and a resin component, and that aims at obtainment of high light-shielding property with a small film thickness is disclosed (for example, see JP-A No. 2007-115921).

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0010] When conventional light-shielding compositions are used for formation of light-shielding regions (light-shielding films) in wafer level lenses, residues generated during formation of the light-shielding films tend to remain on or in the vicinity of lenses. The residues cause problems such as deterioration of the light transmittance of the lenses, which have not been mitigated yet.

[0011] A first ~~aspect~~embodiment of the present ~~invention~~disclosure aims at achievement of the following objects.

That is, an object of the first ~~aspect~~embodiment is to provide a photosensitive resin composition for a wafer level lens which is used for formation of a light-shielding film provided in a wafer level lens, and which has excellent curability, and which is capable of decreasing photosensitive composition-derived residues in a region other than regions in which a light-shielding film is formed, and a titanium black dispersion for a wafer level lens for use in the photosensitive resin composition.

Another object of the first ~~aspect~~embodiment is to provide a wafer level lens that can suppress scattering or decrease in transmittance of light in the vicinity of the light-shielding film, and a solid-state image pickup device provided with the wafer level lens.

[0012] A second ~~aspect~~embodiment of the present ~~invention~~disclosure aims at achievement of the following objects.

That is, an object of the second ~~aspect~~embodiment is to provide a photosensitive resin composition for a wafer level lens which is used for formation of a light-shielding film provided in a wafer level lens, and which is capable of decreasing photosensitive composition-derived residues in a region other than regions in which a light-shielding film is formed, and a titanium black dispersion for a wafer level lens for use in the photosensitive resin composition.

Another object of the second ~~aspect~~embodiment is to provide a wafer level lens that can suppress scattering or decrease in transmittance of light in the vicinity of the light-shielding film, and a solid-state image pickup device provided with the wafer level lens.

In recent years, due to downsizing, thinning, and sensitivity increase of solid-state image pickup devices, it has been more strongly desired that infrared light incident upon a silicon substrate, which has an image pickup device section on one side thereof, from the other side of the silicon substrate be shielded.

The reason therefor is that the silicon substrate, which is a base body of a solid-state

image pickup device, exhibits high transmittance to infrared light, and that the image pickup device provided in the solid-state image pickup device exhibits sensitivity not only to visible light but also to infrared light.

[0013] Under these circumstances, a light-shielding film in which carbon black is used cannot sufficiently meet these requests since the light-shielding film has high transmittance to infrared light. In contrast, a light-shielding film in which titanium black is used has low transmittance to infrared light and excellent ability to shield against infrared light, thus being favorable as a light-shielding film that satisfies the above requests.

However, a study carried out by the present inventor clarified that formation of a light-shielding film using a titanium black-containing dispersion or a titanium black-containing photosensitive resin composition tends to leave residues derived from the photosensitive resin composition in a region other than regions in which the light-shielding film is formed.

[0014] A third ~~aspect~~embodiment of the present ~~invention~~disclosure aims at achievement of the following objects.

That is, an object of the third ~~aspect~~embodiment is to provide a photosensitive resin composition with which a light-shielding film having excellent ability to shield against infrared light can be formed, and residues in a region other than regions in which the light-shielding film is formed is decreased when the light-shielding film is formed, and a titanium black dispersion for use in the photosensitive resin composition.

Another object of the third ~~aspect~~embodiment is to provide a light-shielding film having excellent ability to shield against infrared light, and a method for producing a light-shielding film whereby a light-shielding film having excellent ability to shield against infrared light can be formed, and residues in a region other than regions in which the light-shielding film is formed is decreased when the light-shielding film is formed.

Yet another object of the third ~~aspect~~embodiment is to provide a solid-state image pickup device in which noise due to infrared light is decreased, and noise due to residues is also decreased.

SOLUTION TO PROBLEM

[0015] Means for solving the problems of the first ~~aspect~~embodiment are as follows.

<1> A titanium black dispersion for a wafer level lens including titanium black particles, a dispersant, and an organic solvent, wherein 90% or more of dispersed objects that consist of the titanium black particles have particle diameters of 30 nm or less.

<2> A photosensitive resin composition for a wafer level lens including the titanium black dispersion according to <1>, a photopolymerizable compound, and a photopolymerization initiator.

<3> A wafer level lens including, at a peripheral portion of a lens present on a substrate, a light-shielding film obtained by curing the photosensitive resin composition according to <2>.

<4> A solid-state image pickup device including the wafer level lens according to <3>.

[0016] Means for solving the problems of the second ~~aspect~~embodiment are as follows.

<5> A titanium black dispersion for a wafer level lens including titanium black particles, a dispersant, and an organic solvent, wherein dispersed objects including titanium black particles contain Si atoms, and the content ratio of Si atoms to Ti atoms (Si/Ti) in the dispersed objects is 0.05 or higher.

<6> A photosensitive resin composition for a wafer level lens including the titanium black dispersion according to <5>, a photopolymerizable compound, and a photopolymerization initiator.

<7> A wafer level lens including, at a peripheral portion of a lens present on a substrate, a light-shielding film obtained by curing the photosensitive resin composition according to <6>.

<8> A solid-state image pickup device including the wafer level lens according to <7>.

[0017] Means for solving the problems of the third ~~aspect~~embodiment are as follows.

<9> A titanium black dispersion including titanium black particles, a dispersant, and an organic solvent, wherein 90% or more of dispersed objects that consist of the titanium black particles have particle diameters of 30 nm or less, and the titanium black dispersion is used for formation of a light-shielding film that is provided on one side of a silicon substrate having an image pickup device section on the other side thereof, and that shields against infrared light.

<10> The titanium black dispersion according to <9>, wherein the dispersant is a graft copolymer having a graft chain in which the number of atoms excluding hydrogen atoms is from 40 to 10000.

[0018] <11> The titanium black dispersion according to <10>, wherein the graft copolymer contains at least a structural unit represented by any one of the following Formulae (1) to (5):

[0019]

according to <13>.

<15> A method for producing a light-shielding film including:

applying the photosensitive resin composition according to <13> to one side of a silicon substrate having an image pickup device section on the other side thereof to form a photosensitive layer;

patternwise exposing the photosensitive layer to light; and

developing the photosensitive layer after exposure to form a pattern.

<16> A solid-state image pickup device including the light-shielding film according to <14> on the one side of the silicon substrate having an image pickup device section on the other side thereof.

[0022] <17> The solid-state image pickup device according to <16> including:

the silicon substrate having the image pickup device section on the other side thereof;

a metal electrode provided on the one side of the silicon substrate and electrically connected to the image pickup device section; and

the light-shielding film according to <14> provided on the side of the silicon substrate on which the metal electrode is provided, and patterned to expose at least a part of the metal electrode.

<18> The solid-state image pickup device according to <16>, further including a metal electrode provided on the one side of the silicon substrate and electrically connected to the image pickup device section, the light-shielding film being patterned to expose at least a part of the metal electrode.

[0022a] In an aspect, there is provided a titanium black dispersion for a wafer level lens comprising:

titanium black particles;

a dispersant; and

an organic solvent,

wherein dispersed objects including titanium black particles contain Si atoms, and a content ratio of Si atoms to Ti atoms (Si/Ti) in the dispersed objects is 0.05 or higher.

[0022b] In another aspect, there is provided a photosensitive resin composition for a wafer level lens comprising:

the titanium black dispersion as defined above;

a photopolymerizable compound; and

a photopolymerization initiator.

[0022c] In another aspect, there is provided a wafer level lens comprising, at a peripheral portion of a lens present on a substrate, a light-shielding film obtained by curing the photosensitive resin composition as defined above.

[0022d] In another aspect, there is provided a solid-state image pickup device comprising the wafer level lens as defined above.

ADVANTAGEOUS EFFECTS OF INVENTION

[0023] According to the first ~~aspect~~embodiment, it is possible to provide a photosensitive resin composition for a wafer level lens which is used for formation of a light-shielding film provided in a wafer level lens, and which has excellent curability, and which is capable of decreasing photosensitive composition-derived residues in a region other than regions in which a light-shielding film is formed, and a titanium black dispersion for a wafer level lens for use in the photosensitive resin composition.

According to the first ~~aspect~~embodiment, it is also possible to provide a wafer level lens that can suppress scattering or decrease in transmittance of light in the vicinity of the light-shielding film, and a solid-state image pickup device provided with the wafer level lens.

[0024] According to the second ~~aspect~~embodiment, it is possible to provide a photosensitive resin composition for a wafer level lens which is used for formation of a light-shielding film provided in a wafer level lens, and which is capable of decreasing photosensitive

composition-derived residues in a region other than regions in which a light-shielding film is formed, and a titanium black dispersion for a wafer level lens for use in the photosensitive resin composition.

According to the second ~~aspect~~embodiment, it is also possible to provide a wafer level lens that can suppress scattering or decrease in transmittance of light in the vicinity of the light-shielding film, and a solid-state image pickup device provided with the wafer level lens.

[0025] According to the third ~~aspect~~embodiment, it is possible to provide a photosensitive resin composition with which a light-shielding film having excellent ability to shield against infrared light can be formed, and residues in a region other than regions in which the light-shielding film is formed is decreased when the light-shielding film is formed, and a titanium black dispersion for use in the photosensitive resin composition.

According to the third ~~aspect~~embodiment, it is also possible to provide a light-shielding film having excellent ability to shield against infrared light, and a method for producing a light-shielding film whereby a light-shielding film having excellent ability to shield against infrared light can be formed, and residues in a region other than regions in which the light-shielding film is formed is decreased when the light-shielding film is formed.

According to the third ~~aspect~~embodiment, it is also possible to provide a solid-state image pickup device in which noise due to infrared light is decreased, and noise due to residues is also decreased.

BRIEF DESCRIPTION OF DRAWINGS

[0026] Fig. 1 is a plan view showing an example of a wafer level lens array.

Fig. 2 is a cross-sectional view taken along the line A-A shown in Fig. 1.

Fig. 3 is a view showing a state in which a molding material for forming a lens is supplied onto a substrate.

Figs. 4A to 4C are schematic views showing a procedure of forming lenses on a substrate using a mold.

Figs. 5A to 5C are schematic views showing a process of forming a patterned light-shielding film on a substrate on which lenses have been formed.

Fig. 6 is a cross-sectional view showing an example of a wafer level lens array.

Figs. 7A to 7C are schematic views showing another embodiment of a process of forming a light-shielding film.

Figs. 8A to 8C are schematic views showing a process of forming a lens on a substrate having a patterned light-shielding film.

Fig. 9 is a schematic cross-sectional view illustrating a configuration of a camera