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- S60-74880

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By: 

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SPECIFICATION

1. Title of the Invention

Solid State Image Capturing Device

2. Claims

1. A solid state image capturing device, wherein a conductor that connects a light detection semiconductor element and a signal processing circuit element is formed on a side face of at least one semiconductor chip formed along a light incidence direction relative to the light detection semiconductor element and the signal processing circuit element.

2. The solid state image capturing device as claimed in claim 1, wherein the light detection semiconductor element and the signal processing circuit element are formed on separate semiconductor chips, the semiconductor chips are disposed in an overlapping manner along the light incidence direction with insulating members interposed thereamong, and conductors that connect the light detection semiconductor element and the signal processing circuit element are formed on side faces of the semiconductor chips and the insulating members.

3. The solid state image capturing device as claimed in claim 1 or claim 2, wherein leads connecting the solid state image capturing device to external circuitry are provided to rear faces of the semiconductor chips.

3. Detailed Description of the Invention

Technical Field

The present invention relates to a solid state image capturing device, and more particularly relates to a solid state image capturing device suitable for use built into an endoscope for observing interiors of body cavities or interiors of mechanical structures.

Prior Art

In conventional endoscopes, a light guide and an image guide comprising optical fiber bundles are extended into a flexible outer cylinder that is inserted into a subject body, light radiated by an externally provided illumination light source is guided through the light guide to a distal end of the endoscope and passes through an illumination lens group to illuminate the subject body. An image of the subject body is guided out through an object lens group and the image guide, where it is directly observed through an eyepiece or is captured by an image capturing device and displayed to a monitor. Resolution of conventional endoscopes using such image guides is determined by a diameter of the fibers making up the image guide, but making the fiber diameter even thinner than currently poses significant challenges, meaning resolution has substantially reached a limit. The image guide also tends to break, and therefore has problems in terms of durability.

To solve this problem, proposals have been made to incorporate a compact image capturing device into the distal end of the endoscope, capture images of the subject body using this and convert them into an image signal which is then guided out through a lead and displayed to a monitor. Various semiconductor solid state image capturing devices have been developed, such as CCDs, BBDs, MOS-FET arrays, pin-photodiode arrays, SIT arrays, and so on as image capturing devices which have the advantages of being compact and yet having high resolution and long life spans, making them suitable for incorporation in endoscopes. Nevertheless, while the solid state image capturing devices manufactured today are smaller than conventional image capturing tubes, challenges exist in incorporating them in the tip of an endoscope. In particular, endoscopes designed for observing body cavities have a diameter of several dozen millimeters at most (in the largest-diameter endoscopes for use in observing the rectum), making it impossible to incorporate current solid state image capturing devices. These issues are not limited to endoscopes, but can also arise in relation to other types of image capturing equipment.

Detection signals from light detection semiconductor elements that make up semiconductor solid state image capturing devices are weak, and therefore in general rather than using such devices alone, semiconductor image capturing devices on which such devices are mounted together with a signal processing circuit element constituting an amplification circuit or the like that amplifies the detection signal are widely used. Such cases include cases where a light detection semiconductor element and a signal processing circuit element are configured in a single semiconductor chip and cases where they are configured in a plurality of semiconductor chips. FIG. 1 shows one example of a configuration of a conventional solid state image capturing device. In the example shown in FIG. 1, a single semiconductor chip 2 is provided on a ceramic substrate 1 that constitutes a package, a light detection semiconductor element such as a charge transfer element such as a CCD or a BBD, MOS transistor, a photodiode, a phototransistor, a static induction transistor, or the like being formed in a left-side section 2L, and a signal processing circuit element including horizontal and vertical shift registers, an address register, various selection switches, load resistors connected to a video line, capacitors, amps, and so on being formed in a right-side section 2R. The light-shielding film or a light-shielding plate 8 is provided to the section 2R where the signal processing circuit element is formed, preventing adverse effects of stray current caused by electron-positive hole pairs formed inside the semiconductor by light irradiated through a transparent glass cap 4 from affecting the signal processing circuit.

Transmission and reception of signals between the light detection semiconductor element and the signal processing circuit element is done via

semiconductor regions or conductor patterns, and transmission and reception of output signals from the signal processing circuit element and control signals and the like from external circuits is done via leads 5 and bonding pads 6 and leads 7 provided to the ceramic substrate 1. Because the light detection semiconductor element and the signal processing circuit element can be formed inside a single semiconductor chip in a solid state image capturing device having this configuration, they can be made smaller than if they were formed in separate semiconductor chips, but not small enough for incorporation into the tip of an endoscope. Moreover, heat produced by the amplification circuit, etc., inside the signal processing circuit is transmitted to the light detection semiconductor element, increasing the amount of dark current, while carrier charge created by light entering the light detection region causes malfunctions if scattered to the amplification or surrounding circuits. An even bigger problem is that since the light detection semiconductor element and the signal processing circuit element are configured on a single semiconductor chip, cost increases caused by combining characteristics and chip manufacturing processes are incurred.

Technical Background

To solve these problems, a mounting method called back coupling as shown in FIG. 2 was proposed by the applicant in JP S58-46967 A. In FIG. 2, a light detection semiconductor element is formed on an upper semiconductor chip 11 and a signal processing circuit element is formed on a lower semiconductor chip 12. These chips are separated and supported by a separating wall 14 that is formed integrally with an insulating holder 13. In order to perform transmission and reception of signals between the light detection semiconductor element and the signal processing circuit element, contact pads 15 and 16 that are formed on a front surface of the semiconductor chips 11 and 12 are connected to contact pads 19 and 20 provided to a rear surface of the holder 13 via leads 17 and 18, and the contact pads 19 and 20 are further connected to one another by a lead 21 that extends along a side face of the holder 13. Furthermore, a lead 22 for connecting the solid state image capturing device to external circuitry extends from the holder 13. In an actual solid state image capturing device, everything shown in FIG. 2 is contained in a package, but in FIG. 2 the package is not shown.

In the back coupled structure shown in FIG. 2, the semiconductor chip 11 on which the light detection semiconductor element is formed and the semiconductor chip 12 on which the signal processing circuit element is formed are separate bodies layered vertically with the separating wall in between. Therefore, the surface area as seen from the light incidence side is smaller than in the conventional solid state image capturing device shown in FIG. 1, and the problems of the effects of heat and the scattering of carrier charges are resolved. However, it is impossible in practice to incorporate this into the tip of an endoscope. In other words, the diameter of the endoscope is extremely small, so there is not enough space to incorporate the solid state image capturing device. For example, forceps for taking specimens and wires for operating the forceps must also be inserted besides the aforementioned light guide, in endoscopes for observation of body cavities. Additionally, water supply tubes for washing a front lens in the object lens group, an air supply tube for blowing away any washing water attached to the front lens and inflating the body cavity are also inserted, making the space which can be used for containing a solid state image capturing device extremely small. Accordingly, in order to incorporate a high-resolution solid state image capturing device into a narrow space, the structure of the solid state image capturing device itself must be improved, but there are many challenging problems which must be solved, such as connection and arrangement of the light detection semiconductor element and the signal processing circuit element, connection of the signal lines between the semiconductor chips, packaging methods, how to bring out the leads, etc.

Object of the Invention

An object of the present invention is to eliminate these problems and provide a solid state image capturing device that can be configured compactly, improve resolution by raising mounting density, and be incorporated into an extremely small-diameter end of an endoscope, being particularly suitable for incorporation into an end of an endoscope.

Summary of the Invention

In a solid state image capturing device according to the present invention, conductors that connect a light detection semiconductor element and a signal processing circuit element are formed on side faces of at least one semiconductor chip formed in a direction of light incidence relative to the light detection semiconductor element and the signal processing circuit element.

Embodiments

The present invention is described in detail below, with reference to the drawings.

FIG. 3 is a line drawing showing a configuration of one embodiment of a solid state

image capturing device of the present invention. In the present embodiment, a light detection semiconductor region 31a and a signal processing circuit region 31b are formed on front and rear faces of a single semiconductor chip 31. Semiconductor image capturing elements such as charge-coupled semiconductor elements like CCDs or BBDs, MOS transistor arrays, pin-photodiode arrays, phototransistor arrays, static induction transistor arrays, and the like are formed in the light detection semiconductor region 31a. A mosaic color filter film is formed on the front surface with an insulating film interposed therebetween, but the regions, insulating films, color filter films, and other aspects of these devices are omitted from the drawing. Horizontal and vertical shift registers, an amplification circuit, switches, and other semiconductor elements and load resistors, capacitors, and other passive elements are formed in the signal processing circuit region 31b, but these, too, are omitted from the drawing. In the present invention, to perform transmission and reception of signals between the light detection semiconductor region 31a and the signal processing circuit region 31b, regions 32 and 33 formed on surfaces of these regions are connected by conductors 34 that are formed through vacuum deposition of metal onto side faces of the semiconductor chip 31. Furthermore, leads 35 for performing transmission and reception of signals between the solid state image capturing device and external circuitry are formed on front and rear faces of the semiconductor chip 31. In the present invention, the light detection semiconductor element and the signal processing circuit element are connected by conductors attached to side faces of the semiconductor chip, making it possible to reduce the dimensions of the solid state image capturing device relative to the light incidence direction. Furthermore, the entire rear face of the semiconductor chip can be used for lead connections, so many leads can easily be connected.

FIG. 4 is a cross-sectional line drawing showing another embodiment of a solid state image capturing device of the present invention. In the present embodiment, a light detection semiconductor element is formed inside a region 41a of a semiconductor chip 41, and a signal processing circuit element is formed inside a region 42a of a semiconductor chip 42. These semiconductor chips 41 and 42 are arranged in a light incidence direction with insulating members 43 of an appropriate thickness interposed therebetween. A predetermined region 44 on the semiconductor chip 41 is connected to a predetermined region 46 formed on the semiconductor chip 42 by conductors 45 that are formed by vacuum deposition of metal on side faces of the semiconductor chips 41 and 42 and the insulating members 43. In the present embodiment, the semiconductor chip 41 on which the light detection semiconductor element is formed and the semiconductor chip 42 on which the signal processing circuit element is formed are configured separately, so there is no need to combine circuit characteristics or semiconductor chip manufacturing processes. Moreover, the adverse effects of heat and carrier charges can be eliminated, the lateral dimensions relative to the light incidence direction can be made smaller, and mounting density can be improved.

In the present embodiment, the leads are not bonded directly to the rear face of the semiconductor chip 42, but rather a contact region 47 is provided to the rear face of the semiconductor chip 42 and tips of the leads 49 attached to an attachment plate 48 are abutted against and thereby electrically connected to the contact region. By attaching the leads to an attachment plate and attaching this plate to the semiconductor chip rear face as in the present embodiment, mechanical strength of the leads can be increased, allowing easier electrical connection of the leads.

FIG. 5 is an oblique line drawing showing yet another embodiment of a solid state image capturing device of the present invention. In the present embodiment, a semiconductor chip 51 on which a light detection semiconductor element is formed and a semiconductor chip 52 on which a signal processing circuit element is formed are arranged along a light incidence direction, as in the previous embodiment. Connection of the semiconductor chips 51 and 52 is done by conductors 53 formed by vacuum deposition of metal on side faces of the semiconductor chips. In the present embodiment, to connect the solid state image capturing device with external circuitry, holes are formed in the semiconductor chip 52 which is at the back, and tips of the leads 54 are inserted into and soldered to the holes. FIG. 6 is a cross-sectional view showing connections between the semiconductor chip 52 and the lead lines 54 enlarged. Holes 56 are formed in the middle of a predetermined region 55 in the front face of the semiconductor chip, conductor cores 54a of the leads 54 are inserted into these holes, and the region 55 and the conductor cores 54a are

connected by solder 57. With this configuration, the leads 54 do not protrude out of the semiconductor chip 52, allowing a smaller dimension to be used relative to the light incidence direction, and making possible simple and secure electrical connection, which reduces trouble.

FIG. 7 is a

Cross-sectional view showing a configuration of one embodiment of an endoscope in which a solid state image capturing device of the present invention as described above is incorporated into a tip. The endoscope in the present embodiment is for observation inside body cavities. A tip body 62 that is made of stainless steel, for example, is fitted onto a tip of a flexibly outer cylinder 61 that is inserted into a subject body. Multiple channels 62a, 62b, 62c, ... are formed in the tip body 62. A light guide 63 comprising optical fiber bundle is inserted into the light guide channel 62a, and a concave lens 64 is fitted onto the tip. A light guide 63 is covered by a cover tube 65 and extended into the outer cylinder 61, guided into an operating section, and connected to an illumination light source. An object lens group 66 is fitted onto a tip inside the observation channel 62b, and a solid state image capturing device 67 is fitted inside. The solid state image capturing device 67 of the present embodiment is configured as shown in FIG. 4. Namely, two semiconductor chips are arranged vertically. A lead bundle 69 is connected to leads 68 that are attached to a rear face of the rear semiconductor chip, and the lead bundle 69 is extended into the outer cylinder via a flexible tube 70, guided to the operating section and connect, and connected to a signal processing circuit. An air tube 71 is linked to the air supply channel 62c and an air supply nozzle 2 is attached to a tip and aimed at the front lens of the object lens group 66, allowing air supply thereto. A water supply tube is linked to a water supply channel and a water supply nozzle is provided to a tip, allowing water supply to the front lens of the object lens group 66 in order to wash away any soiling. In FIG. 7, the water supply tube and the water supply nozzle are not shown. The air supply nozzle 72 blows washing water attached to the front lens away, and blows air into the subject body to inflate it as needed. A forceps channel is also formed in the tip body 62, into which forceps for taking specimens and wires for operating the forceps from outside can be inserted. Screw threads are formed on an outer circumferential surface of the tip body 62, and a tip hood 73 is screwed on.

The present invention is not limited to the above embodiments. May variations are possible. For example, in the embodiment shown in FIG. 3, the leads are directly connected to the semiconductor chip, but the leads can be affixed to an attachment plate which can be affixed to the rear face of the semiconductor chip, as shown in FIG. 4. Furthermore, the conductors extending over side faces of the semiconductor chip can be formed over all side faces of the semiconductor chip, although it is advantageous from a manufacturing standpoint not to form conductors on at least one face. Furthermore, the solid state image capturing device of the present invention can be incorporated into a lateral view endoscope, and not just a front view endoscope as shown in FIG. 7. Moreover, in the endoscope mentioned above, the light from the light source exits from the tip of the outer cylinder after having passed through the light guide, but it is also possible to illuminate the subject body by providing a light source, such as a lamp or an LED, to the tip of the outer cylinder, instead of using the light guide. In this case, three-color LEDs, red, blue, and green, can be used and illuminated in sequence, eliminating the need for a color filter attached to a light-receiving surface of the solid state image capturing device. The solid state image capturing device of the present invention can also be incorporated into an image capturing device other than an endoscope, naturally.

Effects of the Invention

With the present invention, a light detection semiconductor element and a signal processing circuit element are formed along a light incidence direction, and the light detection semiconductor element and the signal processing circuit element are connected by conductors formed on side faces of a semiconductor chip. Therefore, lateral dimensions in the light incidence direction can be made as small as the dimensions of the light receiving surface, allowing effective incorporation into the tip of a narrow-diameter endoscope. Furthermore, attaching leads to a rear side of the semiconductor chip significantly contributes to a compact size and is also easy to manufacture. Electrical characteristics are also improved, among other effects.

4. Brief Description of the Drawings

FIG. 1 is a cross-sectional view showing a configuration of one embodiment of a conventional solid state image capturing device.

FIG. 2 is a cross-sectional view showing a configuration of a back-coupled-type solid state image capturing device proposed before by the applicant.

FIG. 3 is a line drawing showing a configuration of one embodiment of a solid state image capturing device of the present invention.

FIG. 4 is a cross-sectional line drawing showing a configuration of another embodiment of a solid state image capturing device of the present invention.

FIG. 5 is an oblique view showing a configuration of yet another embodiment of a solid state image capturing device of the present invention.

FIG. 6 is a cross-sectional view showing one part thereof enlarged.

FIG. 7 is a cross-sectional view showing one embodiment of an endoscope in which a solid state image capturing device of the present invention is incorporated into a tip.

31	semiconductor chip
32, 33	regions
34	conductors
34	leads
41, 42	semiconductor chips
43	insulating members
44, 46, 47	regions
45	conductors
49	leads
51, 52	semiconductor chips
53	conductors
54	leads
55	regions
56	holes
57	solder

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FIG. 1

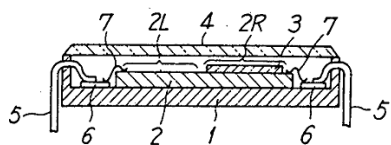


FIG. 2

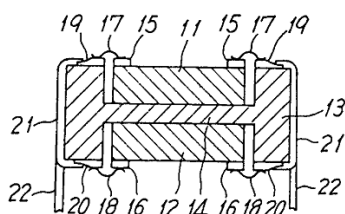


FIG. 3

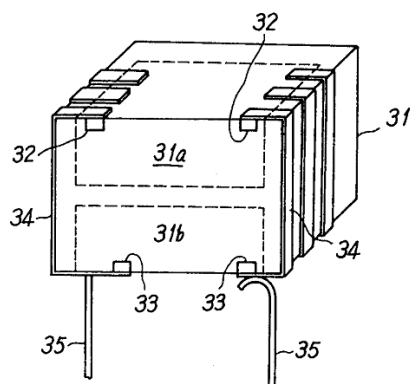


FIG. 4

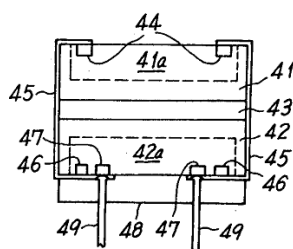


FIG. 5

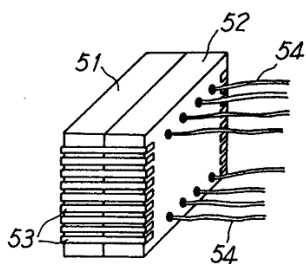


FIG. 6

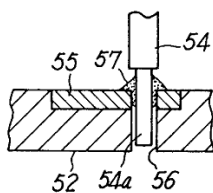
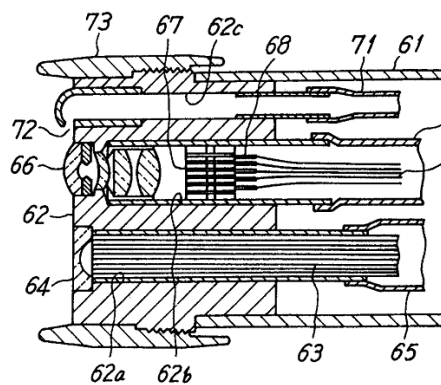


FIG. 7



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