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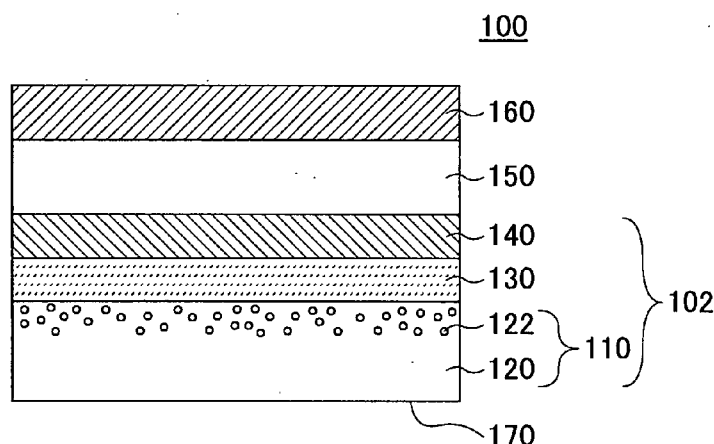
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(54) Title: ELECTRODE-ATTACHED TRANSLUCENT SUBSTRATE, PHOTONIC DEVICE, AND METHOD OF MANUFACTURING ELECTRODE-ATTACHED TRANSLUCENT SUBSTRATE

FIG.1



(57) Abstract: An electrode-attached translucent substrate includes a translucent glass substrate including a base glass material and scattering bodies dispersed in the base glass material; a covering layer including a first layer made of a material selected from a group of a metal nitride, a metal oxide and a metal nitride-oxide directly formed on the translucent glass substrate; and a translucent electrode formed on the covering layer.

DESCRIPTIONTitle of the Invention

ELECTRODE-ATTACHED TRANSLUCENT SUBSTRATE,
5 PHOTONIC DEVICE, AND METHOD OF MANUFACTURING
ELECTRODE-ATTACHED TRANSLUCENT SUBSTRATE

Technical Field

The present invention relates to an
10 electrode-attached translucent substrate, a
photonic device, and a method of manufacturing the
electrode-attached translucent substrate.

Background Art

15 A photonic device has been developed such as
an optoelectronic device capable of emitting and
collecting light such as an organic light-emitting
diode (OLED), a light collector such as an organic
photovoltaic cell (a solar cell) or the like. It
20 is required for such a photonic device to be
manufactured with a good internal light efficiency,
expressed in terms of internal quantum efficiency
(IQE) which represents the number of photons
obtained by the injection of an electron. However,
25 the quantity of light which effectively exits from
such a photonic device is limited by the losses
associated with interface reflection phenomena.

In general, for example, an OLED device
includes a translucent support, a translucent
30 electrode (anode) formed on the translucent
support, another electrode (cathode) and an
organic layer (including an organic light-emitting
layer) provided between these electrodes. With

this structure, when applying a voltage between the electrodes, holes and electrons are injected into the organic layer from the respective electrodes. When the holes and the electrons are
5 recombined in the organic layer, binding energy is generated to excite luminescent materials in the organic layer. As light emissions occur as the excited luminescent materials return to the ground state, an electroluminescent (EL) element is
10 obtained by using this phenomenon.

The translucent electrode is generally made of a transparent thin layer such as a transparent conductive coating (TCC) such as a transparent conductive oxide like indium-doped tin oxide (ITO)
15 or a multilayer stack of them. The translucent support is made of glass, ceramic glass or polymer film, for example (see WO2010/094775 A1, for example).

Here, the various materials inside the device
20 do not exhibit the same refraction index (n). For example, in most of the cases, the translucent support presents a very low refraction index compared to the neighboring translucent electrode such as TCC. This difference of refraction index
25 causes total internal reflections for some part of the emitted light inside the device. This light is then trapped and lost as it does not exit from the device surface. Furthermore, these multiple reflections also enhance interference phenomenon
30 inside the device and can induce color variation of the emitted light against the angle of observation or against thickness variation in the OLED. This is particularly unpleasant and

unaesthetic for a white light emitting device.

The losses resulting from such reflections occurring at the interfaces cause the main reduction in external quantum efficiency (EQE).

5 The EQE is equal to the IQE minus the losses through reflections and absorption inside the device. Extracting light from the device to increase EQE as well as higher color stability with observation angle or thicknesses variation
10 are key challenges for the future success of solid state surface lighting.

It has been suggested recently to provide a scattering layer including scattering materials between the translucent electrode such as TCC and
15 the translucent support (US patent No. 8,018,140, for example). In such a structure, it is disclosed that a part of the light emissions occurring in the organic layer is scattered by the scattering materials in the scattering layer so
20 that the light quantity of the light trapped in the translucent electrode such as TCC or the translucent support (the light quantity of totally reflected light) can be decreased to increase light extracting efficiency of the OLED.

25 The described scattering solution not only advantageously enhances the EQE but also suppresses most of the color dependency due to interference.

Further, it has been suggested in
30 US2007/0241668 A1 that the OLED has an antireflection coating having a thickness and a refractive index for which the integral reflectivity at the boundary faces of the

antireflection coating is minimal for light beams emerging from the active layer at all angles for a wavelength in the spectral region of the emission spectrum, or for which the integral reflectivity is at most 25% higher than the minimum. However, for this case as well, it is necessary to provide an additional scattering layer.

However, unfortunately, the suggested solution demands costly processes as it requires deposition of a base material including scattering materials with a required flatness for further deposition of the translucent electrode and the organic layer. For example, it may be necessary to form a specific additional planarization layer after forming the scattering layer.

Summary of Invention

The present invention is made in light of the above problems, and provides an electrode-attached translucent substrate, a photonic device, and a method of manufacturing the electrode-attached translucent substrate capable of improving light extracting/absorbing efficiency with a simple structure.

According to an embodiment, there is provided an electrode-attached translucent substrate including a translucent glass substrate including a base glass material and scattering bodies dispersed in the base glass material; a covering layer including a first layer made of a material selected from a group of a metal nitride, a metal oxide and a metal nitride-oxide directly formed on

the translucent glass substrate; and a translucent electrode formed on the covering layer.

According to another embodiment, there is provided a photonic device including the above
5 electrode-attached translucent substrate; an organic light emitting layer formed on the translucent electrode; and a reflective or semi-reflective electrode formed on the organic light emitting layer.

10 According to another embodiment, there is provided a method of manufacturing the electrode-attached translucent substrate including forming a covering layer directly on a translucent glass substrate including a base glass material, the
15 covering layer including a first layer made of a material selected from a group of a metal nitride, a metal oxide and a metal nitride-oxide directly formed on the translucent glass substrate; forming a translucent electrode on the covering layer; and
20 performing a heat treatment at least on the covering layer and the translucent glass substrate such that scattering bodies are generated to be dispersed in the base glass material of the translucent glass substrate.

25 Note that also arbitrary combinations of the above-described constituents, and any exchanges of expressions in the present invention, made among methods, devices, systems and so forth, are valid as embodiments of the present invention.

30 Brief Description of Drawings

Other objects, features and advantages of the present invention will become more apparent from

the following detailed description when read in conjunction with the accompanying drawings.

Fig. 1 is a schematic cross-sectional view showing an example of a structure of an OLED of an embodiment;

Fig. 2 is a flowchart showing an example of a method of manufacturing the OLED of the embodiment;

Fig. 3A to Fig. 3C are schematic cross-sectional views showing a manufacturing process of the OLED of the embodiment;

Fig. 4 is a schematic top view showing another example of the structure of the OLED of the embodiment; and

Fig. 5 is a cross-sectional view showing bubbles generated by a heat treatment in an example.

Description of Embodiments

The invention will be described herein with reference to illustrative embodiments. Those skilled in the art will recognize that many alternative embodiments can be accomplished using the teachings of the present invention and that the invention is not limited to the embodiments illustrated for explanatory purposes.

It is to be noted that, in the explanation of the drawings, the same components are given the same reference numerals, and explanations are not repeated.

The present inventors have found that scattering bodies (scattering centres) such as

pores in a material, which have a scattering function, can be generated in and at an interface of a translucent glass substrate by forming a covering layer capable of applying a certain compressive stress on the translucent glass substrate, and performing a heat treatment at a predetermined temperature on the covering layer and the translucent glass substrate.

This new solution uses cheaper materials and a simplified process using a known dry-coating deposition process and a single heating step.

In the following embodiments, an organic light-emitting device (OLED) is exemplified as a photonic device.

Fig. 1 is a schematic cross-sectional view showing an example of a structure of an OLED 100 of the embodiment.

The OLED 100 includes an electrode-attached translucent substrate 102, an organic light emitting layer 150, and a reflective (or semi-reflective) electrode 160 stacked in this order. The electrode-attached translucent substrate 102 includes a translucent glass substrate 110, a covering layer 130 formed on the translucent glass substrate 110 and a translucent electrode (anode) 140 formed on the covering layer 130. For the example shown in Fig. 1, a surface at a lower side (an exposed surface of the translucent glass substrate 110) of the OLED 100 is a light extraction surface 170.

The translucent glass substrate 110 includes a base glass material 120 and scattering bodies 122 dispersed in the base glass material and

having a refraction index different from that of the base glass material 120.

Specifically, in this embodiment, the scattering bodies 122 are selectively positioned at an interface or in the vicinity of the interface with the covering layer 130. The scattering bodies 122 are plural pores (bubbles) in the base glass material 120 or the like.

With this structure, the translucent glass substrate 110 has a function to reduce reflection of light at an interface with a layer (the covering layer 130) adjacent to the translucent glass substrate 110 by scattering incident light. It means that according to the OLED 100 of the embodiment, as will be explained later in detail, the light quantity of the light transmitted from the light extraction surface 170 can be significantly improved by providing the scattering bodies 122 in the translucent glass substrate 110 without introducing an additional scattering layer.

In this embodiment, the covering layer 130 (first layer) is directly formed on the translucent glass substrate 110 and is made of a material selected from a group of a metal nitride, a metal oxide and a metal nitride-oxide. Specifically, the covering layer 130 is made of a material selected from a group of a titanium oxide layer, a zirconium oxide layer, a tantalum oxide layer, a tin oxide layer, a zinc oxide layer, a niobium oxide layer, a hafnium oxide layer, an aluminum oxide, nitride, oxynitride or oxide layer, a silicon nitride or oxynitride layer, and a magnesium nitride layer or any mixture thereof.

Further specifically in this embodiment, the covering layer 130 may be a titanium oxide layer.

The translucent electrode 140 is made of a transparent metal oxide thin film such as ITO, for example, and the thickness of which is about 50 nm to 1.0 μm . The reflective electrode 160 is made of a metal such as aluminum or silver, for example.

The organic light emitting layer 150 is, generally, composed of multiple layers such as an electron transport layer, an electron injection layer, a hole transport layer, a hole injection layer and the like in addition to a light emitting layer.

Fig. 2 is a flowchart showing an example of a method of manufacturing the OLED 100 of the embodiment. The method of manufacturing the OLED 100 is briefly explained with reference to Fig. 2.

First, the translucent glass substrate 110 is prepared (S110). Then, the covering layer 130 is formed directly on the translucent glass substrate 110 (S120). Subsequently, the translucent electrode 140 is formed on the covering layer 130 (S130). Then, a heat treatment is performed on the translucent electrode 140, the covering layer 130 and the translucent glass substrate 110 such that scattering bodies 122 are generated to be dispersed in the base glass material 120 of the translucent glass substrate 110 (S140).

Subsequently, the organic light emitting layer 150 is formed on the translucent electrode 140 (S150). Thereafter, the reflective electrode 160 is formed on the organic light emitting layer 150 (S160).

Fig. 3A to Fig. 3C are schematic cross-

sectional views showing a manufacturing process of the OLED 100 of the embodiment. The method of manufacturing the OLED 100 of the embodiment is further explained with reference to Fig. 3A to Fig. 3C in detail in the following.

With reference to Fig. 3A, the translucent glass substrate 110 is prepared (corresponding to S110 in Fig. 2). The translucent glass substrate 110 is composed of the base glass material 120 and does not include the scattering bodies 122 at this time. The translucent glass substrate 110 is made of a material having high transmittance of visible light. For the base glass material 120, an inorganic glass such as alkali glass, soda-lime glass or borosilicate glass, non-alkali glass (alkali-free glass), quartz glass or the like may be used.

The thickness of the translucent glass substrate 110 is not especially limited but may be, for example, within a range of 0.1 mm to 3.0 mm. When considering the strength and the weight, the thickness of the translucent glass substrate 110 may be, 0.5 mm to 3 mm. The glass can also be laminated to another glass with an interlayer, typically of polyvinyl butyral (PVB).

Further, the translucent glass substrate 110 may include a certain amount of water (H_2O). The translucent glass substrate 110, before performing the heat treatment, may include more than or equal to 320 ppm of water, more preferably, more than or equal to 400 ppm, and further more preferably, more than or equal to 450 ppm. The water content in the translucent glass substrate 110 may be

determined based on a two-band method described in F. Geotti-Bianchini et. al., "Infrared spectroscopic analysis of water incorporated in the structure of industrial soda-lime-silica glasses", Glastech Ber. Glass Sci. Technol., 68. No. 7 (1995) 228 or F. Geotti-Bianchini et. al., "Recommended procedure for the IR spectroscopic determination of water in soda-lime-silica glass", Glastech Ber. Glass Sci. Technol., 72. No. 4 (1999) 103.

With this configuration, the scattering bodies 122 are appropriately generated in the following step.

Then, with reference to Fig. 3B, the covering layer 130 is formed directly on the translucent glass substrate 110 (corresponding to S120 in Fig. 2). In this embodiment, the covering layer 130 may be a layer capable of applying a certain compressive stress on the surface of the translucent glass substrate 110. In this view, the thickness of the covering layer 130 may be greater than or equal to 50 nm, more preferably, greater than or equal to 100 nm. The thickness of the covering layer 130 may be within a range of about 50 to 1000 nm. Further, the covering layer 130 may have a relatively high density. The density of the covering layer 130 may be greater than or equal to 80% of the tabulated density, (averaged in case of mixture) and more preferably to 90% of this tabulated density (For table, see W. M. Haynes, David R. Lide, Thomas J. Bruno, CRC Handbook of Chemistry and Physics 2012-2013, (2012)).

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Further, the covering layer 130 may be made of a material having a higher melting point than a glass transition temperature of the translucent glass substrate 110.

5 As explained above, as an example, the covering layer 130 may be a titanium oxide (TiO_2) layer. The method of providing the covering layer 130 is not especially limited but a method of forming a film by a dry-coating deposition process
10 such as magnetron sputtering, vapor deposition, chemical vapor deposition or the like may be used, for example.

Then, with reference to Fig. 3C, the translucent electrode 140 is formed on the
15 covering layer 130 (corresponding to S130 in Fig. 2). The translucent electrode 140 may be a Transparent conductive oxide (TCO) like indium-doped tin oxide (ITO) or Aluminium doped Zinc oxide (AZO).

20 Alternatively, the translucent electrode 140 may be a transparent conductive coating (TCC) made of at least one conductive metallic thin film (<30nm, preferably <25nm, more preferably <20nm) embedded inside metal or semi-metal oxide, nitride
25 or oxynitride layer.

The translucent electrode 140 may include a conductive layer based on silver or on a silver based alloy.

30 The conductive layer based on silver or on a silver based alloy may be formed on a zinc oxide based layer having a function of insulation. The conductive layer based on silver or on a silver based alloy may be directly formed on the zinc

oxide based layer.

The translucent electrode 140 may have a stacked structure including a conductive metallic film and at least one coating as disclosed in
5 WO2012/007575A1. At this time, the coating may be the zinc oxide based layer and the conductive layer based on silver or on a silver based alloy may be directly formed on the zinc oxide based layer.

10 Alternatively, the zinc oxide based layer may be included in the covering layer 130.

Further, for example, the translucent electrode 140 may have at least Metal oxynitride /Ag/Metal oxynitride structure.

15 The method of providing the translucent electrode 140 is not especially limited but a method of forming a film such as sputtering, vapor deposition, chemical vapor deposition or the like may be used, for example. The thickness of the
20 translucent electrode 140 is not especially limited but may be within a range of 50 nm to 1.0 μm , for example.

Further, the heat treatment is performed on the translucent glass substrate 110 (corresponding
25 to S130 in Fig. 2). The applied temperature in the heat treatment may be greater than the glass transition temperature of the translucent glass substrate 110. Specifically, the applied temperature in the heat treatment may be greater
30 than or equal to 600 °C, more preferably, greater than or equal to 630 °C. The applied temperature in the heat treatment may be less than or equal to 800 °C, preferably, less than or equal to 750 °C.

The heat treatment may be performed by a fast transfer in front of a flash-lamp annealing system. Alternatively, the heat treatment may be performed by a general annealing process for at least 2
5 minutes. In that last case, an additional residence time in the furnace can then be set to an extra 30 seconds if the sample is reflecting InfraRed, furthermore, if thickness is greater than 1 mm, at least 40 seconds of baking time and
10 preferably 50 seconds have to be added for each extra time.

With this operation, the scattering bodies 122, each of which has a second refraction index different from a first refraction index of the
15 base glass material 120, are generated in the base glass material 120. Specifically, in this embodiment, the scattering bodies 122 are dispersed in the base glass material 120 especially at an interface or in the vicinity of
20 the interface with the covering layer 130. Further, the scattering bodies 122 are plural pores (bubbles).

The difference between the refractive index of the base glass material 120 and the refractive
25 index of the scattering bodies 122 may be 0.1 or more, and more preferably, 0.2 or more. With such a difference, EQE can be effectively increased.

The size (average diameter) of the scattering bodies 122 is not specifically limited, but may be
30 about more than or equal to 50 nm, preferably more than or equal to 100 nm and less than or equal to 1000 nm, preferably less than or equal to 800 nm.

Further, the density of the scattering bodies

122 in the translucent glass substrate 110 at the interface between the translucent glass substrate 110 and the covering layer 130 is higher than that at the center of the translucent glass substrate 110.

The heat treatment may be performed before or after the translucent electrode 140 is formed on the covering layer 130. Alternatively, the heat treatment may be performed while forming the translucent electrode 140 on the covering layer 130. For example, when the translucent electrode 140 is treated with such a heat treatment at a relatively high temperature range, the absorption can be decreased while the conductivity can be increased.

In some cases, the deposition of the covering layer 130, the deposition of the translucent electrode 140, and the heat treatment can be performed within an apparatus which performs magnetron sputtering under vacuum for the translucent electrode 140. With this structure, the process becomes simple and the cost can be reduced.

Thereafter, when manufacturing the OLED 100, the organic light emitting layer 150 is provided to cover the translucent electrode 140. The method of providing the organic light emitting layer 150 is not especially limited, but vapor deposition and/or coating may be used, for example.

Then, the reflective electrode 160 is provided on the organic light emitting layer. The method of providing the reflective electrode 160 is not especially limited but vapor deposition,

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sputtering, chemical vapor deposition or the like may be used, for example.

With the above methods, the OLED 100 as shown in Fig. 1 is manufactured.

5 The mechanism of generation of the scattering bodies 122 is considered as follows.

When the translucent glass substrate 110 having an appropriate range of water content is heated to a temperature as high as described above, 10 which is greater than the glass transition temperature of the translucent glass substrate 110, while a certain compressive stress is being applied by the covering layer 130, the water in the translucent glass substrate 110 diffuses from 15 core to the interface between the translucent glass substrate 110 and the covering layer 130. Then, as the interface is heated to a high temperature, especially at the interface between the translucent glass substrate 110 and the 20 covering layer 130, bubbles are formed.

Thus, the size, content, density, gradient or the like of the bubbles may be controlled by the amount of water included in the translucent glass substrate 110, the magnitude of the compressive 25 stress (mechanical constraint) applied by the covering layer 130, the temperature in the heat treatment or the like. The compressive stress (mechanical constraint) applied by the covering layer 130 may be controlled by the structure, the 30 thickness or the density of the like of the covering layer 130.

Further, when using the flash-lamp annealing, the surface of the translucent glass substrate 110

can be selectively heated so that the bubbles can be further selectively formed at the surface (interface between the translucent glass substrate 110 and the covering layer 130).

5 With the scattering bodies 122, the part of the translucent glass substrate 110 where the scattering bodies 122 are generated can function similarly as the conventional scattering layer.

Further, when the base glass material 120 of
10 the translucent glass substrate 110 is glass including alkali metal (soda-lime glass or the like, for example), the covering layer 130 also functions as a barrier layer between the translucent glass substrate 110 and the
15 translucent electrode 140. If the covering layer 130 does not exist, the alkali metal in the translucent glass substrate 110 may relatively easily move toward the translucent electrode 140 side when using the OLED 100. Such a movement of
20 the alkali metal causes a degradation of characteristics of the translucent electrode 140 (transparency, electrical conductivity or the like, for example). However, when the covering layer 130 exists, the movement of the alkali metal from
25 the translucent glass substrate 110 toward the translucent electrode 140 can be suppressed.
(Alternative embodiment)

The covering layer 130 may be a stacked structure of two or more layers. Fig. 4 is a
30 schematic cross-sectional view showing another example of the OLED 100.

In this embodiment, the structure of the covering layer 130 is different from that shown in

Fig. 1 and Fig. 3. The covering layer 130 includes a first layer 132, an insulating layer 134 and a second layer 136 stacked in this order on the translucent glass substrate 110.

5 In this example, the first layer 132 is directly formed on the translucent glass substrate 110 and is selected from a group of a metal nitride, a metal oxide and a metal nitride-oxide. Specifically, the first layer 132 is made of a
10 material selected from a group of a titanium oxide layer, titanium oxide layer, a zirconium oxide layer, a tantalum oxide layer, a tin oxide layer, a zinc oxide layer, a niobium oxide layer, a hafnium oxide layer, an aluminum oxide, nitride,
15 oxynitride or oxide layer, a silicon nitride or oxynitride layer, and a magnesium nitride layer or any mixture thereof..

Similarly, the second layer 136 is made of a material selected from a group of a metal nitride,
20 a metal oxide and a metal nitride-oxide. Specifically, the second layer 136 is selected from a group of a silicon oxide layer, a tantalum oxide layer, a, a hafnium oxide layer, an aluminum oxide layer, and a magnesium nitride layer or
25 mixture thereof.

Specifically, in this embodiment, the first layer 132 and the second layer 136 may be titanium oxide layers, and the insulating layer 134 may be a silicon oxide layer.

30 By constituting the covering layer 130 with a stacked structure of the plural layers, the covering layer 130 can be formed to be a highly compressive stressed layer.

The thickness of the first layer 132 may be greater than or equal to 50 nm, more preferably, greater than or equal to 100 nm. Further, the thickness of the second layer 136 may be greater than or equal to 50 nm, more preferably, greater than or equal to 100 nm. Further, the thickness of the insulating layer 134 is not specifically limited but may be greater than or equal to 20 nm, more preferably, greater than or equal to 100 nm.

Further, the covering layer 130 may include further more layers.

(Example)

A $\text{TiO}_2/\text{SiO}_2/\text{TiO}_2$ layer (thicknesses of which are 100/180/40 nm, respectively) as the covering layer 130 is formed on a soda-lime glass (thickness of which is 2.6 nm, including about 480 ppm of water) as the translucent glass substrate 110. Then, an ITO layer (thickness of which is 150 nm) as the translucent electrode 140 is formed on the covering layer 130. Subsequently, the structure is annealed at between 600 to 700 °C for at least 5 minutes. Then, bubbles as the scattering bodies 122 appear at the lower TiO_2 /glass interface. Fig. 5 is a cross-sectional view showing the bubbles generated by the heat treatment in this example. It is confirmed that the bubbles as the scattering bodies 122 selectively exist at the lower TiO_2 /glass interface. Further, it is confirmed that the difference between the refractive index 1.52 of the soda-lime glass (as the base glass material 120) and the refractive index of the scattering bodies 122 is 0.2 or more (the refractive index of

the scattering bodies 122 is 1 for voids).

Then, simulation is performed. Calculations by optical simulations demonstrate that the structure obtained in the example can enhance the out-coupling and help to stabilize emitted color. After optimization of the layers, it is confirmed that for this structure, compared with a structure without forming the scattering bodies 122 (without performing the heat treatment), the EQE is increased and color mixing is improved. Further, the conductivity of ITO is increased while the absorption is reduced thank to the annealing.

When a TiO_2 layer is used as the covering layer, the same structure including the bubbles is obtained.

Further, when the heat treatment is performed using a fast flash-lamp annealing step ensuring 600 to 700°C at the glass/first layer interface, the same structure including the bubbles is obtained.

Further, the structure of the organic light emitting layer 150 and the reflective electrode 160 are explained in detail in the following.

The organic light emitting layer 150 has a function to emit light, and generally, includes a hole transport layer, an optional electron blocking layer, a light emitting layer, a optional hole blocking layer and an electron transport layer as well as a top reflective or semi reflective cathode. Here, as long as the organic light emitting layer 150 includes the light emitting layer, it is not necessary to include all of the other layers. Generally, the refraction

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index of the organic light emitting layer 150 is within a range of 1.7 to 1.9.

For the material of the hole injection layer, a high molecular material or a low molecular material is generally used. Among the high molecular materials, polyethylenedioxythiophene (PEDOT: PSS) doped with polystyrene sulfonic acid (PSS) may be used. Among the low molecular materials, copper phthalocyanine (CuPc) of a phthalocyanine system may be used.

The hole transport layer has a function to transfer the holes injected by the hole injection layer to the light emitting layer. For the hole transport layer, a triphenylamine derivative, N,N'-Bis(1-naphthyl)-N,N'-Diphenyl-1,1'-biphenyl-4,4'-diamine (NPD), N,N'-Diphenyl-N,N'-Bis[N-phenyl-N-(2-naphthyl)-4'-aminobiphenyl-4-yl]-1,1'-biphenyl-4,4'-diamine (NPTE), 1,1'-bis[(di-4-tolylamino)phenyl]cyclohexane (HTM2), N,N'-Diphenyl-N,N'-Bis(3-methylphenyl)-1,1'-diphenyl-4,4'-diamine (TPD) or the like may be used, for example.

The thickness of the hole transport layer is within a range of 10 nm to 250 nm, for example. However, the thickness is generally within a range of 10 nm to 150 nm in view of an interelectrode short circuit problem.

The light emitting layer has a function to provide a field at which the injected electrons and the holes are recombined. For the organic luminescent material, a low molecular material or a high molecular material may be generally used.

The light emitting layer may be, for example,

a metal complex of quinoline derivative such as tris(8-quinolinolate) aluminum complex (Alq_3), bis(8-hydroxy) quinaldine aluminum phenoxide ($\text{Alq}'20\text{Ph}$), bis(8-hydroxy) quinaldine aluminum-
5 2,5-dimethylphenoxide (BALq), mono(2,2,6,6-tetramethyl-3,5-heptanedionate)lithium complex (Liq), mono(8-quinolinolate)sodium complex (Naq), mono(2,2,6,6-tetramethyl-3,5-heptanedionate)lithium complex, mono(2,2,6,6-tetramethyl-3,5-
10 heptanedionate) sodium complex, bis(8-quinolinolate) calcium complex (Caq_2) and the like, or a fluorescent substance such as tetraphenylbutadiene, phenylquinacridone (QD), anthracene, perylene, coronene and the like.

15 As for the host material, a quinolinolate complex may be used, especially, an aluminum complex having 8-quinolinol or a derivative thereof as a ligand may be used.

The electron transport layer has a function
20 to transport electrons injected from the electrode. For the electron transport layer, for example, a quinolinol aluminum complex (Alq_3), an oxadiazole derivative (for example, 2,5-bis(1-naphthyl)-1,3,4-oxadiazole (END), 2-(4-t-butylphenyl)-5-(4-
25 biphenyl)-1,3,4-oxadiazole (PBD) or the like), a triazole derivative, a bathophenanthroline derivative, a silole derivative or the like may be used.

For the reflective electrode 160, a metal or
30 a metallic alloy is used. The reflective electrode 160 may be, for example, alkali metal, alkaline earth metal, metals in group 3 of the periodic table and the like. The reflective

electrode 160 may be, for example, silver (Ag), aluminum (Al), magnesium (Mg), the alloy of these metals and the like.

Although a preferred embodiment of the
5 electrode-attached translucent substrate, the photonic device, and the method of manufacturing the electrode-attached translucent substrate has been specifically illustrated and described, it is
10 to be understood that minor modifications may be made therein without departing from the spirit and scope of the invention as defined by the claims.

Although the OLED is exemplified for the photonic device in the above embodiment, the photonic device may be an optoelectronic device
15 capable of emitting and collecting light other than the OLED, a light collector such as an organic photovoltaic cell (a solar cell) or the like.

The present invention is not limited to the
20 specifically disclosed embodiments, and variations and modifications may be made without departing from the scope of the present invention.

CLAIMS

5

Claim 1. An electrode-attached translucent substrate comprising:

- a translucent glass substrate including a base glass material and scattering bodies
- 10 dispersed in the base glass material;
- a covering layer including a first layer made of a material selected from a group of a nitride, oxide and oxynitride directly formed on the translucent glass substrate; and
- 15 a translucent electrode formed on the covering layer.

20

Claim 2. The electrode-attached translucent substrate according to claim 1,

- wherein in the translucent glass substrate, the scattering bodies are selectively positioned
- 25 at an interface with the covering layer.

30 Claim 3. The electrode-attached translucent substrate according to claim 1,

- wherein the scattering bodies are pores in the base glass material.

5 Claim 4. The electrode-attached translucent substrate according to claim 1,

wherein the first layer of the covering layer is selected from a group of a titanium oxide layer, a zirconium oxide layer, a tantalum oxide layer, a
10 tin oxide layer, a zinc oxide layer, a niobium oxide layer, a hafnium oxide layer, an aluminum oxide, nitride, oxynitride or oxide layer, a silicon nitride or oxynitride layer, and a magnesium nitride layer or any mixture thereof.

15

Claim 5. The electrode-attached translucent
20 substrate according to claim 1,

wherein the covering layer includes a stacked structure of

the first layer,

an insulating layer formed on the first
25 layer, and

a second layer formed on the insulating layer and made of a material selected from the group of a metal nitride, a metal oxide and a metal nitride-oxide.

30

Claim 6. The electrode-attached translucent substrate according to claim 5,

wherein the first layer and the second layer of the covering layer are selected from a group of
5 a titanium oxide layer, a zirconium oxide layer, a tantalum oxide layer, a tin oxide layer, a zinc oxide layer, a tin oxide layer, a zinc oxide layer, a niobium oxide layer, a hafnium oxide layer, an aluminum oxide, nitride or oxynitride layer, a
10 silicon nitride or oxynitride layer, and a magnesium nitride layer or any mixture thereof.

15

Claim 7. The electrode-attached translucent substrate according to claim 5,

wherein the first layer and the second layer are titanium oxide based layers and the insulating
20 layer is mainly made of silicon oxide or aluminium based oxide or mixture thereof.

25

Claim 8. The electrode-attached translucent substrate according to claim 1,

wherein the translucent electrode includes a conductive layer based on silver or on a silver
30 based alloy formed on a zinc oxide based layer having a function of insulation.

Claim 9. The electrode-attached translucent substrate according to claim 1,

5 wherein the thickness of the covering layer is more than or equal to 50 nm.

10

Claim 10. A photonic device comprising:

the electrode-attached translucent substrate according to claim 1;

15 an organic light emitting layer formed on the translucent electrode; and

a reflective or semi-reflective electrode formed on the organic light emitting layer.

20

Claim 11. A method of manufacturing an electrode-attached translucent substrate, comprising:

25 forming a covering layer directly on a translucent glass substrate including a base glass material, the covering layer including a first layer made of a material selected from a group of a nitride, oxide and oxynitride directly formed on the translucent glass substrate;

30 forming a translucent electrode on the covering layer; and

performing a heat treatment on the covering layer and the translucent glass substrate such

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that scattering bodies are generated to be dispersed in the base glass material of the translucent glass substrate.

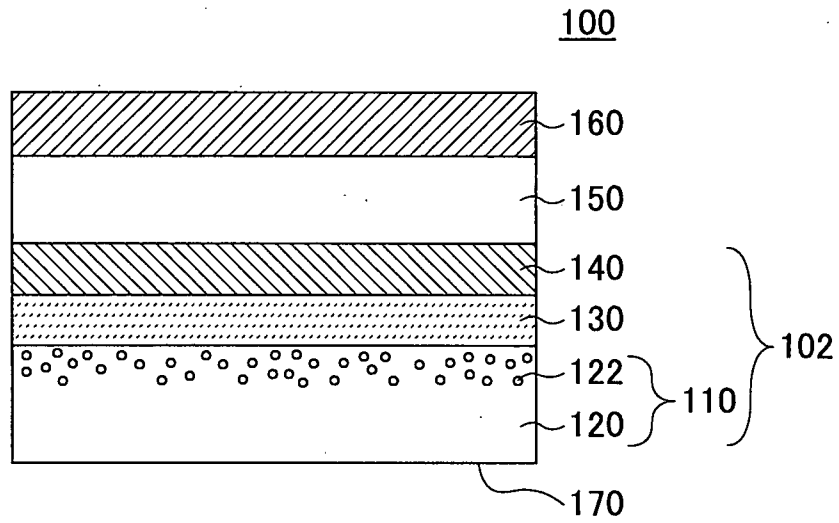
5

Claim 12. The method of manufacturing an electrode-attached translucent substrate according to claim 11,

10 wherein the translucent glass substrate includes more than or equal to 320 ppm of water.

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FIG. 1



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FIG.2

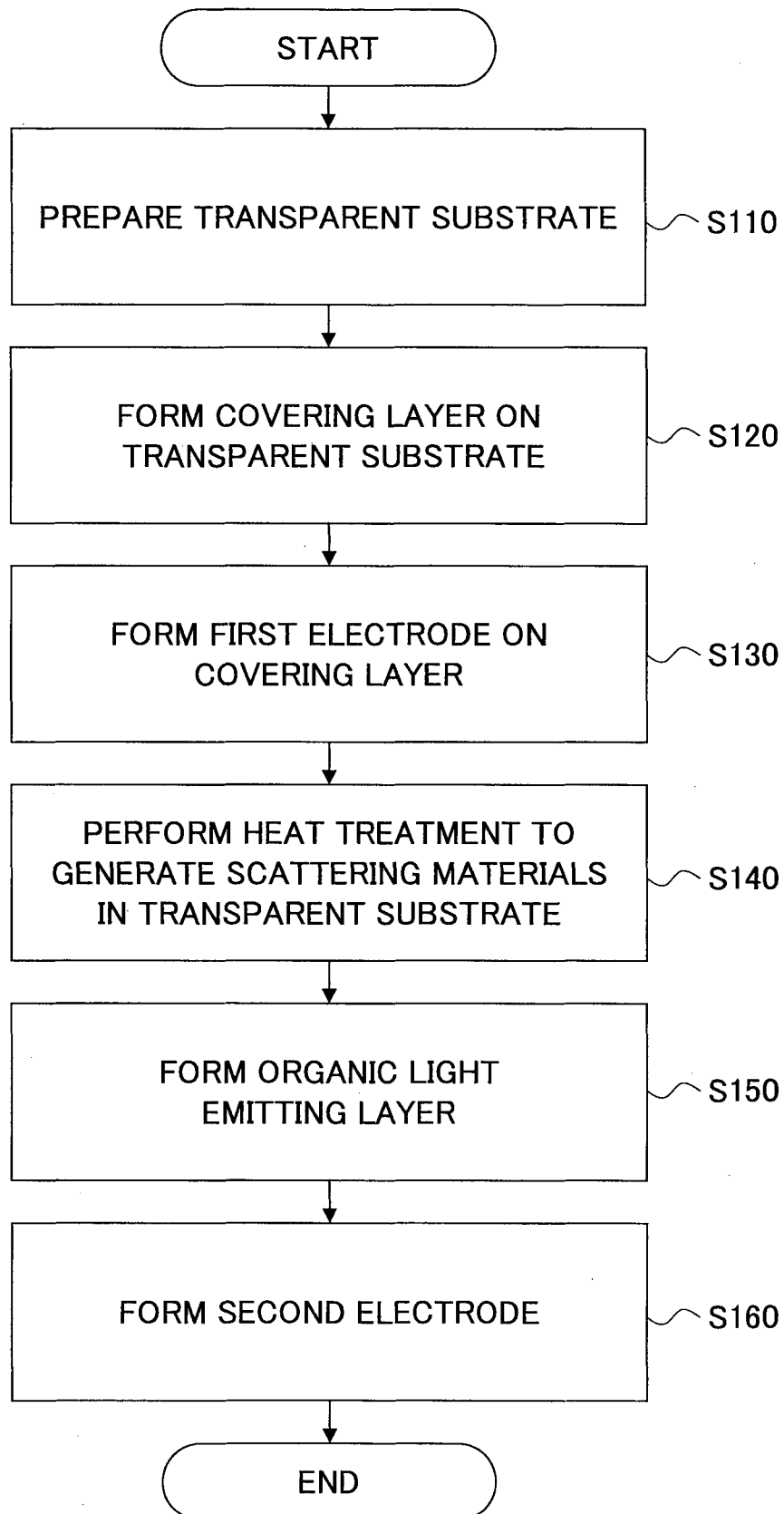


FIG.3A

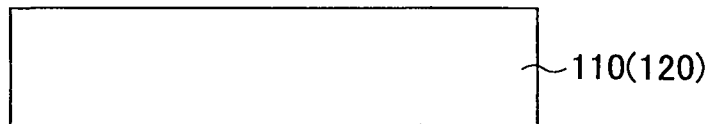


FIG.3B

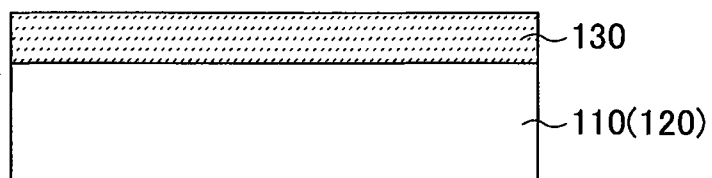
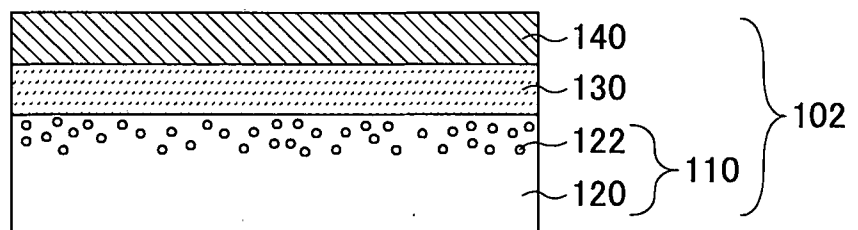


FIG.3C



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FIG.4

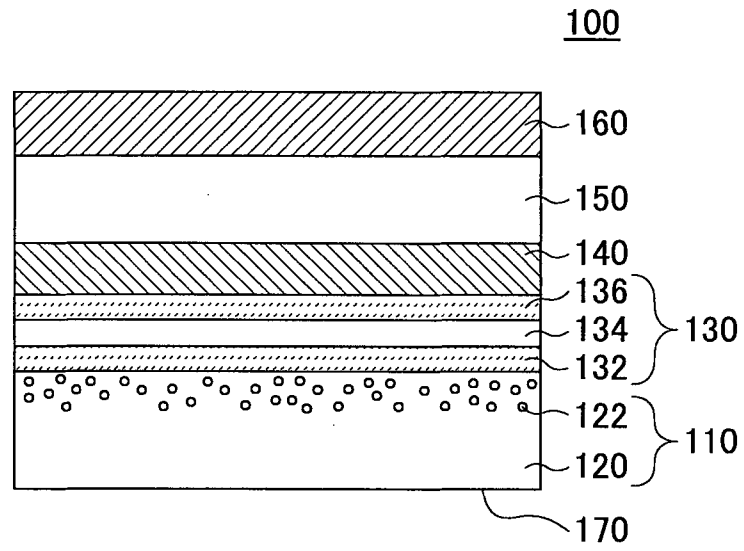
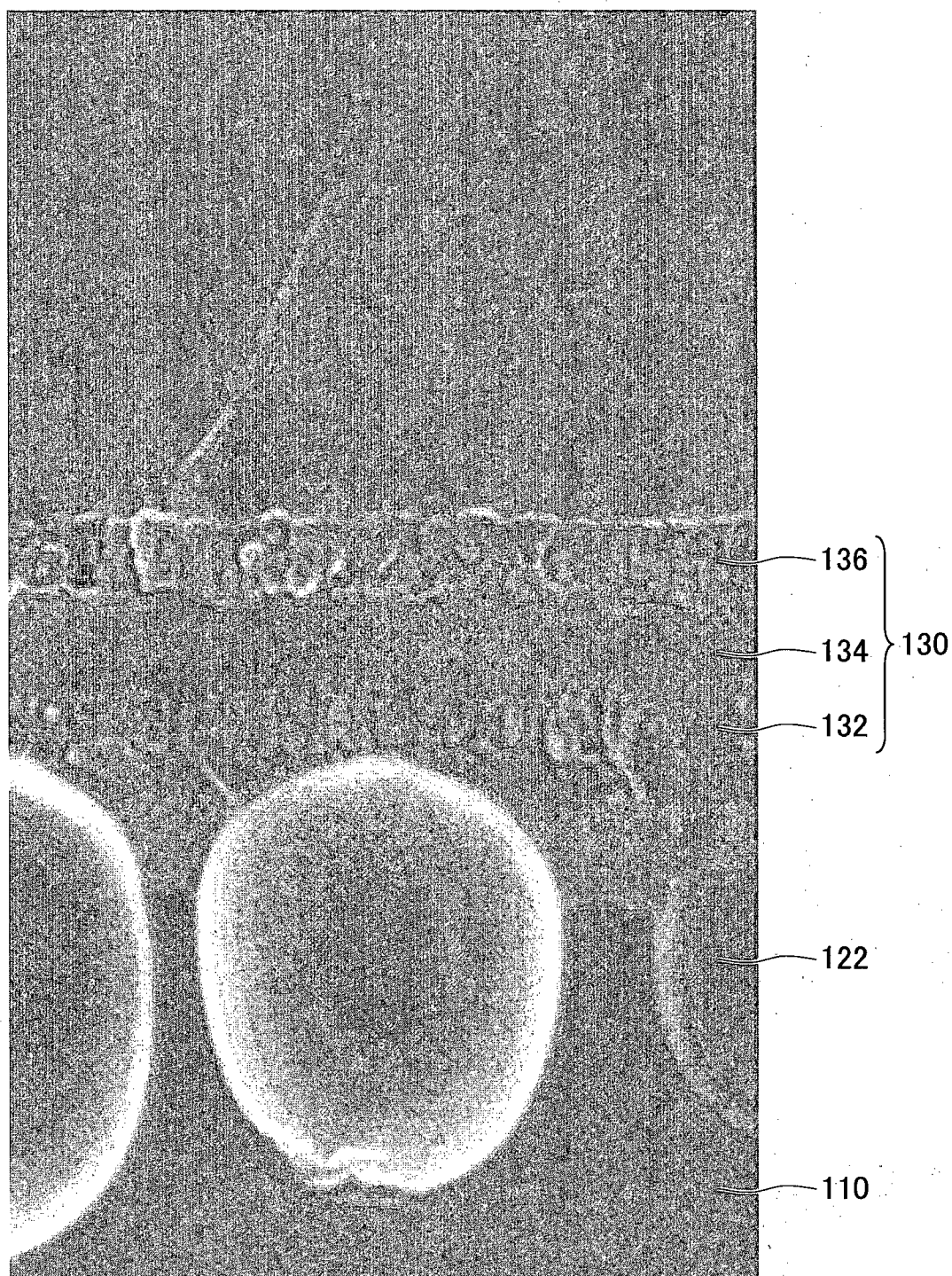


FIG.5



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2013/072039

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L51/00 H01L51/52 G02B5/02 C03C17/00
ADD.

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)
H01L G02B C03C

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 practicable, search terms used)

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	WO 2010/112786 A2 (SAINT GOBAIN [FR]; VERMERSCH FRANCOIS-JULIEN [FR]; GASCON HELENE [FR];) 7 October 2010 (2010-10-07)	1-10
A	page 12, line 26 - page 15, line 11; figure 1 page 16, line 12 - page 17, line 12; example 1 page 6, lines 11-17	11,12
X	DE 10 2011 086805 A1 (OSRAM OPTO SEMICONDUCTORS GMBH [DE]) 23 May 2013 (2013-05-23)	1-10
A	paragraphs [0046] - [0061]; figures 1-3 paragraphs [0030] - [0035] abstract	11,12
	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

2 April 2014

Date of mailing of the international search report

10/04/2014

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INTERNATIONAL SEARCH REPORT

International application No

PCT/JP2013/072039

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	page 6, line 4 - page 15, line 4; figures 1-3 -----	11,12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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