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(54) **ORGANIC LIGHT EMITTING DIODE DISPLAY HAVING IMPROVED MECHANICAL STRENGTH**

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(30) **Foreign Application Priority Data**

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H01L 51/50 (2006.01)
H01L 51/52 (2006.01)

(52) **U.S. Cl.** **313/512**; 313/503; 313/509; 315/169.3

(58) **Field of Classification Search** 313/498–512; 315/169.1, 169.3
See application file for complete search history.

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(57) **ABSTRACT**

The present invention is related to an OLED display, and one aspect of the OLED display includes a substrate member, an insulating layer formed on the substrate member, a metal wire formed on the insulating layer and having a plurality of joining enhancement holes, a sealant formed on the metal wire, and a sealing member attached on the sealant. In some embodiments, the joining enhancement holes efficiently suppress stripping of the sealant from the metal wire, since the sealant can integrally bond with the interlayer insulating layer through the joining enhancement holes. This feature may compensate for any weak bonding adherence between the sealant and metal wire. In some embodiments, the area of the joining enhancement holes may range from about 5% to about 60% of the entire area of the metal wire.

11 Claims, 5 Drawing Sheets

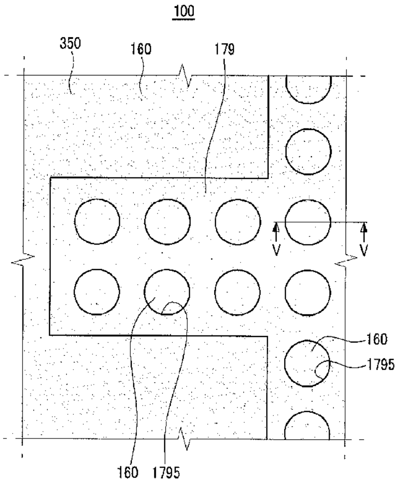

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FIG. 1

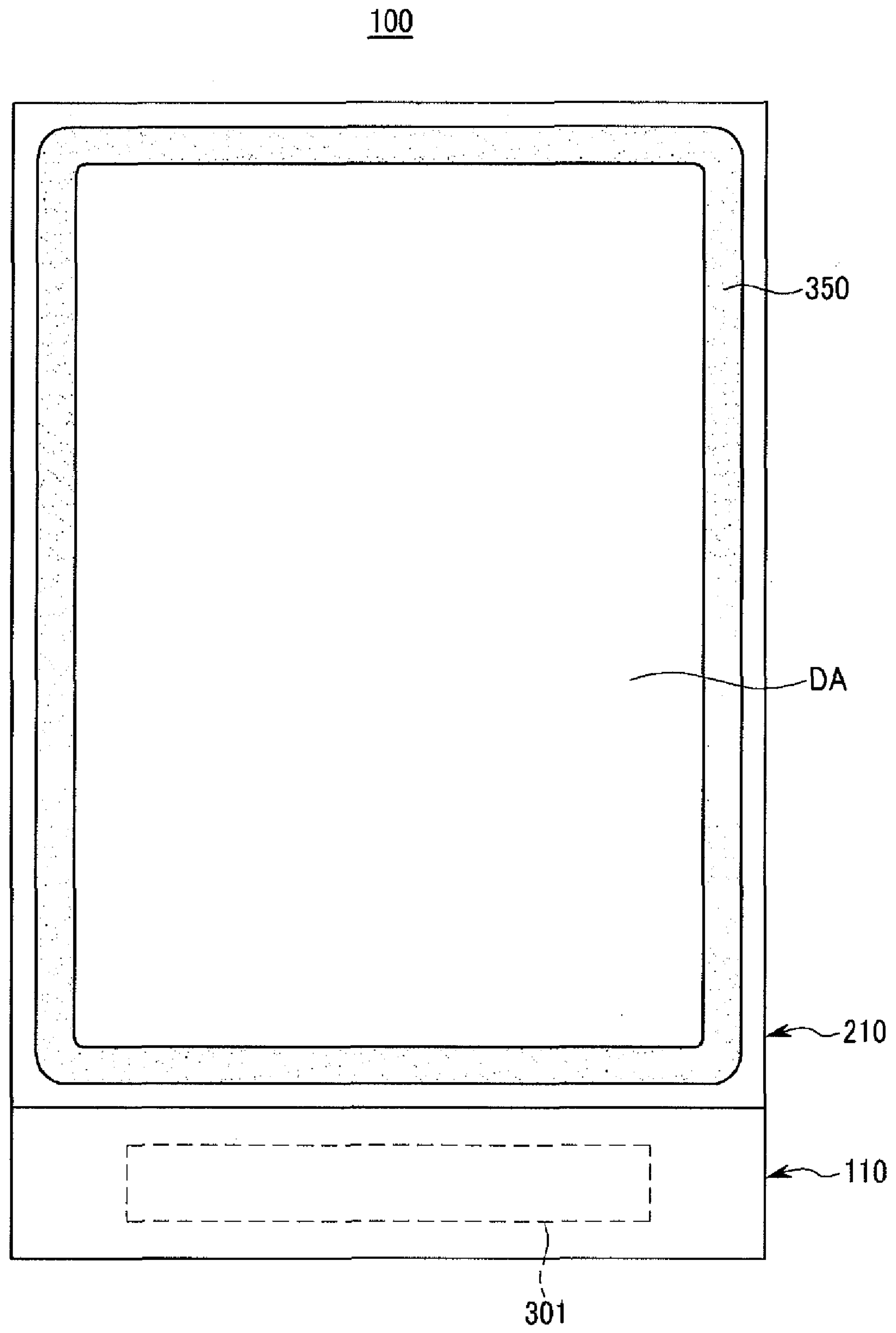


FIG. 2

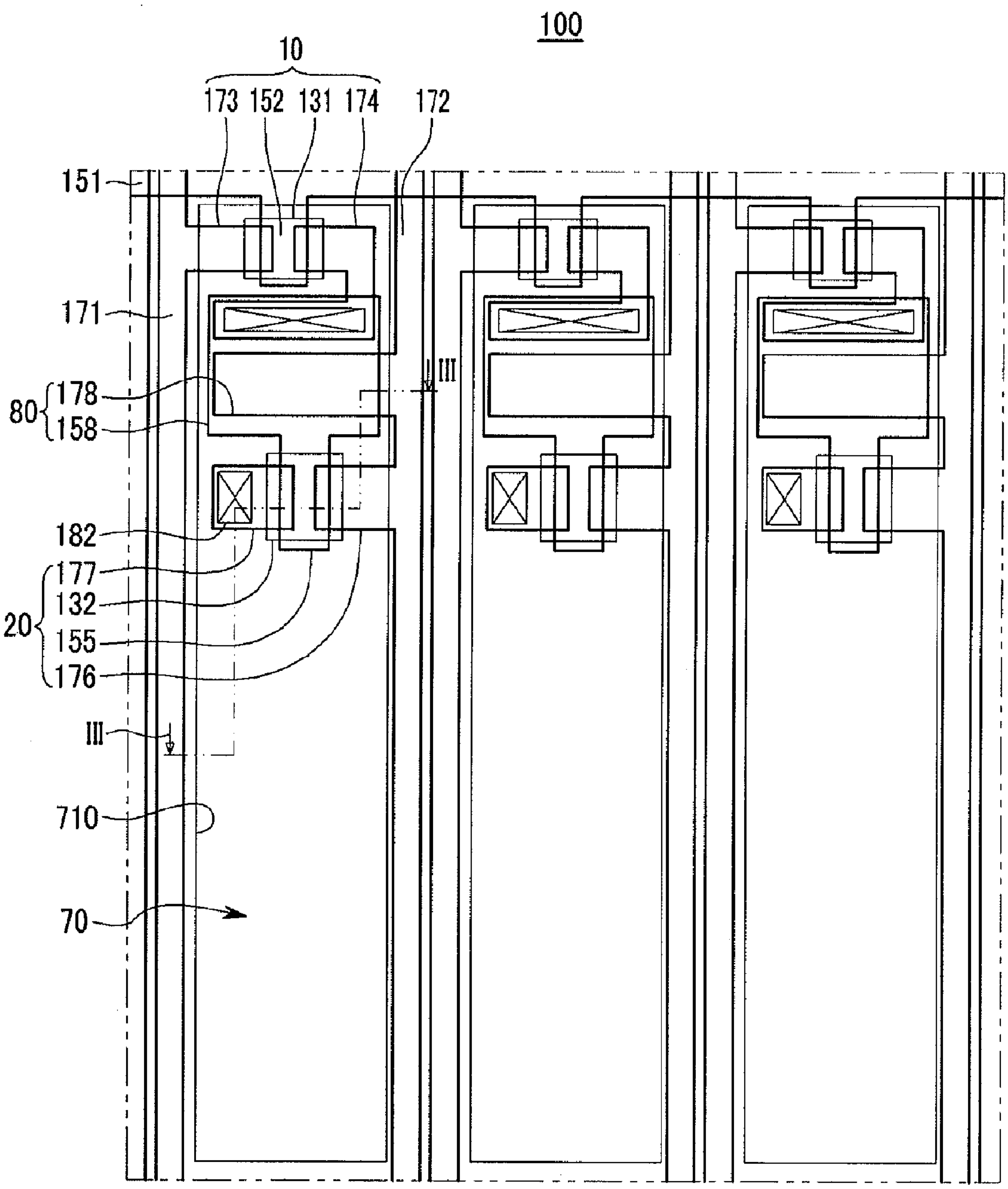

100
10
173
152
131
174
172
151
171
80
178
158
III
182
20
177
132
155
176
III
710
70

FIG. 3

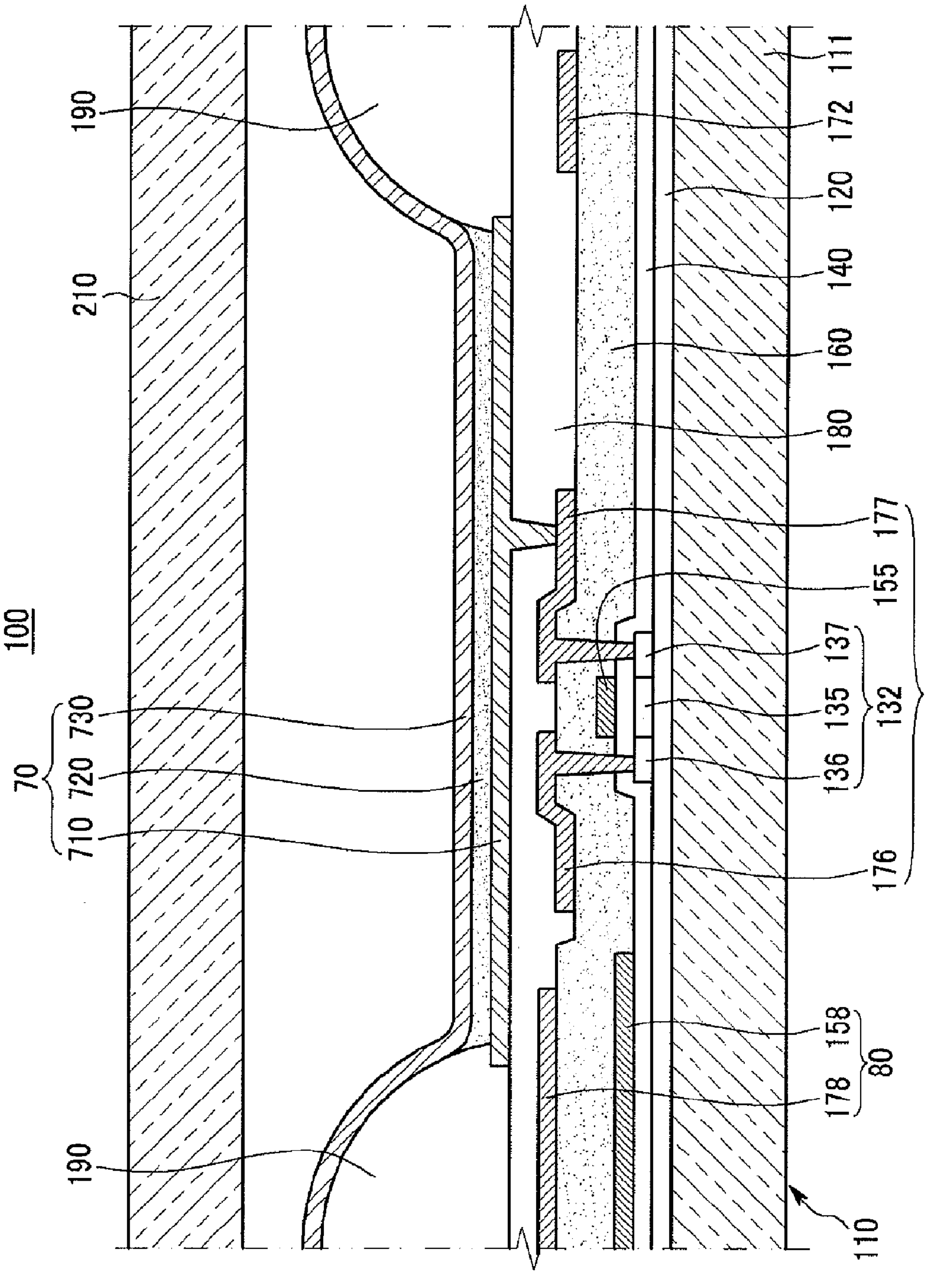

100
70
710
720
730
190
210
190
111
172
120
140
160
180
177
155
137
135
136
132
20
176
158
178
80
110

FIG. 4

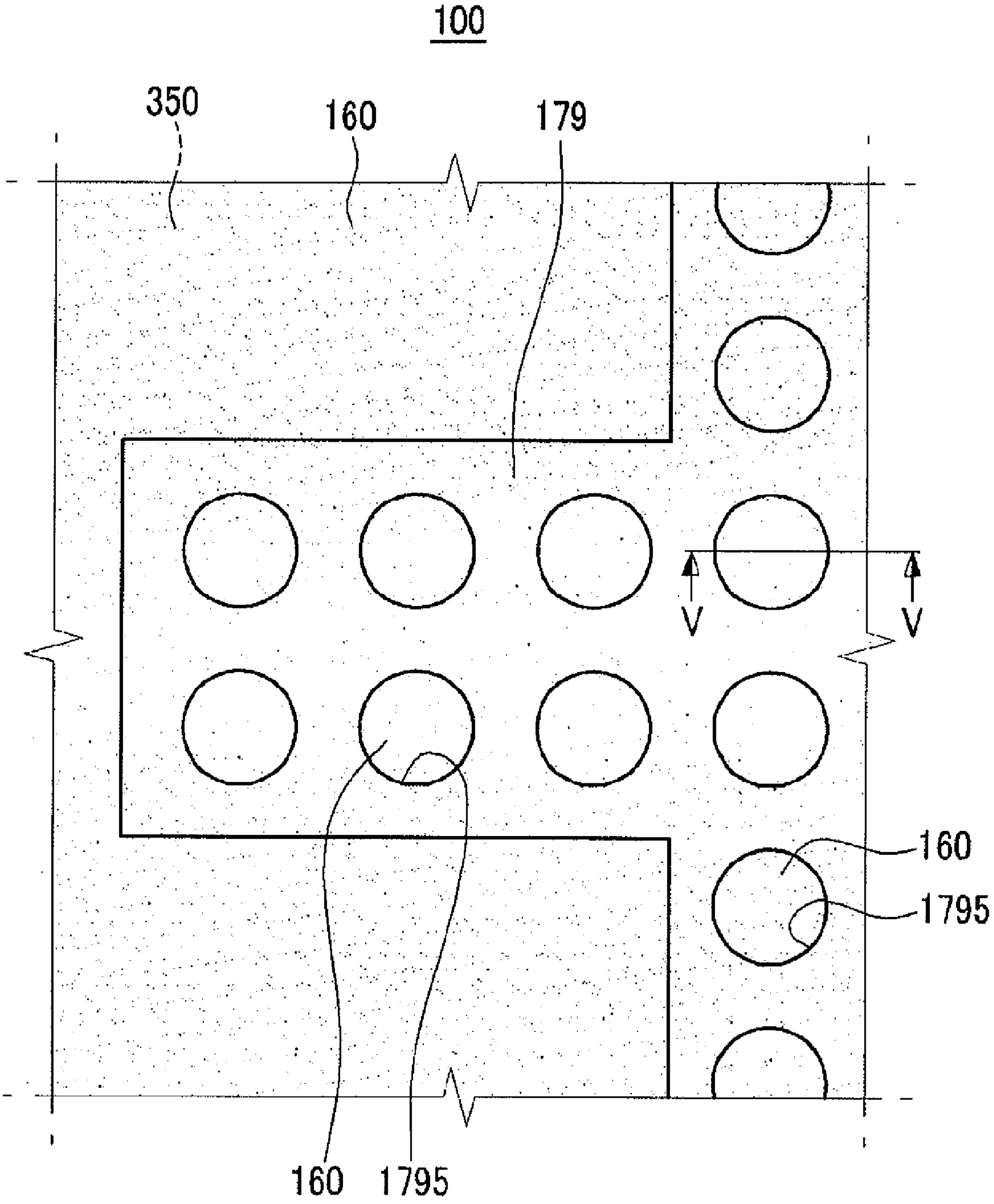
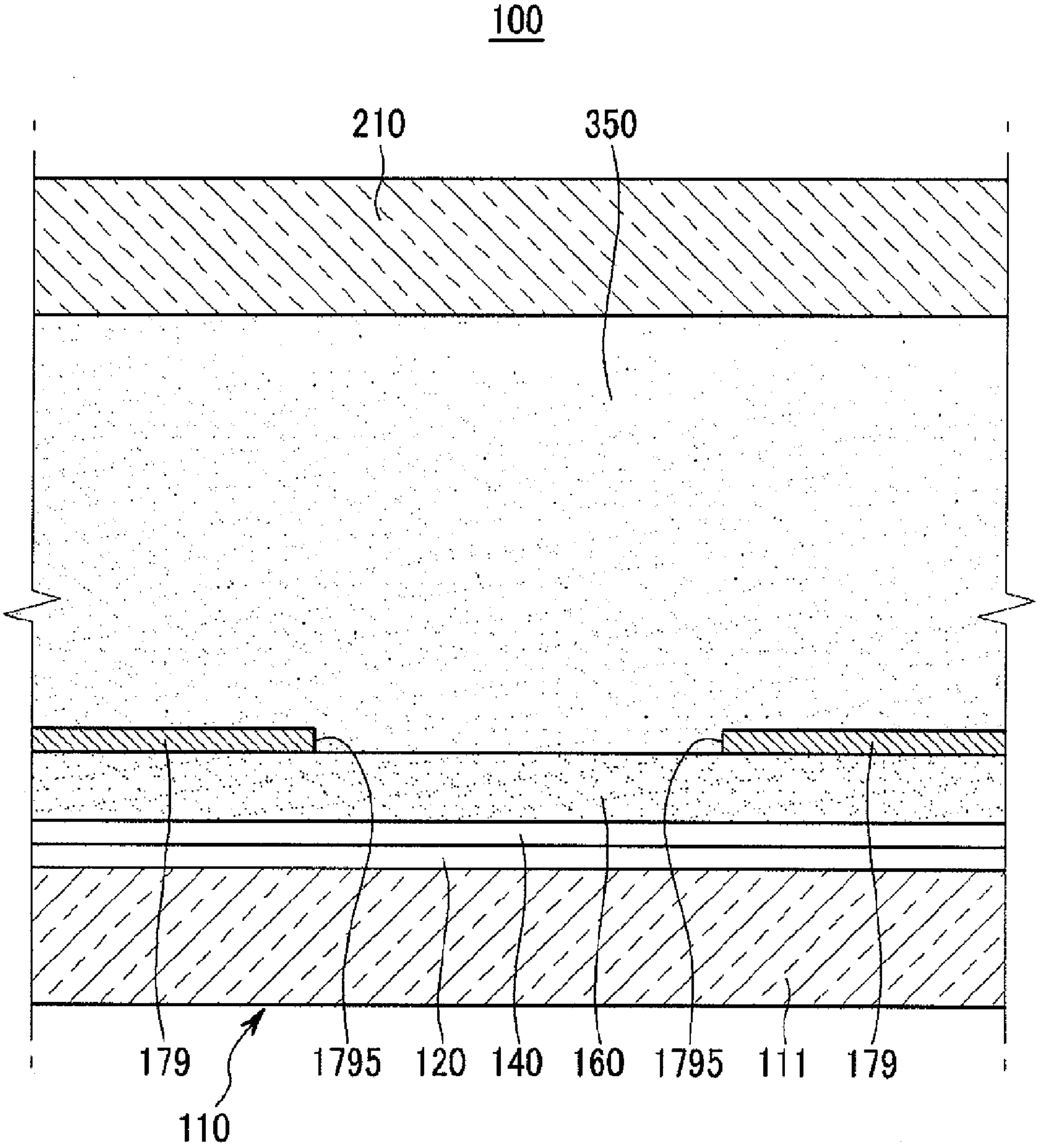


FIG. 5



ORGANIC LIGHT EMITTING DIODE DISPLAY HAVING IMPROVED MECHANICAL STRENGTH

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to and the benefit of Korean Patent Application No. 10-2008-0090342 filed in the Korean Intellectual Property Office on Sep. 12, 2008, the entire contents of which are incorporated herein by reference.

BACKGROUND

1. Field of the Invention

The present invention relates to an organic light emitting diode (OLED) display. More particularly, the present invention relates to an OLED display having improved mechanical strength.

2. Description of the Related Art

An OLED display is a self-luminance display, and thus, does not need a separate light source. This characteristic enables OLED displays to have reduced thickness and weight than other types of displays. Furthermore, OLED displays have other advantages, such as relatively low power consumption, high luminance, and high reaction speed. For these and other reasons, OLED displays are used in many applications, such as mobile electronic devices.

In general, an OLED display includes a display substrate in which a thin film transistor and organic light emitting elements are formed, a sealing member for covering the display substrate, and a sealant that bonds the display substrate and the sealing member. The sealant is coated along the edges of the substrate and forms a sealed space between the display substrate and the sealing member. The sealant, however, partially contacts any metal wire formed in the display substrate.

Unfortunately, the sealant and the metal wire are made of different materials, and thus, the adherence interface between them is usually weak. Therefore, the display substrate and the sealing member can become easily stripped or separated where the sealant and the metal wire contact each other.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the invention and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

SUMMARY

Embodiments of the present invention provide an organic light emitting diode (OLED) display having improved mechanical strength by suppressing stripping. In one embodiment, an exemplary OLED display includes a substrate member, an insulating layer formed on the substrate member, a metal wire formed on the insulating layer and having a plurality of joining enhancement holes, a sealant formed on the metal wire, and a sealing member attached on the sealant.

The insulating layer and the sealant may contact each other through joining enhancement holes of the metal wire. A ratio of an area where the joining enhancement holes are formed may range from about 5% to about 60% of the entire area of the metal wire. In various embodiments, both of the insulating layer and the sealant may be made of ceramic-based materials. The sealing member may also be made of a ceramic-based material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of an organic light emitting diode (OLED) according to an exemplary embodiment of the present invention.

FIG. **2** is an enlarged layout view of a part of a display area of FIG. **1**.

FIG. **3** is a cross-sectional view of FIG. **2**, taken along the line III-III.

FIG. **4** is an enlarged layout view of a part of an area where a sealant of FIG. **1** is formed.

FIG. **5** is a cross-sectional view of FIG. **4**, taken along the line V-V.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

The present invention will be described with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. As those skilled in the art will realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the present invention. Constituent elements having the same configuration are representatively described with reference to one or more embodiments. Other exemplary embodiments may then be described by referring to various differences between the embodiments.

The drawings and description are to be regarded as illustrative in nature and not restrictive. Like reference numerals designate like elements throughout the specification.

In the drawings, the thickness of layers, films, panels, regions, etc., are exaggerated for clarity. In addition, the size and thickness of each element in the drawing are provided for better understanding and ease of description of various embodiments and are not intended to limit the present invention. For example, it should be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, it can be directly on the other element or intervening elements may also be present. When an element is referred to as being "directly on" another element, there are no intervening elements present.

In addition, in the accompanying drawings, an organic light emitting diode (OLED) display is illustrated as an active matrix (AM)-type OLED display in a 2Tr-1Cap structure in which two thin film transistors (TFTs) and one capacitor are formed in one pixel. But, the present invention is not limited thereto and some embodiments of the OLED display can have various structures. For example, three or more TFTs and two or more capacitors can be provided in one pixel of the OLED display and separate wires can be further provided in the OLED display.

As shown in FIG. **1**, an organic light emitting diode (OLED) display **100** includes a display substrate **110**, a sealing member **210** that covers the display substrate **110**, and a sealant **350** interposed between the display substrate **110** and the sealing member **210**. The sealant **350** is disposed along an edge of the sealing member **210**, and attaches the substrate **110** and the sealing member **210** to be sealed. Hereinafter, the inside area between the display substrate **110** and the sealing member **210** surrounded by the sealant **350** will be referred to as a display area DA. A plurality of pixels may be formed in the display area DA to display an image.

The sealing member **210** is smaller than the display substrate **110**. Accordingly, some components may be external to the sealing member **210**. For example, an integrated circuit

(IC) chip **301** may be mounted on an edge of one side of the substrate **110**, and thus, is not covered by the sealing member **210**.

Referring now to FIG. **2** and FIG. **3**, an internal structure of the OLED display **100** will be described with respect to the plurality of pixels formed in the display area DA. As shown in FIG. **2**, the display substrate **110** includes a switching thin film transistor (TFT) **10**, a driving TFT **20**, an OLED **70**, and a capacitor **80** that are formed in each pixel. In addition, the display substrate **110** further includes gate lines **151** disposed along one direction, and data lines **171** and common power lines **172** that respectively cross the gate lines **151** to be insulated therefrom. In the example shown, the boundary of one pixel may be defined by the gate line **151**, the data line **171**, and the common power line **172**.

The switching TFT **10** is used as a switch for selecting a pixel to be light-emitted. The switching TFT **10** includes a switching semiconductor layer **131**, a switching gate electrode **152**, a switching source electrode **173**, and a switching drain electrode **174**, and the driving TFT **20** includes a driving semiconductor layer **132**, a driving gate electrode **155**, a driving source electrode **176**, and a driving drain electrode **177**. The switching gate electrode **152** is connected to the gate line **151**. The switching source electrode **173** is connected to the data line **171**. The switching drain electrode **174** is disposed at a distance from the switching source electrode **173** and is connected to the first capacitive plate **158**.

The driving TFT **20** applies a driving voltage to the first electrode **710** for light emission of on organic emission layer **720** of an OLED **70** in a selected pixel. The driving gate electrode **155** is connected to the first capacitive plate **158**. The driving source electrode **176** and the second capacitive plate **178** are respectively connected to the common power line **172**. The driving drain electrode **177** is connected to the first electrode **710** of the OLED **70** through a contact hole **182**. With the above-described structure, the switching TFT **10** is driven by a gate voltage applied to the gate line **151** to transmit a data voltage applied to the data line **171** to the driving TFT **20**. Although the driving film transistor **20** of FIG. **2** is a polycrystalline thin film transistor including a polysilicon layer, the switching thin film transistor **10** (not shown in FIG. **2**) may be a polycrystalline thin film transistor or an amorphous thin film transistor including an amorphous silicon layer.

The OLED **70** includes a first electrode **710**, an organic emission layer **720** (shown in FIG. **3**) formed on the first electrode **710**, and a second electrode **730** (shown in FIG. **3**) formed on the organic emission layer **720**. Here, the first electrode **710** is a positive (+) electrode which is a hole injection electrode, and the second electrode **730** is a negative (−) electrode which is an electron injection electrode. However, the present invention is not limited thereto. For example, the first electrode **710** can be the negative electrode and the second electrode **730** can be the positive electrode. Holes and electrons are respectively injected from the first electrode **710** and the second electrode **730** into the organic emission layer **720**, and form excitons. When the excitons change from an excited state to a base state, light is emitted.

The capacitor **80** stores the voltage that corresponds to a voltage difference between a common voltage transmitted from the common power line **172** to the driving thin film transistor **20** and the data voltage transmitted from the switching thin film transistor **10**. The capacitor **80** may then provide a current to the OLED **70** through the driving thin film transistor **20** so that the OLED **70** emits light. The capacitor **80** includes a first capacitive plate **158** and a second capacitive plate **178** with a gate insulating layer **140** interposed therebetween. Here, the gate insulating layer **140** becomes a dielectric material. Capacitance of the capacitor **80** is determined by charges charged in the capacitor **80** and a voltage between the first and second capacitive plates **158** and **178**.

Referring now to FIG. **3**, a structure of the OLED display **100** will now be described in further detail in a stack order. In addition, a structure of the TFT **20** will be further described.

First, the display substrate **110** will be described. A first substrate member **111** is formed as an insulation substrate that is made of glass, quartz, ceramic, plastic, etc. However, the present invention is not limited thereto. For example, the first substrate member **111** can be formed from a metal like stainless steel.

A buffer layer **120** is formed on the first substrate member **111**. The buffer layer **120** prevents impurities from permeating. The buffer layer **120** also provides a planarization surface. The buffer layer **120** may be made of various materials for performing such functions. For example, the buffer layer **120** may include one of a silicon nitride (SiNx) layer, a silicon dioxide (SiO2) layer, and a silicon oxynitride (SiOxNy) layer. However, the buffer layer **120** is not always necessary. Thus, the buffer layer **120** may be omitted according to type and process conditions of the first substrate member **111**.

The driving semiconductor layer **132** is formed on the buffer layer **120**. The driving semiconductor layer **132** is formed of a polysilicon layer. In addition, the driving semiconductor layer **132** includes a channel region **135** in which impurities are not doped. A source region **136** and a drain region **137** are doped with p+ impurities at respective sides of the channel region **135**. The doped ion material may be a P-type impurity, such as boron (B) material like B_2H_6, as the doped ion material. Different impurities may be employed in accordance with the type of thin film transistor used. In one embodiment, a PMOS-structured thin film transistor using the P-type impurity is used as the driving thin film transistor **20**. However, a NMOS-structured thin film transistor or a CMOS-structured thin film transistor can also be used as the driving thin film transistor **20**.

The gate insulation layer **140** made of silicon nitride (SiNx) or silicon dioxide (SiO2) is formed on the driving semiconductor layer **132**. A gate wire including the driving gate electrode **155** is formed on the gate insulating layer **140**. The gate wire further includes the gate line **151**, the first capacitive plate **158**, and other wires. In addition, the driving gate electrode **155** is formed to overlap at least a part of the driving semiconductor layer **132**, and particularly, is formed to overlap the channel region **135**.

An interlayer insulation layer **160** that covers the driving gate electrode **155** is formed on the gate insulating layer **140**. The gate insulating layer **140** and the interlayer insulating layer **160** share through-holes exposing the source region **136** and the drain region **137** of the driving semiconductor layer **132**. Like the gate insulating layer **140**, the interlayer insulating layer **160** is made of a ceramic-based material, such as silicon nitride (SiNx) or silicon dioxide (SiO_2).

A data wire including the driving source electrode **176** and the driving drain electrode **177** is formed on the interlayer insulating layer **160**. The data wire further includes the data line **171**, the common power line **172**, the second capacitive plate **178**, and other wires. In addition, the driving source electrode **176** and the driving drain electrode **177** are respectively connected to the source region **136** and the drain region **137** of the driving semiconductor layer **132** through the through-holes respectively formed in the interlayer insulation layer **160** and the gate insulation layer **140**.

A planarization layer **180** that covers the data wires **172**, **176**, **177**, and **178** is formed on the interlayer insulating layer

160. The planarization layer **180** removes steps and performs planarization in order to increase luminous efficiency of the OLED **70**. In addition, the planarization layer **180** has a contact hole **182** through which the drain electrode **177** is partially exposed.

The planarization layer **180** can be made of at least one of polyacrylate resin, epoxy resin, phenolic resin, polyamide resin, polyimide resin, unsaturated polyesters resin, poly phenylenether resin, polyphenylenesulfide resin, and benzocyclobutene (BCB). The first exemplary embodiment of the present invention is not limited to the above-described structure. For example, one of the planarization layer **180** and the interlayer insulating layer **160** can be omitted as desired.

The first electrode **710** of the organic light emitting element **70** is formed on the planarization layer **180**. That is, in the OLED display **100**, a plurality of pixel electrodes **710** are disposed in each of the respective pixels. In this case, the plurality of first electrodes **710** are respectively disposed at a distance from each other. The first electrode **710** ix connected to the drain electrode **177** through the contact hole **182** of the planarization layer **180**.

In addition, a pixel defining layer **190** having an opening that exposes the pixel electrodes **710** is formed on the planarization layer **180**. That is, the pixel defining layer **190** includes a plurality of openings formed in each pixel. In addition, the first electrode **710** is disposed to correspond to the opening of the pixel defining layer **190**. Thus, the first electrode **710** can be disposed under the pixel defining layer **190** to be partially overlapped by the pixel defining layer **190**. The pixel defining layer **190** can be made of an inorganic material of a resin or silica group, such as polyacrylate resin and polyimide.

As described above, the OLED **70** includes the pixel electrode **710**, the organic emission layer **720**, and the common electrode **730**. The organic emission layer **720** is formed on the first electrode **710** and the second electrode **730** is formed on the organic emission layer **720**.

The organic emission layer **720** is made of a low-molecular organic material or a high-molecular organic material. The organic emission layer **720** is formed in a multi-layer structure including at least one of a hole injection layer (HIL), a hole transport layer (HTL), an emission layer, an electron transport layer (ETL), and an electron injection layer (EIL). When the organic emission layer **720** is formed in a multilayer structure including all the layers HIL, HTL, ETL, and EIL, the HIL is formed on the pixel electrode **710**, which is a positive electrode, and the HTL, ETL, and EIL are sequentially stacked thereon.

In addition, as shown in FIG. **3**, the organic emission layer **720** is disposed only in the opening of the pixel defining layer **190**. However, the organic emission layer **720** can be formed not only on the first electrode **170** in the opening of the pixel defining layer **190**, but also between the pixel defining layer **190** and the second electrode **730**. The organic emission layer **720** can further include several layers including an emission layer, an HIL, an HTL, an ETL, and an EIL. In this case, like the second electrode **730**, excluding the emission layer, the HIL, HTL, ETL, and EIL can be formed not only on the first electrode **710**, but also on the pixel defining layer **190** by using an open mask in a manufacturing process. That is, at least one of the layers included in the organic emission layer **720** can be interposed between the pixel defining layer **190** and the second electrode **730**.

Each of the first electrode **710** and the second electrode **730** can be made of a transparent conductive material or a reflective or reflective conductive material. According to materials that form the first electrode **710** and the second electrode **730**, the OLED display **100** can be classified as a top light emitting type, a bottom light emitting type, and a dual-side light emitting type.

In one embodiment, the OLED display **100** is a top light emitting type of OLED display. Thus, the OLED emits light toward an encapsulation substrate **210** to display an image. In addition, the first electrode **710** is made of a reflective conductive material.

For the transparent conductive material, indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), or indium oxide (In2O3) can be used. For the reflective or transflective material, lithium (Li), calcium (Ca), fluorinated lithium/calcium (LiF/Ca), fluorinated lithium/aluminum (LiF/Al), aluminum (Al), silver (Ag), magnesium (Mg), or gold (Au) can be used.

The sealing member **210** is formed on the second electrode **730** and they face each other. The sealing member **210** can be made of a transparent material, such as glass and plastic. The sealing member **210** is bonded to the display substrate **110** through a sealant **350** (shown in FIG. **1**) formed along the edges thereof.

Referring now to FIG. **4** and FIG. **5**, an internal structure of the OLED display **100** will be described with respect to an area where the sealant **350** is formed. As shown in FIG. **4** and FIG. **5**, the buffer layer **120**, the gate insulating layer **140**, and the interlayer insulating layer **160** are sequentially formed on the substrate member **111**. The buffer layer **120**, the gate insulating layer **140**, and the interlayer insulating layer **160** have been previously described in detail. In addition, a metal wire **179** is formed on the interlayer insulating layer **160**.

The metal wire **179** may be one or more of the source electrode **176**, the drain electrode **177** of the TFT **20** formed in the area where the sealant **350** is disposed, the second capacitive plate **178** of the capacitor **80**, the data line **171**, the common power line **172**, and other connection lines. Herein, the connection line may refer to a wire that connects components respectively formed in the display area DA surrounded by the sealant **350** and an external peripheral area of the sealant **350**. The metal wire **179** can be made of the same material as at least one of the source electrode **176**, the drain electrode **177** of the TFT **20** formed in the display area DA, the second capacitive plate **178** of the capacitor **80**, the data line **171**, and the common power line **172**. In addition, the metal wire **179** may include a plurality of joining enhancement holes **1795**. The joint or joining enhancement holes **1795** expose the interlayer insulating layer **160** under the metal wire **179**. One skilled in the art will recognize that the term "holes" should be interpreted broadly. For example, any opening or shape may serve as the joining enhancement holes **1795**. In addition, the joining enhancement holes **1795** may be uniform or varied depending on their location on the metal wire **179** and the desired bonding strength. As shown in FIG. **4**, the joint enhancement holes **1795** may be circular in shape, uniform in size, and uniform in distribution, which are exemplary in nature. One skilled in the art will recognize that the openings which serve as the joint enhancement holes **1795** may also be formed in other shapes, such as elliptical, square, rectangular, hexagon, etc. In addition, the size and distribution of the joining enhancement holes **1795** may vary.

The sealant **350** is formed on the metal wire **179** and the sealing member **210** is attached on the sealant **350**. In addition, the sealant **350** has integrated contact with the interlayer insulating layer **160** through the joint enhancement holes **1795** of the metal wire **179**. One side of the sealant **350** contacts the sealing member **210** and the other side connects the metal wire **179**, the interlayer insulating layer **160** exposed through the joint enhancement holes **1795** of the metal wire **179**, and an interlayer insulating layer **160** formed in an area where the metal wire **179** is not formed. Accordingly, the sealant **350** bonds the sealing member **210** and the display substrate **110** to be sealed. In addition, the sealant **350** may be made of a ceramic-based material, for example, a frit.

When the sealant **350** is made of a ceramic-based material, it may have a relatively weak interface adherence with the metal wire **179**. However, the sealant **350** has a relatively stronger interface adherence compared to the interlayer insulating layer **160**, which is made of the same ceramic-based material.

The plurality of joining enhancement holes **1795** may be formed on the metal wire **179** to efficiently suppress stripping of the sealant **350** and the metal wire **179** that are bonded to each other. That is, since the sealant **350** is integrally bonded with the interlayer insulating layer **160** through the joint enhancement holes **1795** of the metal wire **179**. Accordingly, this feature may compensate for the relatively weak bonding adherence between the sealant **350** and metal wire **1795**.

In addition, a ratio of an area where the joint enhancement holes **1795** are formed may range from about 5% to about 60% of the entire area of the metal wire **179**. When the ratio of the area where the joint enhancement holes **1795** are formed is less than about 5%, the weak bonding state between the sealant **350** and the metal wire **179** often cannot be compensated. However, when the ratio of the area where the joint enhancement holes **1795** are formed is greater than about 60%, the bonding force can be improved and the resistance of the metal wire **179** is increased.

Like the sealant **350**, the sealing member **210** can be made of a ceramic-based material. Therefore, the sealing member **210** and the sealant **350** may have relatively high interface adherence.

With the above-described configuration, the OLED display **100** can improve mechanical strength by suppressing stripping. Hereinafter, an experimental example and a comparative example will be described with reference to the following table.

In an experiment, a plurality of OLED displays according to the experimental example and a plurality of OLED displays according to a comparative example are subjected to forces that cause stripping. In this experiment, the OLED display (i.e., the "Experimental Example") employed a joining enhancement hole in a metal wire according to an exemplary embodiment of the present invention. In addition, a ratio of an area where the joining enhancement hole is formed was about 10% of the entire area of the metal wire. As a comparison, an OLED display (i.e., the "Comparative Example") did not employ a joining enhancement hole in its metal wire. Results of the experiment are shown in Table 1 below.

TABLE 1

	Test	Stripping	Stripping ratio (%)	Average stripping pressure (Mpa)
Experimental Example	620	3	0.5	162
Comparative Example	694	14	2	129

As shown in Table 1, the number of stripping occurrences of the experimental example was relatively small compared to the comparative example. In addition, the stripping pressure needed to create a stripping failure was higher in the experimental example, i.e., 162 Mpa versus 129 Mpa. Thus, the experimental example was able to endure higher pressure forces compared to the comparative example. Accordingly, based at least on this experimental data, it is believed the OLED display **100** possesses improved mechanical strength and resistance or suppression of stripping.

While this invention has been described in connection with what is presently considered to be practical exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. An organic light emitting diode (OLED) display comprising:

a substrate member;

an insulating layer formed on the substrate member;

a metal wire formed on the insulating layer and having a plurality of joining enhancement holes;

a sealant formed on and directly contacting the metal wire; and

a sealing member attached on the sealant.

2. The OLED display of claim **1**, wherein the insulating layer and the sealant contact each other through the joining enhancement holes of the metal wire.

3. The OLED display of claim **2**, wherein a ratio of an area where the joining enhancement holes are formed is greater than about 5% of an area of the metal wire.

4. The OLED display of claim **3**, wherein a ratio of an area where the joining enhancement holes are formed ranges from about 5% to about 60% of an area of the metal wire.

5. The OLED display of claim **1**, wherein the insulating layer and the sealant are respectively made of ceramic-based materials.

6. The OLED display of claim **4**, wherein the sealing member is made of a ceramic-based material.

7. The OLED display of claim **1**, wherein the joining enhancement holes are circular in shape.

8. The OLED display of claim **1**, wherein the joining enhancement holes are uniform in size.

9. The OLED display of claim **1**, wherein the joining enhancement holes are evenly distributed across the metal wire.

10. The OLED display of claim **1**, wherein an area of the joining enhancement holes ranges from about 5% to about 60% of an area of the metal wire.

11. The OLED display of claim **9**, wherein the area of the joining enhancement holes is about 10% of the area of the metal wire.

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专利名称(译)	有机发光二极管显示器具有改善的机械强度		
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摘要(译)

OLED显示器技术领域本发明涉及一种OLED显示器，该OLED显示器的一个方面包括基板构件，形成在基板构件上的绝缘层，形成在绝缘层上并具有多个连接增强孔的金属线，密封剂形成在金属线上的密封构件和附着在密封剂上的密封构件。在一些实施例中，由于密封剂可以通过接合增强孔与层间绝缘层整体结合，因此接合增强孔有效地抑制了密封剂从金属线的剥离。该特征可以补偿密封剂和金属线之间的任何弱粘合粘附。在一些实施例中，接合增强孔的面积可以在金属线的整个面积的约5%至约60%的范围内。