated on plastic or flexible substrates.

III. MATERIAL AND STRUCTURE

OLED is a thin-film, monolithic semi-conductor device emitting light when voltage is applied to it. When electric filed is applied to organic materials, various ways of light are generated.

The basic OLED cell structure consists of a stack of thin organic layers sandwiched between a conducting anode and a conducting cathode. Breakdown of an OLED structure:

- Substrate (can be plastic, glass, or metal foil) – Foundation of the OLED
- Anode (may or may not be transparent depending on the type of OLED) – Positively charged to injects holes (absence of electrons) into the organic layers that make up the OLED device
- Hole Injection Layer (HIL) – Deposited on top of the anode this layer receives holes from the anode and injects them deeper into the device
- Hole Transport Layer (HTL)– This layer supports the transport of holes across it so they can reach the emissive layer
- Emissive Layer – The heart of the device and where light is made, the emissive layer consists of a color defining emitter doped into a host. This is the layer where the electrical energy is directly converted into light.
- Blocking layer (BL) – Commonly used to improve OLED technology by confining electrons (charge carriers) to the emissive layer
- Electron Transport Layer (ETL) – Supports the transport of electrons across it so they can reach the emissive layer.
- Cathode (may or may not be transparent depending on the type of OLED) – Negatively charged to inject electrons into the organic layers that make up the OLED device..

To generate red, green and blue light to render full-color images, there are two main approaches currently being used. The first is to pattern red, green and blue OLED sub-pixels in each pixel of the display, as shown below. This is generally the preferred approach for high-resolution mobile displays.The second approach is to produce white light in every pixel, and then use a color filter to make red, green and blue sub-pixels.There are several types of OLEDs Passive-matrix OLED, Active-matrix OLED ,Transparent OLED ,Top-emitting OLED, Foldable OLED ,White OLED ,Inverted OLED , Stacked OLED.

History Of OLED:

OLED stands for “organic light emitting diode”. As the name suggests OLED is advance generation of regular LEDs and LCDs. OLED diode technology was invented in 1987 by the researchers of Eastman Kodak company . The main inventers of it were chemists Ching W. Tang and Steven Van Slyke. They both received an Industrial Innovation Award for this in June 2001 from America Chemical Society.

Ching Wan Tang is a Hong Kong- American chemist and Steven Van Slyke is also an American chemist.

They alongwith their co-workers at Kodak saw an opportunity to create the first organic light emiting diodes and they have done this by using spin casting and sublimation deposition of the organic components of the device. With patterned electrodes top and bottom. Each organic layer was ca. 50 nm thick.

Kodak released several of the earliest OLED-equipped products including first digital camera which has a 2.2 inch OLED display with 218 pixels. Then Kodak has licensed its OLED technology to many companies and they are still researching advanced versions. In the early 2000’s researchers at Pacific Northwest National Laboratory and the Department Of Energy invented two technologies help in making OLED flexible. These two are –

1. Flexible Glass an engineered substrate that provides flexible surface and,
2. A Barix thin film coating which protects flexible display from air and moisture.

The evolution of OLED is still going on.

IV. OLED PROBLEM SCREEN BURN-IN

When shopping for a TV or phone, you probably aren’t thinking about what type of screen you’re getting. If you’re buying a newer device, especially if it’s a smartphone, chances are it will come with an OLED screen. If you have or plan to purchase a TV or phone with an OLED screen, you can expect exceptional picture and color quality. One thing you may not expect, however, is for remnants of the picture to get “burned” into the display. Screens that use OLED technology deliver the best picture quality on TVs from LG and Sony, & high end phones from Google, Samsung and Apple. But with those lovely images comes a potential problem: BURN-IN. It’s commonly called burn-in or ghosting, and while permanent damage to your OLED screen isn’t likely, it can cause temporary discoloration.

What is screen burn-in:

Burn-in refers to permanent image retention usually caused by leaving a static image on the screen for a long period of time. Burn-in happens when a persistent part of the image on a screen -- navigation buttons on a phone or a channel logo, news ticker or a scoreboard on a TV, for example -- remains as a ghostly background no matter what else appears on-screen.

The name “burn in” is a little misleading, as there’s no actual burning or heat involved. Instead, this term is used to describe a display that’s suffering from permanent discoloration across any part of the panel. This may take the form of a text or image outline, fading of colors, or other noticeable patches or patterns on the display. The display still works as normal, but there’s a somewhat noticeable ghost image or discoloration that persists when the screen is on. To be

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considered as screen burn in, these artifacts have to be permanent and are a defect caused on the display hardware side, rather than a graphical glitch that may be caused by software or a problem with the display driver circuitry.

***CNET BURN-IN Display**

The term actually dates back to old CRT monitors, where phosphor compounds which emit light to produce images lost their luminance with time. LCD panels can exhibit similar problems, but these are much rarer due to the way LCDs are constructed. Although not as bad or noticeable as old CRT issues, today's OLED smartphone displays can eventually suffer from a similar problem

V. IMAGE RETENTION VS BURN IN

Sometimes used interchangeably, "burn-in" and "image retention" are essentially two sides of the same coin. **Image retention** refers to any image that "sticks" on a screen, even when the content changes. It usually appears as a faint ghost, and with most TVs this fades after a moment or two. **Burn-in** is a form of image retention that lasts much longer, and it's usually visible even when playing other content. It's usually caused by leaving a static image on a screen for a long period of time. Though often used interchangeably, "**image retention**" and "**burn**-in" are not the same thing. **Image retention** is temporary: it goes away in time. **Burn**-in is permanent: it doesn't go away. Burn in and image retention are possible on virtually and display. However, with an LG OLED TV. Any risk of burn-in or image retention have been addressed through the use of technology that not only helps protect against damage to the screen, but features self heating properties so that any short-term image retention that may occur is quickly rectified. It is rare for an average TV consumer to create an environment that could result in burn in.

WHAT TO DO:

Generally, **OLED** TV suffers **burn**-in from 4,000-hour test

A months-**long OLED** TV **burn**-in test on LG models show that after 4,000 hours, logos and static images were vulnerable to permanent image retention, much less than the South Korea electronic company's assertion of 30,000 hours.

If you are concerned about the issue, there are a number of preventative measures that you can take to prolong display lifetime and help to prevent the dreaded ghosting effect

1. Keep your display brightness as low as is reasonable. Increased brightness requires more current and therefore shortens LED lifespans. Don't crank up the brightness unless you have to.
2. Shorten your screen-off timer. Turning the screen off when you're not using it will prevent static images from being displayed.
3. Use Dark Mode, if supported. Using a darker interface reduces the amount of illumination and helps LEDs last longer.
4. Use Immersive Mode, where available. This hides the notification bar, so static icons won't be displayed. Alternatively, pick a launcher that offers a similar feature, as well as transparent navigation bar and app drawer options.
5. Pick a wallpaper with darker colors and change it every now and again.
6. Use keyboards that offer darker themes to prevent color degradation in the lower half of the display.
7. If you use a navigation app regularly for long journeys, pick one that doesn't have a lot of bright static UI elements.
8. Switch to gesture navigation and drop the buttons, if your phone supports it. This helps to prevent burn in at the bottom of the screen.

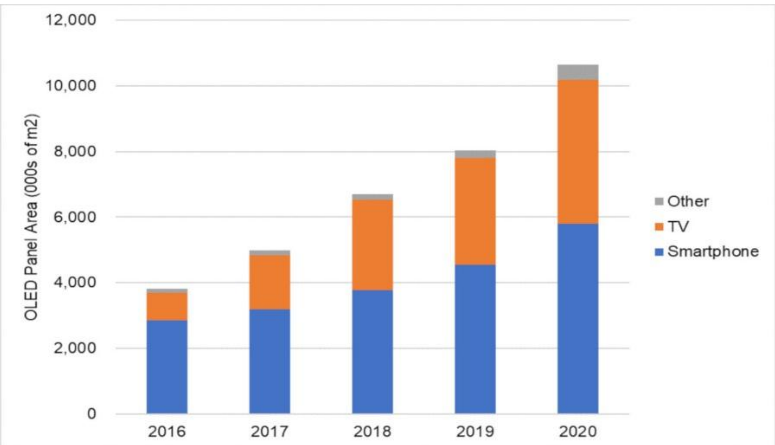
If you leave any kind of bright, static image up on the screen for an extended period of time you're likely to see some image retention. If that happens, here are some basic steps you can take:

1. Turn the TV off for 5-10 minutes and then back on
2. Resume typical use, but watch content that doesn't have static elements
3. Be sure to turn the TV off and on every couple of hours
4. Even right out of the box, long-term damage is not likely if you're using your OLED TV like normal TV. To get permanent damage, you'd need to keep an image on the screen for well over 24 hours straight.

VI. OLED MARKET REPORT

The OLED technology is made by positioning a number of organic thin films between two conductors. Light is emitted when an electric current is applied to these conductors. These displays do not require backlighting and thus are thinner and efficient as compared to LCD displays. OLED displays provide a better image quality, durability, and have a lower consumption rate as compared to LCD displays. Usage of OLEDs in smartphones is expected to drive the global OLED market during the forecast period. Top smartphones manufacturers such as Samsung, Apple, Xiaomi, Huawei, Sony and many more use OLEDs in their display screen.

The global smartphones sales in the first quarter of 2017 had increased by almost 9% as compared to the same period for 2016. Samsung, Apple, and Huawei had a share of 20.7%, 13.7%, and 9% respectively during this period. Further, it is projected that the overall smartphones shipments in 2022 will reach 1.64 billion units. Thus, it is expected that smartphones will fuel the growth of the OLED market during the estimated period. The increasing sales of TVs play a vital role in the rise of the OLED market. In the first quarter of 2017, global OLED TVs that were priced for more than USD 1,000 had a share of almost 14% as compared to 2.4% in 2015 during the same period. Further, it is estimated that the global OLED TV shipments will increase from 723,000 units in 2016 to 6.6 million units in 2021. Thus, the global OLED market is anticipated to grow at a rapid pace during the forecast timeframe. However, the burn in issue that occurs on OLED displays will have an adverse effect on the OLED market growth during the analysis period.



ADVANTAGES

1.POWERCONSUMPTION:

One of the strengths of an organic light-emitting diode or OLED display technology over Other technologies such as LED and LCD is that it consumes less power. Each diode in an OLED panel emits light. The entire panel does not require backlighting as well, unlike LCD.

OLED TV will be the most energy efficient TV technology ever produced. It takes hardly any power to energize the organic light emitting molecules located in the emissive layer of the substrate.

2.HIGH CONTRAST RATIO:

OLED has the deepest blacks in all existing display technologies such as twisted nematic or TNLCD, in-planes witching or IPS LCD, and VALCD technologies. Due to superiorTechnological efficiencies in manipulating lighter, simpler carbon based material, generating deeper blacks, brighter whites and all the grey scales in between should be agree at strength of OLED.

3.PHYSICAL APPEARANCE:

When compared to LCD panels, LED panels are thinner. The organic plastic layer of the panel can have a thinness of 100 to 500 nanometres. Note that this thinness also means that an OLED panel is lighter, flexible and non-breakable.

4.DISPLAY:

OLEDTV does not suffer from motion blur as does LCD displays. In factored technology has the fastest response rate time of any type of display due to utilizing TFT active matrix (AMOLED)technology with the organic light emitting diodes. OLEDs response rate is even faster than plasma and hence there is no motion lagor trailer effect either. OLED TVscreens have near perfective wing angle. OLEDs create light(are emissive) rather than blacklight. Every pixel is lit independently and that light will be seen from off axis viewing angles easily and accurately, also like plasma TV technology. Images displayed on an OLED panel are more vivid and pleasing to the eyes than those Displayed on a TNLCD or IPSLCD panel because it has deeper blacks, higher contrast ratio, wider view in angle, and faster refresh rates.

DISADVANTAGES:

OLED seems to be the perfect technology for all types of displays ,but it also has some problems:

1.LIFETIME:

One of the notable limitations of OLED is that it degrades faster than LCD technologies. Different color-specific organic diodes also have different lifespans. While red and green OLED films have longer lifetimes(46,000to230,000hours),blue Organics currently have much shorter life times(upto around14,000hour).

2.DAMAGES:

- **WATER:** Susceptibility to faster degradation due to water damage is another disadvantage ofan OLED panel. The organic diodes in an OLED display technology are vulnerable to, Water unlike the inorganic crystalline found in LDC technologies.
- **SUNLIGHT:** An operating OLED display panel is hard to use under direct sunlight or bright lighting.The images the panel produces are barely viewable because of the absence ofBack lighting and the fact that organic diodes produce lights with limited brightness.

3.DISPLAY:

Most high-end OLED panels in the market produce over saturated images with colors and contrast that are too harsh. In other words, these panels produce in accurate color and image representation ,thus making them unsuitable for certain applications.

Manufacturing processes are expensive right now.

APPLICATIONS:

- **Current applications:** Currently, OLEDs are used in small-screen devices such as cell phones, PDAs and digital cameras. Several companies have already built prototype computer monitors and large-screen TVs that use OLED technology. OLED displays are mainly used in digital devices such as high-end television systems, computer monitors, pocket-size systems such as Androidphones, mediaplayers, digitalcameras, portable gaming consoles and mini-screens.
- **Future applications :** Research and development in the field of OLED is proceeding rapidly and may lead to future applications in heads-up displays, automotive dashboards, billboard-type displays, home and office lighting and

flexible displays. Because OLEDs refresh faster than LCDs--almost1,000 times faster—a device with an OLED display could change information almost in real time. Video images could be much more realistic and constantly updated. The newspaper of the future might bean OLED display that refreshes with breaking news(think "MinorityReport") and like a regular newspaper, you could fold it up when you're done reading it and stick it in your back pack or brief case. OLED televisions may one day be flexible, cardboard thin and large enough to cover. An 9'X9'wall.

VII. CONCLUSION

Today Organic Light Emitting Diode or OLED technology is extensively seen as next generation component for flat flexible displays. They induced their own light that is why they have large fields of view. They are thinner and more flexible than the displays of LCD and LED. They have many advantages over these displays like-

1. **High contrast ratio**
2. **Wide viewing angle of about 170 degrees**
3. **Fast response**
4. **Higher efficiency**
5. **Lower weight**

However, they have some drawbacks too, the main problem of it is a screen burning. And many researchers have been working on it. OLED still has many challenges like-

1. **High production costs**
2. **Sensitivity to water vapours**

In the future OLEDs will probably conquer a large portion of the micro display market, research and development in the field of OLEDs is proceeding rapidly.

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REFRENCES

1. A Review Paper on an Overview of Organic Light Emitting Diode, Paras Raj Birwa,(2017).
2. A Review Paper on: Organic Light-Emitting Diode (OLED) Technology and Applications, Fazia Batool,vol.5,(2016).
3. Performance Analysis of OLED by Variation of Doping in Hole Transport Layer, Abhilasha, K. M. Singh, vol.8,(2019)
4. Organic Electronics JRC Science and Policy OLED Report in Europe, (2014).
5. OLED: A Modern Display Technology ,Mr. Bhrijesh N. Patel*, Mr. Mrugesh M. Prajapati,vol.-4,(2014).
6. Online Available; en.wikipedia.org,onlinelibrary.wiley.com,depts.washington.edu,www.thoughtco.com
7. International Journal of Advanced Research in Computer and Communication Engineering.