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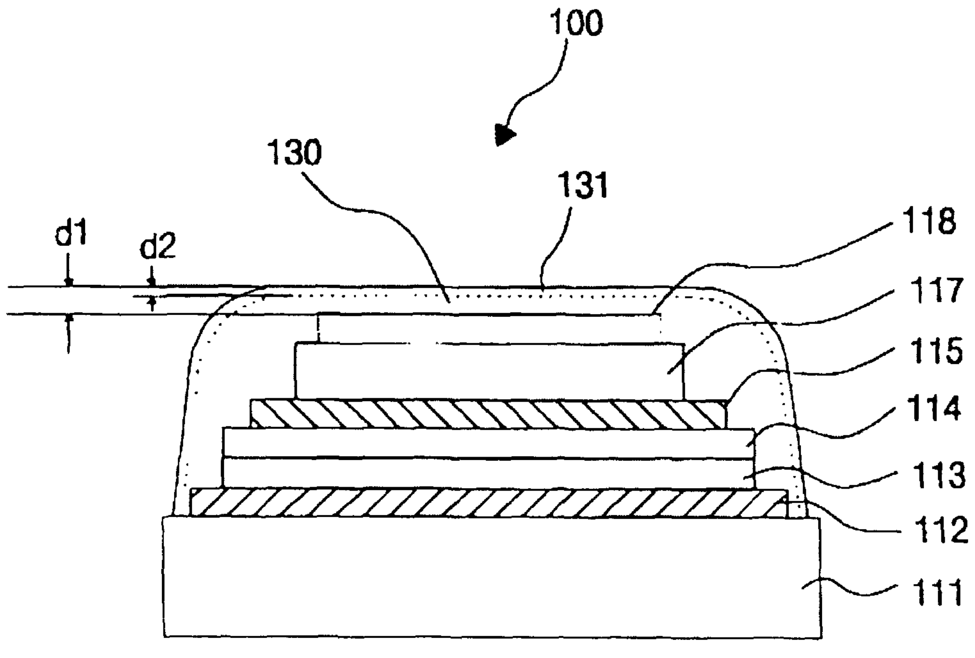
(54) Title: METHOD OF FABRICATING ORGANIC ELECTROLUMINESCENT DISPLAY



(57) Abstract: Disclosed is a method of fabricating an organic electroluminescent display enabling to improve device characteristics and reliance by carrying out laser annealing on a passivation layer locally. The present invention includes forming an anode layer, an organic electroluminescent layer, and a cathode layer successively on a transparent substrate, forming a passivation layer on the transparent substrate including the cathode layer, and carrying out thermal treatment on the passivation layer locally.

WO 02/104077 A1

METHOD OF FABRICATING ORGANIC ELECTROLUMINESCENT DISPLAY

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method of fabricating an organic electroluminescent display(hereinafter abbreviated OELD) enabling to improve device characteristics and reliance by carrying out laser annealing on a passivation layer without affecting any other parts of the device.

Background of the Related Art

As information communication technology is greatly developed, demands for electronic displaying means are highly increased in accordance with a variety of information societies. So does the demand for various displays. In order to meet the demands of the information society, for electronic display devices are required characteristics such as high-resolution, large-size, low-cost, high-performance, slim-dimension, and small-size and the like, for which new flat panel display(FPD) is developed as a substitution for the conventional cathode ray tube(CRT).

In the presently developed or used flat panel displays, there are Liquid Crystal Display(LCD), Light Emitting Display(LED), Plasma Display Panel(PDP), Vacuum Fluorescence Display(VFD), Electroluminescent Display(ELD) and the like.

Compared to the light-receiving device, ELD(electroluminescent display) attracts attention as a flat panel display having characteristics such as a response speed faster than that of the light-receiving device such as LCD, an excellent brightness owing to self-luminescence, an easy fabrication from a simple structure, and a light weight/slim design. ELD is applied to a new flat panel display(FPD) as a next-generation substitute. ELD is generally divided into two categories, i.e. an organic electroluminescent display(hereinafter abbreviated OELD) and an inorganic electroluminescent display(hereinafter abbreviated IELD) in accordance with materials used for field luminescent layers.

In the above-mentioned OELD, a conductive transparent anode layer, a hole injection layer, a hole transport layer, an organic electroluminescent layer, an electron transport layer, and a cathode layer are stacked successively on a transparent substrate formed of glass, quartz or the like. In this case, an organic material constructing the organic electroluminescent layer is very sensitive to oxidation, moisture, and contamination due to impurities, thereby needing an airtight passivation layer. Specifically, the cathode layer is formed of a metal having a low work function in order to reduce a driving voltage and achieve efficient electron injection. Such a metal is very sensitive to external oxygen and moisture. Namely, the oxidation of the metal constructing the cathode layer degrades luminescent characteristics such as luminescent brightness, luminescent uniformity and the like badly, thereby reducing the durability of OELD.

Moreover, when defects such as micro-holes and the like exist on a metal surface of the cathode layer, oxygen, moisture and the like penetrates into the organic electroluminescent layer through these micro-holes so as to degrade the organic electroluminescent layer. Therefore, the device characteristics are abruptly degraded. In order to secure the reliance of OELD, the organic electroluminescent layer as well as the micro-holes in the cathode layer should be cut off from an external air so as to prevent the degradation.

One of the methods for isolating the organic electroluminescent layer of OELD from an external environment is using a metal cap.

FIG. 1 illustrates a cross-sectional view of an OELD using a metal cap according to a related art.

Referring to FIG. 1, an OELD 10 using a metal cap 20 is fabricated in a manner that an anode layer 12 formed of a conductive transparent material is stacked on a transparent substrate 11. And, on the anode layer 12 successively stacked are a hole injection layer 13, a hole transport layer 14, an organic electroluminescent layer 15, an electron transport layer 17, and a cathode layer 18. The cathode, hole injection, hole transport, organic electroluminescent, electron transport, and cathode layers 12, 13, 14, 15, 17, and 18 stacked on the transparent substrate 11 are sealed using a metal cap 20 having a desiccant 19 at a center inside.

In the OELD 10 having the above-constructed metal cap 20, when a voltage is applied between the anode layer 12 and the cathode layer 18, holes are injected into the organic electroluminescent layer 15 through the hole injection layer 13 and hole transport layer 14 while electrons are injected thereto through the electron transport layer 17. Thus, the organic electroluminescent layer 15 emits lights as the holes and electrons are bonded to each other. In this case, the hole injection, hole transport, and electron transport layers 13, 14, and 17 play an auxiliary role in increasing a luminescent efficiency of OELD.

Unfortunately, the metal cap having the desiccant is left apart from a surface of the cathode layer in the related art. When the passivation layer fails to secure 100% sealing by the metal cap, the organic electroluminescent and cathode layers become contacted with oxygen and moisture so as to cause the degradation. Thus, it is difficult to protect the device completely only with the desiccant existing in part. Moreover, steps of attaching the desiccant and metal cap to the OELD are very complicated.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a method of fabricating an organic electroluminescent display that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a method of fabricating an organic electroluminescent display(hereinafter abbreviated OELD) enabling to improve device characteristics and reliance by preventing organic electroluminescent and cathode layers from being contacted with oxygen, moisture and the like.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages, and in accordance with the purpose of the present invention as embodied and broadly described, a method of fabricating an organic electroluminescent display according to the present invention includes the steps of forming an anode layer, an organic electroluminescent layer, and a cathode layer successively on a transparent substrate, forming a passivation layer on the transparent substrate including the cathode layer, and carrying out thermal treatment on the passivation layer locally.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

FIG. 1 illustrates a cross-sectional view of an OELD according to a related art;

FIG. 2 illustrates a cross-sectional view of an OELD according to the present invention;

FIGS. 3A to FIGS. 3C illustrate cross-sectional views of fabricating an OELD according to the present invention; and

FIG. 4A and FIG. 4B illustrate diagrams for chemical bonds of silicon nitride layers.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Where possible, the same reference numerals will be used to illustrate like elements throughout the specification.

FIG. 2 illustrates a cross-sectional view of an OELD according to the present invention.

Referring to FIG. 2, an OELD 100 having a thin passivation layer according to the present invention is fabricated in a manner that an anode layer 112, a hole injection layer 113, a hole transport layer 114, an organic electroluminescent layer 115, an electron transport layer 117, and a cathode layer 118 are stacked on a transparent substrate 111 successively. And, the OELD 100 according to the present invention further includes a thin passivation layer 130 stacked on the cathode layer 118 formed of a silicon based insulating material enabling to exclude oxygen, moisture and the like.

FIGS. 3A to FIGS. 3C illustrate cross-sectional views of fabricating an OELD according to the present invention.

Referring to FIG. 3A, a plurality of anode layers 112 are formed on a transparent substrate 111. In this case, the transparent substrate 111 is formed of one of glass, quartz glass, transparent plastic, and the like.

Preferably, the anode layer 112 is deposited by one of chemical vapor deposition, sputtering, vacuum deposition, and electron beam, and is patterned by photolithography. And, the anode layer(s) is formed 100 to 10,000Å thick, and preferably, 100 to 3,000Å thick. A transmissivity of the anode layer 112 for visible rays is preferably close to 100%. And, at least 30% of the transmission rate is acceptable.

Preferably, the anode layer 112 is formed of one of metal, alloy, electrically conductive chemical compound and their mixtures, of which work function is at least 4.0 eV. For instance, the anode layer 112 is formed of one of ITO(indium tin oxide), IXO, TO(tin oxide), Sn, Au, Pt, Pd, and their mixtures constructing a single layer or double layers.

On the anode layer 112 stacked successively as organic layers are a hole injection layer 113, a hole transport layer 114, an organic electroluminescent layer 115, and an electron transport layer 117.

When the organic layers are formed of a low molecular organic material, the hole injection, hole transport layer, organic electroluminescent layer, and electron transport layers 113, 114, 115, and 117 are stacked 200~600Å, 200~600Å, 400~500Å, and about 600Å thick, respectively.

The hole injection layer 113 is formed of an organic material having star-burst type molecules such as metal-phthalocyanine, non-metal-phthalocyanine, 4,4',4"-tris(di-p-methylphenylamino)triphenylamine or the like. The hole injection layer 113 injects holes of the anode layer 112 into the hole transport layer 114 when an electric field is applied thereto.

The hole transport layer 114 is formed of one of organic materials such as N,N'-diphenyl-N,N'-(4-methylphenyl)-1,1'-biphenyl4,4'-diamine, and 4,4'-bis[N-(1-naphthyl)-N-phenylamino]biphenyl. And, the hole transport layer 114 transports the injected holes to the organic electroluminescent layer 115 by the electric field.

The organic electroluminescent layer 115 is formed of the organic material such as tris(8-hydroxyquinoline)aluminum, tris(4-methyl-8-hydroxyquinoline)aluminum, 3-(2'-benzthiazolyl)-7-N,N-diethylaminocoumarine, 9,18-dihydroxybenzo[h]benzo[8]quino[2,3-b]acrydyne-7,16-dione, 4,4'-bis(2,2'-diphenyl-ethene-4-yl)-diphenyl, phenylene and the like. The organic electroluminescent layer 115 emits to maintain lights generated from the combining reaction between holes transported from the hole transport layer 114 and electrons transported from the electron transport layer 117.

The electron transport layer 117 is formed of one of organic materials such as tris(8-hydroxyquinoline)aluminum, tris(8-hydroxyquinoline)gallium, 1,3-bis[5-(p-tertiary-buphylphenyl)-1,3,4-oxadiasole-2-yl]benzene and the like. And, the electron transport layer 117 transfers the electrons injected from the cathode layer 118 to the organic electroluminescent layer 115 when an electric field is applied thereto.

So far, lightweight molecular organic materials are explained.

In the case of an electroluminescent device using polymer(high molecular) materials, stacked organic layers constructed with a buffer layer such as PEDOT, PSS or the like and a luminescent layer such as poly(phenylvinylene) derivatives, PPV or the like are formed using one of spin-coating, dipping, deposition and the like. In this case, the buffer and organic electroluminescent layers are formed 200~900Å and 200~900Å thick, respectively,

The cathode layer 118, which is formed of a metal of which work function is lower than 4.0 eV such as magnesium, aluminum, indium, lithium, sodium, silver, is constructed with a single layer, double layers, or a layer of their mixtures. And, the cathode layer 118 is formed 100 to 10,000Å, preferably, 100 to 3,000Å thick using sputtering, vacuum deposition, electron beam, or chemical vapor deposition(CVD).

In order to increase an electron injection efficiency, LiF, CsF, Li_2O, Li-Al alloy or the like may be formed 1 to 100Å thick between the cathode and electron transport layers 118 and 117.

Referring to FIG. 3B,a passivation layer 130 is stacked on the transparent substrate 111 including the cathode layer 118. The passivation layer 130 is constructed with at least one layer using selectively one of SiO_2, SiO_xN_y, Si_3N_4, and SiN_x to a minimum thickness d1 of 100 to 50,000 Å thick, preferably, 100 to 3,000 Å. Thus, the passivation layer 130 is formed of a silicon based insulating material enabling to prevent the organic electroluminescent and cathode layers from being degraded by the penetration of oxygen, moisture and the like. The passivation layer 130 is formed or stacked by CVD, sputtering, vacuum deposition or E-beam.

When the passivation layer 130 is formed of the silicon based insulating material using CVD, a temperature of layer formation is 25 to 300°C, inert gas is used as a carrier gas, SiN_x uses SiH_4, NH_3, and N_2 as reaction gases, SiNO uses SiH_4, N_2O, NH_3, and N_2 as reaction gases, and SiO_2 uses SiH_4 and O_2 as reaction gases.

When the passivation layer 130 is formed of the silicon based insulating material using sputtering, a temperature of layer formation is 25 to 300°C, inert gas is used as a carrier gas, and SiN_x, SiNO, and SiO_2 use targets of SiN_x, SiNO, and SiO_2, respectively.

Besides, a silicon based insulating inorganic material, a resin layer, and a silicon based inorganic material are successively deposited so as to form the passivation layer 130. Alternatively, the passivation layer 130 is formed by stacking a resin layer, a silicon based insulating inorganic material, and a resin layer successively.

Referring to FIG. 3C, in order to the defect of the passivation layer 130, thermal treatment is carried out. As the passivation layer 130 is not grown by a thermal growing method but stacked by CVD or sputtering, a plurality of incomplete chemical bonds between silicon and oxygen/nitrogen atoms occur. Such an incomplete combination between atoms generates a plurality of dangling bonds and porosity, thereby bringing about the defect of the passivation layer 130. Namely, such a defect at the passivation layer provides paths through which oxygen and moisture pass. Thus, the defect should be removed therefrom through crystallization.

A temperature of the thermal treatment to remove the defect of the passivation layer 130 formed of the silicon based chemical compounds is 700 to 1100°C. Such a temperature is enough to affect other elements including the organic electroluminescent layer of the OELD fatally. Therefore, the present invention carries out a local thermal treatment process locally using Eximer lasers.

In this case, the thermal treatment is carried out using an eximer laser of Ar_2,

Kr_2, Xe_2, ArF, KrF, XeCl, or F_2. Table 1 illustrates discharge wavelengths of the respective eximer lasers, where annealing power of the eximer laser is 10~2000mJ/cm^2, an ambience temperature is 25~300°C, and the annealing is carried out for several minutes. And, an instant temperature of annealing the passivation layer 130 is a temperature enabling the crystallization. The annealing is carried out at least once.

Therefore, a surface of the passivation layer 130 is annealed so as to form a high-density homogeneous layer 131 to a thickness d2 of 10 to 10,000Å, and preferably, 100 to 200Å. The high-density homogeneous layer 131 is provided with a mesh structure consisting of silicon and oxygen(or nitrogen) from the silicon based insulator constructing the passivation layer 130 by the laser annealing. Thus, a high-density homogeneous layer131 of which hydrogen content is reduced so as to reduce its porosity. The mesh structure and the reduced hydrogen content prevent the organic electroluminescent and cathode layers 115 and 118 from being degraded due to the penetration of moisture and oxygen from external environments.

The species and wavelengths of the eximer lasers used for annealing the surface of the passivation layer 130 are shown in Table 1, where the annealing may be carried out at least once.

Table. 1

Eximer laser	Discharge Wavelength
Ar2	126nm
Kr2	146nm
Xe2	172nm
ArF	190nm
XeF	193nm
KrF	250nm
XeCl	350nm

Besides, in order to prevent the degradation caused by outgassing materials generated inside the device, a metal oxide layer(not shown in the drawing) as a desiccant layer, of which desiccating and adsorbing properties are excellent, may be inserted between the cathode and passivation layers 118 and 130 using one of CaO, Y_2O_3, MgO and the like. The metal oxide layer is formed 100~50,000Å thick, more preferably, 200~10,000Å thick.

Thereafter, an external passivation cap may be formed over the transparent substrate 111 by assembly/sealing so as to cover the above-described structure using one of glass, AS resin, ABS resin, polypropylene(PP), polystyrene(HIPS), polymethyl-meta-crylic acid(PMMA), polycarbonate, metal and the like in order to strengthen the mechanical intensity of the passivation layer 130.

FIG. 4A and FIG. 4B illustrate diagrams for chemical bonds of silicon nitride layers.

Referring to FIG. 4A, the passivation layer 130 formed of the silicon based insulating material is not grown by a thermal growing method but stacked by one of CVD, sputtering, and vacuum deposition. Thus, silicon and nitrogen atoms fail to complete their chemical bonds, thereby providing a plurality of bonds 140 failing to be bonded to others. Therefore, a property of the passivation layer 130 becomes porous. Moreover, the bonds 140 come into forming chemical bonds with hydrogen atoms so as to increase the hydrogen content in the passivation layer 130 as well. The naked bonds 140 and porosity of the passivation layer cause the penetration of oxygen and moisture.

Referring to FIG. 4B, the passivation layer 130 is annealed using an eximer laser. The passivation layer 130 is abruptly crystallized so as to disconnect the chemical bonds between the naked bonds and hydrogen atoms and form new chemical bonds 141 between silicon and nitrogen atoms. Thus, the removal of the naked bonds 140 reduces the hydrogen content as well as minimizes the porosity of the passivation layer 130. Therefore, the uniform passivation layer 130 enabling to restrain the penetration of oxygen and moisture is attained.

Accordingly, the present invention provided with the mesh structure and the reduced hydrogen content enables to prevent the organic electroluminescent and cathode layers from being degraded due to the penetration of moisture and oxygen from outside by carrying out the annealing locally on the passivation layer formed of silicon and nitrogen/oxygen without affecting other elements .

Moreover, considering the case of the related art requiring at least 2 to 5 hours for forming a layer enabling to exclude the external oxygen and moisture by CVD, the present invention enables to reduce a process time greatly using laser annealing of which process time requires only several minutes which are relatively short.

The foregoing embodiments are merely exemplary and are not to be construed as limiting the present invention. The present teachings can be readily applied to other types of apparatuses. The description of the present invention is intended to be illustrative, and not to limit the scope of the claims. Many alternatives, modifications, and variations will be apparent to those skilled in the art.

What is claimed is:

1. A method of fabricating an organic electroluminescent display, comprising the steps of:

forming an anode layer, an organic electroluminescent layer, and a cathode layer successively on a transparent substrate;

forming a passivation layer on the transparent substrate including the cathode layer; and

carrying out thermal treatment on the passivation layer locally.

2. The method of claim 1, wherein a hole injection layer and a hole transport layer are further inserted between the anode and organic electroluminescent layers.

3. The method of claim 1, wherein an electron transport layer is further inserted between the organic electroluminescent and cathode layers.

4. The method of claim 1, wherein a desiccant layer is further inserted between the cathode and passivation layers.

5. The method of claim 4, wherein the desiccant layer is formed using selectively one of one of CaO, Y_2O_3, and MgO.

6. The method of claim 1, wherein the passivation layer is formed of a silicon based insulating layer.

7. The method of claim 1, wherein the passivation layer is formed using selectively one of SiO_x, SiNO, and SiN_y to form a single layer or using selectively at least two of SiO_x, SiNO, and SiN_y to form at least double layers.

8. The method of claim 1, wherein the thermal treatment is carried out using eximer laser.

9. The method of claim 8, wherein an annealing power of the eximer laser is 10~2000mJ/cm^2, an ambience temperature is 25~300°C, and the thermal treatment is carried out for several minutes.

10. The method of claim 8, wherein the eximer laser is one of lasers using Ar_2, Kr_2, Xe_2, ArF, KrF, XeCl, or F_2.

11. The method of claim 1, wherein the passivation layer is formed by stacking a first silicon based inorganic material layer, a resin layer, and a second silicon based inorganic material layer.

12. The method of claim 1, wherein the passivation layer is formed by stacking a first resin layer, a silicon based inorganic material layer, and a second resin layer.

13. The method of claim 1, wherein an external passivation cap is further formed on the passivation layer by assembly/sealing.

14. The method of claim 13, wherein the external passivation cap is formed using one of glass, AS resin, ABS resin, polypropylene(PP), polystyrene(HIPS), polymethyl-meta-crylic acid(PMMA), polycarbonate, and a metal.

FIG. 1

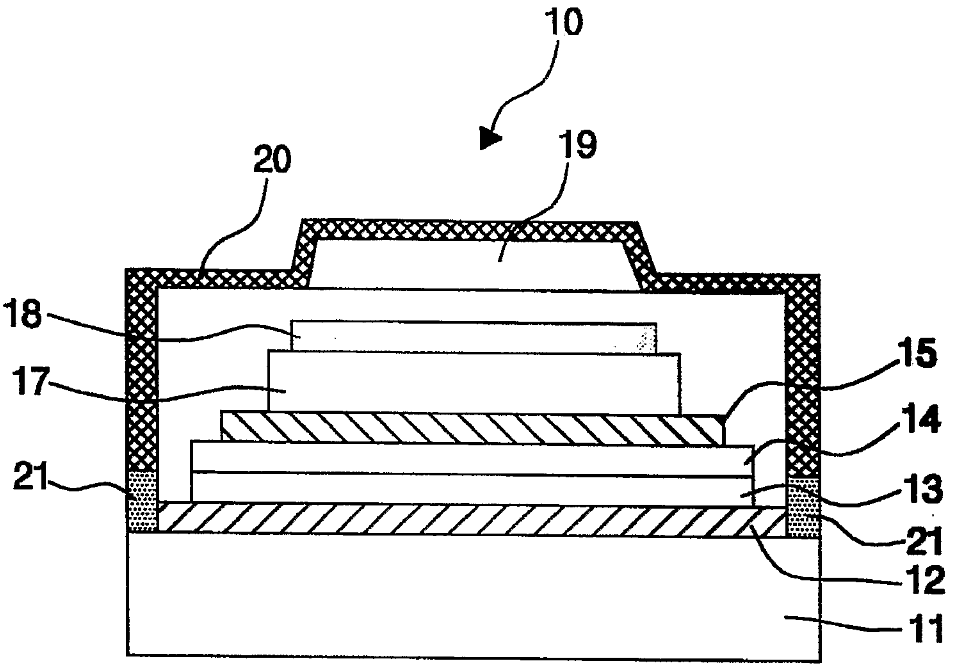

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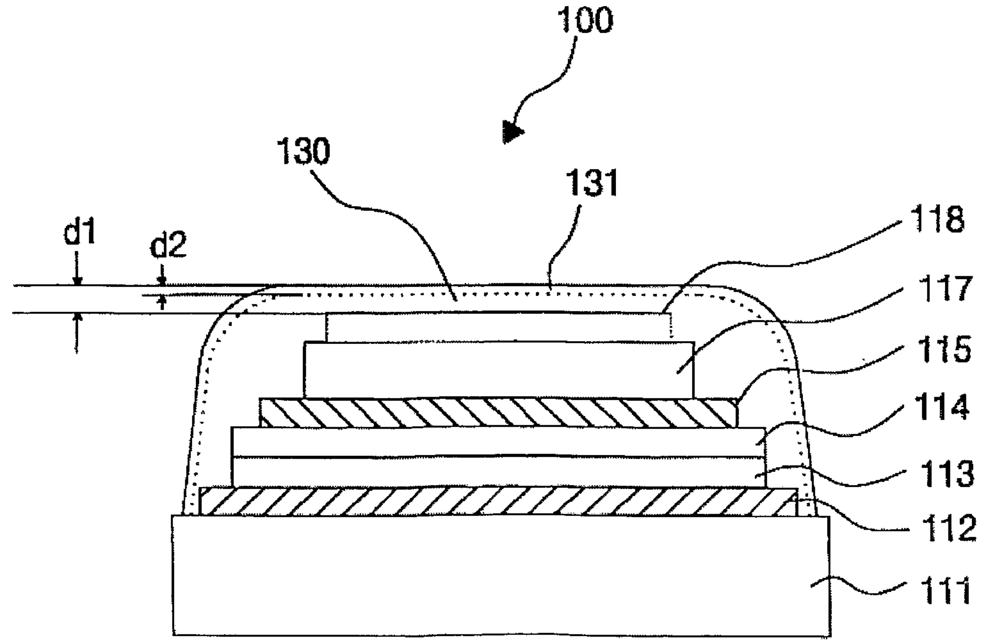
FIG. 2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d1
d2
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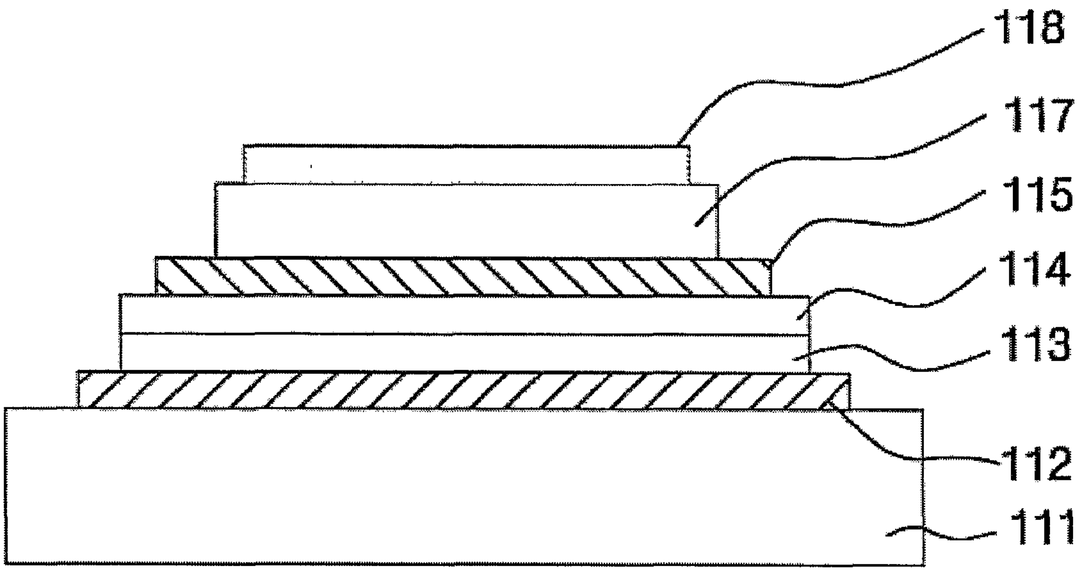
111

FIG. 3A


118
117
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114
113
112
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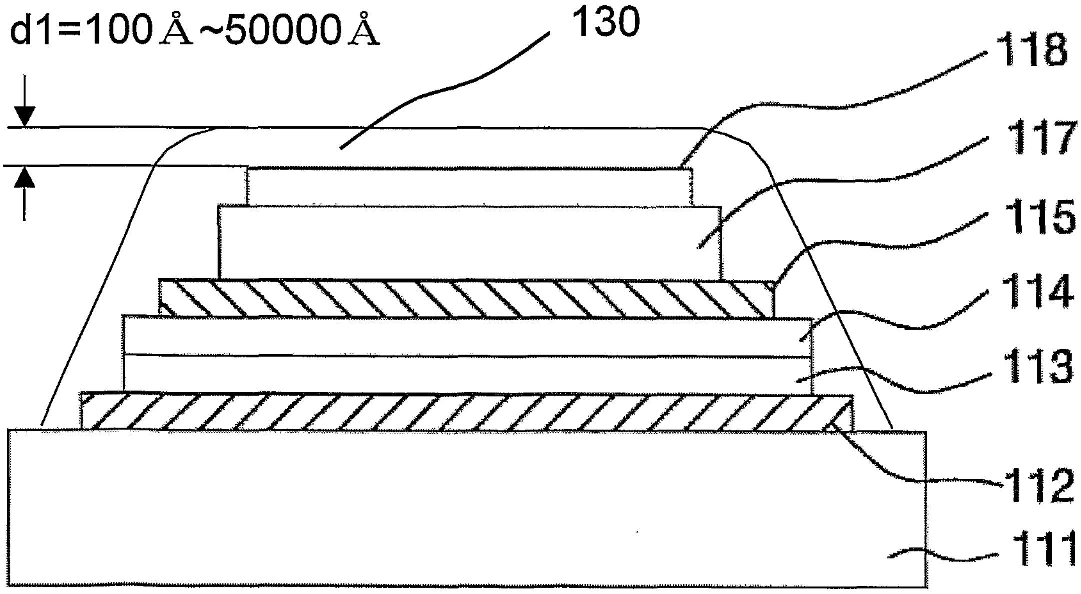
FIG. 3B


d1=100Å~50000Å
130
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112
111

FIG. 3C

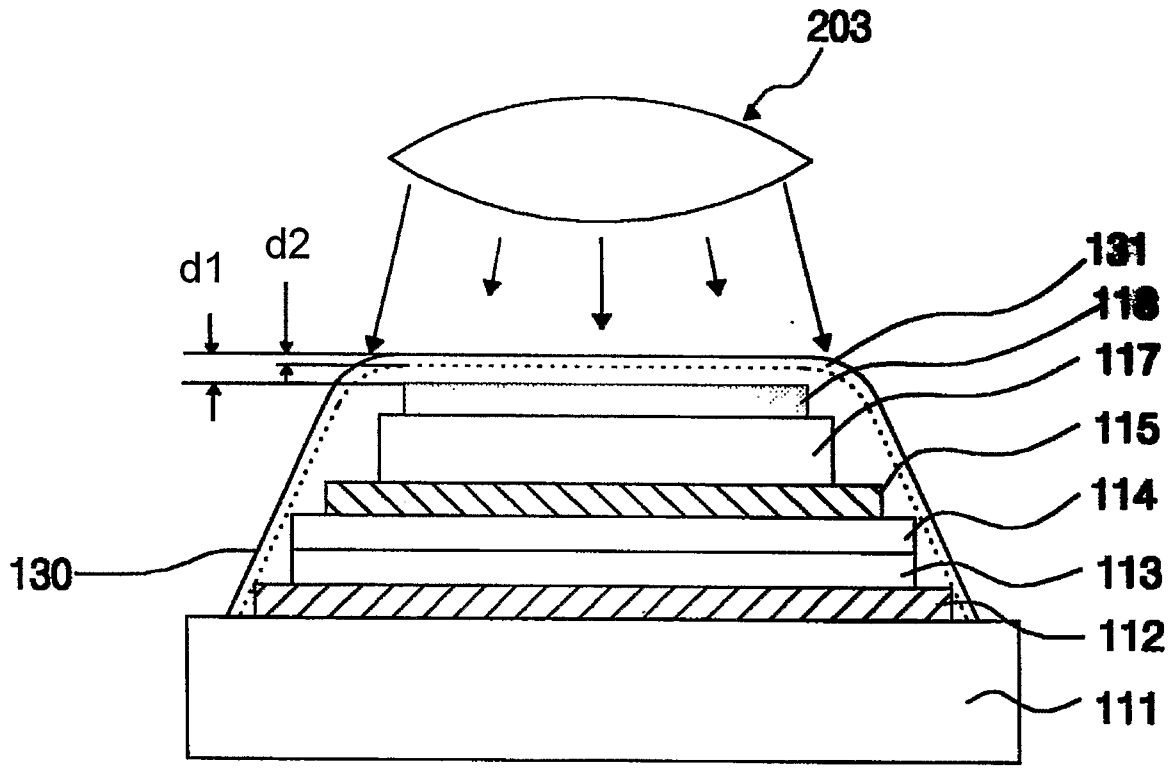


FIG. 4A

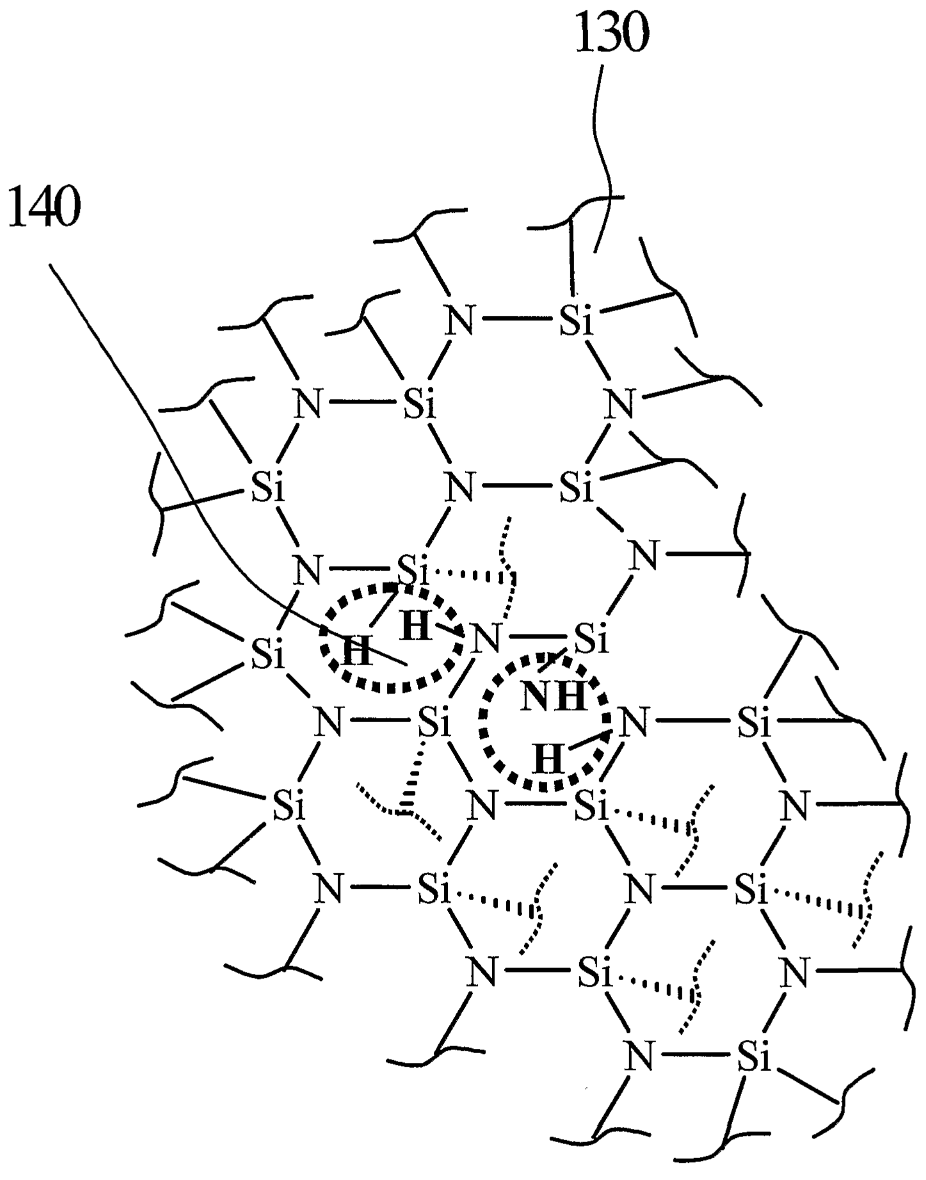
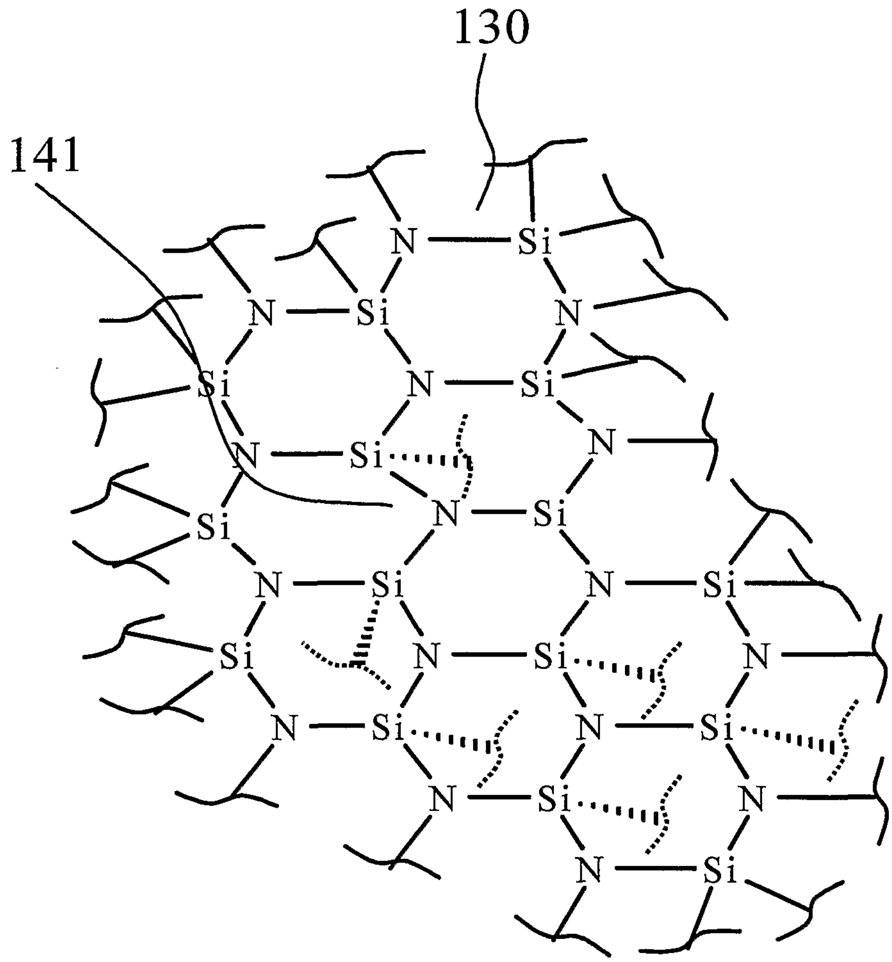


FIG. 4B



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR02/01127

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H05B 33/04

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)

IPC7 H05B 33/04

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

Korean patents and application since 1975
Korean utility models and application for utility models since 1975

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
"A"	EP 0751699 A2 (HEWLLET-PACKARD CO) 02, JAN. 1997 WHOLE DOCUMENT	1-14
"A"	JP 2000-208252 A (TDK CO) 28, JUL. 2000 WHOLE DOCUMENT	1-14
"A"	KR 1999-0041051 A (ETRI) 15, JUN. 1999 WHOLE DOCUMENT	1-14

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

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevence
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevence; 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 relevence; 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
16 OCTOBER 2002 (16.10.2002)	17 OCTOBER 2002 (17.10.2002)

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea	MIN, Kyoung Shin
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5652

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR02/01127

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0751699 A2	02, JAN. 1997	JP 09-017572 A	17,JAN. 1997
JP 2000-208252 A	28, JUL. 2000	EP 1021070 A1	19,JUL. 2000
KR 1999-0041051 A	15, JUN. 1999	NONE	

patsnap

专利名称(译)	制造有机电致发光显示器的方法		
公开(公告)号	EP1410692A1	公开(公告)日	2004-04-21
申请号	EP2002738918	申请日	2002-06-14
[标]申请(专利权)人(译)	大宇电子服务股份有限公司		
申请(专利权)人(译)	CLD，INC.		
当前申请(专利权)人(译)	大宇电子服务有限公司		
[标]发明人	CHOI DO HYUN CHOI KYUNG HEE		
发明人	CHOI, DO-HYUN CHOI, KYUNG-HEE		
IPC分类号	H01L51/52 H05B33/04 H01L51/50 H05B33/10		
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其他公开文献	EP1410692B1 EP1410692A4		
外部链接	Espacenet		

摘要(译)

公开了一种制造有机电致发光显示器的方法，该有机电致发光显示器能够通过局部地在钝化层上进行激光退火来改善器件特性和依赖性。本发明包括在透明基板上依次形成阳极层，有机电致发光层和阴极层，在包括阴极层的透明基板上形成钝化层，并在局部对钝化层进行热处理。