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Photoelectric conversion device, method for producing the same, and appliance

Abstract

A photoelectric conversion device in which first and second substrates are bonded to each other is provided. The first substrate includes a first semiconductor layer having light receiving elements. The second substrate includes a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements. The photoelectric conversion device includes an electrode pad for external connection, an opening extending to the electrode pad, and a conductive pattern located between the first and second semiconductor layers. The conductive pattern includes wiring members that are used to drive the photoelectric conversion device and dummy members that are not used to drive the photoelectric conversion device. The dummy members include a dummy member located on an outer side relative to the opening in a plan view relative to a boundary between the first and second substrates.

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Background/Summary

BACKGROUND OF THE INVENTION

Field of the Invention

(1) The present disclosure relates to a photoelectric conversion device, a method for producing the same, and an appliance.

Description of the Related Art

(2) A technique for forming a semiconductor device by sticking two semiconductor substrates together and electrically connecting the semiconductor substrates is known. Japanese Patent Laid-Open No. 2017-120939 discloses a photoelectric conversion device that is formed by sticking together a pixel substrate in which light receiving elements are formed and a circuit substrate in which a signal processing circuit is formed. Japanese Patent Laid-Open No. 11-265866 discloses a method for providing dummy wiring for improving the flatness of a wiring layer.

SUMMARY OF THE INVENTION

(3) In the case where a photoelectric conversion device is formed by bonding two substrates, if the flatness of the bonding surfaces is low, the bondability between the two substrates may be low. Also, if the bondability of a scribing region, which is cut during dicing, is low, due to the stress applied during dicing, the bonding surfaces may be separated. Accordingly, the entire substrates, including not only a region in which circuits are disposed, but also a region in which circuits are not disposed, are required to have a high bondability. One aspect of the present disclosure provides a technique for improving the bondability between two substrates included in a photoelectric conversion device.

(4) According to some embodiments, a photoelectric conversion device in which a first substrate and a second substrate are bonded to each other is provided. The first substrate includes a first semiconductor layer having light receiving elements, and the second substrate includes a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements. The photoelectric conversion device includes: an electrode pad for external connection; an opening extending to the electrode pad; and a conductive pattern located between the first semiconductor layer and the second semiconductor layer. The conductive pattern includes a plurality of wiring members that are used to drive the photoelectric conversion device and a plurality of dummy members that are not used to drive the photoelectric conversion device. The plurality of dummy members include a dummy member located on an outer side relative to the opening in a plan view relative to a boundary between the first substrate and the second substrate.

(5) Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

Description

BRIEF DESCRIPTION OF THE DRAWINGS

- (1) FIG. 1 is a diagram illustrating an example of a structure of a photoelectric conversion device according to a first embodiment.
- (2) FIGS. 2A to 2C are diagrams illustrating examples of a planar layout of the photoelectric conversion device according to the first embodiment.
- (3) FIGS. 3A to 3D are diagrams illustrating an example of a production method for producing the photoelectric conversion device according to the first embodiment.
- (4) FIGS. 4A and 4B are diagrams illustrating the example of the production method for producing the photoelectric conversion device according to the first embodiment.
- (5) FIGS. 5A and 5B are diagrams illustrating the example of the production method for producing the photoelectric conversion device according to the first embodiment.
- (6) FIGS. 6A to 6C are diagrams illustrating an example of a structure of a photoelectric conversion device according to a comparative example.
- (7) FIG. 7 is a diagram illustrating an example of a structure of a photoelectric conversion device according to a second embodiment.
- (8) FIGS. 8A to 8C are diagrams illustrating an example of a configuration of an appliance according to a third embodiment.

DESCRIPTION OF THE EMBODIMENTS

(9) Hereinafter, embodiments will be described in detail with reference to the attached drawings. Note, the following embodiments are not intended to limit the scope of the claimed invention. Multiple features are described in the embodiments, but limitation is not made to an invention that requires all such features, and multiple such features may be combined as appropriate. Furthermore, in the attached drawings, the same reference numerals are given to the same or similar configurations, and redundant description thereof is omitted.

First Embodiment

- (10) An example of a structure of a photoelectric conversion device **100** according to a first embodiment of the present invention will be described with reference to FIG. 1. FIG. 1 is a cross-sectional view of the photoelectric conversion device **100**, showing mainly a portion close to a side surface **109** of the photoelectric conversion device **100**. The photoelectric conversion device **100** includes a pixel substrate **101** and a circuit substrate **102**. The pixel substrate **101** and the circuit substrate **102** are superposed on each other, and the pixel substrate **101** and the circuit substrate **102** are bonded at a boundary **103** between the pixel substrate **101** and the circuit substrate **102**. As used herein, the term “bond” means that the state in which the pixel substrate **101** and the circuit substrate **102** are superposed on each other is maintained, and may be expressed as “stick together” according to a specific bonding method.
- (11) Hereinafter, a description will be given mainly on an embodiment in which the photoelectric conversion device **100** is used to capture images. In this case, the photoelectric conversion device **100** can be used as an imaging element (image sensor) for producing images. Other examples of the photoelectric conversion device **100** include a distance measurement element (a sensor that is used for focus detection, distance measurement that uses TOF (Time Of Flight), or the like), a photometric element (a sensor that is used to measure the amount of incident light, or the like), a LiDAR (Light Detection and Ranging) sensor, and the like. The embodiment described below can be applied to photoelectric conversion devices in general.
- (12) The photoelectric conversion device **100** includes, as viewed in a plan view relative to the boundary **103**, a light receiving region **104**, a peripheral region **105**, an opening region **106**, and an outer circumferential region **107**. The light receiving region **104** is a region in which a plurality of light receiving elements **108** are arranged. FIG. 1 illustrates an example in which the light receiving

elements **108** are SPAD (Single Photon Avalanche Diode) sensors. Alternatively, the light receiving elements **108** may be sensors with other structures such as, for example, CMOS (Complementary Metal Oxide Semiconductor) sensors. The opening region **106** is a region in which an opening **110** that extends to an electrode pad **111** for external connection is formed. The peripheral region **105** is a region that is provided between the light receiving region **104** and the opening region **106**. The outer circumferential region **107** is a region that is provided outside the opening region **106**. The outer circumferential region **107** includes a side surface **109** of the photoelectric conversion device **100**. The peripheral region **105** and the outer circumferential region **107** do not necessarily need to include circuit elements that are used to drive the photoelectric conversion device **100**.

(13) The pixel substrate **101** includes an optical layer **120**, a semiconductor layer **130**, a wiring layer **140**, and a bonding layer **150**. A bonding surface **101A** of the pixel substrate **101** is bonded to the circuit substrate **102**. Hereinafter, a configuration of each of the layers included in the pixel substrate **101** will be described specifically.

(14) The semiconductor layer **130** includes a semiconductor substrate **131** in which the plurality of light receiving elements **108** are formed. The semiconductor substrate **131** is made using, for example, silicon as a material. The semiconductor substrate **131** includes impurity regions **132** and **133**. The impurity region **132** functions as the anode for the SPAD sensors. The impurity region **133** functions as the cathode for the SPAD sensors. As described above, the light receiving elements **108** are configured with the impurity regions **132** and **133**. A voltage with a large difference from the ground potential (for example, a voltage of about -30 V) is applied to the impurity region **132** (anode) when the SPAD sensors are driven. On the other hand, a voltage of about 1 V is applied to the impurity region **133** (cathode). The voltages applied to the impurity regions are not limited to these values as long as the values are those for which avalanche multiplication is possible in the light receiving elements **108**. For example, a voltage of 0 V may be applied to the anode, and a voltage of about 30 V may be applied to the cathode.

(15) There are two modes in the case where a reverse bias voltage is applied: a geiger mode in which an operation is performed in a state in which the potential difference between the anode and the cathode is larger than a breakdown voltage; and a linear mode in which an operation is performed in a state in which the potential difference between the anode and the cathode is near the breakdown voltage, or lower than the breakdown voltage. APDs that are operated in the geiger mode are called SPADs. APDs require a large voltage as compared with photodiodes that do not perform avalanche multiplication. The light receiving elements **108** of the present embodiment may be operated in the linear mode or in the geiger mode. SPADs are advantageous in that the potential difference is larger as compared with the APDs operated in the linear mode, and a significant withstand voltage effect is obtained.

(16) The wiring layer **140** includes an interlayer insulating film **141**, a plurality of conductive patterns **142** to **144** that are embedded in the interlayer insulating film **141**, and a plurality of vias **147**. Each of the plurality of vias **147** connects different conductive patterns to each other, or connects a conductive pattern and an impurity region to each other. In the example shown in FIG. **1**, three conductive patterns **142** to **144** are shown, but the number of conductive patterns is not limited thereto. Among the three conductive patterns **142** to **144**, the conductive pattern **144** is the closest to the boundary **103**, the conductive pattern **143** is the second closest to the boundary **103**, and the conductive pattern **142** is the third closest to the boundary **103** (or in other words, most distant from the boundary **103**). In other words, the conductive pattern **143** is more distant from the boundary **103** than the conductive pattern **144**, and the conductive pattern **142** is more distant from the boundary **103** than the conductive pattern **143**. The conductive patterns **142** to **144** may be made using aluminum as a material.

(17) Each of the conductive patterns **142** to **144** includes a plurality of conductive members that are used to drive the photoelectric conversion device **100** and a plurality of conductive members that are not used to drive the photoelectric conversion device **100**. As used herein, the expression “a

plurality of conductive members that are used to drive the photoelectric conversion device **100**" may refer to conductive members that are used to transmit signals or supply electric power to drive the photoelectric conversion device **100**. The expression "a plurality of conductive members that are not used to drive the photoelectric conversion device **100**" may refer to conductive members that are not used to transmit signals or supply electric power to drive the photoelectric conversion device **100**.

(18) Hereinafter, the conductive members that are used to drive the photoelectric conversion device **100** will be referred to as "wiring members **146**", and the conductive members that are not used to drive the photoelectric conversion device **100** will be referred to as "dummy members **145**". In the description given below, the term "wiring member **146**" may be used as a collective term for a plurality of wiring members, and thus subscripts may be used to distinguish individual wiring members such as **146a**. Likewise, the term "dummy member **145**" may be used as a collective term for a plurality of dummy members, and thus subscripts may be used to distinguish individual dummy members such as **145a**. In FIG. 1, out of the members included in the plurality of conductive patterns **142** to **144**, those that are connected to the vias **147** are wiring members **146**, and those that are not connected to the vias **147** are dummy members **145**.

(19) The plurality of wiring members **146** include wiring members **146a** that are electrically connected to the impurity region **132** (anode) and wiring members **146b** that are electrically connected to the impurity region **133** (cathode). The wiring members **146a** and the wiring members **146b** are both included in the conductive pattern **142** that is the closest to the semiconductor layer **130** among the plurality of conductive patterns **142** to **144**.

(20) The conductive pattern **142** and the conductive pattern **143** may have the same planar layout. By stacking conductive patterns that have the same planar layout, and connecting the conductive patterns to each other using vias, wiring resistance can be reduced while the thickness of the conductive patterns is kept at a thickness that can be micromachined. In the case where the light receiving elements **108** are SPAD sensors that require a large current, it is advantageous to reduce the wiring resistance as described above. The number of conductive patterns that have the same planar layout may be two as in the present embodiment, or may be more than two.

(21) A plurality of dummy members **145** in the plurality of conductive patterns **142** to **144** include, as viewed in a plan view relative to the boundary **103**, dummy members that are provided on the outer side relative to the opening **110** (for example, dummy members **145a** that are provided in the outer circumferential region **107**). Furthermore, the plurality of dummy members **145** in the plurality of conductive patterns **142** to **144** may include, as viewed in a plan view relative to the boundary **103**, dummy members that are provided on the inner side relative to the opening **110** (for example, dummy members **145b** that are provided in the peripheral region **105**). The conductive pattern **144** further includes an electrode pad **111** for external connection. As described above, the electrode pad **111** is exposed to outside through the opening **110**. A bonding wire is connected to the electrode pad **111** when the photoelectric conversion device **100** is packaged.

(22) The electrode pad **111** may be made using aluminum as a material so that wire bonding can be performed. Other members (for example, the wiring members **146** and the dummy members **145**) included in the conductive pattern **144** may also be made using aluminum as a material. In doing so, all of the members included in the conductive pattern **144** can be collectively processed. As a result, the number of steps included in the production method for producing the photoelectric conversion device **100** can be reduced.

(23) In the photoelectric conversion device **100**, the electrode pad **111** is formed in the pixel substrate **101**. Accordingly, electric power can be supplied from the electrode pad **111** to the impurity region **132** (anode) via the wiring members **146a** (anode connecting members) without the electric power flowing through the circuit substrate **102**. In an SPAD sensor, a high voltage of about -30 V that is a voltage with a large difference from the ground potential is applied to the anode. There is no need to provide a signal path for applying a high voltage as described above in

the circuit substrate **102**, and thus the degree of freedom in the circuit layout of the circuit substrate **102** is improved.

(24) The wiring layer **140** may further include an annular moisture-resistant ring **113** that surrounds the opening **110**. FIG. **1** shows only a portion of the moisture-resistant ring **113** that is located on the outer side relative to the opening **110**. The plurality of dummy members **145** in the plurality of conductive patterns **142** to **144** may include, as viewed in a plan view relative to the boundary **103**, dummy members that are provided on the outer side relative to the moisture-resistant ring **113** (dummy members **145a** that are provided between the moisture-resistant ring **113** and the side surface **109**).

(25) The bonding layer **150** includes vias **151**, a barrier film **152**, a bonding film **153**, and a plurality of electrodes. The plurality of electrodes face the boundary **103**. The plurality of electrodes include a plurality of electrodes that are used to drive the photoelectric conversion device **100** and a plurality of electrodes that are not used to drive the photoelectric conversion device **100**. Hereinafter, the electrodes that are used to drive the photoelectric conversion device **100** will be referred to as “wiring electrodes **154**”, and the electrodes that are not used to drive the photoelectric conversion device **100** will be referred to as “dummy electrodes **155**”. In FIG. **1**, out of the plurality of electrodes that face the boundary **103**, those that are connected to the vias **151** are wiring electrodes **154**, and those that are not connected to the vias **151** are dummy electrodes **155**. The vias **151** connect the wiring electrodes **154** to the conductive pattern **144**. The wiring electrodes **154**, the dummy electrodes **155**, and the vias **151** are made using, for example, copper as a material.

(26) The bonding film **153** is disposed around the plurality of electrodes, and insulates the plurality of electrodes from each other. The bonding film **153** faces the boundary **103**. The bonding film **153** is made using, for example, an oxide as a material. The barrier film **152** is provided between the wiring layer **140** and the bonding film **153**. The barrier film **152** is made using, for example, a nitride as a material. The barrier film **152** prevents copper that is used as the electrode material, from diffusing into the semiconductor layer **130**.

(27) The optical layer **120** includes an optical interlayer film **122**, optical separation members **125**, a color filter interlayer film **121**, a color filter **124**, and microlenses **123**. The optical separation members **125** are embedded in the optical interlayer film **122**. Each optical separation member **125** suppresses color mixing between adjacent light receiving elements **108**. The color filter **124** is embedded in the color filter interlayer film **121**. The microlenses **123** condensate incident light from the optical layer **120** (the upper side in FIG. **1**) to the light receiving elements **108**.

(28) The circuit substrate **102** includes a semiconductor layer **180**, a wiring layer **170**, and a bonding layer **160**. A bonding surface **102A** of the circuit substrate **102** is bonded to the pixel substrate **101**. The circuit substrate **102** includes a signal processing circuit for processing signals generated by the light receiving elements **108**. The signal processing circuit includes circuit elements (for example, transistors) for processing signals generated by the light receiving elements **108**.

(29) The semiconductor layer **180** includes a semiconductor substrate **181**. The semiconductor substrate **181** is made using, for example, silicon as a material. An impurity region **182** is formed in the semiconductor substrate **181**. Also, gate electrodes **183** are formed to cover portions of the surface of the semiconductor substrate **181**.

(30) The wiring layer **170** includes an interlayer insulating film **171**, a plurality of conductive patterns **172** to **174** that are embedded in the interlayer insulating film **171**, and a plurality of vias. The wiring layer **170** has the same configuration as that of the wiring layer **140**, except that the electrode pad **111** is not included. In the wiring layer **170** as well, each of the plurality of conductive patterns **172** to **174** includes a plurality of conductive members (wiring members **176**) that are used to drive the photoelectric conversion device **100** and a plurality of conductive members (dummy members **175**) that are not used to drive the photoelectric conversion device **100**.

Also, the plurality of dummy members **175** in the plurality of conductive patterns **172** to **174** include, as viewed in a plan view relative to the boundary **103**, dummy members that are provided on the outer side relative to the opening **110**. The plurality of dummy members **175** in the plurality of conductive patterns **172** to **174** include, as viewed in a plan view relative to the boundary **103**, dummy members that are provided on the inner side relative to the opening **110**.

(31) As with the wiring layer **140**, the wiring layer **170** may further include a moisture-resistant ring **114**. FIG. **1** shows only a portion of the moisture-resistant ring **114**. The plurality of dummy members **175** in the plurality of conductive patterns **172** to **174** may include, as viewed in a plan view relative to the boundary **103**, dummy members that are provided on the outer side relative to the moisture-resistant ring **114** (dummy members that are provided between the moisture-resistant ring **114** and the side surface **109**).

(32) The bonding layer **160** includes a bonding film **161**, a barrier film **162**, and a plurality of electrodes. The plurality of electrodes include a plurality of electrodes (wiring electrodes **163**) that are used to drive the photoelectric conversion device **100** and a plurality of electrodes (dummy electrodes **164**) that are not used to drive the photoelectric conversion device **100**. The bonding layer **160** has the same configuration as that of the bonding layer **150**, and thus a redundant description is omitted.

(33) The pixel substrate **101** and the circuit substrate **102** are bonded to each other as a result of the bonding film **153** and the bonding film **161** being bonded, the wiring electrodes **154** and the wiring electrodes **163** being bonded, and the dummy electrodes **155** and the dummy electrodes **164** being bonded.

(34) In the pixel substrate **101**, the plurality of conductive patterns **142** to **144** include the dummy members **145**, and thus, as will be described later, the flatness of the bonding surface **101A** of the pixel substrate **101** is improved. Likewise, in the circuit substrate **102**, the plurality of conductive patterns **172** to **174** include the dummy members **175**, and thus the flatness of the bonding surface **102A** of the circuit substrate **102** is also improved. For this reason, the bondability at the boundary **103** when the pixel substrate **101** and the circuit substrate **102** are bonded is improved, and gaps formed between the pixel substrate **101** and the circuit substrate **102** can be reduced. For this reason, it is possible to, for example, suppress the occurrence of cracks due to the load applied when wire bonding is performed on the electrode pad **111**.

(35) At least one of the dummy electrodes **155** is disposed at an overlapping position with the electrode pad **111** as viewed in a plan view relative to the boundary **103**. By disposing at least one dummy electrode **155** as described above, the bondability between the two substrates is further improved, and the bonding strength between the pixel substrate **101** and the circuit substrate **102** in the opening region **106** is further improved. In another embodiment, at least one dummy electrode **155** does not necessarily need to be disposed at an overlapping position with the electrode pad **111**.

(36) Furthermore, at least one of the dummy members **175** of the circuit substrate **102** is disposed at an overlapping position with the electrode pad **111** as viewed in a plan view relative to the boundary **103**. By disposing at least one dummy member **175** as described above, the bondability between the two substrates is further improved. In another embodiment, at least one dummy member **175** does not necessarily need to be disposed at an overlapping position with the electrode pad **111**.

(37) The planar layouts of the conductive patterns **142** to **144** will be described with reference to FIGS. **2A** to **2C**. As described above, the planar layout of the conductive pattern **142** and the planar layout of the conductive pattern **143** may be the same, and thus a description of the planar layout of the conductive pattern **143** is omitted in the following description. In FIGS. **2A** to **2C**, out of the dummy members **145**, those that are included in the conductive pattern **144** will be referred to as “dummy members **200**”, and those that are included in the conductive pattern **142** will be referred to as “dummy members **201**”.

(38) As shown in FIGS. **2A** to **2C**, the plurality of dummy electrodes **155**, the plurality of dummy

members **200**, and the plurality of dummy members **201** are disposed in a periodic lattice configuration. By disposing the dummy members in a periodic lattice configuration as described above, the dummy electrodes or the dummy members can be mechanically arranged. In FIG. **2A**, the dummy electrodes **155**, the dummy members **200**, and the dummy members **201** each have a square shape as viewed in a plan view relative to the boundary **103**.

(39) Each dummy electrode **155** has a width **202** (a side length in the case where the dummy electrodes **155** have a square shape) in a range of, for example, $2.7\ \mu\text{m}$ to $3.3\ \mu\text{m}$, and may have a width **202** of, for example, $3.0\ \mu\text{m}$. An arrangement pitch **205** between the plurality of dummy electrodes **155** is in a range of, for example, $6.0\ \mu\text{m}$ to $6.8\ \mu\text{m}$, and may be, for example, $6.39\ \mu\text{m}$.

(40) Each dummy member **200** has a width **203** (a side length in the case where the dummy members **200** have a square shape) in a range of, for example, $2.0\ \mu\text{m}$ to $2.4\ \mu\text{m}$, and may have a width **203** of, for example, $2.2\ \mu\text{m}$. An arrangement pitch **206** between the plurality of dummy members **200** is in a range of, for example, $3.5\ \mu\text{m}$ to $4.1\ \mu\text{m}$, and may be, for example, $3.8\ \mu\text{m}$.

(41) Each dummy member **201** has a width **204** (a side length in the case where the dummy members **201** have a square shape) in a range of, for example, $2.0\ \mu\text{m}$ to $2.4\ \mu\text{m}$, and may have a width **204** of, for example, $2.2\ \mu\text{m}$. An arrangement pitch **207** between the plurality of dummy members **201** is in a range of, for example, $4.5\ \mu\text{m}$ to $5.5\ \mu\text{m}$, and may be, for example, $5.0\ \mu\text{m}$.

(42) In general, the arrangement pitch **205** may be larger than the arrangement pitch **206**.

Alternatively, the arrangement pitch **205** may be less than or equal to the arrangement pitch **206**.

The arrangement pitch **205** may be larger than the arrangement pitch **207**. Alternatively, the arrangement pitch **205** may be less than or equal to the arrangement pitch **207**. The arrangement pitch **206** may be larger than the arrangement pitch **207**. Alternatively, the arrangement pitch **206** may be less than or equal to the arrangement pitch **207**. The arrangement pitch between the plurality of dummy members **145** of the conductive pattern **142** may be equal to the arrangement pitch between the plurality of dummy members **145** of the conductive pattern **143**. At least one of the arrangement pitch **206** and the arrangement pitch **207** may be smaller than an arrangement pitch **112** between the plurality of light receiving elements **108**.

(43) In general, each dummy electrode **155** may have an area larger than the area of each dummy member **200** as viewed in a plan view relative to the boundary **103**. Alternatively, each dummy electrode **155** may have an area less than or equal to the area of each dummy member **200**. Each dummy member **200** may have an area equal to the area of each dummy member **201** as viewed in a plan view relative to the boundary **103**. Alternatively, each dummy member **200** may have an area different from the area of each dummy member **201**.

(44) In general, as viewed in a plan view relative to the boundary **103**, the area density of the plurality of dummy members **200** included in the conductive pattern **144** may be smaller than the area density of the plurality of dummy members **201** included in the conductive pattern **143**. As viewed in a plan view relative to the boundary **103**, the area density of the dummy members **201** included in the conductive pattern **143** may be substantially equal to the area density of the wiring members **146** included in the conductive pattern **143** (for example, with an error of less than 5%). By configuring the dummy members **201** and the wiring members **146** to have substantially the same area density, the flatness of the upper surface of the wiring layer **140** can be further improved. Alternatively, the dummy members **201** and the wiring members **146** do not necessarily need to have substantially the same area density. For example, the area density of the dummy members **201** included in the conductive pattern **143** may be larger than the area density of the wiring members **146** included in the same conductive pattern **143**. In this case, intrusion light entering from the side surface **109** and passing through the wiring layer **140** can be easily suppressed by the dummy members **201**. Conversely, the area density of the dummy members **201** included in the conductive pattern **143** may be smaller than the area density of the wiring member **146** included in the same conductive pattern **143**. In this case, the wiring layer **140** in the light receiving region **104** is thicker than the wiring layer **140** in other regions. For this reason, the bondability of the wiring electrodes

154 of the pixel substrate **101** with the wiring electrodes **163** of the circuit substrate **102** is improved. The same relationship may be established between the area density of the dummy members **200** included in the conductive pattern **144** and the area density of the wiring members **146** included in the same conductive pattern **144**.

(45) The plurality of dummy members **200** may include dummy members (for example, dummy members **200b**) that each entirely overlap any one of the plurality of dummy electrodes **155** and dummy members (for example, dummy members **200a**) that each do not overlap any one of the plurality of dummy electrodes **155**. Alternatively, the plurality of dummy members **200** may include only either one type of dummy members.

(46) In the example described above as illustrated in FIG. 2A, the dummy members **145** have a square shape as viewed in a plan view relative to the boundary **103**. Alternatively, the dummy members **145** may have other shapes as viewed in a plan view relative to the boundary **103**. For example, the dummy members **145** may each have a circular shape (as illustrated in FIG. 2B) or a polygonal shape (as illustrated in FIG. 2C) with all apexes defining an obtuse angle as viewed in a plan view relative to the boundary **103**. By configuring the dummy members **145** to have a shape as described above, even when wiring members to which a high voltage is applied are provided near the dummy members **145**, electric field concentration of the dummy members **145** is alleviated, and the withstand voltage between conductive members is improved.

(47) Next, an example of a production method for producing the photoelectric conversion device **100** will be described with reference to FIGS. 3A to 5B. In the method described below, a plurality of photoelectric conversion devices **100** are formed by separately forming two semiconductor wafers, bonding the semiconductor wafers together, and dicing the bonded semiconductor wafers. The pixel substrate **101** before dicing (in a state in which the pixel substrate **101** is not separated into the plurality of photoelectric conversion devices **100**) is also referred to as “pixel substrate **101**”. Likewise, the circuit substrate **102** before dicing (in a state in which the circuit substrate **102** is not separated into the plurality of photoelectric conversion devices **100**) is also referred to as “circuit substrate **102**”.

(48) First, impurity regions **132** and **133** are formed in a semiconductor substrate **131**, and an interlayer insulating film **301** is formed on the semiconductor substrate **131**. After that, vias that extend through the interlayer insulating film **301** are formed, and a conductive pattern **142** that includes wiring members **146** and dummy members **145** is formed on the interlayer insulating film **301**. In this way, a structural body as shown in FIG. 3A is formed. The dummy members **145** are disposed in a region other than the region in which the wiring members **146** are disposed. The conductive pattern **142** is formed by, for example, forming an aluminum film by sputtering or the like, and thereafter performing photolithography and dry etching thereon.

(49) After that, an interlayer insulating film **302** is further formed on the conductive pattern **142**, and a structural body as shown in FIG. 3B is thereby formed. The interlayer insulating film **302** may be formed using, for example, plasma CVD (Chemical Vapor Deposition) or the like. The upper surface of the interlayer insulating film **302** has irregularities due to the influence of the conductive pattern **142**.

(50) After that, a portion of the interlayer insulating film **302** is removed by performing etching from the upper surface of the interlayer insulating film **302** to reduce the spacing between irregularities of the interlayer insulating film **302**. In this way, a structural body as shown in FIG. 3C is formed. For etching, for example, photolithography, dry etching, and the like can be used.

(51) After that, the upper surface of the interlayer insulating film **302** is flattened by, for example, performing CMP (Chemical Mechanical Polishing) or the like. In this way, a structural body as shown in FIG. 3D is formed. Because the conductive pattern **142** includes dummy members **145**, the flatness of the upper surface of the interlayer insulating film **302** is improved as compared with the case where the dummy members **145** are not included.

(52) After that, the same process is repeatedly performed to sequentially form conductive patterns

143 and **144**, and a wiring layer **140** is thereby formed. As a result of the plurality of interlayer insulating films **301** and **302**, and the like being sequentially formed, an interlayer insulating film **141** is formed. After that, a bonding layer **150** is formed, and a structural body as shown in FIG. **4A** is formed. Separately from forming the structural body, a circuit substrate **102** is also formed in the same manner.

(53) After that, as shown in FIG. **4B**, the structural body shown in FIG. **4A** prepared in the manner described above and the circuit substrate **102** are superposed on each other such that the bonding layer **150** and the bonding layer **160** oppose each other, and the structural body shown in FIG. **4A** and the circuit substrate **102** are bonded. After that, the semiconductor substrate **131** is thinned, and an optical layer **120** is formed. After that, an opening **110** that extends to an electrode pad **111** is formed. In this way, a structural body as shown in FIG. **5A** is formed.

(54) In FIG. **5A**, a dicing line **501** for dicing the semiconductor wafers is shown. The dicing line **501** passes through the dummy members **145** and **175**. Accordingly, when the semiconductor wafers are diced along the dicing line **501**, due to the influence of the dummy members **145** and **175**, chipping may occur. To address this, before dicing, a groove **500** that extends along the dicing line **501** may be formed. In the example shown in the diagram, the groove **500** is formed from the optical layer **120** side, but the groove **500** may be formed from the opposite side of the optical layer **120**. The groove **500** extends to, for example, the semiconductor substrate **181** of the circuit substrate **102**. The groove **500** is formed by performing processing that uses heat such as, for example, laser processing. After the groove **500** has been formed, residues **502** formed as a result of portions of the dummy members **175** being removed are left in the photoelectric conversion device **100** (specifically, the wiring layer **170**). Although not shown in the diagram, residues formed as a result of portions of the dummy members **145** being removed may be left in the photoelectric conversion device **100** (specifically, the wiring layer **140**). After that, the structural body shown in FIG. **5B** is diced along the dicing line **501**, and a plurality of photoelectric conversion devices **100** are thereby obtained.

(55) A production method for producing a photoelectric conversion device according to a comparative example will be described with reference to FIGS. **6A** to **6C**. FIG. **6A** shows a step that corresponds to FIG. **3C**. In the comparative example, the conductive pattern **142** includes wiring members **146**, but does not include dummy members **145**. Accordingly, a region **600** in which light receiving elements **108** are formed includes conductive members, but a region **601** other than the region **600** does not include conductive members.

(56) After that, as shown in FIG. **6B**, the upper surface of the interlayer insulating film **302** is flattened. The amount of the interlayer insulating film **302** abraded in the region **601** is larger than the amount of the interlayer insulating film **302** abraded in the region **600**, and thus the flatness of the upper surface of the interlayer insulating film **302** is low. Specifically, the interlayer insulating film **302** in the region **601** is thinner than the interlayer insulating film **302** in the region **600**.

(57) After that, as shown in FIG. **6C**, an additional conductive pattern and a bonding layer **150** are formed. In the additional conductive pattern as well, dummy members **145** are not formed, and thus a large height difference is formed. Accordingly, the flatness of the bonding surface according to the comparative example is lower than the flatness of the bonding surface **101A** (FIG. **4A**) of the pixel substrate **101** according to the first embodiment. The flatness of the upper surface of the bonding layer **160** of the circuit substrate **102** of the comparative example that is formed in the same manner is also lower than the flatness of the upper surface of the bonding layer **160** of the photoelectric conversion device **100** of the first embodiment. For this reason, when the pixel substrate and the circuit substrate that both have upper surfaces with low flatness are bonded, gaps may be formed therebetween, causing a bonding failure. In the photoelectric conversion device **100**, dummy members **145** are also provided in the region **601** in which wiring members **146** are not provided, and thus the flatness of the bonding surface can be improved.

(58) In the photoelectric conversion device **100** according to the first embodiment, each of the

plurality of conductive patterns **142** to **144** of the pixel substrate **101** includes dummy members **145**. Alternatively, only a portion of the plurality of conductive patterns **142** to **144** may include dummy members **145**. Even when only a portion of the plurality of conductive patterns **142** to **144** includes dummy members **145**, the flatness of the bonding surface **101A** is improved as compared with the case where dummy members **145** are not included at all. Likewise, only a portion of the plurality of conductive patterns **172** to **174** of the circuit substrate **102** may include dummy members **175**. Also, a configuration may be used in which the pixel substrate **101** includes dummy members **145**, and the circuit substrate **102** does not include dummy members **175**, or vice versa. As long as any one of a plurality of conductive patterns provided between the semiconductor layer **130** of the pixel substrate **101** and the semiconductor layer **180** of the circuit substrate **102** includes dummy members, the bondability between the two substrates is improved as compared with the case where none of the conductive patterns includes dummy members.

(59) In the photoelectric conversion device **100**, the light receiving region **104** does not include dummy members **145**. Alternatively, the light receiving region **104** may include dummy members **145**. By also providing dummy members **145** in the light receiving region **104** as described above, the area density of the conductive members in the conductive patterns can be easily adjusted, and thus the flatness of the bonding surface **101A** is further improved. In order to facilitate disposing dummy members **145** in the light receiving region **104**, the width (the width **203** or the width **204**) of each dummy member **145** may be less than or equal to half the arrangement pitch **112** between the plurality of light receiving elements **108**. In addition thereto, the arrangement pitch (the arrangement pitch **206** or the arrangement pitch **207**) between the plurality of dummy members **145** may be less than or equal to half the arrangement pitch **112** between the plurality of light receiving elements **108**.

(60) As described above, a voltage of about -30 V that is a voltage with a large difference from the ground potential is applied to the wiring members **146a** that are connected to the anodes of the SPAD sensors. Accordingly, in order to ensure the withstand voltage, a dummy member **145** may not be provided between a wiring member **146a** and a wiring member **146b** in the vicinity of the wiring member **146a**. For example, as shown in FIG. **1**, the spacing between a wiring member **146a** and a wiring member **146b** is less than or equal to the arrangement pitch between the plurality of light receiving elements **108** (less than or equal to the arrangement pitch **112**). For this reason, a dummy member that is not used to drive the photoelectric conversion device **100** may not be provided between the wiring member **146a** and the wiring member **146b**.

(61) In the photoelectric conversion device **100**, vias are not connected to the dummy members **145**. For this reason, the positions of the dummy members **145** are not affected by the positions of the dummy members **145** in other layers, and thus the degree of freedom in the layout of the dummy members **145** is improved. Alternatively, vias may be connected to the dummy members **145**. Likewise, in the photoelectric conversion device **100**, vias are not connected to the dummy electrodes **155**. For this reason, the positions of the dummy electrodes **155** are not affected by the positions of the dummy members **145**, and thus the degree of freedom in the layout of the dummy electrodes **155** is improved. Alternatively, vias may be connected to the dummy electrodes **155**.

Second Embodiment

(62) An example of a structure of a photoelectric conversion device **700** according to a second embodiment of the present invention will be described with reference to FIG. **7**. Hereinafter, a description will be given focusing mainly on differences from the first embodiment. The matters that are not described below may be the same as those of the first embodiment. FIG. **7** shows a cross-sectional view of the photoelectric conversion device **700** at a position corresponding to FIG. **1**.

(63) In the photoelectric conversion device **700** according to the second embodiment, an electrode pad **111** is formed in a circuit substrate **102**. Accordingly, an opening **110** extends into a portion of the circuit substrate **102** through a pixel substrate **101**. Dummy electrodes **155** and **164** are not

formed in an opening region **106** at a position at which the opening **110** is formed.
(64) As a result of the electrode pad **111** being provided in the circuit substrate **102**, the distance of wiring between the electrode pad **111** and the signal processing circuit provided in the circuit substrate **102** can be shortened. Accordingly, a signal delay can be reduced.

Other Embodiments

(65) An embodiment of an appliance **800** that includes a semiconductor device **803** will be described in detail with reference to FIG. **8A**. The semiconductor device **803** may be either one of the photoelectric conversion devices described in the embodiments given above. The semiconductor device **803** may include a semiconductor device **801** and a package **802** that houses the semiconductor device **801**. The package **802** may include a substrate to which the semiconductor device **801** is fixed, and a cover such as a glass cover that opposes the semiconductor device **801**. The package **802** may further include a bonding member, such as a bonding wire or a bump, that connects a terminal provided in the substrate and a terminal (bonding pad) provided in the semiconductor device **801**.

(66) The appliance **800** may include at least one of an optical device **804**, a control device **805**, a processing device **806**, a display device **807**, a storage device **808**, and a mechanical device **809**. The optical device **804** is, for example, a lens, a shutter, or a mirror. The control device **805** controls the semiconductor device **803**. The control device **805** is, for example, a semiconductor device such as an FPGA (Field Programmable Gate Array) or an ASIC (Application Specific Integrated Circuit).

(67) The processing device **806** processes a signal output from the semiconductor device **803**. The processing device **806** is a semiconductor device such as a CPU (Central Processing Unit), an ASIC, or the like for constituting an AFE (analog front end) or a DFE (digital front end). The display device **807** is an EL (Electro-Luminescent) display device or a liquid crystal display device that displays information (images) obtained by the semiconductor device **803**. The storage device **808** is a magnetic device or a semiconductor device that stores information (images) obtained by the semiconductor device **803**. The storage device **808** is a volatile memory such as an SRAM (Static Random Access Memory) or a DRAM (Dynamic Random Access Memory), or a non-volatile memory such as a flash memory or a hard disk drive.

(68) The mechanical device **809** includes a movable unit or a propulsion unit such as a motor, an engine, or the like. The appliance **800** displays a signal output from the semiconductor device **803** on the display device **807**, or transmits the signal to the outside via a communication device (not shown) included in the appliance **800**. For this reason, the appliance **800** may further include a storage device **808** and a processing device **806** in addition to a storage circuit and an arithmetic circuit that are included in the semiconductor device **803**. The mechanical device **809** may be controlled based on a signal output from the semiconductor device **803**.

(69) The appliance **800** is suitable for an electronic appliance such as an information terminal (for example, a smartphone or a wearable terminal) that has an image capturing function, or a camera (for example, an interchangeable lens camera, a compact camera, a video camera, or a surveillance camera). In the case of a camera, the mechanical device **809** may drive the components of the optical device **804** to perform a zooming operation, a focusing operation, and a shutter operation. Alternatively, in the case of a camera, the mechanical device **809** may move the semiconductor device **803** to perform a vibration damping operation.

(70) Alternatively, the appliance **800** may be a transport appliance such as a vehicle, a ship, or an aircraft. In the case of a transport appliance, the mechanical device **809** may be used as a moving device. The appliance **800** used as a transport appliance may transport the semiconductor device **803**, or perform driving (steering) assistance and/or automation using the image capturing function. The processing device **806** for performing driving (steering) assistance and/or automation may perform processing for operating the mechanical device **809** used as a moving device based on information obtained by the semiconductor device **803**. Alternatively, the appliance **800** may be a

medical appliance such as an endoscope, a measurement appliance such as an analysis distance measurement sensor, an analysis appliance such as an electron microscope, or an office appliance such as a copying machine.

(71) An image capturing system and a mobile body according to an embodiment will be described with reference to FIGS. **8B** and **8C**. FIG. **8B** shows an example of an image capturing system **810** of an in-vehicle camera. The image capturing system **810** includes a photoelectric conversion device **811**. The photoelectric conversion device **811** may be any of the photoelectric conversion devices described in the embodiments given above. The image capturing system **810** includes an image processing unit **812** that is a processing device that performs image processing on a plurality of image data items acquired by the photoelectric conversion device **811**. Also, the image capturing system **810** includes a parallax acquiring unit **813** that is a processing device that calculates a parallax (a phase difference between parallax images) from a plurality of image data items acquired by the photoelectric conversion device **811**. Furthermore, the image capturing system **810** includes a distance acquiring unit **814** that is a processing device that calculates the distance to a target object based on the calculated parallax, and a collision determination unit **815** that is a processing device that determines, based on the calculated parallax, whether or not there is a possibility of a collision. Here, the parallax acquiring unit **813** and the distance acquiring unit **814** are examples of an information acquiring unit that acquires information such as distance information regarding the distance to a target object. The distance information includes information regarding parallax, defocus amount, the distance to a target object, and the like. The collision determination unit **815** may determine the possibility of a collision based on any one of the distance information items. The various types of processing devices described above may be implemented using specifically designed hardware, or general-purpose hardware that performs arithmetic operations based on a software module. Also, the processing devices may be implemented using FPGA, ASIC, or the like, or a combination thereof.

(72) The image capturing system **810** is connected to a vehicle information acquiring device **816**, and thus can acquire vehicle information such as vehicle speed, yaw rate, and steering angle. Also, the image capturing system **810** is connected to a control ECU **817** that is a control device that outputs a control signal that causes the vehicle to generate a braking force based on the result of determination performed by the collision determination unit **815**. In short, the control ECU **817** is an example of a mobile body control unit that controls the mobile body based on the distance information. Also, the image capturing system **810** is also connected to a warning device **818** that provides a warning to the driver based on the result of determination performed by the collision determination unit **815**. For example, if it is determined, as a result of determination performed by the collision determination unit **815**, that there is a high possibility of a collision, the control ECU **817** controls the vehicle to brake, deaccelerate, or suppress the engine output so as to avoid the collision or reduce damage. The warning device **818** provides a warning to the user by providing a warning sound, displaying warning information on a screen such as the screen of a car navigation system, vibrating the seat belts or the steering wheel, or the like.

(73) In the present embodiment, the image capturing system **810** captures images of the surroundings of the vehicle such as, for example, the front or the back of the vehicle. FIG. **8C** shows the image capturing system **810** in the case where the image capturing system **810** is configured to capture images of the front of the vehicle (an image capturing range **819**). The vehicle information acquiring device **816** transmits an instruction to cause the image capturing system **810** to operate and capture images.

(74) In the description given above, an example has been described in which control is performed to prevent the vehicle from colliding with another vehicle, but the embodiment is also applicable to the case where control is performed to cause the vehicle to follow another vehicle and autonomously drive, the case where control is performed to cause the vehicle to autonomously drive while preventing the vehicle from deviating from the lane, or other cases. Furthermore, the

application of the image capturing system is not limited to a vehicle such as an automobile, and the image capturing system is applicable to a mobile body (transport appliance) such as, for example, a ship, an aircraft, or an industrial robot. In the case of a mobile body (transport appliance), the moving device is any type of moving unit such as an engine, a motor, wheels, or a propeller. In addition, the application is not limited to a mobile body, and the image capturing system is widely applicable to an appliance that utilizes object recognition such as an intelligent transportation system (ITS).

(75) The embodiments described above can be changed as appropriate without departing from the technical ideas of the present disclosure. The content disclosed in the specification of the present application encompasses not only the matters explicitly described in the specification of the present application, but also all matters that can be understood from the specification of the present application and the drawings attached to the specification. Also, the content disclosed in the specification of the present application encompasses a complementary set of the concept described in the specification of the present application. Specifically, for example, the expression “A is larger than B” in the specification of the present application is intended to also disclose “A is not larger than B” even when the expression “A is not larger than B” is not explicitly included in the specification of the present application. This is because when the expression “A is larger than B” is explicitly included in the specification of the present application, it is based on the assumption that consideration is also given to the case where “A is not larger than B”. Claims are attached to publicly disclose the scope of the present invention.

(76) While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

(77) This application claims the benefit of Japanese Patent Application No. 2021-008941, filed Jan. 22, 2021, which is hereby incorporated by reference herein in its entirety.

Claims

1. A photoelectric conversion device in which a first substrate and a second substrate are bonded to each other, the first substrate including a first semiconductor layer having light receiving elements, and the second substrate including a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements, the photoelectric conversion device comprising: an electrode pad for external connection; an opening extending to the electrode pad; and a conductive pattern located between the first semiconductor layer and the second semiconductor layer, wherein the conductive pattern includes a plurality of wiring members that are used to drive the photoelectric conversion device and a plurality of dummy members that are not used to drive the photoelectric conversion device, the plurality of dummy members include a dummy member located on an outer side relative to the opening in a plan view relative to a boundary between the first substrate and the second substrate, and the plurality of dummy members include a dummy member not connected to a via.
2. The photoelectric conversion device according to claim 1, wherein the first substrate includes a plurality of conductive patterns between the boundary and the first semiconductor layer, each of the plurality of conductive patterns includes a plurality of dummy members that are not used to drive the photoelectric conversion device, and the plurality of dummy members included in each of the plurality of conductive patterns include a dummy member located on the outer side relative to the opening in a plan view relative to the boundary.
3. The photoelectric conversion device according to claim 2, wherein the first substrate includes a plurality of dummy electrodes that face the boundary and are not used to drive the photoelectric conversion device, and the plurality of conductive patterns included in the first substrate include a

first conductive pattern, a second conductive pattern that is more distant from the boundary than the first conductive pattern, and a third conductive pattern that is more distant from the boundary than the second conductive pattern.

4. The photoelectric conversion device according to claim 3, wherein an arrangement pitch between the plurality of dummy electrodes is larger than an arrangement pitch between the plurality of dummy members in the first conductive pattern.

5. The photoelectric conversion device according to claim 3, wherein an arrangement pitch between the plurality of dummy electrodes is larger than an arrangement pitch between the plurality of dummy members in the third conductive pattern.

6. The photoelectric conversion device according to claim 3, wherein an arrangement pitch between the plurality of dummy members in the first conductive pattern is larger than an arrangement pitch between the plurality of dummy members in the third conductive pattern.

7. The photoelectric conversion device according to claim 3, wherein an arrangement pitch between the plurality of dummy members in the second conductive pattern is equal to an arrangement pitch between the plurality of dummy members in the third conductive pattern.

8. The photoelectric conversion device according to claim 3, wherein an arrangement pitch between the plurality of dummy electrodes is larger than an arrangement pitch between the plurality of dummy members in the first conductive pattern, and an arrangement pitch between the plurality of dummy members in the first conductive pattern is larger than an arrangement pitch between the plurality of dummy members in the second conductive pattern.

9. The photoelectric conversion device according to claim 3, wherein one dummy electrode of the plurality of dummy electrodes has an area larger than an area of one dummy member of the plurality of dummy members in the first conductive pattern in a plan view relative to the boundary.

10. The photoelectric conversion device according to claim 3, wherein the plurality of dummy members in the first conductive pattern include a dummy member that entirely overlaps one of the plurality of dummy electrodes, and a dummy member that does not overlap any one of the plurality of dummy electrodes in a plan view relative to the boundary.

11. The photoelectric conversion device according to claim 3, wherein an area density of the plurality of dummy members in the first conductive pattern is smaller than an area density of the plurality of dummy members in the second conductive pattern or the third conductive pattern in a plan view relative to the boundary.

12. The photoelectric conversion device according to claim 1, wherein the plurality of dummy members include a dummy member located on an inner side relative to the opening in a plan view relative to the boundary.

13. The photoelectric conversion device according to claim 1, wherein the conductive pattern is made using aluminum as a material.

14. The photoelectric conversion device according to claim 1, wherein the light receiving elements are single photon avalanche diode sensors.

15. The photoelectric conversion device according to claim 1, wherein the plurality of wiring members include a first wiring member connected to an anode of the light receiving elements and a second wiring member connected to a cathode of the light receiving elements, a spacing between the first wiring member and the second wiring member is less than or equal to an arrangement pitch between the light receiving elements, and a dummy member that is not used to drive the photoelectric conversion device is not included between the first wiring member and the second wiring member.

16. The photoelectric conversion device according to claim 1, wherein the plurality of dummy members include a dummy member that has a circular shape in a plan view relative to the boundary.

17. The photoelectric conversion device according to claim 1, wherein the plurality of dummy members include a dummy member that has a polygonal shape with all apexes defining an obtuse

angle in a plan view relative to the boundary.

18. The photoelectric conversion device according to claim 1, wherein the plurality of dummy members include a dummy member that has a width less than or equal to half an arrangement pitch between the light receiving elements.

19. The photoelectric conversion device according to claim 1, wherein an arrangement pitch between the plurality of dummy members is smaller than an arrangement pitch between the light receiving elements.

20. The photoelectric conversion device according to claim 1, wherein an area density of the plurality of dummy members is different from an area density of the plurality of wiring members in a plan view relative to the boundary.

21. An appliance comprising: the photoelectric conversion device according to claim 1; and at least one of the following devices: an optical device for the photoelectric conversion device; a control device configured to control the photoelectric conversion device; a processing device configured to process a signal output from the photoelectric conversion device; a display device configured to display information obtained by the photoelectric conversion device; a storage device configured to store information obtained by the photoelectric conversion device; and a mechanical device configured to operate based on information obtained by the photoelectric conversion device.

22. A method for producing a photoelectric conversion device, the method comprising: preparing a first substrate and a second substrate, the first substrate including a first semiconductor layer having light receiving elements, and the second substrate including a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements; bonding the first substrate and the second substrate to each other; forming an opening for external connection that extends to an electrode pad; forming a groove along a dicing line by performing processing that uses heat; and after forming the groove along the dicing line, dicing the first substrate and the second substrate along the dicing line, wherein at least one of the first substrate and the second substrate prepared includes a conductive pattern, the conductive pattern includes a plurality of wiring members that are used to drive the photoelectric conversion device, and a plurality of dummy members that are not used to drive the photoelectric conversion device, and the plurality of dummy members include a dummy member that is located on an outer side relative to the opening in a plan view relative to a boundary between the first substrate and the second substrate.

23. A photoelectric conversion device in which a first substrate and a second substrate are bonded to each other, the first substrate including a first semiconductor layer having light receiving elements, and the second substrate including a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements, the photoelectric conversion device comprising: an electrode pad for external connection; an opening extending to the electrode pad; and a conductive pattern located between the first semiconductor layer and the second semiconductor layer, wherein the conductive pattern includes a plurality of wiring members that are used to drive the photoelectric conversion device and a plurality of dummy members that are not used to drive the photoelectric conversion device, the plurality of dummy members include a dummy member located on an outer side relative to the opening in a plan view relative to a boundary between the first substrate and the second substrate, and an area density of the plurality of dummy members is different from an area density of the plurality of wiring members in a plan view relative to the boundary.

24. A photoelectric conversion device in which a first substrate and a second substrate are bonded to each other, the first substrate including a first semiconductor layer having light receiving elements, and the second substrate including a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements, the photoelectric conversion device comprising: an electrode pad for external connection; an opening extending to the electrode pad; and a conductive pattern located between the first semiconductor layer and the second

semiconductor layer, wherein the conductive pattern includes a plurality of wiring members that are used to drive the photoelectric conversion device and a plurality of dummy members that are not used to drive the photoelectric conversion device, the plurality of dummy members include a dummy member located on an outer side relative to the opening in a plan view relative to a boundary between the first substrate and the second substrate, the first substrate includes a plurality of conductive patterns between the boundary and the first semiconductor layer, each of the plurality of conductive patterns includes a plurality of dummy members that are not used to drive the photoelectric conversion device, the plurality of dummy members included in each of the plurality of conductive patterns include a dummy member located on the outer side relative to the opening in a plan view relative to the boundary, the first substrate includes a plurality of dummy electrodes that face the boundary and are not used to drive the photoelectric conversion device, and the plurality of conductive patterns included in the first substrate include a first conductive pattern, a second conductive pattern that is more distant from the boundary than the first conductive pattern, and a third conductive pattern that is more distant from the boundary than the second conductive pattern.

25. A photoelectric conversion device in which a first substrate and a second substrate are bonded to each other, the first substrate including a first semiconductor layer having light receiving elements, and the second substrate including a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements, the photoelectric conversion device comprising: an electrode pad for external connection; an opening extending to the electrode pad; and a conductive pattern located between the first semiconductor layer and the second semiconductor layer, wherein the conductive pattern includes a plurality of wiring members that are used to drive the photoelectric conversion device and a plurality of dummy members that are not used to drive the photoelectric conversion device, the plurality of dummy members include a dummy member located on an outer side relative to the opening in a plan view relative to a boundary between the first substrate and the second substrate, the plurality of wiring members include a first wiring member connected to an anode of the light receiving elements and a second wiring member connected to a cathode of the light receiving elements, a spacing between the first wiring member and the second wiring member is less than or equal to an arrangement pitch between the light receiving elements, and a dummy member that is not used to drive the photoelectric conversion device is not included between the first wiring member and the second wiring member.

26. A photoelectric conversion device in which a first substrate and a second substrate are bonded to each other, the first substrate including a first semiconductor layer having light receiving elements, and the second substrate including a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements, the photoelectric conversion device comprising: an electrode pad for external connection; an opening extending to the electrode pad; and a conductive pattern located between the first semiconductor layer and the second semiconductor layer, wherein the conductive pattern includes a plurality of wiring members that are used to drive the photoelectric conversion device and a plurality of dummy members that are not used to drive the photoelectric conversion device, the plurality of dummy members include a dummy member located on an outer side relative to the opening in a plan view relative to a boundary between the first substrate and the second substrate, and the plurality of dummy members include a dummy member that has a circular shape in a plan view relative to the boundary.

27. A photoelectric conversion device in which a first substrate and a second substrate are bonded to each other, the first substrate including a first semiconductor layer having light receiving elements, and the second substrate including a second semiconductor layer having a circuit element for processing a signal generated by the light receiving elements, the photoelectric conversion device comprising: an electrode pad for external connection; an opening extending to the electrode pad; and a conductive pattern located between the first semiconductor layer and the second

semiconductor layer, wherein the conductive pattern includes a plurality of wiring members that are used to drive the photoelectric conversion device and a plurality of dummy members that are not used to drive the photoelectric conversion device, the plurality of dummy members include a dummy member located on an outer side relative to the opening in a plan view relative to a boundary between the first substrate and the second substrate, and the plurality of dummy members include a dummy member that has a polygonal shape with all apexes defining an obtuse angle in a plan view relative to the boundary.
