

DESCRIPTION

PHOTOSENSITIVE ELEMENT, METHOD OF FORMING RESIST PATTERN WITH THE SAME, AND PROCESS FOR PRODUCING PRINTED WIRING BOARD

5 **Technical Field**

[0001] The present invention relates to a photosensitive element, to a resist pattern forming method and to a process for production of a printed circuit board employing it.

Background Art

10 [0002] Photosensitive elements having photosensitive layers laminated on support films have been widely used in the prior art as resist materials for etching, plating and the like in the fields of printed circuit board manufacture and metal precision working. Photosensitive elements are commonly used in the form of a
15 photosensitive layer formed on a support film with a protective film laminated thereover.

[0003] The following is a common method for using a photosensitive element. After first releasing the protective film, the photosensitive layer is contact bonded (laminated) in direct contact with the base
20 material (copper board, etc.). Next, a patterned phototool is attached to an optically transparent film and irradiated with (exposed to) active light rays such as ultraviolet rays. A developing solution is then sprayed and the unexposed sections are removed to form (develop) a resist pattern.

25 [0004] The developing solution used for removal of the unexposed sections is ordinarily one which is able to dissolve or disperse the

photosensitive layer to some degree, and currently alkali development using sodium carbonate aqueous solutions and sodium hydrogen carbonate aqueous solutions is mainly employed. During development, the photosensitive resin composition which is to form the photosensitive layer is dissolved or dispersed in the developing solution.

[0005] Printed circuit boards often contain irregularities from dents and the like. Consequently, a transition layer (photosensitive layer, support film or the like) for attachment to a board preferably has a sufficient conformability property for irregularities in the board, so that no non-adhered sections result between the photosensitive layer and the board. When non-adhered sections result between the photosensitive layer and the board, non-adhered sections will also result between the resist film and the board after exposure, and therefore subsequent etching will lead to defects such as conductor chipping or wire breakage.

[0006] The increasing density of wirings on printed circuit boards in recent years has led to a demand for higher resolution. For higher resolution of a circuit-forming photosensitive element it is effective to lower the thickness of the photosensitive layer, but because this also decreases the volume of the photosensitive layer that follows irregularities on the base material, it has led to more non-adhered sections between the board and the photosensitive layer in conventional photosensitive elements, making it impossible to achieve adequate production yields. Moreover, in a conventional photosensitive element the thickness and hardness needed for the support film renders

the flexibility of the transition layer as a whole insufficient and prevents the transition layer from readily following the irregularities in the base material surface, thereby also resulting in more non-adhered sections between the board and photosensitive layer and making it impossible to achieve adequate production yields.

[0007] Various methods have been proposed to solve these problems. For example, there have been proposed a method of laminating the photosensitive element after coating the base material with water (for example, see Patent documents 1 and 2), a method of laminating the photosensitive element after laminating a liquid resin on the base material to form an adhesive interlayer (for example, see Patent document 3), and a method of using a vacuum laminator for lamination of the photosensitive element under reduced pressure (for example, see Patent documents 4 and 5).

[0008] In addition, there has been proposed a photosensitive element comprising a thermoplastic resin layer, an interlayer and a photosensitive layer on a support film, as a photosensitive element with a conformability property for irregularities on board surfaces (for example, see Patent document 6).

[0009] There has also been disclosed a photosensitive element comprising a cushion layer and a photosensitive layer on a support film, as a photosensitive element having a conformability property for irregularities on board surfaces and high resolution (for example, see Patent document 7).

[Patent document 1] Japanese Unexamined Patent Publication SHO No. 57-21890

[Patent document 2] Japanese Unexamined Patent Publication SHO No. 57-21891

[Patent document 3] Japanese Unexamined Patent Publication SHO No. 52-154363

5 [Patent document 4] Japanese Examined Patent Publication SHO No. 53-31670

[Patent document 5] Japanese Unexamined Patent Publication SHO No. 51-63702

10 [Patent document 6] Japanese Unexamined Patent Publication HEI No. 5-80503

[Patent document 7] Japanese Unexamined Patent Publication No. 2003-5364

Disclosure of the Invention

Problems to be Solved by the Invention

15 [0010] However, in the methods described in Patent documents 1 and 2, the substrate surface must be cleaned due to uniform adhesion of a thin layer of water, and when small through-holes are present, the moisture accumulating in the through-holes tends to react with the photosensitive layer, thus reducing the developing property.

20 [0011] In the method described in Patent document 3, the problem of reduced developing property and release property with small through-holes also occurs, while cost is increased due to the use of a liquid resin coating.

25 [0012] In the methods described in Patent documents 4 and 5, the apparatuses are expensive and time is required to create a vacuum, such that these methods are seldom used for ordinary circuit formation but

are only applicable for permanent mask laminates to be used after conductor formation. Improved conformability properties with respect to conductors are also desired for such permanent mask laminates.

5 [0013] The photosensitive element described in Patent document 6 has an improved conformability property for irregularities on board surfaces, but when the support film is released for exposure after the transition layer has been laminated on the board, the thermoplastic resin layer and interlayer lie between the photosensitive layer and the
10 negative mask, making it difficult to achieve high resolution.

[0014] With the photosensitive element described in Patent document 7, the photopolymerizing compound, photoinitiator, additives and the like present in the photosensitive resin composition layer tend to migrate into the cushion layer, depending on the environments in which
15 the film is used and stored. A photosensitive element is usually used and stored at room temperature, but the aforementioned problems also occur in that type of environment and satisfactory day-to-day stability is not achieved. Moreover, when some of the materials in the photosensitive layer migrate into the cushion layer, the favorable
20 proportion of materials in the photosensitive layer varies. That is, the varying properties of the photosensitive element cause the problem of reduced circuit formation production yield.

[0015] It is an object of the present invention, which has been accomplished in light of the aforementioned problems of the prior art,
25 to provide a photosensitive element with a sufficient conformability property for irregularities on board surfaces that are to be laminated, as

well as excellent adhesive properties, resolution and day-to-day stability. It is another object of the invention to provide a resist pattern forming method employing the photosensitive element, and a process for production of a printed circuit board.

5 Means for Solving the Problems

10 [0016] In order to achieve the objects stated above, the present invention provides a photosensitive element comprising a support film, a cushion layer formed on the support film and a photosensitive layer with a thickness of no greater than 10 μm formed on the cushion layer, wherein the photosensitive layer is a layer composed of a photosensitive resin composition that comprises a binder polymer with a weight-average molecular weight of 10,000-100,000, a first photopolymerizing compound containing at least one polymerizable ethylenic unsaturated bond in the molecule, and a first photopolymerization initiator, and wherein the cushion layer is a layer comprising a second photopolymerizing compound containing at least one polymerizable ethylenic unsaturated bond in the molecule and a second photopolymerization initiator.

20 [0017] Because this photosensitive element has the aforementioned cushion layer, the presence of the cushion layer allows the photosensitive layer to tightly adhere with a good conformability property along the irregularities of the board surface even when the photosensitive resin composition layer is reduced in thickness for higher resolution, so that non-adhered sections between the board and photosensitive layer can be adequately prevented. Furthermore, since
25 the cushion layer comprises a photopolymerizing compound and a

photopolymerization initiator, migration of the photopolymerizing compound and photopolymerization initiator in the photosensitive layer into the cushion layer can be satisfactorily inhibited, thereby resulting in sufficient day-to-day stability. In addition, since the binder polymer in the photosensitive layer has a weight-average molecular weight of 10,000-100,000, it is possible to reduce strand-like development residues that occur at narrow sections between the resist pattern, and to thereby improve the resolution. This can result in satisfactory sides for the resist pattern. Thus, a photosensitive element according to the invention can achieve a high level for the conformability property, adhesive property, resolution and day-to-day stability, to allow an adequately high production yield to be achieved. Furthermore, because of the excellent conformability property, it is possible to laminate the photosensitive layer on a board without increasing production cost, and without producing transfer defects caused by minute contaminants, air bubbles or board surface irregularities.

[0018] The thickness of the support film in the photosensitive element of the invention is preferably 5-20 μm . A support film thickness within this range will allow a more satisfactory conformability property to be achieved.

[0019] The binder polymer in the photosensitive element of the invention preferably comprises styrene and/or a styrene derivative as a monomer unit. This will allow a more satisfactory adhesive property to be achieved while resulting in excellent chemical stability (plating resistance), and is useful for higher density and higher resolution of

printed circuits.

[0020] The binder polymer in the photosensitive element of the invention preferably also comprises methacrylic acid as a monomer unit. This will allow the effect of the invention to be exhibited satisfactorily while resulting in excellent alkali developing solution properties, and is useful for higher density and higher resolution of printed circuits.

[0021] The acid value of the binder polymer in the photosensitive element of the invention is preferably 30-200 mgKOH/g. This will allow the effect of the invention to be exhibited satisfactorily while resulting in excellent alkali developing solution properties, and is useful for higher density and higher resolution of printed circuits.

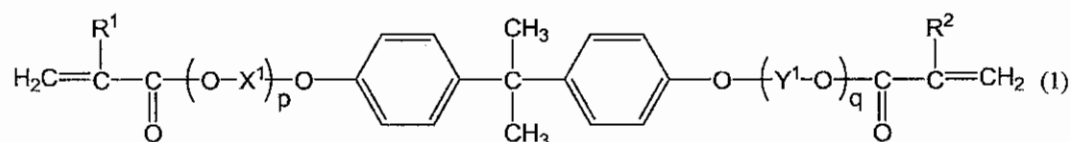
[0022] The photosensitive element of the invention preferably comprises a compound having 4-40 C2-6 oxyalkylene groups in the molecule, as the first photopolymerizing compound and second photopolymerizing compound. This will allow the effect of the invention to be exhibited satisfactorily while resulting in excellent photosensitivity, chemical resistance and release properties, and is useful for higher density and higher resolution of printed circuits.

[0023] The photosensitive element of the invention preferably comprises a bisphenol A-based (meth)acrylate compound or polyalkyleneglycol di(meth)acrylate as the first photopolymerizing compound and second photopolymerizing compound. This will allow the effect of the invention to be exhibited satisfactorily while resulting in excellent photosensitivity, chemical resistance and release properties, and is useful for higher density and higher resolution of

printed circuits.

[0024] From the viewpoint of more excellent photosensitivity, chemical resistance and release properties, the bisphenol A-based (meth)acrylate compound is preferably a compound represented by the following general formula (1).

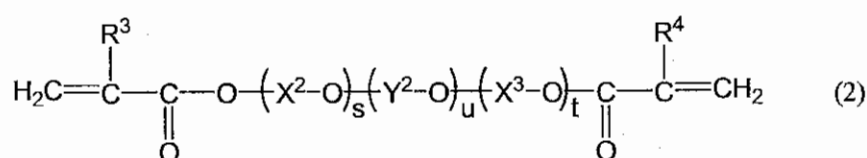
[Chemical Formula 1]



[wherein R^1 and R^2 each independently represent hydrogen atom or methyl group, X^1 and Y^1 each independently represent C2-6 alkylene group, and p and q are positive integers selected within $p+q = 4-40$]

[0025] From the viewpoint of more excellent photosensitivity, chemical resistance and release properties, the polyalkyleneglycol di(meth)acrylate is preferably a compound represented by the following general formula (2).

[Chemical Formula 2]



[wherein R^3 and R^4 each independently represent hydrogen atom or C1-3 alkyl group, X^2 , X^3 and Y^2 each independently represent C2-6 alkylene group, and s , t and u are integers of 0-30 selected within $s+t+u = 4-40$]

[0026] The photosensitive element of the invention preferably also comprises a 2,4,5-triarylimidazole dimer as the first photopolymerization initiator and second photopolymerization initiator.

This will allow more satisfactory resolution and adhesion to be achieved, and is useful for higher density and higher resolution of printed circuits.

[0027] In the photosensitive layer of the photosensitive element of the invention, the content of the first photopolymerizing compound is preferably 30-60 parts by mass with respect to 100 parts by mass as the total of the binder polymer and the first photopolymerizing compound, and the content of the first polymerization initiator is preferably 0.1-20 parts by mass with respect to 100 parts by mass as the total of the binder polymer and the first photopolymerizing compound. This will allow more satisfactory resolution and adhesion to be achieved while resulting in excellent photosensitivity, chemical stability (plating resistance), mechanical strength and flexibility, and is useful for higher density and higher resolution of printed circuits.

[0028] The cushion layer of the photosensitive element of the invention also preferably comprises a copolymer of ethylene and a monomer that is copolymerizable therewith. This will allow a more satisfactory conformability property to be achieved, and is useful for improving the printed circuit board yield.

[0029] From the viewpoint of obtaining a more satisfactory conformability property, the copolymer is preferably an ethylene-vinyl acetate copolymer having an ethylene proportion of 60-90 mass% based on the total monomer composing the copolymer, or an ethylene-ethyl (meth)acrylate copolymer having an ethylene proportion of 60-90 mass% based on the total monomer composing the copolymer.

[0030] The thickness of the cushion layer in the photosensitive

element of the invention is preferably 1-100 μm . This will allow a more satisfactory conformability property to be achieved, and is useful for improving the printed circuit board yield.

5 [0031] The photosensitive element of the invention preferably further comprises a protective film on the photosensitive layer, which covers the photosensitive layer. This will allow the effect of the invention to be exhibited satisfactorily, and will facilitate handling and storage.

10 [0032] The present invention further provides a resist pattern forming method comprising a laminating step in which the aforementioned photosensitive element of the invention is situated so that the aforementioned photosensitive layer, cushion layer and support film are laminated in that order on a circuit-forming board, a release step in which the support film and cushion layer are released from the photosensitive layer, an exposure step in which active light rays are
15 irradiated onto prescribed sections of the photosensitive layer to form photocured sections on the photosensitive layer, and a developing step in which the sections of the photosensitive layer other than the photocured sections are removed.

20 [0033] Since this resist pattern forming method employs a photosensitive element of the invention, all of the properties including conformability property, adhesive property, resolution and day-to-day stability are achieved at high levels, and it is possible to form a resist pattern that is useful for higher density and higher resolution of printed circuits.

25 [0034] The present invention further provides a process for production of a printed circuit board wherein a circuit-forming board

having a resist pattern formed by the resist pattern forming method described above is etched or plated.

[0035] Since a resist pattern is formed by the resist pattern forming method of the invention in this process for production of a printed circuit board, it is possible to produce a printed circuit board with high levels of density and resolution.

Effect of the Invention

[0036] According to the invention, it is possible to provide a photosensitive element having a satisfactory conformability property for irregularities on the surfaces of boards to be laminated, while also exhibiting excellent adhesion, resolution and day-to-day stability, as well as a resist pattern forming method and a printed circuit board production process employing it.

Brief Explanation of the Drawings

[0037] Fig. 1 is a schematic cross-sectional view showing a preferred embodiment of a photosensitive element of the invention.

Figs. 2(a) to (e) are a series of process diagrams showing a preferred embodiment of a resist pattern forming method of the invention.

Fig. 3 is a schematic cross-sectional view showing another preferred embodiment of a photosensitive element of the invention.

Explanation of Symbols

[0038] 1,2: Photosensitive element, 10: support film, 12: cushion layer, 14: photosensitive layer, 16: protective film, 18: circuit-forming board, 22: pattern mask.

Best Mode for Carrying Out the Invention

[0039] Preferred embodiments of the invention will now be explained

in detail, with reference to the accompanying drawings. Throughout the explanation which follows, identical or corresponding parts will be referred to by like reference numerals and will be explained only once. According to the invention, the term "(meth)acrylic acid" means acrylic acid and its corresponding methacrylic acid, while "(meth)acrylate" means acrylate and its corresponding methacrylate.

[0040] Fig. 1 is a schematic cross-sectional view showing a preferred embodiment of a photosensitive element of the invention. The circuit-forming photosensitive element (hereinafter referred to simply as "photosensitive element") 1 shown in Fig. 1 has a structure with a cushion layer 12 and photosensitive layer 14 laminated in that order on a support film 10 as the support. The photosensitive layer 14 has a thickness of no greater than 10 μm , and contains a binder polymer with a weight-average molecular weight of 10,000-100,000, a first photopolymerizing compound with at least one polymerizable ethylenic unsaturated bond in the molecule, and a first photopolymerization initiator. The cushion layer 12 contains a second photopolymerizing compound with at least one polymerizable ethylenic unsaturated bond in the molecule, and a second photopolymerization initiator.

[0041] Each layer composing the photosensitive element 1 of the invention will now be explained.

[0042] The support film 10 is not particularly restricted so long as it can support the cushion layer 12 and photosensitive layer 14, and there may be suitably used, for example, thermostable and solvent resistant polymer films of polyethylene terephthalate, polypropylene, polyethylene, polyester and the like. The support film 10 may have a

single-layer construction, or a multilayer construction with lamination of films of different compositions. Also, one side thereof may be treated by embossing or corona treatment.

[0043] The thickness of the support film 10 is not particularly restricted, but is preferably 2-100 μm , more preferably 5-20 μm and even more preferably 8-16 μm . A thickness of less than 2 μm will tend to result in breakage of the support film 10 when the support film 10 and cushion layer 12 are peeled off from the photosensitive element 1, while a thickness of greater than 100 μm will tend to reduce the flexibility of the photosensitive element 1 as a whole and lower the conformability property for irregularities on the surface of the object to be laminated.

[0044] The photosensitive layer 14 is a layer comprising a binder polymer (hereinafter also referred to as "component (A)"), a first photopolymerizing compound having at least one polymerizable ethylenic unsaturated bond (hereinafter also referred to as "component (B1)") and a first photopolymerization initiator (hereinafter also referred to as "component (C1)").

[0045] The binder polymer as component (A) must have a weight-average molecular weight of 10,000-100,000. The upper limit for the weight-average molecular weight of the binder polymer (A) is preferably 80,000, more preferably 60,000, even more preferably 30,000 and most preferably 25,000. The lower limit for the weight-average molecular weight of the (A) binder polymer is preferably 15,000 and more preferably 20,000. If the weight-average molecular weight is less than 10,000 the photosensitive layer will be brittle, while

if it is greater than 100,000, strand-like development residues (poor resolution) will occur. The weight-average molecular weight is measured by gel permeation chromatography, using the value in terms of standard polystyrene.

5 [0046] As examples for the (A) binder polymer there may be mentioned acrylic-based resins, styrene-based resins, epoxy-based resins, amide-based resins, amide/epoxy-based resins, alkyd-based resins and phenol-based resins. Acrylic-based resins are preferred among these from the viewpoint of alkali developing properties.

10 These may be used alone or in combinations of two or more.

[0047] The (A) binder polymer may be produced, for example, by radical polymerization of a polymerizable monomer. As examples of such polymerizable monomers there may be mentioned styrene, polymerizable styrene derivatives such as vinyltoluene, α -methylstyrene, p-methylstyrene and p-ethylstyrene, vinyl alcohol esters such as acrylamide, acrylonitrile and vinyl-n-butyl ether, (meth)acrylic acid alkyl esters, (meth)acrylic acid tetrahydrofurfuryl esters, (meth)acrylic acid dimethylaminoethyl esters, (meth)acrylic acid diethylaminoethyl esters, (meth)acrylic acid glycidyl esters, 2,2,2-trifluoroethyl (meth)acrylate, 2,2,3,3-tetrafluoropropyl (meth)acrylate, (meth)acrylic acid, α -bromo(meth)acrylic acid, α -chlor(meth)acrylic acid, β -furyl(meth)acrylic acid, β -styryl(meth)acrylic acid, maleic acid, maleic anhydride, maleic acid monoesters such as monomethyl malate, monoethyl malate and monoisopropyl malate, and fumaric acid, 20 cinnamic acid, α -cyanocinnamic acid, itaconic acid, crotonic acid, 25 propiolic acid and the like. These may be used alone or in

combinations of two or more.

[0048] As examples of (meth)acrylic acid alkyl esters there may be mentioned methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, butyl (meth)acrylate, pentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, octyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, and their structural isomers. These may be used alone or in combinations of two or more.

[0049] The (A) binder polymer preferably contains a carboxyl group from the viewpoint of the alkali developing property, and for example, it may be produced by radical polymerization of a carboxyl group-containing polymerizable monomer with another polymerizable monomer. Methacrylic acid is preferred as a carboxyl group-containing polymerizable monomer.

[0050] The (A) binder polymer preferably contains styrene and/or a styrene derivative monomer unit from the viewpoint of adhesion, release property and chemical resistance (plating resistance).

[0051] In order to obtain a binder polymer with satisfactory adhesion, release properties and chemical resistance (plating resistance) when using styrene and/or a styrene derivative as the monomer, the content of the styrene and/or styrene derivative is preferably 3-30 mass%, more preferably 4-28 mass% and most preferably 5-27 mass% based on the total amount of monomer. If the content is less than 3 mass% the adhesion will tend to be inferior, and if it is greater than 30 mass% the release strip will be larger, tending to lengthen the release time.

[0052] The acid value of the (A) binder polymer is preferably 30-200 mgKOH/g and more preferably 45-150 mgKOH/g. If the acid value

is less than 30 mgKOH/g the developing time will tend to be longer, and if it is greater than 200 mgKOH/g the developing solution resistance of the photocured resist will tend to be reduced. When solvent development is carried out for development, it is preferred to
5 adjust the carboxyl group-containing polymerizable monomer to a smaller amount.

[0053] If necessary, the (A) binder polymer may have a photosensitive group.

[0054] Such binder polymers may be used alone or in combinations
10 of two or more. As examples of binder polymers when two or more are used in combination, there may be mentioned two or more binder polymers composed of different copolymerizable components, two or more binder polymers with different weight-average molecular weights, and two or more binder polymers with different
15 dispersibilities. There may also be used a polymer having a multimode molecular weight distribution, as described in Japanese Unexamined Patent Publication HEI No. 11-327137.

[0055] When two or more binder polymers are used, the weight-average molecular weight of the binder polymer with the greatest
20 content is 10,000-100,000.

[0056] The first photopolymerizing compound with at least one polymerizable ethylenic unsaturated bond in the molecule as component (B1) is not particularly restricted, but it is preferably a compound with C2-6 oxyalkylene groups in the molecule.

[0057] As C2-6 oxyalkylene groups there may be mentioned
25 oxyethylene group, oxypropylene group, oxyisopropylene group,

oxybutylene group, oxypentylene group, oxyhexylene group and the like, but preferred are oxyethylene group and oxyisopropylene group from the viewpoint of resolution and plating resistance.

[0058] Particularly preferred among these first photopolymerizing compounds for (B1) are bisphenol A-based (meth)acrylate compounds and polyalkyleneglycol di(meth)acrylates.

[0059] As preferred examples of bisphenol A-based (meth)acrylate compounds there may be mentioned compounds represented by general formula (1) above.

[0060] In general formula (1), R^1 and R^2 each independently represent hydrogen atom or methyl group, and preferably methyl group. In general formula (1), X^1 and Y^1 each independently represent a C2-6 alkylene group, preferably ethylene group or propylene group and more preferably ethylene group. Also in general formula (1), p and q are positive integers selected within $p+q = 4-40$, preferably $p+q = 6-34$, more preferably $p+q = 8-30$, even more preferably $p+q = 8-28$, yet more preferably $p+q = 8-20$, much more preferably $p+q = 8-16$ and most preferably $p+q = 8-12$. If $p+q$ is less than 4, compatibility with the (A) binder polymer will be reduced and the photosensitive element will tend to peel when laminated on a circuit-forming board, while if $p+q$ is greater than 40, hydrophilicity will increase, the resist image will readily peel during development, and the plating resistance against solder plating and the like will tend to be reduced.

[0061] As C2-6 alkylene groups there may be mentioned ethylene group, propylene group, isopropylene group, butylene group, pentylene group, hexylene group and the like, but preferred are ethylene group

and isopropylene group from the viewpoint of resolution and plating resistance.

[0062] The aromatic ring in general formula (1) above may be substituted, and as examples of substituents there may be mentioned halogen atoms, C1-20 alkyl groups, C3-10 cycloalkyl groups, C6-18 aryl groups, phenacyl groups, amino groups, C1-10 alkylamino groups, C2-20 dialkylamino groups, nitro groups, cyano groups, carbonyl groups, mercapto groups, C1-10 alkylmercapto groups, allyl groups, hydroxyl groups, C1-20 hydroxyalkyl groups, carboxyl groups, carboxyalkyl groups with C1-10 alkyl groups, acyl groups with C1-10 alkyl groups, C1-20 alkoxy groups, C1-20 alkoxycarbonyl groups, C2-10 alkylcarbonyl groups, C2-10 alkenyl groups, C2-10 N-alkylcarbamoyl groups and heterocyclic ring-containing groups, as well as aryl groups substituted with these substituents. These substituents may also form fused rings. The hydrogen atoms in these substituents may also be replaced by the aforementioned substituents, such as halogen atoms. If the number of substituents is two or more, the two or more substituents may be the same or different.

[0063] As examples of compounds represented by general formula (1) above there may be mentioned bisphenol A-based (meth)acrylate compounds such as 2,2-bis(4-((meth)acryloxypolyethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxypolypropoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxypolybutoxy)phenyl)propane and 2,2-bis(4-((meth)acryloxypolyethoxypolypropoxy)phenyl)propane.

[0064] As examples of 2,2-bis(4-

((meth)acryloxypolyethoxy)phenyl)propane compounds there may be
 mentioned 2,2-bis(4-((meth)acryloxydiethoxy)phenyl)propane, 2,2-
 bis(4-((meth)acryloxytriethoxy)phenyl)propane, 2,2-bis(4-
 ((meth)acryloxytetraethoxy)phenyl)propane, 2,2-bis(4-
 5 ((meth)acryloxypentaethoxy)phenyl)propane, 2,2-bis(4-
 ((meth)acryloxyhexaethoxy)phenyl)propane, 2,2-bis(4-
 ((meth)acryloxyheptaethoxy)phenyl)propane, 2,2-bis(4-
 ((meth)acryloxyoctaethoxy)phenyl)propane, 2,2-bis(4-
 ((meth)acryloxynonaethoxy)phenyl)propane, 2,2-bis(4-
 10 ((meth)acryloxydecaethoxy)phenyl), 2,2-bis(4-
 ((meth)acryloxyundecaethoxy)phenyl), 2,2-bis(4-
 ((meth)acryloxydodecaethoxy)phenyl), 2,2-bis(4-
 ((meth)acryloxytridecaethoxy)phenyl), 2,2-bis(4-
 ((meth)acryloxytetradecaethoxy)phenyl), 2,2-bis(4-
 15 ((meth)acryloxypentadecaethoxy)phenyl), 2,2-bis(4-
 ((meth)acryloxyhexadecaethoxy)phenyl) and the like, among which
 2,2-bis(4-(methacryloxypentaethoxy)phenyl)propane is commercially
 available as BPE-500 (trade name of Shin-Nakamura Chemical co.,
 Ltd.), and 2,2-bis(4-(methacryloxypentadecaethoxy)phenyl) is
 20 commercially available as BPE-1300 (trade name of Shin-Nakamura
 Chemical Co., Ltd.). These may be used alone or in combinations of
 two or more.

[0065] As examples of 2,2-bis(4-
 ((meth)acryloxypolyethoxypolypropoxy)phenyl)propane compounds
 25 there may be mentioned 2,2-bis(4-
 ((meth)acryloxydiethoxyoctapropoxy)phenyl)propane, 2,2-bis(4-

((meth)acryloxytetraethoxytetrapropoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxyhexaethoxyhexapropoxy)phenyl)propane and the like. These may be used alone or in combinations of two or more.

[0066] As preferred examples of polyalkyleneglycol di(meth)acrylate compounds there may be mentioned compounds represented by general formula (2) above.

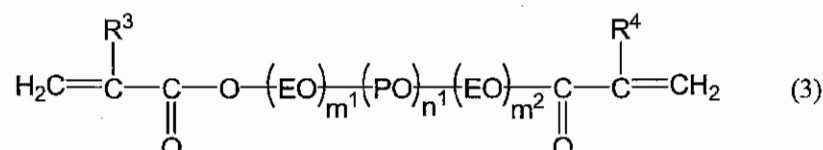
[0067] In general formula (2), R^3 and R^4 each independently represent hydrogen or C1-3 alkyl group, with methyl group being preferred. Also in general formula (2), X^2 , X^3 and Y^2 each independently represent C2-6 alkylene group, with ethylene group and propylene group being preferred. Also in general formula (2), s, t and u are integers of 0-30 selected within $s+t+u = 4-40$, preferably $s+t+u = 5-30$, more preferably $s+t+u = 8-23$ and most preferably $s+t+u = 10-15$. If $s+t+u$ is less than 4 the boiling point of the compound will be reduced, tending to produce stronger odor of the photosensitive layer, while if it is greater than 40, the concentration of reactive sites per unit mass will be lower, tending to prevent a practical level of sensitivity.

[0068] When the oxyalkylene groups $-(Y^1-O)_s-$, $-(Y^2-O)_t-$ and $-(Y^3-O)_u-$ in general formula (2) contain oxyethylene and oxypropylene groups, for example, and a plurality thereof are present, the multiple oxyethylene and oxypropylene groups do not need to exist in a continuous block form, but may be randomly positioned.

[0069] Also, when the oxyalkylene group is oxyisopropylene group, the secondary carbon of the propylene group may be bonded to an oxygen atom and the primary carbon may be bonded to an oxygen atom.

[0070] As preferred examples of compounds represented by general formula (2) there may be mentioned compounds represented by the following general formulas (3)-(5). These may also be used alone or in combinations of two or more.

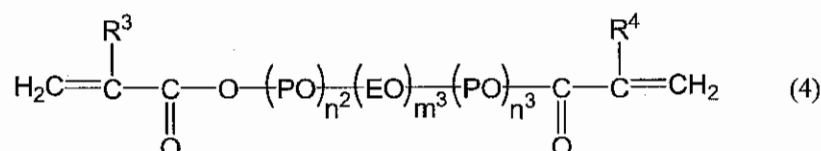
5 [0071] [Chemical Formula 3]



[wherein R^3 and R^4 each independently represent hydrogen atom or C1-3 alkyl group, EO represents ethylene glycol group, PO represents propylene glycol group, and m^1 , m^2 and n^1 are integers of 1-30 selected within $m^1+m^2+n^1 = 4-40$]

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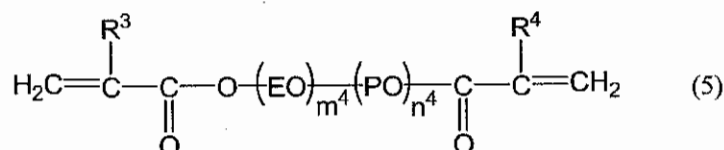
[0072] [Chemical Formula 4]



[wherein R^3 and R^4 each independently represent hydrogen atom or C1-3 alkyl group, EO represents ethylene glycol group, PO represents propylene glycol group, and m^3 , n^2 and n^3 are integers of 1-30 selected within $m^3+n^2+n^3 = 4-40$]

15

[0073] [Chemical Formula 5]



[wherein R^3 and R^4 each independently represent hydrogen atom or C1-3 alkyl group, EO represents ethylene glycol group, PO represents propylene glycol group, and m^4 and n^4 are integers of 1-30 selected

20

within $m^4+n^4 = 4-40$]

[0074] As examples of C1-3 alkyl groups for general formulas (3) to (5) above there may be mentioned methyl group, ethyl group, n-propyl group, isopropyl group and the like.

5 [0075] The total number of repeats of ethylene glycol group in general formulas (3) to (5) (m^1+m^2 , m^3 and m^4) is preferably an integer of 1-30, more preferably an integer of 1-10, even more preferably an integer of 4-9 and most preferably an integer of 5-8. If the number of repeats exceeds 30, the tent reliability and resist shape will tend to be
10 poor.

[0076] The total number of repeats of propylene glycol group in general formulas (3) to (5) (n^1 , n^2+n^3 and n^4) is preferably an integer of 1-30, more preferably an integer of 5-20, even more preferably an integer of 8-16 and most preferably an integer of 10-14. If the
15 number of repeats exceeds 30, the resolution will be poor and sludge will tend to be produced.

[0077] As a specific example of a compound represented by general formula (3) there may be mentioned a vinyl compound wherein R^3 and R^4 is methyl group, $m^1+m^2 = 4$ (average) and $n^1 = 12$ (average)
20 (product name: FA-023M by Hitachi Chemical Co., Ltd.).

[0078] As a specific example of a compound represented by general formula (4) there may be mentioned a vinyl compound wherein R^3 and R^4 is methyl group, $m^3 = 6$ (average) and $n^2+n^3 = 12$ (average) (product name: FA-024M by Hitachi Chemical Co., Ltd.).

25 [0079] As a specific example of a compound represented by general formula (5) there may be mentioned a vinyl compound wherein R^3 and

R^4 are hydrogen atom, $m^4 = 1$ (average) and $n^4 = 9$ (average) (sample name: NK ester HEMA-9P by Shin-Nakamura Chemical Co., Ltd.).

[0080] These may be used alone or in combinations of two or more.

[0081] As the (B1) first photopolymerizing compound there may be mentioned, in addition to photopolymerizing compounds with ethylenic unsaturated bonds as explained above, also other photopolymerizing compounds with ethylenic unsaturated bonds, for example, nonylphenoxypolyalkyleneoxy (meth)acrylates such as nonylphenoxypolyethyleneoxy (meth)acrylate, nonylphenoxypolypropyleneoxy (meth)acrylate and nonylphenoxypolyethyleneoxypolypropyleneoxy (meth)acrylate, phthalic acid-based compounds such as γ -chloro- β -hydroxypropyl- β' -(meth)acryloyloxyethyl-o-phthalate and β -hydroxyalkyl- β' -(meth)acryloyloxyalkyl-o-phthalate, and (meth)acrylic acid alkyl esters.

[0082] The photosensitive layer 14 may contain a photopolymerizing compound other than the (B1) first photopolymerizing compound, and for example, there may be mentioned compounds obtained by reacting α,β -unsaturated carboxylic acids with glycidyl group-containing compounds, and urethane monomers such as (meth)acrylate compounds with urethane bonds in the molecule.

[0083] As examples for the first photopolymerization initiator as component (C1) there may be mentioned aromatic ketones including benzophenone, N, N'-tetraalkyl-4,4'-diaminobenzophenones such as N, N'-tetramethyl-4,4'-diaminobenzophenone (Michler's ketone) and 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butanone-1,2-

5 methyl-1-[4-(methylthio)phenyl]-2-morpholino-propanone-1, quinones
such as alkylanthraquinones, benzoin compounds including
benzoinether compounds such as benzoinalkyl ethers, benzoin and
alkylbenzoin, benzyl derivatives such as benzyldimethyl ketal, 2,4,5-
10 triarylimidazole dimers such as 2-(o-chlorophenyl)-4,5-
diphenylimidazole dimer, 2-(o-chlorophenyl)-4,5-
di(methoxyphenyl)imidazole dimer, 2-(o-fluorophenyl)-4,5-
diphenylimidazole dimer, 2-(o-methoxyphenyl)-4,5-diphenylimidazole
dimer and 2-(p-methoxyphenyl)-4,5-diphenylimidazole dimer, acridine
15 derivatives such as 9-phenylacridine and 1,7-bis(9,9'-acridinyl)heptane,
N-phenylglycine, N-phenylglycine derivatives, coumarin-based
compounds and the like. Substituents on two of the aryl groups of
2,4,5-triarylimidazole may be identical to yield a symmetrical
compound, or they may be different to yield an asymmetrical
15 compound. From the viewpoint of adhesion and sensitivity, a 2,4,5-
triarylimidazole dimer is preferred. These may be used alone or in
combinations of two or more.

[0084] The content of the (A) binder polymer in the photosensitive
layer 14 is preferably 40-70 parts by mass and more preferably 50-60
20 parts by mass with respect to 100 parts by mass as the total of
component (A) and component (B1). If the content is less than 40
parts by mass the resolution and photosensitivity will tend to be
insufficient, and if it is greater than 70 parts by mass the photocured
product will tend to be fragile.

25 [0085] The content of the (B1) first photopolymerizing compound is
preferably 30-60 parts by mass and more preferably 40-50 parts by

mass with respect to 100 parts by mass as the total of component (A) and component (B1). If the content is less than 30 parts by mass the photocured product will tend to be fragile, and if it is greater than 60 parts by mass the resolution and photosensitivity will tend to be insufficient.

[0086] The content of the (C1) first photopolymerization initiator is preferably 0.1-20 parts by mass and more preferably 0.2-10 parts by mass with respect to 100 parts by mass as the total of component (A) and component (B1). If the content is less than 0.1 part by mass the photosensitivity will tend to be insufficient, and if it is greater than 20 parts by mass the absorption on the surface of the composition during exposure will increase, tending to result in insufficient interior photocuring.

[0087] The photosensitive layer 14 may also contain additives (hereinafter also referred to as "component (D1)") in addition to components (A) to (C1) mentioned above. As examples of (D1) additives there may be mentioned photopolymerizing compounds with at least one cation-polymerizable cyclic ether groups in the molecule (oxetane compounds, etc.), cation polymerization initiators, dyes such as malachite green, photochromic agents such as tribromophenylsulfone and leuco crystal violet, thermal development inhibitors, plasticizers such as p-toluenesulfonamide, pigments, fillers, antifoaming agents, flame retardants, stabilizer, tackifiers, leveling agents, release accelerators, antioxidants, aromas, imaging agents, thermal crosslinking agents and the like. These may be added at about 0.01-20 parts by mass each with respect to 100 parts by mass as

the total of component (A) and component (B1). They may also be used alone or in combinations of two or more.

[0088] The photosensitive resin composition comprising components (A) to (D1) mentioned above for formation of the photosensitive layer 14 may, if necessary, be dissolved in a solvent such as methanol, ethanol, acetone, methyl ethyl ketone, methylcellosolve, ethylcellosolve, toluene, N,N-dimethylformamide or propyleneglycol monomethyl ether, or a mixture of such solvents, to produce a solution with a solid portion of about 30-60 mass%, for formation of the photosensitive layer.

[0089] The thickness of the photosensitive layer 14 must be no greater than 10 μm . The upper limit for the thickness of the photosensitive layer 14 is preferably 8 μm , more preferably 6 μm and most preferably 3 μm . The lower limit for the thickness of the photosensitive layer 14 is preferably 1 μm and most preferably 2 μm . If the thickness exceeds 10 μm , sufficient resolution may not be achieved.

[0090] The cushion layer 12 is a layer comprising a second photopolymerizing compound with at least one polymerizable ethylenic unsaturated bond (hereinafter also referred to as "component (B2)") and a second photopolymerization initiator (hereinafter also referred to as "component (C2)").

[0091] By containing these components (B2) and (C2) in the cushion layer 12, it is possible to adequately inhibit migration of components (B1) and (C1) of the photosensitive layer 14 into the cushion layer 12, to obtain a photosensitive element 1 with sufficient day-to-day

stability. When components (B2) and (C2) are not included in the cushion layer 12, particularly materials with low molecular weights will tend to migrate from the photosensitive layer 14 to the cushion layer 12, thereby impairing the properties of the photosensitive element 1.

[0092] The (B2) second photopolymerizing compound may be the same one as used for the aforementioned first photopolymerizing compound. Also, the (C2) second photopolymerization initiator may be the same one as used for the aforementioned first photopolymerization initiator. The second photopolymerizing compound and second photopolymerization initiator may be the same as or different from the first photopolymerizing compound and first photopolymerization initiator. From the standpoint of obtaining sufficient day-to-day stability, the second photopolymerizing compound and second photopolymerization initiator preferably contain, respectively, the material contained in the first photopolymerizing compound and the material contained in the first photopolymerization initiator.

[0093] The cushion layer 12 preferably also contains a copolymer of ethylene with a monomer that is copolymerizable with ethylene. This copolymer is preferably ethylene-vinyl acetate copolymer and/or ethylene-ethyl (meth)acrylate copolymer.

[0094] The proportion of the ethylene component based on the total monomer component of the ethylene-vinyl acetate copolymer, and the proportion of the ethylene component based on the total monomer component of the ethylene-ethyl (meth)acrylate copolymer, are both

preferably 60-90 mass%, more preferably 60-80 mass% and most preferably 60-70 mass%. If the ethylene proportion is less than 60 mass% for either copolymer, adhesion between the cushion layer 12 and photosensitive layer 14 will be too great and release will tend to be hampered. On the other hand, if the proportion of ethylene is greater than 90 mass% for either copolymer, adhesion between the cushion layer 12 and photosensitive layer 14 will be too low, tending to make it difficult to form a photosensitive film 1 with the cushion layer 12.

[0095] The cushion layer 12 may also contain additives (hereinafter also referred to as "component (D2)"), where the (D2) additives used may be the same as the (D1) additives for the photosensitive layer 14 mentioned above.

[0096] The thickness of the cushion layer 12 is preferably 1-100 μm , more preferably 10-50 μm and most preferably 15-40 μm . If the thickness is less than 1 μm the conformability property for irregularities on the surface of the object to be laminated will tend to be reduced, and if it is greater than 100 μm the cost will tend to be increased.

[0097] The photosensitive element 1 preferably also comprises a protective film on the photosensitive layer 14 (on F1). Fig. 3 is a schematic cross-sectional view showing another preferred embodiment of a photosensitive element of the invention. The photosensitive element 2 shown in Fig. 3 has a structure with a cushion layer 12, photosensitive layer 14 and protective film 16 laminated in that order on a support film 10.

[0098] The protective film 16 is released before laminating the

photosensitive element 1 on the board, and therefore it is preferably flexible and releasable from the photosensitive layer 14, while being resistant to damage by the temperature of the drying furnace. As the protective film 16 there may be mentioned, for example, paper, released paper, a film of a polyester such as polyethylene terephthalate, a polyolefin such as polymethylpentene, polypropylene or polyethylene, a halogen-containing vinyl polymer such as polyvinyl fluoride or polyvinyl chloride, a polyamide such as nylon, a cellulose such as cellophane, or polystyrene, which may be either transparent or non-transparent, and may also be release-treated. As a commercially available protective film 16 there may be mentioned E-200HTM by Oji Paper Co., Ltd. and NF-13TM by Tamapoly Co., Ltd.

[0099] The thickness of the protective film 16 is not particularly restricted, but in consideration of size when the photosensitive element 1 is to be wound into a roll, it is preferably 10-30 μm , more preferably 10-25 μm and most preferably 10-20 μm .

[0100] As regards the relationship between interlayer adhesive forces between the cushion layer 12, support film 10 and photosensitive layer 12, preferably the interlayer adhesive force (a1) between the support film 10 and cushion layer 12 is greater than the interlayer adhesive force (a2) between the cushion layer 12 and photosensitive layer 14, in order to facilitate release between the cushion layer 12 and photosensitive layer 14.

[0101] When a protective film 16 is provided on the photosensitive layer 14, the interlayer adhesive force (a3) between the protective film 16 and photosensitive layer 14 is preferably less than the interlayer

adhesive force (a2) between the cushion layer 12 and photosensitive layer 14, in order to facilitate release between the protective film 16 and photosensitive layer 14.

5 [0102] The interlayer adhesive force may be measured as the 180° peel strength at a temperature of 23°C and a humidity of 60%, using a rheometer.

10 [0103] The value of the ratio of the interlayer adhesive force (a1) between the support film 10 and cushion layer 12 and the interlayer adhesive force (a2) between the cushion layer 12 and photosensitive layer 14 $\{(a1)/(a2)\}$, and the value of the ratio of the interlayer adhesive force between the cushion layer 12 and the photosensitive layer 14 and the interlayer adhesive force (a3) between the protective film and the photosensitive layer 14 $\{(a2)/(a3)\}$, are preferably 1.05 or greater, more preferably 1.5 or greater, and most preferably 2.0 or greater. If these interlayer adhesive force ratios are less than 1.05, release will tend to occur between different layers than the desired layers.

20 [0104] There are no particular restrictions on the method for laminating the cushion layer 12 and photosensitive layer 14 on the support film 10, but for example, there may be mentioned (1) a method of laminating the cushion layer 12 on the support film 10 and then laminating the photosensitive layer 14 thereover, (2) a method of simultaneously laminating the cushion layer 12 and photosensitive layer 14 on the support film 10, (3) a method of attaching a laminate of the cushion layer 12 on the support film 10 to a laminate of the photosensitive layer 14 on the protective film 16, (4) a method of

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laminating the photosensitive layer on the protective film 16 and then laminating the cushion layer 12 and support film 10 in that order, and (5) a method of simultaneously laminating the photosensitive layer 14 and cushion layer 12 on the protective film 16 and then laminating the support film 10. Of these, method (3) above is preferred from the viewpoint of improving yield during formation of the resist pattern.

[0105] The photosensitive element 1 obtained in this manner may be stored after winding into a roll. The photosensitive element 1 may also comprise, in addition to the support film 10, cushion layer 12 and photosensitive layer 14, also interlayers such as an adhesive layer, photoabsorbing layer and gas barrier layer as necessary, or another protective layer separate from the protective film 16.

[0106] The photosensitive layer 14 preferably has a transmittance of 5-75%, more preferably 7-60% and most preferably 10-40%, for ultraviolet light with a wavelength of 365 nm. A transmittance of less than 5% will tend to result in inferior adhesion, while a transmittance of greater than 75% will tend to result in inferior resolution. The transmittance may be measured by a UV spectrometer, and the UV spectrometer may be a Model 228A W Beam spectrophotometer by Hitachi, Ltd.

[0107] A resist pattern forming method of the invention will now be explained with reference to Figs. 2(a) to (e).

[0108] Figs. 2(a) to (e) are a series of process diagrams showing a preferred embodiment of a resist pattern forming method of the invention. First, a laminating step is carried out wherein a photosensitive element 1 comprising a laminate of a support film 10,

cushion layer 12 and photosensitive layer 14 in that order is contact bonded onto the surface of a circuit-forming board 18 using a roller 20, with the photosensitive layer 14 contacting the circuit-forming board 18 as shown in Fig. 2(a), to laminate the photosensitive layer 14, cushion layer 12 and base film 10 in that order on the circuit-forming board 18, as shown in Fig. 2(b). When the photosensitive element 1 has a protective film on the photosensitive layer 14, the protective film is released before the laminating step. The next step is a release step wherein the cushion layer 12 and support film 10 are released, as shown in Fig. 2(c), to obtain a laminate board having a photosensitive layer 14 on a circuit-forming board 18.

[0109] The next step, shown in Fig. 2(d) is an exposure step wherein a pattern mask 22 with transparent sections for active light rays such as ultraviolet rays is used to form photocured sections by irradiation with active light rays at prescribed sections of the photosensitive layer 14 of the laminated board. Then, as shown in Fig. 2(e), a developing step is carried out to remove the photosensitive layer 14 at sections other than the photocured sections, to form a resist pattern 24.

[0110] The method of laminating the photosensitive layer 14 on the circuit-forming board 18 in the aforementioned laminating step may be, for example, a method in which the photosensitive layer 14 is contact bonded onto the circuit-forming board 18 at a pressure of about 0.1-1 MPa (about 1-10 kgf/cm²) while heating it at about 70-130°C. The lamination may be carried out under reduced pressure from the viewpoint of better adhesive and conformability properties. For further improved laminating properties, the circuit-forming board 18

may be subjected to preheating. The laminating surface of the circuit-forming board 18 will usually be a metal surface, but this is not restrictive. Irregularities may also be present on the surface of the circuit-forming board 18, and using the photosensitive element 1 of the invention will allow lamination to be accomplished with a satisfactory conformability property for the irregularities.

[0111] After completing lamination of the photosensitive element 1, the support film 10 and cushion layer 12 are removed from the photosensitive layer 14 in the release step. In the subsequent exposure step, the photosensitive layer 14 is irradiated with active light rays in an image form, through a negative or positive pattern mask 22 known as artwork. The light source for the active light rays may be a publicly known light source such as, for example, a carbon arc lamp, mercury vapor arc lamp, ultra-high pressure mercury lamp, high pressure mercury lamp, xenon lamp or the like, which efficiently emits ultraviolet rays. There may also be used a lamp that efficiently emits visible light rays, such as a photographic flood lamp or sun lamp.

[0112] The developing step may be carried out by removing the unexposed section (uncured sections) by wet development, dry development or the like to form the resist pattern. In the case of wet development, a developing solution suitable for photosensitive resin compositions may be used, such as an aqueous alkali solution, aqueous developing solution or organic solvent-based developing solution, and development may be accomplished by a publicly known method such as spraying, reciprocal dipping, brushing, scrapping or the like.

[0113] The developing solution used is one which is safe and stable

and easily manageable, such as an aqueous alkali solution. As bases for the aqueous alkali solution there may be used, for example, alkali hydroxides such as hydroxides of lithium, sodium, potassium and the like, alkali carbonates such as carbonates or bicarbonates of lithium, sodium, potassium, ammonium and the like, alkali metal phosphates such as potassium phosphate and sodium phosphate, and alkali metal pyrophosphates such as sodium pyrophosphate and potassium pyrophosphate. The aqueous alkali solution used for development is preferably a 0.1-5 mass% sodium carbonate dilute solution, a 0.1-5 mass% potassium carbonate dilute solution, a 0.1-5 mass% sodium hydroxide dilute solution or a 0.1-5 mass% sodium tetraborate dilute solution. The pH of the aqueous alkali solution used for development is preferably in the range of 9-11, and the temperature is adjusted as appropriate for the developing property of the photosensitive resin composition layer 14. The aqueous alkali solution may also contain added surfactants, defoaming agents, and small amounts of organic solvent to accelerate development.

[0114] The aforementioned aqueous developing solution is composed of water or an aqueous alkali solution and one or more different organic solvents. As examples of bases of the aqueous alkali solution in an aqueous developing solution there may be mentioned borax or sodium metasilicate, tetramethylammonium hydroxide, ethanolamine, ethylenediamine, diethylenetriamine, 2-amino-2-hydroxymethyl-1,3-propanediol, 1,3-diaminopropanol-2-morpholine and the like. The pH of the developing solution is a range allowing sufficient development of the resist, and is preferably pH 8-12 and more preferably pH 9-10.

[0115] As examples of organic solvents there may be mentioned triacetone alcohol, acetone, ethyl acetate, alkoxyethanols with C1-4 alkoxy groups, ethyl alcohol, isopropyl alcohol, butyl alcohol, diethyleneglycol monomethylether, diethyleneglycol monoethylether, diethyleneglycol monobutylether and the like. These may be used alone or in combinations of two or more. The concentration of the organic solvent is normally preferred to be 2-90 mass%, and the temperature may be adjusted as appropriate for the developing property. The aqueous developing solution may also contain small amounts of added surfactants, defoaming agents and the like.

[0116] As examples of organic solvent-based developing solutions there may be mentioned 1,1,1-trichloroethane, N-methylpyrrolidone, N,N-dimethylformamide, cyclohexanone, methyl isobutyl ketone, γ -butyrolactone and the like. Water is preferably added to these organic solvents in a range of 1-20 mass% for anti-flammability.

[0117] Two or more different developing methods may also be carried out in combination if necessary for the developing step. The developing system may be a dip system, paddle system, spray system, brushing, slapping or the like, but a high-pressure spray system is most suitable for improved resolution.

[0118] Post-development treatment may consist of heating at about 60-250°C or exposure at about 0.2-10 mJ/cm² if necessary for further curing of the resist pattern.

[0119] In the process for production of a printed circuit board according to the invention, a circuit-forming board having a resist pattern formed by the aforementioned resist pattern forming method of

the invention is etched or plated.

[0120] The etching or plating of the circuit-forming board is accomplished by etching or plating the surface of the circuit-forming board by a conventional publicly known process using the developed resist pattern as a mask.

[0121] The etching solution used for etching may be, for example, a copper(II) chloride solution, ferric chloride solution, alkali etching solution or hydrogen peroxide-based etching solution, but a ferric chloride solution is preferred from the viewpoint of a satisfactory etch factor.

[0122] As examples of plating methods for the plating there may be mentioned copper plating such as copper sulfate plating and copper pyrophosphate plating, solder plating such as high throwing solder plating, nickel plating such as Watt bath (nickel sulfate-nickel chloride) plating or nickel sulfamate plating, and gold plating such as hard gold plating or soft gold plating.

[0123] After the etching or plating, the resist pattern is released, for example, with an aqueous solution of stronger alkalinity than the aqueous alkali solution used for development. The strongly alkaline aqueous solution used here may be, for example, a 1-10 mass% sodium hydroxide aqueous solution or a 1-10 mass% potassium hydroxide aqueous solution. The releasing system may be, for example, a dipping system, spraying system or the like, and a dipping or spraying system may be used either alone or in combination. The printed circuit board on which the resist pattern has been formed may also be a multilayer printed circuit board.

[0124] When the plating is carried out for a circuit-forming board provided with an insulating layer and a conductive layer formed on the insulating layer, the sections of the conductive layer other than the pattern must be removed. As examples of removal methods there may be mentioned a method of releasing the resist pattern and then lightly etching, and a method of following the plating by solder plating and then removing the resist pattern to leave a solder mask on the wiring sections, and finally performing treatment using an etching solution capable of etching only the conductive layer.

Examples

[0125] The present invention will now be explained in greater detail by examples and comparative examples, with the understanding that the invention is not limited to the examples.

[0126] [Synthesis of binder polymer A]

In a flask equipped with a stirrer, reflux condenser, thermometer, dropping funnel and nitrogen gas inlet tube there was placed 350 g of a methylcellosolve/toluene mixture (mass ratio: 3/2), and the mixture was stirred while blowing in nitrogen gas and heated to 80°C. Separately, there was prepared a solution comprising a mixture of 150 g of methacrylic acid, 300 g of methyl methacrylate, 150 g of styrene as copolymerizing monomers and 9.0 g of azobisisobutyronitrile (hereinafter referred to as "solution (a)"). After then dropwise adding solution (a) over a period of 4 hours to a methylcellosolve/toluene mixture (mass ratio: 3/2) that had been heated to 80°C, the mixture was stirred while warming at 80°C for 2 hours. Also, a solution of 1.2 g of azobisisobutyronitrile in 50 g of a methylcellosolve/toluene mixture

(mass ratio: 3/2) was added dropwise to the flask over a period of 10 minutes. The dropped solution was warmed at 80°C for 3 hours while stirring, and then heated to 90°C over a period of 30 minutes. After heating at 90°C for 2 hours, it was cooled to obtain a solution of binder polymer A. The non-volatile portion (solid portion) of the solution of binder polymer A was 60 mass%, and the weight-average molecular weight of binder polymer A was 20,000. The weight-average molecular weight was measured by gel permeation chromatography, with calculation based on a standard polystyrene calibration curve.

The GPC conditions were as follows.

[0127] (GPC conditions)

Pump: Hitachi L-6000 (trade name of Hitachi, Ltd.)

Column: Gelpack GL-R420 + Gelpack GL-R430 + Gelpack GL-R440 (total of 3) (all trade names of Hitachi Chemical Co., Ltd.).

Eluant: Tetrahydrofuran

Measuring temperature: 25°C

Flow rate: 2.05 mL/min

Detector: Hitachi L-3300 RI (trade name of Hitachi, Ltd.)

[0128] [Synthesis of binder polymer B]

Synthesis was performed by the same method as the synthesis for binder polymer A except that 3.0 g of azobisisobutyronitrile was added in solution (a), to obtain a solution of binder polymer B. The non-volatile portion (solid portion) of the solution of binder polymer B was 60 mass%, and the weight-average molecular weight of binder polymer B was 60,000.

[0129] [Synthesis of binder polymer C]

Synthesis was performed by the same method as the synthesis for binder polymer A, except that the amount of methylcellosolve/toluene mixture (mass ratio: 3/2) initially placed in the flask was 550 g and the amount of azobisisobutyronitrile added to solution (a) was 0.6 g, to obtain a solution of binder polymer C. The non-volatile portion (solid portion) of the solution of binder polymer C was 50 mass%, and the weight-average molecular weight of binder polymer C was 150,000.

[0130] The weight-average molecular weights and acid values of binder polymers A, B and C are listed in Table 1.

[0131] [Table 1]

	Binder polymer A	Binder polymer B	Binder polymer C
Methacrylic acid	25	25	25
Methyl methacrylate	50	50	50
Styrene	25	25	25
Weight-average mol. wt.	20,000	60,000	150,000
Acid value (mgKOH/g)	163	163	163

[0132] [Production of photosensitive layer material]

The materials shown in Table 2 were combined to produce photosensitive layer materials (I), (II) and (III). The units for the content of each material in Table 2 are parts by mass.

[0133] [Table 2]

Components	Material	Photosensitive layer material		
		(I)	(II)	(III)
Component (A)	Binder polymer A solution	150 (solid portion: 90)	-	-
	Binder polymer B solution	-	150 (solid portion: 90)	-
	Binder polymer C solution	-	-	180 (solid portion: 90)
Component (B1)	2,2-bis(4-(Methacryloxy-pentadecaethoxy)phenyl)propane	30.0	30.0	30.0
	EO-modified nonylphenyl acrylate (ethylene glycol chain repeating units: 8)	10.0	10.0	10.0
Component (C1)	N,N'-Tetraethyl-4,4'-diaminobenzophenone	0.15	0.15	0.15
	2-(o-Chlorophenyl)-4,5-diphenylimidazole dimer	3.0	3.0	3.0
Additive	Leuco crystal violet	0.5	0.5	0.5
	Malachite green	0.05	0.05	0.05
	p-Toluenesulfonamide	4.0	4.0	4.0
Solvent	Acetone	10.0	10.0	10.0
	Toluene	10.0	10.0	10.0
	Methanol	3.0	3.0	3.0
	N-Dimethylformamide	3.0	3.0	3.0

[0134] [Production of cushion layer material]

- 5 The materials shown in Table 3 were combined to produce cushion layer materials (I), (II), (III) and (IV). The units for the content of each material in Table 3 are parts by mass.

[0135] [Table 3]

Components	Material	Cushion layer material			
		(I)	(II)	(III)	(IV)
Main component	EVAFLEX EEA A704 (DuPont-Mitsui Polychemicals Co., Ltd.)	15	15	15	15
Component (B2)	2,2-bis(4-(Methacryloxy-pentadecaethoxy)phenyl)propane	1	1	1	-
	EO-modified nonylphenyl acrylate (ethylene glycol chain repeating units: 8)	1	-	1	-
Component (C2)	2-(o-Chlorophenyl)-4,5-diphenylimidazole dimer	0.3	0.3	-	-
Solvent	Toluene	85	85	85	85
	N-Dimethylformamide	1	1	-	-

[0136] (Examples 1-3 and Comparative Examples 1 and 2)

[Fabrication of photosensitive elements]

For Example 1, the photosensitive layer material (I) and cushion layer material (II) were combined to fabricate a photosensitive element by the following procedure.

[0137] First, there was prepared as the support film a 16 μm -thick polyethylene terephthalate (PET) film (trade name: G2-16, product of Teijin, Ltd.), and the cushion layer material (II) was evenly coated thereover to a dried thickness of 10 μm , and dried for 10 minutes with a hot-air convection drier at 115°C to form a cushion layer. Next, the photosensitive layer material (I) was evenly coated onto the cushion layer to a dried thickness of 10 μm , and dried for 10 minutes with a hot-air convection drier at 100°C to form a photosensitive layer. A 20 μm -thick biaxially stretched polypropylene film (trade name: E-200H, product of Oji Paper Co., Ltd.) was then prepared as a protective film, and laminated on the photosensitive layer to obtain a photosensitive element for Example 1. The obtained photosensitive element was wound with the support film facing outward.

[0138] Photosensitive elements for Examples 2 and 3 and Comparative Examples 1 and 2 were obtained in the same manner as Example 1, except that for Example 2, photosensitive layer material (I) and cushion layer material (II) were combined and the cushion layer thickness was 20 μm , for Example 3, the photosensitive layer material (I) and cushion layer material (II) were combined and the cushion layer thickness was 20 μm , for Comparative Example 1, the photosensitive layer material (I) and cushion layer material (II) were

combined and the cushion layer and photosensitive layer thickness was 20 μm , and for Comparative Example 2, the photosensitive layer material (I) and cushion layer material (IV) were combined and the cushion layer thickness was 20 μm .

5 [0139] (Examples 4-9 and Comparative Examples 3-8)

[Fabrication of photosensitive elements]

For Example 4, the photosensitive layer material (I) and cushion layer material (I) were combined to fabricate a photosensitive element by the following procedure.

10 [0140] First, there was prepared as the support film a 16 μm -thick polyethylene terephthalate (PET) film (trade name: G2-16, product of Teijin, Ltd.), and the cushion layer material (I) was evenly coated thereover to a dried thickness of 10 μm , and dried for 10 minutes with a hot-air convection drier at 115°C to form a cushion layer. Next, a
15 separate 16 μm -thick PET film (trade name: G2-16, product of Teijin, Ltd.) was prepared, and the photosensitive layer material (I) was evenly coated thereover to a dried thickness of 6 μm , and dried for 10 minutes with a hot-air convection drier at 100°C to form a photosensitive layer. The cushion layer and photosensitive layer were then adhesively
20 attached (with the PET film facing outward) to obtain a photosensitive element for Example 4. The photosensitive layer side of the PET film was used as the protective film.

[0141] For Examples 5-9 and Comparative Examples 3-7, photosensitive elements were fabricated by the same procedure as
25 Example 4, except that the photosensitive layer materials and thicknesses and the cushion layer materials and thicknesses were

changed as shown in Tables 5 and 6. This yielded photosensitive elements for Examples 5-9 and Comparative Examples 3-7.

[0142] For Comparative Example 8, a 16 μm -thick PET film (trade name: G2-16, product of Teijin, Ltd.) was prepared, and the photosensitive layer material (I) was evenly coated thereover to a dried thickness of 6 μm , and dried for 10 minutes with a hot-air convection drier at 100°C to form a photosensitive layer. Next, a 20 μm -thick biaxially stretched polypropylene film (trade name: E-200H, product of Oji Paper Co., Ltd.) was prepared as a protective film, and laminated on the photosensitive layer to obtain a photosensitive element for Comparative Example 8.

[0143] [Fabrication of printed circuit board A (evaluation of adhesive property and resolution)]

Each of the photosensitive elements of Examples 1-9 and Comparative Examples 1-8 was used to fabricate a printed circuit board A by the following procedure for evaluation of the adhesion and resolution. The photosensitive elements were used within 12 hours of fabrication.

[0144] First, the copper surface of a glass epoxy board having a 35 μm -thick copper foil laminated on one side thereof (trade name: MCL-E67-35S, product of Hitachi Chemical Co., Ltd.) was polished using a polishing machine with a #600-equivalent brush (Sankei Co., Ltd.), and after cleaning with water, it was dried with an air stream to obtain a copper clad laminate.

[0145] The obtained copper clad laminate was then heated to 80°C, and a high-temperature laminator (HLM-3000 by Hitachi Chemical Co., Ltd.) was used to laminate a photosensitive layer onto the copper

clad laminate while releasing the protective film of the photosensitive element, with the support film side contacting the roll.

[0146] The laminating roll speed during this time was 1.5 m/min, the laminating roll temperature was 110°C, and the roll cylinder pressure was 0.4 MPa.

[0147] Upon completion of lamination, it was cooled to 23°C and the support film and cushion layer of the photosensitive element were released. For the photosensitive element of Comparative Example 8, only the support film was released.

[0148] Next, a negative mask (Stouffer 21-step tablet, negative mask for resolution evaluation with line width/space width = 400/6-400/47 (units: μm) wiring pattern, and negative mask for adhesive property evaluation with line width/space width = 6/400-47/400 (units: μm) wiring pattern), and an exposure apparatus by Orc Manufacturing Co., Ltd. (Model EXM-1201, mercury short arc lamp) were used for exposure with an energy dose for a remaining number of steps of 6.0 after development of the Stouffer 21-step tablet.

[0149] The photosensitive element was then subjected to spray development (spray pressure: 0.18 MPa) with a 1 mass% aqueous sodium carbonate solution (30°C) for the developing times listed in Tables 4 to 6, to form resist patterns on the copper clad laminates.

[0150] The value of the minimum space width for developing residue was measured as the resolution for each resist pattern formed using the negative mask for resolution evaluation, and the minimum resist width of formation without producing meandering or chipping was measured as the adhesive property for each resist pattern formed using the

negative mask for adhesive property evaluation. The results are shown in Tables 4 to 6. A smaller value represents more excellent resolution and adhesive property.

[0151] [Fabrication of printed circuit board B (evaluation of conformability property)]

Each of the photosensitive elements of Examples 1-9 and Comparative Examples 1-8 was used to fabricate a printed circuit board B by the following procedure for evaluation of the conformability property. The photosensitive elements were used within 12 hours of fabrication.

[0152] First, a copper clad laminate having a resist pattern formed thereon was obtained in the same manner as for fabrication of the printed circuit board A, except that a RY-3210 (trade name of Hitachi Chemical Co., Ltd.) was used as the photosensitive element, and a negative mask with a line width/space width of 1,000/100 (units: μm) was used as the negative mask.

[0153] Next, the obtained copper clad laminate was dipped for 1-30 minutes in a 100 g/L aqueous ammonium persulfate solution (30°C), and the resist pattern was released with a release solution (3 mass% aqueous sodium hydroxide, 50°C, spray pressure: 0.18 MPa), to obtain a board for evaluation of the conformability property, having irregularities with a depression depth of 1-15 μm and a depression width of 100 μm .

[0154] The obtained board for evaluation of the conformability property was heated to 80°C, and then a high-temperature laminator (HLM-3000 by Hitachi Chemical Co., Ltd.) was used to laminate a photosensitive layer onto the board while releasing the protective film

of the photosensitive element, with the support film side contacting the roll. The axis of the laminating roll was kept parallel to the lengthwise direction of the depressions of the board. The laminating roll speed during this time was 1.5 m/min, the laminating roll temperature was 110°C, and the roll cylinder pressure was 0.4 MPa.

[0155] Upon completion of lamination, it was cooled to 23°C and the support film and cushion layer of the photosensitive element were released. For the photosensitive element of Comparative Example 8, only the support film was released.

[0156] Next, a negative mask (Stouffer 21-step tablet, negative mask with line width/space width = 100/100 (units: μm) wiring pattern), and an exposure apparatus by Orc Manufacturing Co., Ltd. (Model EXM-1201, mercury short arc lamp) were used for exposure with an energy dose for a remaining number of steps of 6.0 after development of the Stouffer 21-step tablet.

[0157] The photosensitive element was then subjected to spray development (spray pressure: 0.18 MPa) with a 1 mass% aqueous sodium carbonate solution (30°C) for the developing times listed in Tables 4 to 6, to form resist patterns on the copper clad laminates.

[0158] Also, a copper(II) chloride etching solution (2 mol/L CuCl_2 , 2N aqueous HCL solution, 50°C) was sprayed for 100 seconds (spray pressure: 0.2 MPa), the copper at the sections not protected with the resist were dissolved (etched), and the resist pattern was released with a releasing solution (3 mass% aqueous sodium hydroxide, 50°C, spray pressure: 0.2 MPa) to fabricate a printed circuit board B having copper lines formed on a board for evaluation of the conformability property.

[0159] When a photosensitive element fails to follow the irregularity sections on a board for evaluation of the conformability property, gaps are produced between the resist and the board, thus allowing infiltration of the etching solution at the sections where the resist and depressions intersect and causing dissolution of the copper lines, resulting in lack of continuity of the copper lines and thus wire breakage defects. The depth of depressions (μm) at which such wire breakage defects were found was measured as the conformability property, and the results are shown in Tables 4 to 6. A larger value represents a superior conformability property.

[0160] [Fabrication of printed circuit board C (evaluation of day-to-day stability)]

Each of the photosensitive elements of Examples 1-9 and Comparative Examples 1-8 was used to fabricate a printed circuit board C by the following procedure. The photosensitive elements were used within 12 hours after fabrication and after 30 days from fabrication (stored in a dark room at 23°C, 60% RH), and the results were compared to evaluate the day-to-day stability.

[0161] First, the copper surface of a glass epoxy board having a 35 μm -thick copper foil laminated on one side thereof (trade name: MCL-E67-35S, product of Hitachi Chemical Co., Ltd.) was polished using a polishing machine with a #600-equivalent brush (Sankei Co., Ltd.), and after cleaning with water, it was dried with an air stream to obtain a copper clad laminate.

[0162] The obtained copper clad laminate was then heated to 80°C, and a high-temperature laminator (HLM-3000 by Hitachi Chemical

Co., Ltd.) was used to laminate a photosensitive layer onto the copper clad laminate while releasing the protective film of the photosensitive element, with the support film side contacting the roll.

[0163] The laminating roll speed during this time was 1.5 m/min, the laminating roll temperature was 110°C, and the roll cylinder pressure was 0.4 MPa.

[0164] Upon completion of lamination, it was cooled to 23°C and the support film and cushion layer of the photosensitive element were released. For the photosensitive element of Comparative Example 8, only the support film was released.

[0165] Next, a negative mask (Stouffer 21-step tablet, negative mask for resolution evaluation with line width/space width = 400/6-400/47 (units: μm) wiring pattern, and negative mask for adhesive property evaluation with line width/space width = 6/400-47/400 (units: μm) wiring pattern), and an exposure apparatus by Orc Manufacturing Co., Ltd. (Model EXM-1201, mercury short arc lamp) were used for exposure with an energy dose for a remaining number of steps of 6.0 after development of the Stouffer 21-step tablet, when using the photosensitive element within 12 hours after fabrication. The exposure energy dose when using the photosensitive element after 30 days from fabrication was the same exposure energy dose as for the photosensitive element within 12 hours after fabrication.

[0166] The photosensitive element was then subjected to spray development (spray pressure: 0.18 MPa) with a 1 mass% aqueous sodium carbonate solution (30°C) for the developing times listed in Tables 4 to 6, to form resist patterns on the copper clad laminates.

[0167] The value of the minimum space width without development residue was measured as the resolution for each resist pattern formed using the negative mask for resolution evaluation, and the minimum resist width of formation without producing meandering or chipping was measured as the adhesive property for each resist pattern formed using the negative mask for adhesive property evaluation, for both cases, i.e. the photosensitive element within 12 hours after fabrication and the photosensitive element after storage by standing for 30 days in a dark room at room temperature (23°C, 60% RH) after fabrication. A smaller value represents more excellent resolution and a better adhesive property. Since the resolutions and adhesive properties when using the photosensitive elements within 12 hours after fabrication were the same result as obtained above [Fabrication of printed circuit board A (evaluation of adhesive property and resolution)], only the results for using the photosensitive elements after 30 days are shown in Tables 4 to 6.

[0168] Also measured was the number of steps remaining with the photosensitive element after storage by standing for 30 days after fabrication (23°C, 60% RH, dark room). The results are shown in Table 4-6. The numbers of steps remaining when using the photosensitive element within 12 hours after fabrication and when using the photosensitive element after storage by standing for 30 days after fabrication (23°C, 60% RH, dark room) were identical (6.0); the day-to-day stability was evaluated as excellent when no change in resolution or adhesive property was observed, and the day-to-day stability was evaluated as unsatisfactory when the number of remaining

steps, resolution or adhesive property differed.

[0169] [Table 4]

Parameter		Example 1	Example 2	Example 3	Comp. Ex. 1	Comp. Ex. 2
Photosensitive layer	Material	(I)	(I)	(II)	(I)	(I)
	Thickness (μm)	10	10	10	20	10
Cushion layer	Material	(II)	(II)	(II)	(II)	(IV)
	Thickness (μm)	10	20	20	20	20
Developing time (sec)		10	10	10	25	10
Adhesive property (μm)		6	6	6	10	6
Resolution (μm)		6	6	10	12	6
Conformability property (μm)		6	8	8	12	8
Stability	No. remaining steps	6.0	6.0	6.0	6.0	4.0
	Adhesive property (μm)	6	6	6	10	18
	Resolution (μm)	6	6	10	12	15

5

[0170] [Table 5]

Parameter		Example 4	Example 5	Example 6	Example 7	Example 8	Example 9
Photosensitive layer	Material	(I)	(I)	(I)	(I)	(I)	(II)
	Thickness (μm)	6	6	10	10	10	10
Cushion layer	Material	(I)	(I)	(I)	(II)	(II)	(II)
	Thickness (μm)	10	20	10	10	20	20
Developing time (sec)		6	6	10	10	10	10
Adhesive property (μm)		6	6	6	6	6	6
Resolution (μm)		6	6	6	6	6	10
Conformability property (μm)		5	7	6	6	8	8
Stability	No. remaining steps	6.0	6.0	6.0	6.0	6.0	6.0
	Adhesive property (μm)	6	6	6	6	6	6
	Resolution (μm)	6	6	6	6	6	10

[0171] [Table 6]

Parameter		Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5	Comp.Ex. 6	Comp. Ex. 7	Comp. Ex. 8
Photosensitive layer	Material	(III)	(I)	(I)	(I)	(I)	(I)
	Thickness (μm)	10	6	6	10	20	6
Cushion layer	Material	(I)	(III)	(IV)	(IV)	(II)	-
	Thickness (μm)	20	20	20	20	20	-
Developing time (sec)		10	6	6	10	25	6
Adhesive property (μm)		6	6	6	6	10	6
Resolution (μm)		15	6	6	6	12	6
Conformability property (μm)		8	7	7	8	12	1
Stability	No. remaining steps	6.0	4.5	4.5	5.0	6.0	6.0
	Adhesive property (μm)	6	20	25	12	10	6
	Resolution (μm)	15	15	20	10	12	6

[0172] As demonstrated by the results shown in Tables 4 to 6, the photosensitive elements of Examples 1 to 9 had superior adhesive properties, resolutions and conformability properties compared to the photosensitive elements of Comparative Examples 1 to 8, as well as more satisfactory day-to-day stability.

Industrial Applicability

[0173] As explained above, according to the invention it is possible to provide a photosensitive element having a satisfactory conformability property for irregularities on the surfaces of boards to be laminated, while also exhibiting excellent adhesion, resolution and day-to-day stability, as well as a resist pattern forming method and a printed circuit board production process employing it.

CLAIMS

1. A photosensitive element comprising a support film, a cushion layer formed on the support film and a photosensitive layer with a thickness of no greater than 10 μm formed on the cushion layer,

5 wherein the photosensitive layer is a layer comprising a binder polymer with weight-average molecular weight of 10,000-100,000, a first photopolymerizing compound containing at least one polymerizable ethylenic unsaturated bond in the molecule, and a first photopolymerization initiator, and

10 wherein the cushion layer is a layer comprising a second photopolymerizing compound containing at least one polymerizable ethylenic unsaturated bond in the molecule and a second photopolymerization initiator.

15 2. A photosensitive element according to claim 1, wherein the thickness of the support film is 5-20 μm .

3. A photosensitive element according to claim 1 or 2, wherein the binder polymer contains styrene and/or a styrene derivative as a monomer unit.

20 4. A photosensitive element according to any one of claims 1 to 3, wherein the binder polymer contains methacrylic acid as a monomer unit.

5. A photosensitive element according to any one of claims 1 to 4, wherein the acid value of the binder polymer is 30-200 mgKOH/g.

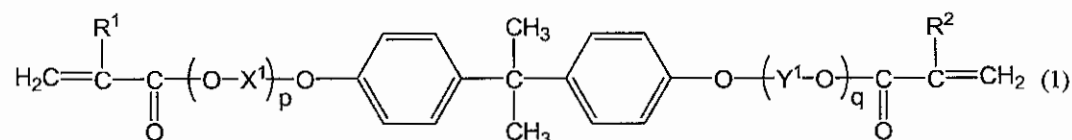
25 6. A photosensitive element according to any one of claims 1 to 5, comprising a compound having 4-40 C2-6 oxyalkylene groups in the molecule as the first photopolymerizing compound and second

photopolymerizing compound.

7. A photosensitive element according to any one of claims 1 to 6, comprising a bisphenol A-based (meth)acrylate compound or polyalkyleneglycol di(meth)acrylate as the first photopolymerizing compound and second photopolymerizing compound.

8. A photosensitive element according to claim 7, wherein the bisphenol A-based (meth)acrylate compound is a compound represented by the following general formula (1).

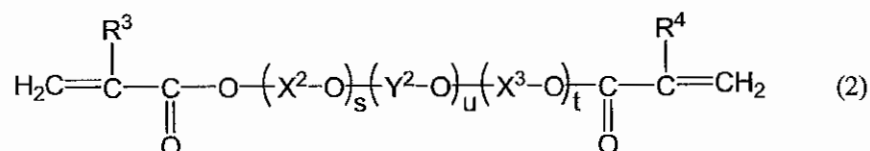
[Chemical Formula 1]



[wherein R^1 and R^2 each independently represent hydrogen atom or methyl group, X^1 and Y^1 each independently represent C2-6 alkylene group, and p and q are positive integers selected within $p+q = 4-40$]

9. A photosensitive element according to claim 7, wherein the polyalkyleneglycol di(meth)acrylate is a compound represented by the following general formula (2).

[Chemical Formula 2]



[wherein R^3 and R^4 each independently represent hydrogen atom or C1-3 alkyl group, X^2 , X^3 and Y^2 each independently represent C2-6 alkylene group, and s , t and u are integers of 0-30 selected within $s+t+u = 4-40$]

10. A photosensitive element according to any one of claims 1 to 9,

comprising 2,4,5-triarylimidazole dimer as the first photopolymerization initiator and second photopolymerization initiator.

11. A photosensitive element according to any one of claims 1 to 10, wherein the content of the first photopolymerizing compound in the photosensitive layer is 30-60 parts by mass with respect to 100 parts by mass as the total of the binder polymer and first photopolymerizing compound, and the content of the first photopolymerization initiator in the photosensitive layer is 0.1-20 parts by mass with respect to 100 parts by mass as the total of the binder polymer and first photopolymerization initiator.

12. A photosensitive element according to any one of claims 1 to 11, wherein the cushion layer further contains a copolymer of ethylene and a monomer that is copolymerizable therewith.

13. A photosensitive film according to claim 12, wherein the copolymer is ethylene-vinyl acetate copolymer with an ethylene proportion of 60-90 mass% based on the total monomer, or ethylene-ethyl (meth)acrylate copolymer with an ethylene proportion of 60-90 mass% based on the total monomer.

14. A photosensitive element according to any one of claims 1 to 13, wherein the thickness of the cushion layer is 1-100 μm .

15. A photosensitive element according to any one of claims 1 to 14, wherein there is further provided on the photosensitive layer a protective film that covers the photosensitive layer.

16. A resist pattern forming method, comprising
a laminating step in which a photosensitive element according to any one of claims 1 to 15 is situated so that the photosensitive layer,

cushion layer and support film are laminated in that order on a circuit-forming board,

a release step in which the support film and cushion layer are released from the photosensitive layer,

5 an exposure step in which active light rays are irradiated onto prescribed sections of the photosensitive layer to form photocured sections on the photosensitive layer, and

a developing step in which the sections of the photosensitive layer other than the photocured sections are removed.

10 17. A process for production of a printed circuit board wherein a circuit-forming board having a resist pattern formed by the resist pattern forming method of claim 16 is etched or plated.