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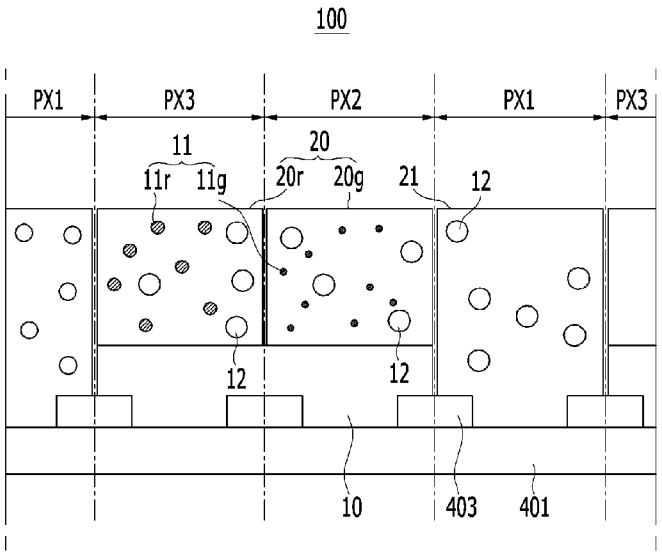
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(54) Title: COLOR FILTER, MANUFACTURING METHOD THEREOF, AND DISPLAY DEVICE COMPRISING THE SAME

[Fig. 2]



(57) Abstract: A color filter is compartmentalized into a first region configured to emit first light, a second region configured to emit second light having longer wavelength than the first light, and a third region configured to emit third light having longer wavelength than the second light, and includes a substrate, and a first layer integrally provided with and on the second region and the third region and a second layer on the first layer in the substrate, wherein the first layer has a absorption rate of greater than or equal to 80 % for the first light and the second layer includes a quantum dot as a light-conversion material, a method of making the same and a display device including the color filter are provided.

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Description

Title of Invention: COLOR FILTER, MANUFACTURING METHOD THEREOF, AND DISPLAY DEVICE COMPRISING THE SAME

Technical Field

[1] A color filter, a making method using the same, and a display device including color filter are disclosed.

Background Art

[2] A liquid crystal display (hereinafter, LCD) is a display in which polarized light passed through liquid crystal expresses a color while passing through an absorptive color filter. Unfavorably, LCD has a narrow viewing angle and a low luminance due to low light transmittance of the absorptive color filter. When such a color filter is replaced by a photoluminescent type color filter, it may widen viewing angles and improve the luminance.

[3] Quantum dots, which are dispersed in a polymer host matrix to have a form of a composite, are applicable for the various display devices. Quantum dots (QD) may be used as a light conversion layer in a light emitting diode (LED) or the like by dispersing in a host matrix of an inorganic material or a polymer. When quantum dot is colloid-synthesized, the particle size may be relatively freely controlled and also uniformly controlled. When quantum dot has a size of less than or equal to 10 nm, the quantum confinement effects in which the bandgap is more increased according to decreasing a size become significant, thus the energy density is enhanced. As quantum dot has a theoretical quantum efficiency (QY) of 100 % and may emit light having a high color purity (e.g., full width at half maximum (FWHM) of less than or equal to 40 nm), it may enhance a luminous efficiency and improve a color reproducibility. Therefore, if the quantum dots are patternable, they may be applied to various devices and when the quantum dots are used for a color filter for an LCD, high quality photoluminescent type LCD may be developed.

Disclosure of Invention

Technical Problem

[4] An embodiment provides a color filter having improved color reproducibility, color purity, and viewing angle characteristics.

[5] Another embodiment provides a method of making the color filter.

[6] Yet another embodiment provides a display device having improved color reproducibility, color purity, and viewing angle characteristics by including the color filter.

Solution to Problem

[7] According to an embodiment, a color filter is compartmentalized into a first region configured to emit first light, a second region configured to emit second light having longer wavelength than the first light, and a third region configured to emit third light having longer wavelength than the second light, and includes a substrate, and a first layer integrally provided with and on the second region and the third region and a second layer on the first layer in the substrate, wherein the first layer has a absorption rate of greater than or equal to 80 % for the first light and the second layer includes a quantum dot as a light-conversion material.

[8] The first layer may fully absorb light in 420 nm to 460 nm wavelength region.

[9] The first layer may have a transmittance of greater than or equal to 80 % for light in a wavelength region of greater than or equal to 540 nm.

[10] A thickness of the first layer may be 0.1 ㎛ to 5 ㎛ and a width of the first layer may be 1 ㎛ to 200 ㎛.

[11] The first light of the first layer may be blue light; the second light may be green light; and the third light may be red light.

[12] In the first layer, a transparent medium may be provided on the first region.

[13] In the transparent medium, a light scatterer selected from a metal oxide particle, a metal particle, and a combination thereof may be dispersed.

[14] The quantum dot may include a Group II-VI compound, a Group III-V compound, a Group IV-VI compound, a Group IV compound, a Group II-III-VI compound, a Group I-II-IV-VI compound, or a combination thereof.

[15] The quantum dot may include a first quantum dot disposed in the second region and absorbing the first light and emitting the second light and a second quantum dot disposed in the third region and adsorbing the first light and emitting the third light.

[16] Meanwhile, another embodiment provides a display device including the color filter, which includes a light source supplying a first light in a first direction; a first substrate disposed in a front side of the light source with reference to the first direction; a color filter disposed in a front side of the first substrate with reference to the first direction; and a second substrate disposed in a front side of the color filter with reference to the first direction, wherein the second layer is disposed in the front side of the first layer with reference to the first direction in the color filter.

[17] The display device may further include a liquid crystal layer disposed between the first substrate and the color filter or between the color filter and the second substrate.

[18] Meanwhile, another embodiment provides a method of making a color filter including preparing a first photosensitive resin composition including a photopolymerizable monomer, a photoinitiator, an alkali soluble resin, and a first solvent;

preparing a second photosensitive resin composition including a photopolymerizable monomer, a photoinitiator, alkali soluble resin, a second solvent, and quantum dots, coating the first photosensitive resin composition on a substrate; coating the second photosensitive resin composition on the first photosensitive resin composition; and curing the first photosensitive resin composition and the second photosensitive resin composition together.

Advantageous Effects of Invention

[19] The color filter may have excellent display characteristics such as color reproducibility, color purity, and viewing angle.

[20] In addition, it may provide a display device having excellent display characteristics by including the color filter.

Brief Description of Drawings

[21] FIG. 1 is a view schematically showing effects on preventing cross-talk due to a second layer in a color filter according to an embodiment.

[22] FIG. 2 is a view showing the color filter of FIG. 1 in more detail.

[23] FIG. 3 is a view further specifically showing a path of first light radiated into the color filter of FIG. 2.

[24] FIG. 4 is a view showing dimensions in the color filter of FIG. 2.

[25] FIG. 5 is a view showing a display device including the color filter of FIG. 2.

[26] FIG. 6 is a graph showing a light transmittance of first light of the color filter according to an embodiment, depending upon a visible light wavelength region.

[27] FIG. 7 is a graph showing a transmission spectrum of color filter according to an embodiment, for the visible wavelength region emitted from a green filter in the visible light wavelength region of.

[28] FIG. 8 is a graph showing a transmission spectrum of color filter according to an embodiment, for the visible wavelength region emitted from a red filter in the visible light wavelength region.

Best Mode for Carrying out the Invention

[29] The present disclosure will be described more fully hereinafter in which example embodiments are shown. However, this disclosure may be embodied in many different forms and is not construed as limited to the exemplary embodiments set forth herein.

[30] In the drawings, the thickness of layers, films, panels, regions, etc., are exaggerated for clarity. Like reference numerals designate like elements throughout the specification. It will be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements

present.

[31] Hereinafter, one part where a first layer and a second layer are formed in the color filter according to one embodiment is schematically illustrated, and through this, the effects on improving color purity, color reproducibility are described.

[32] FIG. 1 is a schematic view showing cross-talk preventing effects by a second layer in a color filter according to an embodiment.

[33] Referring to FIG. 1, a color filter 100 is a stacked structure including a first layer 10 and a second layer 20 formed on the first layer 10. The second layer 20 includes quantum dots 11, and the quantum dots 11 are dispersed in the second layer 20.

[34] As the quantum dot 11 has isotropic optical radiation characteristics, the quantum dot may emit radiation light in a radiation direction while quantum dot is returning to the ground state after having been excited by receiving incident light come from the light source. Thereby, the second layer 20 including quantum dots 11 may be used as an emission layer. In FIG. 1, the propagation path of incident light is represented by a double lined arrow; and the propagation path of radiation light is represented by a bold lined arrow.

[35] In other words, because the quantum dot 11 has a discontinuous energy bandgap due to a quantum confinement effect, the quantum dot 11 receives incident light and emits radiation light having a certain wavelength region. In other words, as the second layer according to an embodiment includes quantum dots 11, it may express an image having a high color purity compared to the case of including other light emitter, and it may provide a display device having excellent viewing angle by the isotropic optical radiation characteristics of quantum dot 11.

[36] Meanwhile, the second layer 20 may further include a light scatterer 12. The light scatterer 12 may be dispersed in the second layer 20 together with quantum dots 11. The light scatterer 12 may induce the incident light to be entered into quantum dot 11 or may induce the radiation direction of the radiation light emitted from the quantum dot 11 to be escaped to the outside of second layer 20. Thereby, the photo efficiency deterioration of the second layer 20 may be minimized.

[37] The first layer 10 may be formed on one surface of the second layer 20, for example, in the rear side of the second layer 20, as shown in FIG. 1.

[38] The first layer 10 may be made of an optically transparent material. The first layer 10 may be made of, for example, a material having a high absorption rate for a predetermined wavelength region.

[39] For example, when the incident light of FIG. 1 is blue light having a visible light wavelength region of less than 500 nm, the first layer 10 may be made of a material having an excellent light absorption rate for a visible light wavelength region of less than 500 nm. For example, the first layer 10 may have a light transmittance of greater

than or equal to 80 %, for example, greater than or equal to 85 %, for example, greater than or equal to 90 %, for example, greater than or equal to 95 % in a wavelength region of greater than 540 nm.

[40] The first layer 10 may have a light absorption rate of 100% in a wavelength region of, for example, 400 nm to 470 nm, for example, 420 nm to 470 nm, for example, 420 nm to 460 nm.

[41] The first layer 10 may have a transmittance of greater than or equal to 60 %, for example, greater than or equal to 70 %, for example, greater than or equal to 80 %, for example, greater than or equal to 90 %, for example, greater than or equal to 95 % in the other visible light wavelength regions besides a predetermined wavelength region.

[42] Like this, light having blue wavelength region band passing the color filter 100 is adsorbed and removed by the first layer 10, and only radiation light radiated from the quantum dot 11 may be emitted to the outside of color filter 100 as shown in FIG. 1. In other words, the first layer 10 may act a kind of a blue cut filter for blocking light in a blue wavelength region band.

[43] That is, an embodiment may provide a color filter 100 having excellent color purity and color reproducibility through the first layer 10.

[44] In addition, the first layer 10 may have similar refractive index to the second layer 20. Thereby, it may minimize the event that the incident light entered into the first layer 10 is reflected or scattered from the first layer 10. That is, the optical loss of interface between the first layer 10 and the second layer 20 is minimized, so that it may provide a color filter 100 having enhanced optical efficiency.

[45] Meanwhile, according to an embodiment, the first layer 10 and the second layer 20 may be each formed in a single layer as shown in FIG. 1, but is not limited thereto, and may be formed in a multilayer of 2 or more layers.

[46] Hereinafter, materials for the first layer and the second layer 20 of the color filter 100 according to an embodiment will be described.

[47] According to an embodiment, the first layer 10 and the second layer 20 may be each a photosensitive material formed by using a photosensitive resin. Thereby, a predetermined pattern may be easily obtained using a photolithography.

[48] In an embodiment, photosensitive resin compositions for forming the first layer 10 and the second layer 20 may include a photopolymerizable monomer, a photoinitiator, an alkali soluble resin, a solvent and a dispersing agent.

[49] The photopolymerizable monomer may be a material having photosensitive characteristics due to a carbon-carbon double bond, and may be a diacrylate compound, a triacrylate compound, tetraacrylate compound, a pentaacrylate compound, a hexaacrylate compound, or a combination thereof.

[50] The photoinitiator may initiate a photopolymerization reaction of the photopoly-

merizable monomers. In an embodiment, the photoinitiator may include, for example, a triazine-based compound, an acetophenone-based compound, a benzophenone-based compound, a thioxanthone-based compound, a benzoin-based compound, an oxime-based compound, or a combination thereof, but is not limited thereto.

[51] Examples of the triazine-based compound may be 2,4,6-trichloro-s-triazine, 2-phenyl-4,6-bis(trichloro methyl)-s-triazine, 2-(3', 4'-dimethoxy styryl)-4,6-bis(trichloro methyl)-s-triazine, 2- (4'-methoxy naphthyl)-4,6-bis(trichloro methyl)-s-triazine, 2-(p-methoxy phenyl)-4,6-bis(trichloro methyl)-s-triazine, 2-(p-tolyl)-4,6-bis(trichloro methyl)-s-triazine, 2-biphenyl-4,6-bis(trichloro methyl)-s-triazine, bis(trichloro methyl)-6-styryl-s-triazine, 2-(naphtho1-yl)-4,6-bis(trichloro methyl)-s-triazine, 2-(4-methoxy naphtho1-yl)-4,6-bis(trichloro methyl)-s-triazine, 2,4-trichloro methyl(piperonyl)-6-triazine, or 2,4-(trichloro methyl (4'-methoxy styryl)-6-triazine, but are not limited thereto.

[52] Examples of the acetophenone-based compound may be 2,2'-diethoxy acetophenone, 2,2'-dibutoxy acetophenone, 2-hydroxy-2-methyl propinophenone, p-t-butyl trichloro acetophenone, p-t-butyl dichloro acetophenone, 4-chloro acetophenone, 2,2'-dichloro-4-phenoxy acetophenone, 2-methyl-1-(4-(methylthio)phenyl)-2-morpholino propan-1-one, or 2-benzyl-2-dimethyl amino-1-(4-morpholino phenyl)-butan-1-one, but are not limited thereto.

[53] Examples of the benzophenone-based compound may be benzophenone, benzoyl benzoate, benzoyl methyl benzoate, 4-phenyl benzophenone, hydroxy benzophenone, acrylated benzophenone, 4,4'-bis(dimethyl amino)benzophenone, 4,4'-dichloro benzophenone, or 3,3'-dimethyl-2-methoxy benzophenone, but are not limited thereto.

[54] Examples of the thioxanthone-based compound may be thioxanthone, 2-methyl thioxanthone, isopropyl thioxanthone, 2,4-diethyl thioxanthone, 2,4-diisopropyl thioxanthone, or 2-chloro thioxanthone, but are not limited thereto.

[55] Examples of the benzoin-based compound may be benzoin, benzoin methyl ether, benzoin ethyl ether, benzoin isopropyl ether, benzoin isobutyl ether, or benzyl dimethyl ketal, but are not limited thereto.

[56] Examples of the oxime-based compound may be 2-(o-benzoyloxime)-1-[4-(phenylthio)phenyl]-1,2-octandione and 1-(o-acetyloxime)-1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]ethanone, but are not limited thereto.

[57] A carbazole-based compound, a diketone compound, a sulfonium borate-based compound, a diazo-based compound, a biimidazole-based compound may be also used as a photoinitiator besides the photoinitiators.

[58] In an embodiment, the alkali soluble resin may be an acryl-based resin having a carboxyl group (-COOH), and may be, for example a copolymer of a monomer mixture of a first monomer including a carboxyl group and a carbon-carbon double bond and a second monomer including a carbon-carbon double bond and a hydrophobic residual group and not including a carboxyl group. The quantum dot may be dispersed (e.g., separated) in the second layer 20 by the alkali soluble resin to form a quantum dot-polymer composite structure.

[59] The first monomer may be, for example acrylic acid, methacrylic acid, maleic acid, itaconic acid, fumaric acid, 3-butanoic acid, vinyl acetate, vinyl carbonic acid vinyl ester compounds such as vinyl acetate, and vinyl benzoate, but are not limited thereto. The first monomer may be one or more compounds.

[60] The second monomer may be, for example alkenyl aromatic compounds such as styrene, α-methyl styrene, vinyl toluene, or vinyl benzyl methyl ether; unsaturated carbonic acid ester compounds such as methyl acrylate, methyl methacrylate, ethyl acrylate, ethyl methacrylate, butyl acrylate, butyl methacrylate, benzyl acrylate, benzyl methacrylate, cyclohexyl acrylate, cyclohexyl methacrylate, phenyl acrylate, or phenyl methacrylate; unsaturated carbonic acid amino alkyl ester compounds such as 2-amino ethyl acrylate, 2-amino ethyl methacrylate, 2-dimethyl amino ethyl acrylate, N-phenylmaleimide, N-benzylmaleimide, N-alkylmaleimide, or 2-dimethyl amino ethyl methacrylate; unsaturated carbonic acid glycidyl ester compounds such as glycidyl acrylate, or glycidyl methacrylate; vinyl cyanide compounds such as acrylo nitrile, or methacrylo nitrile; acryl amide, unsaturated amide compounds such as methacryl amide, but is not limited thereto. The second monomer may be one or more compounds.

[61] In an embodiment, the photosensitive composition may further include various additives such as a leveling agent or a coupling agent. The additive content is not particularly limited but may be appropriately controlled within the range which does not make unfavorable influences on the photosensitive composition and the pattern obtained therefrom.

[62] The leveling agent prevents stains or spots and improves leveling characteristics, and specific examples may be follows without limitation.

[63] A fluorine-based leveling agent may include commercial products, for example BM-1000®, and BM-1100® (BM Chemie Inc.); MEGAFACE F 142D®, F 172®, F 173®, and F 183® of Dainippon Ink Kagaku Kogyo Co., Ltd.; FC-135®, FC-170C®, FC-430®, and FC-431® of Sumitomo 3M Co., Ltd.; SURFLON S-112®, SURFLON S-113®, SURFLON S-131®, SURFLON S-141®, and SURFLON S-145® of Asahi Glass Co., Ltd.); and SH-28PA®, SH-190®, SH-193®, SZ-6032®, and SF-8428®, and the like of Toray Silicone Co., Ltd.).

[64] The leveling agent may be controlled according to desirable properties.

[65] The coupling agent may be used to increase adherence with a substrate and may be a silane-based coupling agent. Specific examples of the silane-based coupling agent may be vinyl trimethoxysilane, vinyl tris(2-methoxyethoxysilane), 3-glycidoxypropyl trimethoxysilane, 2-(3,4-epoxy cyclohexyl)ethyl trimethoxysilane, 3-chloropropyl methyldimethoxysilane, 3-chloropropyl trimethoxysilane, 3-methacryloxylpropyl trimethoxysilane, 3-mercaptopropyl trimethoxysilane, and the like.

[66] In an embodiment, the solvent may be determined considering the amounts of the components (i.e., a photopolymerizable monomer, a photoinitiator, an alkali soluble resin, and an additive) and and/or the quantum dot 11 and the light scatterer 12 which may be described later.

[67] That is, the photosensitive resin composition may include a balance amount of the solvent except amounts of desirable solids (non-volatiles), and the solvent may be appropriately selected considering affinity for other components in the composition (e.g., an alkali soluble resin, a photopolymerizable monomer, a photoinitiator, an additive and/or a quantum dot and a light scatterer which may be described later), affinity for alkali developing solution, and boiling points, and the like. Examples of the solvent may be ethylene glycols such as ethyl 3-ethoxy propionate, ethylene glycol, diethylene glycol, or polyethylene glycol; glycolethers such as ethylene glycolmonomethylether, ethylene glycolmonoethylether, diethylene glycolmonomethylether, ethylene glycoldiethylether, or diethylene glycoldimethylether; glycoletheracetates such as ethylene glycolacetate, ethylene glycolmonoethyletheracetate, diethylene glycolmonoethyletheracetate, or diethylene glycolmonobutyletheracetate; propylene glycols such as propylene glycol; propylene glycolethers such as propylene glycolmonomethylether, propylene glycolmonoethylether, propylene glycolmonopropylether, propylenemonobutylether, propylene glycoldimethylether, dipropylene glycoldimethylether, propylene glycoldiethylether, or dipropylene glycoldiethylether; propylene glycoletheracetates such as propylene glycolmonomethyl ether acetate, or dipropylene glycolmonoethyletheracetate; amides such as N-methylpyrrolidone, dimethyl formamide, or dimethyl acetamide; ketones such as methylethylketone (MEK), methylisobutylketone (MIBK), or cyclohexanone; petroleums such as toluene, xylene, or solvent naphtha; esters such as ethyl acetate, butyl acetate, or ethyl lactate; ethers such as diethyl ether, dipropyl ether, and dibutyl ether; and a mixture thereof.

[68] Meanwhile, in an embodiment, the first solvent included in the first photosensitive resin composition may be a solvent having the different polarity from the second solvent included in the second photosensitive resin composition. That is, either the first solvent or the second solvent may be non-polar, and the other may have polarity. In an embodiment, the solvent having non-polarity may include alkanes such as pentane,

hexane, heptanes; aromatic hydrocarbons such as toluene, xylene; diethyl ether, dipropyl ether, dibutyl ether, diisoamyl ethers; alkyl halides such as chloroform, trichloromethane; cycloalkanes such as cyclopropane, cyclobutane, cyclopentane, cyclohexane; and a mixture thereof, but is not necessarily limited thereto, and may include all nonpolar solvents having relative polarity index (PI) of less than or equal to 5.0 when water (H_2O) is assumed to have a PI of 9.0.

[69] The non-polar solvent, which is either the first solvent or the second solvent, may be included in 50 parts by weight to 80 parts by weight respectively, based on 100 parts by weight of each the first solvent and the second solvent.

[70] When the non-polar solvent is included within the range, the later-described first photosensitive resin composition and second photosensitive resin composition are controlled to be immiscible, so that the interface between the first layer and the second layer is clearly determined to provide a color filter having excellent coating properties and processability.

[71] Meanwhile, in an embodiment, the first, second photosensitive resin compositions may include a thiol-based hardener. The thiol-based hardener refers to a composition reactive to a carbon-carbon double bond of photopolymerizable monomer and having at least one thiol group being capable of primarily thermally curing the photopolymerizable monomer in a molecule.

[72] In an embodiment, the thiol-based hardener may be any hardener having at least one thiol group, preferably at least two thiol groups in a molecule structure without particular limit.

[73] In an embodiment, the thiol-based hardener may be ethoxylated trimethylolpropane tris(3-mercaptopropionate), trimethylolpropane tris(3-mercaptopropionate), glycol di(3-mercaptopropionate), pentaerythritol tetra(3-mercaptopropionate), 4-mercaptomethyl-3,6-dithia-1,8-octanedithiol, pentaerythritol tetrakis (3-mercaptoacetate), trimethylolpropane tris(3-mercaptoacetate), 4-t-butyl-1,2-benzenedithiol, 2-mercaptoethylsulfide, 4,4'-thiodibenzenethiol, benzenedithiol, glycol dimercaptoacetate, glycol dimercaptopropionate ethylene bis (3-mercaptopropionate), polyethylene glycol dimercaptoacetate, and polyethylene glycol di(3-mercaptopropionate).

[74] On the other hand, in an embodiment, a dispersing agent may be added in order to increase dispersibility of the quantum dot 11 and the light scatterer 12. The dispersing agent may include a non-ionic a dispersing agent, a cationic dispersing agent, an anionic dispersing agent, and a combination thereof. Examples of the dispersing agent may be polyalkylene glycol, or esters thereof, polyoxyalkylene, polyalcoholester-alkyleneoxide addition products, alcohol-alkyleneoxide addition products, sulfonate esters, sulfonate salts, carboxylate esters, carboxylate salts, alkyl amide alkylene oxide

addition products, alkyl amine, or a combination thereof, but is not limited thereto.

[75] Meanwhile, the first photosensitive resin composition for the first layer 10 may include a material absorbing blue light in addition to the components, for example, an organic material or an inorganic material including pigment or dye or a combination thereof. The blue light absorption material may be 5 wt% to 60 wt%, for example 5 wt% to 50 wt%, for example 5 wt% to 40 wt%, for example 5 wt% to 30 wt%, for example 10 wt% to 30 wt%, for example 20 wt% to 30 wt% based on the total weight of the first photosensitive resin composition. Within the ranges, the first layer 10 having a blue light absorption rate of greater than or equal to 80 % may be made.

[76] Meanwhile, the second photosensitive resin composition for the second layer 20 may further include the quantum dot 11 and the light scatterer 12, in addition to the components. As in above, as the second layer 20 further includes the quantum dot 11, it may provide light emitting properties; as further including the light scatterer 12, it may further improve a photoefficiency of second layer 20.

[77] In an embodiment, the quantum dot 11 is not particularly limited and may be a commercially available quantum dot.

[78] For example, the quantum dot may be a Group II-VI compound, a Group III-V compound, a Group IV-VI compound, a Group IV compound, a Group II-III-IV compound, a Group I-II-IV-VI compound or a combination thereof.

[79] The Group II-VI compound may be selected from a binary element compound selected from CdSe, CdTe, ZnS, ZnSe, ZnTe, ZnO, HgS, HgSe, HgTe, MgSe, MgS, and a mixture thereof; a ternary element compound selected from CdSeS, CdSeTe, CdSTe, ZnSeS, ZnSeTe, ZnSTe, HgSeS, HgSeTe, HgSTe, CdZnS, CdZnSe, CdZnTe, CdHgS, CdHgSe, CdHgTe, HgZnS, HgZnSe, HgZnTe, MgZnSe, MgZnS, and a mixture thereof; and a quaternary element compound selected from HgZnTeS, CdZnSeS, CdZnSeTe, CdZnSTe, CdHgSeS, CdHgSeTe, CdHgSTe, HgZnSeS, HgZnSeTe, HgZnSTe, and a mixture thereof. The Group III-V compound may be selected from a binary element compound selected from GaN, GaP, GaAs, GaSb, AlN, AlP, AlAs, AlSb, InN, InP, InAs, InSb, and a mixture thereof; a ternary element compound selected from GaNP, GaNAs, GaNSb, GaPAs, GaPSb, AlNP, AlNAs, AlNSb, AlPAs, AlPSb, InNP, InNAs, InNSb, InPAs, InPSb, and a mixture thereof; and a quaternary element compound selected from GaAlNP, GaAlNAs, GaAlNSb, GaAlPAs, GaAlPSb, GaInNP, GaInNAs, GaInNSb, GaInPAs, GaInPSb, InAlNP, InAlNAs, InAlNSb, InAlPAs, InAlPSb, and a mixture thereof. The Group IV-VI compound may be selected from a binary element compound selected from SnS, SnSe, SnTe, PbS, PbSe, PbTe, and a mixture thereof; a ternary element compound selected from SnSeS, SnSeTe, SnSTe, PbSeS, PbSeTe, PbSTe, SnPbS, SnPbSe, SnPbTe, and a mixture thereof; and a quaternary element compound selected from SnPbSSe,

SnPbSeTe, SnPbSTe, and a mixture thereof. The Group I-III-VI compound may include $CuInSe_2$, $CuInS_2$, CuInGaSe, and CuInGaS but is not limited thereto. The Group I-II-IV-IV compound may include CuZnSnSe, and CuZnSnS but is not limited thereto. The Group IV compound may include a single-element compound selected from Si, Ge, and a mixture thereof; and a binary element compound selected from SiC, SiGe, and a mixture thereof.

[80] The binary element compound, the ternary element compound or the quaternary element compound respectively exist in a uniform concentration in the quantum dot particle or partially different concentrations in the same particle.

[81] In an embodiment, the quantum dot may have a core-shell structure wherein a quantum dot surrounds another quantum dot. The core and shell may have an interface, and an element of at least one of the core or the shell in the interface may have a concentration gradient wherein the concentration of the element(s) of the shell decreases toward the core. In addition, the quantum dot may have one core of a quantum dot and multi-shells surrounding the core. The multi-shell structure has at least two shells wherein each shell may be a single composition, an alloy, or the one having a concentration gradient.

[82] In the quantum dot particle, the materials of the shell may have a larger energy bandgap than that of the core, and thereby the quantum dot may exhibit a quantum confinement effect more effectively. In case of a multi-shell type of quantum dot particle, the bandgap of the material of an outer shell may be higher energy than that of the material of an inner shell (a shell that is closer to the core). In this case, the quantum dot may emit light of a wavelength ranging from UV to infrared light.

[83] On the other hand, an organic material may be further substituted on the shell surface to stabilize a quantum dot in order to improve stability and dispersibility of a quantum dot. Examples of the organic material may be a thiol-based, an amine-based, a phosphine oxide-based, an acryl-based, or a silicon-based organic material, but is not limited thereto.

[84] The quantum dot may have quantum efficiency of greater than or equal to 10 %, for example, greater than or equal to 30 %, greater than or equal to 50 %, greater than or equal to 60 %, greater than or equal to 70 %, or greater than or equal to 90 %.

[85] In a display device, the quantum dot may have a narrow spectrum in order to improve color purity or color reproducibility. The quantum dot may have a full width at half maximum (FWHM) of less than or equal to 100 nm, for example less than or equal to 80 nm, less than or equal to 60 nm, less than or equal to 50 nm, or 20 nm to 50 nm in a light emitting wavelength spectrum. Within such ranges, a device may have enhanced color purity or improved color reproducibility.

[86] The quantum dot may have a particle diameter (an average largest particle diameter

for a non-spherical shape) of about 1 nm to about 100 nm. In an embodiment, the quantum dot may have a particle diameter (an average largest particle diameter for a non-spherical shape) of about 1 nm to about 20 nm, for example about 1 nm to about 15 nm, about 2 nm to about 15 nm, or about 5 nm to about 15 nm.

[87] The quantum dot 11 may be included in an amount of 1 wt% to 50 wt%, for example 5 wt% to 40 wt%, for example 10 wt% to 30 wt% based on the total weight of the second photosensitive resin composition. By adjusting the amount of quantum dot 11 within the range, a color filter 100 may have excellent color reproducibility and color purity.

[88] Meanwhile, for the convenience, the shape of quantum dot is shown in a sphere in FIG. 1 but is not necessarily limited thereto, and the shape of quantum dot is not particularly limited as long as being generally used in this field. For example, the quantum dot may have other shapes of a pyramidal shape or a multi-arm shape, or may be a cubic nanoparticle, a nanotube, a nanowire, a nanofiber, or a nanosheet-shaped particle.

[89] The light scatterer 12 may widely scatter the incident light in the second layer 20 in the various directions, as described above, so as to enhance the photoefficiency in the second layer 20. The light scatterer 12 may include inorganic oxide particles such as alumina, silica, zirconia, a titanium oxide particulate, zinc oxide, and the like, metal particles such as gold, silver, copper, platinum, and the like, but is not limited thereto.

[90] Hereinafter, a specific structure of the color filter 100 according to an embodiment is described with reference to FIGS. 2 to 4.

[91] FIG. 2 is a view showing the color filter of FIG. 1 in more detail; FIG. 3 is a view further specifically showing the path of the first light entered into the color filter of FIG. 2; and FIG. 4 is a view showing inner dimensions of the color filter of FIG. 2.

[92] Referring to FIGS. 2 to 4, the color filter 100 may be compartmented into a first region PX1 indicating a first light, a second region PX2 indicating a second light, and a third region PX3 indicating a third light. Each region may be partitioned by a light blocking member 403.

[93] In addition, the first region PX1 to third region PX3 form a predetermined regular arrangement. For example, supposing that the array in which the first region PX1, the second region PX2, and the third region PX3 are sequentially disposed in a direction from the right side to the left side in FIG. 2 is one unit region, two or more unit regions are regularly repeated to provide an arrangement. In addition, the unit region is two-dimensionally repeated to provide an arrangement, for example, in a matrix. However, the arrangement order or the arrangement direction of the first region PX1 to the third region PX3 may be variously designed.

[94] According to an embodiment, the first region PX1 of color filter expresses blue light

as a first light; the second region PX2 expresses green light as a second light; and the third region PX3 may express red light as a third light.

[95] In this case, for example, the color filter 100 may be a blue light color filter capable of expressing each blue light, green light, red light by being supplied with blue light as a first light as shown in FIG. 3. Thereby, the first layer 10 and the second layer 20 may be not formed in a first region PX1 where expresses blue light, but may be each formed only in the second region PX2 and the third region PX3. The first region PX1 may be filled with transparent medium.

[96] However, the operating method and the composition of the color filter are not necessarily limited thereto, but the color filter may be supplied with white light or ultraviolet (UV) to express each blue light, green light, red light. In this case, the first layer 10 may be formed only in the second region PX2 and the third region PX3; the second layer 20 may be formed in all of the first region PX1 to the third region PX3.

[97] Hereinafter, for the convenience, the blue light color filter is exemplified for describing a color filter 100 according to an embodiment, and for the convenience, the transparent medium filled in the first region PX1 refers to a blue filter 21; the second layer formed in the second region PX2 refers to a green filter 20g; and the second layer formed in the third region PX3 refers to a red filter 20r.

[98] The first region PX1 includes a blue filter 21. The blue filter 21 may not include quantum dots but may include a transparent medium so that the incident light of blue light is emitted and expressed as it is.

[99] The transparent medium may be formed to fully fill the first region PX1 and may have a variety of heights, sizes or the like according to exemplary embodiments. The transparent medium may include the light scatterer 12 which changes only the propagation direction of blue light without changing the wavelength of blue light. Meanwhile, the transparent medium may be omitted according to an exemplary embodiment. In this case, hollow may be provided in the first region PX1, and the hollow may play a role of a blue filter 21.

[100] Meanwhile, the first layer 10 is not formed in the first region PX1, as shown in FIG. 2, the color filter 100 may express blue light through the first region PX1.

[101] The second region PX2 includes a first layer 10 and a green filter 20g disposed on the first layer 10. The green filter 20g includes a first quantum dot 11g emitting green light while being stabilized to the ground state after it was excited by receiving blue light. The light radiated by the first quantum dot 11g passes through the first layer 10 to be emitted to the outside of color filter, but the blue light passed through the green filter 20g is absorbed by the first layer 10 so not to be emitted to the outside of color filter.

[102] In other words, according to one embodiment, as the second region PX2 may express

only green light emitted from the first quantum dot 11g, it may provide a color filter 100 having improved color reproducibility and color purity for green light.

[103] The third region PX3 includes a first layer 10 and a red filter 20r disposed on the first layer 10. The red filter 20r includes a second quantum dot 11r emitting red light while being stabilized to the ground state after it was excited by receiving blue light. The light radiated by the second quantum dot 11r passes the first layer 10 to be emitted to the outside of color filter, but the blue light passed through the red filter 20r is absorbed by the first layer 10 not to be emitted to the outside of color filter.

[104] In other words, according to one embodiment, as the third region PX3 may express only red light emitted from the second quantum dot 11r, it may provide a color filter 100 having improved color reproducibility and color purity for the red light.

[105] Meanwhile, the first quantum dot 11g and second quantum dot 11r may be made of the same materials but may have different size from each other so as to emit each green light and red light having different wavelengths from each other.

[106] For example, the first quantum dot 11g may have a smaller size than the second quantum dot 11r, thereby, it may emit green light having higher energy, which has a center wavelength of 545±10 nm and a full width at half maximum (FWHM) of 20 nm to 60 nm, than red light. On the contrary, the second quantum dot 11r may have a larger size than the first quantum dot 11g, thereby, it may emit red light having lower energy, which has a center wavelength of 650±15 nm and a full width at half maximum (FWHM) of 20 nm to 60 nm, than green light.

[107] In an embodiment, the blue light is converted to green light or red light by the first quantum dot 11g or the second quantum dot 11r, and the provided lights are scattered and emitted by a light scatterer 12 and other scatter-inducing particles, so the propagation direction of the emitted light is wide, and the light grayscale is not changed depending upon a position. That is, the color filter 100 may have a wide viewing angle.

[108] Meanwhile, in an embodiment, the first layer 10 may be integrally formed to fully cover the second region PX2 and third region PX3 in the substrate 401. That is, the first layer 10 blocks visible light in a blue light wavelength region but has a high transmittance in other visible light wavelength regions, so may be integrally formed in a connection under the green filter 20g and the red filter 20r.

[109] In this case, the first layer is not needed to be formed in each the green filter and the red filter by the additional process, so unnecessary processes may be omitted during making the color filter according to one embodiment.

[110] The first layer 10 may have a thickness H1 of 0.05 ㎛ to 10 ㎛, for example, 0.1 ㎛ to 10 ㎛, for example, 0.1 ㎛ to 7 ㎛, for example, 0.1 ㎛ to 5 ㎛, for example, 0.1 ㎛ to 3 ㎛, for example, 0.1 ㎛ to 1 ㎛. Within the range, the blue light absorption rate by

the first layer 10 is greater than or equal to 80 %, and the light amount of green light or red light partially absorbed by the first layer 10 may be minimized.

[111] The first layer 10 may have a width L1 of 1 ㎛ to 200 ㎛. The first layer 10 may effectively and fully absorb blue light emitted from the light source within the width L1 range, so the cross-talk of quantum dot may be prevented.

[112] In addition, the first layer 10 may have a thickness H1 of 0.1 ㎛ to 5 ㎛, for example, 1 ㎛ to 3 ㎛. The first layer 10 may show excellent surface planarity within the thickness H1 range.

[113] Meanwhile, the thickness H2 of red filter 20r and the thickness H3 of green filter 20g may be same or different from each other. The thickness H2 of red filter 20r and the thickness H3 of green filter 20g may be each 0.1 ㎛ to 20 ㎛, for example, 1 ㎛ to 5 ㎛. When the thickness H2 of red filter and the thickness H3 of green filter are each within the range, the color filter 100 may emit light amount of red light or green light by each filter in an appropriate level. That is, the color filter may have excellent color reproducibility and luminance.

[114] The blue filter 21 may be provided to dispose the upper surface on the same plane surface as in the red filter 20r and the green filter 20g, but is not limited thereto.

[115] In other words, the thickness of blue filter 21 may be variously adjusted considering a gap with the adjacent red filter 20r or the adjacent green filter 20g, a width of first region PX1, thicknesses H2 and H3 of red filter 20r or green filter 20g, or a thickness of first layer 10. The thickness H4 of blue filter 21 may be thinner than the thickness of the first layer 10, for example, the thickness H4 of blue filter 21 may be same or thicker than the thickness of first layer 10 and also may be same as or thinner than the sum H1+H2 of the thickness H1 of first layer 10 and the thickness H2 of red filter 20r or the sum H1+H3 of the thickness H1 of first layer 10 and the thickness H3 of green filter 20g.

[116] As in above, the color filter 100 according to one embodiment has excellent color reproducibility and color purity for the green light and the red light, by the first layer 10 integrally formed to fully cover the second region PX2 and the third region PX3 in the substrate 401.

[117] Hereinafter, a method of manufacturing a display device including the color filter of FIG. 2 to FIG. 4 is described.

[118] A method of manufacturing a color filter according to one embodiment includes: preparing a first photosensitive resin composition including a photopolymerizable monomer, a photoinitiator, an alkali soluble resin, and a first solvent; preparing a second photosensitive resin composition including a photopolymerizable monomer, a photoinitiator, an alkali soluble resin, a second solvent, and 2 or more quantum dots; coating the first photosensitive resin composition on a substrate; coating the second

photosensitive resin composition on the first photosensitive resin composition; and curing the coated first photosensitive resin composition and second photosensitive resin composition, together.

[119] The first photosensitive resin composition may be obtained by mixing the photopolymerizable monomer, the photoinitiator, the carboxyl group-contained alkali soluble resin, the hardener, the dispersing agent and the first solvent, as a material for the first layer 10.

[120] In the preparing a second photosensitive resin composition, a light scatterer and quantum dots may be further mixed to the photopolymerizable monomer, the photoinitiator, the carboxyl group-contained alkali soluble resin, the hardener, the dispersing agent, and the second solvent, as a material for the second layer 20.

[121] Meanwhile, as the advance preparing step, a light blocking member is formed to leave a space in a predetermined interval on the substrate. The intervals between light blocking members become first to third regions, respectively.

[122] Then the first photosensitive resin composition is coated on the substrate formed with light blocking member according to spin coating, or slit coating and the like, and the second photosensitive resin composition is coated on first photosensitive resin composition by spin coating, or slit coating and the like.

[123] Thereby, it may provide a stacked structure in which the first photosensitive resin composition and the second photosensitive resin composition are sequentially coated on the substrate. That is, as the first solvent and second solvent have different polarity from each other, the first photosensitive resin composition and the second photosensitive resin composition are immiscible to provide layers.

[124] Then the stacked structure is prebaked to remove moisture existed in the first photosensitive resin composition and the second photosensitive resin composition. The specific conditions such as a temperature, a time, atmosphere of pre-baking are known and may be appropriately adjusted, and may be omitted if desirable.

[125] Subsequently, the stacked structure is exposed to light having a predetermined wavelength under a mask having a predetermined pattern. The wavelength and the intensity of the exposing light may be selected considering the kind and the content of photoinitiator, the kind and the content of quantum dots or the like. Thereby, as the first photosensitive resin composition and the second photosensitive resin composition may be simultaneously cured, a first layer 10 may be integrally formed to cover the second region PX2 and the third region PX3 on the substrate in one process without curing each the first photosensitive resin and the second photosensitive resin composition and then patterning the same for each the second region PX2 and third region PX3.

[126] Like this, the method of manufacturing a color filter 100 according to one em-

bodiment may provide a first layer 10 through one process without separately forming the first layer 10 for each the second region PX2 and the third region PX3, so as to provide a color filter having excellent display characteristics such as color reproducibility, color purity, viewing angle with no significantly increasing the number of processes.

[127] However, the color filter according to one embodiment is not necessarily manufactured by the making method, but may be manufactured in the different methods according to the conditions such as a kind and a size of the product to be applied with the color filter, or according to the various process conditions of the material of the first photosensitive resin composition and the second photosensitive resin composition, a coating speed, a processing temperature or the like.

[128] That is, for the color filter according to one embodiment, for example, the first photosensitive resin composition may be primarily prebaked before coating the second photosensitive resin composition; and the prebaked first photosensitive resin composition may be cured using light or heat, and then the second photosensitive resin composition may be coated.

[129] Hereinafter, a structure of display device including the color filter of FIGS. 2 to 4 is described with reference to FIG. 5. In an embodiment, a liquid crystal display (LCD) is exemplified as the display device including a color filter, but the scope of one embodiment is not necessarily limited thereto and may be applicable to a color filter for the various display devices such as an organic light emitting diode (OLED) display or a light emitting diode.

[130] FIG. 5 is a view showing a display device including the color filter of FIG. 2.

[131] Referring to FIG. 5, the display device 1000 according to one embodiment includes a light source 200 and a lower panel 300 and an upper panel 400.

[132] The light source 200 may supply first light toward the lower panel 300 and the upper panel 400 in the front side of the first direction D1 of FIG. 5. The light source 200 may include a light emitter capable of emitting a first light. The first light emitted from the light source 200 may be, for example, light in a visible light region, for example, blue light, which is light having a high energy in the visible light region. Thereby the first light of blue light may be supplied to a lower panel 300 and a upper panel 400. However, the first light is not necessarily limited thereto, but may be other light besides blue light in the visible light wavelength region or ultraviolet (UV) in the ultraviolet (UV) wavelength region.

[133] The light source 200 may include a light emitting region including a light emitter and a light guide supplying blue light emitted therefrom toward the lower panel 300. The light emitting region may be positioned on one side of the light guide or beneath the light guide.

[134] The lower panel 300 may include a thin film transistor (TFT) array 303 including thin film transistors on a first substrate 301 formed of transparent glass, plastic, and the like. The TFT array 303 may include a gate line, a sustain voltage line, a gate insulating layer, a data line, a source electrode, a drain electrode, a semiconductor, a protective layer, a pixel electrode, and the like, and the thin film transistor is connected to the gate line and the data line. The structures of the gate line, the data line, the source electrode, the drain electrode, the semiconductor, and the pixel electrode may vary depending on examples.

[135] The gate line and the sustain voltage line are electrically separated from each other, and herein, the data line is insulated from and crosses the gate line and the sustain voltage line. The gate electrode, the source electrode, and the drain electrode respectively include a control terminal, an input terminal, and an output terminal of the thin film transistor. The drain electrode is electrically connected with the pixel electrode.

[136] The pixel electrode may be made of a transparent conductive material of indium tin oxide (ITO) or indium zinc oxide (IZO), and generates an electric field to control arrangement directions of liquid crystal molecules.

[137] An alignment layer 501 is disposed on the TFT array 303. The alignment layer 501 may include at least one of polyamic acid, polysiloxane, polyimide, and the like that are generally-used materials in a liquid crystal alignment layer. The alignment layer 501 may initially arrange liquid crystal molecules in the liquid crystal layer 500. Positions of the alignment layer 501 may be different according to embodiments. The alignment layer 501 may be over or under the liquid crystal layer 500, or as shown in FIG. 5, the alignment layer 501 may be disposed over and under the liquid crystal layer 500, and may be omitted as needed.

[138] The liquid crystal layer 500 is disposed between the lower panel 300 and the upper panel 400. The liquid crystal layer 500 may have a thickness, for example, of 5 ㎛ to 6 ㎛. Kinds of liquid crystal molecules in the liquid crystal layer 500, or a driving manner of the liquid crystal layer 500, may be diversified according to embodiments. That is, the liquid crystal layer 500 may be disposed between the first substrate 301 and the color filter 100, as shown in FIG. 5, or may be changed to be disposed between the second substrate 401 and the color filter 100 according to the driving manner.

[139] A first polarizer 302 is adhered to a rear side of the first substrate 301. The first polarizer 302 may include a polarizing element and a protective layer, and the protective layer may include TAC (tri-acetyl-cellulose). The first polarizer 302 may be disposed between the first substrate 301 and the TFT array 303, or at other positions in the lower panel 300.

[140] A common electrode 404 is disposed on the liquid crystal layer 500. The common

electrode 404 may be made of a transparent conductive material of indium tin oxide (ITO) or indium zinc oxide (IZO), and generates an electric field to control arrangement directions of liquid crystal molecules. A position of the common electrode 404 may be diverse according to embodiments, and may be on the lower panel 300.

[141] The upper panel 400 is formed with a second polarizer 402 on the second substrate 401 made of a transparent glass or plastic or the like. The second polarizer 402 may include a polarizing element and a protective layer, and the protective layer may include TAC (tri-acetyl-cellulose). In an embodiment, the second polarizer 402 is disposed on the second substrate 401, but may be disposed on other positions in the upper panel 400, for example, on the common electrode 404 or beneath the second substrate 401, or may be omitted.

[142] The color filter 100 is disposed under the second substrate 401, and the color filter 100 is compartmentalized into the first region PX1 to the third region PX3 by a light blocking member 403 as described in above.

[143] The light blocking member 403 may be formed of a material passing no light, for example, of metal particles such as chromium (Cr), silver (Ag), molybdenum (Mo), nickel (Ni), titanium (Ti), tantalum (Ta), and the like, an oxide of the metal particles, or a combination thereof. The light blocking member 403 prevents light leakage of the display device 1000 and improves its contrast. The light blocking members 403 are formed under the second substrate 401 and are disposed apart from each other by a predetermined distance, as shown in FIG. 5.

[144] In an embodiment, the color filter 100 is partitioned into each region by a light blocking member (black matrix), and thus may block incident light in one region from intrusion into the other regions and may prevent a color mixture of red, green, and blue from being displayed by the display device 100.

[145] Meanwhile, the color filter 100 is disposed in a front side of the first substrate 301. That is, with reference to the first direction D1, which is a direction of supplying the first light, the first substrate 301, the color filter 100, the second substrate 401 are sequentially disposed in the front side of light source along with the first direction D1.

[146] Meanwhile, in an embodiment, the color filter 100 may be disposed in the upper panel 400, but is not necessarily limited thereto, and the color filter 100 may be disposed in the lower panel 300 according to the driving manner of the display device 1000.

[147] With reference to the first direction D1, the second layer 20 of the color filter 100 is disposed in the front side of the first layer 10. That is, as shown in FIG. 5, the color filter 100 has a structure that the first light is entered into each the blue filter 21, the green filter 20g or the red filter 20r, then the light emitted from the green filter 20g or the red filter 20r is passed through the first layer 10 and emitted to the outside of color

filter 100.

[148] Like this, the color filter 100 is formed so that the light converted by the second layer 20 is passed through the first layer 10 and emitted to the outside, so as to provide a display device 1000 having excellent color reproducibility and color purity and viewing angle characteristics.

[149] Hereinafter, the embodiments are illustrated in more detail with reference to examples. However, they are exemplary embodiments, and the present invention is not limited thereto.

[150]

[151] **Preparation Examples 1 and 2: Preparation of Composition for First Layer**

[152] **Preparation Example 1**

[153] 4 g of dipentaerythritol hexaacrylate (DPHA, manufactured by Sartomer), as a photopolymerizable monomer, 2 g of OXE-02 (manufactured by BASF), as a photoinitiator, 3 g of acryl-based resin (SP-RY16, manufactured by Showa denko), as an alkali soluble resin, 11 g of yellow dye (Y138, manufactured by Toyo), as a colorant, 0.02 g of F554 (manufactured by DIC Co., Ltd.), as a leveling agent, a mixed solvent of 65 g of propylene glycol monomethylether acetate (PGMEA) and 15 g of 1-ethoxy-2- (2-methoxyethoxy)ethane (EDM), as a solvent, were used to prepared a composition for a first layer.

[154] **Preparation Example 2**

[155] A composition for a first layer was prepared in accordance with the same procedure as in Preparation Example 1, except that yellow dye (Y150, manufactured by TOYO) was used as a colorant instead of Y138.

[156] Each composition obtained from Preparation Examples 1 and 2 was measured for a transmission spectrum using a UV Spectrophotometer (UV 1600, manufactured by Shimadzu), and the results are shown in FIG. 6.

[157] FIG. 6 is a graph showing a transmission spectrum of the first layer of color filter according to an embodiment, depending upon the visible light wavelength region.

[158] Referring to FIG. 6, it is understood that all photosensitive compositions according to Preparation Examples 1 to 2 had an absorption rate of greater than or equal to 80 % for a blue light wavelength region, particularly, they fully absorbed light in 420 nm to 460 nm wavelength region; on the other hand, had a transmittance of greater than or equal to 80% in greater than or equal to 540 nm, which the light emitted by quantum dots might be fully transmitted.

[159] **Preparation Examples 3 to 8: Preparation of Composition for Second Layer**

[160] A composition for a second layer was prepared as a photosensitive resin composition including quantum dots, with the following components and the composition shown in the following Table 1.

[161] Specifically, after dissolving a photoinitiator into a solvent, it was sufficiently agitated at a room temperature for 2 hours, and then a photopolymerizable monomer and an alkali soluble resin were added together with a light-conversion material (quantum dot) and agitated again at a room temperature for 2 hours. Subsequently, a light scatterer (TiO_2), a fluorine-based surfactant and a thiol-based compound were added thereto and then agitated at a room temperature for 1 hour, and the mixture was filtered for 3 times to remove impurities, thereby a composition for a second layer was prepared.

[162] (A) Light-conversion Material

[163] (A)-1: InP/ZnS quantum dot (fluorescence λ_{em} = 545 nm, FWHM = 45 nm, manufactured by Hansol Chemical, Green QD)

[164] (A)-2: InP/ZnS quantum dot (fluorescence λ_{em} = 630 nm, FWHM = 45 nm, manufactured by Hansol Chemical, Red QD)

[165] (B) Alkali soluble resin

[166] Acryl-based alkali soluble resin (SP-RY16, manufactured by Showa Denko K.K.)

[167] (C) Photopolymerizable monomer

[168] Dipentaerythritolhexaacrylate (DPHA, manufactured by Sartomer)

[169] (D) Photoinitiator

[170] OXE-02 (manufactured by BASF)

[171] (E) Solvent

[172] (E)-1: propylene glycol monomethylether acetate (PGMEA)

[173] (E)-2: 1-ethoxy-2- (2-methoxyethoxy)ethane (EDM)

[174] (E)-3: Cyclohexane

[175] (F) Light scatterer

[176] TiO_2 dispersion liquid (TiO_2 solid: 20 %, TiO_2 average particle diameter: 200 nm to 250 nm, manufactured by Ditto Technology)

[177] (G) Other additive

[178] (G)-1: fluorine-based surfactant (F-554, manufactured by DIC Co., Ltd.,)

[179] (G)-2: thiol-based hardener (ethylene glycol bis(3-mercaptopropionate, manufactured by BOC Sciences)

[180] The component details of the composition for a second layer obtained from Preparation Examples 3 to 8 are shown in the following Table 1.

[181] [Table 1]

(unit: wt%)

		Preparation Example 3	Preparation Example 4	Preparation Example 5	Preparation Example 6	Preparation Example 7	Preparation Example 8
Photopolymerizable monomer		10	8	7	7	4	3
Alkali soluble resin		3.4	3.4	3.4	3.4	3.4	2.4
photoinitiator		0.4	0.4	0.4	0.4	0.4	0.4
Light-conversion material(quantum dot)	(A)-1	10	12	15	-	-	-
	(A)-2	-	-	-	15	18	20
Scatterer		2	2	2	2	2	2
Other additive	(G)-1	0.2	0.2	0.2	0.2	0.2	0.2
	(G)-2	4	4	2	2	2	2
Solvent	(E)-1	25.0	25.0	25.0	15.0	15.0	15.0
	(E)-2	-	-	-	-	-	-
	(E)-3	45.0	45.0	45.0	55.0	55.0	55.0

[182] **Example 1-3: Manufacture of Green Color Filter**

[183] **Example 1**

[184] The photosensitive resin composition obtained from Preparation Example 1 was coated on a 10 $cm^2 \times 10$ cm^2 glass substrate according to a spin coating and pre-baked at 100 °C for 2 minutes. Then it was cooled under the air atmosphere to provide a first layer of organic membrane.

[185] Then 15 ml of the composition for a second layer obtained from Preparation Example 3 was coated on the obtained first layer of organic membrane using a spin coater (Opticoat MS-A150, made by Mikasa) in a thickness of 3.5 ㎛, and then pre-baked at 100 °C for 3 minutes using a hot plate and irradiated with UV in a power of 100 mJ/cm^2 using an exposer (ghi broadband, made by Ushio) to provide a second layer of organic membrane. Subsequently, the stacked structure which the first layer of organic membrane and the second layer of organic membrane sequentially coated on the glass substrate was developed by a 0.2 wt% potassium hydroxide (KOH) aqueous solution using a developer (SSP-200 made by SVS). Then, it was hard-baked at a tem-

perature of 180 °C for 30 minutes in a convection oven to provide a photosensitive organic film having a patterned 2-layered structure.

[186] **Example 2**

[187] A photosensitive organic film having a patterned 2-layered structure was manufactured in accordance with the same procedure as in Example 1, except that the composition for a second layer obtained from Preparation Example 4 was used instead of the composition for a second layer obtained from Preparation Example 3.

[188] **Example3**

[189] A photosensitive organic film having a patterned 2-layered structure was manufactured in accordance with the same procedure as in Example 1, except that the composition for a second layer obtained from Preparation Example 5 was used instead of the composition for a second layer obtained from Preparation Example 3.

[190] **Example 4-6: Manufacture of Red Color Filter**

[191] **Example 4**

[192] A photosensitive organic film having a patterned 2-layered structure was manufactured in accordance with the same procedure as in Example 1, except that the composition for a second layer obtained from Preparation Example 6 was used instead of the composition for a second layer obtained from Preparation Example 3.

[193] **Example 5**

[194] A photosensitive organic film having a patterned 2-layered structure was manufactured in accordance with the same procedure as in Example 1, except that the composition for a second layer obtained from Preparation Example 7 was used instead of the composition for a second layer obtained from Preparation Example 3.

[195] **Example 6**

[196] A photosensitive organic film having a patterned 2-layered structure was manufactured in accordance with the same procedure as in Example 1, except that the composition for a second layer obtained from Preparation Example 8 was used instead of the composition for a second layer obtained from Preparation Example 3.

[197] The photosensitive organic films having a 2-layered structure obtained from Examples 1 to 6 were each measured for a photo-conversion spectrum using a spectroradiometer (CAS140CT, made by Instrument System), and the results are shown in FIG. 7 and FIG. 8.

[198] FIG. 7 is a graph showing a transmission spectrum of color filter according to an embodiment, for a visible light wavelength region emitted from the green filter in the visible light wavelength region.

[199] Referring to FIG. 7, it is confirmed that the green colors filter according to Examples 1 to 3 did not emit blue light in a blue light wavelength region, which is estimated because the blue light was fully absorbed by the first layer.

[200] In addition, in the cases of Examples 2 and 3 gradually increasing the content of quantum dots, comparing to Example 1, the transmission spectrum intensity in the green light emitting region was gradually increased. This is estimated because the generated light amount of internal green light was increased according to increasing the number of quantum dots in the second layer.

[201] FIG. 8 is a graph showing a transmission spectrum of color filter according to an embodiment, for the visible light wavelength region emitted from the red filter in the visible light wavelength region.

[202] Referring to FIG. 8, it is understood that the red color filters according to Examples 4 to 6 did not emit blue light in the blue light wavelength region under the same reasons as in the green color filters of Examples 1 to 3.

[203] In addition, like the green color filters according to Examples 1 to 3, as the amount of quantum dots was gradually increased, the number of quantum dots was increased in the second layer, thus the transmission spectrum intensity in the red light emitting region was gradually increased.

[204] As studied in above, the color filter according to an embodiment had excellent color reproducibility of green light and red light, color purity and viewing angle, by providing a first layer playing a role of a blue cut filter under the second region and the third region of the second layer which is a light emitting layer. In addition, even if green light or red light were partially absorbed by the first layer, it may secure the light amount of green light and red light in an acceptable level as a color filter by adjusting the amount of quantum dots in the green filter or the red filter.

[205] In other words, according to one embodiment, the color filter having excellent color reproducibility, color purity and viewing angle, a method of making the same, and a display device including the same may be provided.

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

Claims

[Claim 1] A color filter compartmentalized into a first region configured to emit first light, a second region configured to emit second light having longer wavelength than the first light, and a third region configured to emit third light having longer wavelength than the second light, and comprising
a substrate, and
a first layer integrally provided with and on the second region and the third region, and
a second layer on the first layer in the substrate,
wherein the first layer has an absorption rate of greater than or equal to 80 % for the first light and
the second layer includes a quantum dot as a light-conversion material.

[Claim 2] The color filter of claim 1, wherein the first layer fully absorbs light in 420 nm to 460 nm wavelength region.

[Claim 3] The color filter of claim 1, wherein the first layer has a transmittance of greater than or equal to 80 % for light in a wavelength region of greater than or equal to 540 nm.

[Claim 4] The color filter of claim 1, wherein a thickness of the first layer is 0.1 ㎛ to 5 ㎛, and a width of the first layer is 1 ㎛ to 200 ㎛.

[Claim 5] The color filter of claim 1, wherein the first light is blue light, the second light is green light, and the third light is red light.

[Claim 6] The color filter of claim 1, wherein in the first layer, a transparent medium is formed on the first region.

[Claim 7] The color filter of claim 6, wherein a light scatterer selected from a metal oxide particle, a metal particle and a combination thereof is dispersed in the transparent medium.

[Claim 8] The color filter of claim 1, wherein the quantum dot includes a Group II-VI compound, a Group III-V compound, a Group IV-VI compound, a Group IV compound, a Group II-III-VI compound, a Group I-II-IV-VI compound, or a combination thereof.

[Claim 9] The color filter of claim 1, wherein the quantum dot comprises:
a first quantum dot disposed in the second region and configured to absorb the first light and to emit the second light,
a second quantum dot disposed in the third region and configured to absorb the first light and to emit the third light.

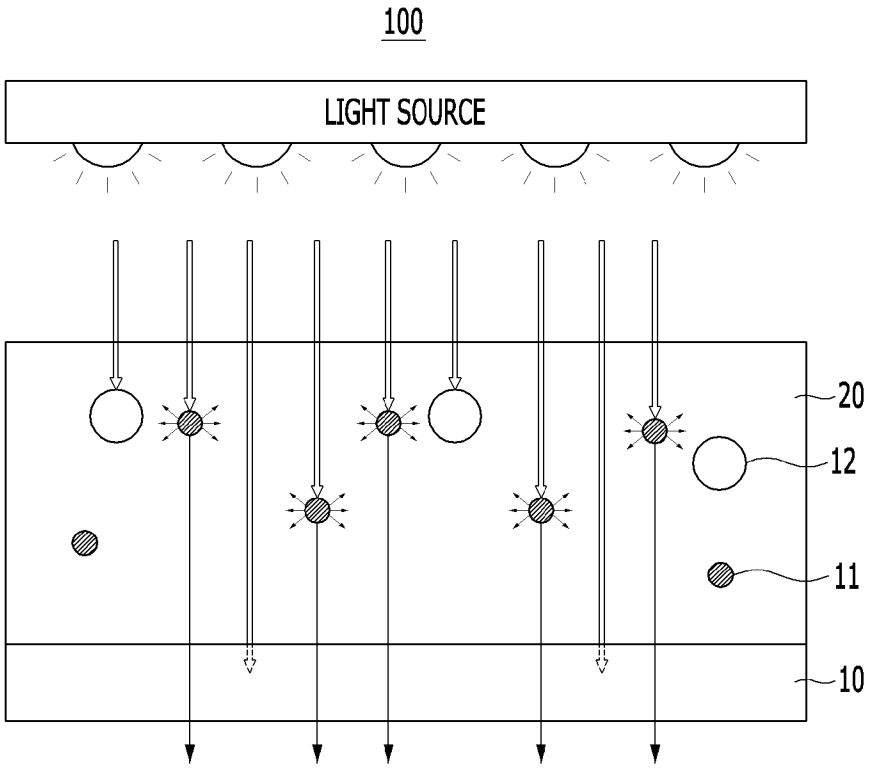
[Claim 10] A display device comprising

the color filter of any one of claims 1 to 9, comprising:
a light source supplying a first light in a first direction,
a first substrate disposed in a front side of the light source with reference to the first direction,
the color filter disposed in a front side of the first substrate with reference to the first direction, and
a second substrate disposed in a front side of the color filter with reference to the first direction,
wherein the second layer of the color filter is disposed in a front side of the first layer with reference to the first direction.

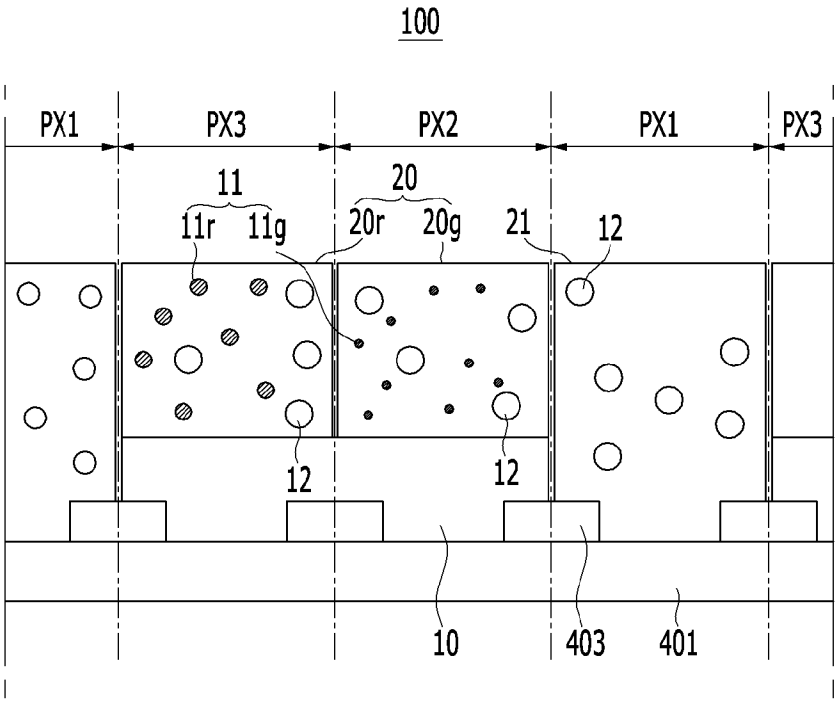
[Claim 11] The display device of claim 10, further comprising a liquid crystal layer disposed between the first substrate and the color filter or between the color filter and the second substrate.

[Claim 12] A method of manufacturing the color filter, comprising:
preparing a first photosensitive resin composition comprising a photopolymerizable monomer, a photoinitiator, an alkali soluble resin, and a first solvent,
preparing a second photosensitive resin composition comprising a photopolymerizable monomer, a photoinitiator, an alkali soluble resin, a second solvent, and a quantum dot,
coating the first photosensitive resin composition on a substrate,
coating the second photosensitive resin composition on the first photosensitive resin composition, and
curing the coated first photosensitive resin composition together with the coated second photosensitive resin composition.

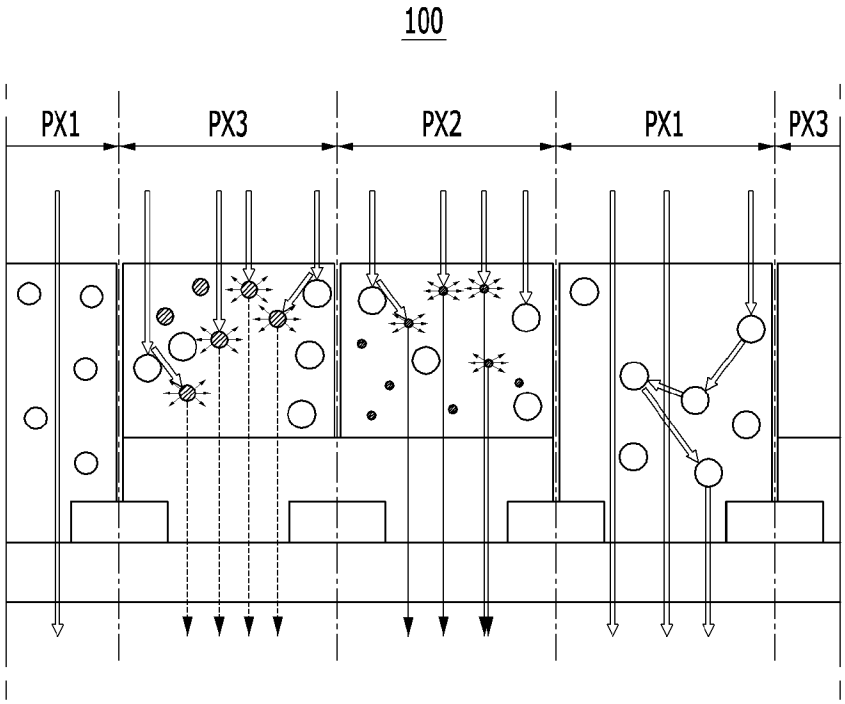
[Fig. 1]


100
LIGHT SOURCE
20
12
11
10

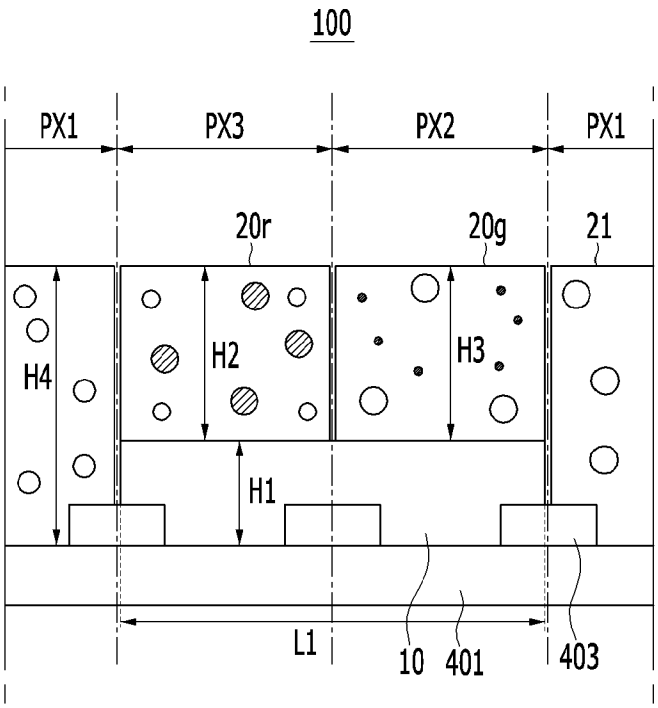
[Fig. 2]


100
PX1
PX3
PX2
PX1
PX3
11
11r
11g
20
20r
20g
21
12
12
12
10
403
401

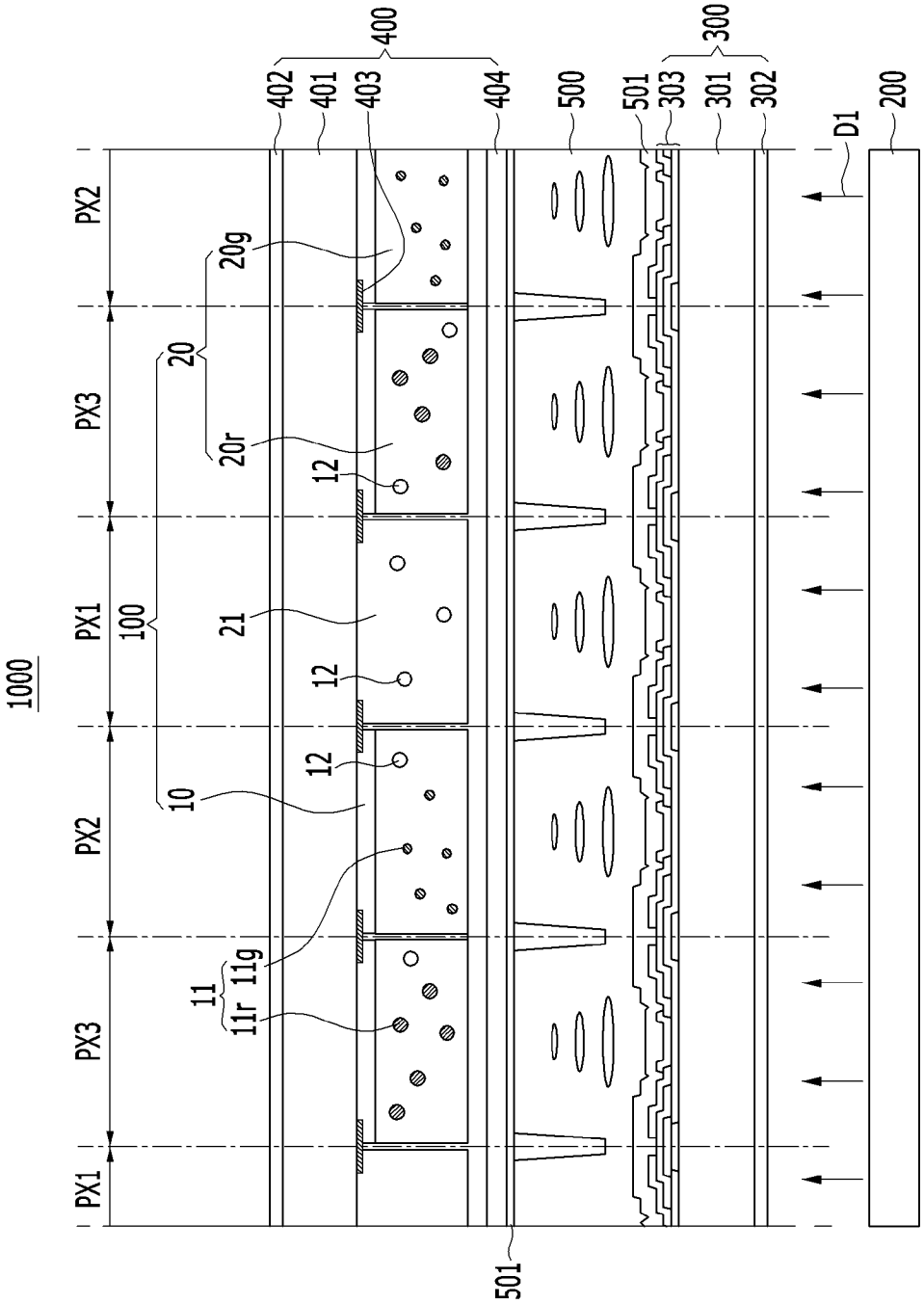
[Fig. 3]


100
PX1
PX3
PX2
PX1
PX3

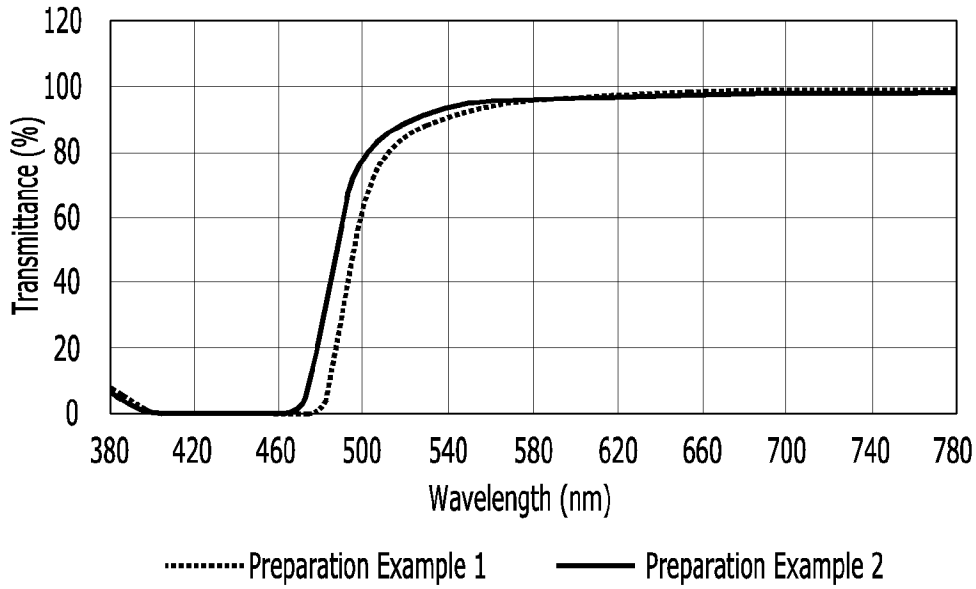
[Fig. 4]


100
PX1
PX3
PX2
PX1
20r
20g
21
H4
H2
H3
H1
L1
10
401
403

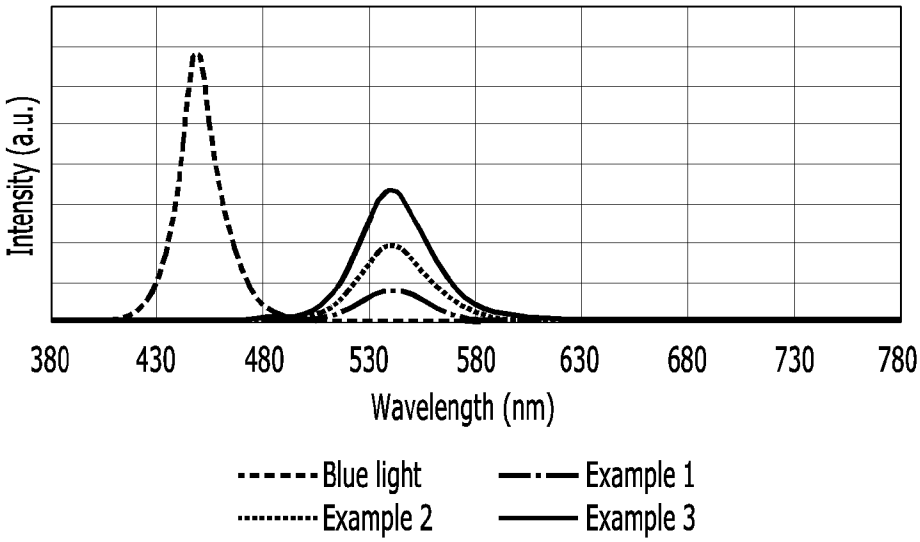
[Fig. 5]


1000
400
300
402
401
403
404
500
501
303
301
302
200
D1
PX2
PX3
PX1
PX2
PX3
PX1
20g
20
20r
12
21
12
12
100
10
11
11r
11g
501

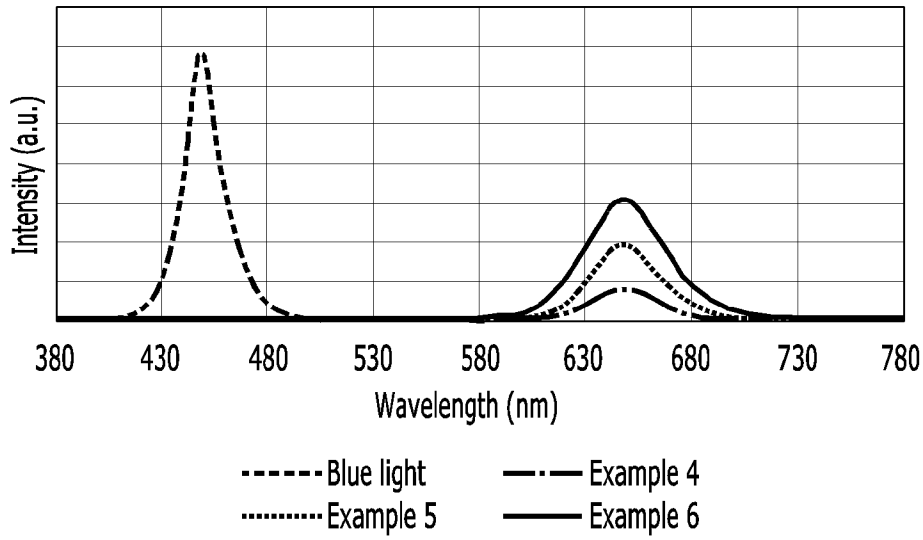
[Fig. 6]



[Fig. 7]



[Fig. 8]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/011240

A. CLASSIFICATION OF SUBJECT MATTER

G02F 1/1335(2006.01)i, G02B 5/28(2006.01)i, G02B 6/293(2006.01)i, G02F 1/017(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02F 1/1335; H01L 27/32; H01J 1/62; G02B 5/20; H01J 63/04; H01L 51/50; H01J 005/16; H01J 061/40; G02B 5/00; G02B 5/28; G02B 6/293; G02F 1/017

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: color filter, wavelength, absorption rate, quantum dot, liquid crystal layer, photosensitive resin, coating

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015-0301408 A1 (BOE TECHNOLOGY GROUP CO., LTD.) 22 October 2015 See paragraphs [0047]-[0051], [0063]-[0067], [0072]-[0079]; and figures 4-5, 7.	1-11
Y		12
Y	KR 10-2013-0000506 A (LG INNOTEK CO., LTD.) 03 January 2013 See paragraphs [0062], [0114]-[0116], [0123]-[0124]; and figures 7-8.	12
A	KR 10-2016-0000569 A (LG DISPLAY CO., LTD.) 05 January 2016 See paragraphs [0099]-[0107]; claim 1; and figure 4.	1-12
A	US 2007-0007881 A1 (BYUNG-KI KIM et al.) 11 January 2007 See paragraphs [0048]-[0051]; and figures 1, 5.	1-12
A	US 2005-0146258 A1 (SHIMON WEISS et al.) 07 July 2005 See paragraph [0023]; and figure 1D.	1-12

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

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17 January 2017 (17.01.2017)	**17 January 2017 (17.01.2017)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2016/011240

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