Advantages and disadvantages of organic light emitting diodes engineering essay

An organic light emitting diode (OLED), also organic electro luminescent device (OELD), is a light-emitting diode (LED) whose emissive electroluminescent layer is composed of a film of organic compounds. This layer of organic semiconductor material is formed between two electrodes, where at least one of the electrodes is transparent.

Such devices can be used in television screens, computer monitors, small, portable system screens such as cell phones and PDAs, watches, advertising, information and indication. OLEDs can also be used in light sources for general space illumination, and large-area light-emitting elements. Due to the younger stage of development, OLEDs typically emit less light per unit area than inorganic solid-state based LEDs which are usually designed for use as point-light sources.

In the context of displays, OLEDs have certain advantages over traditional liquid crystal displays (LCDs). OLED displays do not require a backlight to function. Thus, they can display deep black levels and can be thinner and lighter than LCD panels. OLED displays also naturally achieve higher contrast ratios than either LCD screens using cold cathode fluorescent lamps (CCFLs) or the more recently developed LED backlights in conditions of low ambient light such as dark rooms.

Working principle

A typical OLED is composed of an emissive layer, a conductive layer, a substrate, and both anode and cathode terminals. The layers are made of organic molecules that conduct electricity. The layers have conductivity levels ranging from insulators to conductors, so OLEDs are considered organic semiconductors.

The first, most basic OLEDs consisted of a single organic layer, for example the first light-emitting polymer device synthesised by Burroughs et al. involved a single layer of poly(p-phenylene vinylene). Multilayer OLEDs can have more than two layers to improve device efficiency. As well as conductive properties, layers may be chosen to aid charge injection at electrodes by providing a more gradual electronic profile,[28] or block a charge from reaching the opposite electrode and being wasted.[29]

Schematic of a 2-layer OLED: 1. Cathode (âˆ’), 2. Emissive Layer, 3. Emission of radiation, 4. Conductive Layer, 5. Anode (+)

A voltage is applied across the OLED such that the anode is positive with respect to the cathode. This causes a current of electrons to flow through the device from cathode to anode. Thus, the cathode gives electrons to the emissive layer and the anode withdraws electrons from the conductive layer; in other words, the anode gives electron holes to the conductive layer.

Soon, the emissive layer becomes negatively charged, while the conductive layer becomes rich in positively charged holes. Electrostatic forces bring the electrons and the holes towards each other and they recombine. This happens closer to the emissive layer, because in organic semiconductors holes are more mobile than electrons. The recombination causes a drop in the energy levels of electrons, accompanied by an emission of radiation whose frequency is in the visible region. That is why this layer is called emissive.

The device does not work when the anode is put at a negative potential with respect to the cathode. In this condition, holes move to the anode and electrons to the cathode, so they are moving away from each other and do not recombine.

Indium tin oxide is commonly used as the anode material. It is transparent to visible light and has a high work function which promotes injection of holes into the polymer layer. Metals such as aluminium and calcium are often used for the cathode as they have low work functions which promote injection of electrons into the polymer layer.[30]

Just like passive-matrix LCD versus active-matrix LCD, OLEDs can be categorized into passive-matrix and active-matrix displays. Active-matrix OLEDs (AMOLED) require a thin-film transistor backplane to switch the individual pixel on or off, and can make higher resolution and larger size displays possible.

Material technologies

Small molecules

Efficient OLEDs using small molecules were first developed at Eastman Kodak by Dr. Ching W. Tang. The production of small-molecule displays often involves vacuum deposition, which makes the production process more expensive than other processing techniques. Since this is typically carried out on glass substrates, these displays are also not flexible, though this limitation is not inherent to small-molecule organic materials. The term OLED traditionally refers to this type of device, though some are using the term SM-OLED.

Molecules commonly used in OLEDs include organo-metallic chelates (for example Alq3, used in the first organic light-emitting device)[26] and conjugated dendrimers.

Contrary to polymers, small molecules can be evaporated and therefore very complex multi-layer structures can be constructed. This high flexibility in layer design is the main reason for the high efficiencies of the SM-OLEDs.

Coherent emission from a laser dye-doped tandem SM-OLED device, excited in the pulsed regime, has been demonstrated.[31] The emission is nearly diffraction limited with a spectral width similar to that of broadband dye lasers.[32]

Polymer light-emitting diodes

LEP display showing partial failure

An old OLED display showing wear

Polymer light-emitting diodes (PLED), also light-emitting polymers (LEP), involve an electroluminescent conductive polymer, that emits light when connected to an external voltage source. They are used as a thin film for full-spectrum colour displays and require a relatively small amount of power for the light produced. No vacuum is required, and the emissive materials can be applied on the substrate by a technique derived from commercial inkjet printing.[33][34] The substrate used can be flexible, such as PET.[35] Thus flexible PLED displays, also called Flexible OLED (or FOLED), may be produced inexpensively.

Typical polymers used in PLED displays include derivatives of poly(p-phenylene vinylene) and polyfluorene. Substitution of side chains onto the polymer backbone may determine the colour of emitted light[36] or the stability and solubility of the polymer for performance and ease of processing.[37]

Applications of OLEDs in solid state lighting require the achievement of high brightness with good CIE coordinates (for white emission). The use of macromolecular species like polyhedral oligomeric silsesquioxanes (POSS) in conjunction with the use of phosphorescent species such as Ir for printed OLEDs have exhibited brightnesses as high as 10, 000 cd/m2.[38]

Phosphorescent materials

Phosphorescent OLED (PHOLED) uses the principle of electrophosphorescence to convert electrical energy in an OLED into light in a highly efficient manner.

Patterning technologies

Patternable organic light-emitting device (POLED) uses a light or heat activated electroactive layer. A latent material (PEDOT-TMA) is included in this layer that, upon activation, becomes highly efficient as a hole injection layer. Using this process, light-emitting devices with arbitrary patterns can be prepared.[39]

Colour patterning can be accomplished by means of laser, such as radiation-induced sublimation transfer (RIST).[40]

Organic vapour jet printing (OVJP) uses an inert carrier gas, such as argon or nitrogen, to transport evaporated organic molecules (as in Organic Vapor Phase Deposition). The gas is expelled through a micron sized nozzle or nozzle array close to the substrate as it is being translated. This allows printing arbitrary multilayer patterns without the use of solvents.

Conventional OLED displays are formed by vapor thermal evaporation (VTE) and are patterned by shadow-mask. A mechanical mask has openings allowing the vapor to pass only on the desired location.

Backplane technologies

For a high resolution display like a TV, a TFT backplane is necessary to drive the pixels correctly. Currently, LTPS-TFT (low temperature poly silicon) is used for commercial AMOLED displays. LTPS-TFT has variation of the performance in a display, so various compensation circuits have been reported.[41] Due to the size limitation of the excimer laser used for LTPS, the AMOLED size was limited. To cope with the hurdle related to the panel size, amorphous-silicon/microcrystalline-silicon backplanes have been reported with large display prototype demonstrations.[42]

Structure

Bottom or top emission

Bottom emission uses a transparent or semi-transparent bottom electrode to get the light through a transparent substrate. Top emission[43][41] uses a transparent or semi-transparent top electrode emitting light directly. Top-emitting OLEDs are better suited for active-matrix applications as they can be more easily integrated with a non-transparent transistor backplane.

Transparent OLED

Transparent organic light-emitting device (TOLED) use transparent or semi-transparent contacts on both sides of the device to create displays that can be made to be both top and bottom emitting (transparent). TOLEDs can greatly improve contrast, making it much easier to view displays in bright sunlight[citation needed]. This technology can be used in Head-up displays, smart windows or augmented reality applications.

Stacked OLED

Stacked OLED (SOLED) uses a pixel architecture that stacks the red, green, and blue subpixels on top of one another instead of next to one another, leading to substantial increase in gamut and color depth, and greatly reducing pixel gap. Currently, other display technologies have the RGB (and RGBW) pixels mapped next to each other decreasing potential resolution.

Inverted OLED

In contrast to a conventional OLED, in which the anode is placed on the substrate, an Inverted OLED (IOLED) uses a bottom cathode that can be connected to the drain end of an n-channel TFT especially for the low cost amorphous silicon TFT backplane useful in the manufacturing of AMOLED displays.[44]

Advantages

The different manufacturing process of OLEDs lends itself to several advantages over flat-panel displays made with LCD technology.

Although the method is not currently commercially viable for mass production, OLEDs can be printed onto any suitable substrate using an inkjet printer or even screen printing technologies,[45] they could theoretically have a lower cost than LCDs or plasma displays. However, it is the fabrication of the substrate that is the most complex and expensive process in the production of a TFT LCD, so any savings offered by printing the pixels is easily cancelled out by OLED's requirement to use a more costly P-Si (or LTPS) substrate - a fact that is born out by the significantly higher initial price of AMOLED displays than their TFT LCD competitors. A mitigating factor to this price differential going into the future is the cost of retooling existing lines to produce AMOLED displays over LCDs to take advantage of the economies of scale afforded by mass production.

Use of flexible substrates could open the door to new applications such as roll-up displays and displays embedded in fabrics or clothing.

OLEDs can enable a greater artificial contrast ratio (both dynamic range and static, measured in purely dark conditions) and viewing angle compared to LCDs because OLED pixels directly emit light. OLED pixel colours appear correct and unshifted, even as the viewing angle approaches 90 degrees from normal. LCDs filter the light emitted from a backlight, allowing a small fraction of light through so they cannot show true black, while an inactive OLED element produces no light and consumes no power.

OLEDs can also have a faster response time than standard LCD screens. Whereas LCD displays are capable of a 1ms response time or less[46] offering a frame rate of 1, 000 Hz or higher, an OLED can theoretically have less than 0. 01 ms response time enabling 100, 000 Hz refresh rates.

Disadvantages

Lifespan

The biggest technical problem for OLEDs is the limited lifetime of the organic materials.[47] In particular, blue OLEDs historically have had a lifetime of around 14, 000 hours to half original brightness (five years at 8 hours a day) when used for flat-panel displays, which is lower than the typical lifetime of LCD, LED or PDP technology-each currently rated for about 60, 000 hours to half brightness, depending on manufacturer and model. However, some manufacturers displays aim to increase the lifespan of OLED displays, pushing their expected life past that of LCD displays by improving light outcoupling, thus achieving the same brightness at a lower drive current.[48][49]

In 2007, experimental OLEDs were created which can sustain 400 cd/m2 of luminance for over 198, 000 hours for green OLEDs and 62, 000 hours for blue OLEDs.[50]

Color balance issues

Additionally, as the OLED material used to produce blue light degrades significantly more rapidly than the materials that produce other colors, blue light output will decrease relative to the other colors of light. This differential color output change will change the color balance of the display and is much more noticeable than a decrease in overall luminance.[51] This can be partially avoided by adjusting colour balance but this may require advanced control circuits and interaction with the user, which is unacceptable for some uses.

In order to delay the problem, manufacturers bias the colour balance towards blue so that the display initially has an artificially blue tint, leading to complaints of artificial-looking, over-saturated colors.

Water damage

Water can damage the organic materials of the displays. Therefore, improved sealing processes are important for practical manufacturing. Water damage may especially limit the longevity of more flexible displays.[52]

Outdoor performance

As an emissive display technology, OLEDs are 100% reliant converting electricity to light whereas most LCD displays contain at least some portion of reflective technology and e-ink leads the way in efficiency with ~33% reflectivity of sunlight, enabling the display to be used without any artificial light source.

OLEDs typically produce only around 200 nits of light leading to poor readability in bright ambient light, such as outdoors, whereas displays that use reflective light are able to increase their brightness in the presence of ambient light to help overcome unwanted surface reflections without using any additional power.

Power consumption

While an OLED will consume around 40% of the power of an LCD displaying an image which is primarily black, for the majority of images, it will consume

60-80% of the power of an LCD - however it can use over three times as much power to display an image with a white background[53] such as a document or website. This can lead to disappointing real-world battery life in mobile devices.

Screen burn-in

Unlike displays with a common light source, the brightness of each OLED pixel fades depending on the content displayed. Combined with the short lifetime the organic dyes, this leads to screen burn-in[54], worse than was common in the days of CRT-based displays

Technology demos

Samsung applications

In January 2005, Samsung announced the world's largest OLED TV at the time, at 21 inches (53 cm).[55] This OLED featured the highest resolution at 2. 3 million pixels (WUXGA: widescreen ultra-extended graphics array) at the time. In addition, the company adopted AM-based technology for its low power consumption and high-resolution qualities.

In January 2008, Samsung showcased the world's largest and thinnest OLED TV at the time, at 31-inches and 4. 3 mm.[56]

In May 2008, Samsung unveiled an ultra-thin 12. 1 inch laptop OLED display concept, with a 1, 280Ã-768 resolution with infinite contrast ratio.[57] According to Woo Jong Lee, Vice President of the Mobile Display Marketing Team at Samsung SDI, the company expects OLED displays to be used in notebook PCs as soon as 2010.[58]

In October 2008, Samsung showcased the world's thinnest OLED display, also the first to be 'flappable' and bendable.[59] It measures just 0. 05 mm (thinner than paper), yet a Samsung staff member said that it is " technically possible to make the panel thinner".[59] To achieve this thickness, Samsung etched an OLED panel that uses a normal glass substrate. The drive circuit was formed by low-temperature polysilicon TFTs. Also, low-molecular organic EL materials were employed. The pixel count of the display is 480 Ã- 272. The contrast ratio is 100, 000: 1, and the luminance is 200 cd/m². The colour reproduction range is 100% of the NTSC standard.

In October 2008, Samsung unveiled the world's largest OLED Television at 40-inch with a Full HD resolution of 1920Ã-1080 pixel.[60] In the FPD International, Samsung stated that its 40-inch OLED Panel is the largest size currently possible. The panel has a contrast ratio of 1, 000, 000: 1, a colour gamut of 107% NTSC, and a luminance of 200 cd/m² (peak luminance of 600 cd/m²).

At the Consumer Electronics Show (CES) in January 2010, Samsung demonstrated a laptop computer with a large, transparent OLED display[61] and an animated OLED display in a photo ID card.[62]

Sony applications

In 2004, Sony released the Sony CLIÉ PEG-VZ90, the first commercial device to feature an OLED screen.

In 2006, Sony introduced the MZ-RH1 Portable Minidisc Recorder, which has an OLED screen.[63]

At the Las Vegas CES 2007, Sony showcased 11-inch (28 cm, resolution 960Ã-540) and 27-inch (68. 5 cm, full HD resolution at 1920Ã-1080) OLED TV models.[64] Both claimed 1, 000, 000: 1 contrast ratios and total thicknesses (including bezels) of 5 mm. In April 2007, Sony announced it would manufacture 1000 11-inch OLED TVs per month for market testing purposes.[65] On October 1, 2007, Sony announced that the 11-inch model, now called the XEL-1, would be released commercially;[1] the XEL-1 was first released in Japan in December 2007.[66]

In May 2007, Sony publicly unveiled a video of a 2. 5-inch flexible OLED screen which is only 0. 3 millimeters thick.[67]

At the CES 2008, Sony showcased the Walkman X series with 3" OLED touchscreen.[68]

In April 2008, at " Display 2008", Sony showed a 0. 2 mm (0. 0079 inch) thick 3. 5 inch display with a resolution of 320Ã-200 pixels and a 0. 3 mm thick 11 inch display with 960Ã-540 pixels resolution (one-tenth the thickness of the XEL-1).[69][70]

In July 2008, a Japanese government body said it would fund a joint project of leading firms, which is to develop a key technology to produce large, energy-saving organic displays. The project involves one laboratory and 10 companies including Sony Corp. NEDO said the project was aimed at developing a core technology to mass-produce 40 inch or larger OLED displays in the late 2010s.[71]

In October 2008, Sony has published results of research it carried out with the Max Planck Institute over the possibility of mass-market bending displays, which could replace rigid LCDs and plasma screens. Eventually, bendable, transparent OLED screens could be stacked to produce 3D images with much greater contrast ratios and viewing angles than existing products.[72]

In April 2009, Sony demonstrated a 21" prototype at the Display Japan conference in Tokyo.[73] This was followed up by a 24. 5" 3D OLED demonstration from Sony, during CES 2010.[74]

Other companies

The Optimus Maximus keyboard developed by the Art. Lebedev Studio and released early 2008 uses 113 48Ã-48-pixel OLEDs (10. 1Ã-10. 1 mm) for its keys.

OLEDs can be used in High-Resolution Holography (Volumetric display). Professor Orbit showed on May 12, 2007, EXPO Lisbon the potential application of these materials to reproduce three-dimensional video.[citation needed]

OLEDs could also be used as solid-state light sources. OLED efficiency and lifetime already exceed those of incandescent light bulbs, and OLEDs are investigated worldwide as a source of general illumination; an example is the EU OLLA project.[75]. On May 2009, Philips was the first company to comercialize on his website large area pixels OLEDs (60 cm2) for ambient lighting (Lumiblade OLED Pixels [76] whose shape, size and color can be selected by customers).

On March 11, 2008 GE Global Research demonstrated the first successful roll-to-roll manufactured OLED, marking a major milestone towards cost effective production of commercial OLED technology. The four year, $13 million research project was carried out by GE Global Research, Energy Conversion Devices, Inc and the National Institute of Standards and Technology.[77][78]

Chi Mei Corporation of Taiwan, demonstrated a 25" Low-Temperature Polycrystalline silicon Active Matrix OLED at the Society of Information Displays (SID) conference in Los Angeles, CA, USA on May 20-22, 2008.

On June 5, 2009 DuPont demonstrated a new material that can be printed, so called solution deposition. The breakthrough is the ability to produce economically scalable and durable OLED displays at the 2009 International Symposium, May 31-June 5, 2009, Henry B. Gonzalez Convention Center, San Antonio, TX, USA

The use of OLEDs is also being investigated for the treatment of cancer by photodynamic therapy.[79]

On 30 Aug 2009, South Korea's LG Electronics said it would launch a 15-inch television set using AM-OLED displays for sale in November.[80][81]

According to Isuppli Corp,[82] upward momentum of OLED Shipments for primary cell phone displays is their expectation in coming years. They claimed that global shipments of OLED main cell phone displays would rise to 178 million units in 2015, up from 22. 2 million in 2009. In other words, the shipments will rise eightfold by 2015. Therefore, it's evident that the manufacture of OLED display and OLED equipment by Samsung, DuPont, Anwell, Chi Mei Corporation, etc has expanded dramatically in recent years.

Commercial uses

OLED technology is used in commercial applications such as small screens for mobile phones and portable digital audio players (MP3 players), car radios, digital cameras, and high-resolution microdisplays for head-mounted displays. Such portable applications favor the high light output of OLEDs for readability in sunlight, and their low power drain. Portable displays are also used intermittently, so the lower lifespan of OLEDs is less important here. Prototypes have been made of flexible and rollable displays which use OLEDs' unique characteristics. OLEDs have been used in most Motorola and Samsung colour cell phones, as well as some LG and Sony Ericsson phones, notably the Z610i, and some models of the Walkman.[83] It is also found in the Creative Zen V/V Plus series of MP3 players and iriver U10/clix. Nokia has also introduced recently some OLED products, including the 7900 Prism, the Nokia 8800 Arte, and the Nokia N85 and the Nokia N86 8MP, both of which feature an AMOLED display.

Timeline

October 1, 2007. Sony become the first company to announce an OLED television for commercial sale. The XEL-1 11" OLED Digital Television sells for $2, 499. 99 in the United States and Canada.

December 2007 - July 2008. OLED applications include signs and lighting.[84][85]

January 2009. Handheld computer manufacturer OQO introduce the smallest Windows Vista computer with an OLED display.[86]

March 2009. Samsung Electronics launch a 2. 8" AMOLED capacitive touchscreen phone called the S8300 UltraTOUCH.

April 2009. Samsung bring the first phone using an AMOLED display to the United States, the Impression on AT&T. The Impression has a 3. 2" WQVGA AMOLED.

May 2009. Philips Lighting commercialize the first OLED lights, opening a webshop where OLED lighting samples under the brand name 'Lumiblade' can be ordered online.[87]

May 2009. Samsung Electronics launch a 3. 7" nHD AMOLED capacitive touchscreen phone called the i8910 Omnia HD.

June 2009. Samsung Electronics launch a 3. 1" WVGA AMOLED resistive touchscreen phone called the S8000 Jet.

July 2009. Samsung Electronics launch a 3. 7" WVGA AMOLED 3G full-touchscreen phone called the Omnia II i8000 with Samsung's own touchwiz ui version 2. 0.

August 2009. Sprint Nextel sell phones from Samsung Electronics featuring advanced AMOLED display technology. Company executives claim its technology provides longer battery life and enhanced video and photo images. [88]

September 2009. Microsoft launch a 3. 3" Sixteenth HD1080 OLED capacitive multi-touch portable media player called the Zune HD.

January 5, 2010. Google launch a 3. 7" AMOLED smartphone called the Nexus One

January 2010. Samsung Electronics launch a 14" prototype notebook featuring up to 40% transparency when turned off.

January 2010. Sony display a 24. 5" prototype OLED 3D television during the Consumer Electronics Show.[74]

Patents

Use of OLEDs may be subject to patents held by Eastman Kodak, DuPont, General Electric, Royal Philips Electronics, numerous universities and others.[89][90]

Manufacturers

Current manufacturers of OLED panels include Anwell Technologies Limited,[91] Chi Mei Corporation,[92] DuPont,[93] GE Global Research,[94] LG,[95] Samsung,[96] and Sony.[97]

Samsung SDI

Samsung SDI, a subsidiary of Samsung Group, South Korea's largest conglomerate, is the world's largest OLED manufacturer, producing nearly 50% of the OLED displays made in the world.[98] In October 2008, it unveiled the world's largest OLED TV at 40-inch with a Full HD resolution of 1920x1080 pixel. It was the first company in the industry to develop and manufacture AMOLED displays[99] and has the world's largest market share in both Passive Matrix OLEDs (PMOLED) and Active Matrix OLEDs (AMOLED).[100] The company is leading the world OLED industry, generating $100. 2 million out of the total $475 million revenues in the global OLED market in 2006.[99]

Currently, it holds more than 600 American patents and more than 2800 international patents, making it the largest owner of AMOLED technology patents.[99]

As of April 2009, Samsung has released one phone using the AMOLED display in the United States, the Impression for AT&T.

http://en. wikipedia. org/wiki/Organic_LED