

DESCRIPTION

TITLE OF THE INVENTION: IMPRINT MATERIAL

5 TECHNICAL FIELD

[0001] The present invention relates to an imprint material (a composition for forming a film for imprinting) and a film produced from the material and having a transferred pattern. More specifically, the present invention relates to a film that is
10 produced from the material, has high transparency regardless of increased film thickness, high refractive index, and high Abbe number, and has a transferred pattern. The "increased film thickness" herein means that a film has a thickness of 0.01 mm to 1.5 mm.

15 BACKGROUND ART

[0002] In 1995, Professor Chou who is currently at Princeton University and others proposed a novel technology called nanoimprint lithography (Patent Document 1). The nanoimprint lithography is a technology in which a mold having any pattern is
20 brought into contact with a substrate having a resin film, and the resin film is cured by applying external stimulation such as heat and light to the resin film under pressure, to form a desired pattern in the cured resin film. This nanoimprint lithography enables simpler and less expensive nanoscale processing than photolithography conventionally used in production of semiconductor devices, which is advantageous.

25 The nanoimprint lithography is a technology expected to be applied to production of semiconductor devices, optical devices, displays, storage media, biochips, and the like, instead of photolithography. Thus, various curable compositions for photonanoimprint lithography used for nanoimprint lithography have been reported (Patent Documents 2 and 3).

[0003] As a method for mass-producing a film having a transferred pattern with high efficiency in photonanoimprint lithography, roll-to-roll processing has been proposed. The roll-to-roll processing conventionally proposed in photonanoimprint lithography is mainly a method using a flexible film as a substrate and a solvent-free material that prevents change in pattern dimension as a material used for nanoimprint lithography (in the specification, hereinafter referred to as "imprint material").

Prior Art Documents

Patent Documents

- 10 [0004] Patent Document 1: U.S. Patent No. 5772905 (US 5772905 A)
Patent Document 2: Japanese Patent Application Publication No. 2008-105414 (JP 2008-105414 A)
Patent Document 3: Japanese Patent Application Publication No. 2008-202022 (JP 2008-202022 A)

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SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

- 20 [0005] As described above, the solvent-free material is used as the imprint material conventionally proposed. However, for the imprint material, a material having high transparency to light of visible light region after photoimprinting regardless of increased film thickness, high refractive index, and high Abbe number has not been specifically investigated or reported.

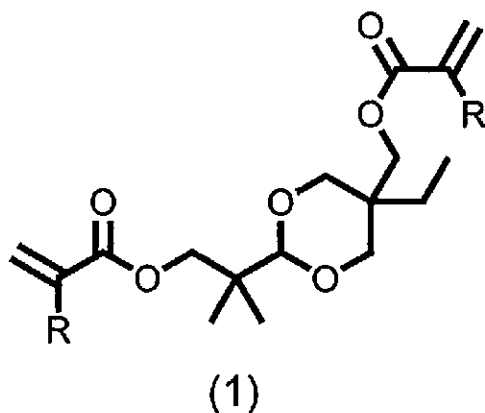
- 25 [0006] The present invention is made based on the circumstances, and an object of the present invention is to provide an imprint material having high transparency to light of visible light region after photoimprinting regardless of increased film thickness, high refractive index, and high Abbe number.

Means for Solving the Problems

[0007] To solve the aforementioned problems, the present inventors have intensively investigated, and as a result, found that when a material containing a compound having a 1,3-dioxane ring and polymerizable groups at both terminals, a compound having a linear alkylene group having a carbon atom number of 6 to 10 and/or an alicyclic structure selected from the group consisting of a cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group, and a photopolymerization initiator is used as an imprint material, the following findings are obtained and the present invention has been accomplished. Specifically, the imprint material of the present invention has high transparency to light of visible light region after photoimprinting regardless of increased film thickness, high refractive index, and high Abbe number.

[0008] A first aspect of the present invention is an imprint material comprising the following components (A), (B), and (C):

Component (A): a compound of the following formula (1):



(wherein two Rs are each independently a hydrogen atom or a methyl group),

Component (B): a compound having a linear alkylene group having a carbon atom number of 6 to 10 and/or an alicyclic structure selected from the group consisting of a cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group, and

Component (C): a photopolymerization initiator.

A second aspect of the present invention is the imprint material according to the first aspect, wherein the polymerizable group is an acryloyloxy group, a methacryloyloxy group, a vinyl group, or an allyl group.

5 A third aspect of the present invention is the imprint material according to the first or second aspect, wherein the number of the polymerizable group is one or two.

A fourth aspect of the present invention is the imprint material according to any one of the first to third aspects, wherein the content of the component (A) is 10% by mass to 90% by mass relative to a total mass of the components (A) and (B) of 100% by mass.

10 A fifth aspect of the present invention is the imprint material according to any one of the first to fourth aspects, further comprising a compound having at least one thiol group as a component (D).

A sixth aspect of the present invention is the imprint material according to any one of the first to fifth aspects, further comprising an antioxidant as a component (E).

15 A seventh aspect of the present invention is the imprint material according to any one of the first to sixth aspects, further comprising a surfactant as a component (F).

An eighth aspect of the present invention is the imprint material according to any one of the first to seventh aspects, further comprising a solvent as a component (G).

20 A ninth aspect of the present invention is a film produced from the imprint material according to any one of the first to eighth aspects and having a transferred pattern.

A tenth aspect of the present invention is the film having a transferred pattern according to the ninth aspect, wherein the pattern has a lens shape.

25 An eleventh aspect of the present invention is the film having a transferred pattern according to the ninth or tenth aspect, wherein the film having a transferred pattern is used as a lens for camera modules.

A twelfth aspect of the present invention is the film having a transferred pattern according to any one of the ninth to eleventh aspects, wherein the film having a transferred pattern has a maximum thickness of 1.5 mm.

A thirteenth aspect of the present invention is a method for producing a film having

a transferred pattern comprising steps of: filling a space between a substrate and a mold contacted to the substrate or a space in a splittable mold with the imprint material according to any one of the first to eighth aspects, and photocuring the imprint material in the space by exposure.

5 A fourteenth aspect of the present invention is the method according to the thirteenth aspect, comprising steps of: releasing the photocured product from the mold after the photocuring step, and heating the photocured product before, during, or after the releasing step.

10 Effects of the Invention

[0009] The imprint material of the present invention contains the compound of formula (1), and the compound having a linear alkylene group having a carbon atom number of 6 to 10 and/or an alicyclic structure selected from the group consisting of a
15 cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group. Thus, a cured film produced from the imprint material has high transparency to light of visible light region after photoimprinting regardless of increased film thickness, high refractive index, and high Abbe number.

20 [0010] The imprint material of the present invention can be photocured. During peeling the photocured product from a mold, a pattern is not partially peeled. Thus, a film on which a desired pattern is accurately formed can be obtained. Accordingly, a favorable pattern for photoimprinting can be formed.

[0011] From the imprint material of the present invention, a film can be formed
25 on any substrate. This film has high transparency to light of visible light region regardless of increased film thickness, high refractive index, and high Abbe number. Therefore, a film on which a pattern formed after imprinting is transferred can be suitably used in production of optical members required to have high transparency, high refractive index, and high Abbe number, such as a solid-state imaging element, a lens for camera

modules, and a lens for sensors. Examples of the lenses include a concave lens, a convex lens, an aspherical lens, a spherical lens, a Fresnel lens, a linear Fresnel lens, and a lens having fine concaves and convexes (anti-reflective structure) on a curved surface.

In the specification, the shape of the curved surfaces of the concave lens, convex lens,
 5 aspherical lens, spherical lens, Fresnel lens, linear Fresnel lens, and lens having fine concaves and convexes (anti-reflective structure) on a curved surface is a lens shape.

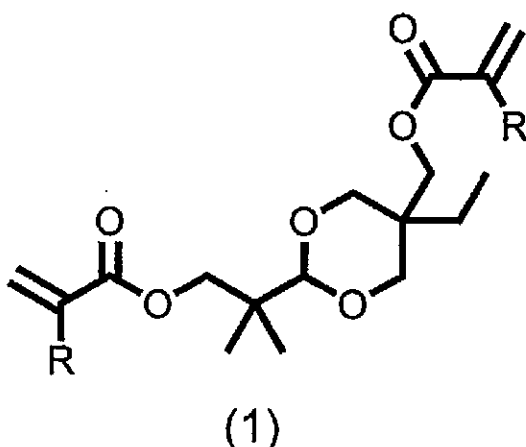
[0012] When the type and content of the compound that is the component (B) are changed, the curing speed, dynamic viscosity, and film thickness of the imprint material of the present invention can be controlled. Thus, the imprint material of the
 10 present invention can be designed in accordance with the type of a device to be produced and the types of an exposure process and a baking process. A process margin can be expanded. Accordingly, the imprint material of the present invention can be suitably used in production of optical members.

MODES FOR CARRYING OUT THE INVENTION

15 [0013] [Component (A)]

A compound that is a component (A) is a compound of the following formula

(1)



20 (wherein two Rs are each independently a hydrogen atom or a methyl group).

[0014] Specific examples of the compound of formula (1) include dioxane glycol diacrylate and dioxane glycol dimethacrylate.

[0015] The compound of formula (1) is available as a commercial product. Specific examples thereof include NK ester A-DOG (available from Shin Nakamura Chemical Co., Ltd.).

[0016] One type of the compound that is the component (A) may be used alone,
5 or two or more types thereof may be used in combination.

[0017] The content of the component (A) in the imprint material of the present invention is preferably 10% by mass or more and 90% by mass or less, and more preferably 40% by mass or more and 60% by mass or less, relative to a total mass of the component (A) and a component (B) described below of 100% by mass. When the
10 content of the component (A) is less than 10% by mass or more than 90% by mass, the transparency of a film to be obtained by heating after photoimprinting may be deteriorated.

[0018] [Component (B)]

A compound that is a component (B) is a compound having a linear alkylene group
15 having a carbon atom number of 6 to 10 and/or an alicyclic structure selected from the group consisting of a cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group. The linear alkylene group having a carbon atom number of 6 to 10 is (-CH₂CH₂CH₂CH₂CH₂CH₂-), (-CH₂CH₂CH₂CH₂CH₂CH₂CH₂-),
20 (-CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂-), (-CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂-), or (-CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂-). The alicyclic structure is a cyclic and non-aromatic hydrocarbon. Examples of the polymerizable group include an acryloyloxy group, a methacryloyloxy group, a vinyl group, and an allyl group. Herein, an acryloyloxy group may also be referred to acryloxy group, and a methacryloyloxy
25 group may also be referred to methacryloxy group. The compound that is the component (B) may or may not have a group or structure other than the linear alkylene group having a carbon atom number of 6 to 10, the alicyclic structure, and the polymerizable group, and preferably has no group or structure other than the linear alkylene group, the alicyclic structure, and the polymerizable group.

[0019] Specific examples of a compound having a linear alkylene group having a carbon atom number of 6 to 10 and at least one polymerizable group as the compound that is the component (B) include n-hexyl (meth)acrylate, n-heptyl (meth)acrylate, n-octyl (meth)acrylate, n-nonyl (meth)acrylate, 1,6-hexanediol di(meth)acrylate, 1,9-nonanediol di(meth)acrylate, and 1,10-decanediol di(meth)acrylate. In the specification, a (meth)acrylate compound means an acrylate compound and a methacrylate compound. For example, (meth)acrylic acid means acrylic acid and methacrylic acid.

[0020] The compound having a linear alkylene group having a carbon atom number of 6 to 10 and at least one polymerizable group as the compound that is the component (B) is available as a commercial product. Specific examples thereof include acrylic acid n-hexyl ester and methacrylic acid n-hexyl ester (all available from Tokyo Chemical Industry Co., Ltd.), n-heptyl acrylate, n-heptyl methacrylate, n-octyl acrylate, n-octyl methacrylate, n-nonyl acrylate, n-nonyl methacrylate, n-decyl acrylate, and n-decyl methacrylate (all available from ABCR GmbH & Co. KG), NK ester A-HD-N, HD-N, A-NOD-N, NOD-N, A-DOD, and DOD-N (all available from Shin Nakamura Chemical Co., Ltd.), NOAA and Viscoat (registered trademark) #230 and #260 (all available from Osaka Organic Chemical Industry Ltd.), and FANCRYL (registered trademark) FA-129AS (available from Hitachi Chemical Company, Ltd.).

[0021] Specific examples of a compound having an alicyclic structure selected from the group consisting of a cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group as the compound that is the component (B) include cyclopentyl (meth)acrylate, cyclohexyl (meth)acrylate, cyclohexanespiro-2-(1,3-dioxolan-4-yl)methyl acrylate, isobornyl (meth)acrylate, 1-adamantyl (meth)acrylate, 1-acryloyloxy-3-hydroxyadamantane, 3-hydroxy-1-methacryloyloxyadamantane, 2-methacryloyloxy-2-methyladamantane, 1,3-diacryloyloxyadamantane, 2-ethyl-2-methacryloyloxyadamantane, 2-isopropyl-2-methacryloyloxyadamantane, and 3,4-epoxycyclohexylmethyl (meth)acrylate.

[0022] The compound having an alicyclic structure selected from the group

consisting of a cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group as the compound that is the component (B) is available as a commercial product. Specific examples thereof include cyclopentyl acrylate and cyclopentyl methacrylate (all available from ABCR GmbH & Co. KG), cyclohexyl acrylate, cyclohexyl methacrylate, isobornyl acrylate, isobornyl methacrylate, 1-acryloyloxy-3-hydroxyadamantane, 3-hydroxy-1-methacryloyloxyadamantane, 2-methacryloyloxy-2-methyladamantane, 2-ethyl-2-methacryloyloxyadamantane, 2-isopropyl-2-methacryloyloxyadamantane (all available from Tokyo Chemical Industry Co., Ltd.), IBXA, Viscoat #155, CHDOL-10, 1-ADA, and 1-ADMA (all available from Osaka Organic Chemical Industry Ltd.), LIGHT ESTER CH and IB-X and LIGHT ACRYLATE (registered trademark) IB-XA (all available from KYOEISHA CHEMICAL CO., LTD.), DIAPURESTE (registered trademark) HADM, HADA, DHADM, ADPM, and ADDA (all available from MITSUBISHI GAS CHEMICAL COMPANY, INC.), NEW FRONTIER (registered trademark) HBPE-4 (available from DAI-ICHI KOGYO SEIYAKU CO., LTD.), and CYCLOMER (registered trademark) M100 (available from Daicel Corporation).

[0023] The compound having a linear alkylene group having a carbon atom number of 6 to 10, an alicyclic structure selected from the group consisting of a cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group as the compound that is the component (B) may be a compound having the linear alkylene group having a carbon atom number of 6 to 10, the alicyclic structure, and the polymerizable group in the molecule.

[0024] The compound having a linear alkylene group having a carbon atom number of 6 to 10, an alicyclic structure selected from the group consisting of a cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group as the compound that is the component (B) is available as a commercial product. Specific examples thereof include UM-90(1/3)DA (available from Ube Industries, Ltd.).

[0025] [Component (C)]

A photopolymerization initiator that is a component (C) is not particularly limited as long as it absorbs light of a light source used during photocuring. Examples thereof include organic peroxides such as tert-butylperoxy-iso-butyrate,

- 5 2,5-dimethyl-2,5-bis(benzoyldioxy)hexane,
1,4-bis[α -(tert-butylldioxy)-iso-propoxy]benzene, di-tert-butyl peroxide,
2,5-dimethyl-2,5-bis(tert-butylldioxy)hexene hydroperoxide,
 α -(iso-propylphenyl)-iso-propyl hydroperoxide, tert-butyl hydroperoxide,
1,1-bis(tert-butylldioxy)-3,3,5-trimethyl cyclohexane,
- 10 butyl-4,4-bis(tert-butylldioxy)valerate, cyclohexanone peroxide,
2,2',5,5'-tetra(tert-butylperoxycarbonyl)benzophenone,
3,3',4,4'-tetra(tert-butylperoxycarbonyl)benzophenone,
3,3',4,4'-tetra(tert-amylperoxycarbonyl)benzophenone,
3,3',4,4'-tetra(tert-hexylperoxycarbonyl)benzophenone,
- 15 3,3'-bis(tert-butylperoxycarbonyl)-4,4'-dicarboxybenzophenone, tert-butyl
peroxybenzoate, and di-tert-butyl diperoxyisophthalate; quinones such as
9,10-anthraquinone, 1-chloroanthraquinone, 2-chloroanthraquinone,
octamethylantraquinone, and 1,2-benzanthraquinone; benzoin derivatives such as
benzoin methyl, benzoin ethyl ether, α -methylbenzoin, and α -phenylbenzoin;
- 20 alkylphenone-based compounds such as 2,2-dimethoxy-1,2-diphenylethan-1-one,
1-hydroxy-cyclohexyl-phenyl-ketone, 2-hydroxy-2-methyl-1-phenyl-propan-1-one,
1-[4-(2-hydroxyethoxy)-phenyl]-2-hydroxy-2-methyl-1-propan-1-one,
2-hydroxy-1-[4-{4-(2-hydroxy-2-methyl-propionyl)benzyl}-phenyl]-2-methyl-propan-1-
one, phenylglyoxylic acid methyl ester,
- 25 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one,
2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-1-butanone, and
2-dimethylamino-2-(4-methyl-benzyl)-1-(4-morpholin-4-yl-phenyl)-butan-1-one;
acylphosphine oxide-based compounds such as bis(2,4,6-trimethylbenzoyl)-phenyl
phosphine oxide, and 2,4,6-trimethylbenzoyl-diphenyl-phosphine oxide; and oxime

ester-based compounds such as

2-(O-benzoyloxime)-1-[4-(phenylthio)phenyl]-1,2-octanedione, and

1-(O-acetyloxime)-1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-ethanone.

[0026] The photopolymerization initiator is available as a commercial product.

5 Specific examples thereof include IRGACURE (registered trademark) 651, 184, 500, 2959, 127, 754, 907, 369, 379, 379EG, 819, 819DW, 1800, 1870, 784, OXE01, OXE02, 250, 1173, MBF, 4265, and TPO (all available from BASF Japan Ltd.), KAYACURE (registered trademark) DETX, MBP, DMBI, EPA, and OA (all available from NIPPON KAYAKU Co., Ltd.), VICURE-10 and 55 (all available from STAUFFER Co. LTD),
10 ESACURE (registered trademark) KIP150, TZT, 1001, KTO46, KB1, KL200, KS300, and EB3, triazine-PMS, triazine A, and triazine B (all available from Nihon SiberHegner K.K.), and ADEKA Optomer N-1717, N-1414, and N-1606 (all available from ADEKA CORPORATION).

[0027] One type of the photopolymerization initiator may be used alone, or two
15 or more types thereof may be used in combination.

[0028] The content of the component (C) in the imprint material of the present invention is, for example, 0.01 phr to 30 phr, preferably 0.05 phr to 20 phr, and more preferably 0.1 phr to 8 phr, relative to the total mass of the components (A) and (B). When the content of the component (C) is less than 0.01 phr, sufficient curing property is
20 not achieved and patterning property is deteriorated. In the specification, "phr" means the mass of a substance, for example, the photopolymerization initiator that is the component (C), relative to a total mass of the components (A) and (B) of 100 g.

[0029] [Component (D)]

Specific examples of a compound having at least one thiol group that is a
25 component (D) include mercaptocarboxylic acid esters such as methyl mercaptoacetate, methyl 3-mercaptopropionate, 2-ethylhexyl 3-mercaptopropionate, 3-methoxybutyl 3-mercaptopropionate, n-octyl 3-mercaptopropionate, stearyl 3-mercaptopropionate, 1,4-bis(3-mercaptopropionyloxy)butane, 1,4-bis(3-mercaptobutyryloxy)butane, trimethylolethane tris(3-mercaptopropionate), trimethylolethane tris(3-mercaptobutyrate),

trimethylolpropane tris(3-mercaptopropionate), trimethylolpropane
 tris(3-mercaptobutyrate), pentaerythritol tetrakis(3-mercaptopropionate), pentaerythritol
 tetrakis(3-mercaptobutyrate), dipentaerythritol hexakis(3-mercaptopropionate),
 dipentaerythritol hexakis(3-mercaptobutyrate), tris[2-(3-mercaptopropionyloxy)ethyl]
 5 isocyanurate, tetraethylene glycol bis(3-mercaptopropionate),
 tris[2-(3-mercaptobutyryloxy)ethyl] isocyanurate, and
 1,3,5-tris(3-mercaptobutyryloxyethyl)-1,3,5-triazine-2,4,6(1H,3H,5H)-trione; alkylthiols
 such as ethanethiol, 2-methylpropane-2-thiol, n-dodecanethiol,
 2,3,3,4,4,5-hexamethylhexane-2-thiol (tert-dodecanethiol), ethane-1,2-dithiol,
 10 propane-1,3-dithiol, and benzylthiol; aromatic thiols such as benzenethiol,
 3-methylbenzenethiol, 4-methylbenzenethiol, naphthalene-2-thiol, pyridine-2-thiol,
 benzoimidazole-2-thiol, and benzothiazole-2-thiol; mercaptoalcohols such as
 2-mercaptoethanol and 4-mercapto-1-butanol; silane-containing thiols such as
 3-(trimethoxysilyl)propane-1-thiol and 3-(triethoxysilyl)propane-1-thiol; and
 15 bis(2-mercaptoethyl) ether.

[0030] The compound having at least one thiol group is available as a
 commercial product. Specific examples thereof include THIOKALCOL (registered
 trademark) 20 (available from Kao Corporation), and KarenzMT (registered trademark)
 PE1, BD1, NR1, TPMB, and TEMB (all available from Showa Denko K.K.).

20 [0031] In the imprint material of the present invention, one type of the
 component (D) may be used alone, or a mixture of two or more types thereof may be
 used. The content of the component (D) is, for example, 0.01 phr to 30 phr, and more
 preferably 0.05 phr to 20 phr, relative to the total mass of the components (A) and (B).

[0032] [Component (E)]

25 Examples of an antioxidant that is a component (E) include a phenol-based
 antioxidant, a phosphoric acid-based antioxidant, and a sulfide-based antioxidant.
 Among these, the phenol-based antioxidant is preferable. Examples of the phenol-based
 antioxidant include IRGANOX (registered trademark) 245, 1010, 1035, 1076, and 1135
 [all available from BASF Japan Ltd.], SUMILIZER (registered trademark) GA-80, GP,

MDP-S, BBM-S, and WX-R [all available from Sumitomo Chemical Co., Ltd.], and ADK STAB (registered trademark) AO-20, AO-30, AO-40, AO-50, AO-60, AO-80, and AO-330 [all available from ADEKA Corporation].

[0033] In the imprint material of the present invention, one type of the component (E) may be used alone, or a mixture of two or more types thereof may be used. The content of the component (E) is, for example, 0.01 phr to 20 phr, and preferably 0.05 phr to 10 phr, relative to the total mass of the components (A) and (B).

[0034] [Component (F)]

Examples of a surfactant that is a component (F) include nonionic surfactants including polyoxyethylene alkyl ethers such as polyoxyethylene lauryl ether, polyoxyethylene stearyl ether, polyoxyethylene cetyl ether, and polyoxyethylene oleyl ether, polyoxyethylene alkylaryl ethers such as polyoxyethylene octylphenyl ether and polyoxyethylene nonylphenyl ether, polyoxyethylene-polyoxypropylene block copolymers, sorbitan fatty acid esters such as sorbitan monolaurate, sorbitan monopalmitate, sorbitan monostearate, sorbitan monooleate, sorbitan trioleate, and sorbitan tristearate, and polyoxyethylene sorbitan fatty acid esters such as polyoxyethylene sorbitan monolaurate, polyoxyethylene sorbitan monopalmitate, polyoxyethylene sorbitan monostearate, polyoxyethylene sorbitan trioleate, and polyoxyethylene sorbitan tristearate.

[0035] The surfactant is available as a commercial product. Specific examples thereof include fluorosurfactants such as Eftop (registered trademark) EF301, EF303, and EF352 (all available from Mitsubishi Materials Electronic Chemicals Co., Ltd.), MEGAFACE (registered trademark) F-171, F-173, F-477, F-486, F-554, F-556, R-08, R-30, R-30N, R-40, R-40-LM, RS-56, RS-75, RS-72-K, RS-76-E, RS-76-NS, RS-78, and RS-90 (all available from DIC Corporation), Fluorad FC430 and FC431 (all available from 3M Japan Limited), and AsahiGuard (registered trademark) AG710, and SURFLON (registered trademark) S-382, SC101, SC102, SC103, SC104, SC105, and SC106 (available from Asahi Glass Co., Ltd.); organosiloxane polymer KP341 (available from Shin-Etsu Chemical Co., Ltd.); and BYK-302, BYK-307, BYK-322, BYK-323,

BYK-330, BYK-333, BYK-370, BYK-375, BYK-378, BYK-UV 3500, and BYK-UV 3570 (all available from BYK Japan KK).

[0036] In the imprint material of the present invention, one type of the component (F) may be used alone, or a mixture of two or more types thereof may be used.

5 The content of the component (F) is preferably 0.01 phr to 40 phr, and more preferably 0.01 phr to 10 phr, relative to the total mass of the components (A) and (B).

[0037] [Component (G)]

The imprint material of the present invention may contain a solvent as a component (G). The solvent adjusts the viscosities of the components (A) and (B).

10 [0038] Examples of the solvent include toluene, p-xylene, o-xylene, styrene, ethylene glycol dimethyl ether, propylene glycol monomethyl ether, ethylene glycol monomethyl ether, propylene glycol monoethyl ether, ethylene glycol monoethyl ether, ethylene glycol monoisopropyl ether, ethylene glycol methyl ether acetate, propylene glycol monomethyl ether acetate, ethylene glycol ethyl ether acetate, diethylene glycol dimethyl ether, propylene glycol monobutyl ether, ethylene glycol monobutyl ether, diethylene glycol diethyl ether, dipropylene glycol monomethyl ether, diethylene glycol monomethyl ether, dipropylene glycol monoethyl ether, diethylene glycol monoethyl ether, triethylene glycol dimethyl ether, diethylene glycol monoethyl ether acetate, diethylene glycol, 1-octanol, ethylene glycol, hexylene glycol, diacetone alcohol, furfuryl alcohol, tetrahydrofurfuryl alcohol, propylene glycol, benzyl alcohol, 1,3-butanediol, 1,4-butanediol, 2,3-butanediol, γ -butyrolactone, acetone, methyl ethyl ketone, methyl isopropyl ketone, diethyl ketone, methyl isobutyl ketone, methyl n-butyl ketone, cyclohexanone, 2-heptanone, ethyl acetate, isopropyl acetate, n-propyl acetate, isobutyl acetate, n-butyl acetate, ethyl lactate, ethyl pyruvate, methanol, ethanol, isopropanol, tert-butanol, allyl alcohol, n-propanol, 2-methyl-2-butanol, isobutanol, n-butanol, 2-methyl-1-butanol, 1-pentanol, 2-methyl-1-pentanol, 2-ethyl hexanol, trimethylene glycol, 1-methoxy-2-butanol, isopropyl ether, 1,4-dioxane, N,N-dimethylformamide, N,N-dimethylacetamide, N-methyl-2-pyrrolidone, 1,3-dimethyl-2-imidazolidinone, dimethylsulfoxide, and N-cyclohexyl-2-pyrrolidine. The solvent is not particularly

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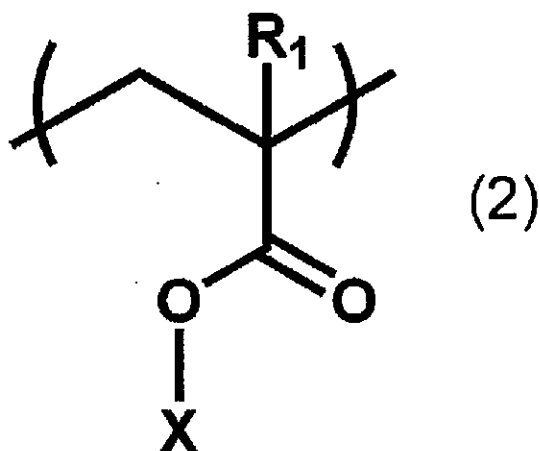
limited as long as it can adjust the viscosities of the components (A) and (B).

[0039] One type of the solvent may be used alone, or two or more types thereof may be used in combination. When the solvent is used, the solid content, which is defined as the content of the whole component in the imprint material of the present invention, that is, the components including the components (A) to (F) and another additive described below except for the solvent that is the component (G), is 50% by mass to 99% by mass, and preferably 70% by mass to 99% by mass.

[0040] [Other Additive]

The imprint material of the present invention may contain an additive selected from the group consisting of a polymer compound, an epoxy compound, a photoacid generator, a photosensitizer, a ultraviolet absorber, a chain transfer agent, an adhesion aid, and a mold release improver, if necessary, as long as the additive does not impair the effects of the present invention.

[0041] The aforementioned polymer compound can be added to adjust the refractive index and the Abbe number without impairing transparency. The polymer compound preferably has a repeating structural unit of the following formula (2). The content of the polymer compound is preferably 0.1% by mass or more and 90% by mass or less, and more preferably 5% by mass or more and 70% by mass or less, relative to the total mass of the components (A) and (B) and the polymer compound.



(wherein R₁ is a hydrogen atom or a methyl group, and X is an organic group having an

alicyclic structure selected from the group consisting of a cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, an adamantane structure, and a tricyclodecane structure.)

[0042] Examples of the epoxy compound include EPOLEAD (registered trademark) GT-401 and PB3600, and CELLOXIDE (registered trademark) 2021P, 2000, 3000, EHPE3150, and EHPE3150CE (all available from Daicel Corporation), and EPICLON (registered trademark) 840, 840-S, N-660, and N-673-80M (all available from DIC Corporation).

[0043] Examples of the photoacid generator include IRGACURE (registered trademark) PAG103, PAG108, PAG121, PAG203, and CGI725 (all available from BASF Japan Ltd.), WPAG-145, WPAG-170, WPAG-199, WPAG-281, WPAG-336, and WPAG-367 (all available from Wako Pure Chemical Industries, Ltd.), TFE-triazine, TME-triazine, MP-triazine, dimethoxy triazine, TS-91, and TS-01 (available from SANWA CHEMICAL Co., Ltd.), CPI-100P, CPI-101A, CPI-200K, CPI-110P, 210S, CPI-110P, and CPI-110B (all available from San-Apro Ltd.).

[0044] Examples of the photosensitizer include thioxanthene-based, thioxanthone-based, xanthene-based, ketone-based, thiopyrylium salt-based, base styryl-based, merocyanine-based, 3-substituted coumarin-based, 3,4-substituted coumarin-based, cyanine-based, acridine-based, thiazine-based, phenothiazine-based, anthracene-based, coronene-based, benzanthracene-based, perylene-based, ketocoumarin-based, coumarin-based, and borate-based photosensitizers. The photosensitizer is available as a commercial product. Specific examples thereof include ANTHRACURE (registered trademark) UVS-581 and UVS-1331 (all available from KAWASAKI KASEI CHEMICALS LTD.) and KAYACURE (registered trademark) DETX-S (available from NIPPON KAYAKU Co., Ltd.). One type of the photosensitizer may be used alone, or two or more types thereof may be used in combination. The photosensitizer can adjust the absorption wavelength of light of UV region.

[0045] Examples of the ultraviolet absorber include TINUVIN (registered

trademark) PS, 99-2, 109, 328, 384-2, 400, 405, 460, 477, 479, 900, 928, 1130, 111FDL, 123, 144, 152, 292, 5100, 400-DW, 477-DW, 99-DW, 123-DW, 5050, 5060, and 5151 (all available from BASF Japan Ltd.). One type of the ultraviolet absorber may be used alone, or two or more types thereof may be used in combination. The ultraviolet
 5 absorber can control the curing speed of an outermost surface of a film during photocuring the imprint material of the present invention, and may improve the mold release property.

[0046] Examples of the chain transfer agent include alkyl disulfides such as diethyl disulfide, dipropyl disulfide, diisopropyl disulfide, dibutyl disulfide, di-tert-butyl
 10 disulfide, dipentyl disulfide, diisopentyl disulfide, dihexyl disulfide, dicyclohexyl disulfide, didecyl disulfide, bis(2,3,3,4,4,5-hexamethylhexan-2-yl)disulfide (di-tert-dodecyl disulfide), bis(2,2-diethoxyethyl) disulfide, bis(2-hydroxyethyl) disulfide, and dibenzyl disulfide; aromatic disulfides such as diphenyl disulfide, di-p-tolyl disulfide, di(pyridin-2-yl)pyridyl disulfide, di(benzimidazol-2-yl) disulfide, and
 15 di(benzothiazol-2-yl) disulfide; thiuram disulfides such as tetramethylthiuram disulfide, tetraethylthiuram disulfide, tetrabutylthiuram disulfide, and bis(pentamethylene)thiuram disulfide; and α -methylstyrene dimer. One type of the chain transfer agent may be used alone, or two or more types thereof may be used in combination.

[0047] Examples of the adhesion aid include
 20 3-methacryloxypropyltrimethoxysilane and 3-acryloxypropyltrimethoxysilane. The adhesion aid improves the adhesion to a substrate. The content of the adhesion aid is preferably 5 phr to 50 phr, and more preferably 10 phr to 50 phr, relative to the total mass of the components (A) and (B).

[0048] Examples of the mold release improver include fluorine-containing
 25 compounds. Examples of the fluorine-containing compounds include R-5410, R-1420, M-5410, M-1420, E-5444, E-7432, A-1430, and A-1630 (all available from Daikin Industries, Ltd.).

[0049] [Preparation of Imprint Material]

A method for preparing the imprint material of the present invention is not

particularly limited as long as the imprint material is obtained by mixing the components (A), (B), and (C), the components (D), (E), (F), and (G), which are optional components, and if desired, the other additive, and the imprint material is in a homogeneous state.

The order of mixing the components (A) to (G) and if desired, the other additive is not

5 particularly limited as long as the obtained imprint material is in a homogeneous state.

Examples of the method for preparing the imprint material include a method in which the components (A) and (B) are mixed at a predetermined ratio, the component (C) is added, and the components (D), (E), (F), and (G) are optionally mixed as appropriate to obtain a homogeneous imprint material, and a method in which the other additive is further mixed

10 in an appropriate stage of the aforementioned method, if desired.

[0050] [Photoimprinting and Film having Transferred Pattern]

The imprint material of the present invention can be applied to a substrate and photocured to obtain a desired coating film. Examples of a coating method include publicly or well known methods including a spin coating method, a dip method, a flow

15 coating method, an inkjet method, a spraying method, a bar coating method, a gravure coating method, a slit coating method, a roll coating method, a transfer printing method, coating by a brush, a blade coating method, and an air-knife coating method.

[0051] Examples of a substrate to be coated with the imprint material of the present invention include a substrate formed from silicon, a glass having a film formed from indium tin oxide (ITO) (ITO substrate), a glass having a film formed from silicon nitride (SiN) (SiN substrate), a glass having a film formed of indium zinc oxide (IZO), and substrates formed from polyethylene terephthalate (PET), triacetylcellulose (TAC), acrylics, plastics, glass, quartz, and ceramics. As a flexible substrate, for example, a substrate formed from triacetylcellulose, polyethylene terephthalate, polymethyl

25 methacrylate, cycloolefin (co)polymer, polyvinyl alcohol, polycarbonate, polystyrene, polyimide, polyamide, polyolefin, polypropylene, polyethylene, polyethylene naphthalate, polyethersulfone, and a copolymer obtained by combining the polymers can be used.

[0052] Examples of a light source for photocuring the imprint material of the present invention include, but are not particularly limited to, a high-pressure mercury

lamp, a low-pressure mercury lamp, an electrodeless lamp, a metal halide lamp, a KrF excimer laser, an ArF excimer laser, a F₂ excimer laser, an electron beam (EB), extreme ultraviolet light (EUV), and ultraviolet light LED (UV-LED). A g-line with a wavelength of 436 nm, a h-line with a wavelength of 405 nm, an i-line with a wavelength of 365 nm, or a ghi-mixed line can be generally used. The exposure dose is preferably 30 mJ/cm² to 2,000 mJ/cm², and more preferably 30 mJ/cm² to 1,000 mJ/cm².

[0053] When the solvent that is the component (G) is used, a step of baking at least one of a coating film before light irradiation and a cured product after light irradiation may be carried out for evaporation of the solvent. A baking device is not particularly limited as long as baking can be achieved by using a hot plate, an oven, or a furnace under an appropriate atmosphere, that is, in air, an inert gas such as nitrogen, or vacuum. The baking temperature is not particularly limited as long as the solvent is evaporated, and for example, may be 40°C to 200°C.

[0054] Even when a film having a transferred pattern that is produced from the imprint material of the present invention has a thickness of 1 mm, the film has high transparency to light of visible light region, and exhibits high refractive index and Abbe number. Thus, the film can be suitably used for an optical article such as a lens for camera modules and a resin mold for imprinting.

[0055] A device for photoimprinting is not particularly limited as long as a desired pattern is obtained. For example, a commercially available device such as ST50 manufactured by TOSHIBA MACHINE CO., LTD., Sindre (registered trademark) 60 manufactured by Obducat, and NM-0801HB manufactured by Meisyo Kiko Co., Ltd., can be used in a method in which a substrate and a mold are roller-pressed, photocuring is carried out, and the cured product is released from the mold.

[0056] A mold material used for photoimprinting, which is used in the present invention, is not particularly limited as long as a desired pattern can be obtained. Examples thereof include quartz, silicon, nickel, alumina, carbonyl silane, and glassy carbon. To enhance mold release property, a mold may be subjected to a mold release treatment for forming a thin film of a fluorine-containing compound or the like on a

surface of the mold. A mold release agent used for the mold release treatment is not particularly limited as long as a desired pattern can be obtained. Examples thereof include OPTOOL (registered trademark) HD and DSX available from Daikin Industries, Ltd.

- 5 [0057] The photoimprint pattern size in the present invention is not limited to particular values. For example, a favorable pattern in a nanometer order, a micrometer order, or a millimeter order can be obtained.

Examples

- 10 [0058] Hereinafter, the present invention will be described in detail with reference to Examples and Comparative Examples; however, the present invention is not limited to these Examples.

- [0059] The weight average molecular weights of polymers in the following Synthesis Examples 1 and 2 were measured by gel permeation chromatography
15 (hereinafter abbreviated as "GPC" in the specification). In the measurement, a GPC system manufactured by Shimadzu Corporation was used. The configuration of the GPC system and the measurement conditions are as follows.

GPC system configuration

- System controller: CBM-20A, Column oven: CTO-20, Autosampler: SIL-10AF,
20 Detector: SPD-20A and RID-10A, and Exhaust air unit: DGU-20A3

 GPC column: Shodex (registered trademark) KF-804L and KF-803L

 Column temperature: 40°C

 Solvent: tetrahydrofuran

 Flow rate: 1 mL/minute

- 25 Standard sample: six types of polystyrene having weight average molecular weights different from each other (197,000, 55,100, 12,800, 3,950, 1,260, and 580)

 [0060] <Synthesis Example 1>

 9.18 g of tricyclo[5.2.1.0^{2,6}]decanedimethanol, 2.72 g of 2-hydroxyethyl acrylate, 0.013 g of 2,6-di-tert-butyl-p-cresol, 0.019 g of dibutyltin dilaurate, and 37.4 g of ethyl

acetate were placed in a three-necked flask, and heated to 80°C. To the mixture, 13.00 g of isophorone diisocyanate was added dropwise over 3 hours, and a reaction was caused at 80°C for 12 hours. The reaction solution was cooled to room temperature. To the reaction solution, hexane was added to precipitate a solid. The precipitated solid was collected and dried at 40°C and 1 mmHg to obtain a compound G1. The obtained compound G1 corresponded to a component (B). The weight average molecular weight thereof measured by GPC was 3,610.

[0061] <Synthesis Example 2>

A three-necked flask was charged with 34.58 g of propylene glycol monomethyl ether acetate (hereinafter abbreviated as "PGMEA" in the specification), degassed, and purged with nitrogen. The propylene glycol monomethyl ether acetate was heated to 90°C. To the propylene glycol monomethyl ether acetate, a solution in which 20.00 g of 1-ADMA (available from Osaka Organic Chemical Industry Ltd.) (hereinafter abbreviated as "ADMA" in the specification), 0.75 g of azobisisobutyronitrile, and 48.41 g of PGMEA were uniformly compatible with one another was added dropwise over 3 hours. A reaction was caused at 90°C for 24 hours. The reaction solution was cooled to room temperature. The reaction solution was added to methanol to precipitate a solid. The precipitated solid was collected and dried at 80°C in vacuum to obtain a compound G2. The obtained compound G2 corresponded to a polymer compound among the aforementioned other additives. The weight average molecular weight thereof measured by GPC was 11,322.

[0062] [Preparation of Imprint Material]

<Example 1>

1 g of NK ester A-DOG (hereinafter abbreviated as "A-DOG" in the specification) (available from Shin Nakamura Chemical Co., Ltd.) and 9 g of UM-90(1/3)DA (available from Ube Industries, Ltd.) were mixed. To the mixture, 0.2 g of IRGACURE (registered trademark) 184 (available from BASF Japan Ltd.) (hereinafter abbreviated as "IRGACURE 184") (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a1.

[0063] <Example 2>

2 g of A-DOG and 8 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a2.

5 [0064] <Example 3>

3 g of A-DOG and 7 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a3.

[0065] <Example 4>

10 4 g of A-DOG and 6 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a4.

[0066] <Example 5>

15 5 g of A-DOG and 5 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a5.

[0067] <Example 6>

20 6 g of A-DOG and 4 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a6.

[0068] <Example 7>

7 g of A-DOG and 3 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a7.

25 [0069] <Example 8>

8 g of A-DOG and 2 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a8.

[0070] <Example 9>

9 g of A-DOG and 1 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) was added to prepare an imprint material PNI-a9.

[0071] <Example 10>

5 1 g of A-DOG and 9 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) and 0.05 g of THIOKALCOL (registered trademark) 20 (available from Kao Corporation) (hereinafter abbreviated as "THIOKALCOL 20" in the specification) (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were
10 added to prepare an imprint material PNI-a10.

[0072] <Example 11>

2 g of A-DOG and 8 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the
15 total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material PNI-a11.

[0073] <Example 12>

3 g of A-DOG and 7 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and
20 UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material PNI-a12.

[0074] <Example 13>

4 g of A-DOG and 6 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of
25 IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material PNI-a13.

[0075] <Example 14>

5 g of A-DOG and 5 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material

5 PNI-a14.

[0076] <Example 15>

5 g of A-DOG and 5 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) and 0.05 g of KarenzMT (registered trademark) PE1 (available from Showa Denko K.K.) (hereinafter abbreviated as "KarenzMT PE1" in the specification) (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material PNI-a15.

[0077] <Example 16>

6 g of A-DOG and 4 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material PNI-a16.

[0078] <Example 17>

7 g of A-DOG and 3 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material PNI-a17.

[0079] <Example 18>

8 g of A-DOG and 2 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material

PNI-a18.

[0080] <Example 19>

9 g of A-DOG and 1 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and
5 UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material PNI-a19.

[0081] <Example 20>

5 g of A-DOG and 5 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of
10 IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA), 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA), and 0.01 g of ADK STAB (registered trademark) AO-60 (available from ADEKA CORPORATION) (in an amount of 0.1 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an
15 imprint material PNI-a20.

[0082] <Example 21>

5 g of A-DOG and 5 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA), 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the
20 total mass of A-DOG and UM-90(1/3)DA), and 0.01 g of ADK STAB (registered trademark) AO-80 (available from ADEKA CORPORATION) (in an amount of 0.1 phr relative to the total mass of A-DOG and UM-90(1/3)DA) were added to prepare an imprint material PNI-a21.

[0083] <Example 22>

25 5 g of A-DOG and 5 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA), 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA), and 0.01 g of BYK-UV 3570 (available from BYK Japan KK) (in an amount of 0.1 phr relative to the total mass of A-DOG and

UM-90(1/3)DA) were added to prepare an imprint material PNI-a22.

[0084] <Example 23>

5 g of A-DOG and 5 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and UM-90(1/3)DA), 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and UM-90(1/3)DA), and 1.139 g of PGMEA were added to prepare an imprint material PNI-a23.

[0085] <Reference Example 24>

5 g of A-DOG and 5 g of NK ester A-DCP (available from Shin Nakamura Chemical Co., Ltd.) (hereinafter abbreviated as "A-DCP" in the specification) were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and A-DCP) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and A-DCP) were added to prepare an imprint material PNI-a24.

15 [0086] <Example 25>

5 g of A-DOG and 5 g of ADMA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and ADMA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and ADMA) were added to prepare an imprint material PNI-a25.

20 [0087] <Example 26>

5 g of A-DOG and 5 g of IBXA (available from Osaka Organic Chemical Industry Ltd.) were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and IBXA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and IBXA) were added to prepare an imprint material PNI-a26.

[0088] <Example 27>

5 g of A-DOG and 5 g of NEW FRONTIER (registered trademark) HBPE-4 (available from DAI-ICHI KOGYO SEIYAKU CO., LTD.) (hereinafter abbreviated as "HBPE-4" in the specification) were mixed. To the mixture, 0.2 g of IRGACURE 184

(in an amount of 2phr relative to the total mass of A-DOG and HBPE-4) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and HBPE-4) were added to prepare an imprint material PNI-a27.

[0089] <Example 28>

5 5 g of A-DOG and 5 g of Viscoat #230 (available from Osaka Organic Chemical Industry Ltd.) (hereinafter abbreviated as "V#230" in the specification) were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2phr relative to the total mass of A-DOG and V#230) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and V#230) were added to prepare an imprint material PNI-a28.

10 [0090] <Example 29>

5 g of A-DOG and 5 g of Viscoat #260 (available from Osaka Organic Chemical Industry Ltd.) (hereinafter abbreviated as "V#260" in the specification) were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2phr relative to the total mass of A-DOG and V#260) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and V#260) were added to prepare an imprint material PNI-a29.

[0091] <Example 30>

5 g of A-DOG, 2.5 g of ADMA, and 2.5 g of UM-90(1/3)DA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG, ADMA, and UM-90(1/3)DA) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG, ADMA, and UM-90(1/3)DA) were added to prepare an imprint material PNI-a30.

[0092] <Example 31>

5 g of A-DOG, 2.5 g of ADMA, and 2.5 g of HBPE-4 were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG, ADMA, and HBPE-4) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG, ADMA, and HBPE-4) were added to prepare an imprint material PNI-a31.

[0093] <Example 32>

5 g of A-DOG, 2.5 g of ADMA, and 2.5 g of G1 obtained in Synthesis Example 1

were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG, ADMA, and G1) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG, ADMA, and G1) were added to prepare an imprint material PNI-a32.

5 [0094] <Example 33>

5 g of A-DOG, 2.5 g of ADMA, and 2.5 g of G2 obtained in Synthesis Example 2 were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG, ADMA, and G2) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG, ADMA, and G2) were added to
10 prepare an imprint material PNI-a33.

[0095] <Example 34>

7 g of A-DOG and 3 g of HBPE-4 were mixed. To the mixture, 0.01 g of IRGACURE 184 (in an amount of 0.1 phr relative to the total mass of A-DOG and HBPE-4) was added to prepare an imprint material PNI-a34.

15 [0096] <Example 35>

6 g of A-DOG and 4 g of HBPE-4 were mixed. To the mixture, 0.01 g of IRGACURE 184 (in an amount of 0.1 phr relative to the total mass of A-DOG and HBPE-4) was added to prepare an imprint material PNI-a35.

[0097] <Example 36>

20 5 g of A-DOG and 5 g of HBPE-4 were mixed. To the mixture, 0.01 g of IRGACURE 184 (in an amount of 0.1 phr relative to the total mass of A-DOG and HBPE-4) was added to prepare an imprint material PNI-a36.

[0098] <Example 37>

25 4 g of A-DOG and 6 g of HBPE-4 were mixed. To the mixture, 0.01 g of IRGACURE 184 (in an amount of 0.1 phr relative to the total mass of A-DOG and HBPE-4) was added to prepare an imprint material PNI-a37.

[0099] <Example 38>

3 g of A-DOG and 7 g of HBPE-4 were mixed. To the mixture, 0.01 g of IRGACURE 184 (in an amount of 0.1 phr relative to the total mass of A-DOG and

HBPE-4) was added to prepare an imprint material PNI-a38.

[0100] <Example 39>

5 g of A-DOG and 5 g of HBPE-4 were mixed. To the mixture, 0.01 g of IRGACURE 184 (in an amount of 0.1 phr relative to the total mass of A-DOG and HBPE-4) and 0.05 g of THIOKALCOL 20 (in an amount of 0.5 phr relative to the total mass of A-DOG and HBPE-4) were added to prepare an imprint material PNI-a39.

[0101] <Example 40>

5 g of A-DOG and 5 g of HBPE-4 were mixed. To the mixture, 0.01 g of IRGACURE 184 (in an amount of 0.1 phr relative to the total mass of A-DOG and HBPE-4) and 0.05 g of KarenzMT PE1 (in an amount of 0.5 phr relative to the total mass of A-DOG and HBPE-4) were added to prepare an imprint material PNI-a40.

[0102] <Example 41>

5 g of A-DOG and 5 g of HBPE-4 were mixed. To the mixture, 0.01 g of IRGACURE 184 (in an amount of 0.1 phr relative to the total mass of A-DOG and HBPE-4) and 0.05 g of KarenzMT (registered trademark) NR1 (available from Showa Denko K.K.) (in an amount of 0.5 phr relative to the total mass of A-DOG and HBPE-4) were added to prepare an imprint material PNI-a41.

[0103] <Comparative Example 1>

From 10 g of A-DOG and 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the mass of A-DOG), an imprint material PNI-b1 was prepared. The imprint material of Comparative Example 1 contained components (A) and (C), but contained no component (B).

[0104] <Comparative Example 2>

From 10 g of UM-90(1/3)DA and 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the mass of UM-90(1/3)DA), an imprint material PNI-b2 was prepared. The imprint material of Comparative Example 2 contained components (B) and (C), but contained no component (A).

[0105] <Comparative Example 3>

From 10 g of ADMA and 0.2 g of IRGACURE 184 (in an amount of 2 phr relative

to the mass of ADMA), an imprint material PNI-b3 was prepared. The imprint material of Comparative Example 3 contained components (B) and (C), but contained no component (A).

[0106] <Comparative Example 4>

5 From 10 g of V#230 and 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the mass of V#230), an imprint material PNI-b4 was prepared. The imprint material of Comparative Example 4 contained components (B) and (C), but contained no component (A).

[0107] <Comparative Example 5>

10 5 g of A-DOG and 5 g of KAYARAD (registered trademark) NPGDA (available from NIPPON KAYAKU Co., Ltd.) (hereinafter abbreviated as "NPGDA" in the specification) were mixed. To the mixture, 0.2 g of IRGACUE 184 (in an amount of 2 phr relative to the total mass of A-DOG and NPGDA) was added to prepare an imprint material PNI-b5. NPGDA used in Comparative Example 5 did not correspond to a
15 component (B). The imprint material in Comparative Example 5 contained components (A) and (C), but contained no component (B).

[0108] <Comparative Example 6>

5 g of A-DOG and 5 g of NPGDA were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and
20 NPGDA) and 0.05 g of THIOKALCOL 20 (in an amount of 2 phr relative to the total mass of A-DOG and NPGDA) were added to prepare an imprint material PNI-b6. NPGDA used in Comparative Example 6 did not correspond to a component (B). The imprint material in Comparative Example 6 contained components (A), (C), and (D), but contained no component (B).

25 [0109] <Comparative Example 7>

5 g of A-DOG and 5 g of NK ester APG-400 (available from Shin Nakamura Chemical Co., Ltd.) (hereinafter abbreviated as "APG-400" in the specification) were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2phr relative to the total mass of A-DOG and APG-400) was added to prepare an imprint material PNI-b7.

APG-400 used in Comparative Example 7 did not correspond to a component (B). The imprint material in Comparative Example 7 contained components (A) and (C), but contained no component (B).

[0110] <Comparative Example 8>

5 5 g of A-DOG and 5 g of APG-400 were mixed. To the mixture, 0.2 g of IRGACURE 184 (in an amount of 2 phr relative to the total mass of A-DOG and APG-400) and 0.05 g of THIOKALCOL 20 (in an amount of 2 phr relative to the total mass of A-DOG and APG-400) were added to prepare an imprint material PNI-b8. APG-400 used in Comparative Example 8 did not correspond to a component (B). The
10 imprint material in Comparative Example 8 contained components (A), (C), and (D), but contained no component (B).

[0111] [Mold Release Treatment of Mold]

A silicon mold having a line and space pattern (hereinafter referred to as L/S) of 20 μm was immersed in a solution obtained by diluting OPTOOL (registered trademark)
15 DSX (available from Daikin Industries, Ltd.) with Novec (registered trademark) HFE-7100 (hydrofluoroether available from 3M Japan Limited) (hereinafter abbreviated as "Novec HFE-7100" in the specification) into 0.1% by mass, treated for 1 hour by a high-temperature and high-humidity device of a temperature of 90°C and a humidity of 90 RH%, rinsed with Novec HFE-7100, and dried by air.

20 [0112] [Photoimprinting]

The mold that had been subjected to the mold release treatment was potted with the imprint material obtained in each of Examples 1 to 23 and 25 to 41, Reference Example 24, and Comparative Examples 1 to 8, and covered with quartz glass. Photoimprinting was carried out by a nanoimprint device NM-0801HB (manufactured by MEISYO KIKO
25 CO., Ltd.).

In the photoimprinting, a) pressurization to 500 N over 10 seconds, b) exposure using a high-pressure mercury lamp at 6,000 mJ/cm², c) depressurization over 10 seconds, and d) release of the substrate from the mold were sequentially performed always under a condition of 23°C. The obtained L/S pattern on the quartz glass was heated on a hot

plate at 170°C for 5 minutes. The presence or absence of peeling and cracking of the L/S pattern was observed by an industrial microscope ECLIPSE L150 (manufactured by Nikon Corporation). The obtained results are shown in Tables 1 and 2.

[0113] [Production of Cured Product and Evaluation of Optical Properties]

The imprint material obtained in each of Examples 1 to 23 and 25 to 41, Reference Example 24, and Comparative Examples 1 to 8 was placed between two glass substrates surface-treated with Novec (registered trademark) 1720 (available from 3M Japan Limited) with a silicone rubber spacer having a thickness of 1 mm. The placed polymerizable composition was exposed to ultraviolet light at 20 mW/cm² for 300 seconds by a batch process UV irradiation device (high-pressure mercury lamp 2 kW × 1 lamp) (manufactured by EYE GRAPHICS CO., LTD.). The obtained cured product was peeled from the glass substrate, and then heated on a hot plate at 170°C for 5 minutes to produce a molded body having a diameter of 40 mm and a thickness of 1 mm. The transmittance of the produced molded body at 410 nm was measured by a spectrophotometer UV2600 (manufactured by Shimadzu Corporation) using air as a reference. The refractive index n_D and Abbe number v_D at a wavelength of 589.3 nm (d-line) were measured by an automatic refractometer (multiwavelength) Abbemat-WR/MW (manufactured by Anton Paar GmbH). The obtained results are shown in Tables 1, 2, and 3.

[0114] Table 1

	Presence or absence of peeling and cracking of pattern	Transmittance at 410 nm	n_D	v_D
Example 1	None	94.5%	1.49	57.2
Example 2	None	94.4%	1.49	57.1
Example 3	None	92.5%	1.49	57.1
Example 4	None	92.0%	1.50	57.1
Example 5	None	91.8%	1.50	57.0
Example 6	None	90.5%	1.50	56.9
Example 7	None	90.2%	1.50	56.5
Example 8	None	90.0%	1.50	56.5
Example 9	None	90.0%	1.50	56.4
Example 10	None	95.0%	1.49	57.5

Example 11	None	94.8%	1.49	57.2
Example 12	None	92.8%	1.49	57.3
Example 13	None	92.3%	1.50	57.3
Example 14	None	92.3%	1.50	57.2
Example 15	None	92.4%	1.50	57.1
Example 16	None	90.9%	1.50	57.2
Example 17	None	90.8%	1.50	57.0
Example 18	None	90.6%	1.50	57.0
Example 19	None	90.4%	1.50	57.0
Example 20	None	92.9%	1.50	57.2
Example 21	None	92.8%	1.50	57.2
Example 22	None	92.5%	1.50	57.0
Example 23	None	92.5%	1.50	57.0

[0115] [Table 2]

	Presence or absence of peeling and cracking of pattern	Transmittance at 410 nm	n _D	v _D
Reference Example 24	None	90.0%	1.51	56.0
Example 25	None	90.2%	1.50	56.1
Example 26	None	90.3%	1.50	56.2
Example 27	None	90.1%	1.51	56.5
Example 28	None	90.2%	1.49	56.0
Example 29	None	90.7%	1.50	56.5
Example 30	None	90.8%	1.50	56.6
Example 31	None	90.7%	1.50	56.5
Example 32	None	90.0%	1.51	56.0
Example 33	None	90.2%	1.51	56.0
Example 34	None	90.2%	1.50	56.0
Example 35	None	90.0%	1.50	56.0
Example 36	None	90.5%	1.50	56.0
Example 37	None	90.4%	1.51	56.1
Example 38	None	90.5%	1.51	57.1
Example 39	None	90.6%	1.51	56.1
Example 40	None	90.6%	1.51	56.0
Example 41	None	90.7%	1.51	56.0

[0116] [Table 3]

	Presence or absence of peeling and cracking of pattern	Transmittance at 410 nm	n _D	v _D
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Comparative Example 1	None	85.2%	1.50	56.5
Comparative Example 2	None	84.0%	1.48	57.5
Comparative Example 3	None	87.6%	1.52	55.0
Comparative Example 4	None	85.1%	1.51	55.7
Comparative Example 5	None	84.4%	1.50	55.6
Comparative Example 6	None	86.3%	1.50	55.7
Comparative Example 7	None	87.0%	1.48	57.2
Comparative Example 8	None	87.5%	1.48	57.2

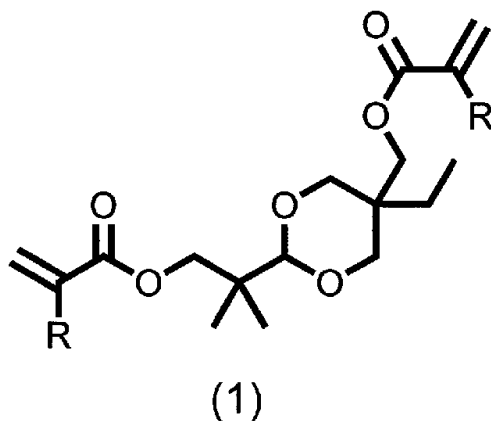
[0117] The results in Tables 1, 2, and 3 show that all the molded bodies produced from the imprint materials prepared in Examples 1 to 23 and 25 to 41 had a transmittance of 90% or more at 410 nm though the molded bodies have a thickness of 1 mm. The molded bodies exhibited high transparency. Further, the results show that all the molded bodies had a high refractive index of 1.49 or more at a wavelength of 589.3 nm (d-line), and a high Abbe number of 56 or more. On the other hand, all the molded bodies produced from the imprint materials prepared in Comparative Examples 1 to 8 had a transmittance of lower than 90% at 410 nm. The molded bodies were less transparent.

10 The molded bodies in Comparative Examples 2 to 8 had a refractive index of less than 1.49 or an Abbe number of less than 56. This shows that the molded bodies in Comparative Examples 2 to 8 did not have both high refractive index and high Abbe number at the same time. As described above, the molded body produced from the imprint material of the present invention has high transparency to light of visible light

15 region, high refractive index, and high Abbe number.

1. An imprint material comprising the following components (A), (B), (C) and a compound having at least one thiol group as a component (D):

5 Component (A): a compound of the following formula (1):



(wherein two Rs are each independently a hydrogen atom or a methyl group),

Component (B): a compound having a linear alkylene group having a carbon atom number of 6 to 10 and/or an alicyclic structure selected from the group consisting of a
10 cyclopentane structure, a cyclohexane structure, a norbornane structure, an isobornyl structure, and an adamantane structure, and at least one polymerizable group, and

Component (C): a photopolymerization initiator.

2. The imprint material according to claim 1, wherein the polymerizable group is
15 an acryloyloxy group, a methacryloyloxy group, a vinyl group, or an allyl group.

3. The imprint material according to claim 1 or 2, wherein the number of the polymerizable group is one or two.

20 4. The imprint material according to any one of claims 1 to 3, wherein the content of the component (A) is 10% by mass to 90% by mass relative to a total mass of the components (A) and (B) of 100% by mass.

5. The imprint material according to any one of claims 1 to 4, further comprising an antioxidant as a component (E).

5 6. The imprint material according to any one of claims 1 to 5, further comprising a surfactant as a component (F).

7. The imprint material according to any one of claims 1 to 6, further comprising a solvent as a component (G).

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8. A film produced from the imprint material according to any one of claims 1 to 7 and having a transferred pattern.

9. The film having a transferred pattern according to claim 8, wherein the pattern
15 has a lens shape.

10. The film having a transferred pattern according to claim 8 or 9, wherein the film having a transferred pattern is used as a lens for camera modules.

20 11. The film having a transferred pattern according to any one of claims 8 to 10, wherein the film having a transferred pattern has a maximum thickness of 1.5 mm.

12. A method for producing a film having a transferred pattern comprising steps of: filling a space between a substrate and a mold contacted to the substrate or a space in
25 a splittable mold with the imprint material according to any one of claims 1 to 7, and photocuring the imprint material in the space by exposure.

13. The method according to claim 12, comprising steps of: releasing the photocured product from the mold after the photocuring step, and heating the photocured product before, during, or after the releasing step.

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