Claims

[Claim 1] A curable composition that satisfies the following formula (1) in a cured state:

$Er_1/Er_2 \geqq 1.10$ (1)

wherein Er_1 denotes a surface reduced modulus (GPa) of a cured product of the curable composition, and Er_2 denotes an internal reduced modulus (GPa) of the cured product.

[Claim 2] A curable composition, comprising: a polymerizable compound component (A) and a photopolymerization initiator component (B), wherein the curable composition satisfies the following formula (1) when a cured product of the curable composition cured at an exposure dose of 200 mJ/cm^2 has an average film thickness of 3.2 μm:

$Er_1/Er_2 \geqq 1.10$ (1)

wherein Er_1 denotes an average reduced modulus (GPa) in a depth range of 4 μm or less from a surface of the cured product, and Er_2 denotes a reduced modulus (GPa) at a depth of 200 nm from the surface of the cured product.

[Claim 3] The curable composition according to Claim 1 or 2, wherein Er_1 is an average surface reduced modulus (GPa) of the cured product measured with a nanoindenter and determined by a Hertz method, and Er_2 is an internal reduced modulus (GPa) of the cured product measured with a nanoindenter and determined by an Oliver-Pharr method.

[Claim 4] The curable composition according to any one of Claims 1 to 3, further satisfying the following formula (3):

$Er_1 \geqq 3.00$ (3)

wherein Er_1 denotes a surface reduced modulus (GPa) of the cured product.

[Claim 5] The curable composition according to any one of Claims 1 to 4, wherein the component (A) is composed mainly of a monofunctional (meth)acrylic compound and/or a polyfunctional (meth)acrylic compound.

[Claim 6] The curable composition according to any one of Claims 1 to 5, wherein the component (A) contains at least one of isobornyl acrylate, benzyl acrylate, 2-naphthylmethyl acrylate, dicyclopentanyl acrylate, m-xylylene diacrylate, dimethyloltricyclodecane diacrylate, phenylethylene glycol diacrylate, 1,10-decanediol diacrylate, and neopentyl glycol diacrylate.

[Claim 7] The curable composition according to any one of Claims 1 to 6, wherein the component (A) is composed mainly of a (meth)acrylic compound, and 20% by weight or more of the component (A) is a poly-functional (meth)acrylic compound.

[Claim 8] The curable composition according to any one of Claims 1 to 7, wherein the component (A) is composed mainly of a (meth)acrylic compound, and 30% by weight or more of the component (A) is a (meth)acrylic compound having a ring structure.

[Claim 9] The curable composition according to any one of Claims 1 to 8, wherein the component (A) is composed mainly of dicyclopentanyl acrylate and m-xylylene diacrylate, and the weight ratio of dicyclopentanyl acrylate to m-xylylene diacrylate ranges from 40:60 to 60:40.

[Claim 10] The curable composition according to any one of Claims 1 to 9, wherein the component (B) contains at least one of alkylphenone polymerization initiators and acylphosphine oxide polymerization initiators.

[Claim 11] The curable composition according to any one of Claims 1 to 10, wherein the component (B) contains at least one of 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butanone-1 and 2,4,6-trimethylbenzoyldiphenylphosphine oxide.

[Claim 12] The curable composition according to any one of Claims 1 to 11, wherein the component (A) is composed mainly of dicyclopentanyl acrylate and m-xylylene diacrylate, the weight ratio of dicyclopentanyl acrylate to m-xylylene diacrylate ranges from 40:60 to 60:40, and the amount of component (B) ranges from 0.01% to 10% by weight of the total amount of the component (A).

[Claim 13] The curable composition according to any one of Claims 1 to 12, further comprising at least one of fluorosurfactants and hydrocarbon surfactants as an internal release agent.

[Claim 14] The curable composition according to any one of Claims 1 to 13, further comprising at least one sensitizer having a benzophenone structure.

[Claim 15] The curable composition according to any one of Claims 1 to 14, further comprising at least one hydrogen donor having a benzophenone structure.

[Claim 16] The curable composition according to any one of Claims 1 to 15, wherein the curable composition has a viscosity of 1 cP or more and 100 cP or less.

[Claim 17] The curable composition according to any one of Claims 1 to 16, wherein the curable composition is a composition for photo-nanoimprinting.

[Claim 18] A cured product of the curable composition according to any one of Claims 1 to 17.

[Claim 19] A method for producing a patterned film, comprising:
a step [1] of placing the curable composition according to any one of Claims 1 to 17 on a substrate;
a step [2] of bringing the curable composition into contact with a mold having an original pattern to be transferred;
a step [3] of aligning the substrate with the mold;
a step [4] of forming a cured film by photoirradiation of the curable composition; and
a step [5] of separating the cured film from the mold.

[Claim 20] The method for producing a patterned film according to Claim 19, wherein the mold in the step of bringing the curable composition into contact with a mold having an original pattern to be transferred has a pattern height of 4 nm or more and 200 nm or less and an aspect ratio of 1 or more and 10 or less.

[Claim 21] The method for producing a patterned film according to Claim 19 or 20, wherein the exposure dose in the step of forming a cured film by photoirradiation of the curable composition is 90 mJ/cm^2 or less.

[Claim 22] The method for producing a film according to any one of Claims 19 to 21, wherein the mold contact step is performed in an atmosphere containing a condensable gas.

[Claim 23] The method for producing a film according to Claim 22, wherein the condensable gas is 1,1,1,3,3-pentafluoropropane.

[Claim 24] The method for producing a film according to Claim 22 or 23, wherein the atmosphere containing a condensable gas is a gas mixture of helium and the condensable gas.

[Claim 25] A method for manufacturing an optical component, comprising a step of forming a patterned film by the method for producing a film according to any one of Claims 19 to 24.

[Claim 26] A method for manufacturing a circuit board, comprising: a step of forming a patterned film by the method for producing a film according to any one of Claims 19 to 24; and a step of subjecting the substrate to etching or ion implantation using the patterned film as a mask.

[Claim 27] The method for manufacturing a circuit board according to Claim 26,

wherein the circuit board is a semiconductor device.

[Claim 28] A method for manufacturing an electronic component, comprising a step of forming a patterned film by the method for producing a film according to any one of Claims 19 to 24.

[CLAIMS]

[Claim 1]

A curable composition that satisfies the following formula (1) in a cured state:

$Er_1/Er_2 \geqq 1.10$ (1)

wherein Er_1 denotes a surface reduced modulus (GPa) of a cured product of the curable composition, and Er_2 denotes an internal reduced modulus (GPa) of the cured product.

[Claim 2]

A curable composition, comprising: a polymerizable compound component (A) and a photopolymerization initiator component (B), wherein the curable composition satisfies the following formula (1) when a cured product of the curable composition cured at an exposure dose of 200 mJ/cm^2 has an average film thickness of 3.2 μm:

$Er_1/Er_2 \geqq 1.10$ (1)

wherein Er_1 denotes an average reduced modulus (GPa) in a depth range of 4 nm or less from a surface of the cured product, and Er_2 denotes a reduced modulus (GPa) at a depth of 200 nm from the surface of the cured product.

[Claim 3]

The curable composition according to Claim 1 or 2, wherein

Er_1 is an average surface reduced modulus (GPa) of the cured product measured with a nanoindenter and determined by a Hertz method, and

Er_2 is an internal reduced modulus (GPa) of the cured product measured with a nanoindenter and determined by an Oliver-Pharr method.

[Claim 4]

The curable composition according to any one of Claims 1 to 3, further satisfying the following formula (3):

$Er_1 \geqq 3.00$ (3)

wherein Er_1 denotes a surface reduced modulus (GPa) of the cured product.

[Claim 5]

The curable composition according to any one of Claims 1 to 4, wherein the component (A) is composed mainly of a monofunctional (meth)acrylic compound and/or a polyfunctional (meth)acrylic compound.

[Claim 6]

The curable composition according to any one of Claims 1 to 5, wherein the component (A) contains at least one of isobornyl acrylate, benzyl acrylate, 2-naphthylmethyl acrylate, dicyclopentanyl acrylate, m-xylylene diacrylate, dimethyloltricyclodecane diacrylate, phenylethylene glycol diacrylate, 1,10-decanediol diacrylate, and neopentyl glycol diacrylate.

[Claim 7]

The curable composition according to any one of Claims 1 to 6, wherein the component (A) is composed mainly of a (meth)acrylic compound, and 20% by weight or more of the component (A) is a polyfunctional (meth)acrylic compound.

[Claim 8]

The curable composition according to any one of Claims 1 to 7, wherein the component (A) is composed mainly of a (meth)acrylic compound, and 30% by weight or more of the component (A) is a (meth)acrylic compound having a ring structure.

[Claim 9]

The curable composition according to any one of Claims 1 to 8, wherein the component (A) is composed mainly of dicyclopentanyl acrylate and m-xylylene diacrylate, and the weight ratio of dicyclopentanyl acrylate to m-xylylene diacrylate ranges from 40:60 to 60:40.

[Claim 10]

The curable composition according to any one of Claims 1 to 9, wherein the component (B) contains at least one of alkylphenone polymerization initiators and acylphosphine oxide polymerization initiators.

[Claim 11]

The curable composition according to any one of Claims 1 to 10, wherein the component (B) contains at least one of

2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butanone-1 and 2,4,6-trimethylbenzoyldiphenylphosphine oxide.

[Claim 12]

The curable composition according to any one of Claims 1 to 11, wherein the component (A) is composed mainly of dicyclopentanyl acrylate and m-xylylene diacrylate, the weight ratio of dicyclopentanyl acrylate to m-xylylene diacrylate ranges from 40:60 to 60:40, and the amount of component (B) ranges from 0.01% to 10% by weight of the total amount of the component (A).

[Claim 13]

The curable composition according to any one of Claims 1 to 12, further comprising at least one of fluorosurfactants and hydrocarbon surfactants as an internal release agent.

[Claim 14]

The curable composition according to any one of Claims 1 to 13, further comprising at least one sensitizer having a benzophenone structure.

[Claim 15]

The curable composition according to any one of Claims 1 to 14, further comprising at least one hydrogen donor having a benzophenone structure.

[Claim 16]

The curable composition according to any one of Claims 1 to 15, wherein the curable composition has a viscosity of 1 cP or more and 100 cP or less.

[Claim 17]

The curable composition according to any one of Claims 1 to 16, wherein the curable composition is a composition for photo-nanoimprinting.

[Claim 18]

A cured product of the curable composition according to any one of Claims 1 to 17.

[Claim 19]

A method for producing a patterned film, comprising:

a step [1] of placing the curable composition according to any one of Claims 1 to 17 on a substrate;

a step [2] of bringing the curable composition into contact with a mold having an original pattern to be transferred;
a step [3] of aligning the substrate with the mold;
a step [4] of forming a cured film by photoirradiation of the curable composition; and
a step [5] of separating the cured film from the mold.

[Claim 20]
The method for producing a patterned film according to Claim 19, wherein the mold in the step of bringing the curable composition into contact with a mold having an original pattern to be transferred has a pattern height of 4 nm or more and 200 nm or less and an aspect ratio of 1 or more and 10 or less.

[Claim 21]
The method for producing a patterned film according to Claim 19 or 20, wherein the exposure dose in the step of forming a cured film by photoirradiation of the curable composition is 90 mJ/cm^2 or less.

[Claim 22]
The method for producing a film according to any one of Claims 19 to 21, wherein the mold contact step is performed in an atmosphere containing a condensable gas.

[Claim 23]
The method for producing a film according to Claim 22, wherein the condensable gas is 1,1,1,3,3-pentafluoropropane.

[Claim 24]
The method for producing a film according to Claim 22 or 23, wherein the atmosphere containing a condensable gas is a gas mixture of helium and the condensable gas.

[Claim 25]
A method for manufacturing an optical component, comprising a step of forming a patterned film by the method for producing a film according to any one of Claims 19 to 24.

[Claim 26]
A method for manufacturing a circuit board, comprising: a step of forming a patterned film by the method for producing a film according to any one of Claims 19 to 24; and a step of subjecting

the substrate to etching or ion implantation using the patterned film as a mask.

[Claim 27]

The method for manufacturing a circuit board according to Claim 26, wherein the circuit board is a semiconductor device.

[Claim 28]

A method for manufacturing an electronic component, comprising a step of forming a patterned film by the method for producing a film according to any one of Claims 19 to 24.

[Claim 29]

A curable composition, comprising: a polymerizable compound component (A) and a photopolymerization initiator component (B), wherein the curable composition satisfies the following formula (1) when a cured product of the curable composition cured at an exposure dose of 200 mJ/cm^2 has an average film thickness of 3.2 μm:

$Er_1/Er_2 \geqq 1.10$ (1)

wherein Er_1 denotes an average reduced modulus (GPa) in a depth range of 4 nm or less from a surface of the cured product, and Er_2 denotes a reduced modulus (GPa) at a depth of 200 nm from the surface of the cured product.