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(54) METHOD OF MANUFACTURING FLEXIBLE OLED DISPLAY PANEL

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G06F 3/041	(2006.01)
H01L 27/32	(2006.01)

(52) **U.S. Cl.**

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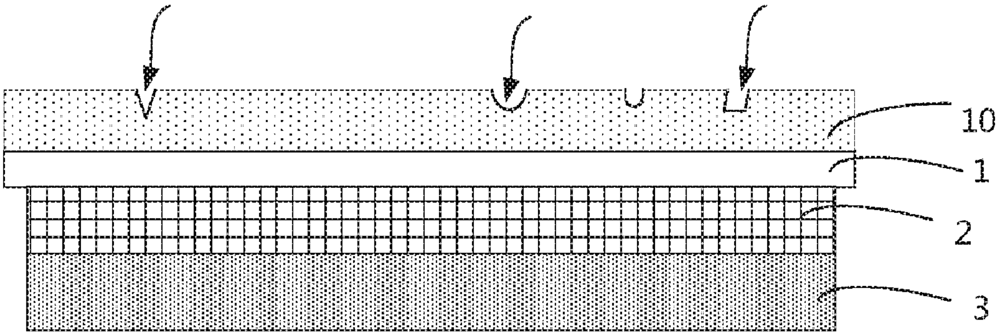
(57) ABSTRACT

A method of manufacturing flexible OLED display panel is provided. The method comprises following steps. Providing a glass carrier, sequentially forming a flexible substrate, a low temperature poly-Si layer and OLED element layer on a surface of the glass carrier; forming a planar layer on a surface of the glass carrier which is backward to the flexible substrate and obtaining a planning OLED display panel; removing the glass carrier by laser lift-off the planning OLED display panel and obtaining the flexible OLED display panel. The method could better improve the problem of laser is unevenly distributing in the flexible substrate during the laser lift-off process causes lower peeling successful rate.



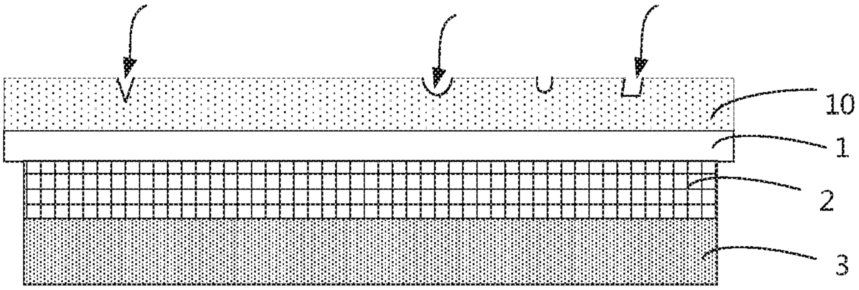


FIG. 1

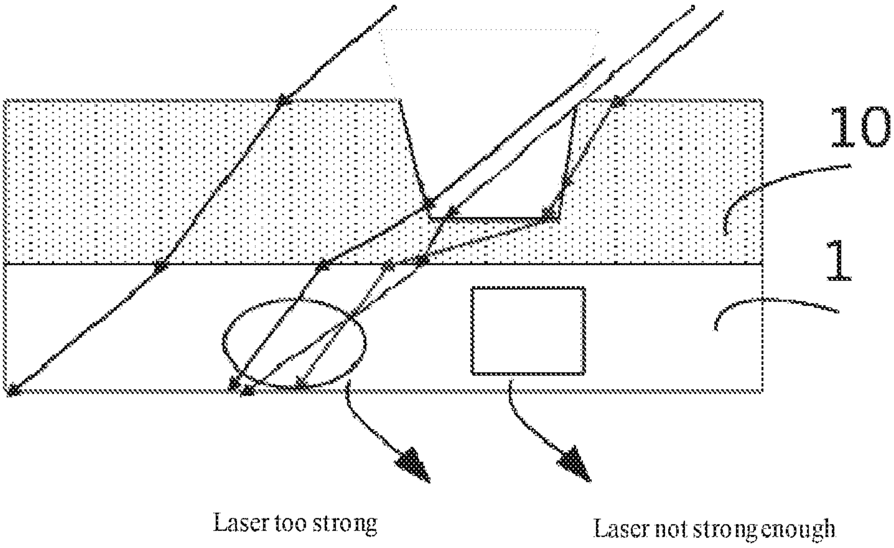
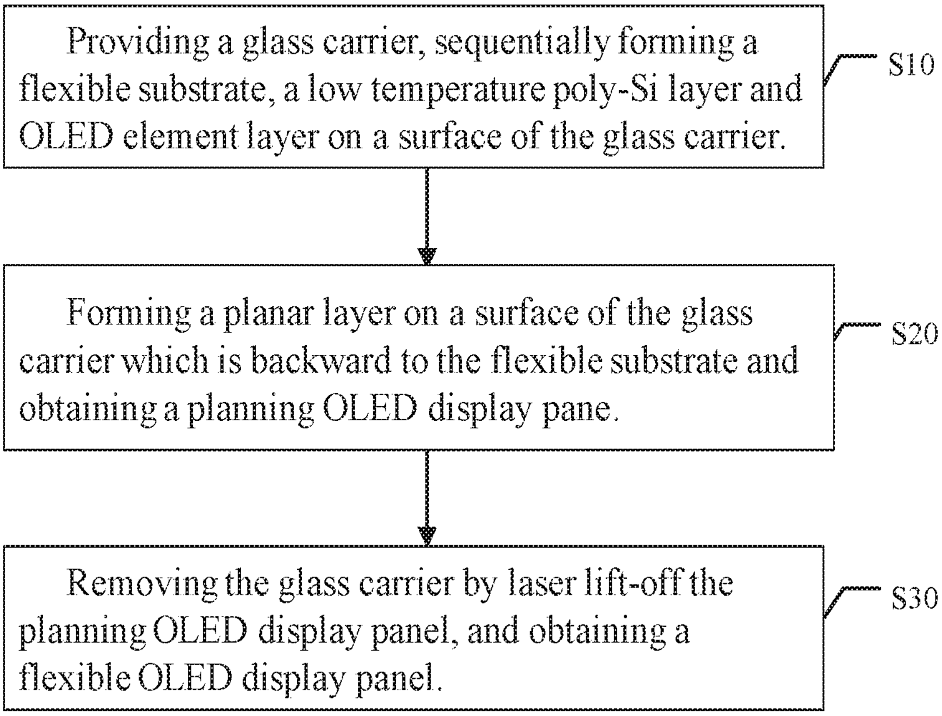


FIG. 2



S10: Providing a glass carrier, sequentially forming a flexible substrate, a low temperature poly-Si layer and OLED element layer on a surface of the glass carrier.

S20: Forming a planar layer on a surface of the glass carrier which is backward to the flexible substrate and obtaining a planning OLED display pane.

S30: Removing the glass carrier by laser lift-off the planning OLED display panel, and obtaining a flexible OLED display panel.

FIG. 3

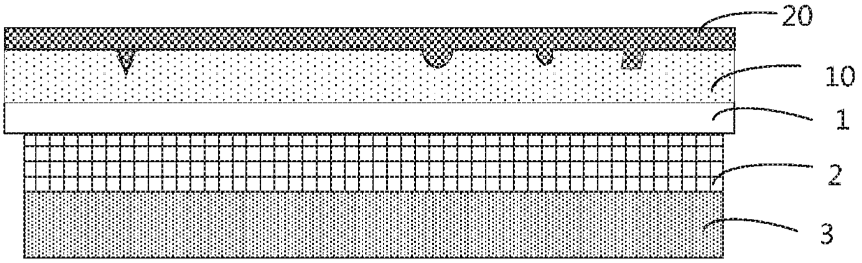


FIG. 4

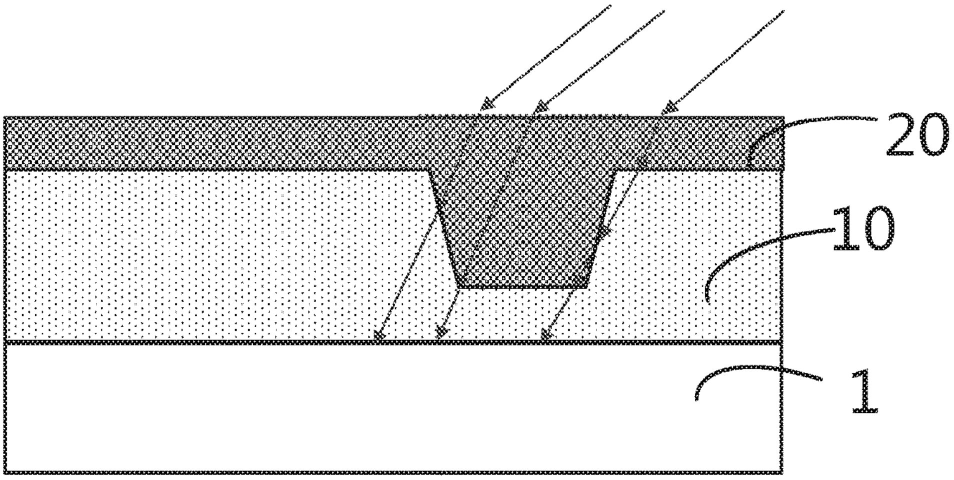


FIG. 5

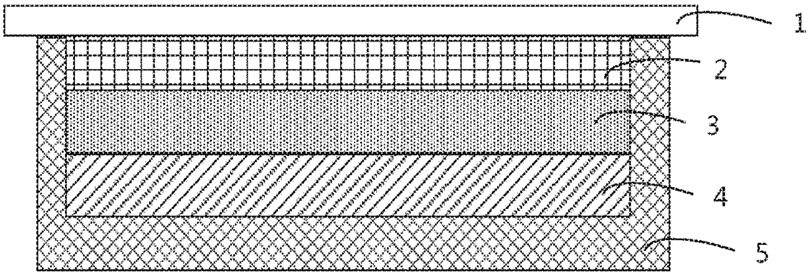


FIG. 6

METHOD OF MANUFACTURING FLEXIBLE OLED DISPLAY PANEL

RELATED APPLICATIONS

[0001] This application is a continuation application of PCT Patent Application No. PCT/CN2018/071589, filed Jan. 5, 2018, which claims the priority benefit of Chinese Patent Application No. 201711269186.0, filed Dec. 5, 2017, which is herein incorporated by reference in its entirety.

FIELD OF THE DISCLOSURE

[0002] The disclosure relates to an OLED display technical field, and more particularly to a method of manufacturing flexible OLED display panel.

BACKGROUND

[0003] The OLED (Organic Light-Emitting Diodes) is a self-luminous element. It has number of advantageous such as light, low consumption, fast response, high luminescence efficiency and could achieve flexible display, such that became widely using display element for recent years. Wherein, the flexible OLED display panel became the mainstream product of currently display field.

[0004] While manufacturing the method of flexible OLED display panel, the laser lift-off (LLO) process is very important, this process is for separating the carrier and the flexile substrate of the panel which has carrier, and then achieve to transfer the panel from rigid to flexible. Wherein, the panel has carrier generally comprises glass carrier and flexile substrate (preparing the touch circuit) on the glass carrier, a low temperature poly-Si, OLED element layer (please refer to FIG. **1**.). The principle of LLO process is that using the laser passing through the glass carrier and modify the flexible substrate (ex: PI) and separate to the glass. But the mechanism damage (such as pits or cracks) on the glass carrier will affect the evenly distributing of laser in the PI, and cause failure separate the PI and carrier, cause damage of OLED element, decreases yield. Please refer to FIG. **2**, on the region has more laser distribution, many ashes produced of PI by laser burning, it may damage the circuit and TFT of the PI substrate; on the region has less laser distribution, PI can't absorb enough laser energy, it is not easy separate to glass, so that PI will pull the wire and TFT while separating process.

[0005] Hence, it is necessary to improve method manufacturing the flexible OLED display panel.

SUMMARY

[0006] A technical problem to be solved by the disclosure is to provide a method of manufacturing flexible OLED display panel. It could solve the problem of unevenly distribution laser on flexible substrate during LLO process caused by pits on surface of glass carrier, and enhances successful rate of LLO process.

[0007] Furthermore, the disclosure further provides a display device including a method of manufacturing flexible OLED display panel.

[0008] An objective of the disclosure is achieved by following embodiments. In particular, a method of manufacturing flexible OLED display panel comprising following steps.

[0009] providing a glass carrier, sequentially forming a flexible substrate, a low temperature poly-Si layer and OLED element layer on a surface of the glass carrier **10**;

[0010] forming a planar layer on a surface of the glass carrier which is backward to the flexible substrate and obtaining a planning OLED display panel;

[0011] removing the glass carrier by laser lift-off the planning OLED display panel, and obtaining a flexible OLED display panel.

[0012] In an embodiment, the planar layer has laser transmittance ≥90% in 300-400 nm wavelength range.

[0013] In an embodiment, roughness of the planar layer is $Ra \leq 0.4$ μm.

[0014] In an embodiment, thickness of the planar layer is 50-120 μm.

[0015] In an embodiment, thickness of the glass carrier is 400-500 μm.

[0016] In an embodiment, the planar layer and the glass carrier which are stacking positioned have laser transmittance ≥40% in 300-400 nm wavelength range.

[0017] In an embodiment, composite material of the planar layer comprises at least one of organic material or inorganic material, the organic material comprises at least one of epoxy, acrylic resin and silicone; the inorganic material comprises at least one of silicon dioxide, magnesium fluoride, calcium fluoride and barium fluoride.

[0018] In an embodiment, the step of forming the planar layer which is that mixing the composite material of the planar layer and solvent to obtain a sizing mixture; coating the sizing mixture on the surface of the glass carrier which is backward to the flexible substrate; and curing to from the planar layer.

[0019] In an embodiment, during the laser lift-off, the laser wavelength is 300-400 nm; the laser energy is 290-350 mJ.

[0020] In an embodiment, sequentially forming a packaging protecting layer, a flexible rear cover on the OLED element layer.

[0021] The method of manufacturing flexible OLED display panel of this disclosure. Before laser lift-off processing the OLED display panel which has glass carrier, forming the planar layer on surface of the glass carrier which is backward to the flexible substrate, so that flatting the surface of the glass carrier which is backward to the flexible substrate. While the laser lift-off, laser could uniform hitting on the flexible substrate, it is easy to achieve separating the glass carrier and the flexible substrate and won't damage the touch circuit, TFT on the flexible substrate. The method of manufacturing flexible OLED display panel of this disclosure could better improve the problem of the laser uneven distributing in the flexile substrate because of the surface of glass carrier is damaged by the mechanical during the present LLO process, and enhances successful rate of LLO process, enhances yield product of flexible OLED display panel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Accompanying drawings are for providing further understanding of embodiments of the disclosure. The drawings form a part of the disclosure and are for illustrating the principle of the embodiments of the disclosure along with the literal description. Apparently, the drawings in the description below are merely some embodiments of the disclosure, a person skilled in the art can obtain other drawings according to these drawings without creative efforts. In the figures:

[0023] FIG. **1** is a structural schematic view of an OLED display panel before LLO in prior art;

[0024] FIG. **2** is a light path of laser in the panel during LLO process in prior art;

[0025] FIG. **3** is a flow chart diagram of a method of manufacturing flexible OLED display panel according to an embodiment of the disclosure;

[0026] FIG. **4** is a structural schematic view of an OLED display panel after forming the planar layer according to an embodiment of the disclosure;

[0027] FIG. **5** is a schematic view of transmitting path of UV laser in the planar layer, the glass substrate and the flexible substrate according to an embodiment of the disclosure; and

[0028] FIG. **6** is a structural schematic view of the flexible OLED display panel after LLO process according to an embodiment of the disclosure.

[0029] Label of the figures, **10** is glass carrier, **20** is planar layer, **1** is flexible substrate, **2** is low temperature ply-Si, **3** is OLED element.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0030] The specific structural and functional details disclosed herein are only representative and are intended for describing exemplary embodiments of the disclosure. However, the disclosure can be embodied in many forms of substitution, and should not be interpreted as merely limited to the embodiments described herein.

[0031] The disclosure will be further described in detail with reference to accompanying drawings and preferred embodiments as follows.

[0032] Please refer to FIG. **3**, a method of manufacturing OLED display panel comprises following steps.

[0033] S**10**, providing a glass carrier **10**, sequentially forming a flexible substrate **1**, a low temperature poly-Si layer **2** and an OLED element layer **3** on a surface of the glass carrier **10**, and obtaining the OLED display panel has the glass carrier shows as FIG. **1**;

[0034] S**20**, forming a planar layer **20** on a surface of the glass carrier **10** which is backward to the flexible substrate **1** and obtaining a planning OLED display panel;

[0035] S**30**, removing the glass carrier by laser lift-off the planning OLED display panel, and obtaining the flexible OLED display panel.

[0036] In the step S**10**, the surface of the glass carrier **10** which is backward to the flexible substrate **1** has mechanical damage (such as pits, scratches shown as arrow in FIG. **1**). These mechanical damage usually formed by at least one of structures of thimbles, roller and brush or the objects thereon such that causes pits, scratches, while forming the flexible substrate **1**, the low temperature poly-Si layer **2** and the OLED element layer **3** on the glass carrier **10**, and using the glass carrier **10** to be support and contacting with those objects.

[0037] In addition, structure of the OLED display panel has glass carrier is not limited in FIG. **1**. It will be described as following steps S**300**.

[0038] In the step S**20**, purpose of preparing planar layer **20** is for filling mechanical damage (such as pits, scratches) on the glass carrier **10**, and then the surface of the glass carrier **10** which is backward to the flexible substrate is planarization. Therefore, it is easy to uniform distributing laser on the flexible substrate while laser lift-off process.

[0039] Wherein, the planar layer **20** has laser transmittance ≥90% in 300-400 nm wavelength range. Preferably, the laser transmittance is ≥95%. The transmittance of the planar layer **20** is dose to the transmittance of the glass carrier **10** such that will not affect the original transmittance of the glass carrier while extra positions a planar layer **20**.

[0040] Selectively, the material of the planar layer has laser absorption rate ≤6% in 300-400 nm wavelength range. Therefore, it will not cause significant attenuation of laser energy of laser lift-off.

[0041] Wherein, the roughness of the planar layer is Ra≤0.4 μm (profile arithmetic average deviation). Wherein, the thickness of the planar layer is 50-120 μm. The thickness of here is indicates the thickness of the planar layer **20** of the glass carrier **10** without pits. The thickness of the planar layer **20** cannot too thick to prevent effect laser passing to nearby the flexible substrate **1**.

[0042] Selectively, the thickness of the glass carrier **10** is 400-500 μm. The thickness of here is indicates the thickness of the glass carrier **10** without pits.

[0043] Selectively, the planar layer **20** and the glass carrier **10** which are stacking positioned, and has laser transmittance ≥40% in 300-400 nm wavelength range.

[0044] The composite material of the planar layer **20** comprises at least one of organic material or inorganic material. Specifically, the inorganic material for example silicon dioxide (SiO_2), magnesium fluoride (MgF_2), calcium fluoride (CaF_2) and barium fluoride (BaF_2) and so on.

[0045] The organic material for example acrylic resin (ex, polymethyl methacrylate (PMMA)), epoxy and organic silicone and so on. For example, the planar layer is an organic silicone is copolymerization by polydimethylsiloxane (PDMS), acrylate and silane coupling agent (ex, Vinyl-Methoxysiloxane). The planar layer also could be organic silicone formed by bisphenol A epoxy acrylate resin, KH-57 silane coupling agent (γ-methacryloxy propyl trimethoxyl silane) and dibenzoyl peroxide (BPO) initiator crosslinking and solidation.

[0046] Selectively, the organic material better not contains aromatic ring, hydroxyl group, amino group, halogen, sulfur group. Therefore, it could avoid these structures have high absorption of UV light and lower transmittance. It could adjust the molecular chain, group of the organic material to change optical property such that let the material has high transmittance and low absorption close to the glass.

[0047] Preferably, the material of the planar layer **20** is SiO_2.

[0048] The planar layer **20** is achieves by coating method, chemical vapor deposition. It could choose by the material, prefer to prepare by the coating method such that could better to fill mechanical damage (such as pits, scratches) on the glass carrier **10**

[0049] Specifically, the step of forming the planar layer **20** which is mixing the composite material of the planar layer **20** and solvent to obtain a sizing mixture; coating the sizing mixture on the surface of the glass carrier **10** which is backward to the flexible substrate; and curing to from the planar layer **20**.

[0050] Wherein, the solvent is selective from one or more normal chemical solvent such as water, ethanol, isopropyl, propanol, butanone and benzene, but here is not limited thereto. The specifically selective way of solvent is according to the dissolvability of composite material of planar layer **20**. For example, while choose the SiO_2 or MgF_2 to be material of planar layer **20**, it could be using the water to be solvent and forming the sizing mixture; while using the PMMA to be the material of the planar layer **20**, it could be using volatile solvent such of propanol, chloroform, dichloromethane and forming the sizing mixture.

[0051] After treating the step S**20**, the obtaining OLED display panel structure which already planarization shown as FIG. **4**. Comparing with the FIG. **1** and the FIG. **4**, after coating and forming the planar layer **20** on the surface of the glass carrier **10** which is backward to the flexible substrate **1**, the mechanical damage on the backside of the glass carrier **10** such as pits, scratches will disappear by filling the material of planar layer, and the surface of the planer layer **20** which is backward to the glass carrier **10** is more flat and lower roughness.

[0052] The planning OLED display panel, a planar layer **20** which has flat surface is covering on the backside of the glass carrier **10**, so that while laser lift-off, the laser could uniform hit on the flexible substrate (please refer to FIG. **5**). It is easy to achieve separate the carrier and flexible substrate, and won't be damage the circuit, TFT array on the flexible substrate.

[0053] Selectively, during the laser lift-off, the laser wavelength is 300-400 nm; the laser energy is 290-350 mJ. In the present technology, generally using the laser energy is 260-290 mJ to the OLED display panel which is not planation.

[0054] Selectively, in the step S**30**, after removing the glass carrier, further comprising a module preparing process, for example examination, reparation, washing, IC bounding.

[0055] In sum, the method of manufacturing flexible OLED display panel of this disclosure. Before laser lift-off the OLED display panel which has glass carrier, forming the planar layer **20** on surface of the glass carrier **10** which is backward to the flexible substrate **1**, so that flatting the surface of the glass carrier **10** which is backward to the flexible substrate **1**. While the laser lift-off, laser could uniform hitting on the flexible substrate **1**, it is easy to achieve separating the glass carrier **10** and the flexible substrate **1** and won't damage the touch circuit on the flexible substrate **1**. The method of manufacturing flexible OLED display panel of this disclosure could better improve the problem of the laser unevenly distributing in the flexile substrate because of the surface of glass carrier is damaged by the mechanical during the present LLO process, and enhances successful LLO process, enhances yield product of flexible OLED display panel.

[0056] After laser lift-off, the flexible OLED display panel be obtained is a regulator structure of the present technology, it could not be limited by flexible substrate **1**, low temperature poly-Si **2**, OLED element **3** shown as FIG. **6**.

[0057] Wherein, directly preparing touch wire, touch sensing element on the flexible substrate; or preparing a first blocking layer on the flexible substrate, and then preparing touch wire.

[0058] The low temperature poly-Si **2** is formed by laser crystallization to amorphous silicon, and achieve to artificial control supper horizontal growth. It also called Low Temperature Poly Silicon thin film transistor (LPST-TFT) layer, thin film transistor array (TFT array) layer. The forming polycrystalline contains less crystal boundary such that balances performance of the TFT element.

[0059] Selectively, a second blocking layer is positioned between the touch wire and the low temperature poly-Si **2**. The first blocking layer and the second blocking layer are providing the function of block water, ensure flat function.

[0060] The manufacturing method of OLED element **3** could refer to the present technologies, for example evaporation. The OLED element **3** cloud include an anode, an organic emitting layer, a cathode; the OLED element **3** also could sequentially stacking position anode, hole transparent layer, organic emitting layer, electrode transparent layer, cathode; the OLED element **3** further could sequentially stacking position anode, hole injecting layer, hole transparent layer, organic emitting layer, electrode transparent layer, electrode injecting layer, cathode and so on, but it is not limited thereto.

[0061] Wherein, sequentially forming a packaging protecting layer **4**, a flexible rear cover **5** on the OLED element layer **3**, the flexible substrate **1** and the flexible rear cover **5** are forming an enclosed space for accommodating the OLED element layer **3** and the packaging protecting layer **4**.

[0062] Further, the packaging protecting layer **4** is encapsulating the OLED element layer **3** and the low temperature poly-Si layer **2** on the flexible substrate **1**.

[0063] Further, the packaging protecting layer **4** is formed by organic film and inorganic film are alternatively positioned, the organic film and the inorganic film both have certain water blocking ability. The flexible rear cover **5** could make by polyethylene terephthalate (PET) material and so on.

[0064] The foregoing contents are detailed description of the disclosure in conjunction with specific preferred embodiments and concrete embodiments of the disclosure are not limited to these descriptions. For the person skilled in the art of the disclosure, without departing from the concept of the disclosure, simple deductions or substitutions can be made and should be included in the protection scope of the application.

What is claimed is:

1. A method of manufacturing flexible OLED display panel, comprising

providing a glass carrier, sequentially forming a flexible substrate, a low temperature poly-Si layer and OLED element layer on a surface of the glass carrier,

forming a planar layer on a surface of the glass carrier which is backward to the flexible substrate and obtaining a planning OLED display panel;

removing the glass carrier by laser lift-off the planning OLED display panel, and obtaining a flexible OLED display panel.

2. The method of manufacturing flexible OLED display panel according to claim **1**, wherein the planar layer has laser transmittance ≥90% in 300-400 nm wavelength range.

3. The method of manufacturing flexible OLED display panel according to claim **2**, wherein material of the planar layer has laser absorption rate ≤6% in 300-400 nm wavelength range.

4. The method of manufacturing flexible OLED display panel according to claim **1**, wherein roughness of the planar layer is Ra≤0.4 μm.

5. The method of manufacturing flexible OLED display panel according to claim **3**, wherein roughness of the planar layer is 0.05-0.3 μm.

6. The method of manufacturing flexible OLED display panel according to claim **1**, wherein thickness of the planar layer is 50-120 μm.

7. The method of manufacturing flexible OLED display panel according to claim **6**, wherein thickness of the glass carrier is 400-500 μm.

8. The method of manufacturing flexible OLED display panel according to claim **7**, wherein the planar layer and the glass carrier which are stacking positioned have laser transmittance ≥40% in 300-400 nm wavelength range.

9. The method of manufacturing flexible OLED display panel according to claim **1**, wherein composite material of the planar layer comprises at least one of organic material or inorganic material, the organic material comprises at least one of epoxy, acrylic resin and silicone; the inorganic material comprises at least one of silicon dioxide, magnesium fluoride, calcium fluoride and barium fluoride.

10. The method of manufacturing flexible OLED display panel according to claim **3**, wherein composite material of the planar layer comprises at least one of organic material or inorganic material, the organic material comprises at least one of epoxy, acrylic resin and silicone; the inorganic material comprises at least one of silicon dioxide, magnesium fluoride, calcium fluoride and barium fluoride.

11. The method of manufacturing flexible OLED display panel according to claim **5**, wherein composite material of the planar layer comprises at least one of organic material or inorganic material, the organic material comprises at least one of epoxy, acrylic resin and silicone; the inorganic material comprises at least one of silicon dioxide, magnesium fluoride, calcium fluoride and barium fluoride.

12. The method of manufacturing flexible OLED display panel according to claim **8**, wherein composite material of the planar layer comprises at least one of organic material or inorganic material, the organic material comprises at least one of epoxy, acrylic resin and silicone; the inorganic material comprises at least one of silicon dioxide, magnesium fluoride, calcium fluoride and barium fluoride.

13. The method of manufacturing flexible OLED display panel according to claim **12**, wherein composite material of the planar layer is silicon dioxide.

14. The method of manufacturing flexible OLED display panel according to claim **9**, wherein the step of forming the planar layer which is mixing the composite material of the planar layer and solvent to obtain a sizing mixture; coating the sizing mixture on the surface of the glass carrier which is backward to the flexible substrate; and curing to from the planar layer.

15. The method of manufacturing flexible OLED display panel according to claim **12**, wherein the step of forming the planar layer which is mixing the composite material of the planar layer and solvent to obtain a sizing mixture; coating the sizing mixture on the surface of the glass carrier which is backward to the flexible substrate; and curing to from the planar layer.

16. The method of manufacturing flexible OLED display panel according to claim **1**, wherein during the laser lift-off, the laser wavelength is 300-400 nm; the laser energy is 290-350 mJ.

17. The method of manufacturing flexible OLED display panel according to claim **1**, wherein sequentially forming a packaging protecting layer, a flexible rear cover on the OLED element layer, the flexible substrate and the flexible rear cover are forming an enclosed space for accommodating the OLED element layer and the packaging protecting layer.

18. The method of manufacturing flexible OLED display panel according to claim **17**, wherein the packaging protecting layer encapsulating the OLED element and the low temperature poly-Si layer on the flexible substrate; the packaging protecting layer is formed by organic film and inorganic film are alternatively positioned.

19. The method of manufacturing flexible OLED display panel according to claim **17**, wherein forming a touch wire on the flexible substrate; or forming a first blocking layer on the flexible substrate, and forming the touch wire on the first blocking layer.

20. The method of manufacturing flexible OLED display panel according to claim **19**, wherein a second blocking layer is positioned between the touch wire and the low temperature poly-Si layer.

* * * * *

专利名称(译)	制造柔性OLED显示面板的方法		
公开(公告)号	US20190173029A1	公开(公告)日	2019-06-06
申请号	US15/916470	申请日	2018-03-09
[标]发明人	JIN XIANG		
发明人	JIN, XIANG		
IPC分类号	H01L51/00 H01L51/50 H01L51/52 H01L51/56 G06F3/041 H01L27/32		
CPC分类号	H01L51/0097 H01L51/5096 H01L51/0016 H01L51/5206 H01L51/5221 H01L51/56 G06F3/0412 H01L27/3262 H01L2251/5338 H01L51/003 H01L2227/326		
优先权	201711269186.0 2017-12-05 CN		
外部链接	Espacenet USPTO		

摘要(译)

提供一种制造柔性OLED显示面板的方法。该方法包括以下步骤。提供玻璃载体，在玻璃载体的表面上依次形成柔性基板，低温多晶硅层和OLED元件层;在玻璃载体的表面上形成平面层，该平面层位于柔性基板的后面，并获得规划的OLED显示面板;通过激光剥离规划OLED显示面板并获得柔性OLED显示面板来移除玻璃载体。该方法可以更好地改善激光剥离过程中激光在柔性基板上不均匀分布的问题，导致剥离成功率降低。