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Image pickup unit and endoscope

Abstract

An image pickup unit includes an image sensor, a first circuit board on which a first land is disposed around four first side surfaces, a second circuit board on which a second land is disposed around four second side surfaces, a movement detection sensor housed in a recess of the first circuit board, and a rectangular tube bonded to the first land and the second land and sealing the recess in an airtight manner.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
6547721	12/2002	Higuma et al.	N/A	N/A
10511774	12/2018	Takeuchi	N/A	H04N 5/145
2004/0176661	12/2003	Futatsugi	N/A	N/A
2009/0078873	12/2008	Sakemoto et al.	N/A	N/A
2017/0255001	12/2016	Yamashita	N/A	A61B 1/051
2019/0038117	12/2018	Motohara	N/A	A61B 1/04
2020/0333581	12/2019	Kobayashi	N/A	G02B 23/2423

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
0 978 251	12/1999	EP	N/A
1 455 216	12/2003	EP	N/A
2000-115594	12/1999	JP	N/A
2000-225089	12/1999	JP	N/A
2002-159438	12/2001	JP	N/A
2004-267351	12/2003	JP	N/A
3955458	12/2006	JP	N/A
2010-016733	12/2009	JP	N/A
6574448	12/2018	JP	N/A
2017/195605	12/2016	WO	N/A
WO-2020218335	12/2019	WO	H01L 21/4853

OTHER PUBLICATIONS

International Search Report dated Jul. 13, 2021 received in PCT/JP2021/017419. cited by applicant

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION (1) This application is a continuation application of PCT/JP2021/017419 filed on May 6, 2021, the entire contents of which are incorporated herein by this reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

(1) The present invention relates to an image pickup unit in which an electronic component is disposed in a recess of a circuit board, and an endoscope including an image pickup unit in which an electronic component is disposed in a recess of a circuit board.

2. Description of the Related Art

(2) An endoscope is widely used in medical and industrial fields. An endoscope in which an electronic component other than an image pickup device is disposed at a distal end portion of an insertion portion to add a new function to the endoscope and increase performance has been developed.

(3) Japanese Patent No. 657448 discloses an endoscope configured to control focusing by detecting a relative moving amount with respect to an object by using a motion sensor disposed at a distal end portion of an insertion portion. The sensor is connected to a sensor cable for transmitting and receiving signals.

SUMMARY OF THE INVENTION

(4) An image pickup unit of an embodiment includes: an image sensor including a front surface and a back surface on which a back surface electrode is disposed; a first circuit board including a first principal surface on which a first electrode is disposed, a second principal surface on which a second electrode is disposed, and four first side surfaces, a first land being disposed around the four first side surfaces, the first electrode being bonded to the back surface electrode; a second circuit board including a third principal surface on which a third electrode is disposed, a fourth principal surface, and four second side surfaces, a second land being disposed around the four second side surfaces, the third electrode being bonded to the second electrode; an electronic component housed in a recess, at least one of the second principal surface or the third principal surface including the recess; and a rectangular tube bonded to the first land and the second land and sealing the recess in an airtight manner.

(5) An endoscope of an embodiment includes an image pickup unit, and the image pickup unit includes; an image sensor including a front surface and a back surface on which a back surface electrode is disposed; a first circuit board including a first principal surface on which a first electrode is disposed, a second principal surface on which a second electrode is disposed, and four first side surfaces, a first land being disposed around the four first side surfaces, the first electrode being bonded to the back surface electrode; a second circuit board including a third principal surface on which a third electrode is disposed, a fourth principal surface, and four second side surfaces, a second land being disposed around the four second side surfaces, the third electrode being bonded to the second electrode; an electronic component housed in a recess, at least one of the second principal surface or the third principal surface including the recess; and a rectangular tube bonded to the first land and the second land and sealing the recess in an airtight manner.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a perspective view of an image pickup unit according to a first embodiment;

(2) FIG. **2** is a cross-sectional view taken along line **11**-**11** in FIG. **1**;

(3) FIG. **3** is a perspective exploded view of the image pickup unit according to the first embodiment;

(4) FIG. **4** is a cross-sectional view of an image pickup unit of Modification 1 of the first embodiment;

(5) FIG. **5**A is a cross-sectional view of a rectangular tube of the image pickup unit according to the first embodiment:

(6) FIG. **5**B is a cross-sectional view of a rectangular tube of an image pickup unit of Modification 2 of the first embodiment;
(7) FIG. **5**C is a cross-sectional view of a rectangular tube of an image pickup unit of Modification 3 of the first embodiment;
(8) FIG. **5**D is a cross-sectional view of a rectangular tube of an image pickup unit of Modification 4 of the first embodiment;
(9) FIG. **6**A is a side view of a circuit board of an image pickup unit of Modification 5 of the first embodiment;
(10) FIG. **6**B is a side view of a circuit board of an image pickup unit of Modification 6 of the first embodiment;
(11) FIG. **6**C is a side view of a circuit board of an image pickup unit of Modification 7 of the first embodiment;
(12) FIG. **7** is an exterior diagram of an endoscope according to a second embodiment; and
(13) FIG. **8** is a cross-sectional view of a distal end portion of the endoscope according to the second embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

(14) An image pickup unit **1** according to the present embodiment illustrated in FIGS. **1**, **2**, and **3** includes a first ceramic circuit board **10**, a second ceramic circuit board **20**, an image sensor **30**, a rectangular tube **40**, a movement detection sensor **50** as an electronic component, and a cable **60**.
(15) Note that diagrams based on embodiments are schematic. A relation between thickness and width of each part, a thickness ratio of each part, and the like are different from those in reality. A dimensional relation and a ratio are different between parts of drawings. Illustration and reference sign provision of some constituent components are omitted. A side on which light is incident is referred to as “front”.
(16) The first ceramic circuit board **10** (hereinafter referred to as “first circuit board **10**”) and the second ceramic circuit board **20** (hereinafter referred to as “second circuit board **20**”) are stereoscopic circuit boards in which a plurality of ceramic wiring layers are stacked. Each ceramic circuit board is produced by stacking and baking a plurality of unbaked ceramic sheets each having surface wiring and through wiring.
(17) The first circuit board **10** has a first principal surface **10**SA, a second principal surface **10**SB opposite the first principal surface **10**SA, and four first side surfaces **10**SS**1** to **10**SS**4**. Hereinafter, each of the four first side surfaces **10**SS**1** to **10**SS**4** is referred to as a first side surface **10**SS. A principal surface is a surface orthogonal to an optical axis O, and a side surface is a surface parallel to the optical axis O.
(18) A plurality of first electrodes **17** are disposed on the first principal surface **10**SA. A plurality of second electrodes **18** are disposed on the second principal surface **10**SB.
(19) The second principal surface **10**SB has a recess R**10**. The recess R**10** is a groove reaching the two first side surfaces **10**SS**2** and **10**SS**4**. The recess R**10** may be a bottomed hole. An electronic component **51** such as a chip capacitor is mounted on a bottom surface of the recess R**10**. A first land **15** is disposed on the first circuit board **10** around the four first side surfaces **10**SS**1** to **10**SS**4** without discontinuity. Note that corners at which the four first side surfaces **10**SS**1** to **10**SS**4** intersect each other may be chamfered. Lands and electrodes made of a sintered electric conductor have high solder wettability.
(20) The second circuit board **20** includes a third principal surface **20**SA, a fourth principal surface **20**SB opposite the third principal surface **20**SA, and four second side surfaces **20**SS**1** to **20**SS**4**. Hereinafter, each of the four second side surfaces **20**SS**1** to **20**SS**4** is referred to as a second side surface **20**SS.
(21) A plurality of third electrodes **27** and a plurality of fourth electrodes **26** are disposed on the third principal surface **20**SA. The second circuit board **20** has a land side surface **20**SSL parallel to

the second side surface **20**SS**1** at a back part. A plurality of cable lands **28** are disposed on the land side surface **20**SSL. The cables **60** for the image sensor **30** or the movement detection sensor **50** to transmit and receive electric signals are bonded to the cable lands **28** by solder **76**. A second land **25** is disposed on the second circuit board **20** around the four second side surfaces **20**SS**1** to **20**SS**4** without discontinuity.

(22) Electrodes **57** of the movement detection sensor **50** as an electronic component are bonded to the plurality of fourth electrodes **26** by fourth solder **74**. The movement detection sensor **50** is, for example, a six-axis inertial measurement unit (IMU) constituted by a three-axis acceleration sensor and a three-axis gyro sensor. The acceleration sensor measures acceleration, and the gyro sensor measures angular velocity. The IMU is manufactured by an MEMS technology of simultaneously and collectively manufacturing, on a silicon wafer, a large number of components including a movable member such as a cantilever and a piezoelectric element or the like configured to detect change of the movable member. The movement detection sensor **50** may be, for example, the acceleration sensor or the gyro sensor.

(23) The second electrodes **18** on the second principal surface **10**SB of the first circuit board **10** are bonded to the third electrodes **27** on the third principal surface **20**SA of the second circuit board **20** by first solder **71**. When the first circuit board **10** and the second circuit board **20** are bonded to each other, a front part of the movement detection sensor **50** is disposed in the recess R**10** of the first circuit board **10**. Note that each first side surface **10**SS of the first circuit board **10** and the corresponding second side surface **20**SS of the second circuit board **20** are positioned on the same plane. In other words, when projected onto a virtual surface orthogonal to the optical axis O, a first projection image of the first principal surface **10**SA and a third projection image of the third principal surface **20**SA overlap each other.

(24) The image sensor **30** has a front surface **30**SA and a back surface **30**SB opposite the front surface **30**SA. A plurality of back surface electrodes **38** are disposed on the back surface **30**SB. The image sensor **30** includes an image pickup device **31**, a cover glass **33**, and a transparent resin layer **32** bonding the cover glass **33** to the image pickup device **31**. The back surface electrodes **38** connected to the image pickup device **31** via through wiring (not illustrated) are bonded to the first electrodes **17** of the first circuit board **10** by fifth solder **75**. The image pickup device **31** is, for example, a CCD element or a CMOS image pickup element. The image pickup device **31** may be a front-illuminated image sensor or a back-illuminated image sensor.

(25) One or more semiconductor elements configured to process image pickup signals may be stacked on a back surface of the image pickup device **31**, and the back surface electrodes **38** may be disposed on a back surface of each semiconductor element, which is the back surface **30**SB of the image sensor **30**.

(26) The rectangular tube **40** having a substantially rectangular cylindrical outer shape is a metal plate sealing the recess R**10** in an airtight manner. For example, the rectangular tube **40** is made of copper having a thickness of 50 μm to 100 μm. As illustrated in FIG. **5**A, a hollow of the rectangular tube **40** has a rectangular section orthogonal to the optical axis O. Comparison of projection images projected onto a virtual surface orthogonal to the optical axis O indicates that the hollow has a projection image slightly larger than the first projection image of the first principal surface **10**SA and the third projection image of the third principal surface **20**SA.

(27) A length (dimension in a direction parallel to the optical axis O) of the rectangular tube **40** is longer than a distance between the first land **15** of the first circuit board **10** and the second land **25** of the second circuit board **20**. Thus, the first land **15** and the second land **25** are covered by the rectangular tube **40**. Corners of inner and outer surfaces of the rectangular tube **40** may be chamfered.

(28) The inner surface of the rectangular tube **40** and the first land **15** are bonded to each other without a gap by second solder **72**A, and the inner surface of the rectangular tube **40** and the second land **25** are bonded to each other without a gap by second solder **72**B. Hereinafter, each of

the second solders **72**A and **72**B is referred to as a second solder **72**.
(29) The recess R**10** is sealed in an airtight manner by the rectangular tube **40**. Specifically, the first circuit board **10**, the second circuit board **20**, the rectangular tube **40**, and the second solders **72**A and **72**B form an airtight-sealing (hermetic seal) structure that blocks the recess R**10** from external air.
(30) A distal end portion of an insertion portion is affected by humidity and external air in sterilization processing as well as in use and storage. Thus, characteristics of an electronic component, which is likely to be affected by humidity and external air, potentially change and reliability of an endoscope degrades. Furthermore, in an endoscope including an electronic component at a distal end portion of an insertion portion, a cable for the electronic component needs to be disposed at the distal end portion having a small diameter, and thus manufacturing of the endoscope is complicated.
(31) The image pickup unit **1** includes the movement detection sensor **50** and thus has high performance. Ceramic and metal have extremely small moisture permeability and gas permeability. The movement detection sensor **50** is sealed by resin and thus swells due to influence of humidity or the like, and accordingly, the movable member inside is pressed, which potentially causes error to output values. However, since airtight sealing is provided by ceramic (the first circuit board **10** and the second circuit board **20**) and metal (the rectangular tube **40** and the second solders **72**A and **72**B), the influence of humidity or the like is reduced and occurrence of error in output values is reduced, and thus the image pickup unit **1** has high reliability. Moreover, since the rectangular tube **40** is a thin metal plate, a dimension of the image pickup unit **1** in a direction orthogonal to the optical axis does not increase when the image pickup unit **1** is provided with an airtight sealing function.
(32) In the image pickup unit **1**, the movement detection sensor **50** is integrated with the image sensor **30** and transmits and receives signals through the cables **60** bonded to the second circuit board **20**, and thus can be easily manufactured.
(33) The rectangular tube **40** is made of metal with high thermal conductivity and thus has a high heat-releasing effect. Note that a front part of the rectangular tube **40** may contact the image sensor **30** to efficiently release heat generated by the image sensor **30**. Moreover, the rectangular tube **40** is made of an electric conductor and thus also has an electromagnetic noise shielding effect.
(34) In a method of manufacturing the image pickup unit **1**, the movement detection sensor **50** is bonded to the second circuit board **20** by the fourth solder **74**. Then, the first circuit board **10** and the second circuit board **20** are bonded to each other by the first solder **71**. Then, the rectangular tube **40** is bonded to the first land **15** and the second land **25** by the second solders **72**A and **72**B.
(35) To prevent remelting of any bonded part already soldered, a melting point of the first solder **71** is preferably lower than a melting point of the fourth solder **74** and higher than a melting point of the second solders **72**A and **72**B. Note that the melting point of the first solder **71** is more preferably lower than the melting point of the fourth solder **74** and higher than the melting point of the second solders **72**A and **72**B.
(36) For example, a metal film such as copper may be disposed by using a plating method on electrodes and lands made of a sintered electric conductor. A solder ball, solder paste, or the like for bonding does not need to be disposed on electrodes and lands on which a solder film made of Sn or the like is disposed. In the first circuit board in which the recess R**10** is a bottomed hole, a width (dimension in the optical axis direction) of the first land **15** may be substantially equal to a width of each first side surface **10**SS. Voids of the solder film can be reduced by increasing the width of the first land **15**.
(37) The electronic component sealed in the recess R**10** is not limited to the movement detection sensor **50**. However, effects of the present invention are particularly significant when the electronic component is a sensor that includes a movable member and is likely to be affected by extremal air. As in the image pickup unit **1**, not only the movement detection sensor **50** but also the electronic

component **51** for signal processing at the image pickup device **31** may be housed in the recess R**10**.

(38) <Modifications of First Embodiment>

(39) Image pickup units **1**A to **1**C**3** according to Modifications 1 to 7 of the first embodiment are similar to the image pickup unit **1** and have the same effects, and thus any constituent component having the same function is denoted by the same reference sign and description of the constituent component is omitted.

(40) <Modification 1 of First Embodiment>

(41) A rectangular tube **40**A of the image pickup unit **1**A according to the present modification illustrated in FIG. **4** has a length (dimension in the optical axis direction) L shorter than the rectangular tube **40** and substantially equal to an interval between the first land **15** and the second land **25**.

(42) Side surfaces of the rectangular tube **40**A at both ends are bonded to the first land **15** and the second land **25** without a gap by the second solders **72**A and **72**B, respectively. Accordingly, the movement detection sensor **50** disposed in the recess R**10** is sealed in an airtight manner.

(43) Since an inner surface of the rectangular tube **40**A contacts the first side surfaces **10**SS and the second side surfaces **20**SS, the image pickup unit **1**A has a small outer dimension orthogonal to the optical axis O. Moreover, with the image pickup unit **1**A, it is easy to observe disposition of the second solders **72**A and **72**B and whether the rectangular tube **40**A is bonded without a gap by the second solders **72**A and **72**B.

(44) In the image pickup unit **1**A, the recess R**10** is filled with sealing resin **80**. The sealing resin **80** is, for example, epoxy resin, polyimide resin, benzocyclobutene (BCB) resin, or silicone resin.

(45) Since the recess R**10** is filled with the sealing resin **80**, the movement detection sensor **50** is unlikely to be affected by external air and thus the image pickup unit **1**A has higher reliability than the image pickup unit **1**. The sealing resin **80** may fill a gap between the second principal surface **10**SB and the third principal surface **20**SA and a gap between the inner surface of the rectangular tube **40**A and each of the first side surfaces **10**SS and the second side surfaces **20**SS. The image pickup unit **1** preferably includes the sealing resin **80** filling the recess R**10** or the like.

(46) <Modification 2 of First Embodiment>

(47) As illustrated in FIG. **5**B, a rectangular tube **40**B of the image pickup unit **1**B**1** according to the present modification includes four metal plates **41**A, **41**B, **41**C, and **41**D and third solder **73** bonding the metal plates **41**A, **41**B, **41**C, and **41**D.

(48) A method of manufacturing the rectangular tube **40**B will be briefly described below. The metal plate **41**A is bonded to the first land **15** on the first side surface **10**SS**1** and the second land **25** on the second side surface **20**SS**1** by using the second solders **72**A and **72**B. The metal plate **41**C is bonded to the first land **15** on the first side surface **10**SS**3** and the second land **25** on the second side surface **20**SS**3** by using the second solders **72**A and **72**B.

(49) Thereafter, the metal plate **41**B is bonded to the first land **15** on the first side surface **10**SS**2** and the second land **25** on the second side surface **20**SS**2** by using the second solders **72**A and **72**B. The metal plate **41**D is bonded to the first land **15** on the first side surface **10**SS**4** and the second land **25** on the second side surface **20**SS**4** by using the second solders **72**A and **72**B. Then, the four metal plates **41**A. **41**B, **41**C, and **41**D are bonded to each other by using the third solder **73**.

(50) <Modification 3 of First Embodiment>

(51) As illustrated in FIG. **5**C, a rectangular tube **40**C of the image pickup unit **1**B**2** according to the present modification includes four metal plates **41**E, **41**F, **41**G, and **41**H and the third solder **73** bonding the metal plates **41**E, **41**F, **41**G, and **41**H.

(52) A method of manufacturing the rectangular tube **40**C will be briefly described below. The metal plates **41**E, **41**F, **41**G, and **41**H are each bonded to the first land **15** of the first circuit board **10** and the second land **25** of the second circuit board **20** by using the second solders **72**A and **72**B. Then, the four metal plates **41**E, **41**F, **41**G, and **41**H are bonded to each other by using the third

solder **73**.
(53) <Modification 4 of First Embodiment>
(54) As illustrated in FIG. **5**C, a rectangular tube **40**D of the image pickup unit **1**B**3** according to the present modification includes two metal plates **41**J and **41**K having L-shaped sections orthogonal to the optical axis O, and the third solder **73** bonding the metal plates **41**J and **41**K.
(55) A method of manufacturing the rectangular tube **40**D will be briefly described below. The metal plate **41**J is bonded to the first land **15** on the first side surfaces **10**SS**1** and **10**SS**4** and the second land **25** on the second side surfaces **20**SS**1** and **20**SS**4** by using the second solders **72**A and **72**B. The metal plate **41**K is bonded to the first land **15** on the first side surfaces **10**SS**2** and **10**SS**3** and the second land **25** on the second side surfaces **20**SS**2** and **20**SS**3** by using the second solders **72**A and **72**B. Then, the two metal plates **41**J and **41**K are bonded to each other by using the third solder **73**.
(56) The image pickup units **1**B**1** to **1**B**3** including the rectangular tubes **40**B to **40**D in which a plurality of metal plates are bonded to each other without a gap by the third solder **73** can be more easily manufactured than the image pickup unit **1**. Note that each metal plate is not limited to a flat plate made of copper but only needs to be any plate that can be bonded by soldering. Each metal plate may have a U-shaped section.
(57) To prevent remelting of a bonded part already soldered, a melting point of each second solder **72** is preferably lower than the melting point of the first solder **71** and higher than a melting point of the third solder **73**. Note that the melting point of each second solder **72** is more preferably lower than the melting point of the first solder **71** and higher than the melting point of the third solder **73**.
(58) <Modification 5 of First Embodiment>
(59) In the image pickup unit **1**C**1** according to the present modification illustrated in FIG. **6**A, a first circuit board **10**A has the recess R**10** and a second circuit board **20**A has a recess R**20**.
(60) <Modification 6 of First Embodiment>
(61) In the image pickup unit **1**C**2** according to the present modification illustrated in FIG. **6**B, a first circuit board **10**B has no recess and a second circuit board **20**B has the recess R**20**. Side surfaces **20**SSP of the second circuit board **20**B protrude by a step D as compared to the second side surfaces **20**SS**2** on which the second land **25** is disposed.
(62) The step D is set to thicknesses of the second solders **72**A and **72**B. The first land **15** of the first circuit board **10**B has the same dimensions as dimensions of the second land **25**. Thus, although not illustrated, when the rectangular tube **40** is bonded to the first land **15** and the second land **25** by the second solders **72**A and **72**B, the inner surface of the rectangular tube **40** contacts the four side surfaces **20**SSP, and accordingly, the image pickup unit **1**C**2** has a small outer dimension orthogonal to the optical axis.
(63) <Modification 7 of First Embodiment>
(64) In the image pickup unit **1**C**3** according to the present modification illustrated in FIG. **6**C, a first circuit board **10**C has a circuit board **10**C**1** bonded to a tubular circuit board **10**C**2**. Specifically, a recess R**10**C is formed by the tubular circuit board **10**C**2**. The tubular circuit board **10**C**2** may be bonded to a second circuit board **20**C. The tubular circuit board may be bonded to each of the first circuit board and the second circuit board.
(65) In the image pickup unit **1**C**3**, a spacer member **19**, such as a heat contraction tube, having a thickness D**1** and surrounding an outer periphery of the tubular circuit board **10**C**2** is disposed on the tubular circuit board **10**C**2**. The thickness D**1** is set to the thicknesses of the second solders **72**A and **72**B. Since the inner surface of the rectangular tube contacts the spacer member **19**, the image pickup unit **1**C**3** has a small outer dimension orthogonal to the optical axis.
(66) As described for the image pickup units **1**C**1** to **1**C**3** according to Modifications 5 to 7, in each image pickup unit of the present invention, at least one of the second principal surface or the third principal surface needs to have a recess in which an electronic component is disposed and that is sealed in an airtight manner. The recess may be constituted by a tubular circuit board separated

from the first circuit board and the second circuit board. Moreover, the inner surface of the rectangular tube **40** may contact the side surfaces of the circuit boards.
(67) Note that each image pickup unit of the present invention may include two or more configurations of the image pickup units **1**A to **1**C**3** according to Modifications 1 to 7. For example, the second circuit board of the image pickup unit **1**A according to Modification 1 may have a recess as in the image pickup unit **1**C**1** according to Modification 5.
Second Embodiment
(68) An endoscope **9** according to the present embodiment illustrated in FIGS. **7** and **8** includes an insertion portion **9**B in which the image pickup unit **1** is disposed at a distal end portion **9**A, an operation portion **9**C disposed on a proximal end side of the insertion portion **9**B, and a universal code **9**D extending from the operation portion **9**C.
(69) As illustrated in FIG. **8**, a lens unit **2** in which a plurality of optical elements are stacked is bonded to the front surface **30**SA of the image pickup unit **1** by using transparent resin **3**. The image pickup unit **1** is inserted into a through-hole of the distal end portion **9**A. A through-hole H**9** as a treatment instrument channel is formed in the distal end portion **9**A.
(70) The lens unit **2** is, for example, a hybrid lens unit including a plano-concave lens, a convexo-plane lens, a convexo-convex lens, an infrared cut filter, a flare aperture, a brightness aperture, and the like. The lens unit **2** forms, on the image pickup device **31**, an image of light incident from a front surface **2**SA. The lens unit **2** has a configuration that is set as appropriate in accordance with specifications.
(71) As described above, the image pickup unit **1** includes the movement detection sensor **50** and thus has high performance. The movement detection sensor **50** including a movable member is likely to be affected by humidity or the like but is sealed in an airtight manner by ceramic (the first circuit board **10** and the second circuit board **20**) and metal (the rectangular tube **40** and the second solders **72**A and **72**B). Moreover, the dimension of the image pickup unit **1** in the direction orthogonal to the optical axis does not increase when the image pickup unit **1** is provided with an airtight sealing function.
(72) The endoscope **9** includes the image pickup unit **1** and thus has high performance and high reliability and includes a small-diameter distal end portion. Moreover, the image pickup unit **1** can be easily manufactured since the movement detection sensor **50** is integrated with the image sensor **30**.
(73) It should be clear that an endoscope including any of the image pickup units **1**A to **1**C**3** according to Modifications 1 to 6 at the distal end portion has effects of the endoscope **9** including the image pickup unit **1** as well as the effects of the relevant image pickup unit.
(74) The endoscope may be a flexible endoscope including a flexible insertion portion or may be a rigid endoscope including a rigid insertion portion. The endoscope may be used in medical and industrial fields.
(75) The present invention is not limited to the above-described embodiments and modifications but may be changed and modified in various kinds of manners without changing the scope of the invention.

Claims

1. An image pickup unit comprising: an image sensor including a back surface on which a back surface electrode is disposed; a first circuit board including: a first principal surface on which a first electrode is disposed, the first electrode being bonded to the back surface electrode; a second principal surface on which a second electrode is disposed, and a first side surface; a second circuit board including: a third principal surface on which a third electrode is disposed, the third electrode being bonded to the second electrode; and a second side surface; an electronic component housed in a recess, at least one of the second principal surface or the third principal surface including the

recess; and a tube bonded to each of the first land and the second land to seal the recess in an airtight manner.

2. The image pickup unit according to claim 1, wherein the electronic component is a movement detection sensor.

3. The image pickup unit according to claim 1, wherein the first circuit board includes a first land disposed on the first side surface, the second circuit board includes a second land disposed on the second side surface, the second and the third electrodes are bonded to each other by first solder, and each of the first and the second lands are bonded to the tube by second solder.

4. The image pickup unit according to claim 3, wherein the tube is a rectangular tube comprising a plurality of plates and third solder bonding the plurality of plates.

5. The image pickup unit according to claim 4, wherein a melting point of the second solder is lower than a melting point of the first solder and higher than a melting point of the third solder.

6. The image pickup unit according to claim 1, further comprising sealing resin filling the recess.

7. The image pickup unit according to claim 6, wherein the sealing resin fills a gap between an inner surface of the tube and each of the first and the second side surfaces.

8. An endoscope comprising: an image pickup unit comprising: an image sensor including a back surface on which a back surface electrode is disposed; a first circuit board including: a first principal surface on which a first electrode is disposed, the first electrode being bonded to the back surface electrode; a second principal surface on which a second electrode is disposed, and a first side surface; a second circuit board including: a third principal surface on which a third electrode is disposed, the third electrode being bonded to the second electrode; and a second side surface; an electronic component housed in a recess, at least one of the second principal surface or the third principal surface including the recess; and a tube bonded to each of the first land and the second land to seal the recess in an airtight manner.

9. The image pickup unit according to claim 2, wherein the first and the second circuit boards are each formed of ceramic and the tube is formed of metal.

10. The image pickup unit according to claim 3, wherein the first land is distal to the recess and the second land is proximal to the recess.

11. The image pickup unit according to claim 3, wherein the first and the second side surfaces each extend in a longitudinal direction and the first and the second lands have a width in the longitudinal direction less than a width of the first and the second side surfaces in the longitudinal direction.

12. The image pickup unit according to claim 1, wherein the second circuit board further comprising a plurality of cable connection electrodes.

13. The image pickup unit according to claim 1, wherein the electronic component is a first electronic component, the image pickup unit further comprising one or more second electronic components for processing an image signal from the image sensor, the one or more second electronic components being disposed in the recess.

14. The image pickup unit according to claim 13, wherein the recess comprising first and second recess portions, the first recess portion being larger than the second recess portion, the first electronic component being disposed in the first recess portion, the one or more second electronic components being disposed in the second recess portion.

15. The image pickup unit according to claim 14, wherein the second recess portion is closer to the image sensor than the first recess portion.

16. The image pickup unit according to claim 1, wherein a portion of the recess is disposed on each of the second and the third principal surfaces.

17. The image pickup unit according to claim 3, wherein the first side surface comprises four first side surfaces; the second side surface comprises four second side surfaces; the first land is disposed on at least one of the four first side surfaces; the second land is disposed on at least one of the four second side surfaces; and the tube is a rectangular tube having a rectangular shape in a cross-section orthogonal to a longitudinal axis direction.

18. The image pickup unit according to claim 17, wherein the recess is in communication with a gap between the second and the third principal surfaces; and the rectangular tube is configured to cover the gap and at least a portion of each of the four first and the four second side surfaces.
19. The image pickup unit according to claim 18, the rectangular tube extends in the longitudinal axis direction to cover at least the portion of each of the four first and the four second side surfaces such that the rectangular tube is bonded to each of the first and the second lands.
20. The image pickup unit according to claim 19, wherein each of the first and the second lands are disposed around the four first and the four second side surfaces, respectively, without a discontinuity.