

INTRODUCTION

Light emitting polymers or polymer based light emitting diodes discovered by Friend et al in 1990 has been found superior than other displays like, liquid crystal displays (LCDs) vacuum fluorescence displays and electro luminescence displays. Though not commercialised yet, these have proved to be a mile stone in the filed of flat panel displays. Research in LEP is underway in Cambridge Display Technology Ltd (CDT), the UK.

In the last decade, several other display 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 broad demands of the computer industry.

Today the trend is towards the non_crt flat panel displays. As LEDs are inexpensive devices these can be extremely handy in constructing flat panel displays. The idea was to combine the characteristics of a CRT with the performance of an LCD and added design benefits of formability and low power. Cambridge

Display Technology Ltd 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 used is plastic.

WHAT IS LEP ?

LEP is a polymer that emits light when a voltage is applied to it. The structure comprises a thin film semi conducting polymer sandwiched between two electrodes namely 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 escape through glass substrate.

The band gap, that is energy difference between valence band and conduction band of the semi conducting polymer determines the wave length, that is colour of the emitted light.

The first polymer LEPs used poly phenylene 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 electro luminescence(EL)

PPV and its derivatives, including poly thiophenes, poly pyridines, poly phenylenes and copolymers are still the most commonly used materials.

Efforts are on to improve stability, lifetime and 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 delocalised 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 application as conductor in battery electrodes, transparent conductive coatings, capacitor electrolytes and through hole plating in PCB's. 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

An LEP display solely consists of the polymer material manufactured on a substrate of glass or plastic and doesn't require additional elements like polarizers that are typical of LCDs. LEP emits light as a function of its electrical operation.

The basic LEP consists of a stack of thin organic polymer layers sandwiched between a transport anode and a metallic cathode. Figure shows the basic structure. 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. This phenomenon is called electroluminescence. It is shown in figure 2&3. The greater the difference in energy/between the hole and the electron, the higher the frequency of the emitted light.

The development of blue LEF material enthused the world about the possibility full colour display.

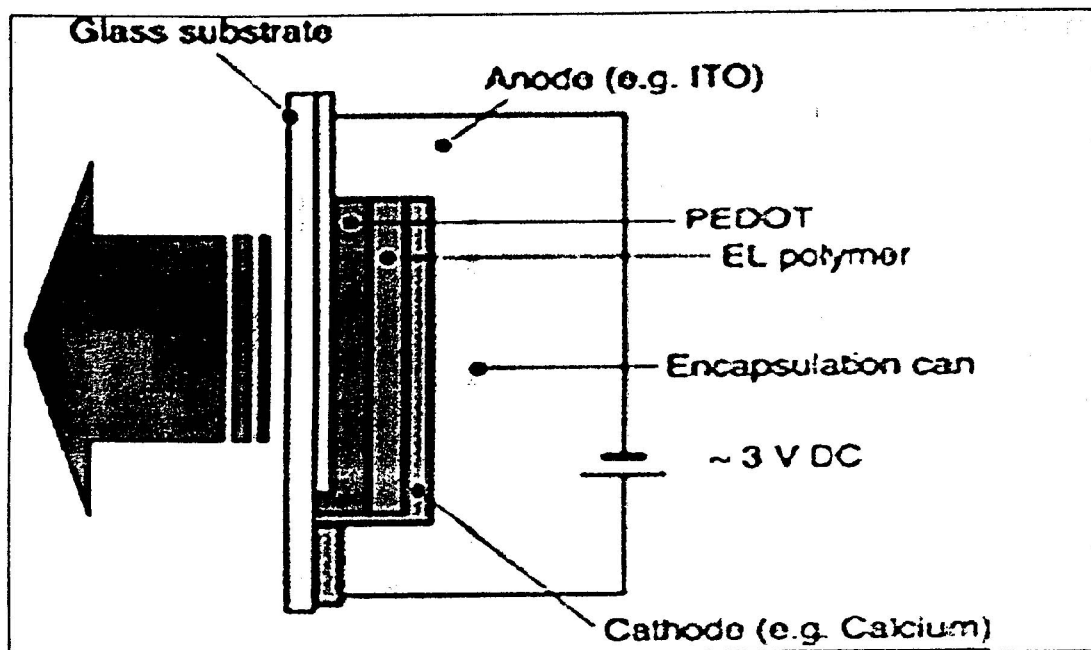


Figure: basic structure of LEP

Two types of displays: The LEP displays are two types, namely, passive matrix and active matrix.

To drive a passive matrix display, the current is passed through select pixels by applying a voltage to the drivers attached to the corresponding rows and columns. These schemes pattern the anode and cathode into perpendicular rows and columns and apply a data signal to the columns while addressing the sequentially. As the number of rows in the display increases, each pixel must be red brightness by a factor of the number of row times the desired brightness, which can exceed 20000cd/m². the current required to achieve this brightness, levels limits this architecture to relatively small screen sizes. Philips Flat Display systems (Sunnyvale, CA) and Dupont Displays have demonstrated full-colour passive matrix displays.

In active matrix architecture, a thin film polysilicon transistor on the substrate address each pixel individually. Active matrix displays are not limited by current consideration. Seiko-Epson, Toshiba (Tokyo, Japan), and Samsung (Seoul, Korea) have now demonstrated full colour active matrix displays. One exciting possibility is that polymer transistors, which can be

manufactured by techniques similar to those used for LEP patterning, could be used to drive an LEP display. Such an approach would potentially lend itself to roll-to-roll processing on flexible substrates.

Performance table of different colours of LEP

Electric Parameters	Deep blue	Blue	Green	Orange	Red
Maximum Cd/A	1.90	4.09	14.90	3.5	1.20
At 3.5v dc Supply					
Lm/w	0.77	3.41	10.60	2.8	1.30
Cd/A	0.90	2.14	1.16	3.2	1.50
Cd/m ²	56.00	68.00	830.00	1200.0	300.00
MA/cm ²	6.24	3.18	7.17	38.0	20.00

MANUFACTURING

In order to manufacture the polymer two techniques are used.

Spin coating process

This technique involves spinning a disk, that is glass substrate at a fixed angular velocity and letting a small amount of polymer solution to drop on the top of the disk. It is shown in the figure. Spin coating machine used has a few thousands 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 nanometers. Once the polymer is evenly spread, it is baked in an oven to evaporate any remnant liquid.

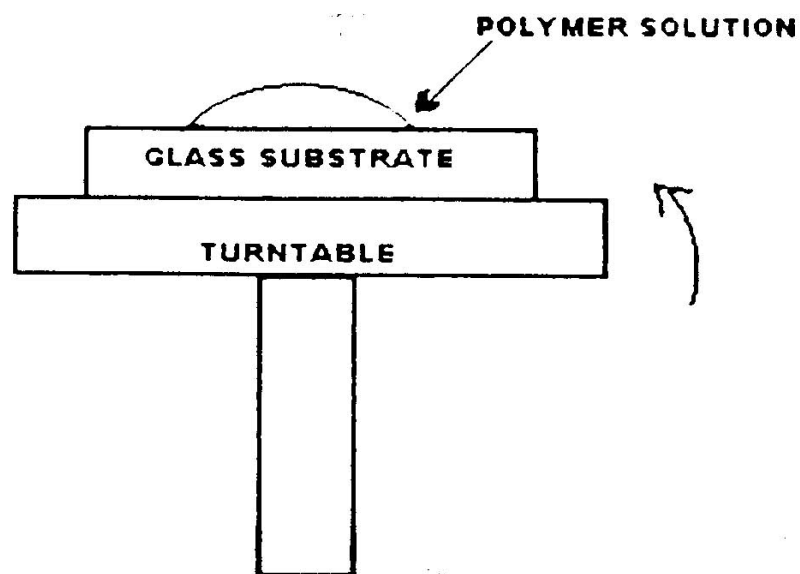
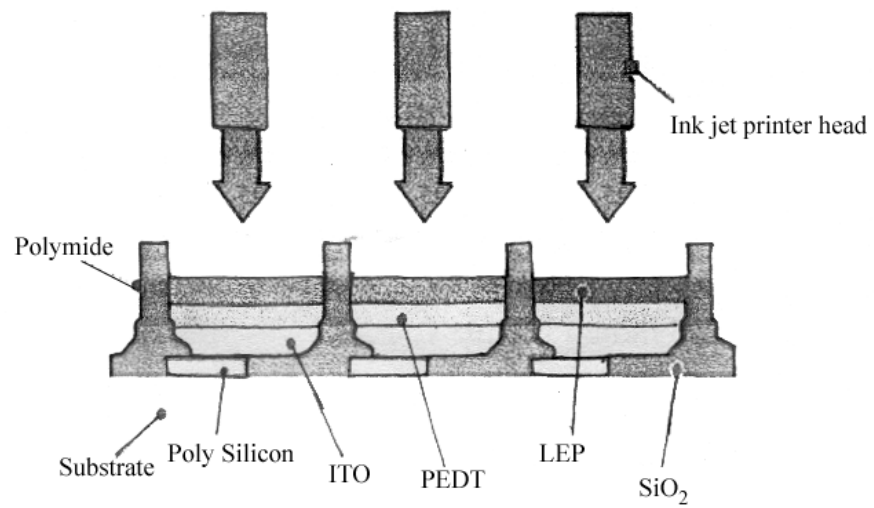


Figure: spin coating process.

Printer based technique

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

Printer based technique



TYPES OF LEPs

The types of LEPs available in the market include flexible, stacked and transparent.

Flexible organic LEPs

They are built on flexible substrates instead of glass substrates. These materials provide the ability to conform, bend or roll a display into any shape. So these find application on helmet face shields, military uniforms, shirtsleeves and automotive windshields.

Stacked organic LEPs

They use pixel architecture and offers high-definition display resolution and true-colour quality for the next generations display applications. With this type, each pixel emits the desired colour and thus is perceived correctly, no matter what size it is and from where it is viewed.

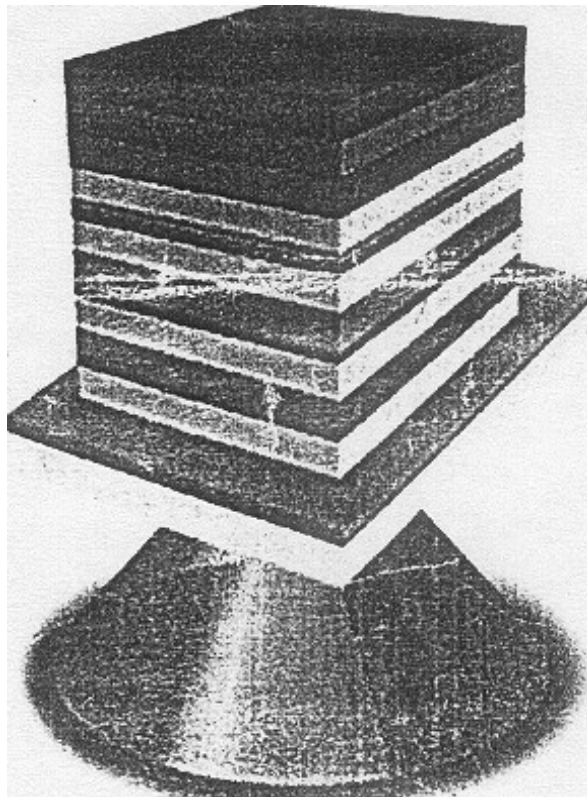
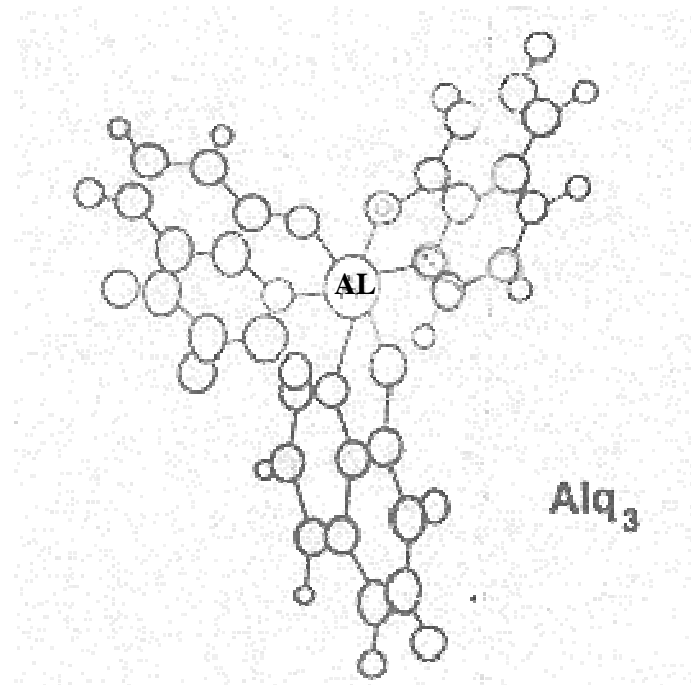
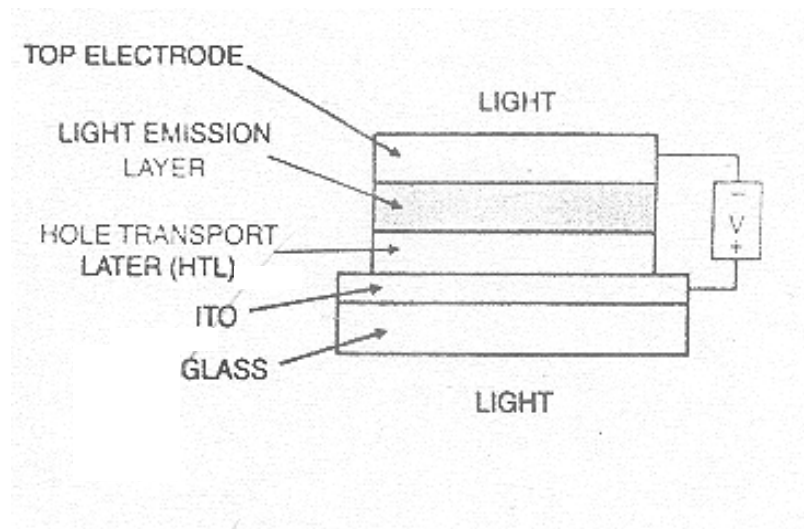


Figure SOLEP

Transparent organic LEPs

The employ an innovative transparent contact to achieve an enhanced display. They can be top, bottom or both top and bottom emitting (transparent). Bi-directional LEPs will provide two independent displays emitting from opposite faces of the display. With portable products shrinking and desired information content expanding, transparent LEPs are a great way to double the display area for the same display size.



TOLED STRUCTURE

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 upto 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.
- They don't need additional elements like the backlights, filters and polarizers that are typical of LCDs.

LIMITATIONS

1. Aging of LEP

One of the major barriers to the commercial development of LEP is its useful lifetime. Even under ideal conditions, the light intensity gradually decreases and some discrete regions become totally dark. This phenomenon is the 'aging of LEP'.

One method to reduce or stop aging is that the final soldering of the displays is to be done in an airtight environment because as soon as the LEP molecules come in contact with oxygen, these would disintegrate. The solution was to do the final soldering in a glass jar filled 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.

2. Space charge effect

The effect of space charge on the voltage-current characteristics and current-voltage characteristics becomes more

pronounced when the difference in the electron hole mobilities is increased. Consequences of space charge include lowering of the electric fields near the contacts and therefore suppression of the injected tunnel currents and strongly asymmetric recombination profiles for unequal mobility thereby decreasing the luminescence and hence decreases the efficiency. Research is underway to overcome this barrier

Even though this limitations are there LEPs found to be superior to other flat panel displays like LCD, FED (field emission display) and etc.

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 replace bulky and heavy CRT displays in the near future. However research is underway to improve the efficiency and lifetime of the polymer displays.

A panel of industry leaders predicted that LEP technology would storm the market in the near few years and we will find LEP in every sphere of life about ten years from now.

LEP technology is now set to change the products we use to view the world.

REFERENCES

Journals

- Electronics for you April 2002(pgs, 90-93)
- Electronics for you June 2003 (99-102)
- IEE spectrum June 2003 (26-29)
- Hindu(newspaper) July 31 2003 (16)

Websites

- www.iec.org
- www.cdtltd.co.uk
- www.cknow/ckinfo/aco-l/lep-lstm

ABSTRACT

Organic light emitting diode (OLED) display technology has been grabbing headlines in recent years. Now one form of OLED displays, LIGHT EMITTING POLYMER (LEP) technology is rapidly emerging as a serious candidate for next generation flat panel displays. LEP technology promises thin, light weight emissive displays with low drive voltage, low power consumption, high contrast, wide viewing angle, and fast switching times.

One of the main attractions of this technology is the compatibility of this technology with plastic-substrates and with a number of printer based fabrication techniques, which offer the possibility of roll-to-roll processing for cost-effective manufacturing.

LEPs are inexpensive and consume much less power than any other flat panel display. Their thin form and flexibility allows devices to be made in any shape. One interesting application of these displays is electronic paper that can be rolled up like newspaper.

Cambridge Display Technology, the UK, is betting that its light weight, ultra thin light emitting polymer displays have the right stuff to finally replace the bulky, space consuming and power-hungry cathode ray tubes (CRTs) used in television screens and computer monitors and become the ubiquitous display medium of the 21st century.

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Naeem Sherfuddin