



RADIATION SENSITIVE COMPOSITION FOR USE AS A PROJECTION
MATERIAL FOR VERTICALLY ALIGNED COLOR LIQUID CRYSTAL
DISPLAYS PANELS

5 Field of the Invention

The present invention relates to a radiation sensitive composition for use as a projection material for vertically aligned color liquid crystal display panels (LCD).

Description of the Prior Art

10 A color liquid crystal display panel is the most widely used among flat panel displays nowadays. Requirements for the display quality of TFT (thin film transistor) color liquid crystal display panels are becoming higher and higher along with the popularization of OA equipment such as personal
15 computers and word processors, and liquid crystal TVs.

TN (Twisted Nematic) LCD is now the most widely used for TFT-LCD. This TN system enables the aligning direction of liquid crystals to be twisted at 90° from one electrode side toward the other electrode side by disposing polarizer
20 films whose aligning directions differ from each other by 90° outside two transparent electrodes, placing alignment films on the inner sides of the two transparent electrodes and arranging nematic liquid crystals between these alignment layers. When nonpolarized light is input into this
25 TN LCD in this state, linearly polarized light going through one of the polarizers passes through the liquid crystals while its polarization direction is shifted. Therefore, it can pass through the other polarizer and makes it bright. Then, when liquid crystal molecules are erected by applying voltage
30 to the both electrodes, linearly polarized light which has reached the liquid crystals passes through the liquid crystals as it is. Therefore, it cannot pass through the other polarizer and makes it dark. When the application of voltage is stopped, the polarizer returns bright.



This TN LCD is equivalent to or superior to CRT in terms of contrast or color reproducibility on the front side by recent technical improvement. However, TN LCD has a problem such as a narrow view angle.

5 As means of solving this problem, STN (Super Twisted Nematic) LCD and MVA (Multi-domain Vertically Aligned) LCD have been developed. Out of these, STN LCD enables the alignment axis of liquid crystal molecules to be twisted at 180° or more between two electrodes by blending a chiral agent
10 as an optically active material into the nematic liquid crystals of TN LCD. As described in "Liquid Crystal", vol. 3, No. 2, pp. 117 (1999) and JP-A 11-258605 (the term "JP-A" as used herein means an "unexamined published Japanese patent application"), MVA LCD makes use of the birefringence mode
15 and not rotary mode of TN LCD by combining negative liquid crystals having anisotropy in negative dielectric constant with a vertically aligned film. Since the alignment direction of liquid crystals at a position close to the alignment film is kept almost vertical even when voltage is
20 not applied, MVA LCD is excellent in contrast and view angle and is excellent in step of preparation because it does not need rubbing for the alignment of liquid crystals.

In MVA LCD, the display-side electrode has a slit in each pixel area and a projection having slopes (for example,
25 a triangular pyramid-like projection) is formed at a position away from the slit of the electrode in the same pixel area on the light input-side electrode as domain restricting means in order to enable liquid crystals in this pixel area to be aligned in a plurality of directions. However, the
30 projection material of the prior art has a problem such as a bad influence upon the display quality of a display panel, for example, burning or nonuniformity in display. A new projection material which can avoid the above bad influence is strongly desired.

Summary of the Invention

It is an object of the present invention to provide a radiation sensitive composition for use as a projection material for vertically aligned color liquid crystal display panels, which provides high film hardness, is excellent in projection surface smoothness, hardly produces the residue or stain on the substrate of an unexposed portion and hardly causes a display failure such as burning or nonuniformity in display.

10 According to the present invention, firstly, the above objects and advantages of the present invention are attained by a radiation sensitive composition for use as a projection material for vertically aligned color liquid crystal display panels, which provides a cured product having an electric
15 resistance of 10^{12} $\Omega \cdot \text{cm}$ or less.

According to the present invention, secondly, the above objects and advantages of the present invention are attained by a radiation sensitive composition for use as a projection material for vertically aligned color liquid crystal display
20 panels, which comprises (A) conductive particles, (B) an alkali-soluble resin, (C) a polyfunctional monomer and (D) a photopolymerization initiator.

The "radiation" as used herein includes visible radiation, ultraviolet radiation, far ultraviolet radiation,
25 electron beams and X-radiation.

Detailed Description of the Preferred Embodiment

The present invention will be described in detail hereinunder.

30 The "radiation sensitive composition for use as a projection material for vertically aligned color liquid crystal display panels, which provides a cured product having an electric resistance of 10^{12} $\Omega \cdot \text{cm}$ or less" in the present invention is not particularly limited if it is a radiation sensitive composition which is prepared by blending

conductive particles to ensure that the electric resistance of the cured product should become $10^{12} \Omega \cdot \text{cm}$ or less, has sufficiently high strength and adhesion to a substrate as projections for vertically aligned color liquid crystal display panels and is capable of forming predetermined projections by a lithographic process to be described hereinafter. A radiation sensitive composition for use as a projection material for vertically aligned color liquid crystal display panels, which comprises (A) conductive particles, (B) an alkali-soluble resin, (C) a polyfunctional monomer and (D) a photopolymerization initiator (to be referred to as "radiation sensitive composition for use as a projection material (d)" hereinafter) is particularly preferred.

The present invention will be described in detail hereniunder.

conductive particles

The conductive particles in the present invention are used to reduce the resistance value of the radiation sensitive composition. Examples of the conductive particles include carbon black, metal particles and metal oxide particles. Out of these, carbon black is preferred.

Examples of the above carbon black include furnace blacks such as SAF, SAF-HS, ISAF, ISAF-LS, ISAF-HS, HAF, HAF-LS, HAF-HS, NAF, FEF, FEF-HS, SRF, SRF-LM, SRF-LS, GPF, ECF, N-339 and N-351; thermal blacks such as FT and MT; and acetylene black.

Examples of the above metal particles include Cu, Fe, Ag, Au, Pt, Mg, Cr, Mn, Co, W, Al, Mo, Sn, Zn and Pb particles.

Examples of the above metal oxide particles include ITO (tin doped indium oxide) particles, antimony pentaoxide particles and tin oxide particles.

The diameters of the conductive particles preferably range from 0.001 to 10 μm , more preferably 0.01 to 5 μm , much

more preferably 0.1 to 2 μm . The volume resistivity of the conductive particles is preferably $10^6 \Omega\cdot\text{cm}$ or less, more preferably $10^4 \Omega\cdot\text{cm}$ or less.

In the present invention, the conductive particles may
5 be used alone or in combination of two or more.

The content of the conductive particles in the radiation sensitive composition (α) for use as a projection material is suitably adjusted according to the type of the conductive particles and the types and amounts of other
10 components contained in the radiation sensitive composition. It is preferably 0.1 to 30 wt%, more preferably 0.5 to 20 wt%, particularly preferably 1 to 15 wt% based on the total solids content of the radiation sensitive composition. When the content of the conductive particles is smaller than 0.1
15 wt%, the electric resistance of the obtained cured product may exceed $10^{12} \Omega\cdot\text{cm}$ and when the content is larger than 30 wt%, adhesion to a substrate may be impaired or the development residue may be produced.

In the present invention, the conductive particles may
20 be used in conjunction with a dispersant.

The dispersant may be an anionic, cationic, nonionic, amphoteric, silicone-based or fluorine-based surfactant.

Examples of the above surfactant include polyoxyethylene alkyl ethers such as polyoxyethylene lauryl
25 ether, polyoxyethylene stearyl ether and polyoxyethylene oleyl ether; polyoxyethylene alkylphenyl ethers such as polyoxyethylene n-octylphenyl ether and polyoxyethylene n-nonylphenyl ether; polyethylene glycol diesters such as polyethylene glycol dilaurate and polyethylene glycol
30 distearate; sorbitan fatty acid esters; fatty acid modified polyesters; tertiary amine modified polyurethanes and polyethylene-imines. Commercially available products of the surfactant include KP (of Shin-Etsu Chemical Co., Ltd.), Polyflow (of Kyoeisha Kagaku Co., Ltd.), F Top (of Tokem

Products Co., Ltd.), Megafac (of Dainippon Ink and Chemicals, Inc.), Florade (of Sumitomo 3M Limited) and Asahi Guard and Surflon (of Asahi Glass Co., Ltd.).

These surfactants may be used alone or in combination
5 of two or more.

The amount of the surfactant is preferably 50 parts or less, more preferably 0 to 30 parts by weight based on 100 parts by weight of the conductive particles.

(B) alkali-soluble resin

10 Any alkali-soluble resin is acceptable in the present invention if it serves as a binder for the conductive particles (A) and is soluble in a developer used to form projections, particularly preferably an alkali developer. The alkali-soluble resin in the present invention is
15 preferably a resin containing a carboxyl group, particularly preferably a copolymer (to be simply referred to as "carboxyl group-containing copolymer" hereinafter) of an ethylenically unsaturated monomer having at least one carboxyl group (to be simply referred to as "carboxyl
20 group-containing unsaturated monomer" hereinafter) and another copolymerizable ethylenically unsaturated monomer (to be simply referred to as "another unsaturated monomer" hereinafter).

Examples of the carboxyl group-containing unsaturated
25 monomer include unsaturated monocarboxylic acids such as acrylic acid, methacrylic acid, crotonic acid, α -chloroacrylic acid and cinnamic acid; unsaturated dicarboxylic acids (anhydrides) such as maleic acid, maleic anhydride, fumaric acid, itaconic acid, itaconic anhydride,
30 citraconic acid, citraconic anhydride and mesaconic acid; unsaturated polycarboxylic acids (anhydrides) having three or more carboxyl groups; mono(2-acryloyloxyethyl)esters or mono(2-methacryloyloxyethyl)esters of a nonpolymerizable dicarboxylic acid such as mono(2-acryloyloxyethyl)succinate,

mono(2-methacryloyloxyethyl)succinate,
 mono(2-acryloyloxyethyl)phthalate and
 mono(2-methacryloyloxyethyl)phthalate; and
 ω-carboxy-polycaprolactone monoacrylate and
 5 ω-carboxy-polycaprolactone monomethacrylate.

These carboxyl group-containing ethylenically
 unsaturated monomers may be used alone or in combination of
 two or more.

Examples of the another unsaturated monomer include
 10 aromatic vinyl compounds such as styrene, α-methylstyrene,
 o-vinytoluene, m-vinytoluene, p-vinytoluene,
 p-chlorostyrene, o-methoxystyrene, m-methoxystyrene,
 p-methoxystyrene, p-vinylbenzylmethyl ether and
 p-vinylbenzylglycidyl ether; indene compounds such as indene
 15 and 1-methylindene; unsaturated carboxylic acid esters such
 as methyl acrylate, methyl methacrylate, ethyl acrylate,
 ethyl methacrylate, n-propyl acrylate, n-propyl
 methacrylate, i-propyl acrylate, i-propyl methacrylate,
 n-butyl acrylate, n-butyl methacrylate, i-butyl acrylate,
 20 i-butyl methacrylate, sec-butyl acrylate, sec-butyl
 methacrylate, t-butyl acrylate, t-butyl methacrylate,
 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate,
 2-hydroxypropyl acrylate, 2-hydroxypropyl methacrylate,
 3-hydroxypropyl acrylate, 3-hydroxypropyl methacrylate,
 25 2-hydroxybutyl acrylate, 2-hydroxybutyl methacrylate,
 3-hydroxybutyl acrylate, 3-hydroxybutyl methacrylate, 4-
 hydroxybutyl acrylate, 4-hydroxybutyl methacrylate, allyl
 acrylate, allyl methacrylate, benzyl acrylate, benzyl
 methacrylate, phenyl acrylate, phenyl methacrylate,
 30 methoxydiethylene glycol acrylate, methoxydiethylene glycol
 methacrylate, methoxytriethylene glycol acrylate,
 methoxytriethylene glycol methacrylate, methoxydipropylene
 glycol acrylate, methoxydipropylene glycol methacrylate,
 glycerol monoacrylate and glycerol monomethacrylate;

unsaturated carboxylic acid aminoalkyl esters such as 2-aminoethyl acrylate, 2-aminoethyl methacrylate, 2-dimethylaminoethyl acrylate, 2-dimethylaminoethyl methacrylate, 2-aminopropyl acrylate, 2-aminopropyl methacrylate, 2-dimethylaminopropyl acrylate, 2-dimethylaminopropyl methacrylate, 3-aminopropyl acrylate, 3-aminopropyl methacrylate, 3-dimethylaminopropyl acrylate and 3-dimethylaminopropyl methacrylate; unsaturated carboxylic acid glycidyl esters such as glycidyl acrylate and glycidyl methacrylate; carboxylic acid vinyl esters such as vinyl acetate, vinyl propionate, vinyl butyrate and vinyl benzoate; unsaturated ethers such as vinylmethyl ether, vinylethyl ether, allylglycidyl ether and methacrylglycidyl ether; vinyl cyanide compounds such as acrylonitrile, methacrylonitrile, α -chloroacrylonitrile and vinylidene cyanide; unsaturated amides such as acrylamide, methacrylamide, α -chloroacrylamide, N-2-hydroxyethyl acrylamide, N-2-hydroxyethyl methacrylamide, N-methylol acrylamide and N-methylol methacrylamide; N-substituted maleimides such as N-cyclohexyl maleimide, N-phenyl maleimide, N-o-hydroxyphenyl maleimide, N-m-hydroxyphenyl maleimide, N-p-hydroxyphenyl maleimide, N-o-methylphenyl maleimide, N-m-methylphenyl maleimide, N-p-methylphenyl maleimide, N-o-methoxyphenyl maleimide, N-m-methoxyphenyl maleimide and N-p-methoxyphenyl maleimide; aliphatic conjugated dienes such as 1,3-butadiene, isoprene and chloroprene; and macromonomers having a monoacryloyl group or monomethacryloyl group at a terminal of the molecular chain of a polymer such as polystyrene, polymethyl acrylate, polymethyl methacrylate, poly-n-butyl acrylate, poly-n-butyl methacrylate and polysiloxane.

These another unsaturated monomers may be used alone or in combination of two or more.

The carboxyl group-containing copolymer is

particularly preferably a copolymer (to be referred to as "carboxyl group-containing copolymer (I)" hereinafter) of (1) a carboxyl group-containing unsaturated monomer containing acrylic acid and/or methacrylic acid as an essential component and optionally mono(2-acryloyloxyethyl)succinate and/or mono(2-methacryloyloxyethyl)succinate and (2) at least one selected from the group consisting of styrene, methyl acrylate, methyl methacrylate, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, benzyl acrylate, benzyl methacrylate, phenyl acrylate, phenyl methacrylate, glycerol monoacrylate, glycerol monomethacrylate, N-phenylmaleimide, polystyrene macromonomer and polymethyl methacrylate macromonomer.

Illustrative examples of the carboxyl group-containing copolymer (I) include copolymers and terpolymers (to be referred to as "carboxyl group-containing copolymers (Ia)" hereinafter) such as a copolymer of (meth)acrylic acid and benzyl (meth)acrylate, terpolymer of (meth)acrylic acid, styrene and benzyl (meth)acrylate, terpolymer of (meth)acrylic acid, benzyl (meth)acrylate and polystyrene macromonomer, and terpolymer of (meth)acrylic acid, benzyl (meth)acrylate and polymethyl methacrylate macromonomer; tetrapolymers (to be referred to as "carboxyl group-containing copolymers (Ib)" hereinafter) such as a tetrapolymer of (meth)acrylic acid, 2-hydroxyethyl (meth)acrylate, benzyl (meth)acrylate and polystyrene macromonomer, tetrapolymer of (meth)acrylic acid, 2-hydroxyethyl (meth)acrylate, benzyl (meth)acrylate and polymethyl methacrylate macromonomer, tetrapolymer of (meth)acrylic acid, styrene, benzyl (meth)acrylate and N-phenyl maleimide, tetrapolymer of (meth)acrylic acid, styrene, phenyl (meth)acrylate and N-phenyl maleimide, and tetrapolymer of (meth)acrylic acid, glycerol

mono(meth)acrylate, styrene and N-phenyl maleimide;
 pentapolymers (to be referred to as "carboxyl
 group-containing copolymers (Ic)" hereinafter) such as a
 pentapolymer of (meth)acrylic acid, styrene, benzyl
 5 (meth)acrylate, N-phenyl maleimide and polystyrene
 macromonomer, pentapolymer of (meth)acrylic acid, styrene,
 benzyl (meth)acrylate, N-phenyl maleimide and polymethyl
 methacrylate macromonomer, pentapolymer of (meth)acrylic
 acid, styrene, phenyl (meth)acrylate, N-phenyl maleimide and
 10 polystyrene macromonomer, pentapolymer of (meth)acrylic
 acid, styrene, phenyl (meth)acrylate, N-phenyl maleimide and
 polymethyl methacrylate macromonomer, pentapolymer of
 (meth)acrylic acid, glycerol mono(meth)acrylate, styrene,
 methyl (meth)acrylate and N-phenyl maleimide, pentapolymer
 15 of (meth)acrylic acid, glycerol mono(meth)acrylate, styrene,
 2-hydroxyethyl (meth)acrylate and N-phenyl maleimide,
 pentapolymer of (meth)acrylic acid, glycerol
 mono(meth)acrylate, styrene, benzyl (meth)acrylate and
 N-phenyl maleimide, pentapolymer of (meth)acrylic acid,
 20 glycerol mono(meth)acrylate, styrene, phenyl (meth)acrylate
 and N-phenyl maleimide, pentapolymer of (meth)acrylic acid,
 mono[2-(meth)acryloyloxyethyl]succinate, glycerol
 mono(meth)acrylate, styrene and N-phenyl maleimide,
 pentapolymer of (meth)acrylic acid, glycerol
 25 mono(meth)acrylate, styrene, N-phenyl maleimide and
 polystyrene macromonomer, and pentapolymer of (meth)acrylic
 acid, glycerol mono(meth)acrylate, styrene, N-phenyl
 maleimide and polymethyl methacrylate macromonomer; and
 hexapolymers (to be referred to as "carboxyl
 30 group-containing copolymers (Id)" hereinafter) such as a
 hexapolymer of (meth)acrylic acid, styrene, 2-hydroxyethyl
 (meth)acrylate, benzyl (meth)acrylate, N-phenyl maleimide
 and polystyrene macromonomer, hexapolymer of (meth)acrylic
 acid, styrene, 2-hydroxyethyl (meth)acrylate, benzyl

(meth)acrylate, N-phenyl maleimide and polymethyl methacrylate macromonomer, hexapolymer of (meth)acrylic acid, styrene, 2-hydroxyethyl (meth)acrylate, phenyl (meth)acrylate, N-phenyl maleimide and polystyrene
5 macromonomer, and hexapolymer of (meth)acrylic acid, styrene, 2-hydroxyethyl (meth)acrylate, phenyl (meth)acrylate, N-phenyl maleimide and polymethyl methacrylate macromonomer.

The copolymerization proportion of the carboxyl
10 group-containing unsaturated monomer to the carboxyl group-containing copolymer is preferably 5 to 50 wt%, more preferably 10 to 40 wt%. When the copolymerization proportion of the carboxyl group-containing unsaturated monomer is smaller than 5 wt%, the solubility in an alkali
15 developer of the obtained radiation sensitive composition may lower and when the copolymerization proportion is larger than 50 wt%, the formed projection may fall off from the substrate or the surface thereof may be roughened at the time of development with an alkali developer.

20 The weight average molecular weight in terms of polystyrene (to be abbreviated as Mw hereinafter) measured by gel permeation chromatography (GPC; tetrahydrofuran as a dissolving solvent) of the alkali-soluble resin in the present invention is preferably 1,000 to 1,000,000, more
25 preferably 5,000 to 100,000.

In the present invention, the alkali-soluble resins may be used alone or in combination of two or more.

The amount of the alkali-soluble resin in the present invention is preferably 300 to 100,000 parts by weight, more
30 preferably 100 to 10,000 parts by weight based on 100 parts by weight of the conductive particles (A). When the amount of the alkali-soluble resin is smaller than 300 parts by weight, alkali developability may lower, or a stain and the film residue may be produced in an area other than a portion

for forming a projection and when the amount is larger than 100,000 parts by weight, the concentration of the conductive particles relatively lowers, whereby a display failure such as image sticking or nonuniformity in display may occur when
 5 a display panel is produced therefrom.

(C) polyfunctional monomer

Examples of the polyfunctional monomer in the present invention include diacrylates and dimethacrylates of alkylene glycol such as ethylene glycol and propylene glycol;
 10 diacrylates and dimethacrylates of polyalkylene glycol such as polyethylene glycol and polypropylene glycol; polyacrylates and polymethacrylates of a polyhydric alcohol having 3 or more hydroxyl groups and dicarboxylic acid modified products thereof such as glycerin,
 15 trimethylolpropane, pentaerythritol and dipentaerythritol; oligoacrylates and oligomethacrylates such as polyester, epoxy resin, urethane resin, alkyd resin, silicone resin and spiran resin; diacrylates and dimethacrylates of a both terminal hydroxylated polymer such as poly-1,3-butadiene
 20 having a hydroxyl group at both terminals, polyisoprene having a hydroxyl group at both terminals and polycaprolactone having a hydroxyl group at both terminals; and tris(2-acryloyloxyethyl)phosphate and tris(2-methacryloyloxyethyl)phosphate.

25 Out of these polyfunctional monomers, polyacrylates and polymethacrylates of a polyhydric alcohol having 3 or more hydroxyl groups and dicarboxylic acid modified products thereof are preferred, as exemplified by trimethylolpropane triacrylate, trimethylolpropane trimethacrylate,
 30 pentaerythritol triacrylate, pentaerythritol trimethacrylate, succinic acid modified product of pentaerythritol triacrylate, succinic acid modified product of pentaerythritol trimethacrylate, pentaerythritol tetraacrylate, pentaerythritol tetramethacrylate,

dipentaerythritol tetraacrylate, dipentaerythritol tetramethacrylate, dipentaerythritol hexaacrylate and dipentaerythritol hexamethacrylate. Trimethylolpropane triacrylate, pentaerythritol triacrylate and

5 dipentaerythritol hexaacrylate are particularly preferred because the strength of the obtained projection is high, the surface smoothness of the projection is excellent, and a stain and the film residue are hardly produced in an area other than a portion for forming a projection.

10 The above polyfunctional monomers may be used alone or in combination of two or more.

The amount of the polyfunctional monomer in the present invention is preferably 5 to 500 parts by weight, more preferably 20 to 300 parts by weight based on 100 parts by weight of the alkali-soluble resin (B). When the amount of
15 the polyfunctional monomer is smaller than 5 parts by weight, the strength and surface smoothness of the projection may become unsatisfactory and when the amount is larger than 500 parts by weight, alkali developability may lower, or a stain
20 and the film residue may be produced in an area other than a portion for forming a projection.

In the present invention, part of the above polyfunctional monomer may be substituted by a monofunctional monomer.

25 The monofunctional monomer is, for example, a carboxyl group-containing unsaturated monomer or another unsaturated monomer constituting the alkali-soluble resin (B), 2-hydroxy-3-phenoxypropyl acrylate, 2-hydroxy-3-phenoxypropyl methacrylate or M-5300 as a
30 commercially available product (trade name, manufactured by Toagosei Chemical Industry Co., Ltd.).

Out of these monofunctional monomers, preferred are mono(2-acryloyloxyethyl)succinate, mono(2-methacryloyloxyethyl)succinate,

ω-carboxypolycaprolactone monoacrylate (M-5300),
 ω-carboxypolycaprolactone monomethacrylate,
 methoxytriethylene glycol acrylate, methoxytriethylene
 glycol methacrylate, methoxydipropylene glycol acrylate,
 5 methoxydipropylene glycol methacrylate,
 2-hydroxy-3-phenoxypropyl acrylate and
 2-hydroxy-3-phenoxypropyl methacrylate.

The above monofunctional monomers may be used alone or in combination of two or more.

10 The amount of the monofunctional monomer is preferably
 0 to 90 wt%, more preferably 0 to 50 wt% based on the total
 of the polyfunctional monomer and the monofunctional
 monomer.

(D) photopolymerization initiator

15 The photopolymerization initiator in the present
 invention is a compound which forms active species capable
 of initiating the polymerization of the above polyfunctional
 monomer (C) and an optionally used monofunctional monomer,
 such as a radical, anion or cation, through its decomposition
 20 or the cleavage of its bond upon exposure to radiation (to
 be simply referred to as "exposure" hereinafter).

Examples of the photopolymerization initiator include
 biimidazole compounds, acetophenone compounds, other
 optically radical generating agents and compounds having a
 25 trihalomethyl group.

The biimidazole compounds include
 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis
 (4-ethoxycarbonylphenyl)-1,2'-biimidazole,
 2,2'-bis(2-bromophenyl)-4,4',5,5'-tetrakis
 30 (4-ethoxycarbonylphenyl)-1,2'-biimidazole,
 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-
 biimidazole,
 2,2'-bis(2,4-dichlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-
 biimidazole,

2,2'-bis(2,4,6-trichlorophenyl)-4,4',5,5'-tetraphenyl-
1,2'-biimidazole,

2,2'-bis(2-bromophenyl)-4,4',5,5'-tetraphenyl-1,2'-
biimidazole,

5 2,2'-bis(2,4-dibromophenyl)-4,4',5,5'-tetraphenyl-1,2'-
biimidazole and

2,2'-bis(2,4,6-tribromophenyl)-4,4',5,5'-tetraphenyl-
1,2'-biimidazole.

These biimidazole compounds have excellent solubility
10 in a solvent, do not form foreign matter such as an undissolved
product and a precipitate, have high sensitivity and high
contrast, fully promote a curing reaction by exposure with
a small amount of energy and do not cause a curing reaction
in an unexposed portion. Therefore, the coating film after
15 exposure is clearly divided into a cured portion insoluble
in a developer and an uncured portion having high solubility
in the developer, thereby making it possible to form an
excellent projection free from a missing part, lost part and
undercut.

20 The above acetophenone compounds include
2-hydroxy-2-methyl-1-phenylpropan-1-one,
1-(4-i-propylphenyl)-2-hydroxy-2-methylpropan-1-one,
4-(2-hydroxyethoxy)phenyl-(2-hydroxy-2-propyl)ketone,
1-hydroxycyclohexylphenyl ketone,
25 2,2-dimethoxy-2-phenylacetophenone,
2,2-dimethoxy-1,2-diphenylethan-1-one,
2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-
one and
2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butan-1-
30 one.

The above other optically radical generating agents
include benzophenone, 3,3'-dimethyl-4-methoxybenzophenone,
2,4-diethylthioxanthone, 4-azidobenzaldehyde,
4-azidoacetophenone, 4-azidobenzalacetophenone,

azidopyrene, 4-diazodiphenylamine,
4-diazo-4'-methoxydiphenylamine,
4-diazo-3-methoxydiphenylamine,
bis(2,6-dimethoxybenzoyl)-2,4,4-trimethylpentylphosphine
5 oxide, dibenzoyl, benzoin isobutyl ether,
N-phenylthioacridone and triphenylpyrylium perchlorate.

The above compounds having a trihalomethyl group
include 1,3,5-tris(trichloromethyl)-s-triazine,
1,3-bis(trichloromethyl)-5-(2-chlorophenyl)-s-triazine,
10 1,3-bis(trichloromethyl)-5-(4-chlorophenyl)-s-triazine,
1,3-bis(trichloromethyl)-5-(2-methoxyphenyl)-s-triazine
and
1,3-bis(trichloromethyl)-5-(4-methoxyphenyl)-s-triazine.

Out of the acetophenone compounds, other optically
15 radical generating agents and compounds having a
trihalomethyl group,
2-hydroxy-2-methyl-1-phenylpropan-1-one,
2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-
one and
20 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butan-1-
one are preferred because the formed projection hardly falls
off from the substrate at the time of development and the
strength and sensitivity of the projection are high.

In the present invention, the above
25 photopolymerization initiators may be used alone or in
combination of two or more.

In the present invention, at least one selected from
the group consisting of a sensitizer, curing promoting agent
and optical crosslinking agent or optical sensitizer which
30 comprises a polymer compound (to be referred to as "polymer
optical crosslinking/sensitizing agent" hereinafter) may be
further used in combination with the above
photopolymerization initiator as required.

Examples of the above sensitizer include

4,4'-bis(dimethylamino)benzophenone,
 4,4'-bis(diethylamino)benzophenone,
 4-diethylaminoacetophenone, 4-dimethylaminopropiophenone,
 ethyl-4-dimethylaminobenzoate,
 5 2-ethylhexyl-1,4-dimethylaminobenzoate,
 2,5-bis(4-diethylaminobenzal)cyclohexanone,
 7-diethylamino-3-(4-diethylaminobenzoyl)coumarin and
 4-(diethylamino)chalcone.

Examples of the above curing promoting agent include
 10 chain transfer agents such as 2-mercaptobenzoimidazole,
 2-mercaptobenzothiazole, 2-mercaptobenzooxazole,
 2,5-dimercapto-1,3,4-thiadiazole,
 2-mercapto-4,6-dimethylaminopyridine,
 1-phenyl-5-mercapto-1H-tetrazole and
 15 3-mercapto-4-methyl-4H-1,2,4-triazole.

Further, the above polymer optical
 crosslinking/sensitizing agent is a polymer compound having
 a functional group which can function as an optical
 crosslinking agent and/or optical sensitizer in the main
 20 chain and/or side chain. Examples of the agent include a
 condensate of 4-azidobenzaldehyde and polyvinyl alcohol,
 condensate of 4-azidobenzaldehyde and phenol novolak resin,
 homopolymer or copolymer of 4-acryloylphenyl cinnamoyl ester,
 1,4-polybutadiene and 1,2-polybutadiene.

25 Out of the above sensitizers, curing promoting agents
 and polymer optical crosslinking/sensitizing agents,
 4,4'-bis(dimethylamino)benzophenone,
 4,4'-bis(diethylamino)benzophenone and
 2-mercaptobenzothiazole are preferred because the formed
 30 projection hardly falls off from the substrate at the time
 of development and the strength and sensitivity of the
 projection are high.

In the present invention, the photopolymerization
 initiator is particularly preferably a combination of a

biimidazole compound and at least one selected from the group consisting of an acetophenone compound, benzophenone sensitizer and thiazole curing promoting agent.

Examples of the particularly preferred combination

5 include a combination of

2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis
(4-ethoxycarbonylphenyl)-1,2'-biimidazole and
4,4'-bis(diethylamino)benzophenone, combination of

2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis
10 (4-ethoxycarbonylphenyl)-1,2'-biimidazole,
4,4'-bis(diethylamino)benzophenone and
2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-
one, combination of

2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis
15 (4-ethoxycarbonylphenyl)-1,2'-biimidazole,
4,4'-bis(diethylamino)benzophenone and
2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-
one, combination of

2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis
20 (4-ethoxycarbonylphenyl)-1,2'-biimidazole,
4,4'-bis(dimethylamino)benzophenone,
2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-
one and 2-mercaptobenzothiazole, combination of

2,2'-bis(2,4-dichlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-
25 biimidazole and 4,4'-bis(diethylamino)benzophenone,
combination of

2,2'-bis(2,4-dibromophenyl)-4,4',5,5'-tetraphenyl-1,2'-
biimidazole, 4,4'-bis(diethylamino)benzophenone and
2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-
30 one, combination of

2,2'-bis(2,4-dibromophenyl)-4,4',5,5'-tetraphenyl-1,2'-
biimidazole, 4,4'-bis(diethylamino)benzophenone and
2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-
one, and combination of

2,2'-bis(2,4,6-trichlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, 4,4'-bis(dimethylamino)benzophenone, 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one and 2-mercaptobenzothiazole.

5 In the present invention, the total amount of the acetophenone compound, other optically radical generating agent and compound having a trihalomethyl group is preferably 80 wt% or less based on the whole photopolymerization initiator. The total amount of the sensitizer and the curing
10 promoting agent is preferably 80 wt% or less based on the whole photopolymerization initiator. Further, the amount of the polymer optical crosslinking/sensitizing agent is preferably 200 parts or less by weight, more preferably 0.01 to 200 parts by weight, particularly preferably 50 to 180
15 parts by weight based on 100 parts by weight of the biimidazole compound.

 In the present invention, the amount of the photopolymerization initiator is preferably 0.01 to 500 parts by weight, more preferably 1 to 300 parts by weight,
20 particularly preferably 10 to 200 parts by weight based on 100 parts by weight of the total of the polyfunctional monomer (C) and an optionally used monofunctional monomer. When the amount of the photopolymerization initiator is smaller than 0.01 part by weight, curing by exposure becomes incomplete
25 with the result that part of the projection may be missing or lost, or the projection may be undercut. When the amount is larger than 500 parts by weight, the formed projection readily falls off from the substrate at the time of development, or a stain and the film residue may be produced
30 in an area other than a portion for forming a projection.

Additives

 The radiation sensitive composition (α) for use as a projection material may optionally contain various additives.

The additives include a dispersion aid such as a blue pigment derivative or yellow pigment derivative exemplified by copper phthalocyanine derivatives; polymer compound such as polyvinyl alcohol, polyethylene monoalkyl ether or
 5 poly(fluoroalkylacrylate); nonionic, cationic or anionic surfactant; adhesion accelerator such as vinyl trimethoxysilane, vinyl triethoxysilane, vinyl tris(2-methoxyethoxy)silane, N-(2-aminoethyl)-3-aminopropylmethyl dimethoxysilane,
 10 N-(2-aminoethyl)-3-aminopropyl trimethoxysilane, 3-aminopropyl triethoxysilane, 3-glycidoxypropyl trimethoxysilane, 3-glycidoxypropylmethyl dimethoxysilane, 2-(3,4-epoxycyclohexyl)ethyl trimethoxysilane, 3-chloropropylmethyl dimethoxysilane, 3-chloropropyl
 15 trimethoxysilane, 3-methacryloxypropyl trimethoxysilane or 3-mercaptopropyl trimethoxysilane; antioxidant such as 2,2-thiobis(4-methyl-6-t-butylphenol) or 2,6-di-t-butylphenol; ultraviolet light absorber such as 2-(3-t-butyl-5-methyl-2-hydroxyphenyl)-5-
 20 chlorobenzotriazole or alkoxybenzophenone; and coagulation preventing agent such as sodium polyacrylate.

When the alkali-soluble resin (B) is a copolymer having a carboxyl group, the radiation sensitive composition (α) for use as a projection material may contain an organic acid
 25 to further improve the solubility in an alkali developer of a coating film formed therefrom and suppress the existence of an undissolved product after development.

The organic acid is preferably an aliphatic carboxylic acid or phenyl group-containing carboxylic acid.

30 Examples of the above aliphatic carboxylic acid include monocarboxylic acids such as formic acid, acetic acid, propionic acid, butyric acid, valeric acid, pivalic acid, caproic acid, diethylacetic acid, enanthic acid and caprylic acid; dicarboxylic acids such as oxalic acid, malonic acid,

succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, brassylic acid, methylmalonic acid, ethylmalonic acid, dimethylmalonic acid, methylsuccinic acid, tetramethylsuccinic acid,
 5 cyclohexanedicarboxylic acid, itaconic acid, citraconic acid, maleic acid, fumaric acid and mesaconic acid; and tricarboxylic acids such as tricarballylic acid, aconitic acid and camphoronic acid.

The above phenyl group-containing carboxylic acid is,
 10 for example, an aromatic carboxylic acid having a carboxyl group directly bonded to a phenyl group or a carboxylic acid having a carboxyl group bonded to a phenyl group through a carbon chain.

Illustrative examples of the phenyl group-containing
 15 carboxylic acid include aromatic monocarboxylic acids such as benzoic acid, toluic acid, cuminic acid, hemellitic acid and mesitylic acid; aromatic dicarboxylic acids such as phthalic acid, isophthalic acid and terephthalic acid; aromatic polycarboxylic acids having three or more carboxyl
 20 groups such as trimellitic acid, trimesic acid, mellophanic acid and pyromellitic acid; phenylacetic acid, hydroatropic acid, hydrocinnamic acid, mandelic acid, phenylsuccinic acid, atropic acid, cinnamic acid, cinnamylidenic acid, coumaric acid and umbellic acid.

25 Out of these organic acids, aliphatic dicarboxylic acids and aromatic dicarboxylic acids such as malonic acid, adipic acid, itaconic acid, citraconic acid, fumaric acid, mesaconic acid and phthalic acid are preferred from the viewpoints of alkali solubility, solubility in a solvent to
 30 be described hereinafter, and the prevention of a stain and the like in an area other than a portion for forming a projection.

The above organic acids may be used alone or in combination of two or more.

The amount of the organic acid is preferably 10 wt% or less, more preferably 0.001 to 10 wt%, particularly preferably 0.01 to 1 wt% based on the whole radiation sensitive composition. When the amount of the organic acid is larger than 10 wt%, the adhesion of the formed projection to the substrate may lower.

Solvent

The radiation sensitive composition (α) for use as a projection material of the present invention comprises the above conductive particles (A), alkali-soluble resin (B), polyfunctional monomer (C) and photopolymerization initiator (D) as essential components and the above additives as optional components. It is generally prepared as a liquid composition by dispersing the component (A) and dissolving other components in a suitable solvent.

Any solvent is acceptable if it does not react with the components (A) to (D) and has suitable volatility.

Illustrative examples of the solvent include (poly)alkylene glycol monoalkyl ethers such as ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol mono-n-propyl ether, diethylene glycol mono-n-butyl ether, triethylene glycol monomethyl ether, triethylene glycol monoethyl ether, propylene glycol monomethyl ether, propylene glycol monoethyl ether, dipropylene glycol monomethyl ether, dipropylene glycol monoethyl ether, dipropylene glycol mono-n-propyl ether, dipropylene glycol mono-n-butyl ether, tripropylene glycol monomethyl ether and tripropylene glycol monoethyl ether; (poly)alkylene glycol monoalkyl ether acetates such as ethylene glycol monomethyl ether acetate, ethylene glycol monoethyl ether acetate, diethylene glycol monomethyl ether acetate, diethylene glycol monoethyl ether acetate, propylene glycol monomethyl ether acetate and

propylene glycol monoethyl ether acetate; other ethers such as diethylene glycol dimethyl ether, diethylene glycol methylethyl ether, diethylene glycol diethyl ether and tetrahydrofuran; ketones such as methyl ethyl ketone, methyl isobutyl ketone, cyclohexanone, 2-heptanone and 3-heptanone; lactic acid alkyl esters such as methyl 2-hydroxypropionate and ethyl 2-hydroxypropionate; other esters such as methyl 2-hydroxy-2-methylpropionate, ethyl 2-hydroxy-2-methylpropionate, methyl 3-methoxypropionate, ethyl 3-methoxypropionate, methyl 3-ethoxypropionate, ethyl 3-ethoxypropionate, ethyl ethoxyacetate, ethyl hydroxyacetate, methyl 2-hydroxy-3-methylbutanoate, 3-methyl-3-methoxybutylacetate, 3-methyl-3-methoxybutylpropionate, ethyl acetate, n-propyl acetate, i-propyl acetate, n-butyl acetate, i-butyl acetate, n-amyl acetate, i-amyl acetate, n-butyl propionate, ethyl butyrate, n-propyl butyrate, i-propyl butyrate, n-butyl butyrate, methyl pyruvate, ethyl pyruvate, n-propyl pyruvate, methyl acetoacetate, ethyl acetoacetate and ethyl 2-oxybutanoate; aromatic hydrocarbons such as toluene and xylene; and carboxylic acid amides such as N-methylpyrrolidone, N,N-dimethylformamide and N,N-dimethylacetamide.

These solvents may be used alone or in combination of two or more.

Further, a high-boiling solvent such as benzyl ethyl ether, di-n-hexyl ether, acetonylacetone, isophorone, caproic acid, caprylic acid, 1-octanol, 1-nonanol, benzyl alcohol, benzyl acetate, ethyl benzoate, diethyl oxalate, diethyl maleate, γ -butyrolactone, ethylene carbonate, propylene carbonate or ethylene glycol monophenyl ether acetate may be used in combination with the solvent.

The above high-boiling solvents may be used alone or in combination of two or more.

Out of the above solvents, propylene glycol monomethyl ether, ethylene glycol monomethyl ether acetate, propylene glycol monomethyl ether acetate, propylene glycol monoethyl ether acetate, diethylene glycol dimethyl ether, 5 cyclohexanone, 2-heptanone, 3-heptanone, ethyl 2-hydroxypropionate, 3-methyl-3-methoxybutylpropionate, ethyl 3-methoxypropionate, methyl 3-ethoxypropionate, ethyl 3-ethoxypropionate, n-butyl acetate, i-butyl acetate, n-amyl acetate, i-amyl acetate, n-butyl propionate, ethyl 10 butyrate, i-propyl butyrate, n-butyl butyrate and ethyl pyruvate are preferred from the viewpoints of solubility, pigment dispersibility and coatability. γ -butyrolactone is preferred as the high-boiling solvent.

The amount of the solvent is preferably 100 to 10,000 15 parts by weight, more preferably 500 to 5,000 parts by weight based on 100 parts by weight of the alkali-soluble resin (B).

Method of forming projection

A lithographic process is employed to form a projection from the radiation sensitive composition for use as a 20 projection material in the present invention. A description is subsequently given of the method of forming a projection from the radiation sensitive composition for use as a projection material.

The liquid radiation sensitive composition for use as 25 a projection material is first applied to a substrate and prebaked to evaporate the solvent in order to form a coating film. Thereafter, this coating film is exposed in a predetermined shape through a photomask to be cured, developed with an alkali developer to dissolve and remove 30 an unexposed portion of the coating film and then preferably postbaked to obtain a substrate having a projection with a predetermined shape formed thereon.

The above substrate is made from glass, silicon, polycarbonate, polyester, aromatic polyamide,

polyamide-imide or the like.

The substrate may be subjected to a suitable pre-treatment such as a chemical treatment with a silane coupling agent, plasma treatment, ion plating, sputtering,
5 vapor-phase reaction or vacuum deposition.

To apply the liquid radiation sensitive composition for use as a projection material to the substrate, a suitable coating technique such as rotational coating, cast coating or roll coating may be used.

10 The thickness of the coating film is preferably 0.1 to 10 μm , more preferably 0.2 to 5.0 μm , particularly preferably 0.2 to 3.0 μm after drying.

The radiation used to form the projection is selected from visible radiation, ultraviolet radiation, far
15 ultraviolet radiation, electron beams and X-radiation. The radiation preferably has a wavelength of 190 to 450 nm. The amount of exposure energy of the radiation is preferably 10 to 10,000 J/m².

The above alkali developer is preferably an aqueous
20 solution of sodium carbonate, sodium hydroxide, potassium hydroxide, tetramethylammonium hydroxide, choline, 1,8-diazabicyclo-[5.4.0]-7-undecene or 1,5-diazabicyclo-[4.3.0]-5-nonene.

An appropriate amount of a water-soluble organic
25 solvent such as methanol or ethanol, or a surfactant may be added to the above alkali developer. The coating film is preferably washed in water after development with the alkali developer.

Development may be shower development, spray
30 development, dip development, puddle development or the like. Development is preferably carried out at normal temperature for 5 to 300 sec.

The electric resistance of the thus formed projection as a cured product is 10¹² $\Omega\cdot\text{cm}$ or less, preferably 10¹⁰ $\Omega\cdot\text{cm}$

or less, particularly preferably $10^6 \Omega \cdot \text{cm}$ or less. The lower limit of electric resistance of the cured product obtained from the radiation sensitive composition for use as a projection material of the present invention, which changes
5 according to the types and amounts of the conductive particles and other components contained in the radiation sensitive composition, is generally $10^4 \Omega \cdot \text{cm}$.

The projection formed from the radiation sensitive composition for use as a projection material of the present
10 invention is extremely useful as domain restriction means of restricting the aligning direction of liquid crystals in a vertically aligned color liquid crystal display device.

The following examples are provided for the purpose of further illustrating the present invention but are in no way
15 to be taken as limiting.

Examples

Example 1

10 parts by weight of carbon black (electric
20 resistance: $10^2 \Omega \cdot \text{cm}$) as conductive particles (A), 50 parts by weight of a tetrapolymer of methacrylic acid, 2-hydroxyethyl methacrylate, benzyl methacrylate and polystyrene macromonomer (weight ratio: 15/15/60/10, $M_w = 25,000$) as an alkali-soluble resin (B), 40 parts by weight
25 of dipentaerythritol hexaacrylate as a polyfunctional monomer (C), 10 parts by weight of 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis (4-ethoxycarbonylphenyl)-1,2'-biimidazole, 10 parts by weight of 4,4'-bis(diethylamino)benzophenone and 20 parts
30 by weight of 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one as photopolymerization initiators (D), and 1,500 parts by weight of ethyl 3-ethoxypropionate as a solvent were mixed together to prepare a liquid radiation sensitive

composition.

This liquid composition was applied to the surface of a soda glass substrate having a silica (SiO_2) film for preventing the dissolution of sodium ions on the surface with
5 a spin coater and prebaked at 90°C for 4 minutes to form a 1.3 μm -thick coating film.

Thereafter, this substrate was cooled to room temperature and exposed to $2,000\text{ J/m}^2$ of ultraviolet radiation having a wavelength of 365 nm through a photomask
10 using a high-pressure mercury lamp to cure the coating film. This substrate was then immersed in a 0.04 wt% aqueous solution of potassium hydroxide at 23°C for 1 minute to develop the coating film, washed in super pure water and dried with air. Subsequently, it was postbaked at 250°C for 30
15 minutes to form a black projection having a predetermined shape on the substrate.

The residue was not observed on the obtained substrate of an unexposed portion, the separation of the projection and missing and lost parts of the projection were not seen,
20 and yet the projection had high film hardness and excellent surface smoothness. When a vertically aligned liquid crystal display panel was manufactured using this substrate, no display failure such as image sticking or nonuniformity in display was observed.

25 When the electric resistance of a cured product formed from this liquid radiation sensitive composition separately was measured, it was $10^8\ \Omega\cdot\text{cm}$.

Comparative Example 1

A liquid radiation sensitive composition was prepared
30 to form a projection on the substrate in the same manner as in Example 1 except that the conductive particles (A) were not used.

When a vertically aligned liquid crystal display panel was manufactured using the obtained substrate, a display

failure such as image sticking or nonuniformity in display was observed.

When the electric resistance of a cured product formed from this liquid radiation sensitive composition separately
5 was measured, it was $10^{14} \Omega \cdot \text{cm}$.

Example 2

5 parts by weight of carbon black (electric resistance: $10^2 \Omega \cdot \text{cm}$) as conductive particles (A), 50 parts by weight of a pentapolymer of methacrylic acid, glycerol
10 monomethacrylate, styrene, benzyl methacrylate and N-phenylmaleimide (weight ratio: 15/10/15/35/25, $M_w = 10,000$) as an alkali-soluble resin (B), 40 parts by weight of dipentaerythritol hexaacrylate as a polyfunctional monomer (C), 10 parts by weight of
15 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, 10 parts by weight of 4,4'-bis(diethylamino)benzophenone and 20 parts by weight of
2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-
20 one as photopolymerization initiators (D), and 1,500 parts by weight of ethyl 3-ethoxypropionate as a solvent were mixed together to prepare a liquid radiation sensitive composition.

This liquid composition was used to form a black
25 projection having a predetermined shape on the substrate in the same manner as in Example 1.

The residue was not observed on the obtained substrate of an unexposed portion, the separation of the projection and missing and lost parts of the projection were not seen,
30 and yet the projection had high film hardness and excellent surface smoothness. When a vertically aligned liquid crystal display panel was manufactured using this substrate, no display failure such as image sticking or nonuniformity in display was observed.

When the electric resistance of a cured product formed from this liquid radiation sensitive composition separately was measured, it was $10^{10} \Omega \cdot \text{cm}$.

As described above, the radiation sensitive
5 composition for use as a projection material for vertically aligned color liquid crystal display panels of the present invention provides high film hardness and excellent projection surface smoothness, hardly produces the residue or stain on the substrate of an unexposed portion, is
10 excellent in the adhesion of the projection to the substrate at the time of development, is free from the separation of the projection and missing and lost parts of the projection and hardly causes a display failure such as image sticking or nonuniformity in display when a display panel is formed
15 therefrom.

What is claimed is:

1. A radiation sensitive composition for use as a projection material for vertically aligned color liquid crystal display panels, which provides a cured product having
5 an electric resistance of 10^{12} $\Omega \cdot \text{cm}$ or less.
2. A radiation sensitive composition for use as a projection material for vertically aligned color liquid crystal display panels, comprising (A) conductive particles,
10 (B) an alkali-soluble resin, (C) a polyfunctional monomer and (D) a photopolymerization initiator.
3. The radiation sensitive composition of claim 2, wherein the conductive particles (A) contain carbon black.
15
4. The radiation sensitive composition of claim 2 or 3, wherein the content of the conductive particles (A) is 0.1 to 30 wt% based on the total solids content.
- 20 5. The radiation sensitive composition of claim 2, wherein the alkali-soluble resin (B) is a carboxyl group-containing copolymer.
6. The radiation sensitive composition of claim 2, wherein
25 the alkali-soluble resin (B) is a carboxyl group-containing copolymer (I).
7. The radiation sensitive composition of claim 2, wherein the alkali-soluble resin (B) contains at least one selected
30 from the group consisting of a carboxyl group-containing copolymer (Ia), carboxyl group-containing copolymer (Ib), carboxyl group-containing copolymer (Ic) and carboxyl group-containing copolymer (Id).

8. The radiation sensitive composition of claim 2, wherein the functional monomer (C) is at least one selected from the group consisting of trimethylolpropane triacrylate, pentaerythritol triacrylate and dipentaerythritol
 5 hexaacrylate.

9. The radiation sensitive composition of claim 2, wherein the photopolymerization initiator (D) is a combination of a biimidazole compound and at least one selected from the
 10 group consisting of an acetophenone compound, benzophenone sensitizer and thiazole curing promoting agent.

10. The radiation sensitive composition of claim 2, wherein the photopolymerization initiator (D) is a combination of
 15 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis (4-ethoxycarbonylphenyl)-1,2'-biimidazole and 4,4'-bis(diethylamino)benzophenone, combination of 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis (4-ethoxycarbonylphenyl)-1,2'-biimidazole,
 20 4,4'-bis(diethylamino)benzophenone and 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one, combination of 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis (4-ethoxycarbonylphenyl)-1,2'-biimidazole,
 25 4,4'-bis(diethylamino)benzophenone and 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one, combination of 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis (4-ethoxycarbonylphenyl)-1,2'-biimidazole,
 30 4,4'-bis(dimethylamino)benzophenone, 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one and 2-mercaptobenzothiazole, combination of 2,2'-bis(2,4-dichlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole and 4,4'-bis(diethylamino)benzophenone,

combination of

2,2'-bis(2,4-dibromophenyl)-4,4',5,5'-tetraphenyl-1,2'-
biimidazole, 4,4'-bis(diethylamino)benzophenone and
2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-

5 one, combination of

2,2'-bis(2,4-dibromophenyl)-4,4',5,5'-tetraphenyl-1,2'-
biimidazole, 4,4'-bis(diethylamino)benzophenone and
2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-
one, and combination of

10 2,2'-bis(2,4,6-trichlorophenyl)-4,4',5,5'-tetraphenyl-1,
2'-biimidazole, 4,4'-bis(dimethylamino)benzophenone,
2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-
one and 2-mercaptobenzothiazole.

15 11. A process for forming a projection, comprising the
steps of applying the radiation sensitive composition of
claim 2 to a substrate to form a coating film, exposing the
coating film to radiation through a photomask, and developing
it by an alkaline developer to remove an unexposed portion
20 so as to form the projection.

12. A projection formed on a substrate from the radiation
sensitive composition of claim 2.