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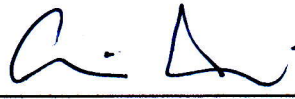
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- Japanese Unexamined Patent Application Publication No. H07-78951

I hereby certify under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed this 20th day of February, 2016.

By: 
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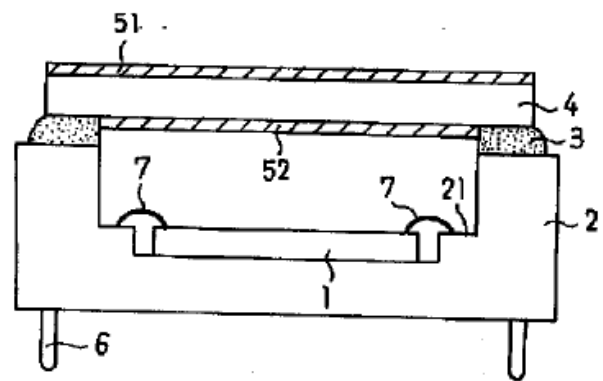
(54) (Title of the Invention)

SOLID-STATE IMAGE PICKUP DEVICE

(57) (Abstract)

(Object) Provide a solid-state image pickup device capable of preventing the separation of the antireflective film and the adhesive formed at the light transmitting window attributable to the application of the adhesive, thereby reducing the degradation of image characteristics attributable to the occurrences of loose dust and compromised hermetic seal.

(Construction) The image pickup device comprises a package 2, a solid-state image sensor 1 comprising a CCD or the like formed inside the package 2, a lid 4 sealing the opening of the package 2, antireflective film 51 and 52 formed on the front and back faces of the lid 4, and an adhesive layer 3 adhering the lid 4 and the package 2. The adhesive layer 3 formed on the back face of the lid is in contact with the antireflective film 52 formed on the back face of the lid, but not overlapped, or even if overlapped, the overlap is 0.5 mm or less. The absence or the negligible degree of overlap can prevent the antireflective film from separating from the light transmitting window together with the adhesive in the event of an occurrence of thermal stress.



(Claims)

(Claim 1) A solid-state image pickup device characterized by comprising: a package, a solid-state image sensor disposed in said package and converting optical input signals into electrical signals, a lid sealing the opening of said package, antireflective film formed on the front and back faces of said lid and preventing the incoming light from being reflected, and an adhesive layer formed on the back face of said lid and adhering said lid and said package, said adhesive layer formed on said back face being in contact with said antireflective film formed on the back face of said lid, but not overlapping therewith.

(Claim 2) A solid-state image pickup device characterized by comprising: a package, a solid-state image sensor secured in said package and converting optical input signals into electrical signals, a lid sealing the opening of said package, antireflective film formed on the front and back faces of said lid and preventing the incoming light from being reflected, and an adhesive layer formed on the back face of said lid and adhering said lid and said package, said adhesive layer formed on said back face being partially overlapped with said antireflective film formed on the back face of said lid, and the overlap width being 0.5 mm or less.

(Claim 3) A solid-state image pickup device according to claim 1 or 2, wherein said adhesive layer extends to the section not in contact with said package, and the extended section is used as a light shielding film to shield the external light from entering.

(Detailed Explanation of the Invention)

(0001)

(Field of Industrial Applications) The present invention relates to solid-state image pickup devices, particularly to light transmitting optical windows (light transmitting windows) used in solid-state image pickup devices.

(0002)

(Prior Art) Solid-state image devices are considered promising as cameras for use in various surveillance televisions and high-definition televisions. This is because they have the beneficial features not achievable by conventional image pickup tubes, and their superior characteristics include no image distortions, low voltage, low power consumption, compact and light weight, reduced afterimages, no burns from direct sunlight, and shock resistant. FIG. 8 is a sectional view of a conventional image pickup device. An image pickup device normally has a package in which a charge transfer device, such as a CCD (charge coupled device), serving as a solid-state image sensor, is hermetically housed. The package 2 is made of ceramic, such as alumina, and the opening is hermetically sealed with a lid 4 made of a transparent material, such as glass. This section is referred to as a light transmitting window 4 because it can transmit the light from the outside. The solid-state image sensor 1 is placed on the bottom face of the interior of the ceramic package 2. The solid-state image sensor 1 comprises, for example, a silicon semiconductor substrate in which a CCD, including a drive circuit, is formed (hereinafter referred to as a chip). An adhesive, such as an epoxy resin (not shown), is applied to

the back face of the chip 1 and is thereby secured to the bottom face of the package.

(0003) The package 2 has a stepped section 21 along the inner side walls, and the connection wiring (not shown) is partially exposed at the flat part of the stepped section. The connection wiring is embedded in the package 2 and internally connected to the electrode pins 6 that project from the bottom face of the package. The electrode pins 6, as shown in the figure, are arranged at two opposing sides at the bottom face of the package 2. Electrode pins 6 can be implanted at all sides of the bottom face. They can be arranged in not only one row, but also multiple rows, such as three rows, at two or four sides of the bottom face. The solid-state image pickup device is mounted on a circuit board or the like, the electrode pins 6 are connected to the circuit board to electrically connect the external circuit formed on the circuit board to the solid-state image pickup device, and the connection electrodes (not shown) formed on the chip 1 are electrically connected to the aforementioned connection wiring of the package 2. For this purpose, the connection wiring exposed at the flat part of the stepped section 21 and the connection electrodes of the chip 1 are connected by bonding wires 7 such as Al, Au, or the like. The package 2 is hermetically sealed after mounting the chip 1 to protect the chip 1 from the outside air and maintain the hermetic seal. For this purpose, the package opening is sealed with a transparent glass lid 4.

(0004) Semiconductor devices are normally packaged to protect the chips from the outside air and maintain the hermetic seal as described above, but solid-state image pickup devices additionally need to have the function of allowing the external light to transmit therethrough to be incident on the solid-state image sensors. For this purpose, a transparent material, such as glass, is used for the lid 4. However, because the incoming light is reflected between the solid-state image sensor and the lid, a sufficient amount of light does not enter the solid-state image sensor. In order to prevent such reflection, antireflective film 5 is normally formed on the front face of the transparent lid 4. The antireflective film 5 is formed on not only the front face facing the outside air, but also the back face facing the interior of the package 2 to prevent imaging problems attributable to unnecessary reflection. The antireflective film 5 is deposited across the entire glass surface by vacuum deposition or the like. MgF_2 or the like is used to form the antireflective film, but the antireflection effect is enhanced by forming multiple layers of film using other materials. What is aimed by the use of the multilayer film as the antireflective film is not limited to the antireflection effect. If used alone, the MgF_2 film can occasionally separate from the glass lid when the solid-state image pickup device's temperature becomes high because the thermal expansion coefficient of the film is higher than that of the glass. (0005) Accordingly, multiple layers each having a thermal expansion coefficient between those of the MgF_2 film and the glass lid 4 are interposed between the two. Thus, the antireflective film 5 used on both front and back faces shown in FIG. 10 [sic.] comprises, for example, an

MgF₂/ZrO₂/Al₂O₃ three-layer film. The lid 4 having antireflective film 5 deposited on both faces is secured at the opening of the package 2 by the adhesive layer 3 made of an epoxy resin or the like disposed in the peripheral section thereof. Since the adhesive layer 3 shields the external light, the peripheral region of the lid where the adhesive is applied is not a light transmitting region even though the lid 4 is a light transmitting window. FIG. 9 is a plan view of the back face of the lid 4 facing the interior of the package 2 shown in FIG. 8. The adhesive layer 3 is formed in the peripheral section of the back face overlapping the antireflective film 5 which is deposited across the entire back face.

(0006)

(Problems to be Solved by the Invention) The light transmitting window in which the antireflective film is deposited across the entire surface has the following problems. First, the adhesion between the aforementioned antireflective film and the light transmitting window material, such as glass, is not as good as the adhesion between the antireflective film and the adhesive. In cases where the adhesive is applied on the antireflective film as shown in FIG. 8, in particular, the antireflective film separates from the light transmitting window in the condition where it remains adhered to the adhesive layer when subjected to thermal stress. If such a separation were to occur after sealing the package, what has been separated would become loose dust, obstructing the incoming light thereby degrading the image characteristics. If the antireflective film is separated after the chip has been sealed in the package, the adhesive in that section is necessarily separated, breaching the hermetic seal of the package. As a result, the inner wall of the light transmitting window fogs up, or the solid-state image sensor incurs damage from external influences, thereby degrading the image characteristics. The present invention was created under these circumstances, and the object thereof is to provide a solid-state image pickup device capable of preventing the separation of the antireflective film and the adhesive formed at the light transmitting window attributable to the application of the adhesive, thereby reducing the degradation of image characteristics attributable to the occurrences of loose dust and compromised hermetic seal.

(0007)

(Means for Solving the Problems) The present invention is characterized by not overlapping the adhesive layer with the antireflective film formed on the light transmitting window of the solid-state image pickup device, or minimizing the overlap. In other words, the first characteristic of the solid-state image pickup device of the invention is such that it comprises a package, a solid-state image sensor disposed in said package and converting optical input signals into electrical signals, a lid sealing the opening of said package, antireflective film formed on the front and back faces of said lid and preventing the incoming light from being reflected, and an adhesive layer formed on the back face of said lid and adhering said lid and said package, said adhesive layer formed on said back face being in contact with said antireflective film formed on the back face of said lid, but not

overlapping therewith. The second characteristic is such that it comprises a package, a solid-state image sensor secured in said package and converting optical input signals into electrical signals, a lid sealing the opening of said package, antireflective film formed on the front and back faces of said lid and preventing the incoming light from being reflected, and an adhesive layer formed on the back face of said lid and adhering said lid and said package, said adhesive layer formed on said back face being partially overlapped with said antireflective film formed on the back face of said lid, and the overlap width being 0.5 mm or less. The adhesive layer may extend to the section not in contact with the package, and the extended section may be used as a light shielding film to shield the external light from entering.

(0008)

(Operation) By not overlapping the adhesive layer with the antireflective film formed on the light transmitting window of the solid-state image pickup device, or minimizing such an overlap, the separation of the antireflective film from the light transmitting window together with the adhesive in the event of an occurrence of thermal stress after sealing the solid-state image sensor in the package can be prevented.

(0009)

(Examples) Examples of the invention will be explained below with reference to the drawings. The first example will be explained with reference to FIGS. 1 and 2. FIG. 1 is a sectional view of the solid-state image pickup device, and FIG. 2 is a plan view of the back face of the lid used in the solid-state image pickup device. The solid-state image pickup device has a charge transfer device, such as a CCD, serving as a solid-state image sensor sealed in the package 2. The package 2 is made of, for example, ceramic containing about 90 wt% alumina, having a linear thermal expansion coefficient of about $70.0 \times 10^{-7}/^{\circ}\text{C}$. The package 2 is formed by stacking green sheets, creating a recess for mounting a chip, followed by sintering by heating. The opening of the package 2 is sealed by a lid 4 made of a transparent material such as glass. This section is referred to as a light transmitting window 4 as it allows the light from the outside to transmit therethrough. A solid-state image sensor 1 is placed on the bottom face of the interior of the package 2. The solid-state image sensor 1 comprises, for example, a silicon semiconductor substrate in which a CCD, including a drive circuit, (chip) is formed. An adhesive, such as an epoxy resin (not shown), is applied to the back face of the chip 1 by which it is secured to the bottom face of the package.

(0010) The package 2 has a stepped section 21 along the inner side walls, and the connection wiring (not shown) is formed to be partially exposed at the flat part of the stepped section 21. The connection wiring is embedded in the package 2, and internally connected to the electrode pins 6 projecting from the bottom face. The electrode pins 6, as shown in the figure, are arranged at two opposing sides of the bottom face of the package 2. Electrode pins 6 can be implanted at all sides of the bottom face. They can be arranged in not only one row, but also plural rows, such as three rows, at two or four sides of the bottom face. The

material for the electrode pins, for example, is an Fe alloy containing 45 wt% Ni, the surface of which is Au plated. The solid-state image pickup device is mounted on a circuit board or the like, the electrode pins 6 are connected to the circuit board to electrically connect the external circuit formed on the circuit board to the solid-state image pickup device, and the connection wiring exposed at the flat part of the stepped section 21 and the connection electrodes of the chip 1 are connected using bonding wires 7, such as Al or Au, to connect the connection electrodes (not shown) formed on the chip 1 to the connection wiring of the package 2.

(0011) The package 2 is hermetically sealed after mounting the chip 1 to protect the chip 1 from the outside air and maintain the hermetic seal. For this purpose, the opening of the package 2 is sealed with a transparent glass lid 4. The composition of the glass for the lid 4, for example, is 69 wt% SiO₂, 10.5 wt% Na₂O+K₂O, and 11.0 wt% B₂O₃, and the linear thermal expansion coefficient is about $65.5 \times 10^{-7}/^{\circ}\text{C}$. For the glass used as the lid, those having a linear thermal expansion coefficient of from about 10 to $100 \times 10^{-7}/^{\circ}\text{C}$ can be used. Unlike the package lids for other semiconductor devices, the package lid used in the solid-state image pickup device needs to have the function of allowing the light from the outside to transmit therethrough to be incident on the solid-state image sensor in addition to protecting the chip from the outside air and maintaining the hermetic seal. For this purpose, a transparent material, such as glass, is used for the lid 4. If the incoming light is reflected between the solid-state image sensor and the lid, the reflected light becomes an optical input signal to be converted into an electrical signal, which would adversely affect a correct input signal. In order to prevent such reflection, an antireflective film 51 is formed on the front face of the transparent lid 4. Besides the front face facing the outside air, an antireflective film 52 is formed on the back face of the lid 4 facing the interior of the package 2 to prevent imaging problems attributable to unnecessary reflection. The antireflective film 51 is deposited across the entire glass surface by vacuum deposition or the like.

(0012) On the other hand, the antireflective film 52 is not applied across the entire back face of the lid, i.e., the antireflective film is not deposited in the region where the adhesive layer 3 will be applied to secure the lid to the package 2. The characteristic of this example is such that the adhesive is directly applied to the back face of the lid 4 so as not to overlap with the antireflective film 52. In this example, a three-layer film is used for each antireflective film 51 and 52 where an MgF₂ film is disposed as the uppermost layer. For each lowermost layer in contact with the glass face, an Al₂O₃ film is formed, and a ZrO₂ film is formed between the two layers. Employing a multilayer film as in the case of this example is more effective in preventing reflection than a single layer film. For example, assuming that the light transmittance of the glass sheet used as the lid 4 is about 92%, the light transmittance is improved to about 95% when employing an antireflective film made of an MgF₂ film alone. Employing the three-layer antireflective film 51 and 52 of this example, the light transmittance of the lid 4 is further improved to about 98-99%. The antireflective film

can be multilayered in which two or more materials are alternately layered. Moreover, different materials can be used between the outer antireflective layer 51 and the inner antireflective layer 52.

(0013) In forming a multilayer antireflective film on the lid 4, moderating the stress generated by the thermal stress occurring between the two is also taken into consideration. The linear thermal expansion coefficient of the Al₂O₃ film directly in contact with the glass sheet used as the lid 4 is $67.0 \times 10^{-7}/^{\circ}\text{C}$, which is substantially the same as that of the glass sheet ($65.5/^{\circ}\text{C}$). The linear thermal expansion coefficient of the MgF₂ film formed as the uppermost layer is $188.0/^{\circ}\text{C}$ which differs considerably from that of the glass sheet. Accordingly, the stress is moderated by forming a ZrO₂ film between the two to reduce the difference in the thermal expansion coefficients between the two materials that are in contact with one another. Thus, the antireflective film 51 and 52 each comprises an MgF₂/ZrO₂/Al₂O₃ three-layer film. In the lid 4 having antireflective film deposited on both faces, an adhesive layer 3 made of an epoxy resin or the like is formed in the peripheral region of the back face where the antireflective film 52 is not formed. The package 2 is sealed by the lid 4 by inserting the package 2 and the lid 4 in an organic sealing apparatus in the state in which the adhesive layer 3 is abutted against the end of the opening of the package 2, and curing the thermosetting epoxy resin by heating at about 100-200°. The lid 4 becomes the light transmitting window, but the peripheral section of the lid where the adhesive is applied does not become the light transmitting region because the adhesive layer 3 shields the external light. FIG. 2 is a plan view of the back face of the lid 4 which faces the interior of the package 2 shown in FIG. 1. As shown in the figure, unlike the conventional solid-state image pickup device (see FIG. 11 [sic.]), the adhesive layer 3 and the antireflective film 52 do not overlap. Accordingly, the adhesive layer 3 will never separate from the lid 4 taking the antireflective film 52 along.

(0014) Next, the characteristics of the solid-state image pickup device of this example will be explained in comparison to the aforementioned example of the conventional device. The MIL-Stec [sic. MIL-SPEC?] tests (TCT) show the properties of the adhesive layers formed on the lid of the solid-state image pickup device of the first example, the fourth conventional example, and so on. The tests entail cooling of the samples from room temperature to -65°C, maintaining them at this temperature for 20 minutes, then heating them to 150°C over 5-10 seconds, maintaining them at this temperature for 20 minutes, and cooling them to -65°C over 5-10 seconds. This is one cycle, which was repeated a prescribed number of times. The conventional example represented the properties of the adhesive layer on the lid of the solid-state image pickup device shown in FIG. 8. For the appearance of the adhesive layer among the items evaluated, the separation at the bonding interface was determined based on the optical interference fringes. Samples showing interference fringes exceeding 2/3 of the adhesive layer width were determined as failures. The hermeticity was evaluated by fine and gross leak testing. As

for the first example, no failures occurred up to 300 cycles in the TCT test, whereas with the conventional example, both the appearance and the hermeticity deteriorated after 100 cycles. As such, when the antireflective film was applied across the entire surface of the lid as in the case of the conventional example, the adhesive layer separated thereby considerably compromising the hermeticity.

(0015) Next, the second example will be explained with reference to FIGS. 3 and 4. FIG. 3 is a sectional view of the solid-state image pickup device, and FIG. 4 is a plan view of the back face of the lid used in the solid-state image pickup device. The bonding wires for connecting the electrode pins for external circuit connection and the wiring of the package's stepped section to the chip are the same as in the case of FIG. 1, and thus the description will be omitted. This solid-state image pickup device has a charge transfer device, such as a CCD, as the solid-state image sensor sealed in the package 2. The package 2 is made of ceramic, and its opening is hermetically sealed with a glass lid 4. This section is referred to as a light transmitting window 4 as it allows the light from the outside to transmit therethrough. A solid-state image sensor 1 is placed on the bottom face of the interior of the package 2. The chip 1 is secured to the bottom face of the package using an adhesive. The package 2 has a stepped section 21 along the inner side walls, and the connection wiring is formed to be partially exposed at the flat part of the stepped section 21. The connection wiring is embedded in the package 2, and internally connected to the electrode pins projecting from the bottom face. The solid-state image pickup device is mounted on a circuit board or the like, the electrode pins are connected to the circuit board to electrically connect the external circuit formed on the circuit board to the solid-state image pickup device, and the connection electrodes (not shown) formed on the chip 1 and the aforementioned connection wiring of the package 2 are electrically connected.

(0016) This is achieved by connecting the connection wiring exposed at the flat part of the stepped section 21 and the connection electrodes of the chip 1 using bonding wires. In order to prevent light reflection, an antireflective film 51 is formed on the front face of the transparent lid 4. Besides the front face facing the outside air, an antireflective film 52 is formed on the back face of the lid 4 facing the interior of the package 2 to prevent imaging problems attributable to unnecessary reflection. The antireflective film 51 is deposited across the entire glass surface by vacuum deposition or the like. On the other hand, the antireflective film 52 is not applied across the entire back face of the lid, i.e., the antireflective film is not deposited in the region where the adhesive layer 3 will be applied to secure the lid to the package 2. The adhesive is directly applied to the back face of the lid 4 so as not to overlap with the antireflective film 52. In this example, the region for the adhesive layer 3 is expanded, and the expanded region is used as a light shielding section. The solid-state image sensor is an integrated circuit which satisfies the three basic functions: photoelectric conversion, accumulation, and scanning. For signal extraction, for example, a charge transfer method

having a functional device, such as a CCD, is used. Broadly categorized, there are two modes for the CCDs used as two-dimensional imaging sensors that have been put to practical use: frame transfer (FT) and interline transfer (ILT). The frame transfer mode requires a light receiving section and a storage section that are equal in area on one chip, but the structure of the clock circuit is relatively simple as compared to interline transfer. Light enters the light receiving section, and the signal charges are accumulated. The charges are then transferred to the light shielded storage section at high speed and read out sequentially per line at a relatively low speed. While the charges are being read out, charge accumulation is performed for the subsequent light entry. As such, the frame transfer mode requires that the storage section be light shielded. In cases where the frame transfer mode is applied to the invention, the adhesive layer of this example is appropriately concurrently used as the light shielding section.

(0017) Next, the third example will be explained with reference to FIGS. 5 and 6. FIG. 5 is a sectional view of the solid-state image pickup device, and FIG. 6 is a plan view of the back face of the lid used in the solid-state image pickup device. The electrode pins for external circuit connection are the same as in the case of FIG. 1, and thus the description will be omitted. The opening of the package 2 is hermetically sealed with a glass lid 4. A chip 1 is placed on the bottom face of the interior of the package 2. The chip 1 is secured to the bottom face of the package using an adhesive. The package 2 has a stepped section 21 along the inner side walls, connection wiring is formed to be partially exposed at the flat part of the stepped section, and the connection wiring is embedded in the package 2 and internally connected to the electrode pins implanted at the bottom face. The connection electrodes (not shown) of the chip 1 and the connection wiring of the package 2 are connected using bonding wires 7. In order to prevent light reflection, an antireflective film 51 is formed on the front face of the transparent lid 4. Besides the front face facing the outside air, an antireflective film 52 is formed on the back face of the lid 4 facing the interior of the package 2 to prevent imaging problems attributable to unnecessary reflection. The antireflective film 51 is deposited across the entire glass surface by vacuum deposition or the like. On the other hand, the antireflective film 52 is not applied across the entire back face of the lid, i.e., in the region where the adhesive layer 3 will be applied to secure the lid to the package 2, the antireflective film is deposited only partially. (0018) Then, the adhesive is directly applied to the back face of the lid 4 so as to partially overlap with the end section of the antireflective film 52. As shown in FIG. 6, the epoxy resin adhesive layer 3, for example, overlaps with the antireflective film 52 deposited in the central section of the back face of the lid 4 as in the case of FIG. 1 only in a small width (L). In this example, the width L is about 0.5 mm. The lid 4 is a 15-20 mm square in size. Assuming that the overlapped section has the same width $L=0.5\text{mm}$ at any location, and the lid 4 has the aforementioned size, the ratio of the overlapped area to the area of the adhesive layer 3 is

about 1:13. If the overlapped section is roughly smaller than this areal ratio value, it can be said that the occurrences of the separation of the antireflective film and the adhesive layer from the lid is effectively decreased. Practically, however, the separation phenomenon does not necessarily depend on the size of the overlapped section. Rather, the separation of the adhesive layer at the overlapped section depends on the state of the minute regions in the section (e.g., region A in FIG. 6). Moreover, the overlap width of the overlapped section varies from minute region to minute region, and consequently, the occurrences of separation increases in any minute region where the overlap width L exceeds about 0.5 mm, and decreases if less than that. In other words, the separation phenomenon depends on the overlap widths L , not the areal ratio of the overlapped section as a whole to the adhesive layer.

(0019).

(Effect of the Invention) As described above, the invention prevents the separation of the antireflective film and the adhesive due to thermal stress and thus prevents the image characteristics from being degraded by loose dust and compromised hermeticity by not overlapping the adhesive layer, which secures the antireflective film formed on the inner side of the light transmitting window and the light transmitting window to the package of the solid-state image pickup device, with the antireflective film, or minimizing the overlap.

(Brief Explanation of the Drawings)

FIG. 1

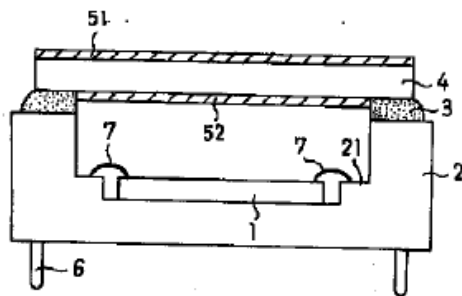


FIG. 3

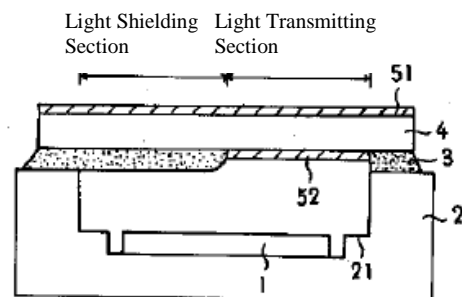


FIG. 2

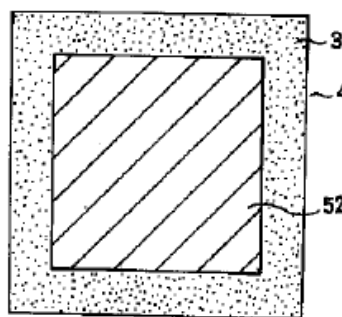


FIG. 4

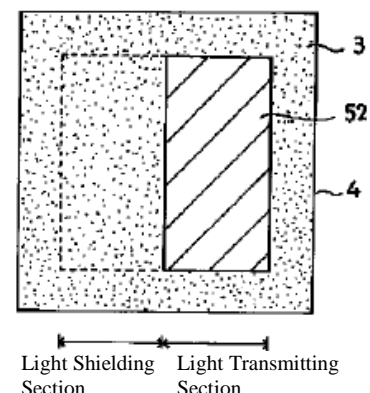


FIG. 9

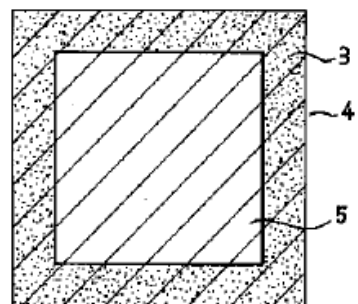


FIG. 1 is a sectional view of the solid-state image pickup device according to the first example of the invention.

FIG. 2 is a plan view of the back face of the lid used in the solid-state image pickup device shown in FIG. 1.

FIG. 3 is a sectional view of the solid-state image pickup device according to the second example of the invention.

FIG. 4 is a plan view of the back face of the lid used in the solid-state image pickup device shown in FIG. 3.

FIG. 5 is a sectional view of the solid-state image pickup device according to the third example of the invention.

FIG. 6 is a plan view of the back face of the lid used in the solid-state image pickup device shown in FIG. 5.

FIG. 7 is a sectional view of the solid-state image pickup device according to the fourth example of the invention.

FIG. 8 is a sectional view of a conventional solid-state image pickup device.

FIG. 9 is a plan view of the back face of the lid used in the conventional solid-state image pickup device.

(Explanation of Reference Numerals)

- | | |
|-----------|--------------------------------|
| 1 | chip |
| 2 | package |
| 3 | adhesive layer |
| 4 | lid |
| 5, 51, 52 | antireflective film |
| 6 | electrode pin |
| 7 | bonding wire |
| 21, 22 | stepped section of the package |

FIG. 5

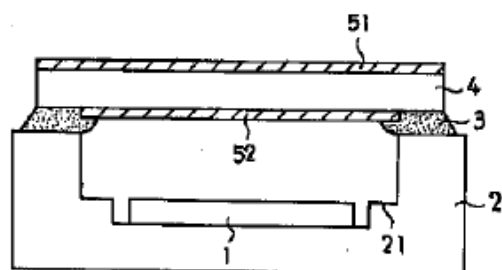


FIG. 6

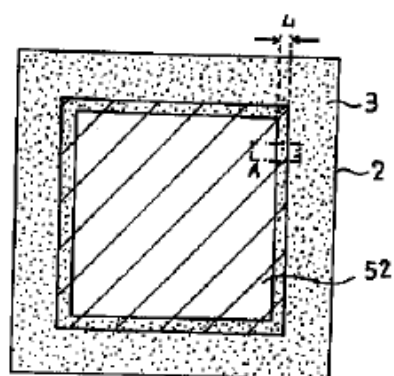


FIG. 7

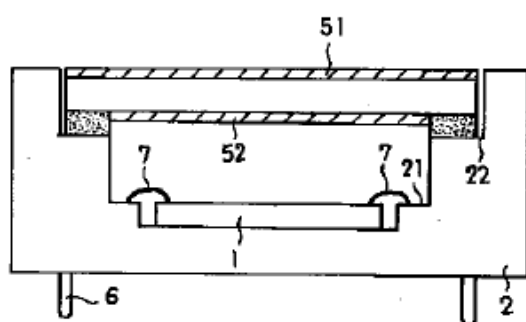


FIG. 8

