ABSTRACT

The seminar is about polymers that can emit light when a voltage is applied to it. The structure comprises of a thin film of semiconducting polymer sandwiched between two electrodes (cathode and anode).When electrons and holes are injected from the electrodes, the recombination of these charge carriers takes place, which leads to emission of light .The band gap, ie. The energy difference between valence band and conduction band determines the wavelength (colour) of the emitted light.

They are usually made by ink jet printing process. In this method red green and blue polymer solutions are jetted into well defined areas on the substrate. This is because, PLEDs are soluble in common organic solvents like toluene and xylene .The film thickness uniformity is obtained by multi-passing (slow) is by heads with drive per nozzle technology .The pixels are controlled by using active or passive matrix.

The advantages include low cost, small size, no viewing angle restrictions, low power requirement, biodegradability etc. They are poised to replace LCDs used in laptops and CRTs used in desktop computers today.

Their future applications include flexible displays which can be folded, wearable displays with interactive features, camouflage etc.

INTRODUCTION

After watching the breakfast news on TV, you roll up the set like a large handkerchief, and stuff it into your briefcase. On the bus or train journey to your office, you can pull it out and catch up with the latest stock market quotes on CNBC.

- Somewhere in the Kargil sector, a platoon commander of the Indian Army readies for the regular satellite updates that will give him the latest terrain pictures of the border in his sector. He unrolls a plastic-like map and hooks it to the unit's satellite telephone. In seconds, the map is refreshed with the latest high resolution camera images grabbed by an Indian satellite which passed over the region just minutes ago.

Don't imagine these scenarios at least not for too long.The current 40 billion-dollar display market, dominated by LCDs (standard in laptops) and cathode ray tubes (CRTs, standard in televisions), is seeing the introduction of full-color LEP-driven displays that are more efficient, brighter, and easier to manufacture. It is possible that organic light-emitting materials will replace older display technologies much like compact discs have relegated cassette tapes to storage bins.

The origins of polymer OLED technology go back to the discovery of conducting polymers in 1977,which earned the co-discoverers- Alan J. Heeger , Alan G. MacDiarmid and Hideki Shirakawa - the 2000 Nobel prize in chemistry. Following this discovery , researchers at Cambridge University UK discovered in 1990 that conducting polymers also exhibit electroluminescence and the light emitting polymer(LEP) was born!

HISTORY OF LIGHT EMITING POLYMER

Polymers

Much of the terminology we will encounter for polymers, also a_ectionately known as macromolecules, rose out of the combined e_orts of organic chemists, who created them, and the physical chemists, who characterized their physical properties. Polymers are chains of smaller molecular components, called monomers. As a simple example, the polymer polyethylene (PE) is constructed (or polymerized) from the precursor ethylene by breaking the double bond in the ethylene molecule, as shown successively in Figures 1 and 2 below.

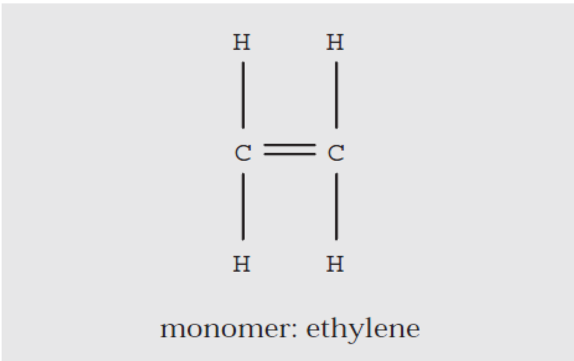


Figure 1: The double-bonded precursor to polyethylene:ethylene

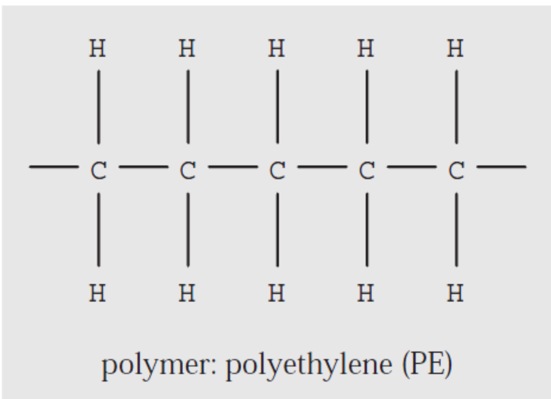


Figure 2: The single-bonded polymer polyethylene

Polymers exist in many varieties ranging from the very simple repeating patterns of chains of monomers, to the somewhat more sophisticated molecular patterns as found in copolymers| polymers composed of two or more chemically distinguishable monomers. Copolymers, in turn, can exist in many conjurations, owing to the many ways the individual monomers can be ordered. There are block polymers, in which large sections are repeated along the polymer chain; graft polymers where another polymer is attached as a side chain; random polymers where the deferent monomer units take on, as the name suggests a random ordering to form the polymer chain; and so on. Another important class of polymers is conjugated polymers. Conjugated polymers consist of carbon backbones with alternating single and double bonds and have shown great potential as light emitting materials.

The first organic electroluminescent devices were discovered around the time the first light emitting diodes (LEDs) were introduced into the Commercial market in 1962. Like today, early devices were hampered by fabrication and packaging problems and short lifetimes Electroluminescence (EL) was first observed in conjugated polymers in 1990 by Burroughs et al. , which reveals the relative youth of this field. Evidence for electro luminescence from the seminal paper by Burroughs et al. is shown in Figure 3.

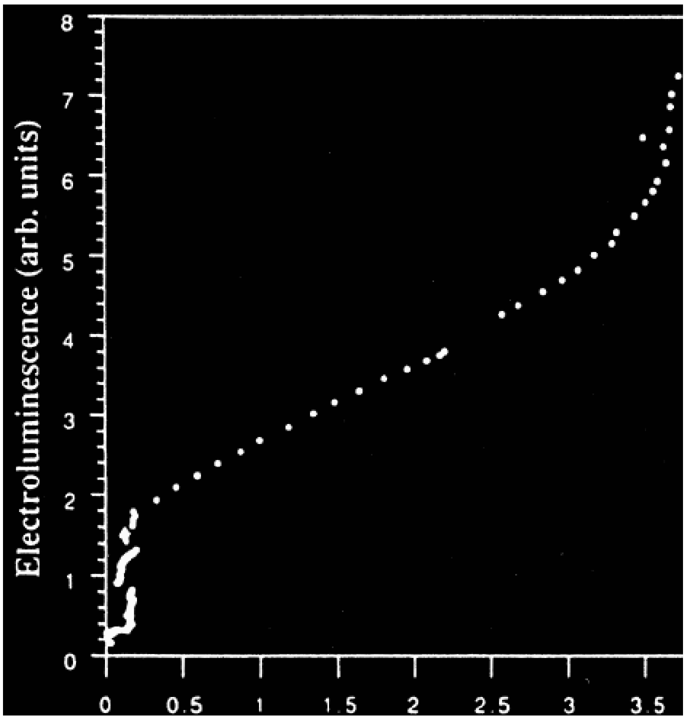


Figure 3: Electroluminescence in PPV. From Burroughs[4]

Prior to this, electroluminescence had been witnessed in organic molecules by Tang and Van Slyke in 1987, who revived interest in organic EL. All of these were originally preceded by the work of Partridge in 1983 , whose work largely went unnoticed. Since the advent of electroluminescent polymers, conjugated polymeric materials with emissions spanning the broad spectrum of visible and non-visible radiation (near infrared) have been fabricated, as shown in Figure 4. A voltage tunable-luminescent device has been fabricated using poly (thiophene) blends. One group has created white-light devices by using appropriate combinations of these EL materials. Many polymers are now known to display electroluminescence. The similar electroluminescent (EL) and photo luminescent (PL) spectra of these materials suggest that the same mechanisms are responsible for both phenomena, justifying, in many cases, why these terms are used interchangeably in the literature.

SUBJECT DETAILING

LIGHT EMITTING POLYMER

It is a polymer that emits light when a voltage is applied to it. The structure comprises a thin-film of semiconducting polymer sandwiched between two electrodes (anode and cathode) as shown in fig.1. 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 band gap, i.e. energy difference between valence band and conduction band of the semiconducting polymer determines the wavelength (colour) of the emitted light.

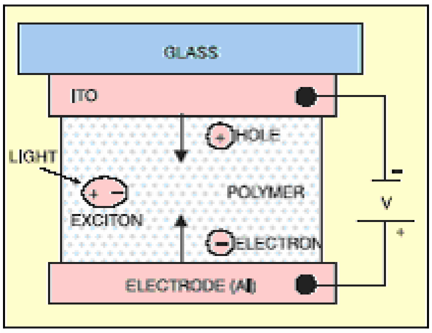
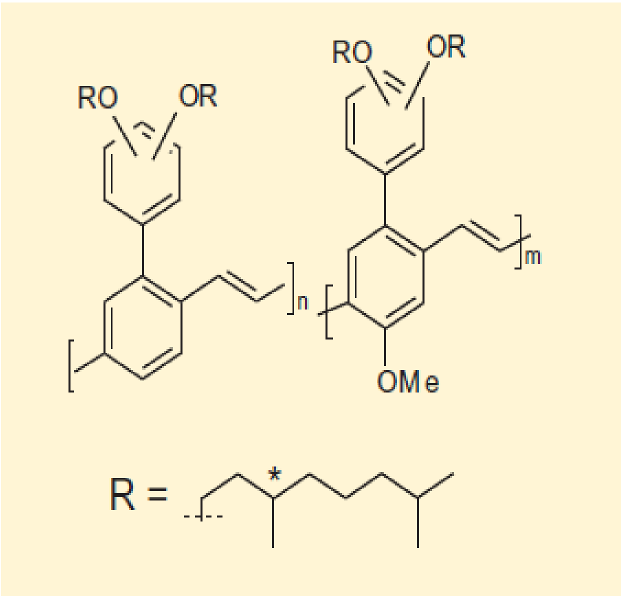


Fig.1 structure of PLED

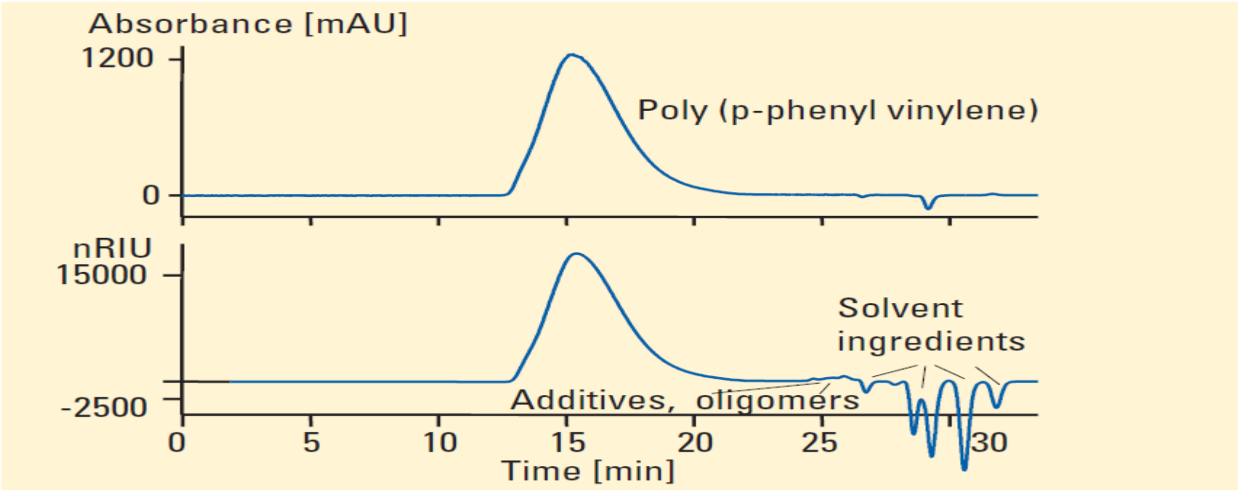
Characterization of light-emitting polymers

Light-emitting polymer technology is set to open a complete new world of applications for a wide range of products, such as small (and eventually large) flat screen displays, warning signs, decorative lighting and illuminated advertising 1,2. The active layer of polymer-LEDs can be prepared by simple coating methods, such as spin coating. All colors are now available for these displays which can be made as thin as one millimeter. High brightness can be achieved at low power

Consumption and long life times of more than 30000 hours. Light emitting polymers are organic, conjugated, macromolecules of very high molecular weight. An important example are phenyl-substituted poly(p-phenylene vinylene) (PPV). To make them soluble and to process them into thin films they are modified, for example, by introducing alkyl or alkoxy side chains. Figure 1 shows the structure of a commercially available phenyl alkoxyphenyl PPV copolymer. The compound is soluble in aromatic hydrocarbons, cyclic ethers and certain ketons.The quality of the film coating process (and thus also the resulting polymer-LED) strongly depends on the polymerization and the resulting molecular weight data/molecular weight distribution. The latter parameters can be monitored



1. Structure of phenyl alkoxyphenyl PPV copolymer



2.Overlay of chromatograms obtained simultaneously by diode array and refractive index detection setting/evaluation

Conditions
Sample preparation Samples were dissolved in stablized THF and filtered (concentration 0.1 %)
Column 3 × PLGel mixed C, 7.5 × 300 mm, 5 µm (Agilent p/n 79911GP-MXC)
Polymer standards Polystyrene EasyCal vial standards (Agilent p/n 5064-8281)
Flow rate 1 ml/min
Column compartment temperature 20° C
Injection volume 100 µl

easily and precisely by GPC with Agilent Technologies PL gel columns and tetrahydrofuran as eluent. Figure 2 shows an overlay of the diode array and refractive index detector signals of a phenyl alkoxyphenyl PPV copolymer analysis. The chromatograms and the GPC report obtained with the

ChemStation GPC data analysis software (figure 3) show the high quality resulting from:

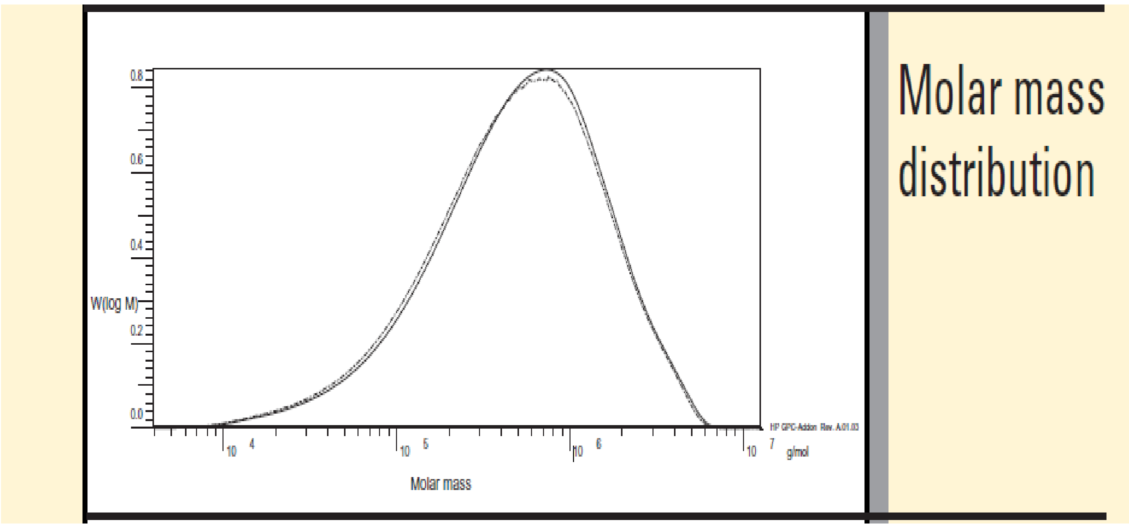
• Broad molecular weight distribution ranging from about 103 to 7×106 Dalton

• Large polydispersity D of about 3.7

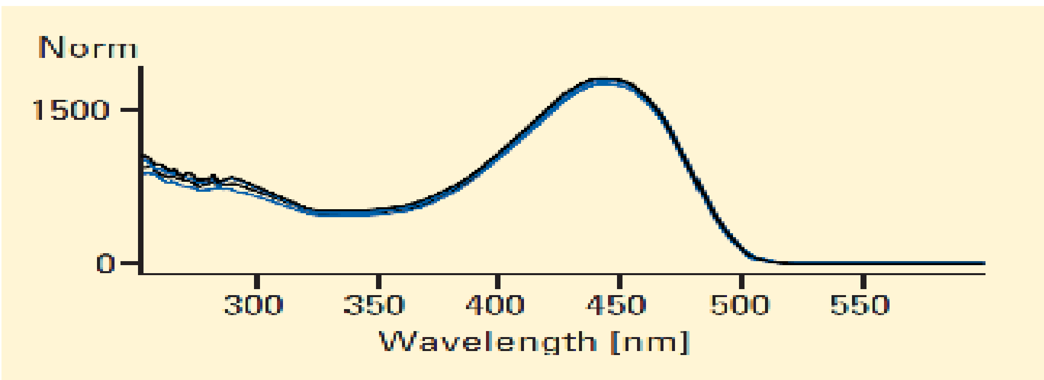
• Very high molecular weight averages, e.g. Mw is larger than 800000 Dalton

• Low concentration of additives and other compounds (figure 2)

• the purity of the polymer peak as proven by the overlay of UV-visible spectra acquired at various retention times (figure 4)



3. Single page GPC report including method parameters, molar mass distribution and molecular weight data



4. Proof of PPV peak purity by overlay of seven spectra acquired at different retention times

CONSTRUCTION

Light emitting devices concict of active –emitting layer sandwiched between an cathode and a anode indium –tin oxide s typically used for the anode and aluminum or calcium of the cathode fig2.1(a) 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. Fig.2.1 (b) shows a symmetrically configured alternating current light-emitting (SCALE) device that works under AC as well as forward and rivers DC bias.

In order to manufacture the polymer, 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 nanometers. 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.

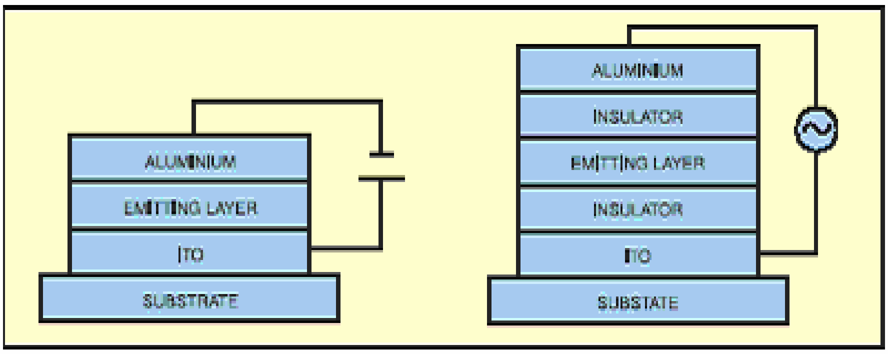


Fig 2.1(a)single layer device (b)symmetrically configured alternating current light emitting(scale)device

INK JET PRINTING

Although inkjet printing is well established in printing graphic images, only now are applications emerging in printing electronics materials. Approximately a dozen companies have demonstrated the use of inkjet
printing for PLED displays and this technique is now at the forefront of developments in digital electronic materials deposition. However, turning inkjet printing into a manufacturing process for PLED displays has required significant developments of the inkjet print head, the inks and the substrates (see Fig.2.1.1).Creating a full colour, inkjet printed display requires the precise metering of volumes in the order of pico liters. Red, green and blue polymer solutions are jetted into well defined areas with an angle of flight deviation of less than 5º. To ensure the displays have uniform emission, the film thickness has to be very uniform.

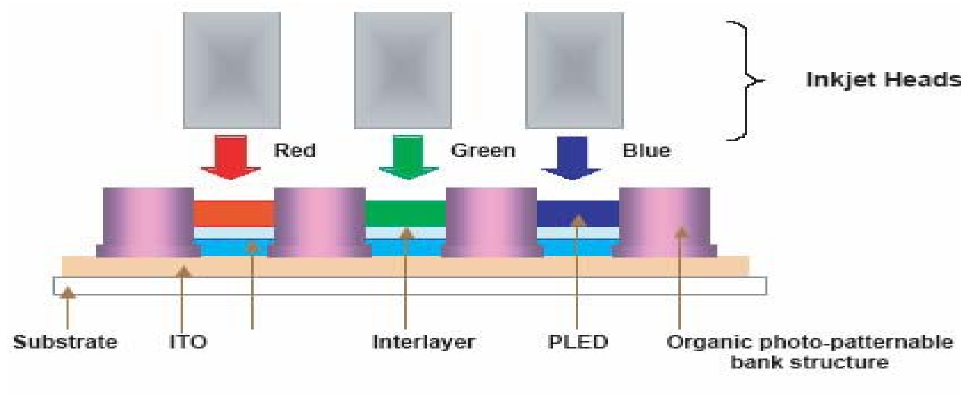


Fig. 2.1.1 Schematic of the ink jet printing for PLED materials

For some materials and display applications the film thickness uniformity may have to be better than ±2 per cent. A conventional inkjet head may have volume variations of up to ±20 per cent from the hundred or so nozzles that comprise the head and, in the worst case, a nozzle may be blocked. For graphic art this variation can be averaged out by multi-passing with the quality to the print dependent on the number of passes. Although multi-passing could be used for PLEDs the process would be unacceptably slow. Recently, Spectra, the world's largest supplier of industrial inkjet heads, has started to manufacture heads where the drive conditions for each nozzle can be adjusted individually – so called drive-per-nozzle (DPN). Litrex in the USA, a subsidiary of CDT, has developed software to allow DPN to be used in its printers. Volume variations across the head of ±2 per cent can be achieved using DPN. In addition to very good volume control, the head has been designed to give drops of ink with a very small angle-of-flight variation. A 200 dots per inch (dpi) display has colour pixels only 40 microns wide; the latest print heads have a deviation of less than ±5 microns when placed 0.5 mm from the substrate. In addition to the precision of the print head, the formulation of the ink is key to making effective and attractive display devices. The formulation of a dry polymer material into an ink suitable for PLED displays requires that the inkjets reliably at high frequency and that on reaching the surface of the substrate, forms a wet film in the correct location and dries to a uniformly flat film. The film then has to perform as a useful electro-optical material. Recent progress in ink formulation and printer technology has allowed 400 mm panels to be colour printed

ACTIVE AND PASSIVE MATRIX

Many displays consist of a matrix of pixels, formed at the intersection of rows and columns deposited on a substrate. Each pixel is a light emitting diode such as a PLED, capable of emitting light by being turned on or off, or any state in between. Coloured displays are formed by positioning matrices

of red, green and blue pixels very close together. To control the pixels, and so form the image required, either 'passive' or 'active' matrix driver methods are used.

Pixel displays can either by active or passive matrix. Fig. 2.1.2 shows the differences between the two matrix types, active displays have transistors so that when a particular pixel is turned on it remains on until it is turned off.

The matrix pixels are accessed sequentially. As a result passive displays are prone to flickering since each pixel only emits light for such a small length of time. Active displays are preferred, however it is technically challenging to incorporate so many transistors into such small a compact area.

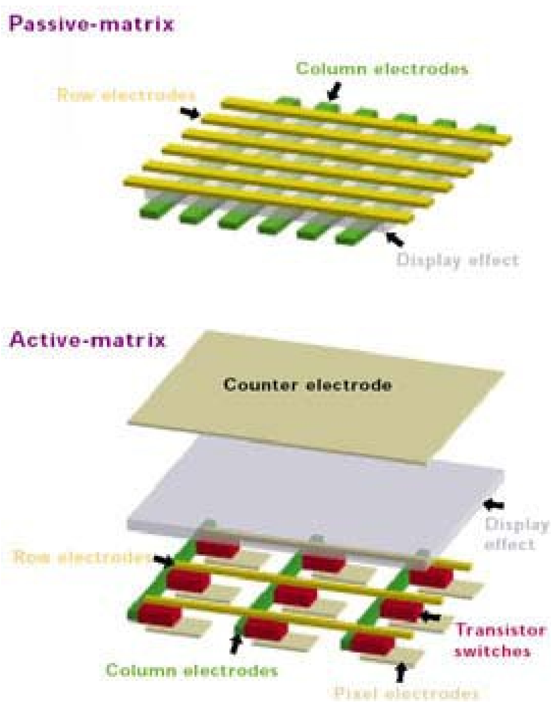


Fig 2.1.2 Active and passive matrices

In passive matrix systems, each row and each column of the display has its own driver, and to create an image, the matrix is rapidly scanned to enable every pixel to be switched on or off as required. As the current required to brighten a pixel increases (for higher brightness displays), and as the display gets larger, this process becomes more difficult since higher currents have to flow down the control lines. Also, the controlling current has to be present whenever the pixel is required to light up. As a result, passive matrix displays tend to be used mainly where cheap, simple displays are required

Active matrix displays solve the problem of efficiently addressing each pixel by incorporating a transistor (TFT) in series with each pixel which provides control over the current and hence the brightness of individual pixel.

Lower currents can now flow down the control wires since this have only to program the TFT driver , and the wires can be finer as a result .also, the transistor is able to hold the current setting, keeping the pixel at the required brightness, until it receives another control signal . Future demands on displays will in path require larger area displays so the active matrix marked segment will grow faster.

PLED devises are especially suitable for incorporating into active matrix displays, as they are processeble in solution and, can be manufactured using ink get printing over larger areas.

BASIC PRINCIPLE AND TECHNOLOGY

Polymer properties are dominated by the covalent nature of carbon bonds making up the organic molecules backbone. The immobility of electrons that form the covalent bonds explain why plastics were classified almost exclusively insulators until the 1970's.

A single carbon-carbon bond is composed of two electrons being shared in overlapping wave functions. For each carbon, the four electrons in the valence bond form tetrahedral oriented hybridized sp^3 orbital's from the s & p orbital's described quantum mechanically as geometrical wave functions.

The properties of the spherical s orbital and bimodal p orbital's combine into four equal, unsymmetrical, tetrahedral oriented hybridized sp^3 orbitals. The bond formed by the overlap of these hybridized orbitals from two carbon atoms is referred to as a 'sigma' bond.

A conjugated 'pi' bond refers to a carbon chain or ring whose bonds alternate between single and double (or triple) bonds. The bonding system tend to form stronger bonds than might be first indicated by a structure with single bonds.

The single bond formed between two double bonds inherits the characteristics of the double bonds since the single bond is formed by two sp^2 hybrid orbitals. The p orbitals of the single bonded carbons form an effective 'pi' bond ultimately leading to the significant consequence of 'pi' electron de-localization.

Unlike the ‘sigma’ bond electrons, which are trapped between the carbons, the ‘pi’ bond electrons have relative mobility. All that is required to provide an effective conducting band is the oxidation or reduction of carbons in the backbone. Then the electrons have mobility, as do the holes generated by the absence of electrons through oxidation with a dopant like iodine.

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 polarizes 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. Light-Emitting Polymers

These moving holes and electrons combine together to form hole electron pairs known as “exactions’. These exactions are in excited

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.

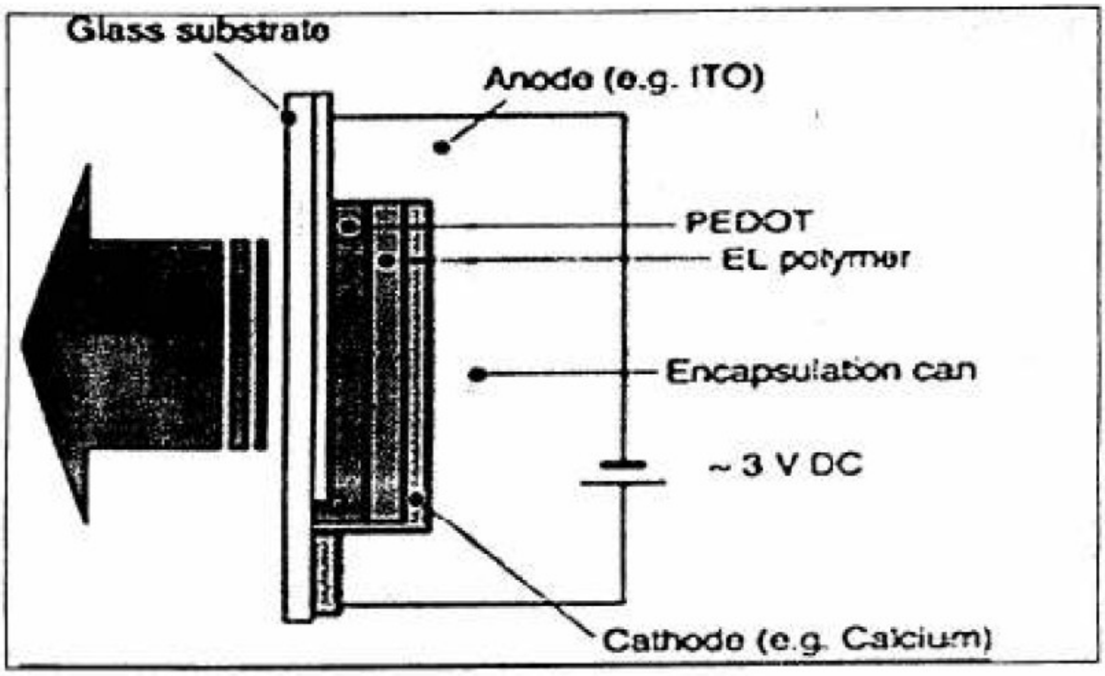


Figure: basic structure of LEP

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 or 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 addresses 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

Light-Emitting Polymers 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

LIGHT EMISSION

The production of photons from the energy gap of a material is very similar for organic and ceramic semiconductors. Hence a brief description of the process of electroluminescence is in order.

Electroluminescence is the process in which electromagnetic(EM) radiation is emitted from a material by passing an electrical current through it. The frequency of the EM radiation is directly related to the energy of separation between electrons in the conduction band and electrons in the valence band. These bands form the periodic arrangement of atoms in the crystal structure of the semiconductor. In a ceramic semiconductor like GaAs or ZnS, the energy is released when an electron from the conduction band falls into a hole in the valence band. The electronic device that accomplishes this electron-hole interaction is that of a diode, which consists of an n-type material (electron rich) interfaced with p-type material (hole rich). When the diode is forward biased (electrons across interface from n to p by an applied voltage) the electrons cross a neutralized zone at the interface to fill holes and thus emit energy.

The situation is very similar for organic semiconductors with two notable exceptions. The first exception stems from the nature of the conduction band in an organic system while the second exception is the recognition of how conduction occurs between two organic molecules.

With non-organic semiconductors there is a band gap associated with Brillion zones that discrete electron energies based on the periodic order of the crystalline lattice. The free electron's mobility from lattice site to lattice site is clearly sensitive to the long-term order of the material. This is not so for the organic semiconductor. The energy gap of the polymer is more a function of the individual backbone, and the mobility of electrons and holes are limited to the linear or branched directions of the molecule they statistically inhabit. The efficiency of electron/hole transport between polymer molecules is also unique to polymers. Electron and hole mobility occurs as a 'hopping' mechanism which is significant to the practical development of organic emitting devices.

PPV has a fully conjugated backbone (figure 1), as a consequence the HOMO (exp link remember 6th form!) of the macromolecule stretches across the entire chain, this kind of situation is ideal for the transport of charge; in simple terms, electrons can simply "hop" from one π orbital to the next since they are all linked.

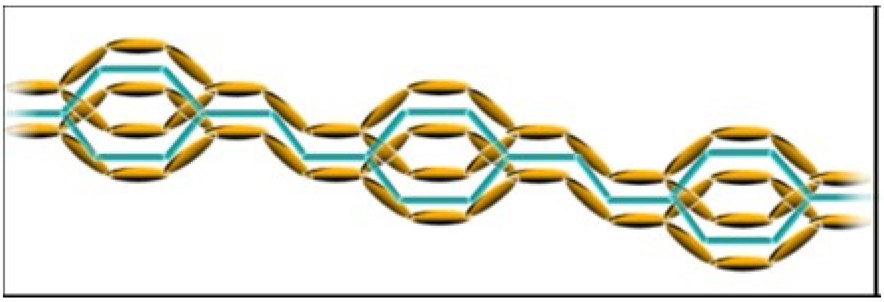


Figure .1 A demonstration of the full conjugation of π Electrons in PPV.The delocalized π electron clouds are coloured yellow.

PPV is a semiconductor. Semiconductors are so called because they have conductivity that is midway between that of a conductor and an insulator. While conductors such as copper conduct electricity with little to no energy (in this case potential difference or voltage) required to "kick-start" a current, insulators such as glass require huge amounts of energy to conduct a current. Semi-conductors require modest amounts of energy in order to carry a current, and are used in technologies such as transistors, microchips and LEDs.

Band theory is used to explain the semi-conductance of PPV, see figure 5. In a diatomic molecule, a molecular orbital (MO) diagram can be drawn showing a single HOMO and LUMO, corresponding to a low energy π orbital and a high energy π* orbital. This is simple enough, however, every time an atom is added to

the molecule a further MO is added to the MO diagram. Thus for a PPV chain which consists of ~1300 atoms involved in conjugation, the LUMOs and HOMOs will be so numerous as to be effectively continuous, this results in two bands, a valence band (HOMOs, π orbital's) and a conduction band (LUMOs, π* orbital's). They are separated by a band gap which is typically 0-10eV (check) and depends on the type of material. PPV has a band gap of 2.2eV (exp eV). The valence band is filled with all the π electrons in the chain, and thus is entirely filled, while the conduction band, being made up of empty π* orbital's (the LUMOs) is entirely empty).

In order for PPV to carry a charge, the charge carriers (e.g. electrons) must be given enough energy to "jump" this barrier - to proceed from the valence band to the conduction band where they are free to ride the PPV chain's empty LUMOs

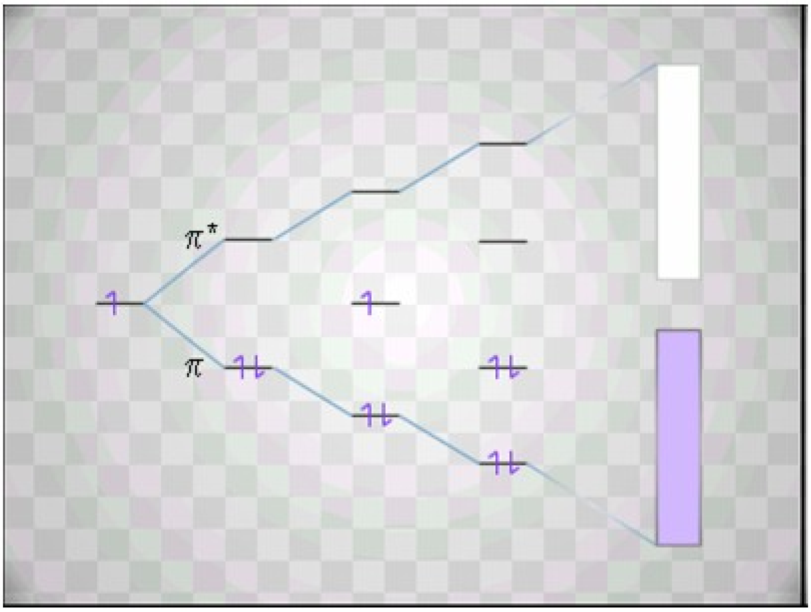


Figure 2.2.2 A series of orbital diagrams.

• A diatomic molecule has a bonding and an anti-bonding orbital, two atomic orbital's gives two molecular orbital's. The electrons arrange themselves following, Auf Bau and the Pauli Principle.

• A single atom has one atomic orbital

• A tri atomic molecule has three molecular orbitals, as before one bonding, one anti-bonding, and in addition one non-bonding orbital.

• Four atomic orbitals give four molecular orbitals.

• Many atoms results in so many closely spaced orbitals that they are effectively continuous and non-quantum. The orbital sets are called bands. In this case the bands are separated by a band gap, and thus the substance is either an insulator or a semi-conductor.

It is already apparent that conduction in polymers is not similar to that of metals and inorganic conductors; however there is more to this story! First we need to imagine a conventional diode system, i.e. PPV sandwiched between an electron injector (or cathode), and an anode. The electron injector needs to inject electrons of sufficient energy to exceed the band gap; the anode operates by removing electrons from the polymer and consequently leaving regions of positive charge called holes. The anode is consequently referred to as the hole injector.

In this model, holes and electrons are referred to as charge carriers; both are free to traverse the PPV chains and as a result will come into contact. It is logical for an electron to fill a hole when the opportunity is presented and they are said to capture one another. The capture of oppositely charged carriers is referred to as recombination. When captured, an electron and a hole form neutral-bound excited states (termed excitons) that quickly decay and produce a photon up to 25% of the time, 75% of the time, decay produces only heat, this is due to the the possible multiplicities of the exciton. The frequency of the photon is tied to the band-gap of the polymer; PPV has a band-gap of 2.2eV, which corresponds to yellow-green light.

Not all conducting polymers fluoresce, polyacetylene, one of the first conducting-polymers to be discovered was found to fluoresce at extremely low levels of intensity. Excitons are still captured and still decay, however they mostly decay to release heat. This is what you may have expected since electrical resistance in most conductors causes the conductor to become hot.

Capture is essential for a current to be sustained. Without capture the charge densities of holes and electrons would build up, quickly preventing any injection of charge carriers. In effect no current would flow.

COMPARISON TABLE

This table compares the main electronic displays technologies. Each display type is described briefly, and the relative advantages and disadvantages are reviewed. **Display Type**	**Acronym**	**Emissive or Reflective**	**Technology**	**Advantages**	**Disadvantages**
Cathode Ray Tube	CRT	Emissive	The CRT is a vacuum tube using a hot filament to generate thermo-electrons, electrostatic and/or magnetic fields to focus the electrons into a beam attracted to the high voltage anode which is the phosphor coated screen. Electrons colliding with the phosphor emit luminous radiation. Color CRTs typically use 3 electron sources (guns) to target red, green, and blue patterns on phosphor the screen.	Very bright Wide viewing angle No mask, so no pixel size limitation for mono Minimum pixel size 0.2mm (color) Low cost standard sizes Low cost high-res color Wide operating temperature range Moderate (20khrs+) life	High (5kV to 20kV+) drive voltages Not a flat panel (rare exceptions) Can be fragile, particularly neck-end Heavy Source of X-rays unless screened Affected by magnetic fields Difficult to recycle or dispose of

Liquid Crystal Display	LCD	Reflective	An LCD uses the properties of liquid crystals in an electric field to guide light from oppositely polarized front and back display plates. The liquid crystal works as a helical director (when the driver presents the correct electric field) to guide the light through 90° from one plate	Small, static, mono panels can be very low cost Both mono and color panels widely available	Backlight adds cost, and often limits the useful life Requires AC drive waveform Fragile unless

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 posses delocalized pi electrons along the backbone, whose mobility shows properties of semiconductors.

Also this gives it the ability to support positive and negative 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 Light-Emitting Polymers 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 platting 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.

MANUFACTURING

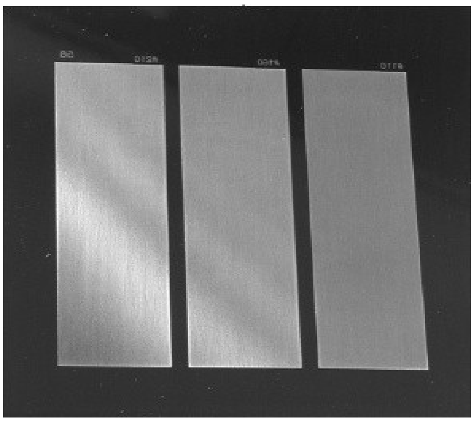
In order to manufacture the polymer two techniques is used. Spin coating process This technique involves spinning a disk, that is glass substrate at a fixed angular velocity and letting a small amount of polymer solution to drop on the top of the disk. It is shown in the figure. Spin coating machine 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 a\baked in an oven to evaporate any remnant liquid

Manufacturing of polymer light-emitting device

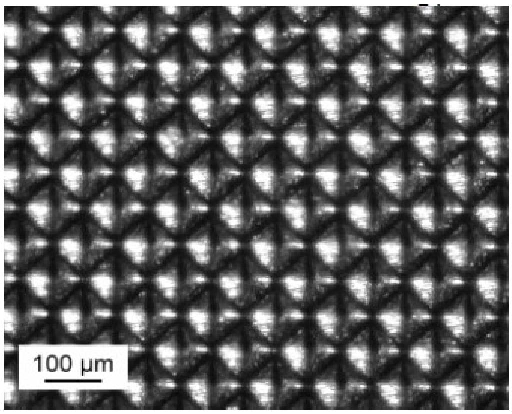
Gravure printing offers a fast and cost-efficient roll-to-roll technique with high potentials in the manufacturing of polymer light emitting devices and adequate patterning resolution. In this technique, the pattern to be printed is engraved into a rotational printing cylinder. During printing, the printing ink is filled into the engraved cells by the use of a flexible doctor blade to remove the excess ink and to ensure that the cells are filled with a reproducible amount of ink and is then transferred to the foil when the cylinder is brought into contact with the surface of the substrate foil. However, extremely thin and uniform PLED structures are setting high demands on the process.

Printing of patterned ITO anodes:

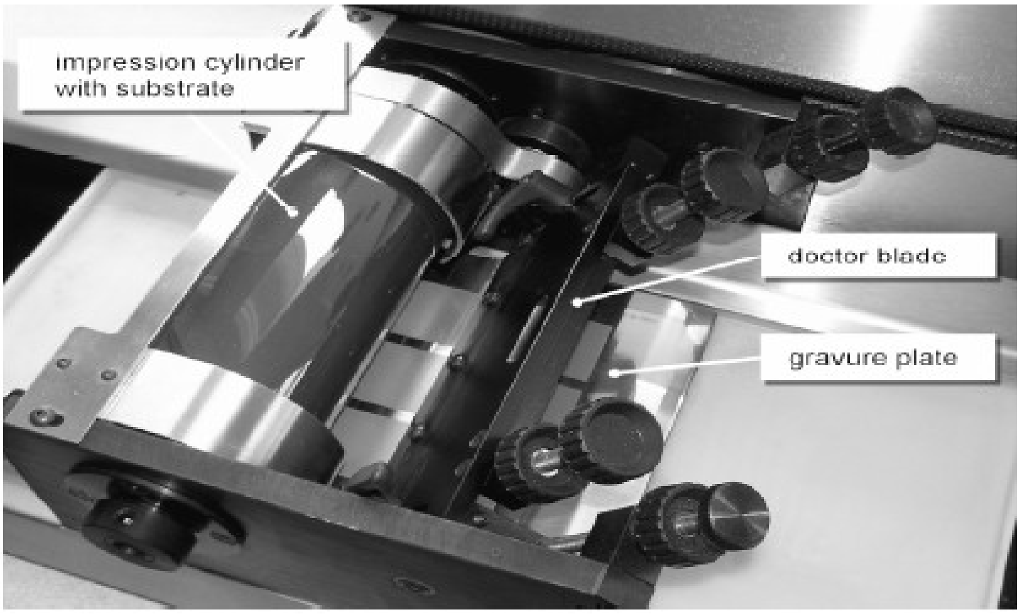
The aim was the development of a patterned anode of transparent conducting ITO on PET foils by a printing process based on ITO nano particle dispersions. The ITO patterns thus prepared were to be used as transparent anodes in PLED devices structures.). Before the start of this project, crystalline ITO nano particles had been developed and dispersed in different solvents mainly for large area coating (e.g. by spin coating).4 By addition of a small amount of a polymerizable hydrolyzed silane and a photo starter, transparent conducting ITO coatings were thus obtained on plastic substrates including foils by a UV-curing at low temperatures (<130°C) with a sheet resistance of 2 to 5 kΩsq and a transmittance of 90 % in the visible range (thickness 500 nm). A post treatment under reducing conditions (N2/H2) at low temperatures (<130°C) resulted in a further decrease in the sheet resistance below 1ohm sq



(a)



(b)



(c)

Photographs of a) the lab-scale gravure printing machine, b) the gravure plate with different patterns (areas are 37x127 mm2in size), and c) the diamond-engraved cells pattern (110 lines/cm).

In a first set of experiments it was intended to obtain full-tone printed areas with a high thickness homogeneity using a lab-scale gravure printer for testing (Figure 2a, Labratester - N. Schläfli Maschinen) and a plate with rectangular stripes (Figure 2b & 2c, 37×127 mm2 each) in order to find the working parameters for ITO coatings such as the feasible printing speed or the characteristics of the gravure cavities. In general, film formation in gravure printing requires a coalescence of adjacent, single liquid dots while at the same time, however, a spreading of the liquid droplets or of the film beyond this coalescence has to be avoided to retain the printed structures.5 This requires an elaborate adjustment of the rheological properties of the printing inks and a thorough control of film drying. Typical printing speeds up to 40 m/min thus could be realized without loss of homogeneity. While homogeneous coatings could be generally obtained for line densities ranging from 40 to 210 lines/cm, this parameter also fundamentally determines the thickness of the resulting coatings as the volume of the engraved cavities is decreasing with the line density. In view of the final application to a direct patterning, however, this means that a compromise has to

be found between the desired coating thickness and the required resolution of the printing as the theology of the inks can only be varied in certain limits mainly given by the limitation in the solid content and by problems arising from the use of printing additives.5 Depending on the ITO solid content in the inks and the geometry of the gravure cells, thus thicknesses ranging from 0.2 to more than 1 μm were realized in a single printing step. Different ITO inks based on solvents with medium and high boiling points were tested. In addition, comparative experiments with different surface modifiers for ITO were initiated to minimize the interaction between the particles during film formation as a major requirement for optically transparent coatings. The total content of solvents and additives in the printing ink generally is a very important parameter for coating quality, as it also influences the film drying and determines the content of organic residues in the resulting ITO film and hence the porosity.

ADVANTAGES

- Require only 3.3 volts and have lifetime of more than 30,000 hours.
- Low power consumption.
- Self luminous.
- No viewing angle dependence.
- Display fast moving images with optimum clarity.
- Cost much less to manufacture and to run than CRTs because the active material is plastic.
- Can be scaled to any dimension.
- Fast switching speeds that are typical of LEDs.

- No environmental draw backs.
- No power in take when switched off.
- All colours of the visible spectrum are possible by appropriate choose of polymers.
- Simple to use technology than conventional solid state LEDs and lasers.
- Very slim flat panel.
- They don’t additional elements like the backlights, filters and polarizes that are typical of LCDs.

DISADVANTAGES

- Vulnerable to shorts due to contamination of substrate surface by dust.
- Voltage drops.
- Mechanically fragile.
- Potential not yet realized.

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 nobilities 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.

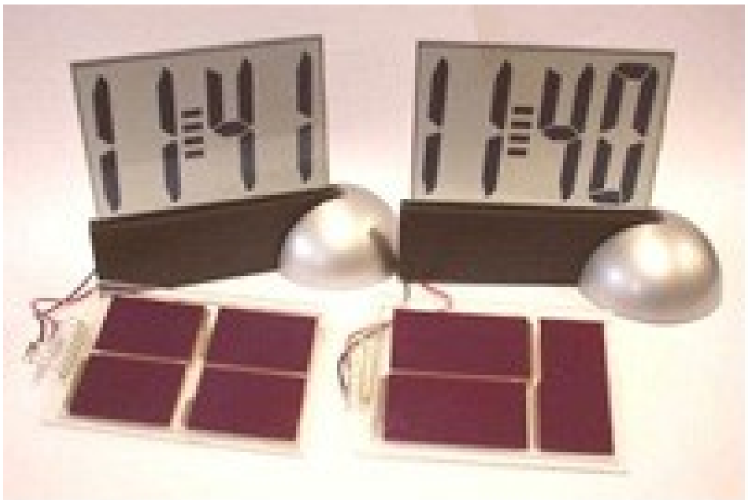
APPLICATIONS AND FEURE DEVELOPMENTS

Applications:

Polymer light-emitting diodes (PLED) can easily be processed into large-area thin films using simple and inexpensive technology. They also promise to challenge LCD's as the premiere display technology for wireless phones, pagers, and PDA's with brighter, thinner, lighter, and faster features than the current display.

PHOTOVOLTAICS

CDT’s PLED technology can be used in reverse, to convert light into electricity. Devices which convert light into electricity are called photovoltaic (PV) devices, and are at the heart of solar cells and light detectors. CDT has an active program to develop efficient solar cells and light detectors using its polymer semiconductor know-how and experience, and has filed several patents in the area.



Digital clocks powered by CDT's polymer solar cells.

POLY LED TV

Philips will demonstrate its first 13-inch PolyLED TV prototype based on polymer OLED (organic light-emitting diode) technology Taking as its reference application the wide-screen 30-inch diagonal display with WXGA (1365x768) resolution, Philips has produced a prototype 13-inch carve-out of this display (resolution 576x324) to demonstrate the feasibility of manufacturing large-screen polymer OLED displays using high-accuracy multi-nozzle, multi-head inkjet printers. The excellent and sparkling image quality of Philips' Poly LED TV prototype illustrates the great potential of this new display technology for TV applications. According to current predictions, a polymer OLED-based TV could be a reality in the next five years.

BABY MOBILE

This award winning baby mobile uses light weight organic light emitting diodes to realize images and sounds in response to gestures and speech of the infant.

MP3 PLAYER DISPLAY

Another product on the market taking advantage of a thin form-factor, light-emitting polymer display is the new, compact, MP3 audio player, marketed by GoDot Technology. The unit employs a polymeric light-emitting diode (pLED) display supplied by Delta Optoelectronics, Taiwan, which is made with green Lumation light-emitting polymers furnished by Dow Chemical Co., Midland, Mich.

MORE 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

FUTURE DEVELOPMENTS

Here's just a few ideas which build on the versatility of light emitting materials

High efficiency displays running on low power and economical to manufacture will find many uses in the consumer electronics field. Bright, clear screens filled with information and entertainment data of all sorts may make our lives easier, happier and safer.

Demands for information on the move could drive the development of 'wearable' displays, with interactive features.

Eywith changing information Cole wool gives many brand ownerve edge

The ability of PLEDs to be fabricated on flexible substrates opens up fascinating possibilities for formable or even fully flexible displays e catching packaging intent at the point of a valuable competition

FEW MORE DEVELOPMENTS

- Because the plastics can be made in the form of thin films or sheets, they offer a huge range of applications. These include television or computer screens that can be rolled up and tossed in a briefcase, and cheap videophones.
- Clothes made of the polymer and powered by a small battery pack could provide their own cinema show.
- Camouflage, generating an image of its surroundings picked up by a camera would allow its wearer to blend perfectly into the background
- A fully integrated analytical chip that contains an integrated light source and detector could provide powerful point-of-care technology. This would greatly extend the tools available to a doctor and would allow on-the-spot quantitative analysis, eliminating the need for patients to make repeat visits. This would bring forward the start of treatment, lower treatment costs and free up clinician time.

The future is bright for products incorporating PLED displays. Ultra-light, ultra-thin displays, with low power consumption and excellent readability allow product designers a much freer rein. The environmentally conscious will warm to the absence of toxic substances and lower overall material requirements of PLEDs, and it would not be an exaggeration to say that all current display applications could benefit from the introduction of PLED technology.

CDT sees PLED technology as being first applied to mobile communications, small and low information content instrumentation, and appliance displays. With the emergence of 3G telecommunications, high quality displays will be critical for handheld devices. PLEDs are ideal for the small display market as they offer vibrant, full-colour displays in a compact, lightweight and flexible form.

Within the next few years, PLEDs are expected to make significant inroads into markets currently dominated by the cathode ray tube and LCD display technologies, such as televisions and computer monitors. PLEDs are anticipated as the technology of choice for new products including virtual reality headsets; a wide range of thin, technologies, such as televisions and computer monitors. PLEDs are anticipated as the technology of choice for new products including virtual reality headsets; a wide range of thin, lightweight, full colour portable computing; communications and information management products; and conformable or flexible displays

CONCLUSION

Organic materials are poised as never before to trans form the world of display technology. Major electronic firms such as Philips and pioneer and smaller companies such as Cambridge Display Technology are betting that the future holds tremendous opportunity for low cost and surprisingly high performance offered by organic electronic and opto electronic devices. Using organic light emitting diodes, organic full colour displays may eventually replace LCDs in laptop and even desktop computers. Such displays can be deposited on flexible plastic coils, eliminating fragile and heavy glass substrate used in LCDs and can emit light without the directionality inherent in LCD viewing with efficiencies higher than that can be obtained with incandescent light bulbs.

Organic electronics are already entering commercial world. Multicolor automobile stereo displays are now available from Pioneer Corp., of Tokyo And Royal Philips Electronics, Amsterdam is gearing up to produce PLED backlights to be used in LCDs and organic ICs.

The first products using organic displays are already in the market. And while it is always difficult to predict when and what future products will be introduced, many manufactures are working to introduce cell phoned and personal digital assistants with organic displays within the next few years. The ultimate goal of using high efficiency, phosphorescent

Flexible organic displays in laptop computers and even for home video applications may be no more than a few years in to the future. The portable and light weight organic displays will soon cover our walls replacing the bulky and power hungry cathode ray tubes.

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