animals and the like, it is not noticed by subjects even when the subject is illuminated with a near-infrared light source at night. Therefore, near-infrared light can be used to take photos of nocturnal wild animals, as well as to photograph persons without provoking them for security purposes. Optical sensors detecting such near-infrared light can be developed for various purposes, and thus there has been a persistent desire to develop a color filter that can be used for solid-state image sensors that detect near-infrared light.

[0006] As a colored composition for producing a color filter having similar spectral characteristics to that of a color filter for near-infrared sensors, a red colored composition containing C.I. Pigment Violet 23, a yellow pigment, and a red pigment is known (for example, see Japanese Patent Application Laid-Open (JP-A) No.2007-138135). Although this composition is effective for illuminance sensors, it also has sensitivity in the red region. In addition, this composition does not enable favorable pattern formation by UV light exposure, since light in the UV region is blocked. Thus, for near-infrared sensors, further improvements in the spectral characteristics and pattern formability of the composition are required.

In addition, a light-shielding photosensitive resin composition that transmits light in the ultraviolet region and exhibits improved pattern formability has been proposed (for example, see JP-A No. 7-28236). This composition, however, exhibits insufficient light-transmission properties in the near-infrared region, so that it has not been useful for near-infrared sensors.

SUMMARY OF INVENTION

Technical Problem

[0007] Embodiments of t~~T~~he invention are~~was~~ made in view of the above circumstances, and to achieve the following results~~objects~~.

Specifically, embodiments~~an object~~ of the invention ~~is to~~ provide a colored radiation-sensitive composition having sufficient light-shielding properties in the visible light region of from 400 nm to 580 nm, and having excellent light-transmission properties in the near-infrared region of from 650 nm to 700 nm, and achieving good pattern formability when used for producing a color filter.

Other embodiments~~objects~~ of the invention ~~are to~~ provide a method for forming a pattern using the colored radiation-sensitive composition, ~~to~~ provide a color filter including a color film formed by using the colored radiation-sensitive composition and a method for producing the color filter, and ~~to~~ provide a solid-state image sensor including the color filter.

Solution to Problem

[0008] As a result of intensive research, the inventor has discovered that the above-mentioned embodimentsobjects could be accomplished by using a colored radiation-sensitive composition for a color filter including (A) a pigment, (B) a photopolymerization initiator, and (C) a polymerizable compound, in which the colored radiation-sensitive composition satisfies the condition that, when a colored radiation-sensitive composition layer is formed on a substrate using the colored radiation-sensitive composition, the colored radiation-sensitive composition layer exhibits a specific spectral transmittance at a specific wavelength, whereby the invention was made.

Specific aspects of the invention for solving the problems are as follows.

[0009] <1> According to a first aspect, there is provided a colored radiation-sensitive composition for a color filter including (A) a pigment, (B) a photopolymerization initiator, and (C) a polymerizable compound, in which the colored radiation-sensitive composition satisfies the following conditions:

when a colored radiation-sensitive composition layer is formed from the colored radiation-sensitive composition such that spectral transmittance at 600 nm becomes 30%, the colored radiation-sensitive composition layer includes the following characteristics:

(1) spectral transmittance at 400 nm is 20% or less;

(2) spectral transmittance at 550 nm is 10% or less;

(3) spectral transmittance at 700 nm is 70% or more;

(4) a wavelength resulting in 50% spectral transmittance is in a range of from 650 nm to 680 nm; and

(5) a film thickness of the colored radiation-sensitive composition layer is in a range of from 0.55 μm to 1.8 μm.

[0010] In an embodiment,<2> The colored radiation-sensitive composition for a color filter according to <1>, in which the colored radiation-sensitive composition layer may further includes the following characteristic:

(6) a difference between spectral transmittance at 700 nm (T700) and spectral transmittance at 550 nm (T550) in the colored radiation-sensitive composition layer is 75% or more.

[0011] In an embodiment,<3> The colored radiation-sensitive composition for a color filter according to <1> or <2>, in which (A) the pigment may includes (A-1) at least one of an azo yellow pigment or an isoindoline yellow pigment and (A-2) a dioxazine violet pigment.

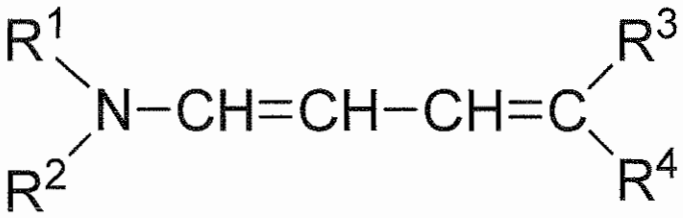
[0012] In an embodiment,<4> The colored radiation-sensitive composition for a color filter according to any one of <1> to <3>, in which the content of (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment may beis from 25% by mass to 50% by mass with respect to a total

content of (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment and (A-2) the dioxazine violet pigment.

In an embodiment,~~<5> The colored radiation-sensitive composition for a color filter according to any one of <1> to <4>, in which~~ the total content of (A) the pigment may be~~is~~ from 5% by mass to 50% by mass with respect to a total solid content of the colored radiation-sensitive composition.

[0013] In an embodiment, the above~~<6> The~~ colored radiation-sensitive composition for a color filter may further include~~according to any one of <1> to <5>, further including~~ (D) an ultraviolet absorber, in which the content of (D) the ultraviolet absorber may be~~is~~ from 0.01% by mass to 10% by mass with respect to a total solid content of the colored radiation-sensitive composition.

In an embodiment,~~<7> The colored radiation-sensitive composition for a color filter according to <6>, in which~~ (D) the ultraviolet absorber may be~~is~~ a compound represented by the following Formula (I):



Formula (I)

wherein, in Formula (I), R^1 and R^2 each independently represent a hydrogen atom, an alkyl group having 1 to 20 carbon atoms, or an aryl group having 6 to 20 carbon atoms, R^1 and R^2 may be the same as or different from each other, but R^1 and R^2 do not simultaneously represent a hydrogen atom; and R^3 and R^4 represent an electron withdrawing group.

In an embodiment, the above~~<8> The~~ colored radiation-sensitive composition for a color filter may further include~~according to any one of <1> to <7>, further including~~ (E) an alkali-soluble resin.

In an embodiment,~~<9> The colored radiation-sensitive composition for a color filter according to <8>, in which~~ the content of (E) the alkali-soluble resin in the colored radiation-sensitive composition may be~~is~~ from 1% by mass to 15% by mass with respect to a total solid content of the colored radiation-sensitive composition.

In an embodiment, the above~~<10> The~~ colored radiation-sensitive composition for a color filter may further include~~according to any one of <1> to <9>, further including~~ (F) an organic solvent.

In an embodiment,~~<11> The colored radiation-sensitive composition for a color filter according to <10>, in which~~ the content of (F) the organic solvent in the colored radiation-sensitive composition may be~~is~~ from 10% by mass to 90% by mass with respect to a total

mass of the colored radiation-sensitive composition.

[0014] ~~<12>~~ According to a second aspect, there is provided a method for forming a pattern, in which the method includes applying the above colored radiation-sensitive composition ~~according to any one of <1> to <11>~~ onto a substrate to form a colored radiation-sensitive composition layer; subjecting the colored radiation-

sensitive composition layer to pattern exposure; and developing the colored radiation-sensitive composition layer after the pattern exposure.

[0015] ~~<13>~~ According to a third aspect, there is provided a color filter including a color film formed using the above colored radiation-sensitive composition ~~according to any one of <1> to <11>~~.

~~<14>~~ According to a fourth aspect, there is provided a method for producing a color filter, in which the method includes applying the above colored radiation-sensitive composition ~~according to any one of <1> to <11>~~ onto a substrate to form a colored radiation-sensitive composition layer; subjecting the colored radiation-sensitive composition layer to pattern exposure; and developing the colored radiation-sensitive composition layer after the pattern exposure to form a color pattern.

~~<15>~~ According to a fifth aspect, there is provided a solid-state image sensor including the above color filter ~~according to <13>~~.

[0016] The color filter obtained by using the colored radiation-sensitive composition of the invention has sufficient light-shielding properties in the visible light region of from 400 nm to 580 nm and has excellent light-transmission properties in the near-infrared region of from 650 nm to 700 nm. Therefore, using the color filter of the invention, a solid stage image sensor having sensitivity to near-infrared light can be provided. Particularly, the colored radiation-sensitive composition that includes (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment and (A-2) the dioxazine violet pigment as (A) the pigment has sufficient light-shielding properties in the visible light region and has excellent light-transmission properties in the near-infrared region of from 650 nm to 700 nm. Therefore, a solid-state image sensor having high sensitivity to near-infrared light can be obtained using such composition. When the content of (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment with respect to a total content of (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment and (A-2) the dioxazine violet pigment is from 25% by mass to 50% by mass, spectral characteristics of the color filter of the invention are improved. In addition, when the colored radiation-sensitive composition further includes the ultraviolet absorber, pattern formability is significantly improved. It is assumed that, the colored radiation-sensitive composition layer blocks UV light such as i-line that is necessary for pattern formation, whereby the reduction in curability of the colored radiation-sensitive composition layer is prevented and the radiation energy absorption capacity necessary for curing the colored radiation-sensitive composition layer is improved.

[0017] When the content of (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment with respect to a total content of (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment and (A-2) the dioxazine violet pigment is from 25% by mass to 50% by mass, light-transmission properties in the near-infrared region of 650 nm or more together with the light-shielding properties in the visible light region of from 400 nm to 580

nm can be improved, whereby sufficient spectral performance for near-infrared sensors can be achieved. When the content of (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment is less than 25% by mass, light-shielding properties in the wavelength region of from 600 nm to 650 nm are sufficient but significantly lowered in the wavelength region of from 400 nm to 500 nm. On the other hand, when the content of (A-1) the at least one of an azo yellow pigment or an isoindoline yellow pigment exceeds 50% by mass, light-shielding properties in the wavelength region of from 400 nm to 500 nm are sufficient but significantly lowered in the wavelength region of from 600 nm to 650 nm. In this case, since i-line transmittance is reduced, pattern formability is also lowered. The composition described in JP-A No. 2007-138135, which is used for illuminance sensors, includes a red pigment and the spectral properties thereof are designed to block light in the wavelength region of from 400 nm to 580 nm for the purpose of determining and evaluating the sensitivity within the human visibility region (the light-sensitive region of humans) based on the following calculation: transmittance in the light-sensitive region = total light transmittance – transmittance in the wavelength region longer than 580 nm. Therefore, the composition described in JP-A No. 2007-138135 is different from a composition used for sensors that transmit light in the near-infrared region (650 nm or more),which is the object of the present invention.

Advantageous Effects of Invention

[0018] According to embodiments of the invention, there can be provided the colored radiation-sensitive composition having sufficient light-shielding properties in the visible light region of from 400 nm to 580 nm, having excellent light-transmission properties in the near-infrared region of from 650 nm to 700 nm, and achieving good pattern formability when used for producing a color filter.

In addition, according to embodiments of the invention, there can be provided a method for forming a pattern using the colored radiation-sensitive composition, a color filter having a colored film formed by using the colored radiation-sensitive composition and a method for producing the color filter, and a solid-state image sensor having the color filter.

DESCRIPTION OF EMBODIMENTS

[0019] Hereinbelow, the present invention is described in greater detail.

Explanations of the constitutional elements described below are based on representative embodiments of the invention, and it is evident that the invention is not limited to them.