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(54) **Title:** DISPLAY DEVICES

(57) **Abstract:** Provided is a display device comprising:(a) a substrate; (b) a first electrode formed on the substrate; (c) a plurality of banks situated between pixel areas; (d) a light emissive layer formed on the pixel areas; and (e) a second electrode formed on the light emissive layer; wherein the banks are arranged in a zigzag pattern. Also provided is a method for producing a display device, which method comprises: (a) depositing a first electrode on a substrate; (b) depositing a plurality of banks on the substrate; (c) depositing a light emissive layer on a plurality of pixel areas; (d) depositing a second electrode on the light emissive layer; wherein the banks are deposited in a zigzag pattern.

DISPLAY DEVICES

This invention relates to display devices and more specifically to organic light emitting devices (OLEDs) which are advantageously employed in such displays. The invention is particularly concerned with displays and devices having improved strength and greater display area.

An emerging class of display devices uses an organic material for light emission. Light-emissive organic materials are described in published international application WO 90/13148 and in published patent specification US 4,539,507. The contents of both of these documents are incorporated herein by reference.

The basic structure of these devices generally comprises a light-emissive organic layer, for instance a film of a poly(p-phenylenevinylene) (usually termed PPV), sandwiched between two electrodes. One of the electrodes (the cathode) injects negative charge carriers (electrons) and the other electrode (the anode) injects positive charge carriers (holes). The electrons and holes combine in the organic layer, generating photons. In published international application WO 90/13148 the organic light-emissive material is a polymer. In US 4,539,507 the organic light-emissive material is of the class known as small molecule materials, such as (8-hydroxyquinolino)aluminium (usually termed Alq3). In a practical device, one of the electrodes is typically transparent, to allow the photons to escape the device.

Figure 1a illustrates the cross-sectional structure of a typical organic light-emissive device. The OLED is typically fabricated on a glass or plastic substrate 1 coated with a transparent first electrode 2 such as indium-tin-oxide ("ITO"). Such coated substrates are commercially available. This ITO-coated substrate is covered with at least a layer of a thin film of an electroluminescent organic material 3 and a final layer forming a second electrode 4, which is typically a metal or alloy. Other layers can be added to the device, for example to improve charge transport between the electrodes and the electroluminescent material. An example of a device having a further charge transport layer 5 for injecting charge carriers (holes or electrons) is shown in Figure 1b.

During the course of the development of these devices, it has been desired to find improved methods for manufacturing the devices which lead to both reductions in production cost and increases in the quality and characteristics in the devices themselves. Generally, the patterning of the component layers of these devices is achieved using standard photolithography techniques or vapour deposition using a shadow mask.

In published US application US 2001/0009689 a process for producing an organic electroluminescent device is disclosed. The process aims to improve the precision of patterning under various conditions without degrading the properties of the organic electroluminescent elements. The process involves patterning device layers using solution deposition techniques (such as ink-jet printing), or vapour deposition. Spacers having a height at least partially exceeding the thickness of the emissive layers are deposited by photolithography. The spacers act as separators for separating the cathode when it is deposited by vapour deposition, although a shadow mask is also placed in contact with the spacers. The spacers allow the shadow mask to be placed in close proximity to the layer surface without damaging it, which in turn leads to more precise patterning. When solution processing techniques are employed, the banks also act to prevent solution flowing into other areas of the device.

Published European application EP-A-0 969 701 uses photolithography to improve electroluminescent devices. It discloses a method in which banks are fabricated on the substrate orthogonally to the anodes. The cathode is patterned using the banks. In this method the banks serve to separate one strip of cathode from another adjacent strip of cathode. Using this method it is possible to deposit the cathode across the whole surface of the device without the need of a shadow mask to ensure that adjacent cathode elements are kept separate.

Despite these improvements in the precision of patterning of these devices, there is still a requirement for further improvement. There is also an ongoing requirement to improve the quality of the devices by increasing the emissive area, increasing the efficiency of the devices, increasing the lifetime of the devices and increasing the yield of usable devices manufactured according to present methods.

It is an aim of the present invention to overcome the problems described above in relation to prior art methods and devices. It is a further aim of the present invention to provide a display device which is easier to manufacture, has a greater emissive area, can be driven at a lower brightness, has a longer lifetime and can be produced in a greater yield in the manufacturing process.

Accordingly, the present invention provides a display device comprising:

(a) a substrate;
(b) a first electrode formed on the substrate;
(c) a plurality of banks situated between pixel areas;
(d) a light emissive layer formed on the pixel areas; and
(e) a second electrode formed on the light emissive layer;

wherein the banks are arranged in a zigzag pattern.

In the context of the present invention, the term zigzag pattern means a pattern in which the photoresist forming each bank is formed from portions alternating in orientation. For example, each portion may be linear, or substantially linear, joining to the next alternate portion at an apex, in the form of a classical zigzag: /\/\/\/\. In this form, each apex has an internal (smaller) and external (larger) angle defining the extent of the zigzag. The zigzag is preferably regular (in which all the portions are of the same length, or substantially the same length, and all the internal angles are the same, or substantially the same) but the present invention is not limited to regular zigzags. Thus, in an alternative embodiment, the 'zig' portions may be of different length to the 'zag' portions or to each other, and/or the internal angles may vary along the length of the bank. The angles may vary within the limits outlined below, provided that the adjacent banks do not come into contact with one another.

Preferably the banks remain parallel, or substantially parallel, to each other. Parallel, in the context of the present invention, means only that adjacent banks do not come into contact with each other and/or at least remain at sufficient distance from one another such that they are able to act as separators for separating the second electrode. Preferably, adjacent banks remain at the same distance from each other, or substantially the same distance from each other, across their full length. Although it is preferred that the banks are formed from two sets of linear portions (the 'zigs' and 'zags'), the term zigzag as used in the present invention is also intended to include banks comprising curved portions, for example banks in which the apexes of the zigzags are curved, and more precisely describe an S shaped pattern or a sinusoidal pattern. In the case of curved banks, the inner angle of zigzag can be determined from the angle between the tangents to adjacent zig and zag midpoints or turning points. Alternatively the shape of such curved banks can be described by the radius of the curve described by the bank.

In the context of the present invention, the pixel area means an area on which the emissive layer is deposited to form a display pixel. The pixel area may be defined by the banks themselves, or the devices may comprise a further layer which defines a well in which the emissive layer forming the pixel can be deposited (see below). The latter embodiment is especially preferred for full colour displays in which the red, green and blue pixels need to be separated from each other, and individually addressed.

The zigzag pattern of the banks is particularly important in the context of the present invention, as will be explained below.

One problem with known methods employing banks, such as the methods described in EP-A-969 701, is that if the banks are too narrow they become weak and can easily break. Often the banks are narrower at the base than at the tip, since this shape provides a natural 'shadow' for ensuring that there is a break between one electrode strip and the next. This shape, whilst being advantageous for this reason, creates weak points at the base of the banks making them more likely to break. If the banks break too easily, then a significant proportion of the devices produced will not function, increasing the cost and decreasing the efficiency and yield of the whole manufacturing process. However, in order to provide the greatest possible emissive area, the banks should be made as narrow as possible. The wider the banks, the more area they occupy on the substrate, which in turn leaves less pixel area available for emissive material (see Figure 2). If the emissive area is small, a device has to be driven at greater brightness to compensate, and this reduces the lifetime of the device. Thus, in the known methods a compromise needs to be reached to provide sufficient emissive area whilst ensuring that the banks have sufficient strength.

The great advantage of the zigzag banks employed in the present invention is that the zigzag structure allows much narrower banks to be formed without reducing their strength. Thus, in the present invention it is possible to employ banks having a width of around 2.0×10^{-5} m, whereas in known methods the banks typically have a width of 4.0×10^{-5} m. This can lead to gains in emissive area of more than 10 %, which improves the quality of the devices and also helps to lengthen the lifetime of the devices, since they can be driven at lower brightness. Moreover, because the banks can be made stronger, the manufacturing process is more efficient and has a higher yield, since fewer defective devices are produced. Furthermore, the devices can tolerate more rigorous cleaning and handling techniques during manufacture, which can also lead to improvements in the overall quality of the devices produced. For example, one of the most problematic impurities that can be present in the devices is glass. Small particles of glass are often produced during manufacture, since the substrate is usually glass. These particles are very difficult to remove from the surface of devices without damaging them, since vigorous cleaning (e.g. high pressure spraying) is often the only way of removing the particles. However, the present zigzag banks can withstand these vigorous techniques.

The present invention will now be described in more detail with reference to the following Figures, in which:

Figure 1a illustrates the cross-sectional structure of a typical organic light-emissive device;

Figure 1b illustrates the cross section of an organic light emissive device comprising a further charge transport layer;

Figure 2 depicts a unit cell (the equilateral triangle) for a hexagonal matrix of pixels having a side-length L and separated by banks of width y, and the formula for the % pixel area of the cell, $3(\frac{1}{2}Lx) / \frac{1}{2}z(2x+y) * 100$; and

Figure 3 illustrates a further layer 7 beneath the banks 6 which further layer defines a well 8 in which the emissive layer is to be deposited – the further layer 7 encircles the pixel area and the front and rear portions defining the marked well are not shown for clarity.

Figure 4 is a photograph of a substrate according to the present invention showing a sinusoidal bank having a curve of radius 80μm and a width of 20μm.

Figure 5 is a further photograph of a substrate according to the present invention showing a sinusoidal bank having a curve of radius 80μm and a width of 20μm.

The angle of the zigzag used in the present invention is not particularly limited, provided that the zigzag is sufficient to strengthen the banks. It should be noted that it is preferred that each inner (or outer) angle (each 'zig' or 'zag' has one smaller inner angle and one larger outer angle) is the same along the length of each bank, however, the present invention is not limited to this preferred embodiment (the angle may vary along the length of the bank). Thus, the preferred values of the angle referred to below are the average inner angles either along the length of the banks, or preferably across the whole display device. Thus the zigzag may have an average inner angle that is acute (less than 90°) or is a right angle (90°) or is an obtuse angle (more than 90° and less than 180°). In a preferred embodiment of the present invention the average inner zigzag angle is an obtuse angle. It is particularly preferred that the average inner zigzag angle is from 100°-150°. Most preferably the average inner angle is from 120°-140°.

Where the device comprises curved banks it is preferred that these have a sinusoidal pattern, preferably with a radius of curvature of 20-180μm, more preferably the banks have a radius of curvature of 40-100μm. A substrate with banks having a sinusoidal pattern is shown in Figures 4 and 5. Figure 4 shows a photograph of a substrate comprising banks 1 and wells 2, the bank has a width of 20 μm and a radius of 80μm. Figure 5 shows the layout of banks 1 and wells 2 over a greater surface area of the substrate of Figure 4.

In an alternative embodiment the banks may be comprised of two parallel lines of material, in effect the bank itself may be described as being formed from two banks. The advantages of such a structure are disclosed in US6005344

The shape of the pixel areas of the present devices is not especially limited, and the zigzag banks can be effectively employed in devices having any type of pixel shape. The banks may help to define the pixel shape, but preferably the pixel areas are defined by depositing a further layer on the first electrode, before depositing the banks. This further layer encircles each pixel area, defining a well for accepting the emissive layer. Preferably the further layer is deposited and pattered using photolithography.

Preferably, the pixel areas are hexagonal, or substantially hexagonal. When the pixel areas are hexagonal, the average inner angle of the zigzag is preferably about 120°. The term hexagonal is intended to extend beyond regular hexagons, and elongated or truncated hexagons may be employed if desired, or other non-regular six-sided figures. A particular advantage of hexagonal pixel areas is that the corners are more open as compared with more conventional rectangular pixels (120° compared with 90°). This open structure allows the substance forming the emissive layer to flow into the corner more easily to cover the entire pixel area.

The second electrode is preferably deposited by vapour deposition. A function of the banks is to ensure that there is a 'shadow' which causes a break between adjacent sections (generally parallel strips) of the electrode. The shape of the banks is not especially limited provided that this can be achieved. Typically, however, the banks comprise an upwardly protruding portion, which is wider at its tip than at its base (i.e. the banks have a protruding portion with an inverted trapezoidal cross-section). This is termed a 'negative wall profile' and serves to ensure that sufficient 'shadow' exists to separate the second electrode formed on one pixel area from the second electrode formed on an adjacent pixel area. Irrespective of the shape of the cross section of the banks, the width of the banks is preferably 3.0×10^{-5} m or less. More preferably the width of the banks is 2.5×10^{-5} m or less. Most preferably, the width of the banks is from 1.0×10^{-5} m to 2.5×10^{-5} m. This width can be the width of the protruding portion of the banks at the tip, at the base, or an average width, depending on whether the banks have a negative wall profile, a positive wall profile, or are rectangular respectively.

Using the zigzag banks in the present invention, it is possible to fabricate devices having a greater emissive area. A comparison of the emissive areas possible using the present invention, as compared with prior art devices can be drawn with reference to Figure 2 which depicts a unit cell (the equilateral triangle) for a hexagonal matrix of pixels. For a hexagonal pixel having a side length (L), the total area of the unit cell is $\frac{1}{2}z(2x + y)$. The area occupied by pixels is $3(\frac{1}{2}Lx)$. In the prior art devices the width of the banks (y) is generally around 4.0×10^{-5} m. The side length of a pixel is typically around 24.0×10^{-5} m. Thus, the percentage area occupied by pixels (emissive area) in known devices is around 83 %. However, using the present banks, which may have a width as narrow as 1.0×10^{-5} m, the percentage emissive area for pixels having the same side length is more than 95 %.

Thus, it is preferred that in the present devices, the pixel areas comprise 85.0 % or more of the total substrate area. More preferably the pixel areas comprise 90 % or more of the total substrate area. Most preferably the pixel areas comprise 95 % or more of the total substrate area.

Substrates suitable for the organic electroluminescent devices of the present invention include glass, ceramics and plastics such as acrylic resins, polycarbonate resins, polyester resins, polyethylene terephthalate resins and cyclic olefin resins. The substrate may be transparent, semi-transparent or, in cases where light is to be emitted from the opposite side of the device, opaque. The substrate may be rigid or flexible and may comprise a composite material such as, for example, the glass and plastic composite disclosed in EP 0,949,850.

In the devices of the present invention it is preferred that the first electrode comprises a plurality of parallel strips (e.g. hexagonal zones connected by narrow strips) and the banks are oriented such that they are orthogonal to the strips of the first electrode. This in turn allows the second electrode to be deposited and separated by the banks into electrode strips, which are orthogonal to the first electrode. The first electrode may be transparent, in which case it is preferred that the substrate is also transparent. However, in an alternative arrangement, the second electrode may be transparent, in which case the substrate and first electrode do not need to be transparent. Thus, at least one of the electrodes is suitably light transmissive, and preferably transparent, suitably to light emitted from the light-emissive regions. Preferably the first electrode is the anode.

The organic electroluminescent material used in the emissive layer is suitably a polymer material, preferably semiconductive polymer material and preferably a conjugated (either fully or partially) polymer material. Alternatively, the electroluminescent material may be a non-polymeric organic material, such as a small molecule material, an oligomer material or a monomer material. The organic electroluminescent material may comprise one, two or more electroluminescent components, for instance as a mixture or a copolymer.

The present devices may have one or more further layers if desired, such as one or more further charge transport layer adjacent the emissive layer. Preferably the charge transport layer is situated between the first electrode and the light emissive layer. When the first electrode is an anode, such as ITO, it is preferred that the charge transport layer is a hole injection layer. The or each charge transport layer may suitably comprise one or more polymers such as polystyrene sulphonic acid doped polyethylene dioxythiophene ("PEDOT-PSS"), poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-(4-imino(benzoic acid))-1,4-phenylene-(4-imino(benzoic acid))-1,4-phenylene)) ("BFA"), polyaniline and PPV.

Photolithography is particularly useful for patterning the banks in the required zigzag arrangement. The further advantage of photolithography is that it is capable of patterning the further layer so that it encircles the pixel areas, and helps to ensure that the emissive layer is deposited on the pixel area and not on any other part of the substrate. This is advantageous because typically the emissive layer is deposited by ink jet printing methods. In these methods the emissive layer flows into the well and is prevented from flowing to other portions of the substrate.

The present invention further provides an electronic or electroluminescent device comprising a display element as defined above. In operating the devices, it is preferred that the first electrode is an anode and the second electrode is a cathode.

The present invention also provides a method for producing the display devices described above. The method comprises:

(a) depositing a first electrode on a substrate;
(b) depositing a plurality of banks on the substrate;
(c) depositing a light emissive layer on a plurality of pixel areas; and
(d) depositing a second electrode on the light emissive layer;

wherein the banks are deposited in a zigzag pattern, preferably by photolithography.

The process will now be discussed in more detail.

The method for depositing the first electrode is not especially limited, and any suitable method known to those in the art may be employed, such as solution processing or vapour deposition techniques. Thus the first electrode may be deposited by sputtering. Preferably, the first electrode is patterned using photoresist, to shape the pixel areas for accepting the light emissive layer, e.g. in hexagonal zones connected by narrow strips. It is also preferred that the non-pixel areas, such as the narrow strip sections, of the first electrode are metalised, to improve the conductivity of the first electrode. When the first electrode is transparent, the portion of the first electrode which is to be part of the pixel area is not metalised, since this should remain transparent.

In a preferred embodiment, the first electrode (preferably the anode) comprises a layer of conductive material of high work function of the eventual light-emitting device. Where it is desired that light be emitted through the substrate, this conductive material should be transparent or semi-transparent and is suitably selected from materials having a work function greater than 4.3eV, such as a metal oxide. Preferred materials for the first electrode include indium tin oxide (ITO), tin oxide (TO), aluminium doped zinc oxide, indium doped zinc oxide, magnesium-indium oxide, cadmium tin-oxide, gold, silver, nickel, palladium and platinum.

Typically, the conductive layer on the substrate is then patterned. This is generally carried out using photolithography, wherein the layer of the first electrode is coated with a photoresist, patterned, for example using a UV source and a photomask, and developed using the appropriate developing solution. Exposed electrode is then removed by chemical etching, leaving a patterned layer. Typically the electrode is patterned to form a series of parallel strips, preferably comprising pixel area zones having the desired pixel shape, such as hexagons.

Generally, one or more layers of photoresist (such as a fluorinated polyimide) are then deposited onto the patterned electrode. The photoresist may be deposited by spin-coating, doctor blade coating or any other suitable technique. These layers of photoresist form the wells defining the pixel areas and the banks for separating the second electrode.

Typically, following deposition, the photoresist is patterned using conventional photolithographic techniques. For example, after deposition the photoresist is dried, exposed to UV light through a mask, soft baked, developed using, for example, tetramethylammonium hydroxide, rinsed and hard baked. Preferred patterns are those that define zigzag banks, as described above, or wells, which are two dimensional patterns of recesses in the photoresist, also as described above. Regions of first electrode between the banks of photoresist are exposed.

In a preferred embodiment, the photolithographic method employed for depositing the banks comprises negative photolithography. This involves removing irradiated photoresist rather than non-irradiated photoresist. This technique creates the inverted trapezoidal cross section (negative wall profile) of the upwardly protruding portions of the banks, which is preferred in the present invention. The further layer defining the well of the pixel area is also preferably deposited by photolithography, but a positive wall profile is preferred for the well. Thus, the further layer is preferably deposited using positive photolithography in which non-irradiated photoresist is removed. The further layer may be formed from the same photoresist as the banks, or a different photoresist. The photoresist material used for the banks and the further layer is preferably a polyimide and more preferably a fluorinated polyimide. Fluorinated polyimide photoresists are typically co-polymers formed from photosensitive imide monomer units and fluorinated monomer units. An example of fluorinated polyimide that can be used in the present invention is PI2771® obtained from HD Microsystems. An example of a polyimide photoresist which can be used in the present invention is Brewer Polyin T15010®.

Techniques for obtaining banks with a negative wall profile are known in the art and typically, in the case of a negative photoresist, involve underexposing and then overdeveloping the photoresist. The provision of banks with a negative wall profile is beneficial for the further processing of the substrate, in particular banks having a negative wall profile aid the patterned deposition of the metallic cathode. EP 0,969,701 discloses the use of banks having a negative wall profile in the deposition of a cathode in an organic electroluminescent device. Where the photoresist comprises a pattern of wells these generally have a positive wall profile, this enables any deposited solution to flow more easily into the well. Techniques for obtaining wells with a positive wall profile are known in the art and typically, in the case of a negative photoresist, involve overexposing and then underdeveloping the photoresist.

In particular, it is preferred that the zigzag banks are deposited by coating a layer of photoresist onto a pre-patterned layer of the first electrode (such as ITO), or a pre-patterned photoresist layer defining the wells and pixel areas, exposing the photoresist to UV light through a mask having the desired zigzag pattern, soft baking the layer of exposed photoresist, developing the photoresist, rinsing to remove exposed or unexposed photoresist (depending on whether a negative or positive photoresist is used) and finally hard baking the photoresist.

EXAMPLE

A glass substrate was coated with ITO, and patterned by photolithography to form an anode comprising parallel lines of thickness 270 x 10^{-6} m (270 microns) with gaps of 15 x 10^{-6} m (15 microns) between the lines.

The substrate was then exposed to an O_2/CF_4 plasma treatment to render the surface energy of the ITO suitable for solution deposition. The O_2/CF_4 plasma treatment was carried out in a RF barrel etcher of dimensions 300 mm diameter, 450 mm depth, with a gas mixture of 0.5-2 % CF_4 in oxygen, at a pressure of 200 Pa (1.5 Torr) and a power of 400 W.

A layer of polyimide (Polyin® T15010 obtained from Brewer Science) was then spin coated onto the substrate. The polyimide was patterned by photolithography into regular zigzag banks (having a zig/zag length of approximately 250 x 10^{-6} m (250 microns) and an average inner angle of approximately 120°), to form banks orthogonal to the parallel lines of ITO having a height of 10 x 10^{-6} m (10 microns) and a width of 20 x 10^{-6} m (20 microns), leaving a channel of exposed ITO between the banks having a width of 265 x 10^{-6} m (265 microns).

A layer of PEDOT:PSS (charge transport layer) in a 0.5 wt.% aqueous solution (available from Bayer as Baytron®) was then ink-jet printed onto the substrate, to form a layer of thickness 50 nm over the exposed regions of ITO (the ink-jet printer was from Litrex, USA). A layer of a polyfluorene light-emitting polymer (light-emissive layer) was then ink-jet printed onto the PEDOT:PSS layer from a 1.5 wt.% solution in a xylene:trimethylbenzene solvent. In this way layer of polyfluorene of thickness 100 nm was formed over the PEDOT:PSS.

A cathode comprising a layer of calcium of thickness 50 nm and a layer of aluminum of thickness 250 nm was then deposited upon the polyfluorene layer by means of vacuum deposition. The device was then encapsulated using a metal can.

The device was tested and found to be fully functional, showing that the zigzag banks had successfully acted as cathode separators without breaking, despite being only 20 x 10^{-6} m (20 microns) in width.

Further substrates were prepared according to the above described method with an additional layer of wells provided using photolithography. Banks were provided over the layer of wells as described above. In each case the width of the bank was 20µm. Substrates were prepared with banks having a zigzag pattern comprising straight sections with an average inner angle of 127° and with banks having a sinusoidal pattern with radii of curvature of 40µm and 80µm, the latter of these is shown in Figures 4 and 5. The substrates were provided with a layer of PEDOT:PSS in the wells by ink jet printing using a Litrex 140L ink jet printer (available from Litrex). A layer of light-emitting polymer was provided over the PEDOT:PSS and the light-emitting devices were provided with a cathode and encapsulation as described above.

No doubt the teaching herein makes many other embodiments of, and effective alternatives to, the present invention apparent to a person skilled in the art. The present invention is not limited to the specific embodiments described herein but encompasses modifications which would be apparent to those skilled in the art and lying with the spirit and scope of the attached claims.

CLAIMS:

1. A display device comprising:

(a) a substrate;
(b) a first electrode formed on the substrate;
(c) a plurality of banks situated between pixel areas;
(d) a light emissive layer formed on the pixel areas; and
(e) a second electrode formed on the light emissive layer;

wherein the banks are arranged in a zigzag pattern.

2. A device according to claim 1, wherein the substrate is a transparent substrate.

3. A device according to claim 1 or claim 2, wherein the average inner zigzag angle is an obtuse angle.

4. A device according to claim 3, wherein the average inner zigzag angle is from 100°-150°, more preferably the average inner zigzag angle is from 120°-140°.

5. A device according to claim 1 wherein the banks are curved.

6. A device according to claim 5 wherein the banks have a sinusoidal pattern with a radius of curvature of 20-180μm, more preferably the banks have a sinusoidal pattern with a radius of curvature of 40-100μm.

7. A device according to any preceding claim, wherein the banks comprise an upwardly protruding portion, which portion has a negative wall profile, which portion serves to separate the second electrode formed on one pixel area from the second electrode formed on an adjacent pixel area.

8. A device according to claim 7, wherein the width of the banks at the tip is 3.0×10^{-5} m or less, preferably wherein the width of the banks at the tip is 2.5×10^{-5} m or

less, most preferably wherein the width of the banks at the tip is from 1.0×10^{-5} m to 2.5×10^{-5} m.

9. A device according to any preceding claim, wherein the device comprises a further layer defining a well encircling the pixel areas.

10. A device according to claim 9, wherein the further layer defining the well is separate from the banks, and the banks are formed on the further layer.

11. A device according to any preceding claim, wherein the pixel areas comprise 85.0 % or more of the total substrate area.

12. A device according to claim 11, wherein the pixel areas comprise 90 % or more of the total substrate area.

13. A device according to claim 12, wherein the pixel areas comprise 95 % or more of the total substrate area.

14. A device according to any preceding claim, wherein the pixel areas are hexagonal.

15. A device according to any preceding claim, which device comprises a further charge transport layer adjacent the emissive layer.

16. A device according to claim 15, wherein the charge transport layer is situated between the first electrode and the light emissive layer.

17. A device according to any preceding claim, wherein the first electrode comprises a plurality of parallel strips and the banks are oriented such that they are orthogonal to the strips of the first electrode.

18. A method for producing a display device, which method comprises:

(a) depositing a first electrode on a substrate;
(b) depositing a plurality of banks on the substrate;
(c) depositing a light emissive layer on a plurality of pixel areas;
(d) depositing a second electrode on the light emissive layer;

wherein the banks are deposited a zigzag pattern.

19. A method according to claim 18, wherein the average inner zigzag angle is an obtuse angle.

20. A method according to claim 19, wherein the average inner zigzag angle is from 100°-150°, more preferably the average inner zigzag angle is from 120°-140°.

21. A method according to claim 18 wherein the banks are curved.

22. A method according to claim 21 wherein the banks have a sinusoidal pattern with a radius of curvature of 20-180μm, more preferably the banks have a sinusoidal pattern with a radius of curvature of 40-100μm.

23. A method according to any of claims 18-22, wherein the banks comprise an upwardly protruding portion, which portion has a negative wall profile, which portion serves to separate the second electrode formed on one pixel area from the second electrode formed on an adjacent pixel area.

24. A method according to any of claims 18-23, wherein a further layer is deposited defining a well encircling the pixel areas.

25. A method according to claim 24, wherein the further layer defining the well is separate from the banks and is deposited prior to forming the banks.

26. A method according to any of claims 18-25, wherein the photolithographic method employed for depositing the banks comprises negative photolithography.

27. A method according to any of claims 18-26, wherein the pixel areas are hexagonal.

28. A method according to any of claims 18-27, which method comprises a further step of depositing a charge transport layer adjacent the emissive layer.

29. A method according to claim 28, wherein the charge transport layer is deposited on the first electrode.

30. A method according to any of claims 18-29, wherein the first electrode forms a plurality of parallel strips and the banks are deposited such that they are they are orthogonal to the strips of the first electrode.

31. A method according to claim 30, wherein the first electrode is patterned by photolithography to form the pixel areas for accepting the light emissive layer.

32. An electronic or electroluminescent device comprising a display device as defined in any of claims 1-17.

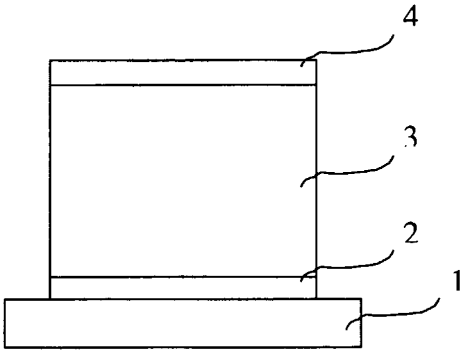


Figure 1A

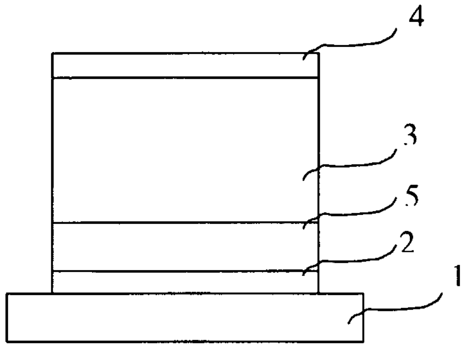
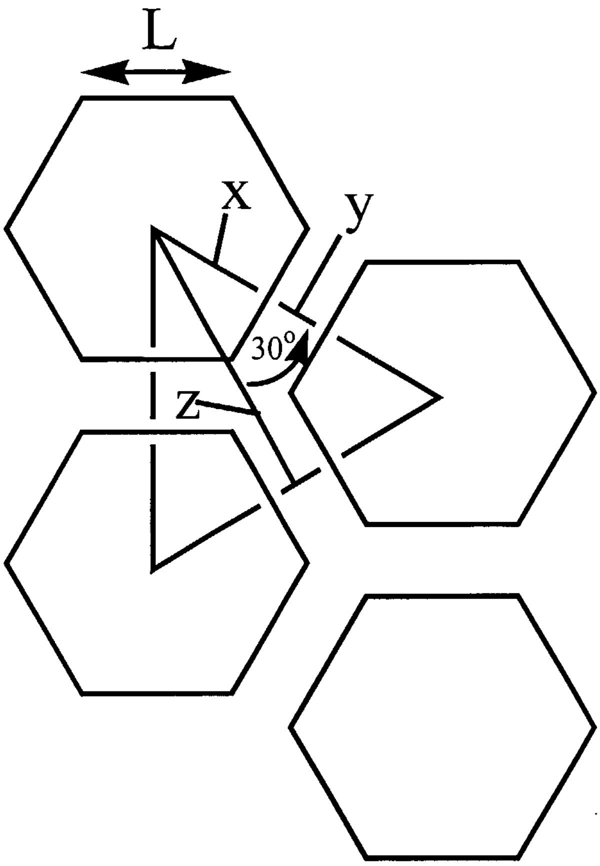


Figure 1B



% pixel area = 3(½Lx) / ½z(2x+y) * 100

Figure 2

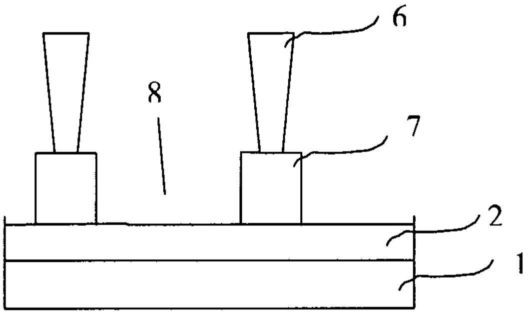


Figure 3

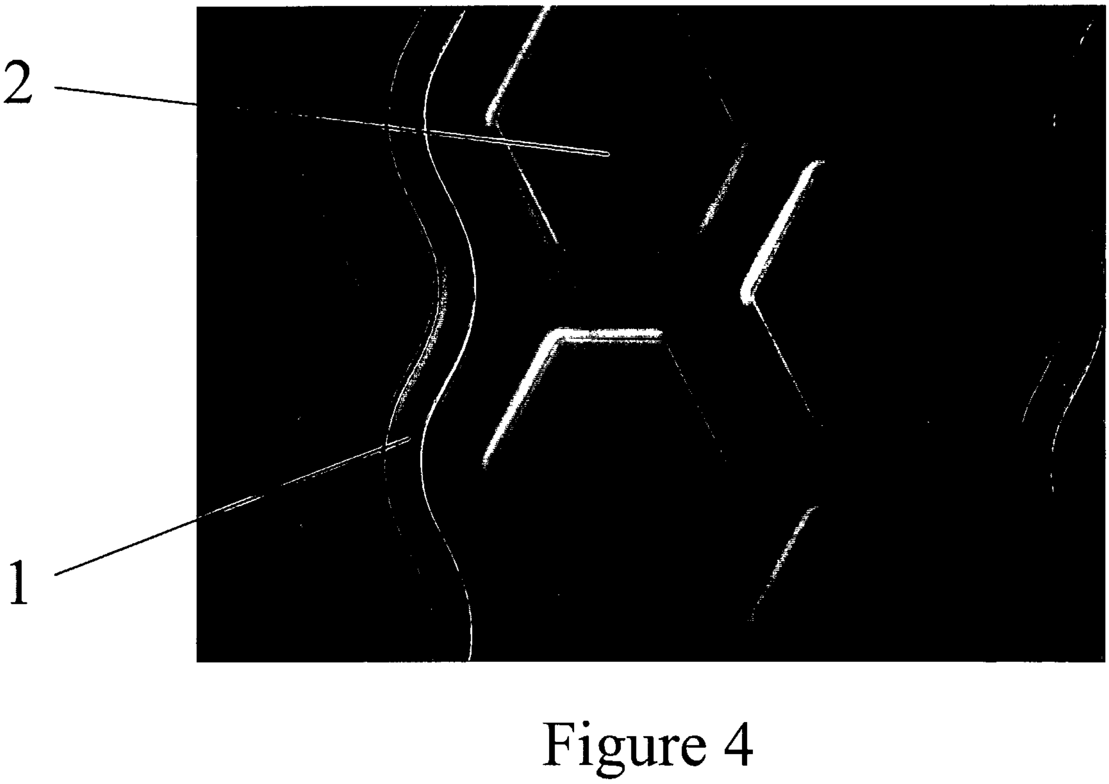


Figure 4

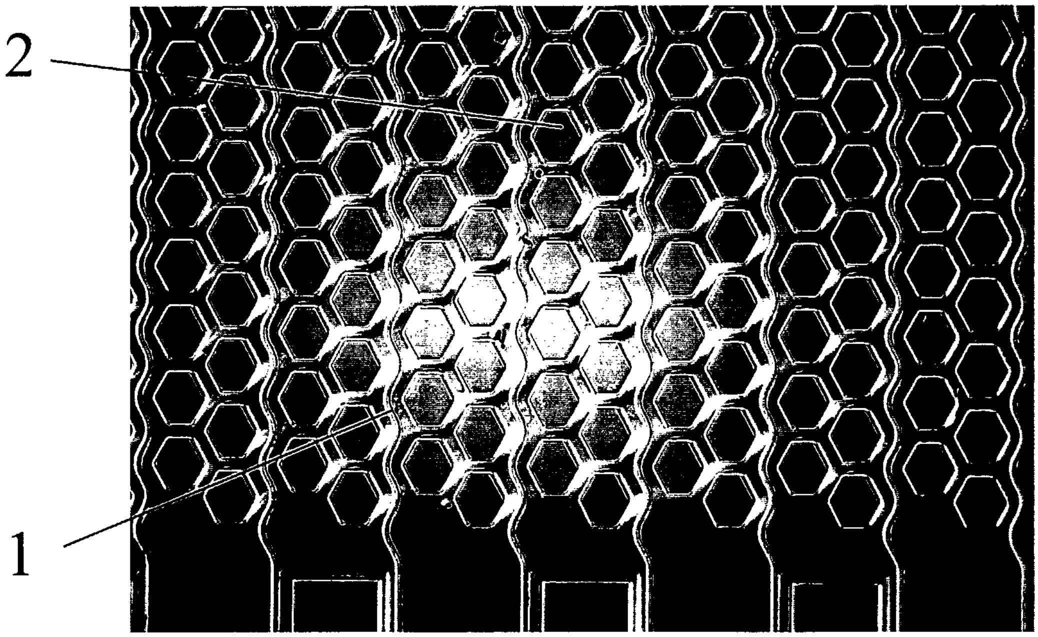


Figure 5

专利名称(译)	显示设备		
公开(公告)号	EP1497866A2	公开(公告)日	2005-01-19
申请号	EP2003747168	申请日	2003-04-23
[标]申请(专利权)人(译)	剑桥显示技术有限公司		
申请(专利权)人(译)	剑桥显示科技有限公司		
当前申请(专利权)人(译)	剑桥显示科技有限公司		
[标]发明人	GUNNER ALECC O CAMBRIDGE DISPLAY TECH LTD SMITH EUANC O CAMBRIDGE DISPLAY TECH LTD GREGORY HAYDN CAMBRIDGE DISPLAY TECH LTD		
发明人	GUNNER, ALECC/O CAMBRIDGE DISPLAY TECHNOLOGY LTD. SMITH, EUANC/O CAMBRIDGE DISPLAY TECHNOLOGY LTD. GREGORY, HAYDN, CAMBRIDGE DISPLAY TECHNOLOGY LTD.		
IPC分类号	H05B33/22 H01L27/32 H01L51/50 H05B33/10 H01L27/00		
CPC分类号	H01L27/3283		
优先权	2002009513 2002-04-25 GB		
外部链接	Espacenet		

摘要(译)

提供一种显示装置，包括：（a）基板;（b）在基板上形成的第一电极;（c）位于像素区域之间的多个堤岸;（d）在像素区域上形成的发光层;（e）在发光层上形成的第二电极;其中堤以Z字形图案排列。还提供了一种制造显示装置的方法，该方法包括：（a）在基板上沉积第一电极;（b）在基板上沉积多个堤岸;（c）在多个像素区域上沉积发光层;（d）在发光层上沉积第二电极;其中堤以Z字形图案沉积。