A

Seminar report

On

Light Emitting Polymers

Submitted in partial fulfillment of the requirement for the award of degree
Of ECE

SUBMITTED TO: SUBMITTED BY:

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Preface

I have made this report file on the topic **Light Emitting Polymers;** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

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INTRODUCTION

Light emitting polymers (LEPs) or polymer-based light-emitting diodes discovered by Friend et al in 1990 have been found better than other displays like liquid crystal displays (LCDs), vacuum fluorescence displays, and electroluminescence displays. Though not commercialized yet, these have proved to be a milestone in the field of Flat Panel Displays (FPDs). Research on LEP is underway in Cambridge Display Technology Ltd, CDT, Cambridge, UK. The Cathode Ray Tube (CRT), invented by German physicist Karl Ferdinand Braun in 1897, remained the ubiquitous display in the last half of the 20th century. But the CRT's long heritage in an environment where product life cycles are measured in months rather than years doesn't mean that it is an ideal display solution. It is bulky, power hungry and expensive to manufacture.

The fact is that researchers haven't come up with a better solution. Liquid Crystal Display (LCD) was pitched as the savior of the display industry. Its creators claimed that a slim profile would quickly make it the display of choice. But today, LCDs are far more pervasive. These offer a little bit benefit over their predecessor, the CRT. The cost of a LCD as well as a CRT monitor one-third of the total price of a computer. Says David Mentley, Vice President and display industry analyst at Stanford Resources, California, USA, "Although LCD is a highly successful technical achievement, the manufacturing archetype must change if flat panel displays are to compete directly across all applications." In the last decade, several other contenders, such as Plasma and field emission displays were hailed as the solution to the pervasive display. Like LCD, they suited certain niche applications, but failed to meet the broad demands of the computer industry.

What if a new type of display could combine the characteristics of a CRT with the performance of an LCD and the added design benefits of formability and low power? Cambridge Display Technology Ltd (CDT) is developing a display medium with exactly these characteristics. The technology uses a light emitting polymer (LEP) that costs much less to manufacture and run than CRTs because the active material is plastic.

WHAT IS LEP?

It is a polymer that emits light when a voltage is applied to it. The structure comprises a thin-film semiconducting polymer sandwiched between two electrodes (anode and cathode). When electrons and holes are injected from the electrodes, the recombination of these charge carriers takes place, which leads to emission of light that escapes through glass substrate. The bandgap i.e. the energy difference between valence band and conduction band, of the semiconducting polymer determines the wavelength (colour) of the emitted light.

SEC/CDT FULL-COLOUR LEP DISPLAY

The first polymer LEPs used poly phinylene vinylene (PPV) as the emitting layer. Since 1990, a number of polymers have been shown to emit light under the application of an electric field; the property is called the electroluminescence (EL).Efforts are on to improve the efficiency of polymer devices by modifying their configuration.

CHEMISTRY BEHIND LEP

LEPs are constructed from a special class of polymers called conjugated polymers. Plastic materials with metallic and semiconductor characteristics are called conjugated polymers. These polymers possess delocalized pi electrons along the backbone, whose mobility shows properties of semiconductors. Also this gives it the ability to support positive and negative charge carriers with high mobility along the polymer chain. The charge transport mechanism in conjugated polymers is different from traditional inorganic semiconductors.

The amorphous chain morphology results in inhomogeneous broadening of the energies of the chain segments and leads to hopping type transport. Conjugated polymers have already found applications in battery electrodes, transparent conductive coatings, capacitor electrolytes and through hole platting in PCBs. There are fast displaying traditional materials such as natural polymers etc owing to better physical and mechanical properties and amenability to various processes.

BASIC STRUCTURE AND WORKING

Like the CRT, LEP emits light as a function of its electrical operation. An LEP display solely consists of the polymer material manufactured on a substrate of glass or plastic and doesn't require additional elements like the backlights, filters, and polarisers that are typical of LCDs. Fig. shows the structure of an LEP device. The indium-tin oxide (ITO) coated glass is coated with a polymer. On the top of it, there is a metal electrode of Al, Li, Mg, or Ag. When a bias voltage is applied, holes and electrons move into the polymer. These moving holes and electrons combine together to form hole-electron pairs known as 'excitons'. These excitons are in excited state and go back to their initial state by emitting energy. When this energy drop occurs, light comes out from the device.

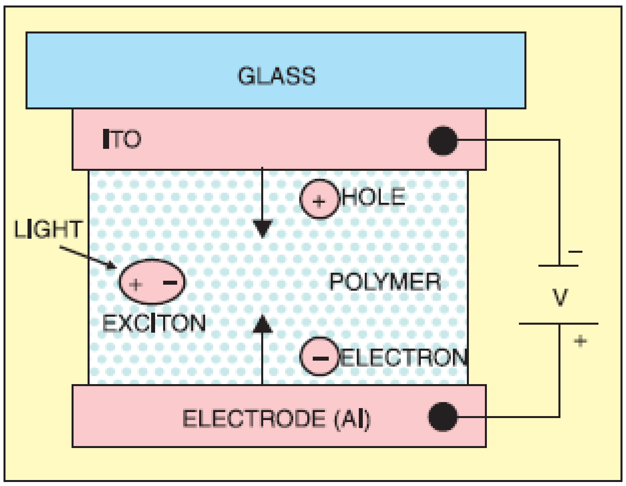

FIGURE 1:THE STRUCTURE OF AN LEP DEVICE

Light-emitting devices consist of active/emitting layers sandwiched between a cathode and an anode. Indium-tin oxide is typically used for the anode and aluminium or calcium for the cathode. Fig.2 shows the structure of a simple single layer device with electrodes and an active layer. Single-layer devices typically work only under a forward DC bias. Also it shows a symmetrically configured alternating current light-emitting (SCALE) device that works under AC as well as forward and reverse DC bias.

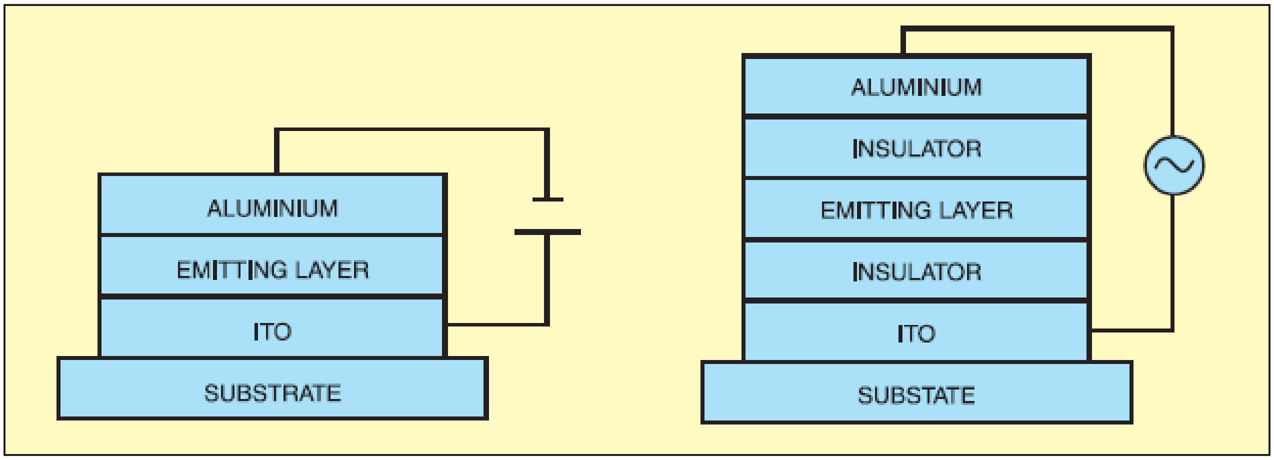

FIGURE 2:THE STRUCTURE OF SINGLE-LAYER DEVICE AND SYMMETRICALLY CONFIGURED ALTERNATING CURRENT LIGHT EMITTING (SCALE) DEVICE.

MANUFACTURING

In order to manufacture the polymer, two types of techniques are used. They are

(i) SPIN COATING PROCESS

A spin-coating machine is used that has a plate spinning at the speed of a few thousand rotations per minute. The robot pours the plastic over the rotating plate, which, in turn, evenly spreads the polymer on the plate. This results in an extremely fine layer of the polymer having a thickness of 100 nanometres. Once the polymer is evenly spread, it is baked in an oven to evaporate any remnant liquid. The same technology is used to coat the CDs.

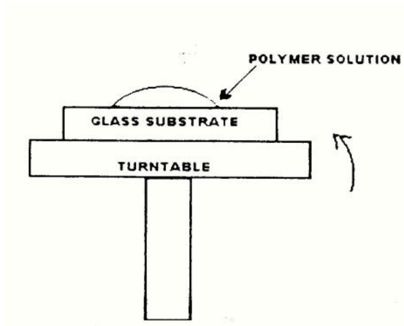

FIGURE 3: SPIN COATING PROCESS

(ii) PRINTER BASED TECHNIQUE

LEPs can be patterned using a wide variety of printing techniques. The most advanced is ink-jet printing. Resolution as high as 360 dpi have been demonstrated and the approach are scalable to large-screen displays. Printing promises much lower manufacturing cost.

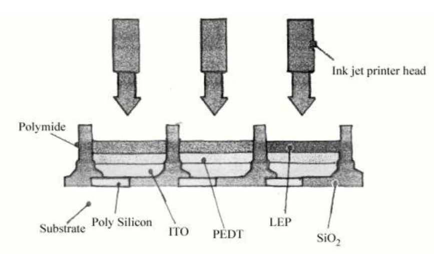

FIGURE 4:PRINTER BASED TECHNIQUE

TYPES OF LEPs

The types of organic light-emitting devices available in the market include flexible, stacked, and transparent.

FLEXIBLE ORGANIC LEDs

FOLEDs are built on flexible substrates. Flat-panel displays have traditionally been fabricated on glass substrates, in part because these have intrinsic structural and/or processing constraints that preclude the use of non-rigid substrates. Nonetheless, flexible materials are highly desired substrates because these have significant performance and cost advantages. UDC's proprietary FOLED technology is the result of a pioneering work to demonstrate that OLEDs are functional and durable in a flexible format and can be built with the same performance as their rigid substrate counterparts.

Flexibility. For the first time, FOLEDs may be made on substrates ranging from optically clear plastic films to reflective metal foils. These materials provide the ability to conform, bend, or roll a display into any shape, so a FOLED may be laminated onto helmet face shields, military uniforms, shirtsleeves, aircraft cockpit instruments panel, or automotive windshields.

Ultra-lightweight, thin form. The use of thin plastic substrates will significantly reduce the weight of flat-panel displays in cell phones, portable computers, and especially large-screen on-the-wall-televisions. For instance, the display in a laptop can be reduced from several pounds to a few ounces by using FOLED technology.

Durability. FOLEDs are generally less fragile and more impact resistant and durable than their glass-based counterparts.

TOLED and SOLED features. FOLEDs offer excellent performance characteristics and features of both TOLEDs and SOLEDs.

Cost-effective processing. Researchers have demonstrated a continuous organic vapour phase deposition method for large area roll-to-roll FOLED processing. While this technique requires further development, it provides the basis for very low cost
mass production.

A PASSIVE-MATRIX 0.18MM THICK FOLED FABRICATED IN UDC'S PILOT LINE FACILITY

SOLEDs

The award-winning stacked OLED (SOLED) pixel architecture is a radical new approach for full-colour displays. UDC's proprietary SOLED technology offers high-definition display resolution and
true-colour quality for next-generation display applications. The SOLED consists of an array of vertically stacked TOLED sub-pixels. To separately tune colour and brightness, each of the red, green, and blue (R-G-B) sub-pixel elements is individually controlled. By adjusting the ratio of currents in the three elements, colour is tuned. By varying the total current through the stack, brightness is varied. By modulating the pulse width, gray scale is achieved. With this SOLED architecture, each pixel can provide full colour. The SOLED architecture is a significant departure from the traditional side by-side (SxS) approach used today in CRTs
and LCDs. SOLEDs offer the following performance enhancements over SxS configurations:

- Full-colour tunability for true colour quality at each pixel—valuable when colour fidelity is important.
- Three times higher resolution than the comparable SxS display. While it takes Three SxS pixels (R, G, and B) to generate full colour, it takes only one SOLED pixel—or one-third the area—to achieve the same. This is especially advantageous when maximising pixel density is important.
- Nearly 100 per cent fill factor; for example, when a full-colour display calls for green, red and blue pixels are turned off in the SxS structure, whereas all the pixels turn on green in a SOLED under the same conditions. This means that SOLED colour definition and picture quality are superior.
- No upper limit to pixel size. In large screen displays, individual pixels are frequently large enough to be seen by the eye at a short range. With the SxS format, the eye may perceive individual red, green, and blue instead of the intended colour mixture. With a SOLED, each pixel emits the desired colour and thus is perceived correctly, no matter what size it is and from where it is viewed.

STACKED ORGANIC LIGHT-EMITTING DEVICE

TOLEDs

TOLEDs employ an innovative transparent contact to achieve an enhanced display. With this proprietary transparent OLED structure, TOLEDs can be top, bottom, or both top and bottom emitting (transparent). This option creates a host of exciting new display opportunities. In its most basic form, the TOLED is a monolithic solid state device consisting of a series of small-molecule organic thin films sandwiched between two transparent, conductive layers (refer to Fig. 5). As
a result, TOLEDs are bright, self-emitting displays that can be directed to emit from either or both surfaces. This is possible because in addition to having transparent contacts, the organic materials are transparent over their own emission spectrum and throughout most of the visible spectrum.

Structure: A transparent conductive material such as indium-tin oxide for hole injection is deposited directly onto a glass substrate. Then a series of organic materials are deposited by vacuum sublimation on the indium-tin oxide layer: The first organic layer serves as a hole-transporting layer (HTL) and the second layer serves as both a light emitting layer (EL) and an
electron-transporting layer (ETL). Finally, a UDC proprietary transparent contact for electron injection is deposited by vacuum evaporation or sputtering on the top of the organic films. When a voltage is applied across the device, it emits light. This light emission is based upon the luminescence phenomenon, wherein injected electrons and holes migrate from the contacts toward the organic heterojunction under the applied electric field. These carriers meet to form excitons (electron-hole pairs) that recombine radiatively to emit light. Compared to other FPDs, TOLEDs offer better energy efficiency (hence longer battery life), full viewing angle, brighter

and higher-contrast light emission, faster response, and better environmental robustness. These thin-film, solid state devices are durable and ideal for portable applications. In full production, TOLEDs cost significantly less than LCDs because these require fewer process steps and use fewer and lower-cost materials than LCDs.

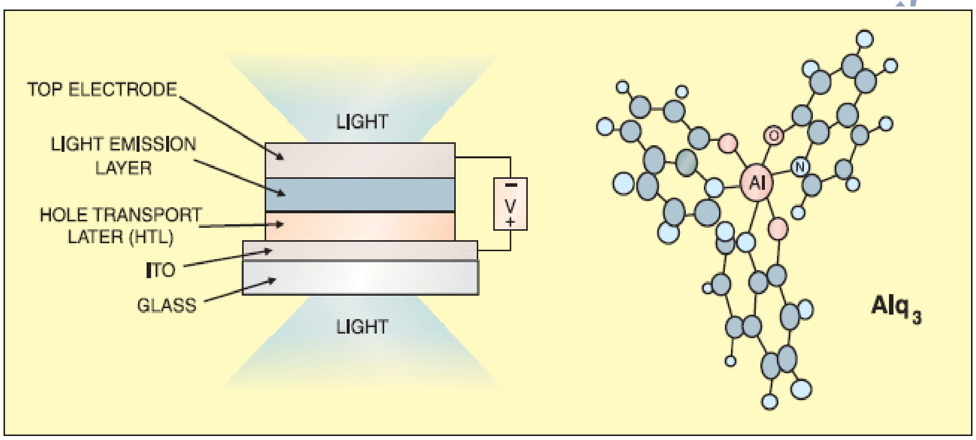

FIGURE 5: TOLED STRUCTURE

Directed top emission: As standard OLEDs have reflective back contacts, these are bottom emitters and must be built on transparent substrates. TOLEDs have a transparent structure, so these may instead be built on opaque surfaces to effect top emission. These displays have the potential to be directly integrated with future dynamic credit cards and may also be built on metal, e.g. automotive components. Top-emitting TOLEDs achieve better fill factor and characteristics in high-resolution, high-information-content displays using active-matrix silicon back-planes.

Transparency: TOLEDs can be as clear as the glass or the substrate they're built on. TOLEDs built between glass plates are transparent up to 70 per cent or more
when turned off. This indicates the potential of TOLEDs in applications where maintaining vision area is important. Today, smart windows are penetrating the multibillion dollar flat-glass architectural and automotive marketplaces. TOLEDs may be fabricated on windows for home entertainment and teleconferencing purposes, on windshields and cockpits for navigation and warning systems, and into helmet-mounted or head-up systems for virtual reality applications.

Enhanced high-ambient contrast: TOLEDs offer enhanced contrast ratio. By using a low-reflectance absorber (a black surface) behind the top or the bottom TOLED surface, contrast ratio can be significantly improved. This feature is particularly important in daylight readable applications; for examples cell phones and military fighter aircrafts' cockpits.

Multi-stacked devices: TOLEDs are fundamental building blocks for many multi structure and hybrid devices; for example, UDC's novel, vertically-stacked SOLED architecture. Biplanar TOLEDs will give two readouts through one surface. Bidirectional TOLEDs will provide two independent displays emitting from opposite faces of the display. With portable products shrinking and desired information content expanding, TOLEDs are a great way to double the display area for the same display size!

ADVANTAGES

- Require only 3.3 volts and have lifetime of more than 30,000 hours.
- Greater power efficiency than all other flat panel displays.
- No directional or blurring effects.
- Can be viewed at any angle.
- Glare free view up to 160 degree.
- Cost much less to manufacture and run than CRTs, because the active material used is plastic.
- Can scale from tiny devices millimetres in dimension to high definition device up to 5.1 meters in diameter.
- Fast switching speed, that is 1000 times faster than LCDs.
- Higher luminescence efficiency. Due to high refractive index of the polymer, only a small fraction of the light generated in the polymer layer escapes the film.

LIMITATIONS

AGING OF LEP

One of the major barriers to the commercial development of light emitting devices based upon electroluminescent polymers is their useful lifetime. The lifetime of these devices can be greatly extended by operating in an inert environment under dry box conditions. However, even under ideal
conditions, the light intensity gradually decreases and some discrete regions become totally dark. Various tests like AC impedance measurement and optical microscopy are being carried out in Cambridge University to determine physical and/or chemical changes that correlate with the loss of
electroluminescent intensity from polymeric light emitting devices and thereby find out the way to increase the useful lifetime. One problem that the engineers encountered was to stop or delay the aging process of the polymer. The trickiest stage was the final soldering of the displays—this needed to be done in an airtight environment because as soon as the LEP molecules came in contact with oxygen, these would disintegrate. The solution was to do the soldering in a glass jar filled with nitrogen. The enclosure protects the device from impurities and provides a higher degree of efficiency by giving the screen an estimated life span of 30,000 working hours.

SPACE CHARGE EFFECT

The effects of space charge on the current-voltage (I-V) and capacitance-voltage (C-V) characteristics of polymer LEDs have been investigated theoretically. Space charge effects are important in polymer LEDs due to the low carrier mobilities and significant recombination in the device. This effect becomes more pronounced as the difference between electron and hole mobilities is increased. Consequences of space charge include lowering of the electric fields near the contacts and therefore suppression of the injected tunnelling currents, and strongly asymmetric recombination profiles for unequal mobilities thereby decreasing the luminescence. Research is underway to overcome this barrier.

POTENTIAL APPLICATIONS

- Multi or full colour cell phone displays
- Full colour high-resolution personal digital assistants(PDAs)
- Heads-up instrumentation for cars
- Lightweight wrist watches
- High definition televisions
- Roll-up daily refreshable electronic newspapers
- Automobile light systems without bulbs
- Windows/wall/partitions that double as computer screens
- Military uniforms
- Aircraft cockpit instrumentation panel a lot of others
- Manufactures like Dupont Displays, OSRAM, Philips,

Seiko-Epson, Ritek and many others have already started producing LEP displays and these displays will replace the active matrix LCDs as the market-dominant display by 2010.

CONCLUSION

LEPs are promising, low-cost solutions for today's flat-panel displays. Although not commercialised yet, these may replace bulky and heavy CRT displays in the near future. At the Wall Street Journal CEO Forum that took place in London, the UK, a panel of industry leaders predicted thatLEP technology would storm the market in the next few years.

REFERENCES

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