US009837633B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.: US 9,837,633 B2**
(45) **Date of Patent: Dec. 5, 2017**

(54) **ORGANIC LIGHT EMITTING DIODE DISPLAY APPARATUS**

(71) Applicant: **SAMSUNG SDI CO., LTD.**, Yongin-si, Gyeonggi-do (KR)

(72) Inventors: **Ji Yeon Lee**, Suwon-si (KR); **Seong Ryong Nam**, Suwon-si (KR); **Sung Min Ko**, Suwon-si (KR); **Mi Sun Kim**, Suwon-si (KR); **Hye Jin Kim**, Suwon-si (KR); **Mi Jeong Choi**, Suwon-si (KR)

(73) Assignee: **Samsung SDI Co., Ltd.**, Yongin-si, Gyeonggi-do (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/094,091**

(22) Filed: **Apr. 8, 2016**

(65) **Prior Publication Data**

US 2016/0372704 A1 Dec. 22, 2016

(30) **Foreign Application Priority Data**

Jun. 19, 2015 (KR) 10-2015-0087824

(51) **Int. Cl.**
H01L 51/52 (2006.01)
H01L 27/32 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 51/5253*** (2013.01); ***H01L 27/3244*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,093,666 B2 * 7/2015 Young H01L 51/5237
2008/0278070 A1 11/2008 Kim
2015/0252125 A1 * 9/2015 Moro C08F 230/08
428/447

FOREIGN PATENT DOCUMENTS

KR 10-2011-0071039 A 6/2011
WO WO 2014/109455 A1 7/2014

OTHER PUBLICATIONS

U.S. Appl. No. 15/094,049, filed Apr. 8, 2016.
U.S. Office action dated Mar. 20, 2017, in U.S. Appl. No. 15/094,049.

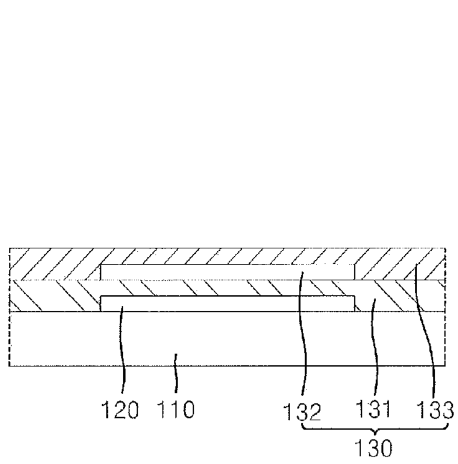
* cited by examiner

Primary Examiner — Michelle Mandala
(74) *Attorney, Agent, or Firm* — Lee & Morse, P.C.

(57) **ABSTRACT**

Disclosed is an organic light emitting diode display apparatus including: a substrate; an organic light emitting diode disposed on the substrate; and an encapsulation layer encapsulating the organic light emitting diode. The encapsulation layer has a structure in which two or more inorganic layers and one or more organic layers are alternately stacked one above another, each of the inorganic layers has a thickness of about 40 nm to about 1000 nm and an index of refraction of about 1.41 to about 2.0, each of the organic layers has a thickness of about 0.2 μm to about 15 μm and an index of refraction of about 1.4 to about 1.65, and the organic layers are formed of an encapsulating composition. The encapsulating composition includes: about 10 wt % to about 70 wt % of (A) a non-silicon-based di(meth)acrylate, about 20 wt % to about 70 wt % of (B) a silicon-based di(meth)acrylate, about 5 wt % to about 40 wt % of (C) a mono(meth)acrylate, and about 1 wt % to about 10 wt % of (D) an initiator, the (B) silicon-based di(meth)acrylate being represented by Formula 1.

12 Claims, 1 Drawing Sheet



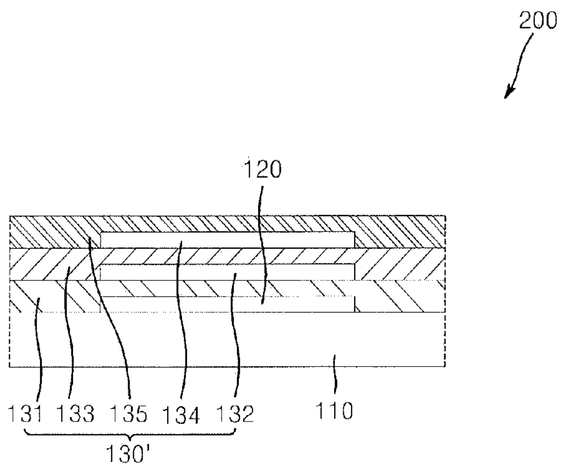


FIG. 1

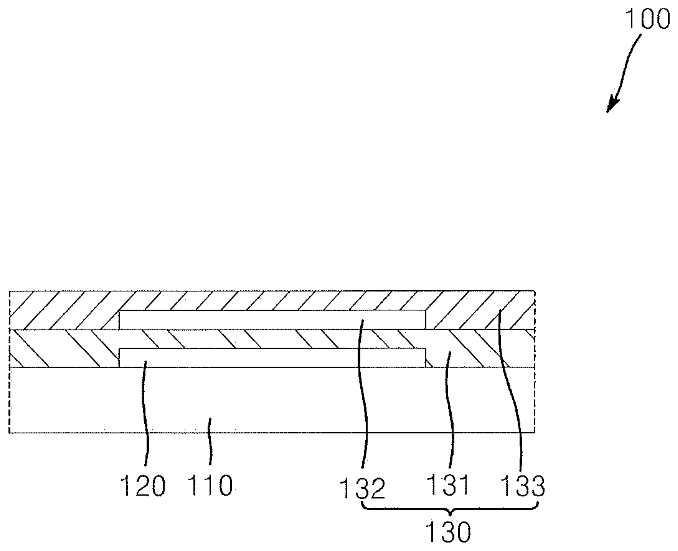
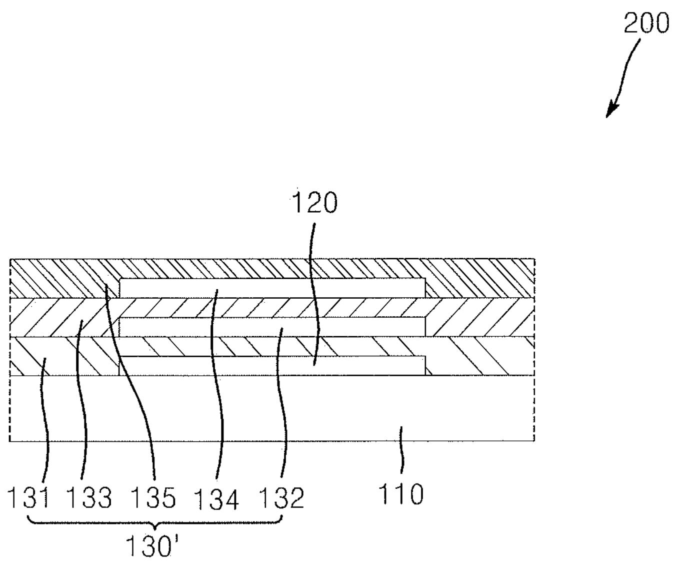


FIG. 2



ORGANIC LIGHT EMITTING DIODE DISPLAY APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Korean Patent Application No. 10-2015-0087824, filed on Jun. 19, 2015 in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to an organic light emitting diode display apparatus.

DESCRIPTION OF THE RELATED ART

Organic light emitting diodes are vulnerable to moisture and/or gas. Organic light emitting diodes can suffer from delamination at an interface between a metal field and a light emitting layer due to moisture. The organic light emitting diodes can have high resistance due to oxidation of metals and can suffer from degradation of organic materials in the light emitting layer due to moisture and/or oxygen. The organic light emitting diode can suffer from deterioration in light emission due to oxidation of the light emitting layer or the metal field by outgassing inside or outside the organic light emitting diodes. Thus, the organic light emitting diode must be encapsulated by an encapsulation composition capable of protecting the organic light emitting diode from moisture and/or gas.

The organic light emitting diode can be encapsulated by an encapsulation layer having a multilayer structure in which organic layers and inorganic layers are alternately stacked one above another. The organic layers can be formed by plasma deposition. However, the organic layers can be etched by plasma. Etching of the organic layers can deteriorate an encapsulation function of the organic layers and provide adverse influence on formation of the inorganic layers. Each of the organic layers is formed between two adjacent inorganic layers. If the organic layers exhibit low resistance to plasma, there can be difficulty in formation of the inorganic layers. As a result, the organic light emitting diode can suffer from deterioration in luminous characteristics and reliability.

The encapsulation layer includes a plurality of inorganic layers on a substrate. Thus, the encapsulation layer can suffer from slight lifting between the inorganic layers and/or delamination or slight lifting between the substrate and the inorganic layer. As a result, the inorganic layers cannot sufficiently prevent moisture and/or oxygen from penetrating the organic light emitting diode.

The background technique of the present invention is disclosed in Korean Patent Laid-open Publication No. 2011-0071039.

SUMMARY OF THE INVENTION

It is one aspect of the present invention to provide an organic light emitting diode display apparatus that includes an organic layer exhibiting high plasma resistance.

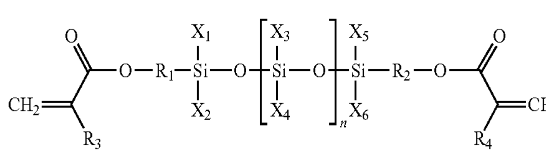
It is another aspect of the present invention to provide an organic light emitting diode display apparatus that includes an organic layer having considerably low water vapor permeability and oxygen permeability.

It is a further aspect of the present invention to provide an organic light emitting diode display apparatus that includes an organic layer exhibiting excellent transparency.

It is yet another aspect of the present invention to provide an organic light emitting diode display apparatus that includes an organic layer capable of securing reliability in elapsed time by protecting the organic light emitting diode display apparatus from surroundings including moisture and gas.

It is yet another aspect of the present invention to provide an organic light emitting diode display apparatus that secures light extraction efficiency for driving the organic light emitting diode display apparatus with low power.

In accordance with one aspect of the present invention, an organic light emitting diode display apparatus includes: a substrate; an organic light emitting diode disposed on the substrate; and an encapsulation layer encapsulating the organic light emitting diode, wherein the encapsulation layer has a structure in which two or more inorganic layers and one or more organic layers are alternately stacked one above another, each of the inorganic layers having a thickness of about 40 nm to about 1000 nm and an index of refraction of about 1.41 to about 2.0, each of the organic layers having a thickness of about 0.2 μm to about 15 μm and an index of refraction of about 1.4 to about 1.65, the organic layers being formed of an encapsulating composition, and wherein the encapsulating composition includes about 10 wt % to about 70 wt % of (A) a non-silicon-based di(meth)acrylate, about 20 wt % to about 70 wt % of (B) a silicon-based di(meth)acrylate, about 5 wt % to about 40 wt % of (C) a mono(meth)acrylate, and about 1 wt % to about 10 wt % of (D) an initiator, the (B) silicon-based di(meth)acrylate being represented by Formula 1:



(where R_1, R_2, R_3, R_4, X_1, X_2, X_3, X_4, X_5, X_6, and n are the same as defined in the following detailed description).

The present invention provides an organic light emitting diode display apparatus that includes an organic layer exhibiting high plasma resistance.

The present invention provides an organic light emitting diode display apparatus that includes an organic layer having considerably low water vapor permeability and oxygen permeability.

The present invention provides an organic light emitting diode display apparatus that includes an organic layer exhibiting excellent transparency.

The present invention provides an organic light emitting diode display apparatus that includes an organic layer capable of securing reliability in elapsed time by protecting the organic light emitting diode display apparatus from surroundings including moisture and gas.

The present invention provides an organic light emitting diode display apparatus that secures light extraction efficiency for driving the organic light emitting diode display apparatus with low power.

The present invention provides an organic light emitting diode display apparatus, in which two adjacent inorganic layers are formed to contact each other to prevent slight lifting and/or delamination between the inorganic layers or between a substrate and an inorganic layer, thereby suppressing permeation of moisture and/or oxygen into an encapsulation layer through an edge thereof.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a sectional view of an organic light emitting diode display apparatus in accordance with one embodiment of the present invention.

FIG. **2** is a sectional view of an organic light emitting diode display apparatus in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings. It should be understood that the present invention is not limited to the following embodiments and may be embodied in different ways, and that the following embodiments are given to provide complete disclosure of the invention and to provide a thorough understanding of the invention to those skilled in the art. It should be noted that the drawings are not to precise scale and some of the dimensions, such as width, length, thickness, and the like, are exaggerated for clarity of description in the drawings. Further, although only a portion of a component is illustrated for convenience of description, other portions of the component can become apparent to those skilled in the art. Furthermore, it should be understood that the present invention can be realized in various ways by those skilled in the art without departing from the spirit and scope of the invention.

As used herein, spatially relative terms such as "upper" and "lower" are defined with reference to the accompanying drawings. Thus, it will be understood that "upper" can be used interchangeably with "lower". It will be understood that when a layer is referred to as being "on" another layer, it can be directly formed on the other layer, or intervening layer(s) may also be present. Thus, it will be understood that when a layer is referred to as being "directly on" another layer, no intervening layer is interposed therebetween.

As used herein, the term "(meth)acryl" refers to acryl and/or methacryl.

Unless otherwise stated herein, the term "substituted" means that at least one hydrogen atom in a functional group is substituted with a halogen atom (for example (F, Cl, Br or I), a hydroxyl group, a nitro group, a cyano group, an imino group (=NH, =NR, R being a C_1 to C_{10} alkyl group)), an amino group (—NH_2, —NH(R'), —N(R")(R'"), R', R" and R'" each being independently a C_1 to C_{10} alkyl group), an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group, a C_1 to C_{20} alkyl group, a C_6 to C_{30} aryl group, a C_3 to C_{30} cycloalkyl group, a C_3 to C_{30} heteroaryl group, or a C_2 to C_{30} heterocycloalkyl group.

As used herein, the term "aryl group" refers to a functional group in which all elements of a cyclic substituent have p-orbitals and these p-orbitals are conjugated. The aryl group includes monocyclic, non-fused polycyclic or fused polycyclic functional groups. Here, the term "fused" means that a pair of carbon atoms is shared by contiguous rings. The aryl group also includes biphenyl groups, terphenyl groups, or quaterphenyl groups, in which at least two aryl groups are connected to each other through a sigma bond. The aryl group may refer to a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, a chrysenyl group, and the like.

As used herein, the term "heteroaryl group" refers to a functional group in which an aryl group contains 1 to 3 hetero atoms selected from the group consisting of N, O, S, P and Si, and the other atoms in the aryl group are carbon. The heteroaryl group also includes a functional group in which at least two heteroaryl groups are directly connected through a sigma bond. The heteroaryl group also includes a functional group in which at least two heteroaryl groups are fused. If the heteroaryl groups are fused, each ring may include 1 to 3 heteroatoms as set forth above. The heteroaryl group may refer to, for example, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, and the like.

More specifically, the C_6 to C_{30} aryl group and/or the C_3 to C_{30} heteroaryl group may be a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphtyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted phenanthryl group, a substituted or unsubstituted naphthacenyl group, a substituted or unsubstituted pyrenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted p-terphenyl group, a substituted or unsubstituted m-terphenyl group, a substituted or unsubstituted chrysenyl group, a substituted or unsubstituted triphenylenyl group, a substituted or unsubstituted phenylenyl group, a substituted or unsubstituted indenyl group, a substituted or unsubstituted furanyl group, a substituted or unsubstituted thiophenyl group, a substituted or unsubstituted pyrrolyl group, a substituted or unsubstituted pyrazoyl group, a substituted or unsubstituted imidazolyl group, a substituted or unsubstituted triazolyl group, a substituted or unsubstituted oxazolyl group, a substituted or unsubstituted thiazolyl group, a substituted or unsubstituted oxadiazolyl group, a substituted or unsubstituted thiadiazolyl group, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted pyrimidinyl group, a substituted or unsubstituted pyrazinyl group, a substituted or unsubstituted triazinyl group, a substituted or unsubstituted benzofuranyl group, a substituted or unsubstituted benzothiophenyl group, a substituted or unsubstituted benzimidazolyl group, a substituted or unsubstituted indolyl group, a substituted or unsubstituted quinolinyl group, a substituted or unsubstituted isoquinolinyl group, a substituted or unsubstituted quinazolinyl group, a substituted or unsubstituted quinoxalinyl group, a substituted or unsubstituted naphthyridinyl group, a substituted or unsubstituted benzoxazinyl group, a substituted or unsubstituted benzothiazinyl group, a substituted or unsubstituted acridinyl group, a substituted or unsubstituted phenazinyl group, a substituted or unsubstituted phenothiazinyl group, a substituted or unsubstituted phenoxazinyl group, a substituted or unsubstituted dibenzofuranyl group, a substituted or unsubstituted dibenzothiophenyl group, or combinations thereof, without being limited thereto.

As used herein, the term "etching rate of an organic layer due to plasma" or "plasma etching rate" refers to a value calculated by Equation 2 after the following procedures: an initial height T1 (unit: μm) of an organic layer, which is formed by depositing an encapsulating composition to a predetermined thickness and photocuring the composition, is measured, followed by measuring height T2 (unit: μm) of the organic layer after plasma treatment under conditions of inductively coupled plasma (ICP) power: 2500 W, radio frequency (RF) power: 300 W, DC bias: 200 V, Ar flow: 50 sccm, etching time: 1 min and pressure: 10 mtorr. Here, the initial height (T1) of the organic layer may range from about 1 μm to about 10 μm. The value calculated by Equation 2 is inversely proportional to plasma resistance of the organic layer.

$$\text{Etching rate of organic layer due to plasma (\%)} = (T1-T2)/T1\times 100 \qquad \text{<Equation 2>}$$

As used herein, the tern "index of refraction" means a value measured with respect to an organic layer or an inorganic layer by spectroscopic ellipsometry.

The organic light emitting diode display apparatus according to the present invention includes a substrate; an organic light emitting diode disposed on the substrate; and an encapsulation layer encapsulating the organic light emitting diode, wherein the encapsulation layer has a structure in which two or more inorganic layers and one or more organic layers are alternately stacked one above another, each of the inorganic layers has a thickness of about 40 nm to about 1000 nm and an index of refraction of about 1.41 to about 2.0, each of the organic layers has a thickness of about 0.2 μm to about 15 μm and an index of refraction of about 1.4 to about 1.65, and the organic layers may be formed of an encapsulating composition.

The encapsulating composition according to the present invention can realize an organic layer having excellent plasma resistance. Accordingly, in the organic light emitting diode display apparatus according to the present invention, such an organic layer is formed between the inorganic layers to realize an effect of blocking permeation of external moisture and oxygen by blocking defects of the inorganic layers while flattening the inorganic layers, thereby realizing a thin thickness of the encapsulation layer.

The encapsulating composition according to the present invention can realize an organic layer exhibiting significantly low water vapor permeability and oxygen permeability. Accordingly, the organic light emitting diode display apparatus according to the present invention can further suppress permeation of external moisture and/or oxygen into the organic light emitting diode while improving reliability of the organic light emitting diode in elapsed time.

Each of the inorganic layers may have a thickness of about 40 nm to about 1000 nm and an index of refraction of about 1.41 to about 2.0. Within these ranges, the inorganic layers can block permeation of external moisture and/or oxygen into the organic light emitting diode while securing light extraction efficiency. Specifically, each of the inorganic layers may have a thickness of about 100 nm to about 1000 nm and an index of refraction of about 1.41 to about 1.8. Within these ranges, the inorganic layers can secure light extraction efficiency while exhibiting transparency.

Each of the organic layers may have a thickness of about 0.2 μm to about 15 μm and an index of refraction of about 1.4 to about 1.65. within these ranges, the organic layers can realize effects of blocking permeation of external moisture and oxygen, and can secure light extraction efficiency by blocking defects of the inorganic layers while flattening the inorganic layers, thereby realizing a thin thickness of the encapsulation layer. Specifically, each of the organic layers may have a thickness of about 1 μm to about 15 μm, for example, about 1 μm, about 2 μm, about 3 μm, about 4 μm, about 5 μm, about 6 μm, about 7 μm, about 8 μm, about 9 μm, or about 10 μm, and an index of refraction of, for example, about 1.4, about 1.45, about 1.5, about 1.55, or about 1.6. Within these ranges, the organic layers can more efficiently block defects of the inorganic layers while flattening the inorganic layers and can secure further improved light extraction efficiency while exhibiting transparency.

The inorganic layers and the organic layers may have the same or difference indexes of refraction and/or the same or different thicknesses.

For example, in the organic light emitting diode display apparatus according to the present invention, the inorganic layers include a first inorganic layer and a second inorganic layer; the organic layer includes a first organic layer; and the encapsulation layer includes the first inorganic layer, the first organic layer, and the second inorganic layer alternately stacked one above another.

The encapsulation layer may have a structure wherein the first inorganic layer and the second inorganic layer are sequentially stacked at an edge thereof. In one embodiment, the first inorganic layer and the second inorganic layer may have the same area. In another embodiment, the second inorganic layer may be formed to surround the first organic layer. In other embodiments, the inorganic layers may have the same area or may have a gradually increasing area with increasing distance from the organic light emitting diode.

Next, an organic light emitting diode display apparatus according to one embodiment of the invention will be described with reference to FIG. **1**. FIG. **1** is a partially sectional view of an organic light emitting diode display apparatus in accordance with one embodiment of the invention.

Referring to FIG. **1**, an organic light emitting diode display apparatus **100** according to one embodiment includes a substrate **110**, an organic light emitting diode **120**, and an encapsulation layer **130**, which can encapsulate the organic light emitting diode **120**.

The substrate **110** may be disposed under the organic light emitting diode **120** and the encapsulation layer **130** to support the organic light emitting diode **120** and the encapsulation layer **130**. The substrate **110** may include a luminous region in which the organic light emitting diode **120** is formed, and a non-luminous region corresponding to a region excluding the luminous region.

The substrate **110** may be a glass substrate, a quartz substrate or a transparent plastic substrate. The transparent plastic substrate may be applied to flexible products by providing flexibility to the organic light emitting diode display apparatus. The transparent plastic substrate may be formed of at least one among polyimide resins, acrylic resins, polyacrylate resins, polycarbonate resins, polyether resins, polyester resins including polyethylene terephthalate, and sulfonic acid resins, without being limited thereto.

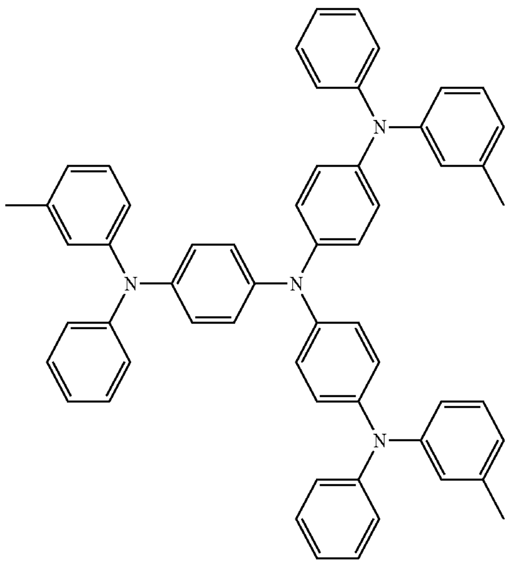
The organic light emitting diode **120** may be formed on the luminous region of the substrate **110** to drive the organic light emitting diode display apparatus. The organic light emitting diode is a self-emissive device and may include a typical structure publicly known in the art.

Specifically, the organic light emitting diode may have a structure wherein an anode, a hole transport region, a light emitting layer, an electron transport region, and a cathode are sequentially stacked in this order. The hole transport region may include at least one of a hole injection layer, a hole transport layer and an electron blocking layer. The electron transport region may include at least one of a hole blocking layer, an electron transport layer and an electron injection layer. Light is emitted from the light emitting layer through recombination of holes generated from the anode and electrons generated from the cathode in the light emitting layer. Details of the anode, the hole transport region, the light emitting layer, the electron transport region, and the cathode are well known to those skilled in the art.

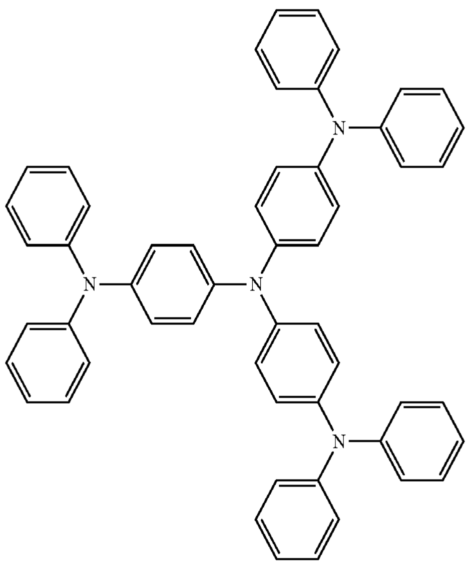
Specifically, the anode may be formed of a material having high work function to allow efficient injection of holes into the light emitting layer. Examples of materials for the anode may include metals such as nickel, platinum, vanadium, chromium, copper, zinc, and gold, metal alloys thereof, metal oxides such as zinc oxide, indium oxide, indium tin oxide, and indium zinc oxide, combinations of metals and metal oxides, such as a combination of zinc oxide and aluminum, a combination or zinc oxide and antimony. The cathode may be formed of a material having low work function to allow easy injection of electrons into an organic light emitting layer. Examples of materials for the cathode may include metals such as magnesium, calcium, sodium, potassium, titanium, indium, yttrium, lithium, gadolinium, aluminum, silver, tin, lead, cesium, barium, or metal alloys thereof.

The light emitting layer may include a material known to those skilled in the art. For example, the light emitting layer may include fluorine derivatives and metal complexes, without being limited thereto.

The hole transport region may be formed of materials such as m-MTDATA, TDATA, 2-TNATA, NPB, β-NPB, TPD, Spiro-TPD, Spiro-NPB, α-NPB, TAPC, HMTPD, PEDOTT/PSS (poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate), and PANI/PSS (polyaniline/poly(4-styrenesulfonate) as follows, without being limited thereto.

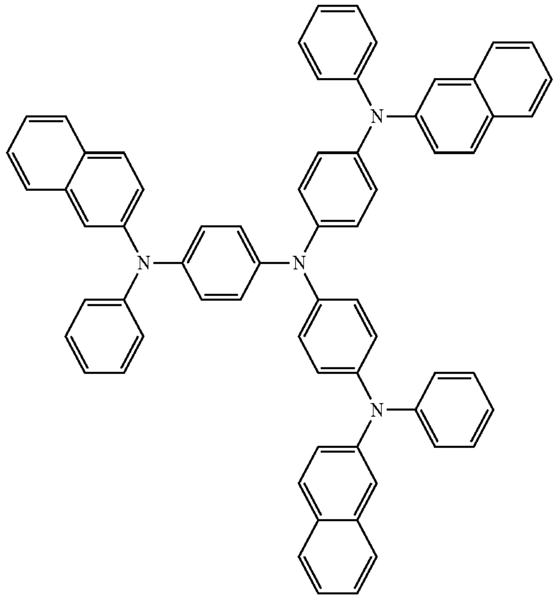


m-MTDATA

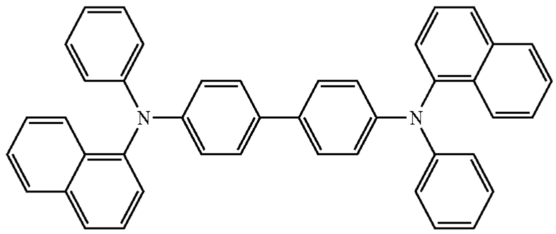


TDATA

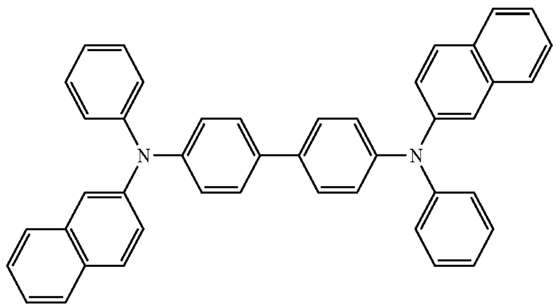
-continued



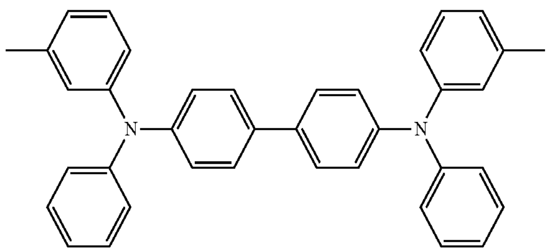
2-TNATA



NPB

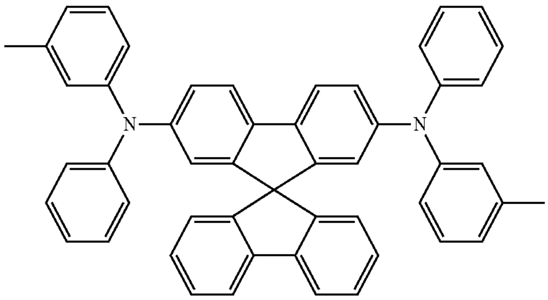


β-NPB

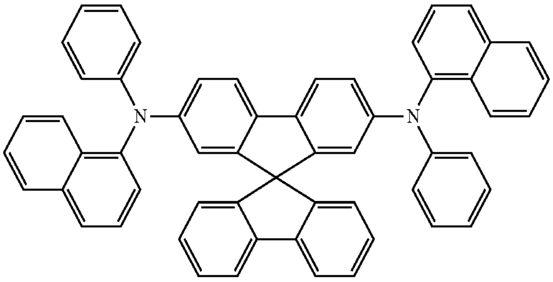


TPD

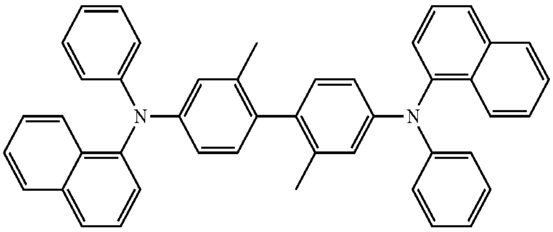
-continued



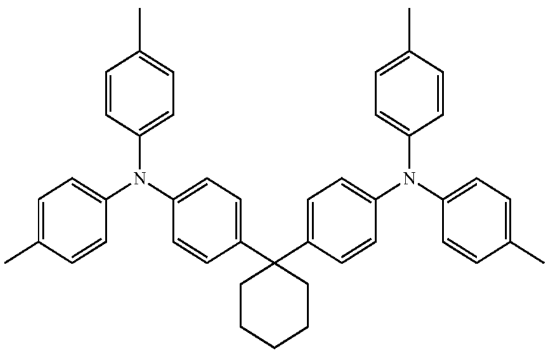
Spiro-TPD



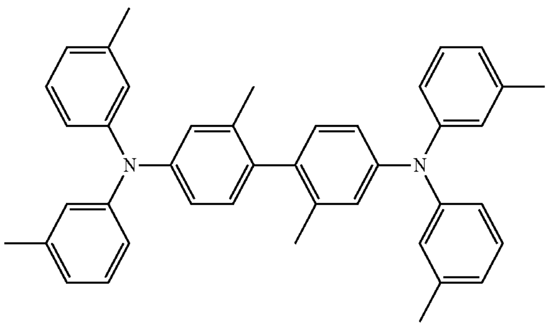
Spiro-NPB



α-NPB

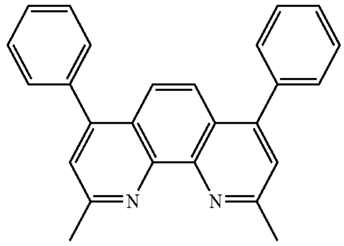


TAPC

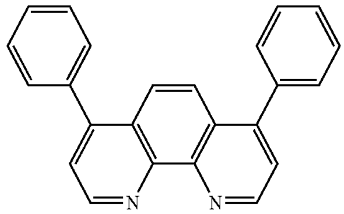


HMTPD

In the electron transport region, the hole blocking layer may include at least one of BCP and Bphen as follows, without being limited thereto.

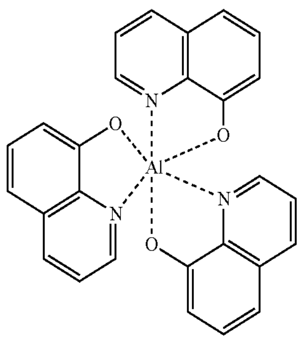


BCP

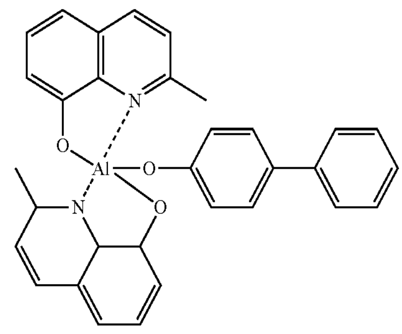


Bphen

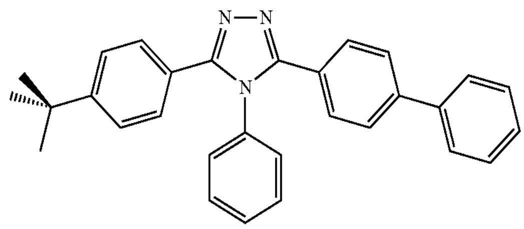
The electron transport layer may include at least one of BCP and Bphen as above, and Alq_3, BAlq, TAZ, NTAZ, ET1, and ET2 as follows, without being limited thereto.



Alq_3

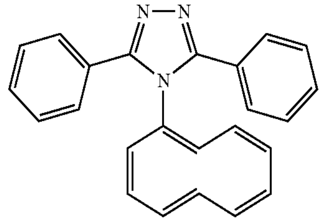


BAlq



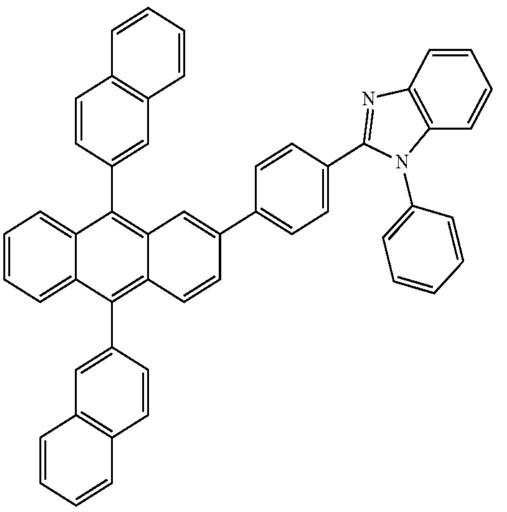
TAZ

-continued

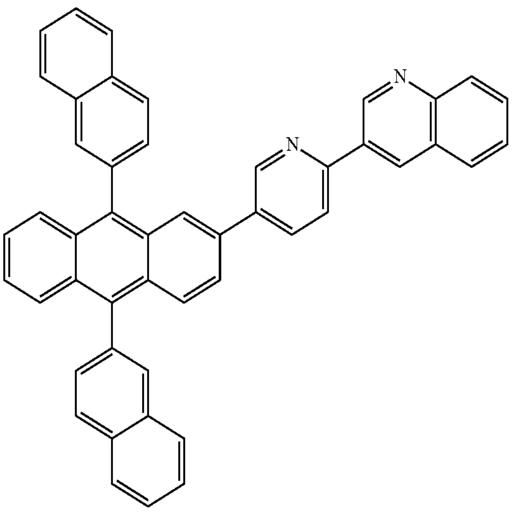


NTAZ

ET1



ET2



The electron injection layer may include at least one of LiF, NaCl, CsF, Li_2O, and BaO, without being limited thereto:

The encapsulation layer **130** may be directly formed on the organic light emitting diode **120** to encapsulate the organic light emitting diode **120**. Herein, the expression "directly formed on" means that no adhesive layer, bonding layer and/or air layer is interposed between the encapsulation layer and the organic light emitting diode.

The encapsulation layer **130** may have a multilayer structure in which two or more inorganic layers and one or more organic layers are alternately stacked one above another. FIG. **1** shows an organic light emitting diode display apparatus including an encapsulation layer in which two inorganic layers and one organic layer are alternately stacked in a total of three layers. Specifically, FIG. **1** shows an organic light emitting diode display apparatus including an encapsulation layer in which a first inorganic layer **131**, a first organic layer **132**, and a second inorganic layer **133** are alternately stacked. In other embodiments, the encapsulation layer may have other types of multilayer structure in which the inorganic layers and the organic layers are alternately stacked in a total of 5 to 15 layers, specifically, 5 layers, 6 layers or 7 layers. For example, in the structure wherein the encapsulation layer includes a total of 5 layers, the encapsulation layer may include a first inorganic layer, a first organic layer, a second inorganic layer, a second organic layer, and a third inorganic layer alternately stacked one above another. In the structure wherein the encapsulation layer includes a total of 7 layers, the encapsulation layer may include a first inorganic layer, a first organic layer, a second inorganic layer, a second organic layer, a third inorganic layer, a third organic layer, and a fourth inorganic layer alternately staked one above another. Generally, the outermost layer of the encapsulation layer may be an inorganic layer. With this structure, the organic light emitting diode display apparatus according to the present invention can secure reliability in elapsed time.

For example, in the organic light emitting diode display apparatus according to the present invention, the inorganic layers includes a first inorganic layer and a second inorganic layer; the organic layer includes a first organic layer; and the encapsulation layer includes the first inorganic layer, the first organic layer, and the second inorganic layer alternately stacked one above another, wherein the first inorganic layer and the second inorganic layer may at least partially contact each other. In some embodiments, the encapsulation layer may have a structure wherein the first inorganic layer and the second inorganic layer are sequentially stacked at an edge thereof. Further, in the organic light emitting diode display apparatus according to the present invention, each of the inorganic layers and the organic layers may have a gradually increasing area with increasing distance from the organic light emitting diode.

In the organic light emitting diode display apparatus according to the present invention, the inorganic layers may have the same area or a gradually increasing area with increasing distance from the organic light emitting diode **120**.

Referring to FIG. **1**, the structure of the encapsulation layer wherein the inorganic layers include the first inorganic layer **131** and the second inorganic layer **133**, and the organic layer includes the first organic layer **132** will be described in more detail.

Each of the first inorganic layer **131** and the second inorganic layer **133** has a different composition than the first organic layer **132** and can compensate for effects of the first organic layer **131**. Each of the first and second inorganic layers **131**, **133** can suppress permeation of oxygen or moisture into the organic light emitting diode **120**.

Each of the first inorganic layer **131** and the second inorganic layer **133** has a thickness of about 40 nm to about 1000 nm and an index of refraction of about 1.41 to about 2.0. Within these ranges, the inorganic layers can block permeation of external moisture and/or oxygen into the organic light emitting diode while securing light extraction efficiency.

The first inorganic layer **131** is formed to directly contact the organic light emitting diode **120** and the substrate **110**. With this structure, the first inorganic layer **131** can suppress permeation of external moisture and/or oxygen into the organic light emitting diode **120**. As used herein, the expression "formed to directly contact" means that no adhesive layer, bonding layer and/or air layer is interposed between the organic light emitting diode **120** and the first inorganic layer **131**.

The second inorganic layer **133** is directly formed on the first organic layer **132**. The first organic layer **132** has high plasma resistance. Accordingly, the second inorganic layer **133** can secure a uniform thickness and the encapsulation layer **130** can secure uniform surface roughness.

The second inorganic layer **133** is formed to at least partially contact the first inorganic layer **131**. Thus, the encapsulation layer **130** may have a structure wherein the first inorganic layer **131** and the second inorganic layer **133** are sequentially stacked on the substrate **110**. With this structure, the encapsulation layer **130** can further suppress permeation of external moisture and/or oxygen into the organic light emitting diode **120** while further improving encapsulation functions at side surfaces of the organic light emitting diode **120**. Furthermore, the encapsulation layer **130** can improve reliability of the organic light emitting diode **120** by preventing slight lifting and/or delamination between the first inorganic layer **131** and the second inorganic layer **133**. Referring to FIG. **1**, the encapsulation layer **130** has a structure wherein the first inorganic layer **131** and the second inorganic layer **133** are sequentially stacked at an edge thereof.

The second inorganic layer **133** has a lower surface contacting the first inorganic layer **131**. With this structure, a contact area between the first inorganic layer **131** and the second inorganic layer **133** is enlarged, thereby further improving encapsulation effects. Alternatively, the second inorganic layer **133** may be formed to contact the first inorganic layer **131** at an edge of the second inorganic layer **133**, particularly, a thickness portion or an upper surface of the second inorganic layer **133**.

The second inorganic layer **133** surrounds the first organic layer **132** and is sequentially stacked on the first inorganic layer **131**. In this structure, the first inorganic layer **131** has the same area as the second inorganic layer **133**. Alternatively, the second inorganic layer **133** may be formed to surround both the first organic layer **132** and the first inorganic layer **131**. Alternatively, the inorganic layer may have a gradually increasing area with increasing distance from the organic light emitting diode **120**. With this structure, the encapsulation layer **130** can suppress permeation of external moisture and/or oxygen into the organic light emitting diode **120** while further suppressing delamination and/or slight lifting between the first inorganic layer **131** and the second inorganic layer **132**.

Each of the first inorganic layer **131** and the second inorganic layer **133** may be formed of an inorganic material having excellent light transmittance. The first inorganic layer **131** and the second inorganic layer **133** may be formed of the same or different inorganic materials. Specifically, the inorganic materials may include metals, nonmetals, intermetallic compounds or alloys, inter non-metallic compounds or alloys, oxides of metals or nonmetals, fluorides of metals or nonmetals, nitrides of metals or nonmetals, carbides of metals or nonmetals, oxynitrides of metals or nonmetals, borides of metals or nonmetals, oxyborides of metals or nonmetals, silicides of metals or nonmetals, and mixtures thereof. The metals or nonmetals may include silicon (Si), aluminum (Al), selenium (Se), zinc (Zn), antimony (Sb), indium (In), germanium (Ge), tin (Sn), bismuth (Bi), transition metals, and lanthanide metals, without being limited thereto. Specifically, the inorganic materials may include silicon oxide (SiO_x), silicon nitride (SiN_x), silicon oxynitride (SiO_xN_y), ZnSe, ZnO, Sb_2O_3, AlO_x including Al_2O_3, In_2O_3, or SnO_2. Here, each of x and y ranges from 1 to 5.

The first organic layer **132** may be disposed inside a region defined between the first inorganic layer **131** and the second inorganic layer **133**. That is, the first organic layer **132** may be completely surrounded by the first inorganic layer **131** and the second inorganic layer **133**.

The first organic layer **132** may have a thickness of about 0.2 μm to about 15 μm and an index of refraction of about 1.4 to about 1.65. Within these ranges, the first organic layer can realize an effect of blocking permeation of external moisture and oxygen and can secure light extraction efficiency by blocking defects of the inorganic layers while flattening the inorganic layers.

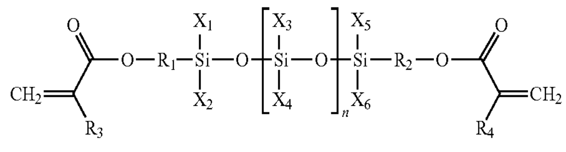
The first organic layer **132** may be formed of an encapsulating composition according to the present invention. Accordingly, the first organic layer **132** can block external moisture and oxygen.

FIG. **1** shows the structure wherein the encapsulation layer **130** includes only the first organic layer **132** as an organic layer. In another embodiment, the encapsulation layer **130** may further include a second organic layer and a third inorganic layer sequentially formed on the second inorganic layer **133**. In this embodiment, the first organic layer **132** and the second organic layer may have the same area. Alternatively, the second organic layer may have a larger area than the first organic layer. That is, the organic layers may have the same area or a gradually increasing area with increasing distance from the organic light emitting diode **120**.

The first organic layer **132** is formed of an encapsulating composition according to embodiments of the present invention. Thus, the organic light emitting diode display apparatus **100** according to the embodiment of the invention has an encapsulation layer having plasma resistance and flatness, and can suppress permeation of external moisture and oxygen. Furthermore, in the organic light emitting diode display apparatus **100** according to the embodiment of the invention, each of the inorganic layers has a thickness of about 40 nm to about 1000 nm and an index of refraction of about 1.41 to about 2.0; each of the organic layers has a thickness of about 0.2 μm to about 15 μm and an index of refraction of about 1.4 to about 1.65 and is formed of the encapsulating composition according to the embodiments of the invention, thereby more effectively blocking permeation of external moisture and oxygen into the organic light emitting diode display apparatus.

Next, an encapsulating composition according to embodiments of the present invention will be described.

An encapsulating composition according to one embodiment of the present invention includes: about 10 wt % to about 70 wt % of (A) a non-silicon-based di(meth)acrylate; about 20 wt % to about 70 wt % of (B) a silicon-based di(meth)acrylate; about 5 wt % to about 40 wt % of (C) a mono(meth)acrylate; and about 1 wt % to about 10 wt % of (D) an initiator, wherein the (B) silicon-based di(meth) acrylate may be represented by Formula 1:



(wherein R_1, R_2, R_3, R_4, X_1, X_2, X_3, X_4, X_5, X_6, and n will be described in detail below).

The encapsulating composition according to the embodiment of the invention may include the (A) non-silicon-based di(meth)acrylate, the (B) silicon-based di(meth)acrylate represented by Formula 1, the (C) mono(meth)acrylate, and the (D) initiator. In addition, the encapsulating composition according to the embodiments may include the (A) non-silicon-based di(meth)acrylate, the (B) silicon-based di(meth)acrylate represented by Formula 1, the (C) mono(meth) acrylate, and the (D) initiator in the specific amounts as set forth above. Thus, the encapsulating composition can exhibit significantly improved photocuring rate. Further, the encapsulating composition can realize an organic layer exhibiting excellent light transmittance after curing while exhibiting significantly high plasma resistance. Thus, the encapsulating composition according to the embodiment can realize an organic layer having low etching rate due to plasma used in formation of an inorganic layer and thus can improve reliability of an organic light emitting diode.

Specifically, the encapsulating composition according to the embodiment may have a photocuring rate of about 88% or more, specifically about 88% to about 99%, more specifically about 90% to about 99%, for example, about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 99%, or about 99%. In addition, the encapsulating composition according to the embodiment may have a light transmittance of about 93% after curing, for example, about 93.5% to about 100%, about 94.2% to about 100%, about 95% to about 99%, or about 96% to about 99%, at a wavelength of about 380 nm to about 700 nm. Further, the encapsulating composition according to the embodiment may have an etching rate of an organic layer due to plasma of about 20% or less after curing, for example, about 0.1%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 11%, about 12%, about 13%, about 14%, about 15%, about 16%, about 17%, about 18%, about 19%, or about 20%. Within these ranges of photocuring rate, light transmittance and etching rate of the organic layer due to plasma, the encapsulating composition according to the embodiment can significantly improve reliability of the organic light emitting diode.

In one embodiment, the encapsulating composition may include about 10 wt % to about 50 wt % of the (A) non-silicon-based di(meth)acrylate, about 20 wt % to about 70 wt % of the (B) silicon-based di(meth)acrylate, about 5 wt % to about 40 wt % of the (C) mono(meth)acrylate, and about 1 wt % to about 10 wt % of the (D) initiator, based on the total weight of (A), (B), (C) and (D).

As used herein, the (A) non-silicon-based di(meth)acrylate, the (B) silicon-based di(meth)acrylate. the (C) mono (meth)acrylate and the (D) initiator are different compounds.

Hereinafter, the (A) non-silicon-based di(meth)acrylate, the (B) silicon-based di(meth)acrylate, the (C) mono(meth) acrylate and the (D) initiator will be described in more detail.

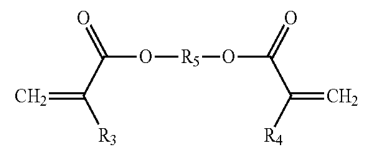
(A) Non-Silicon-Based di(meth)acrylate

The (A) non-silicon-based di(meth)acrylate is a photocurable monomer which does not include silicon (Si) and has two (meth)acrylate groups. Thus, the encapsulating composition can have improved photocuring rate and improved post-curing light transmittance. In addition, the (A) non-silicon-based di(meth)acrylate has low viscosity at 25° C. and thus can reduce viscosity of the encapsulating composition. Thus, the encapsulating composition can facilitate formation of an organic layer on an organic light emitting diode or on an inorganic layer encapsulating the organic light emitting diode using a method such as inkjet printing and the like.

The (A) non-silicon-based di(meth)acrylate is a non-aromatic non-silicon-based di(meth)acrylate not containing an aromatic group, and may include a substituted or unsubstituted long-chain alkylene group-containing non-silicon-based di(meth)acrylate. In this case, the encapsulating composition facilitates formation of the organic layer on the organic light emitting diode or on the inorganic layer encapsulating the organic light emitting diode using a method such as deposition and the like.

Specifically, the (A) non-silicon-based di(meth)acrylate may be a substituted or unsubstituted C_1 to C_{20} alkylene group-containing di(meth)acrylate. More specifically, the (A) non-silicon-based di(meth)acrylate may include a di(meth)acrylate having an unsubstituted C_1 to C_{15} alkylene group between (meth)acrylate groups. Here, the number of carbon atoms in the alkylene group refers to the number of carbon atoms present only in the alkylene group excluding carbon atoms present in the di(meth)acrylate group.

In one embodiment, the (A) non-silicon-based di(meth) acrylate may be represented by Formula 2:



wherein R_3 and R_4 are each independently hydrogen or a methyl group, and R_5 is a substituted or unsubstituted C_1 to C_{20} alkylene group.

Since the encapsulating composition according to the present invention includes the (A) non-silicon-based di(meth)acrylate represented by Formula 2, the encapsulating composition can exhibit higher photocuring rate and allows more easy deposition due to low viscosity thereof.

For example, R_5 in Formula 2 may be an unsubstituted C_8 to C_{12} alkylene group. More specifically, the (A) non-silicon-based di(meth)acrylate may include at least one of octanediol di(meth)acrylate, nonanediol di(meth)acrylate, decanediol di(meth)acrylate, undecanediol di(meth)acrylate, and dodecanediol di(meth)acrylate.

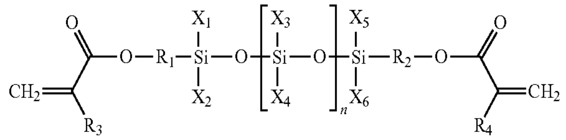
The (A) non-silicon-based di(meth)acrylates may be used alone or in combination thereof in the encapsulating composition.

The (A) non-silicon-based di(meth)acrylate may be present in an amount of about 10 wt % to about 70 wt % based on the total weight of (A), (B), (C) and (D). For example, the (A) non-silicon-based di(meth)acrylate may be present in an amount of about 10 wt % to about 50 wt %, for example, about 35 wt %, about 36 wt %, about 37 wt %, about 38 wt %, about 39 wt %, about 40 wt %, about 41 wt %, about 42 wt %, about 43 wt %, about 44 wt %, about 45 wt %, about 46 wt %, about 47 wt %, or about 48 wt %, based on the total weight of (A), (B), (C) and (D). Within this range, the encapsulating composition can exhibit improved photocuring rate, and can realize an organic layer exhibiting high light transmittance and low plasma etching rate.

(B) Silicon-Based di(meth)acrylate

The (B) silicon-based di(meth)acrylate includes at least one substituted or unsubstituted C_6 to C_{30} aryl group, which is connected to a silicon atom. Thus, the encapsulating composition can realize an organic layer having very high plasma resistance, thereby exhibiting low plasma etching rate.

The (B) silicon-based di(meth)acrylate may be represented by Formula 1:



wherein R_1 and R_2 are each independently a single bond, a substituted or unsubstituted C_1 to C_{20} alkylene group, a substituted or unsubstituted C_1 to C_{30} alkylene ether group, *—N(R')—(R")—* (* representing a binding site for an element, R' being hydrogen or a substituted or unsubstituted C_1 to C_{30} alkyl group, and R" being a substituted or unsubstituted C_1 to C_{20} alkylene group), a substituted or unsubstituted C_6 to C_{30} arylene group, a substituted or unsubstituted C_7 to C_{30} arylalkylene group, or *—(R')—O—** (* representing a binding site for O in Formula 1, ** representing a binding site for Si in Formula 1, and R' being a substituted or unsubstituted C_1 to C_{30} alkylene group);

X_1, X_2, X_3, X_4, X_5 and X_6 are each independently hydrogen, a hydroxyl group, a halogen, a cyano group, a substituted or unsubstituted C_1 to C_{30} alkyl group, a substituted or unsubstituted C_1 to C_{30} heterocycloalkyl group, a substituted or unsubstituted C_3 to C_{30} cycloalkyl group, a substituted or unsubstituted C_1 to C_{30} alkyl ether group, *—N(R')—(R")—* (* representing a binding site for an element, and R' and R" being each independently hydrogen or a substituted or unsubstituted C_1 to C_{30} alkyl group), a substituted or unsubstituted C_1 to C_{30} alkyl sulfide group, a substituted or unsubstituted C_6 to C_{30} aryl group, a substituted or unsubstituted C_2 to C_{30} heteroaryl group, or a substituted or unsubstituted C_7 to C_{30} arylalkyl group;

at least one of X_1, X_2, X_3, X_4, X_5 and X_6 is a substituted or unsubstituted C_6 to C_{30} aryl group, or a substituted or unsubstituted C_2 to C_{30} heteroaryl group;

R_3 and R_4 are each independently hydrogen or a methyl group; and

n is an integer from 0 to 30, or ranges from 0 to 30 on average.

The term "single bond" means that Si and O are directly connected (Si—O) in Formula 1.

Specifically, in Formula 1, R_1 and R_2 may be each independently a single bond, a substituted or unsubstituted C_1 to C_{20} alkylene group, or a substituted or unsubstituted C_1 to C_{30} alkylene ether group. Specifically, X_1, X_2, X_3, X_4, X_5 and X_6 may be each independently hydrogen, a substituted or unsubstituted C_1 to C_{30} alkyl group, a substituted or unsubstituted C_3 to C_{30} cycloalkyl group, a substituted or unsubstituted C_1 to C_{30} alkyl ether group, a substituted or unsubstituted C_6 to C_{30} aryl group, a substituted or unsubstituted C_2 to C_{30} heteroaryl group, or a substituted or unsubstituted C_7 to C_{30} arylalkyl group; and at least one of X_1, X_2, X_3, X_4, X_5 and X_6 may be a substituted or unsubstituted C_6 to C_{30} aryl group.

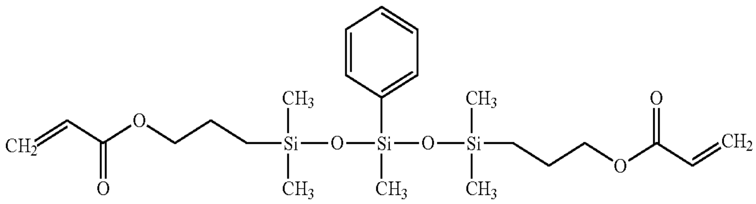
More specifically, in Formula 1, R_1 and R_2 may be each independently a single bond, or a substituted or unsubstituted C_1 to C_{20} alkylene group. In this case, the encapsulating composition can further reduce the plasma etching rate.

More specifically, in Formula 1, X_1, X_2, X_3, X_4, X_5 and X_6 may be each independently a substituted or unsubstituted C_1 to C_{10} alkyl group, or a substituted or unsubstituted C_6 to C_{10} aryl group; and at least one of X_1, X_2, X_3, X_4, X_5 and X_6 may be a substituted or unsubstituted C_6 to C_{10} aryl group. More specifically, X_1, X_2, X_3, X_4, X_5 and X_6 may be each independently a methyl, ethyl, propyl, butyl, pentyl, phenyl, biphenyl, or naphthyl group; and one, two, three or six of X_1, X_2, X_3, X_4, X_5 and X_6 may be a phenyl or naphthyl group. In this case, the encapsulating composition can further reduce the plasma etching rate.

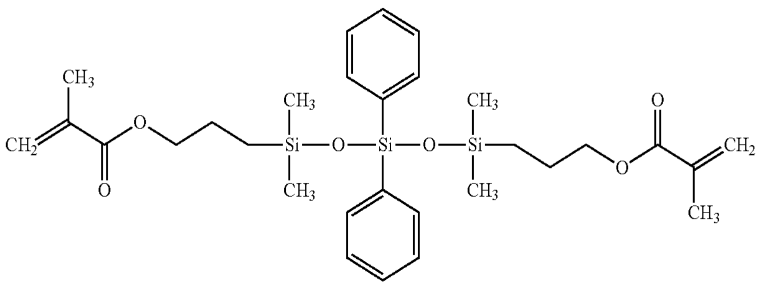
More specifically, n is an integer from about 1 to about 5. In this case, the encapsulating composition can further reduce the plasma etching rate.

More specifically, the (B) silicon-based di(meth)acrylate may be represented by any one of Formulae 3 to 8.

<Formula 3>

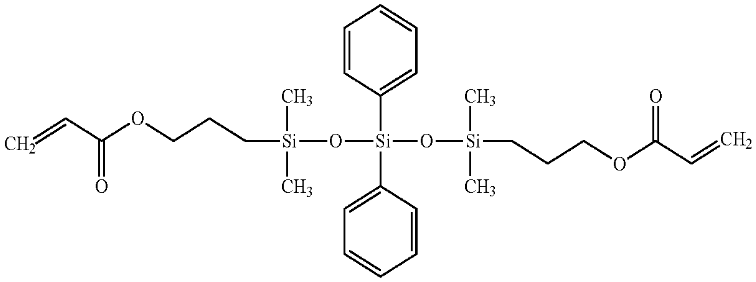


<Formula 4>

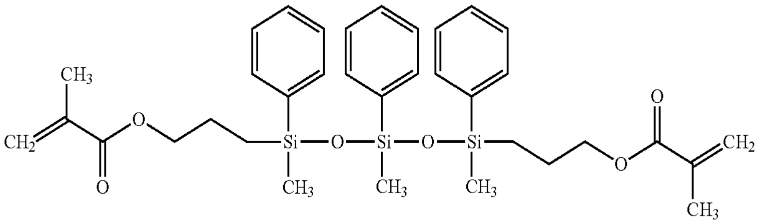


-continued

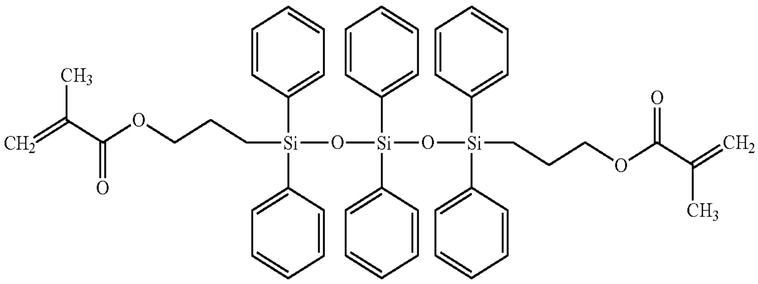
<Formula 5>



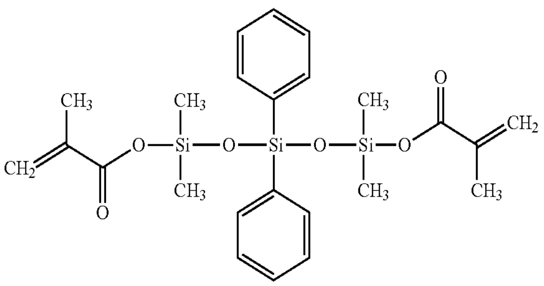
<Formula 6>



<Formula 7>



<Formula 8>



The (B) silicon-based di(meth)acrylates may be used alone or in combination thereof.

The (B) silicon-based di(meth)acrylate may be present in an amount of about 20 wt % to about 70 wt % based on the total weight of (A), (B), (C) and (D). For example, the (B) silicon-based di(meth)acrylate may be present in an amount of about 25 wt % to about 45 wt %, for example, about 28 wt %, about 29 wt %, about 30 wt %, about 31 wt %, about 32 wt %, about 33 wt %, about 34 wt %, about 35 wt %, about 36 wt %, about 37 wt %, about 38 wt %, about 39 wt %, about 40 wt %, or about 41 wt %, based on the total weight of (A), (B), (C) and (D). Within this range, the encapsulating composition can exhibit high photocuring rate. In addition, the encapsulating composition can realize an organic layer exhibiting high light transmittance and low plasma etching rate.

The (A) non-silicon-based di(meth)acrylate and the (B) silicon-based di(meth)acrylate represented by Formula 1 may be present in a total amount of about 50 wt % to about 90 wt %, specifically about 60 wt % to about 90 wt % based on the total weight of (A), (B), (C) and (D). Within this range, the encapsulating composition can realize an organic layer exhibiting low plasma etching rate.

The (A) non-silicon-based di(meth)acrylate and the (B) silicon-based di(meth)acrylate represented by Formula 1 may be present in a weight ratio (A:B) of, for example, about 1:0.1 to about 1:1, about 1:0.1 to about 1:85, about 1:0.1 to about 1:80, about 1:0.1 to about 1.75, about 1:0.1 to about 1:70, about 1:0.1 to about 1:0.65, or about 1:0.1 to about 1:0.6. Within this range, the encapsulating composition can realize an organic layer exhibiting further reduced plasma etching rate.

The (B) silicon-based di(meth)acrylate may be prepared by a typical method. For example, the (B) silicon-based di(meth)acrylate may be prepared by reacting a siloxane compound, in which a substituted or unsubstituted C_6 to C_{30} aryl group or a substituted or unsubstituted C_2 to C_{30} heteroaryl group is connected to at least one silicon atom, with a compound extending a carbon chain (for example, allyl alcohol), followed by reaction with (meth)acryloyl chloride, without being limited thereto. Alternatively, the (B) silicon-based di(meth)acrylate may be prepared by reacting a siloxane compound, in which a substituted or unsubstituted C_6 to C_{30} aryl group or a substituted or unsubstituted C_2 to C_{30} heteroaryl group is connected to at least one silicon atom, with (meth)acryloyl chloride, without being limited thereto.

(C) Mono(meth)acrylate

The (C) mono(meth)acrylate included in the encapsulating composition can increase a photocuring rate of the encapsulating composition. In addition, the (C) mono(meth) acrylate can reduce a plasma etching rate of the organic layer while increasing light transmittance of the organic layer.

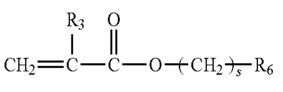
The (C) mono(meth)acrylate may include a non-silicon-based mono(meth)acrylate not containing silicon. Specifically, the (C) mono(meth)acrylate may include at least one of aromatic mono(meth)acrylates containing an aromatic group and non-aromatic mono(meth)acrylates not containing an aromatic group.

The (C) mono(meth)acrylates may be used alone or in combination thereof. The aromatic mono(meth)acrylates among the (C) mono(meth)acrylates may be used alone or in combination thereof. The non-aromatic mono(meth)acrylates among the (C) mono(meth)acrylates may be used alone or in combination thereof.

In one embodiment, the (C) mono(meth)acrylate may include an aromatic group-containing mono(meth)acrylate. Since both the aromatic group-containing mono(meth)acrylate and the (B) silicon-based di(meth)acrylate as set forth above contain an aromatic group, the aromatic group-containing mono(meth)acrylate and the (B) silicon-based di(meth)acrylate exhibit further improved compatibility in the encapsulating composition when used together. Thus, the (C) mono(meth)acrylate can exhibit further improved miscibility with the (B) silicon-based di(meth)acrylate. In this case, the encapsulating composition can have an improved effect of reducing a plasma etching rate of the organic layer.

The aromatic mono(meth)acrylate may include a substituted or unsubstituted aromatic group-containing mono (meth)acrylate. Here, the term "aromatic group" refers to a monocyclic aromatic group or a polycyclic aromatic group including fused forms and the like, or refers to a form in which single rings are connected to each other by a sigma bond. For example, the aromatic group may refer to at least one of a substituted or unsubstituted C_6 to C_{50} aryl group, a substituted or unsubstituted C_7 to C_{50} arylalkyl group, a substituted or unsubstituted C_3 to C_{50} heteroaryl group, and a substituted or unsubstituted C_3 to C_{50} heteroarylalkyl group. More specifically, the aromatic group may include at least one of phenyl, biphenyl, terphenyl, quaterphenyl, naphthyl, anthracenyl, phenanthrenyl, chrysenyl, triphenylenyl, tetracenyl, pyrenyl, benzopyrenyl, pentacenyl, coronenyl, ovalenyl, corannulenyl, benzyl, pyridinyl, pyrazinyl, pyrimidinyl, pyridazinyl, triazinyl, quinolinyl, isoquinolinyl, quinoxalinyl, acridinyl, quinazolinyl, cinnolinyl, phthalazinyl, thiazolyl, benzothiazolyl, isoxazolyl, benzisoxazolyl, oxazolyl, benzoxazolyl, pyrazolyl, indazolyl, imidazolyl, benzimidazolyl, purinyl, thiophenyl, benzothiophenyl, furanyl, benzofuranyl, and isobenzofuranyl groups.

For example, the aromatic mono(meth)acrylate may be represented by Formula 9.



wherein R_3 is hydrogen or a methyl group; s is an integer from 0 to 10; and R_6 is a substituted or unsubstituted C_6 to C_{50} aryl group or a substituted or unsubstituted C_6 to C_{50} aryloxy group.

For example, R_6 may be a phenylphenoxyethyl group, a phenoxyethyl group, a benzyl group, a phenyl group, a phenylphenoxy group, a phenoxy group, a phenylethyl group, a phenylpropyl group, a phenylbutyl group, a methylphenylethyl group, a propylphenylethyl group, a methoxyphenylethyl group, a cyclohexylphenylethyl group, a chlorophenylethyl group, a bromophenylethyl group, a methylphenyl group, a methylethylphenyl group, a methoxyphenyl group, a propylphenyl group, a cyclohexylphenyl group, a chlorophenyl group, a bromophenyl group, a phenylphenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, an anthracenyl group, a naphthalenyl group, a triphenylenyl group, a methylphenoxy group, an ethylphenoxy group, a methylethylphenoxy group, a methoxyphenyloxy group, a propylphenoxy group, a cyclohexylphenoxy group, a chlorophenoxy group, a bromophenoxy group, a biphenyloxy group, a terphenyloxy group, a quaterphenyloxy group, an anthracenyloxy group, a naphthalenyloxy group, or a triphenylenyloxy group.

Specifically, the aromatic mono(meth)acrylate may include at least one of 2-phenylphenoxyethyl (meth)acrylate, phenoxyethyl (meth)acrylate, phenyl (meth)acrylate, phenoxy (meth)acrylate, 2-ethylphenoxy (meth)acrylate, benzyl (meth)acrylate, 2-phenylethyl (meth)acrylate, 3-phenylpropyl (meth)acrylate, 4-phenylbutyl (meth)acrylate, 2-(2-methylphenyl)ethyl (meth)acrylate, 2-(3-methylphenyl)ethyl (meth)acrylate, 2-(4-methylphenyl)ethyl (meth) acrylate, 2-(4-propylphenyl)ethyl (meth)acrylate, 2-(4-(1-methylethyl)phenyl)ethyl (meth)acrylate, 2-(4-methoxyphenyl)ethyl (meth)acrylate, 2-(4-cyclohexylphenyl)ethyl (meth)acrylate, 2-(2-chlorophenyl) ethyl (meth)acrylate, 2-(3-chlorophenyl)ethyl (meth) acrylate, 2-(4-chlorophenyl)ethyl (meth)acrylate, 2-(4-bromophenyl)ethyl (meth)acrylate, 2-(3-phenylphenyl)ethyl (meth)acrylate, 4-(biphenyl-2-yloxy)butyl (meth)acrylate, 3-(biphenyl-2-yloxy)butyl (meth)acrylate, 2-(biphenyl-2-yloxy)butyl (meth)acrylate, 1-(biphenyl-2-yloxy)butyl (meth)acrylate, 4-(biphenyl-2-yloxy)propyl (meth)acrylate, 3-(biphenyl-2-yloxy)propyl (meth)acrylate, 2-(biphenyl-2-yloxy)propyl (meth)acrylate, 1-(biphenyl-2-yloxy)propyl (meth)acrylate, 4-(biphenyl-2-yloxy)ethyl (meth)acrylate, 3-(biphenyl-2-yloxy)ethyl (meth)acrylate, 2-(biphenyl-2-yloxy)ethyl (meth)acrylate, 1-(biphenyl-2-yloxy)ethyl (meth)acrylate, 2-(4-benzylphenyl)ethyl (meth)acrylate, 1-(4-benzylphenyl)ethyl (meth)acrylate, and structural isomers thereof, without being limited thereto. In addition, it should be understood that the (meth)acrylates as set forth herein are provided only by way of example and the present invention is not limited thereto. Further, the (meth)acrylates according to the present invention include all acrylates corresponding to structural isomers. For example, although only 2-phenylethyl (meth)acrylate is mentioned by way of example, the (meth)acrylates according to the present invention include all of 3-phenylethyl (meth)acrylate and 4-phenyl (meth)acrylate.

The non-aromatic mono(meth)acrylate may be a substituted or unsubstituted C_1 to C_{20} alkyl group-containing mono(meth)acrylate. Specifically, the non-aromatic mono (meth)acrylate may be an unsubstituted linear C_1 to C_{20} alkyl group-containing mono(meth)acrylate, more specifically an unsubstituted linear C_{10} to C_{20} alkyl group-containing mono(meth)acrylate. For example, the non-aromatic mono(meth)acrylate may include at least one of decyl (meth)acrylate, undecyl (meth)acrylate, lauryl (meth)acrylate, tridecyl (meth)acrylate, tetradecyl (meth)acrylate, pentadecyl (meth)acrylate, hexadecyl (meth)acrylate, heptadecyl (meth)acrylate, octadecyl (meth)acrylate, nonadecyl (meth)acrylate, and arachidyl (meth)acrylate, without being limited thereto.

The (C) mono(meth)acrylate may be present in an amount of about 5 wt % to about 40 wt % based on the total weight of (A), (B), (C) and (D). For example, the (C) mono(meth) acrylate may be present in an amount of about 5 wt % to about 30 wt % based on the total weight of (A), (B), (C) and (D). Within this range, the encapsulating composition can exhibit high photocuring rate. In addition, the encapsulating composition can realize an organic layer exhibiting high light transmittance and low plasma etching rate.

(D) Initiator

The (D) initiator allows the organic layer to be formed by curing the (A) non-silicon-based di(meth)acrylate, the (B) silicon-based di(meth)acrylate and the (C) mono(meth)acrylate, and may include any typical photopolymerization initiators without limitation.

The (D) initiator may include at least one of triazine, acetophenone, benzophenone, thioxanthone, benzoin, phosphorus, and oxime initiators, without being limited thereto. For example, the phosphorus initiator may include diphenyl (2,4,6-trimethylbenzoyl)phosphine oxide, benzyl(diphenyl) phosphine oxide, bis(2,6-dimethoxybenzoyl)(2,4,4-trimethylpentyl)phosphine oxide, and mixtures thereof. For example, the phosphorus initiator can exhibit better initiation performance under UV light of long wavelengths in the composition according to the present invention.

In the encapsulating composition, the (D) initiators may be used alone or in combination thereof.

The (D) initiator may be present in an amount of about 1 wt % to about 10 wt % based on the total weight of (A), (B), (C) and (D). Within this range, the encapsulating composition allows sufficient photopolymerization under exposure to light. In addition, the unreacted initiator remaining after photopolymerization can be reduced, whereby the organic layer can exhibit further improved light transmittance. Specifically, the (D) initiator may be present in an amount of about 2 wt %, about 3 wt %, about 4 wt %, or about 5 wt %, based on the total weight of (A), (B), (C) and (D).

The encapsulating composition may be formed by mixing the (A) non-silicon-based di(meth)acrylate, the (B) silicon-based di(meth)acrylate, the (C) mono(meth)acrylate and the (D) initiator. For example, the encapsulating composition may be formed as a solvent-free composition not containing a solvent. For example, when the composition for encapsulation of an organic light emitting diode is a solvent-free composition, wt % is based on the total weight of the (A) non-silicon-based di(meth)acrylate, the (B) silicon-based di(meth)acrylate, the (C) mono(meth)acrylate and the (D) initiator.

The encapsulating composition may include about 10 wt % to about 50 wt % of Si. Within this range, the composition can further reduce the plasma etching rate of the organic layer.

The encapsulating composition may have a viscosity at 25° C.±2° C. (23° C. to 27° C.) of about 0 cPs to about 200 cPs, specifically about 100 cPs or less, more specifically about 5 cPs to about 50 cPs, about 5 cPs to about 40 cPs, or about 5 cPs to about 30 cPs. Within this range, the encapsulating composition can facilitate formation of the organic layer. Within this range, it is advantageous to perform a method such as deposition and inkjet printing upon formation of the organic layer.

The encapsulating composition is a photocurable composition, and may be cured by UV irradiation at about 100 mW/cm^2 to about 500 mW/cm^2 for about 1 second to about 100 seconds, without being limited thereto

The encapsulating composition may further include a heat stabilizer.

Hereinafter, an encapsulating composition according to another embodiment of the present invention will be described.

According to another embodiment of the present invention, the encapsulating composition may include (A) a non-silicon-based di(meth)acrylate, (B) a silicon-based di(meth)acrylate, (C) a mono(meth)acrylate, (D) an initiator and (E) a heat stabilizer, wherein the (B) silicon-based di(meth)acrylate may be represented by Formula 1, and wherein the encapsulating composition may include: about 10 wt % to about 70 wt % of the (A) non-silicon-based di(meth)acrylate; about 20 wt % to about 70 wt % of the (B) silicon-based di(meth)acrylate; about 5 wt % to about 40 wt % of the (C) mono(meth)acrylate; and about 1 wt % to about 10 wt % of the (D) initiator, based on the total weight of (A), (B), (C) and (D).

The encapsulating composition according to this embodiment can suppress change in viscosity at room temperature. The encapsulating composition according to this embodiment can exhibit higher light transmittance, higher photocuring rate and lower plasma etching rate than compositions for encapsulation materials which do not include the heat stabilizer. The components of the encapsulating composition according to this embodiment are the same as those of the composition according to the above embodiment excluding the heat stabilizer. Therefore, only the heat stabilizer will be described in detail hereinafter.

The (E) heat stabilizer is included in the composition for encapsulation to suppress change in viscosity at room temperature, and may include any typical heat stabilizers. In some embodiments, the (E) heat stabilizer may be a sterically hindered phenolic heat stabilizer.

Specifically, the (E) heat stabilizer may include at least one of pentaerythritol-tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], stearyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate, 1,3,5-tris(2,6-dimethyl-3-hydroxy-4-t-butylbenzyl)isocyanurate, 1,3,5-tris(3,5-di-t-butyl-4-hydroxybenzyl)isocyanurate, 1,3,5-tris(2-hydroxyethyl)isocyanurate, pentaerythritol-tetrakis[3-(3,5-di-t-butylhydroxyphenyl)propionate], and tris(4-t-butyl-3-hydroxy-2,6-dimethylbenzyl)isocyanurate, without being limited thereto.

The (E) heat stabilizer may be present in an amount of about 2,000 ppm or less, specifically about 0.01 ppm to about 2,000 ppm, more specifically about 100 ppm to about 800 ppm, or about 100 ppm to about 750 ppm, based on the total weight of (A), (B), (C) and (D). Within this range, the heat stabilizer can further improve storage stability and processability of the encapsulating composition in a liquid state.

In one embodiment, the encapsulating composition may include the (A) non-silicon-based di(meth)acrylate, which includes a C_1 to C_{20} alkylene group-containing di(meth) acrylate, the (B) silicon-based di(meth)acrylate represented by one of Formula 3 to Formula 8, the (C) mono(meth) acrylate represented by Formula 9, the (D) initiator including a phosphorus initiator, and the (E) heat stabilizer.

Although not shown in FIG. **1**, the organic light emitting diode display apparatus **100** may include a drive circuit for driving the organic light emitting diode **120**. In some embodiments, although not shown in FIG. **1**, the organic light emitting diode display apparatus may further include a thin film transistor (TFT) layer and a buffer layer between the substrate **110** and the organic light emitting diode **120**. The TFT layer drives the organic light emitting diode and may include a gate line, a data line, a drive power line, a reference power line, and a capacitor.

In some embodiments, although not shown in FIG. **1**, the organic light emitting diode display apparatus may further include a bonding layer covering the encapsulation layer and a substrate bonded to the bonding layer to encapsulate the organic light emitting diode. The bonding layer may be a transparent bonding film. The bonding layer and the substrate may be formed of a typical material known to those skilled in the art.

Next, an organic light emitting diode display apparatus according to another embodiment of the present invention will be described with reference to FIG. **2**.

Referring to FIG. **2**, an organic light emitting diode display apparatus **200** according to this embodiment includes a substrate **110**, an organic light emitting diode **120**, and an encapsulation layer **130'**, which encapsulates the organic light emitting diode **120**.

In the organic light emitting diode display apparatus **200** according to this embodiment, the encapsulation layer **130'** includes a first inorganic layer **131**, a first organic layer **132**, a second inorganic layer **133**, a second organic layer **134**, and a third inorganic layer **135**. In this embodiment, the second inorganic layer **133** is formed to contact at least a portion of the third inorganic layer **135**, and the second organic layer **134** is disposed within a region between the second inorganic layer **133** and the third inorganic layer **135**.

Next, a method of fabricating an organic light emitting diode display apparatus according to one embodiment of the present invention will be described.

The method of fabricating an organic light emitting diode display apparatus according to one embodiment of the invention may include forming an organic light emitting diode on a substrate, and forming an encapsulation layer in which inorganic layers and organic layers are alternately formed on the organic light emitting diode, wherein the organic layers may be formed of the encapsulating composition according to the embodiments of the present invention.

First, an organic light emitting diode is formed on a substrate. Specifically, a cathode is formed on the substrate; and a light emitting layer and other layers are formed thereon by dry coating, such as vacuum deposition, sputtering, plasma plating and ion plating, or wet coating, such as spin coating, dipping and flow coating, followed by formation of an anode thereon, thereby forming an organic light emitting diode on the substrate.

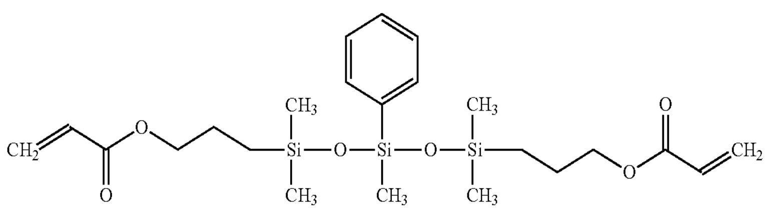
The inorganic layers may be formed by any suitable vacuum process including sputtering, evaporation, sublimation, CVD, PECVD, ECR-PECVD (electron cyclotron resonance plasma enhanced chemical vapor deposition), and combinations thereof, without being limited thereto. The organic layers may be formed by any method such as deposition, spin coating, printing, inkjet printing, and spraying, without being limited thereto.

Next, the present invention will be described in more detail with reference to some examples. It should be understood that these examples are provided for illustration only and are not to be construed in any way as limiting the present invention.

PREPARATIVE EXAMPLE 1

In a 1000 ml flask provided with a cooling tube and a stirrer, 300 ml of ethyl acetate, 25 g of 3-phenyl-1,1,3,5,5-pentamethyltrisiloxane (Gelest Inc.) and 43 g of allyl alcohol (Daejung Chemicals & Materials Co., Ltd.) were placed, followed by nitrogen purging for 30 minutes. Next, 72 ppm of Pt-on-carbon black powder (Aldrich GmbH) was added to the mixture, followed by heating the flask to 80° C. and stirring the mixture for 4 hours. The remaining solvent was removed by distillation, thereby obtaining a compound. 71.5 g of the obtained compound and 39 g of triethylamine were sequentially added to 300 ml of dichloromethane, followed by slowly adding 34.3 g of acryloyl chloride while stirring the mixture at 0° C. The remaining solvent was removed by distillation, thereby obtaining a monomer (molecular weight: 522.85 g/mol) represented by Formula 3 and having a purity of 97% as determined by HPLC. (1H NMR: δ7.61, m, 3H; δ7.12, m, 2H; δ6.25, d, 2H; δ6.02, dd, 2H;δ5.82, t, 1H;δ5.59, d, 2H;δ3.87, m, 4H;δ1.54, m, 4H;δ0.58, m, 4H;δ0.02, m, 15H)

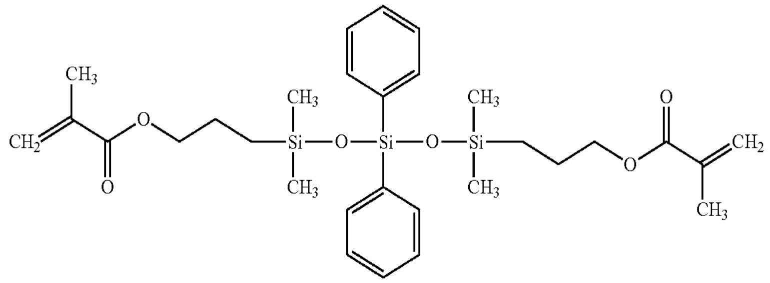
<Formula 3>



PREPARATIVE EXAMPLE 2

A monomer (molecular weight: 584.92 g/mol) represented by Formula 4 was prepared in the same manner as in Preparative Example 1 except that 21 g of 3,3-diphenyl-1,1,5,5-tetramethyltrisiloxane was used instead of 25 g of 3-phenyl-1,1,3,5,5-pentamethyltrisiloxane and 30.2 g of methacryloyl chloride was used instead of 34.3 g of acryloyl chloride. The obtained monomer had a purity of 96% as determined by HPLC. (1H NMR:δ7.52, m, 6H;δ7.42, m, 4H;δ6.25, d, 2H;δ6.02, dd, 2H;δ5.82, t, 1H;δ5.59, d, 2H;δ3.86, m, 4H; δ1.52, m, 4H;δ0.58, m, 4H;δ0.04, m, 12H)

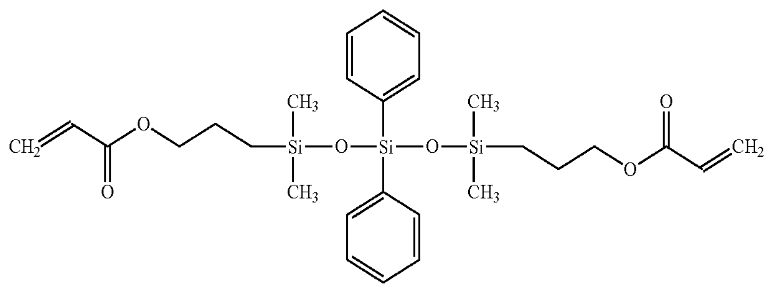
<Formula 4>



PREPARATIVE EXAMPLE 3

A monomer (molecular weight: 646.99 g/mol) represented by Formula 5 was prepared in the same manner as in Preparative Example 1 except that 21 g of 3,3-diphenyl-1,1,5,5-tetramethyltrisiloxane was used instead of 25 g of 3-phenyl-1,1,3,5,5-pentamethyltrisiloxane. The obtained monomer had a purity of 94% as determined by HPLC. (1H NMR:δ7.61, m, 6H;δ7.12, m, 4H;δ6.25, d, 2H;δ6.02, dd, 2H;δ5.82, t, 2H;δ3.87, m, 4H;δ1.54, m, 4H;δ0.58, m, 4H;δ0.02, m, 12H).

<Formula 5>



Details of components used in Examples and Comparative Examples were as follows.

(A) Non-silicon-based di(meth)acrylate: (A1) 1,12-dodecanediol dimethacrylate (Sartomer Co., Ltd.), (A2) 1,10-decanediol dimethacrylate (Shin Nakamura Chemical Co., Ltd.).

(B) Silicon-based di(meth)acrylate: (B1) monomer of Preparative Example 1, (B2) monomer of Preparative Example 2, (B3) monomer of Preparative Example 3.

(C) Mono(meth)acrylate: (C1) HRI-07 (Daelim Chemical Co., Ltd.), (C2) benzyl methacrylate (TCI Co., Ltd.), (C3) lauryl acrylate (Aldrich GmbH).

(D) Initiator: Darocur TPO (BASF GmbH).

(E) Heat stabilizer: IRGANOX 1010 (BASF GmbH).

(F) Monomer represented by Formula 10 (X-22-164, molecular weight: 460.78 g/mol, Shin-Etsu Co., Ltd.)

EXAMPLE 1

47.8 parts by weight of (A1), 28.7 parts by weight of (B1), 19.2 parts by weight of (C1) and 4.3 parts by weight of (D) were placed in a 125 ml brown polypropylene bottle, followed by mixing at room temperature for 3 hours using a shaker, thereby preparing an encapsulating composition (viscosity at 25° C.: 21 cPs).

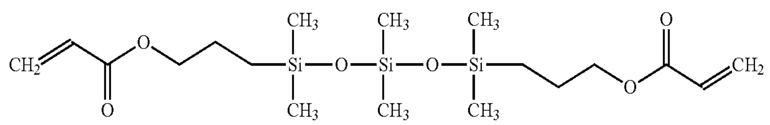
EXAMPLE 2 TO EXAMPLE 13 AND COMPARATIVE EXAMPLES 1 TO 4

Compositions for encapsulation materials were prepared in the same manner as in Example 1 except that kinds and/or amounts of (A), (B), (C), (D) and (E) were changed as listed in Table 1 (unit: parts by weight).

COMPARATIVE EXAMPLE 5

An encapsulating composition was prepared in the same manner as in Example 1 except that 28.7 parts by weight of the (F) monomer was used instead of 28.7 parts by weight of the (B 1) monomer of Preparative Example 1.

<Formula 10>



Each of the compositions for encapsulation materials prepared in Examples and Comparative Examples was evaluated as to properties as listed in Table 1. Results are shown in Tables 1 and 2.

TABLE 1

		Example												
		1	2	3	4	5	6	7	8	9	10	11	12	13
A	A1	47.8	47.8	38.8	38.8	47.8	48.5	38.25	38.8	—	—	—	47.8	47.8
	A2	—	—	—	—	—	—	—	—	38.3	38.3	38.3	—	—
B	B1	28.7	28.7	38.8	29.1	—	—	—	—	28.7	—	—	—	—
	B2	—	—	—	—	28.7	29.1	38.25	29.1	—	28.7	—	28.7	—
	B3	—	—	—	—	—	—	—	—	—	—	28.7	—	40.2
C	C1	19.2	19.2	19.5	29.1	19.2	19.5	19.2	29.1	28.7	28.7	28.7	—	—
	C2	—	—	—	—	—	—	—	—	—	—	—	—	—
	C3	—	—	—	—	—	—	—	—	—	—	—	19.2	7.7
D		4.3	4.3	2.9	3.0	4.3	2.9	4.3	3.0	4.3	4.3	4.3	4.3	4.3
E (ppm)		—	750	750	750	750	750	750	750	750	750	750	750	750
F		—	—	—	—	—	—	—	—	—	—	—	—	—
Photocuring rate (%)		94.7	95.7	95.9	94.2	95.4	95.4	96.2	95.2	96.4	95.2	94.7	95.3	96.6
Light transmittance (%)		93.5	93.7	93.8	94.6	94.2	94.2	94.6	94.4	95.2	96.1	95.8	94.8	95.2
Plasma etching rate (%)		11.5	11.5	11.1	10.9	7.5	7.6	7.3	7.2	9.8	6.5	6.8	15.8	14.2
Index of refraction		1.489	1.489	1.496	1.492	1.508	1.508	1.509	1.521	1.489	1.500	1.500	1.502	1.491

TABLE 2

		Comparative Example				
		1	2	3	4	5
A	A1	76.7	67.0	67.0	67.0	47.8
	A2	—	—	—	—	—
B	B1	16	28.7	—	—	—
	B2	—	—	—	—	—
	B3	—	—	—	—	—
C	C1	3	—	—	—	19.2
	C2	—	—	28.7	—	—
	C3	—	—	—	28.7	—
D		4.3	4.3	4.3	4.3	4.3
E (ppm)		—	750	750	750	—
F		—	—	—	—	28.7
Photocuring rate (%)		92.5	94.2	93.5	92.4	89.5
Light transmittance (%)		91.5	90.4	87.5	86.5	91.8
Plasma etching rate (%)		23.5	22.1	32.5	38.7	25.5
Index of refraction		1.473	1.483	1.494	1.493	1.529

As shown in Table 1, the encapsulating composition according to the present invention could realize an organic layer exhibiting high photocuring rate, high light transmittance, and low plasma etching rate.

Furthermore, even when the compositions of Examples and Comparative examples had similar indexes of refraction as defined herein, the compositions of Examples exhibited superior plasma resistance to the compositions of Comparative Examples, thereby improving durability and reliability of an organic light emitting diode.

Furthermore, the compositions of Examples exhibited superior light transmittance to the compositions of Comparative Examples, thereby enabling an organic light emitting diode display apparatus to realize clearer image quality.

Conversely, as shown in Table 2, the encapsulating composition of Comparative Example 1, which included (A), (B) and (C) in amounts outside the range according to the present invention, had a problem of high plasma etching rate. In addition, the encapsulating composition of Comparative Examples 2 to 4, which did not include any one of (B) and (C), also had a problem of high plasma etching rate. Further, the encapsulating composition of Comparative Example 5, which included the silicon-based di(meth)acrylate not containing an aryl group, also had a problem of high plasma etching rate.

<Evaluation of Properties>

(1) Photocuring rate: The encapsulating composition was measured as to the intensity of absorption peaks in the vicinity of 1635 cm^{-1} (C=C) and 1720 cm^{-1} (C=O) using FT-IR (NICOLET 4700, Thermo Co., Ltd.). The composition was coated onto a glass substrate using a sprayer, followed by UV curing through UV irradiation at 100 mW/cm^2 for 10 seconds, thereby obtaining a specimen having a size of 20 cm×20 cm×3 μm (width×length×thickness). Then, the cured film was aliquoted and the intensities of absorption peaks of the cured film were measured in the vicinity of 1635 cm^{-1} (C=C) and 1720 cm^{-1} (C=O) using FT-IR (NICOLET 4700, Thermo Co., Ltd.). Photocuring rate was calculated by Equation 1:

$$\text{Photocuring rate } (\%) = |1-(A/B)| \times 100$$

(wherein A is a ratio of the intensity of an absorption peak in the vicinity of 1635 cm^{-1} to the intensity of an absorption peak in the vicinity of 1720 cm^{-1} for the cured film; and B is a ratio of the intensity of an absorption peak in the vicinity of 1635 cm^{-1} to the intensity of an absorption peak in the vicinity of 1720 cm^{-1} for the encapsulating composition).

(2) Light transmittance: The encapsulating composition was subjected to UV curing under N_2 to form a 10 μm thick film. Next, light transmittance of the film in the visible light range of 550 nm was measured using a Lambda 950 (Perkin Elmer Co., Ltd.).

(3) Plasma etching rate: The encapsulating composition was coated to a predetermined thickness and photo-cured to form an organic layer, followed by measuring an initial coating height (T1, 1 μm to 10 μm) of the organic layer. The organic layer was subjected to plasma treatment under conditions of ICP power: 2500 W, RF power: 300 W, DC bias: 200V, Ar flow: 50 sccm, etching time: 1 min, and pressure: 10 mtorr, followed by measuring the height (T2,

unit: μm) of the organic layer. The plasma etching rate of the organic layer was calculated by Equation 2:

$$\text{Etching rate of organic layer due to plasma (\%)} = (T1-T2)/T1\times 100$$

(4) Index of refraction: An encapsulating composition was deposited to a predetermined thickness on a glass plate and was subjected to photocuring to form an organic layer. Index of refraction was measured with respect to the specimen used in measurement of the coating height (T1, 1 μm to 10 μm) of the organic layer using EC-400 (J. A. WooLLAM Co., Ltd.), followed by fitting in a Cauchy model. An index of refraction at a wavelength of 550 nm was determined as a representative index of refraction.

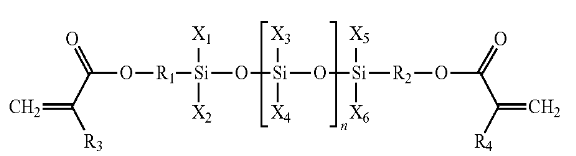
It should be understood that various modifications, changes, alterations, and equivalent embodiments can be made by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An organic light emitting diode display apparatus, comprising: a substrate; an organic light emitting diode disposed on the substrate; and an encapsulation layer encapsulating the organic light emitting diode,

wherein the encapsulation layer having a structure in which two or more inorganic layers and one or more organic layers are alternately stacked one above another, each of the inorganic layers having a thickness of about 40 nm to about 1000 nm and an index of refraction of about 1.41 to about 2.0, each of the organic layers having a thickness of about 0.2 μm to about 15 μm and an index of refraction of about 1.4 to about 1.65, the organic layers being formed of an encapsulating composition, and

wherein the encapsulating composition comprises about 10 wt % to about 70 wt % of (A) a non-silicon-based di(meth)acrylate, about 20 wt % to about 70 wt % of (B) a silicon-based di(meth)acrylate, about 5 wt % to about 40 wt % of (C) a mono(meth)acrylate, and about 1 wt % to about 10 wt % of (D) an initiator, the (B) silicon-based di(meth)acrylate being represented by Formula 1:



(where R_1 and R_2 are each independently a single bond, a substituted or unsubstituted C_1 to C_{20} alkylene group, a substituted or unsubstituted C_1 to C_{30} alkylene ether group, *—N(R')—(R")—* (* representing a binding site for an element, R' being hydrogen or a substituted or unsubstituted C_1 to C_{30} alkyl group, and R" being a substituted or unsubstituted C_1 to C_{20} alkylene group), a substituted or unsubstituted C_6 to C_{30} arylene group, a substituted or unsubstituted C_7 to C_{30} arylalkylene group, or *—(R')—O—**(* representing a binding site for O in Formula 1, ** representing a binding site for Si in Formula 1, and R' being a substituted or unsubstituted C_1 to C_{30} alkylene group);

X_1, X_2, X_3, X_4, X_5 and X_6 are each independently hydrogen, a hydroxyl group, a halogen, a cyano group, a substituted or unsubstituted C_1 to C_{30} alkyl group, a substituted or unsubstituted C_1 to C_{30} heterocycloalkyl group, a substituted or unsubstituted C_3 to C_{30} cycloalkyl group, a substituted or unsubstituted C_1 to C_{30} alkyl ether group, *—N(R')—(R")—* (* representing a binding site for an element, and R' and R" being each independently hydrogen or a substituted or unsubstituted C_1 to C_{30} alkyl group), a substituted or unsubstituted C_1 to C_{30} alkyl sulfide group, a substituted or unsubstituted C_6 to C_{30} aryl group, a substituted or unsubstituted C_2 to C_{30} heteroaryl group, or a substituted or unsubstituted C_7 to C_{30} arylalkyl group;

at least one of X_1, X_2, X_3, X_4, X_5 and X_6 is a substituted or unsubstituted C_6 to C_{30} aryl group, or a substituted or unsubstituted C_2 to C_{30} heteroaryl group;

R_3 and R_4 are each independently hydrogen or a methyl group; and

n is an integer from 0 to 30, or ranges from 0 to 30 on average).

2. The organic light emitting diode display apparatus according to claim **1**, wherein the inorganic layers comprises a first inorganic layer and a second inorganic layer; the organic layer comprises a first organic layer; the encapsulation layer comprises the first inorganic layer, the first organic layer, and the second inorganic layer alternately stacked one above another;

and the first inorganic layer and the second inorganic layer at least partially contact each other.

3. The organic light emitting diode display apparatus according to claim **2**, wherein the encapsulation layer has a structure in which the first inorganic layer and the second inorganic layer are sequentially stacked at an edge thereof.

4. The organic light emitting diode display apparatus according to claim **2**, wherein the first inorganic layer and the second inorganic layer have the same area.

5. The organic light emitting diode display apparatus according to claim **2**, wherein the second inorganic layer is formed to surround the first organic layer.

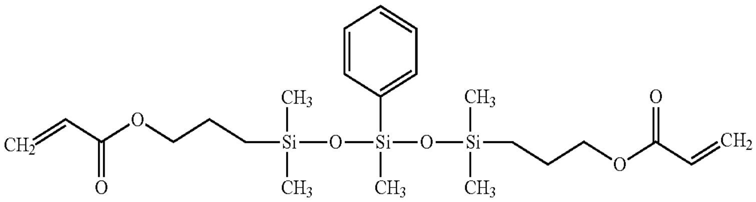
6. The organic light emitting diode display apparatus according to claim **1**, wherein the inorganic layers have the same area or a gradually increasing area with increasing distance from the organic light emitting diode.

7. The organic light emitting diode display apparatus according to claim **1**, wherein the inorganic layers comprise at least one of silicon oxide, silicon nitride, silicon oxynitride, ZnSe, ZnO, Sb_2O_3, Al_2O_3, In_2O_3, and SnO_2.

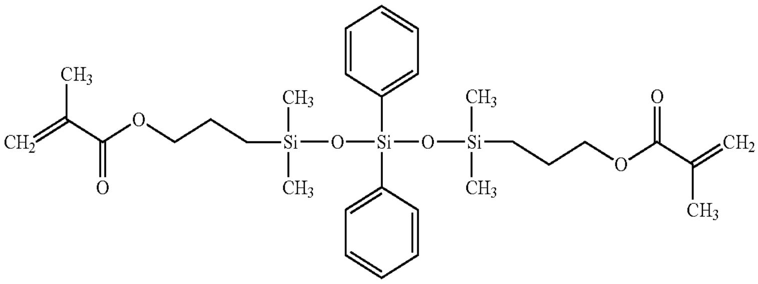
8. The organic light emitting diode display apparatus according to claim **1**, wherein, in Formula 1, R_1 and R_2 are each independently a single bond, a substituted or unsubstituted C_1 to C_{20} alkylene group, or a substituted or unsubstituted C_1 to C_{30} alkylene ether group; X_1, X_2, X_3, X_4, X_5, and X_6 are each independently hydrogen, a substituted or unsubstituted C_1 to C_{30} alkyl group, a substituted or unsubstituted C_3 to C_{30} cycloalkyl group, a substituted or unsubstituted C_1 to C_{30} alkyl ether group, a substituted or unsubstituted C_6 to C_{30} aryl group, a substituted or unsubstituted C_2 to C_{30} heteroaryl group, or a substituted or unsubstituted C_7 to C_{30} arylalkyl group; and at least one of X_1, X_2, X_3, X_4, X_5 and X_6 is a substituted or unsubstituted C_6 to C_{30} aryl group.

9. The organic light emitting diode display apparatus according to claim **1**, wherein the (B) silicon-based di(meth)acrylate is represented by one of Formula 3 to Formula 8:

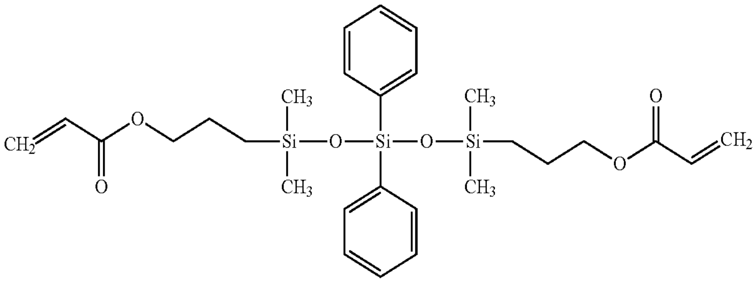
<Formula 3>



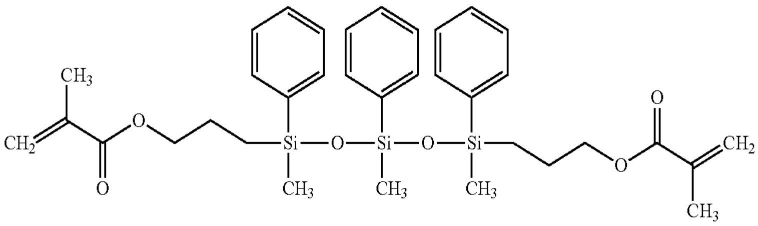
<Formula 4>



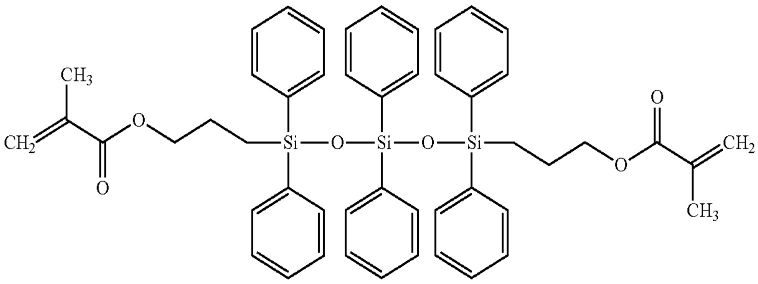
<Formula 5>



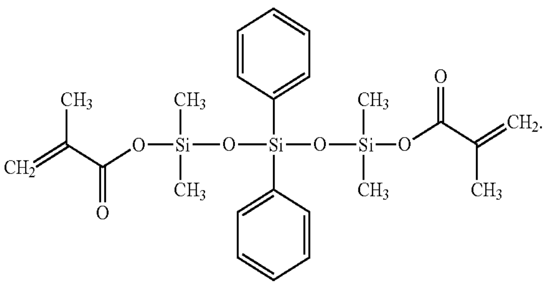
<Formula 6>



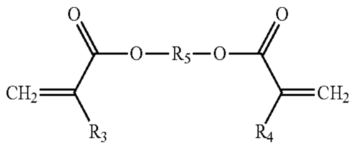
<Formula 7>



<Formula 8>



10. The organic light emitting diode display apparatus according to claim **1**, wherein the (A) non-silicon-based di(meth)acrylate is represented by Formula 2:



(where R_3 and R_4 are each independently hydrogen or a methyl group, and R_5 being a substituted or unsubstituted C_1 to C_{20} alkylene group).

11. The organic light emitting diode display apparatus according to claim **1**, wherein the (C) mono(meth)acrylate comprises one of an aromatic mono(meth)acrylate and a non-aromatic mono(meth)acrylate.

12. The organic light emitting diode display apparatus according to claim **1**, wherein the composition further comprises a heat stabilizer.

* * * * *

专利名称(译)	有机发光二极管显示装置

公开(公告)号	US9837633	公开(公告)日	2017-12-05
申请号	US15/094091	申请日	2016-04-08

申请(专利权)人(译)	三星SDI CO.，LTD.
当前申请(专利权)人(译)	三星SDI CO.，LTD.
[标]发明人	LEE JI YEON NAM SEONG RYONG KO SUNG MIN KIM MI SUN KIM HYE JIN CHOI MI JEONG
发明人	LEE, JI YEON NAM, SEONG RYONG KO, SUNG MIN KIM, MI SUN KIM, HYE JIN CHOI, MI JEONG
IPC分类号	H01L51/52 H01L27/32
CPC分类号	H01L27/3244 H01L51/5253 H01L51/5256
优先权	1020150087824 2015-06-19 KR
其他公开文献	US20160372704A1
外部链接	Espacenet USPTO

摘要(译)

公开了一种有机发光二极管显示装置，包括：基板;有机发光二极管，设置在基板上;以及封装有机发光二极管的封装层。封装层具有这样的结构，其中两个或更多个无机层和一个或多个有机层一个在另一个上方交替堆叠，每个无机层具有约40nm至约1000nm的厚度并且折射率为约1.41。对于约2.0，每个有机层具有约0.2μm至约15μm的厚度和约1.4至约1.65的折射率，并且有机层由包封组合物形成。包封组合物包含：约10重量%至约70重量%的（A）非硅基二（甲基）丙烯酸酯，约20重量%至约70重量%的（B）硅基二（甲基）丙烯酸酯，约5wt%至约40wt%的（C）单（甲基）丙烯酸酯，和约1wt%至约10wt%的（D）引发剂，（B）硅基二（甲基）丙烯酸酯由式1表示。