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Organic Light Emitting Diode Displays: Enabling the Next Generation of Electronics

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ABSTRACT

The current standards of display technologies, such as liquid crystal display (LCD), light emitting diode (LED) and plasma, are limited by their physical and aesthetic properties. Organic light emitting diode (OLED) displays do not have these limitations. They offer many advantages over these standards by being more efficient and versatile, in addition to being flexible and transparent [1]. Because of OLED's superior flexibility, they are also much more durable than other display technologies. Not only are the physical characteristics of OLED displays superior to its competitors, they produce sharper images in vivid colors that are unable to be produced on other displays [2]. These physical and aesthetic advantages are possible because of an OLED's unique composition consisting of very thin layers of material [3],[4]. This is unlike, and superior to, other displays which rely on bulky multi-component structures that need to be bound together. As a direct result of their superior characteristics, OLED displays enable the production of electronics with greater sustainability than current display technologies, such as flexible handheld devices and transparent displays. While OLED displays are not without their own limitations, color longevity and moisture sensitivity being a few, they are overall a far superior alternative to the current standards of display technologies and can be used to create a generation of sustainable electronics.

Keywords: Active matrix organic light emitting diode; Flexible displays; Organic Light Emitting Diode

INTRODUCTION

In this day and age, anywhere you look you will likely see some type of display. Whether it be a smartphone, tablet, laptop, or television, all of this display-based technology has become essentially ubiquitous. Despite how common displays are in today's world, the current standards of display technology, which include LCD, LED and plasma, face many limitations and drawbacks. Price, material and power are the major factors that contribute to these drawbacks. This means that the potential of current generation electronic devices is greatly limited compared to what could be achieved with better displays. These improved displays come in

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the form of OLEDs.

The development of new and innovative electronics is being bottlenecked by current display technology standards, which are lacking in the physical and aesthetic properties seen in OLED's. Resulting from superior characteristics, OLEDs will easily be able to eliminate the current developmental bottleneck, and bring new possibilities to the electronics industry. This ensures the sustainability of OLED technology by meeting the needs of the current generation, while not inhibiting the needs of future generations. These improvements and superior capabilities are what enable the technology to meet the increasing needs and expectations of the future of the electronics industry. These improvements can be attributed to factors such as OLED's unique structure and manufacturing process, which are drastically different than their electronic predecessors. These changes are what enable most of the unique applications and functions that can be achieved by OLED displays.

With OLED implementation, these 'next generation' devices will have capabilities never imagined, such as being flexible and/or transparent, while also producing unparalleled visual quality. These OLED displays can be used in conventional electronic devices, such as cell phones, tablets, televisions, and much more. Researchers are continually finding new ways to implement these superior displays, such as in windows, cars, or watches. These advantageous aspects and applications of OLEDs are crucial to their success in replacing today's display technology standards and enabling a sustainable electronics for the future.

CURRENT DISPLAY STANDARDS

The current generation of display technologies (LCD, LED and plasma) have been adequate to this point in time, but their limitations have been reached. These limitations are mainly due to their construction and how they function. Plasma displays are comprised of many layers of components including: gas chambers, electrode layers, phosphor layers, and glass substrates [5]. When a current is applied to one of the thousands of gas chambers, which are filled with a mixture of gasses, an electrically charged plasma is created. The created plasma reacts with phosphor layers to produce colored light [5]. When thousands of these color producing reactions occur, an image is produced. As a result of these plasma and phosphor reactions, the images produced by plasma displays are very accurate, but are prone to burn-in. When a stationary image is displayed over extended period of time that image will burn permanently into display. While plasma displays are capable of producing accurate images in a slim package, their development has reached a point where they can no longer be improved and their limitations cannot be overcome.

Like plasma displays, LCD displays consist of many layers. These include a mirror, polarizing films, color filters, electrode planes, a backlighting element and, of course, a liquid crystal substrate. LCDs produce images when a current is passed through the liquid crystal substrate, which is a substance in a state between liquid and solid [6]. When introduced to a current, the liquid crystal reacts in a way that controls the passage of light created by the backlighting element in a way that produces an image. The backlighting element in LCD displays is most commonly a fluorescent tube [6]. The structure of LCD and LED displays are almost identical, with the exception being the backlighting. While LCD displays use a fluorescent tube for backlighting, LED displays use a light emitting diode. Both of these displays have reached their full potential, and are unable to meet the current standard of display technologies due to limitations regarding their produced image quality. Thus, a new and sustainable standard of displays, OLEDs, must be implemented.

GENERAL STRUCTURE AND OPERATION OF OLEDS

OLEDs unique structure consists of organic (carbon based) materials layered together that produce an extremely thin composition 200 times thinner than a human hair, see figure 1 [4]. OLED's do not contain toxic materials like other displays, meaning less damaging pollution. Traditional displays contain many harmful chemicals and require special disposal procedures to ensure that these chemicals do not pollute the environment. Because OLED's consist of organic layers, these special disposal procedures are not needed. This will save the time and resources typically put into the disposal of traditional electronics, furthering the sustainability of these displays.

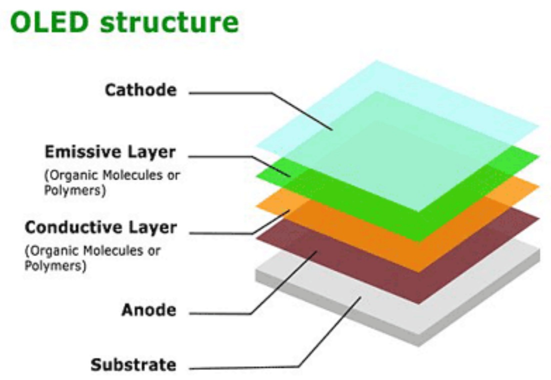

Fig. 1 [7].

General structure of OLED displays with listed components

The organic layers within OLEDs include:

- **Substrate -** The substrate is what supports the OLED and its components and is commonly made from flexible plastic or thin foil.
- **Anode** – The anode acts in order to promote injection of electron holes into the conducting layer and is usually made of indium tin oxide (ITO).
- **Cathode** – The cathode acts in order to promote injecting electrons into the emissive layer, materials such as barium and aluminum are used.
- **Conducting layer** – This layer is used to transport the electron holes created in the anode to the emissive layer. One material used for this is polyaniline.
- **Emissive layer** – This is where light is produced, the electrons and electron holes meet and bind together; this layer is commonly made of polyfluorene.
- **Encapsulation layer** – Protects the OLED from oxygen and moisture for improved lifespan, typically made of plastic that encases the entire OLED structure.

Full color OLEDs, which are capable of producing 16.7 million colors, require 3 different organic films, one for each of the primary colors: red, green and blue. OLEDs emit light through a process called electrophosphorescence [7]. This process of emitting light in OLED's begins when the power source applies voltage, and therefore passes a current, from the positive to the negative electrodes of the device (anode to cathode). This causes the cathode to give electrons, which are negatively charged, to the emissive layer and the anode to remove electrons from the conducting layer, creating electron "holes", gaps that are positively charged.

The boundary between the emissive and conducting layers is an efficient site for the combination of an injected electron-hole pair. This combination occurs when an electron and an electron hole localize on the same molecule and bind together, caused by their opposing charges. This combination forms an excited pair called an exciton [8]. Upon combination, excitons spontaneously release their stored energy as light, and return to a relaxed ground state. This process produces a very bright and crisp display with power consumption lesser than the usual LCD and LED [8].

Colored light is emitted according to what organic molecule makes up the emissive layer in which combination occurs. Combinations of the 3 primary colors are used to create any color in the 16.7 million color spectrum [1]. Due to the fact that OLED displays undergo electrophosphorescence, the process of emitting their own light, they do not require the backlighting needed in LCD, LED and plasma displays. This lack of backlighting allows them to be thinner, cheaper and more efficient than their competitors. The method of image production from these colors depends on whether the display is a passive matrix organic light emitting diode (PMOLED) or active matrix organic light emitting diode (AMOLED) display. Both PMOLED and AMOLED are very similar structurally, only differing by the components that drive the display.

Passive Matrix Light Emitting Diodes

PMOLED displays were the first OLED display commercially available. They were introduced to the market as early as 1998 and have now become cheap and easy to produce [9]. Despite their simple and cheap production, the capabilities of PMOLED displays are limited due to their structure and image processing hardware. The layers within PMOLED displays are structured in such a way that the cathode rows are perpendicular to the anode columns, and the two are split by uninterrupted organic layers, as seen in figure 2.

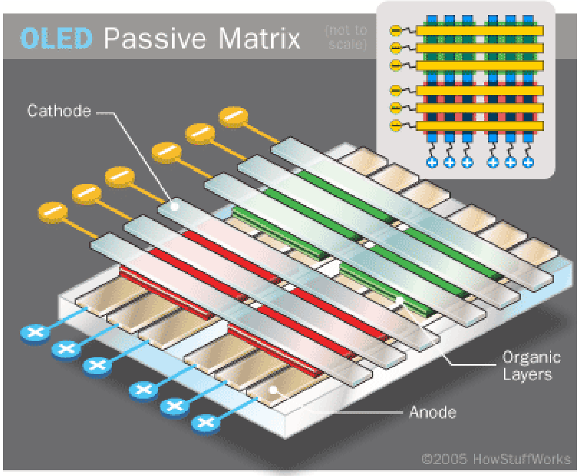

Fig. 2 [10].

Structure of a PMOLED display with listed components

The intersections of these cathode rows and anode columns are what forms individual pixels in PMOLED displays. The pixel array is driven by external driver circuitry that controls when they turn on. The brightness of each pixel is also controlled by this driver, and is proportional to how much current is sent to it.

The external driving circuitry controls the pixels sequentially by row, telling which pixels to turn on and which ones to remain off. As the size of PMOLED displays increases, and/or as the number of lines increases in order to create higher resolutions, so does the required voltage. This is due to most pixels being off at any given time and others having to be brighter to compensate, as well as the power needs of the external driver circuitry itself [11]. Because of this, they consume more electricity than AMOLED displays, but still less than LCD, LED and plasma. Another effect of the electrical needs with increasing size and number of lines, is that they are generally not seen in sizes above 3 inches or with high resolutions [12].

PMOLED displays also have a shorter lifespan than AMOLEDs because of the higher voltages required for operation. As a result of these limitations, the lower priced PMOLED displays are mostly used in small devices that don't require the best quality image. Although PMOLED displays still have their place, they have been mostly replaced by the more advanced OLED variant, AMOLED [11],[1].

Active Matrix Light Emitting Diodes

AMOLED displays are a more recent development than PMOLED displays, and were first introduced in cell phones in 2006 [9]. AMOLED displays are more expensive then PMOLED to manufacture, but still cheaper than the standard of LCD, LED and plasma. Unlike PMOLED displays, the driving circuitry of AMOLED displays is completely internal. They use metal oxide thin foil transistors (TFTs) and storage capacitors as a replacement for the external circuitry [4]. The structure of an AMOLED consists of a single cathode, and uninterrupted organic layers which are on top of the anode. The anode is overlaid on an array of TFTs and storage capacitors, forming a matrix of pixels. This is illustrated in figure 3.

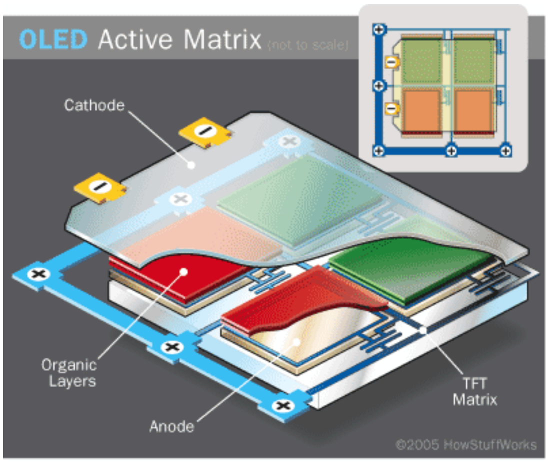

Fig. 3 [10].

Structure of AMOLED displays with listed components

"Active matrix displays, instead of having current distributed row by row, use TFTs that act like switches to control the amount of current, hence brightness, of each pixel'' [4]. Usually each pixel is controlled by two TFTs. One TFT switches to charge the storage capacitor for each pixel, acting like an on off switch, and maintains the state of that individual pixel. The other TFT allows the capacitor to act as a power source, and illuminates the pixel [4]. This structure causes AMOLED displays to be top emitting, rather than bottom emitting like PMOLED displays [13]. Top emitting structures offer more efficient light emission and enhanced color purity [4]. The TFT based driver structure provides many advantages over its external predecessor. The main advantage is that AMOLED displays do not experience the excessive electrical requirements. Since the rows are not controlled individually, and the entire matrix is controlled at once, AMOLED displays are much more power efficient. Using only 24 to 150 watts, AMOLED displays are much more efficient than plasma displays which use 300-660 watts [1]. This driving method also eliminates the size and resolutions restrictions seen in PMOLED displays. AMOLED displays produce far superior images to current display standard, creating brighter and crisper images of higher resolutions, all while using less electricity.

THE OLED MANUFACTURING PROCESS

OLED displays are manufactured in a way that is much more sustainable than its competitors. The cost to produce OLED displays is significantly less than the cost to produce its competitors, providing an incentive for both producers and consumers to invest in the implementation of the technology as a standard. Under very realistic conditions, such as a higher than average TFT cost, and even a 10-20% lower yield than the LCDs, OLED displays are capable of being produced at costs up to 30% less than LCD and plasma displays [12]. The most crucial part of OLED production is the application of the non-toxic organic layers to the substrate, which can be done in a number of different ways. Vacuum thermal evaporation (vacuum deposition), organic vapor phase deposition (OVPD), and inkjet printing are currently in use.

Vacuum deposition is done in a vacuum chamber (10^{-5} - 10^{-7} torr) where organic molecules are lightly heated and introduced to a chilled substrate. This allows the molecules to condense and form an even layer on the substrate [8]. While this method was the original, it is fairly expensive and inefficient. Because of this, an alternative production technique was developed.

OVPD is much more efficient than vacuum deposition and is also significantly cheaper. Carried out in hot-walled reactor chambers at low pressure, OVPD uses a carrier gas to transport evaporated organic molecules. These molecules are transported onto cooled substrates [8]. This allows them to condense into thin, even layers. Although this method is better than vacuum deposition, Inkjet printing is still superior.

Inkjet printing is currently the most cost efficient and commonly used technique of OLED display production. Similar to how inkjet printers work with ink and paper, the organic molecules are sprayed onto substrates. This method is ideal for extremely large applications such as electronic billboards and greatly reduces the production cost of OLEDs [8]. This allows large scale, high-volume production of OLEDs, making it the most sustainable manufacturing process, as it is all too easy to swiftly meet the demands of the consumers.

Another crucial step in the manufacturing process of OLED displays is encapsulation. Impermeable encapsulation is crucial because, when bare, OLED displays have a high vulnerability to moisture and oxygen exposure, causing them to fail [14]. This encapsulation layer is applied using the familiar method of deposition, and uses organic materials like TPD, or even inorganic synthetic materials [15]. Overall, the cheap and efficient manufacturing process of OLED displays is a large advantage for manufacturing companies and consumers alike by allowing the price to be less than the competition.

ADVANTAGES OF OLED DISPLAYS OVER TRADITIONAL DISPLAY TECHNOLOGIES

The unique structure and composition of OLED displays enable a wide variety of advantages over current display technologies. Some of these advantages and applications, such as flexible, transparent displays, were previously thought of as science fiction, and not currently attainable. However, this technology is very real, and very close to being widely available to everyday consumers. But the consumers are not the only party that can reap the immense benefits that OLED displays provide. In addition to the exciting applications possible, there are several advantages that make OLED displays very sustainable in the technology industry.

Flexible Displays: A Durable Innovation

Flexible displays represent one of the most unique and attractive features made possible with OLED display technology, and also one of the most beneficial. This is due to the ability of thin organic films to be deposited on equally thin and flexible substrates, such as plastic or thin metal foils. This allows for very lightweight, robust displays that can be rolled up and stowed away in very small volumes [16]. Traditional electronic displays (LED, LCD, plasma), all have one thing in common: the support and protective layers are glass [3]. The unfortunate fact of this is the breakability of the display. In today's world of widespread mobile devices, consumers are all too familiar with what happens when a device is accidentally dropped. With one wrong move, their several hundred-dollar devices become a paperweight; OLED display technology provides a simple solution to this problem, by replacing these glass layers with ones of flexible plastic or metal foil.

What most consumers are not aware of is what actually causes the device to become non-operational when dropped. "Typically, a dropped device does not break because the glass screen cracks; it stops working because of damage to the glass-based transistor layer buried within" [3]. By utilizing plastic or foil substrates, OLED displays will be easily resist damage from accidental drops, a major issue with nearly all current mobile devices.

With flexible displays, the possibilities are endless in the consumer market, making OLED displays extremely versatile. Figure 4 demonstrates a current working prototype of a flexible display. Among just a few of the additional concepts that will be made possible in the near future are: displays that wrap around your wrist and act as a type of watch-like smart device, book-sized tablet devices that literally fold up into a smartphone, and full-sized tablets and even televisions that roll up and can be stored in containers the width of a pen. Through innovative thinking and engineering, there is no telling exactly how far this technology could go with the future of electronic displays.

Fig. 4 [3].

A prototype of Samsung's flexible smartphone

Transparent Displays: The Future of Display Technology

In addition to being flexible, another unique trait that OLED displays can provide to future electronic devices is transparency. For this to be accomplished, light must naturally be able to pass through both sides of the display [12]. Therefore, the appropriate components of the OLED (anode, cathode, emissive and conductive layers, and substrate) must be composed of transparent materials themselves, as illustrated in Figure 5. This all can, and has been, accomplished in OLED displays [12]. The application of transparent displays can be implemented in a variety of ways.

Fig. 5 [11].

A transparent OLED panel that becomes a light source

The application of transparent and flexible OLEDs opens up new possibilities for display technology. Essentially, any normally glass surface can become a display. Windows, for example, would be clear and transparent when not in use, but could be used as a display at the press of a button [17].

Due to the process of electrophosphorescence, and thus OLEDs producing their own light, a transparent panel of OLEDs can function as a cheap, effective, efficient lighting source [18]. This furthers the sustainability of OLED technology by way of versatility. OLED displays can be used for more than conventional electronic devices such as cell phones and tablets; the displays can be used in any setting that utilizes a lighting source. It would be extremely thin, and transparent when not in use. Not only are OLEDs very efficient, they do not contain any toxic metals such as mercury, which are present in the alternative Compact Fluorescent Lamps (CFLs) [18]. White OLEDs consume less power than its competitors and can be manufactured in large sheets in a cost-effective manner. Because of this, they could replace fluorescent lamps and potentially reduce energy costs for lighting in general [12]. Implementing OLEDs to replace current technology could also benefit cell phones or even television sets. They would function as thin, bright, self-illuminating displays that will turn transparent when off. In addition to these highly practical applications, OLED transparent displays can be used in something else nearly everyone uses daily: their cars.

There are so many different aspects to cars that transparent OLED displays can play a role in [18]. As they produce their own light, they can naturally be used for any lighting for the car, both internal and external. The display's flexibility would even permit the lights to form and match the contour of the vehicle. In addition, transparent displays can be utilized for heads up displays on the windshield, to show the current speed, fuel capacity, engine speed, distance traveled, and any information required by the driver, while still being able to see the road. Cars, light sources, and device displays represent just some of the unique possibilities transparent OLED displays provide. The variety of uses for the displays further enforces the sustainability provided by the implementation of OLED displays.

OLED Power Efficiency

OLED display technology represents the future of electronics, not only in its application and unique uses, but in its sustainability as well. OLEDs will secure their place in the electronic display industry with their high power efficiency. When comparing the ratio of light produced by the display to the power consumption required (lm/W or Lumens per Watt), OLEDs beat out all other display alternatives. LCD displays produce ~2 lm/W, whereas OLEDs produce ~10 lm/W [16]. It is quite clear that when it comes to efficiency, OLEDs beat the current standard in nearly every comparable aspect. But power is not the only factor that contributes to OLED displays' sustainability, aesthetic superiority is also pertinent.

Aesthetics: A Clear Improvement in Display Quality

One of the most important aspects of display technologies are their aesthetic properties. Aesthetics are crucial to the sustainability of OLED displays; if the display is not pleasing to the consumer, they are not likely to support it. Therefore, in order to produce a sustainable display, it must be visually superior to the predecessors. The most important aesthetic characteristics include brightness (luminance), contrast ratio, color accuracy, viewing angle, and response time. Unsatisfactory qualities of any of these properties will result in a poor visual experience as all of them work together to provide a visually pleasing viewing experience. Figure 6 shows a comparison of some of these features between OLED, LCD and plasma.

Table 1 [1]

Technology	LCD TV	PLASMA	OLED
Power Consumption (W)	60-300	300-660	24-150
Brightness (cd/m2)	350-500	700-1000	1000
Contrast	350:1-1.000:1	1.000:1 - 5.000:1	1.000.000:1
Response Time	8-12ms	0.01ms	0.05ms
Viewing Angle	170/170	178/178	178/178

A table showing visual qualities of OLED LCD and Plasma displays

In order to achieve optimal visual quality, a display must be capable of producing proper luminance levels for the environment it's in. A display with inadequate luminance capabilities will experience washed out colors and poor contrast ratio, resulting in a poor visual experience. Luminance levels of around 150 candela per meter squared (cd/m^2) are adequate for proper viewing in the majority of ambient lighting scenarios [1]. This luminance level is no challenge for OLED displays which can measure at up to 1000 cd/m^2, without experience the burn in effect seen on plasma displays. The luminance level of OLED displays trumps that of LCDs which average around 300 cd/m^2 [1]. Closely relating to luminance is contrast ratio, which is the ratio of the luminance of the brightest white to the darkest black. Current display standards have contrast ratios in the range of 10,000:1, while OLED displays have an astounding contrast ratio of 1,000,000:1, producing extremely dark blacks and extremely bright whites, drastically increasing visual quality [1].

Color accuracy measures the ability of a display to recreate the colors of the source, and is measured with a spectroradiometer. Colors within 1 minimum perceptible color difference (MPCD) are visually indistinguishable by the human eye. OLED displays are capable of measuring within 0.6 MPCD of the actual colors, visually indistinguishable from perfect [19]. Viewing angles are another crucial aspect of all displays, displays with poor viewing angles will show extreme image degradation as the viewer moves from directly in front of the display, which is seen in LCD displays. "At 30 degrees viewing angle, LCDs typically show a 60 percent decrease in brightness, a 50% decrease in contrast ratio, and a significant change in the Intensity scale and gamma" [19]. OLED displays are not affected by viewing angles nearly as much as LCDs are. At the same 30 degree viewing angle the brightness changed by 1%, the contrast ratio remained the same, and the intensity scale and gamma were also unchanged [19].

Alongside the previously mentioned qualities, motion blur is another major issue that plagues LCD displays and is caused by a slow response times. LCD displays typically have a response time of between 8 and 12 milliseconds, while OLED displays have response times of 0.05 milliseconds [1]. The difference in fast moving objects between displays with these two response rates is exponential. A lab test done by DisplayMate with a test pattern "moving at a very fast 1352 pixels per second" shows that the OLED display produced no visual motion blur, while an LCD display produced a significant amount, see figure 7 [19].

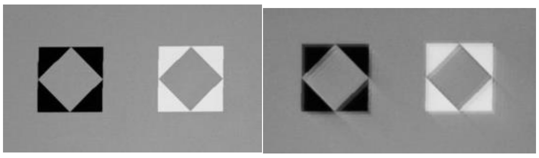

Fig. 6 [19].

Comparison of OLED (left) and LCD (right) refresh rates and motion blur with an image moving at 1352 pixels per second

Economics of OLEDs: The Smart Choice for Industry

OLED displays are an improvement to the current standard of display technology not only for having unique characteristics, but also for their superior economics. Combinations of various factors are responsible for the economic sustainability of OLEDs, structure being a significant example. In all cases, OLEDs require fewer components than competitors [12].

It is important to note that OLED display pixels are only turned on when needed, whereas LCD backlights must be continuously on during use. For the average OLED image, only 25% of the pixels need to be illuminated. This alone means significant power savings over LCD displays [16]. Just the fact that OLEDs do not require a backlight leads to significant savings in both production costs and energy consumption resulting in an increased level of energy efficiency. Since no backlighting is needed, OLED displays naturally have a lower operating temperature [12]. A low operating temperature is very important since it prolongs OLED lifetime as degradation increases with increasing temperature.

As innovation pushes, progress and new theories are developed, OLEDs can only become cheaper and more efficient than they already are. There is no reason that OLEDs should not become the new standard in the ever-improving world of display electronics.

LIMITATIONS OF OLED TECHNOLOGY

As with all new and upcoming technologies, there are always drawbacks and limitations; such is the case with OLEDs. There are a few aspects that are currently preventing OLED technology from thriving; however, those obstacles can be overcome. One unfortunate flaw of current OLED displays is that the components that produce blue color have a significantly shorter life span than the other colors [2]. But as technology and manufacturing process improves, new and improved materials are being discovered and implemented in order to overcome this obstacle.

Another setback involves achieving the goal of completely flexible mobile display technology, although in this case, the fault is not with OLEDs themselves. The problem is quite the opposite. OLED displays are in fact ahead of their time technology wise. The capabilities are there for the displays to bend freely, but other components of devices such as the battery and circuitry are not capable of matching the displays flexibility.

One problem with OLED displays is a fairly common one among all electronic devices, that being exposure to water and moisture causes them to fail. OLEDs are hypersensitive to oxygen and water, which is not an ideal feature for a consumer product. They need to be hermetically sealed, and producing a low-cost hermetic seal is proving to be a problem [3]. This is where the encapsulation process comes in to play. As encapsulation improves with new materials and production methods, so does the lifespan of OLED displays. As with any technology, there are limitations and obstacles that must be overcome for OLED displays. With this in mind, OLED displays are already a more sustainable alternative to the current display standards, and will only increase over time as the mentioned limitations are addressed and resolved.

CONCLUSION

The technological possibilities of todays' electronics are limited by the current displays utilized. LED, LCD and plasma displays can only push so far, and they have reached their limitations, and thus are no longer sustainable in today's electronics market. OLED displays are the sustainable alternative, as well as the future of electronic displays. OLED displays combine the best features from the current display standards and have none of their major downsides. The materials used to produce the displays are cheaper, and OLEDs can be produced in high volumes for lower cost than any other display standard. Furthermore, their composition allows OLED displays to be the brightest display on the market, functioning not just as a display but even a cheap light source. This lighting aspect, along with the rest of OLED's functions, will be much more energy efficient than the competition, leading to economic benefits to both producers and consumers.

Because of the unique structure and composition, OLED displays achieve a variety of unique advantages and applications over predecessors. Flexibility in displays leads to an extremely durable product, allowing much more resistant to accidental consumer dropping. This flexibility also allows for entirely new types of electronics; Screens that can bend, fold, or even roll can be made possible to offer a new meaning to portable electronics. OLED's unique structure of also allows them to be transparent, allowing for displays to be used in windows, car windshields, and even glasses. The numerous possibilities are limited only by ingenuity.

Any drawbacks that OLEDs possess still do not impede the fact that they are superior in all aspects. And these drawbacks are being worked on and improved constantly, with it being only a matter of time before solutions are implemented, resulting in increased sustainability. OLEDs benefit the companies that produce the displays as well as the individuals that buy them in countless ways. They are an improvement in nearly every way, and will allow us to take displays to a whole new level, ushering in the next generation of electronics.

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نمایشگرهای دیود نورگسیل آلی: فعال کردن نسل بعدی الکترونیک

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چکیده

استانداردهای فعلی فناوری‌های نمایش، مانند نمایشگر کریستال مایع، دیود ساطع نور و پلاسما، به دلیل ویژگی‌های فیزیکی و زیبایی‌شناختی آنها محدود است. نمایشگرهای دیود ساطع کننده نور ارگانیک این محدودیت ها را ندارند. آنها با کارآمدتر و همه کاره بودن، علاوه بر انعطاف پذیری و شفاف بودن، مزایای زیادی نسبت به این استانداردها دارند. به دلیل انعطاف‌پذیری برتر OLED، آن‌ها همچنین بسیار بادوام‌تر از سایر فناوری‌های نمایشگر هستند. نه تنها ویژگی‌های فیزیکی نمایشگرهای OLED نسبت به رقبای خود برتری دارند، بلکه تصاویر واضح‌تری را در رنگ‌های زنده تولید می‌کنند که امکان تولید بر روی نمایشگرهای دیگر وجود ندارد. این مزایای فیزیکی و زیبایی شناختی به دلیل ترکیب منحصر به فرد OLED که از لایه های بسیار نازکی از مواد تشکیل شده است امکان پذیر است. این بر خلاف و برتر از سایر نمایشگرها است که بر ساختارهای چند جزئی حجیم تکیه دارند که باید به هم متصل شوند. به عنوان یک نتیجه مستقیم از ویژگی های برتر خود، نمایشگرهای OLED تولید لوازم الکترونیکی را با پایداری بیشتر نسبت به فناوری های نمایشگر فعلی، مانند دستگاه های دستی انعطاف پذیر و نمایشگرهای شفاف، امکان پذیر می کنند. در حالی که نمایشگرهای OLED بدون محدودیت نیستند، طول عمر رنگ و حساسیت به رطوبت معدود است، اما به طور کلی جایگزین بسیار بهتری نسبت به استانداردهای فعلی فناوری‌های نمایشگر هستند و می‌توانند برای ایجاد نسلی از لوازم الکترونیکی پایدار استفاده شوند.

کلید واژه‌ها: دیود های نورگسیل آلی؛ دیود نورگسیل آلی ماتریس فعال؛ نمایشگرهای انعطاف پذیر

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