Hereinafter, in the present specification, each of plural lenses formed on a lens substrate is referred to as "wafer level lens", and a lens group formed on a lens substrate, inclusive of the lens substrate, is referred to as "wafer level lens array".

[0004] A conventional wafer level lens array is known which is obtained by dripping a curable resin material on a surface of a flat plate substrate formed of a light-transmissive material such as glass, shaping the resin material into a given shape in a mold, and curing the resin material in this state to form plural lenses (for example, see Japanese Patent No. 3,926,380 and International Publication No. WO 2008/102648). In some cases, a light-shielding region made of a black film, a metal film, or the like is formed at a region other than the lens region of the wafer level lens, or at a portion of the lens, in order to control an amount of light. The light-shielding region is generally formed by applying a curable light-shielding composition or depositing a metal.

[0005] Another wafer level lens array is known which is obtained by forming plural holes through a silicon substrate, separately-prepared spherical lens material is disposed at each through hole, fusing the lens material to the substrate by soldering, and polishing the lens material to form plural lenses (see US Patent No. 6,426,829). The lens obtained by this method may be provided with a black film, a metal film, or the like similar to the above, in order to control an amount of light.

[0006] Formation of a light-shielding region by deposition of a metal has problems in that the process is complex, the lens bends after deposition, and light scattering occurs due to reflection by the metal light-shielding film, and further improvements are requested from the viewpoint of both productivity and performance.

[0007] In order to exert light-shielding properties, a carbon black-containing black curable composition for use in, for example, black matrices of LCDs is employed for the application. However, provision of sufficient light-shielding properties in the visible light region for use with a lens also causes insufficient light transmittance for a radiation selected from g-line, h-line, i-line, or the like as an exposure light source used for the curing of the curable composition, and, resultantly, inability of the curing to proceed to deep into the film, and peeling of the film during a development process after image-wise exposure.

SUMMARY ~~OF INVENTION~~

[0008] The present disclosure~~invention~~ has been made in view of the above problems, and it is an object of the present disclosure~~invention~~ to provide a black curable composition for a wafer level lens, which is capable of forming a cured film having excellent light-shielding properties and exhibiting excellent curing sensitivity at the time of pattern formation.

A further object of the present disclosure~~invention~~ is to provide a wafer level lens in which the amount of light is appropriately controlled by the presence of a light-shielding film and which is capable of being easily produced.

[0009] As a result of intensive studies, the inventors of the present disclosure~~invention~~ have found that the above objects can be achieved by using a pigment dispersion liquid containing a metal-containing inorganic pigment which has excellent transmittance for an ultraviolet region, and which has light shielding properties in a range of from a visible light region to an infrared region. The present disclosure~~invention~~ has been completed based on these findings.

The black curable composition for a wafer level lens according to the present disclosure~~invention~~ includes (A) a metal-containing inorganic pigment, (B) a polymerization initiator, and (C) a polymerizable compound.

Here, the (A) a metal-containing inorganic pigment to be used is preferably titanium black, from the viewpoint of transmittance in the ultraviolet region, and light shielding properties in a range of from a visible light region to an infrared region.

In the black curable composition, the (A) metal-containing inorganic pigment is contained in the form of preferably a pigment dispersion, from the viewpoint of uniformity of the resultant light-shielding film.

The black curable composition for a wafer level lens according to the present disclosure~~invention~~ includes, as a light-shielding material, (A) a metal-containing inorganic pigment, which is preferably titanium black. As a result, the black curable composition for a wafer level lens according to the present disclosure~~invention~~ cures with high sensitivity while maintaining light shielding properties, and becomes a black resist having excellent resistance against developer.

It is preferable to further add, to the black curable composition, a desired colorant selected from a pigment dispersion liquid containing an organic pigment or a dye, so as to improve light-shielding performance in a visible light region. In an aspect, there is provided a black curable composition for a wafer level lens, comprising (A) titanium black, (B) a polymerization initiator, and (C) a polymerizable compound, and (D) an organic pigment, wherein the (D) organic pigment is at least one selected from the group consisting of a red pigment, an orange pigment and a violet pigment.

In another aspect, a~~The~~ wafer level lens according to the present disclosure~~invention~~ includes a light-shielding section~~region~~ obtained by curing the black curable composition for a wafer level lens as disclosed herein~~according to the present invention~~.

[0010] According to the present disclosure~~invention~~, a black curable composition for a wafer level lens is provided which is capable of forming a cured film having excellent light shielding properties, and which exhibits excellent curing sensitivity at the time of pattern formation.

Further, according to the present disclosure~~invention~~, a wafer level lens is provided with which the amount of light is appropriately controlled by the presence of a light-shielding film, and which is capable of being easily produced.

In yet another aspect, there is provided a method of forming a light-shielding pattern including: forming a black curable layer containing the black curable composition for a wafer level lens as defined herein on a substrate on which a plurality of lenses are provided; and patternwise exposing the black curable layer to light and developing the black curable layer, thereby forming, at peripheral regions of the plurality of lenses, light-shielding portions containing a cured product of the black curable composition for a wafer level lens.

In a further aspect, there is provided the use of the black curable composition as defined herein for the manufacture of a wafer level lens.