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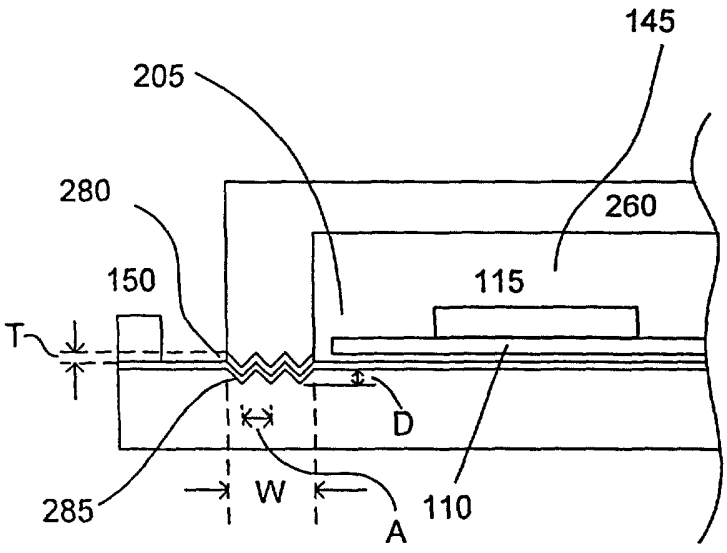
(54) Title: IMPROVED SEALING FOR OLED DEVICES



(57) Abstract: Disclosed is a technique for increasing the shelf life of devices, such as OLED which requires hermetic sealing from moisture and oxygen. In one embodiment, the permeation path of moisture or oxygen is increased without increasing the bonding width of the cap. This is achieved by using a grooved interface between the cap and substrate on which the components of the device are formed. The grooved interface can comprise various geometric shapes.

WO 03/030275 A1

IMPROVED SEALING FOR OLED DEVICES

Field of the Invention

The present invention relates generally to encapsulating or sealing of OLED devices.

Background of the Invention

Fig. 1 shows an OLED device 100 which serve, for example, as a display in various types of consumer electronic products, including cellular phones, cellular smart phones, personal organizers, pagers, advertising panels, touch screen displays, teleconferencing and multimedia products, virtual reality products, and display kiosks.

The OLED device comprises a functional stack formed on a substrate 101. The functional stack comprises of one or more organic functional layers between two conductive layers which serve as electrodes (cathode and anode). The conductive layers are patterned to form rows of cathodes in a first direction and columns of anodes in a second direction. OLED pixels are located where the cathodes and anodes overlap. Charge carriers are injected through the cathodes and anodes via bond pads 150 for recombination in the functional layers.

The recombination of the charge carriers causes the functional layer of the pixels to emit visible radiation.

The device is encapsulated with a cap 160, sealing pixels. OLED devices require hermetic sealing since the active components, such as the cathode, are adversely impacted by moisture and oxygen. Typically, an epoxy based adhesive is used to bond the cap to the substrate. However, epoxy based adhesive can be penetrated by oxygen and moisture. The penetration path of the oxygen and moisture is along the interface 180 of the cap and substrate. The length of the penetration path is defined by the bonding width W. The rate of penetration of oxygen and moisture Q depends on the bonding thickness T and W. The rate Q is directly related to the bonding thickness T and inversely related to the bonding width W. Since there is a limit to how much the bonding thickness can be reduced, extending the shelf life of the OLED device is achieved by lengthening the penetration or permeation path which corresponds to increasing the bonding width. Increasing the bonding width undesirably increases the dimension of the device unnecessarily.

As evidenced from the foregoing discussion, it is desirable to provide improved sealing of OLED device without unnecessarily increasing its dimensions.

Summary of the Invention

The invention relates to improved sealing of devices, particularly those which are require protection from moisture and oxygen such as OLEDs. In one embodiment, the permeation path of oxygen and moisture is increased with out increasing the bonding width of the device by providing a geometrically shaped grooved interface between the cap and substrate. The grooved interface can comprise various shapes, such as a triangular, rectangular, spherical, or a combination thereof.

Brief Description of the Drawings

Fig. 1 shows a conventional OLED device;

Fig. 2 shows an OLED device in accordance with one embodiments of the invention;

Figs. 3-5 show various geometric shaped bonding interfaces in accordance with different embodiments of the invention; and

Fig. 6 shows another embodiment of an OLED device.

Preferred Embodiments of the Invention

Fig. 2 shows a portion of an OLED device 200 in accordance with one embodiment of the invention. As shown, the OLED device comprises active components in the active region 205 of a substrate 201. In one embodiment, the substrate comprises a transparent substrate, such as glass. Other types of transparent materials that can serve as a substrate to support the OLED active components are also useful. Non-transparent substrates can also be used, for example, with applications in which radiation is visible through a cap 260.

The active components typically comprise one or more organic layers 110 sandwiched between first and second electrodes 105 and 115. The electrodes can be patterned to form pixelated, segmented, or other types of devices. In one embodiment, the first electrode(s) 105 are anode(s) and the second electrode(s) 115 are cathode(s). Forming first electrodes that are cathodes and second electrodes that are anodes is also useful. Bond pads or electrical contacts 150 are electrically coupled to the cathodes and anodes.

In accordance with the invention, an interface 280 of a cap 260 and the substrate comprises a geometric shaped formed by one or more grooves 285. Preferably, the interface is formed using less than or equal to 5 grooves. Providing a geometrically shaped interface between the cap and substrate effectively increases the permeation path for oxygen and moisture without increasing the actual bonding width of the cap or dimensions of the OLED device.

In one embodiment, the geometric shape comprises a triangular shape. Using a triangular shape with having sides with length C, the effective width is equal to 2C while the actual width is equal to A, where A < 2C. Thus using the geometrically shaped grooves, the permeation path can be lengthened without lengthening the actual bonding width.

As shown in Table 1, results of theoretical calculations based on the equation 1 below has shown that the present invention resulted in increased shelf life without increasing the actual bonding width. The calculations in table 1 are based on the assumption that the grooves are triangular in shape with D equal to 0.5mm.

$$Q = \{P \times AR \times SL \times \delta p\}/T \quad \text{(Equation 1)}$$

where:

Q = the amount of water penetration;

AR = cross section of the exposed area (bonding thickness T x W, where W = to effective bonding width or length of permeation path);

T = Bonding thickness

P = the permeability of water vapor transmission rate (0.75 gmm/m^2.day for epoxy);

SL = the shelf life;

δp = the partial pressure (assuming a constant)

Table 1

Effective Permeation Path Width (mm)	Bonding Thickness (mm)	Number of Grooves	Actual Bonding Width (mm)	Improvement
35	0.5	35	7	5
25	0.36	25	5	5
20	0.28	20	4	5
15	0.21	15	3	5
3	0.04	3	0.6	5

Let's assume the case where the bonding thickness is 0.21 mm and a 15 mm permeation path is necessary to achieve desired shelf life. As indicated in Table 1, using 15 grooves, the desired shelf life can be achieved

with an actual bonding width of only 3 mm. Thus, the present invention enables a reduction of the actual bond width by about 5 times.

Other geometric shapes can also be used to create the interface between the substrate and cap. For example, as illustrated by Figs. 3-5, the interface can have a rectangular, an elliptical, or a spherical shape. A combination of different geometric shapes can also be employed.

The depth D of the groove should not adversely affect the structural integrity of the substrate. In one embodiment, the D is less than TS and more preferably D is less than ½ TS, where TS is the thickness of the substrate. For example, the depth of a groove is about 0.5 mm for a 1.1 mm thick substrate. If triangular grooves are used, the width of a triangular groove is about 0.2 mm and the length of the sides is about 0.509mm. This produces a permeation path of 1.1 mm with an actual width of only 2 mm, which is about a five folds increase over non-grooved interfaces. For rectangular grooves, the male groove is about 0.15 mm in width while the female groove is about 0.2 mm wide.

As discussed previously, the bonding thickness T impacts the permeability rate of moisture. The smaller

the T, the slower the permeability rate. As such, it is desirable to have as small a T as possible. Furthermore, to ensure that that the modulation of the grooves produces an increase in the permeation path, the bonding thickness T is at least smaller than D. In a preferred embodiment, T << D. In one embodiment, T is less than or equal to 0.14 the actual width A of a groove.

Fig. 6 shows a portion of a substrate 701 in accordance with one embodiment of the invention. The substrate is processed, for example, to include active components in the active region 205. In one embodiment, the active components comprise OLEDs. The OLEDs can be formed using conventional techniques such as those described in, for example, Sheats, J.R. et al. Organic electroluminescent devices, Science 273, 884-888 (1996), which is herein incorporated by reference for all purposes. At the bonding region 761 of the substrate (region where the cap is bonded to the substrate), at least one groove 285 is provided. In one embodiment, the groove is recessed into the substrate, creating a "female" groove. A cap 760 which is mounted to the substrate is provided to hermetically seal the active components. Where the cap is mounted to the substrate,

at least one groove is provided. The groove on the cap protrudes from the cap, forming a male groove. The number of female grooves on the substrate is equal to the number of male grooves on the cap. When the cap is bonded to the substrate, the female and male grooves are fitted together. Providing female grooves on the cap and male grooves on the substrate is also useful. Typically, the cap is bonded to the substrate using conventional adhesives such as epoxy. Other types of adhesive can also be used. Alternatively, for application where the active components or materials used to form the device are not sensitive to heat, soldering or welding can be used to bond the cap and substrate together.

As shown, rectangular geometric shaped grooves are used. Tapered or triangular shaped grooves can be used to, for example, facilitate alignment. Other geometrically shaped grooves or a combination of different geometrically shaped grooves can also be used. In one embodiment, the height H of the male grooves is greater than the depth D of the female grooves to create a cavity 145 in the active region of the device.

The substrate and cap, in one embodiment, comprise glass. Other materials, such as metal, ceramic,

plastics, can also be used. It is not necessary that the substrate and cap be formed from the same material. Conventional techniques are used to form the grooves. The technique used, of course, will depend on the material used to form the substrate and cap. For example, conventional glass cutting and/or etching techniques can be used for glass, stamping techniques for metals, and embossing techniques for plastics. Other techniques, such as sandblasting, grinding, drilling, sawing, other mechanical and resist and etching techniques can be employed to form the grooves. Where stamping techniques are used, the substrate can be locally heated to soften the material to facilitate the stamping process.

In an alternative embodiment, a support rim can be formed on a cap. The support rim could, for example, comprise directly or indirectly patternable material. Support rims are described in, for example, International Patent Application titled "Encapsulation of OLED Devices" (attorney docket number 99E5737SG), which is herein incorporated by reference for all purposes. The grooves are formed on the surface of the support rim that contacts the substrate. The grooves, for example, are formed using lithographic techniques

using resist and wet etching. Dry etching can also be used. Depending whether the substrate is formed from a more ductile material or not, grooves can be formed in the bonding region of the substrate. Alternatively, the support rim can be formed on the substrate.

For application where either the cap or substrate is more ductile that the other, only the more rigid or harder of the two needs to be grooved. When the cap is mounted with sufficient pressure, the more ductile material will conform to the shape of the grooves. If a barrier layer is needed for the ductile material (e.g., polymeric material), the embossing should be performed before the barrier material is formed thereon. This is because the barrier material is typically brittle and could be damaged by the embossing process.

While the invention has been particularly shown and described with reference to various embodiments, it will be recognized by those skilled in the art that modifications and changes may be made to the present invention without departing from the spirit and scope thereof. The scope of the invention should therefore be determined not with reference to the above description but with reference to the appended claims along with their full scope of equivalents.

What is claimed is:

1. A device comprising:

a substrate having a bonding region surrounding an active region, the active region comprising active components;

a cap mounted on the substrate for sealing the active components of the device, the cap contacts the substrate in the bonding region having a bonding width W; and

an interface between the cap and the substrate that includes at least one geometrically shaped groove to create and effective bonding width EW which is greater then W.

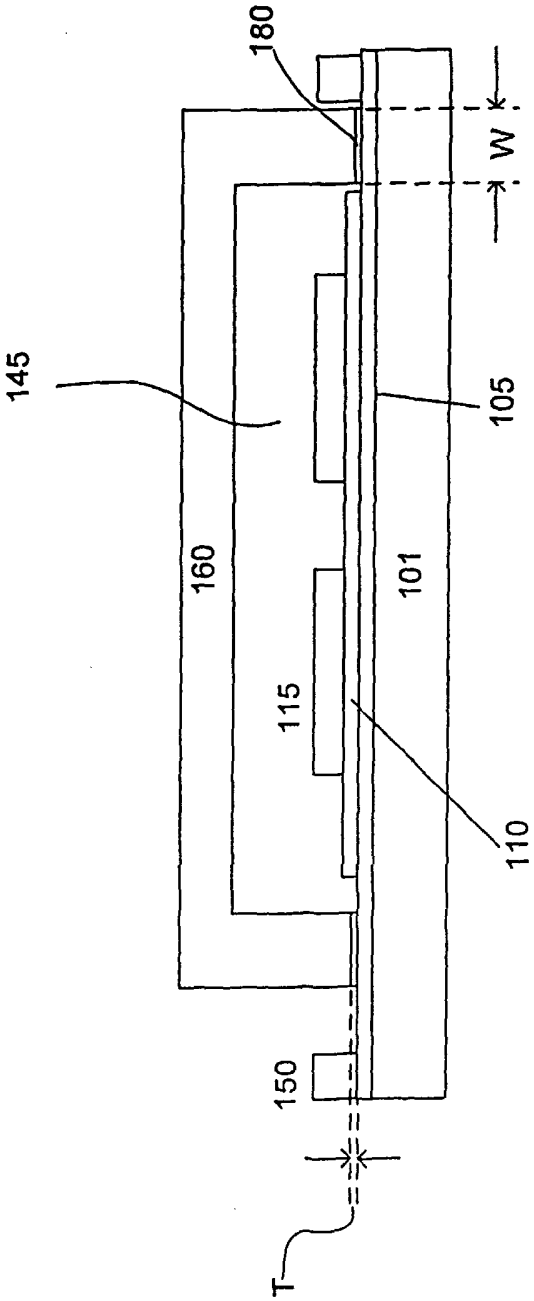


Fig. 1

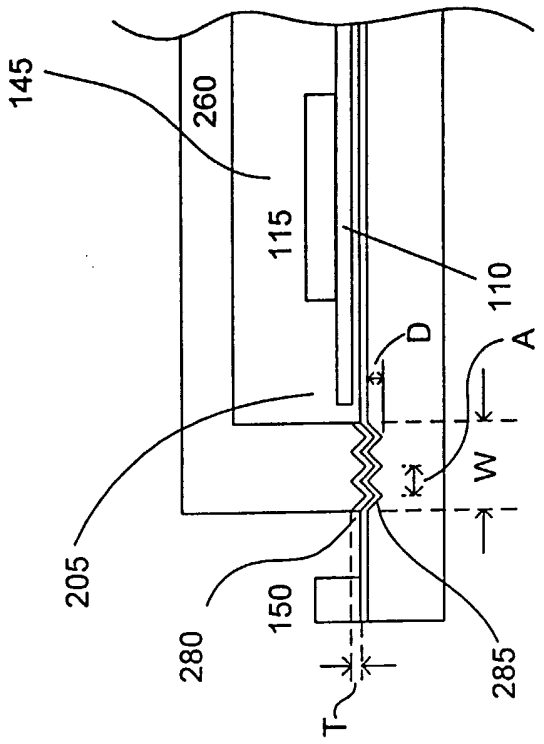


Fig. 2

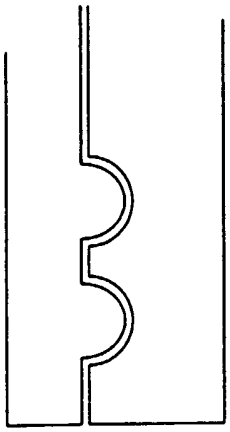


Fig. 5

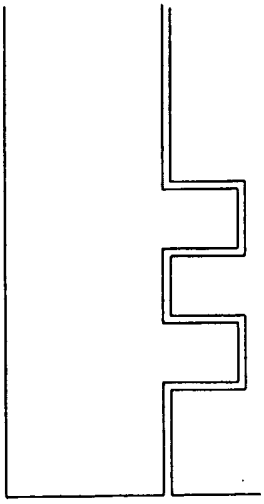


Fig. 3

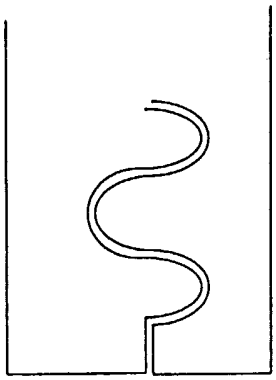


Fig. 4

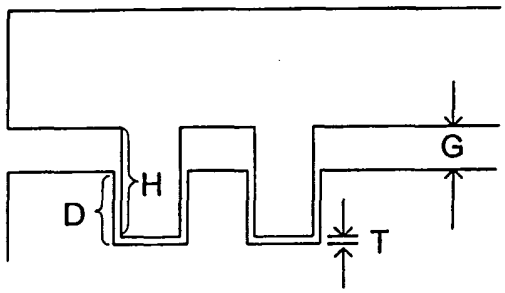


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP 02/10698

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L51/20 H01L23/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 013, no. 433 (E-824), 27 September 1989 (1989-09-27) -& JP 01 161736 A (NEC CORP), 26 June 1989 (1989-06-26) abstract	1
A	WO 00 76276 A (KONINKL PHILIPS ELECTRONICS NV) 14 December 2000 (2000-12-14) page 3, line 5-26	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 January 2003	03/02/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	De Laere, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP 02/10698

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 01161736 A	26-06-1989	NONE	
WO 0076276 A	14-12-2000	WO 0076276 A1	14-12-2000
		EP 1114569 A1	11-07-2001
		US 6489719 B1	03-12-2002