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Inventor(s)

KASASHIMA; Shunsuke

IMAGING ELEMENT AND ELECTRONIC DEVICE

Abstract

The present technology relates to an imaging element and an electronic device capable of arranging pixels having different sizes efficiently. Provided are a first photoelectric converter that generate a charge corresponding to a light amount, and a second photoelectric converter having a smaller light receiving area than the first photoelectric converter, in which the first photoelectric converter has an L shape in plan view, the second photoelectric converter has a quadrangular shape, and a shape obtained by combining the first photoelectric converter and the second photoelectric converter is a quadrangular shape. The present technology can be applied to, for example, an imaging apparatus that acquires an image with a wide dynamic range by arranging pixels having different light receiving areas and processing signals from each of the pixels.

Inventors: KASASHIMA; Shunsuke (Kanagawa, JP)

Applicant: SONY SEMICONDUCTOR SOLUTIONS CORPORATION
(Kanagawa, JP)

Family ID: 1000008576165

Assignee: SONY SEMICONDUCTOR SOLUTIONS CORPORATION
(Kanagawa, JP)

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Background/Summary

TECHNICAL FIELD

[0001] The present technology relates to an imaging element and an electronic device, and, for example, relates to an imaging element and an electronic device capable of expanding a dynamic range.

BACKGROUND ART

[0002] Conventionally, as a method for generating an image with a wide dynamic range, there is known a method in which a first pixel and a second pixel having different sensitivities are provided on a pixel array such as a complementary metal-oxide semiconductor (CMOS) image sensor, and a first image and a second image including respective outputs are synthesized.

[0003] Here, as a method for providing pixels having different sensitivities, for example, there is a method of providing a pixel having a long exposure time and a pixel having a short exposure time, or providing a pixel having a large size (hereinafter, referred to as a large pixel) and a pixel having a small size (hereinafter, referred to as a small pixel) of a photoelectric converter such as a photodiode (PD) (see, for example, Patent Document 1).

CITATION LIST

Patent Document

[0004] Patent Document 1: Japanese Patent Application Laid-Open No. 2017-163010

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0005] In recent years, with the progress of miniaturization of pixels, even in a case where a wide dynamic range image is generated by providing a large pixel and a small pixel, it is desirable to further downsize the large pixel and the small pixel and efficiently arrange the large pixel and the small pixel so as not to generate a useless region as much as possible.

[0006] The present technology has been made in view of such a situation and enables pixels having different sizes to be disposed efficiently.

Solutions to Problems

[0007] An imaging element according to one aspect of the present technology includes a first photoelectric converter that generate a charge corresponding to a light amount, and a second photoelectric converter having a smaller light receiving area than the first photoelectric converter, in which the first photoelectric converter has an L shape in plan view, the second photoelectric converter has a quadrangular shape, and a shape obtained by combining the first photoelectric converter and the second photoelectric converter is a quadrangular shape.

[0008] An electronic device according to one aspect of the present technology includes an imaging element, and a processor that processes a signal from the imaging element, the imaging element including a first photoelectric converter that generate a charge corresponding to a light amount, and a second photoelectric converter having a smaller light receiving area than the first photoelectric converter, in which the first photoelectric converter has an L shape in plan view, the second photoelectric converter has a quadrangular shape, and a shape obtained by combining the first photoelectric converter and the second photoelectric converter is a quadrangular shape.

[0009] An imaging element according to one aspect of the present technology includes a first

photoelectric converter that generates a charge corresponding to a light amount, and a second photoelectric converter having a smaller light receiving area than the first photoelectric converter. The first photoelectric converter has an L shape in plan view, the second photoelectric converter has a quadrangular shape, and a shape obtained by combining the first photoelectric converter and the second photoelectric converter is a quadrangular shape.

[0010] An electronic device according to one aspect of the present technology includes the imaging element.

[0011] Note that the electronic device may be independent devices, or may be internal blocks that form one device.

[0012] Note that a program to be provided may be transmitted via a transmission medium or be recorded on a recording medium.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0013] FIG. 1 is a diagram illustrating a configuration of an embodiment of an imaging apparatus to which the present technology is applied.

[0014] FIG. 2 is a circuit diagram of a unit pixel.

[0015] FIG. 3 is a diagram for describing a unit pixel disposed in a pixel array unit.

[0016] FIG. 4 is a diagram for describing a configuration of the unit pixel.

[0017] FIG. 5 is a diagram for describing an arrangement example of on-chip lenses.

[0018] FIG. 6 is a diagram for describing another arrangement example of the on-chip lenses.

[0019] FIG. 7 is a diagram for describing still another arrangement example of the on-chip lenses.

[0020] FIG. 8 is a diagram illustrating a planar configuration of a unit pixel according to a first embodiment.

[0021] FIG. 9 is a diagram illustrating a sectional configuration of the unit pixel according to the first embodiment.

[0022] FIG. 10 is a diagram illustrating a sectional configuration of the unit pixel according to the first embodiment.

[0023] FIG. 11 is a diagram for describing scattering of light by a slit.

[0024] FIG. 12 is a diagram illustrating a planar configuration of a unit pixel according to a second embodiment.

[0025] FIG. 13 is a diagram illustrating a planar configuration of a unit pixel according to a third embodiment.

[0026] FIG. 14 is a diagram illustrating a sectional configuration of the unit pixel according to the third embodiment.

[0027] FIG. 15 is a diagram illustrating a planar configuration of a unit pixel according to a fourth embodiment.

[0028] FIG. 16 is a diagram illustrating a sectional configuration of the unit pixel according to the fourth embodiment.

[0029] FIG. 17 is a diagram illustrating a planar configuration of a unit pixel according to a fifth embodiment.

[0030] FIG. 18 is a diagram illustrating a sectional configuration of the unit pixel according to the fifth embodiment.

[0031] FIG. 19 is a diagram illustrating a sectional configuration of the unit pixel according to the fifth embodiment.

[0032] FIG. 20 is a diagram illustrating a planar configuration of a unit pixel according to a sixth embodiment.

[0033] FIG. 21 is a diagram illustrating a planar configuration of a unit pixel according to a seventh

embodiment.

[0034] FIG. **22** is a diagram illustrating a planar configuration of a unit pixel according to an eighth embodiment.

[0035] FIG. **23** is a diagram illustrating a planar configuration of a unit pixel according to a ninth embodiment.

[0036] FIG. **24** is a diagram illustrating a planar configuration of a unit pixel according to a tenth embodiment.

[0037] FIG. **25** is a diagram illustrating a planar configuration of a unit pixel according to an eleventh embodiment.

[0038] FIG. **26** is a diagram illustrating a planar configuration of a unit pixel according to a twelfth embodiment.

[0039] FIG. **27** is a diagram illustrating a sectional configuration of the unit pixel according to the twelfth embodiment.

[0040] FIG. **28** is a diagram for describing directions of scattering of light by slits.

[0041] FIG. **29** is a diagram illustrating a planar configuration of a unit pixel according to a thirteenth embodiment.

[0042] FIG. **30** is a diagram illustrating a sectional configuration of the unit pixel according to the thirteenth embodiment.

[0043] FIG. **31** is a diagram illustrating a configuration of a pixel array unit according to a fourteenth embodiment.

[0044] FIG. **32** is a diagram illustrating a configuration of a pixel array unit according to a fifteenth embodiment.

[0045] FIG. **33** is a diagram illustrating a configuration of a pixel array unit according to a sixteenth embodiment.

[0046] FIG. **34** is a diagram illustrating a configuration of a pixel array unit according to a seventeenth embodiment.

[0047] FIG. **35** is a diagram illustrating a configuration of an example of an electronic device.

[0048] FIG. **36** is a block diagram illustrating an example of a schematic configuration of a vehicle control system.

[0049] FIG. **37** is an explanatory diagram illustrating an example of installation positions of an outside-vehicle information detecting section and imaging sections.

MODE FOR CARRYING OUT THE INVENTION

[0050] Hereinafter, modes for carrying out the present technology (hereinafter referred to as embodiments) will be described.

Configuration of Imaging Apparatus

[0051] FIG. **1** is a system configuration diagram schematically illustrating a configuration of an imaging apparatus to which the present technology is applied, for example, a CMOS image sensor as one type of an X-Y address type imaging apparatus. Here, the CMOS image sensor is an image sensor created by applying or partially using a CMOS process. For example, the imaging apparatus includes a back-illuminated CMOS image sensor.

[0052] An imaging apparatus **10** includes a pixel array unit **11** formed on a semiconductor substrate (chip) (not illustrated) and a peripheral circuit unit integrated on the same semiconductor substrate as the pixel array unit **11**. The peripheral circuit unit includes, for example, a vertical drive unit **12**, a column processor **13**, a horizontal drive unit **14**, and a system controller **15**.

[0053] The imaging apparatus **10** further includes a signal processor **18** and a data storage **19**. Each processing of the signal processor **18** and the data storage **19** includes processing performed by an external signal processor provided on a substrate separately from the imaging apparatus **10**, for example, processing performed by a digital signal processor (DSP) circuit or software.

[0054] The pixel array unit **11** has a configuration in which unit pixels (hereinafter, may be simply described as “pixels”) having a photoelectric converter that generates and accumulates charges

according to an amount of received light are two-dimensionally arranged in a row direction and a column direction, that is, in a matrix. Here, the row direction refers to an arrangement direction of the pixels in a pixel row (that is, a horizontal direction), and the column direction refers to an arrangement direction of the pixels in a pixel column (that is, a vertical direction). A specific circuit configuration and a pixel structure of the unit pixel will be described later in detail.

[0055] In the pixel array unit **11**, a pixel drive line **16** is wired along the row direction for every pixel row, and a vertical signal line **17** is wired along the column direction for every pixel column with respect to a matrix pixel arrangement. The pixel drive line **16** transmits a drive signal for performing driving to read a signal from a pixel. Note that in FIG. **1**, the pixel drive line **16** is illustrated as one wire but is not limited to one. One end of the pixel drive line **16** is connected to an output end corresponding to each row of the vertical drive unit **12**.

[0056] The vertical drive unit **12** includes a shift register, an address decoder, and the like and drives each pixel of the pixel array unit **11** at the same time for all the pixels, in units of rows, or the like. That is, the vertical drive unit **12** constitutes a drive unit that controls operation of each pixel of the pixel array unit **11** together with the system controller **15** that controls the vertical drive unit **12**. Although a specific configuration of the vertical drive unit **12** is not illustrated, the vertical drive unit **12** generally includes two scanning systems of a read scanning system and a sweep scanning system.

[0057] The read scanning system selectively scans the unit pixels in the pixel array unit **11** sequentially on a row-by-row basis in order to read signals from the unit pixels. The signal read from the unit pixel is an analog signal. The sweep scanning system performs sweep scanning on a read row on which the read scanning is to be performed by the read scanning system earlier than the read scanning by an exposure time.

[0058] When the sweep scanning is performed by the sweep scanning system, an unnecessary charge is swept from the photoelectric converter of the unit pixel in the read row. Therefore, the photoelectric converter is reset. Then, when the unnecessary charge is swept (reset) by the sweep scanning system, a so-called electronic shutter operation is performed. Here, the electronic shutter operation refers to operation of discharging the charge of the photoelectric converter and newly starting exposure (starting accumulation of charges).

[0059] The signal read by the read operation of the read scanning system corresponds to the amount of the received light after the immediately preceding read operation or electronic shutter operation. Then, a period from a read timing in the immediately preceding read operation or a sweep timing in the electronic shutter operation to a read timing in the current read operation is an exposure period of the charge in the unit pixel.

[0060] The signal output from each unit pixel in the pixel row selectively scanned by the vertical drive unit **12** is input to the column processor **13** through each of the vertical signal lines **17** for every pixel column. The column processor **13** performs, for every pixel column of the pixel array unit **11**, a predetermined signal processing on the signal output through the vertical signal line **17** from each pixel in a selected row, and temporarily holds a pixel signal which have been subjected to the signal processing.

[0061] Specifically, the column processor **13** performs, as signal processing, at least noise removal processing, for example, correlated double sampling (CDS) processing or double data sampling (DDS) processing. For example, in the CDS processing, fixed pattern noise unique to the pixel, such as reset noise or threshold variation of an amplification transistor in the pixel, is removed. The column processor **13** may have, for example, an analog-digital (AD) conversion function in addition to the noise removal processing, and convert an analog pixel signal into a digital signal and output the digital signal.

[0062] The horizontal drive unit **14** includes a shift register, an address decoder, and the like, and sequentially selects a unit circuit corresponding to the pixel column in the column processor **13**. When the selective scanning is performed by the horizontal drive unit **14**, the pixel signal subjected

to the signal processing for every unit circuit in the column processor **13** is sequentially output.
[0063] The system controller **15** includes a timing generator that generates various timing signals and the like, and performs drive control for the vertical drive unit **12**, the column processor **13**, the horizontal drive unit **14**, and the like on the basis of various timings generated by the timing generator.

[0064] The signal processor **18** has at least an arithmetic processing function, and performs various signal processing such as arithmetic processing on the pixel signal output from the column processor **13**. The data storage **19** temporarily stores data necessary for signal processing when the signal processing is performed by the signal processor **18**.

Circuit Configuration of Unit Pixel

[0065] FIG. **2** is a circuit diagram illustrating a configuration example of a unit pixel **100** disposed in the pixel array unit **11** of FIG. **1**.

[0066] The unit pixel **100** includes a first photoelectric converter **101**, a second photoelectric converter **102**, a first transfer transistor **103**, a second transfer transistor **104**, a third transfer transistor **105**, a fourth transfer transistor **106**, a floating diffusion (FD) unit **107**, a reset transistor **108**, an amplification transistor **109**, and a selection transistor **110**.

[0067] The reset transistor **108** and the amplification transistor **109** are connected to a power supply VDD. The first photoelectric converter **101** includes a so-called embedded photodiode in which an n-type impurity region is formed inside a p-type impurity region formed in a silicon semiconductor substrate. Similarly, the second photoelectric converter **102** includes an embedded photodiode. The first photoelectric converter **101** and the second photoelectric converter **102** generate signal charges corresponding to the amount of received light, and accumulate the generated charges to a certain amount.

[0068] The unit pixel **100** further includes a charge accumulator **111**. The charge accumulator **111** is, for example, a MOS capacitance or a MIS capacitance.

[0069] In FIG. **2**, the first transfer transistor **103**, the second transfer transistor **104**, the third transfer transistor **105**, and the fourth transfer transistor **106** are connected in series between the first photoelectric converter **101** and the second photoelectric converter **102**. A floating diffusion layer connected between the first transfer transistor **103** and the second transfer transistor **104** serves as the FD unit **107**. The FD unit **107** is provided with a parasitic capacitance C10.

[0070] A floating diffusion layer connected between the second transfer transistor **104** and the third transfer transistor **105** serves as a node **112**. The node **112** is provided with a parasitic capacitance C11. A floating diffusion layer connected between the third transfer transistor **105** and the fourth transfer transistor **106** serves as a node **113**. The charge accumulator **111** is connected to the node **113**.

[0071] For the unit pixel **100**, a plurality of drive lines as the pixel drive lines **16** in FIG. **1** is wired, for example, for each pixel row. Then, various drive signals TGL, FDG, FCG, TGS, RST, and SEL are supplied from the vertical drive unit **12** in FIG. **1** via the plurality of drive lines. Since each transistor of the unit pixel **100** is an NMOS transistor, these drive signals are pulse signals that enter an active state in a high level state (for example, power supply voltage VDD) and enter an inactive state in a low level state (for example, negative potential).

[0072] The drive signal TGL is applied to a gate electrode of the first transfer transistor **103**. When the drive signal TGL enters the active state, the first transfer transistor **103** enters a conductive state, and the charges accumulated in the first photoelectric converter **101** are transferred to the FD unit **107** via the first transfer transistor **103**.

[0073] The drive signal FDG is applied to a gate electrode of the second transfer transistor **104**. When the drive signal FDG enters the active state and the second transfer transistor **104** enters the conductive state, potentials of the FD unit **107** and the node **112** are thereby coupled to form one charge accumulation region.

[0074] The drive signal FCG is applied to a gate electrode of the third transfer transistor **105**. When

the drive signal FDG and the drive signal FCG enter the active state and the second transfer transistor **104** and the third transfer transistor **105** enter the conductive state, potentials from the FD unit **107** to the charge accumulator **111** are coupled to form one charge accumulation region. [0075] The drive signal TGS is applied to a gate electrode of the fourth transfer transistor **106**. When the drive signal TGS enters the active state, the fourth transfer transistor **106** enters the conductive state, and the charges accumulated in the second photoelectric converter **102** are transferred to the charge accumulator **111** via the fourth transfer transistor **106**. In a case where the fourth transfer transistor **106**, the third transfer transistor **105**, and the second transfer transistor **104** are in the active state, the potentials from the charge accumulator **111** to the FD unit **107** are coupled, and the charges accumulated in the second photoelectric converter **102** are transferred to the coupled charge accumulation region.

[0076] Furthermore, in a channel region under the gate electrode of the fourth transfer transistor **106**, for example, the potential is in a slightly positive direction (in other words, the potential is slightly deeper) as compared with a channel region under the gate electrode of the first transfer transistor **103**, the second transfer transistor **104**, or the third transfer transistor **105**, and thus, an overflow path of charges is formed. In a case where a charge exceeding a saturation charge amount of the second photoelectric converter **102** is generated as a result of the photoelectric conversion in the second photoelectric converter **102**, the charge exceeding the saturation charge amount overflows from the second photoelectric converter **102** to the charge accumulator **111** through the overflow path described above. The overflowed charge is accumulated in the charge accumulator **111**.

[0077] Note that, hereinafter, the overflow path formed in the channel region below the gate electrode of the fourth transfer transistor **106** is simply referred to as an overflow path of the fourth transfer transistor **106**.

[0078] In FIG. 2, among the two electrodes included in the charge accumulator **111**, a first electrode is a node electrode connected to the node **113** between the third transfer transistor **105** and the fourth transfer transistor **106**. Among the two electrodes included in the charge accumulator **111**, a second electrode is a grounded electrode.

[0079] Note that, as a modification, the second electrode may be connected to a specific potential other than the ground potential, for example, a power supply potential.

[0080] In a case where the charge accumulator **111** is a MOS capacitance or a MIS capacitance, as an example, the second electrode is an impurity region formed on a silicon substrate, and a dielectric film that forms the capacitance is an oxide film or a nitride film formed on the silicon substrate. The first electrode is an electrode including a conductive material, for example, polysilicon or metal, above the second electrode and the dielectric film.

[0081] In a case where the second electrode is a ground potential, the second electrode may be a p-type impurity region electrically connected to a p-type impurity region provided in the first photoelectric converter **101** or the second photoelectric converter **102**. In a case where the second electrode is a specific potential other than a ground potential, the second electrode may be an n-type impurity region formed in the p-type impurity region.

[0082] In addition to the second transfer transistor **104**, the reset transistor **108** is also connected to the node **112**. A specific potential, for example, a power supply VDD is connected ahead of the reset transistor. The drive signal RST is applied to a gate electrode of the reset transistor **108**. When the drive signal RST enters the active state, the reset transistor **108** enters the conductive state, and the potential of the node **112** is reset to a level of the voltage VDD.

[0083] When the drive signal FDG of the second transfer transistor **104** and the drive signal FCG of the third transfer transistor **105** are set to the active state when the drive signal RST is set to the active state, the coupled potentials of the node **112**, the FD unit **107**, and the charge accumulator **111** are reset to the level of the voltage VDD.

[0084] Note that by individually controlling the drive signal FDG and the drive signal FCG, the

potentials of the FD unit **107** and the charge accumulator **111** may be reset alone (independently) to the level of the voltage VDD.

[0085] The FD unit **107** which is a floating diffusion layer is charge-voltage conversion means. That is, when the charge is transferred to the FD unit **107**, the potential of the FD unit **107** changes in accordance with the amount of the transferred charge.

[0086] In the amplification transistor **109**, a current source **121** connected to one end of the vertical signal line **17** is connected to a source side, and the power supply VDD is connected to a drain side to form a source follower circuit altogether. The FD unit **107** is connected to a gate electrode of the amplification transistor **109** to serve as an input of the source follower circuit.

[0087] The selection transistor **110** is connected between a source of the amplification transistor **109** and the vertical signal line **17**. The drive signal SEL is applied to a gate electrode of the selection transistor **110**. When the drive signal SEL is brought into the active state, the selection transistor **110** enters the conductive state, and the unit pixel **100** enters a selection state.

[0088] When the charges are transferred to the FD unit **107**, the potential of the FD unit **107** becomes a potential corresponding to the amount of transferred charges, and the potential is input to the source follower circuit described above. When the drive signal SEL enters the active state, the potential of the FD unit **107** corresponding to the amount of charges is output to the vertical signal line **17** via the selection transistor **110** as an output of the source follower circuit.

[0089] The first photoelectric converter **101** has a larger light receiving area of the photodiode than the second photoelectric converter **102**. Therefore, in a case where a subject with predetermined illuminance is imaged with a predetermined exposure time, the charge generated in the first photoelectric converter **101** is larger than the charge generated in the second photoelectric converter **102**.

[0090] Therefore, when the charge generated in the first photoelectric converter **101** and the charge generated in the second photoelectric converter **102** are transferred to the FD unit **107** and subjected to charge-voltage conversion, a voltage change before and after transferring the charge generated in the first photoelectric converter **101** to the FD unit **107** is larger than a voltage change before and after transferring the charge generated in the second photoelectric converter **102** to the FD unit **107**. As a result, comparing the first photoelectric converter **101** with the second photoelectric converter **102**, the first photoelectric converter **101** has higher sensitivity than the second photoelectric converter **102**.

[0091] On the other hand, even in a case where light with high illuminance is incident and a charge exceeding the saturation charge amount of the second photoelectric converter **102** is generated, the second photoelectric converter **102** can accumulate the charge generated exceeding the saturation charge amount in the charge accumulator **111**. Therefore, when charge-voltage conversion is performed on the charge generated in the second photoelectric converter **102**, charge-voltage conversion can be performed after both the charge accumulated in the second photoelectric converter **102** and the charge accumulated in the charge accumulator **111** are added.

[0092] Therefore, the second photoelectric converter **102** can capture an image having gradation over a wider illuminance range, in other words, capture an image having a wider dynamic range, than the first photoelectric converter **101**.

[0093] Two images of an image with high sensitivity captured with the first photoelectric converter **101** and an image with a wide dynamic range captured with the second photoelectric converter **102** are synthesized into one image through wide dynamic range image synthesis processing of synthesizing one image from the two images in, for example, an image signal processing circuit provided inside the imaging apparatus **10** or an image signal processing device connected to the outside of the imaging apparatus **10**.

Configuration Example of Unit Pixel

[0094] FIG. **3** is a diagram illustrating a planar configuration example of the unit pixel **100** disposed in the pixel array unit **11**. FIG. **3** exemplifies nine unit pixels **100** in 3×3 disposed in the

pixel array unit **11**.

[0095] The unit pixel **100** includes the first photoelectric converter **101** having an L shape and the second photoelectric converter **102** having a quadrangular shape. The first photoelectric converter **101** and the second photoelectric converter **102** are combined, in other words, the unit pixel **100** has a quadrangular shape (square in FIG. 3).

[0096] In the following description, an L shape is described, but the L shape is a shape divided into a longitudinal line and a lateral line, and the lengths of the longitudinal line and the lateral line are different. In the present embodiment, a case where the lengths of the longitudinal line and the lateral line are the same is also included in the L shape. The L shape also includes shapes in a case where L is rotated by 90 degrees, 180 degrees, and 270 degrees.

[0097] In the pixel array unit **11**, the unit pixels **100** each including the first photoelectric converter **101** and the second photoelectric converter **102** are disposed in a matrix. The unit pixels **100** are isolated by an inter-pixel isolator **173** (described later with reference to FIG. 9). The inter-pixel isolator **173** is also formed between the first photoelectric converter **101** and the second photoelectric converter **102**, and the first photoelectric converter **101** and the second photoelectric converter **102** are isolated by the inter-pixel isolator **173**.

[0098] FIG. 4 illustrates one unit pixel **100**, and the configuration of the unit pixel **100** will be further described. In a case where the size of the second photoelectric converter **102** is one, the size of the first photoelectric converter **101** is about three. As indicated by a dotted line in FIG. 4, the first photoelectric converter **101** is divided into three units of a first photoelectric converter **101-1**, a first photoelectric converter **101-2**, and a first photoelectric converter **101-3**. The first photoelectric converter **101-1** is located at the lower left of the unit pixel **100** in the drawing, the first photoelectric converter **101-2** is located at the upper left of the unit pixel **100** in the drawing, and the first photoelectric converter **101-3** is located at the upper right of the unit pixel **100** in the drawing.

[0099] It is assumed that the first photoelectric converter **101-1**, the first photoelectric converter **101-2**, and the first photoelectric converter **101-3** are regions having an equal light receiving area. Each of the first photoelectric converter **101-1**, the first photoelectric converter **101-2**, and the first photoelectric converter **101-3** has an equal size (area) to the size of the second photoelectric converter **102**. That is, the first photoelectric converter **101** has an area about three times the area of the second photoelectric converter **102**. The first photoelectric converter **101-1**, the first photoelectric converter **101-2**, and the first photoelectric converter **101-3** are respectively disposed at the lower left, upper left, and upper right of the unit pixel **100** as described above, and so disposed in an L shape.

[0100] In the first photoelectric converter **101-1**, the first photoelectric converter **101-2**, and the first photoelectric converter **101-3**, for example, N-type impurity regions are continuously formed in the silicon substrate to form one photoelectric converter.

[0101] The first photoelectric converter **101** has an L shape and is formed as a region having a light receiving area three times the light receiving area of the second photoelectric converter **102**. The unit pixel **100** includes a large pixel having a light receiving area three times the light receiving area of the second photoelectric converter **102** and a small pixel having a light receiving area one third of the light receiving area of the first photoelectric converter **101**. In a case where viewed in the unit pixel **100**, a three fourths region of the unit pixel **100** is the first photoelectric converter **101** (large pixel), and a one fourth region is the second photoelectric converter **102** (small pixel).

[0102] The first photoelectric converter **101** is configured in an L shape, and the second photoelectric converter **102** is configured to be accommodated in a recessed region of the L-shaped first photoelectric converter **101**. Then, the first photoelectric converter **101** and the second photoelectric converter **102** can be efficiently disposed without generating an unnecessary gap between the first photoelectric converter **101** and the second photoelectric converter **102**.

[0103] Note that, here, a case where the first photoelectric converter **101** has a size three times as

large as the size of the second photoelectric converter **102** will be described as an example. However, the light receiving area of the second photoelectric converter **102** that is a small pixel can be configured to be small (configured to have a size of one or less in a case where the size of the second photoelectric converter **102** illustrated in FIG. 3 is one). In such a case, the size of the first photoelectric converter **101** is three times or more as large as the size of the second photoelectric converter **102**. The present technology can be applied to a case where the size of the first photoelectric converter **101** (the size of the large pixel) is three times or more as large as the size of the second photoelectric converter **102** (the size of the small pixel), and is not limited to three times.

[0104] The description will be continued where the first photoelectric converter **101** is virtually divided into the first photoelectric converter **101-1**, the first photoelectric converter **101-2**, and the first photoelectric converter **101-3** as necessary.

Arrangement of On-Chip Lenses

[0105] The arrangement of on-chip lenses will be described with reference to FIGS. 5 to 7. FIG. 5 illustrates an example in which a plurality of on-chip lenses **131** is disposed on the first photoelectric converter **101**.

[0106] Referring to FIG. 5, an on-chip lens **131-1**, an on-chip lens **131-2**, and an on-chip lens **131-3** are disposed on the first photoelectric converter **101-1**, the first photoelectric converter **101-2**, and the first photoelectric converter **101-3** of the first photoelectric converter **101**, respectively. An on-chip lens **131-4** is disposed on the second photoelectric converter **102**.

[0107] The on-chip lenses **131-1** to **103-4** have the same shape and size. By forming the on-chip lens **131** as large as possible on the photoelectric converter, sensitivity can be improved. In the example illustrated in FIG. 5, the on-chip lens **131** has a quadrangular shape with rounded corners, and has a shape that is as large as possible on a quadrangular photoelectric converter.

[0108] In a case where the on-chip lenses **131** disposed on the first photoelectric converter **101** and the second photoelectric converter **102** have the same shape and size, it is easy to form the on-chip lenses **131** at a time of manufacturing, and it is possible to form the on-chip lenses without increasing the number of steps.

[0109] As described with reference to FIG. 5, three on-chip lenses **131** on the first photoelectric converter **101** having an L shape can be disposed.

[0110] Referring to A of FIG. 6, an on-chip lens **131-5** and an on-chip lens **131-6** are disposed on the first photoelectric converter **101**, and one on-chip lens **131-4** is disposed on the second photoelectric converter **102**. In the example illustrated in FIG. 6, the on-chip lens **131-4** disposed on the second photoelectric converter **102** (small pixel) has the same shape and size as the on-chip lens **131-4** illustrated in FIG. 5.

[0111] The combined shape of the on-chip lens **131-5** and the on-chip lens **131-6** on the first photoelectric converter **101** has the same shape as the first photoelectric converter **101**, that is, an L shape in this case.

[0112] The on-chip lens **131-5** has such a size and shape as to cover the first photoelectric converter **101-1** and the first photoelectric converter **101-2** disposed in a longitudinal direction in the drawing among the first photoelectric converters **101** having an L shape. The on-chip lens **131-6** has such a size and shape as to cover the first photoelectric converter **101-3** disposed on the upper right of the first photoelectric converter **101** having an L shape. The on-chip lens **131-6** has an equal size and shape to the size and shape of the on-chip lens **131-4**.

[0113] Referring to B of FIG. 6, an on-chip lens **131-7** and an on-chip lens **131-8** are disposed on the first photoelectric converter **101**, and one on-chip lens **131-4** is disposed on the second photoelectric converter **102**.

[0114] The combined shape of the on-chip lens **131-7** and the on-chip lens **131-8** on the first photoelectric converter **101** has the same shape as the first photoelectric converter **101**, that is, an L shape in this case.

[0115] The on-chip lens **131-7** has such a size and shape as to cover the first photoelectric converter **101-3** disposed on the lower left of the first photoelectric converter **101** having an L shape. The on-chip lens **131-7** has an equal size and shape to the size and shape of the on-chip lens **131-4**. The on-chip lens **131-8** has such a size and shape as to cover the first photoelectric converter **101-2** and the first photoelectric converter **101-3** disposed in the horizontal direction in the drawing among the first photoelectric converters **101** having an L shape.

[0116] In a case where the two on-chip lenses **131** are disposed on the first photoelectric converter **101**, a gap generated between the on-chip lenses **131** can be one place, for example, one place between the on-chip lens **131-5** and the on-chip lens **131-6** in the case of the example illustrated in A of FIG. 6. Therefore, a region where the on-chip lenses **131** are disposed can be enlarged, and sensitivity can be improved.

[0117] As described with reference to FIG. 6, two on-chip lenses **131** on the first photoelectric converter **101** having an L shape can be disposed.

[0118] Referring to FIG. 7, one on-chip lens **131-9** is disposed on the first photoelectric converter **101**, and one on-chip lens **131-4** is disposed on the second photoelectric converter **102**. In the example illustrated in FIG. 6, the on-chip lens **131-4** disposed on the second photoelectric converter **102** (small pixel) has the same shape and size as the on-chip lens **131-4** illustrated in FIG. 5.

[0119] The on-chip lens **131-9** on the first photoelectric converter **101** has the same shape as the first photoelectric converter **101**, that is, an L shape in this case. The on-chip lens **131-5** is a lens formed in an L shape, and has a size about three times as large as the size of the on-chip lens **131-4**.

[0120] In a case where one on-chip lens **131** is disposed on the first photoelectric converter **101**, a gap generated between the on-chip lenses **131** can be eliminated. Therefore, a region where the on-chip lens **131** is disposed can be enlarged to the maximum, and sensitivity can be improved.

[0121] As described with reference to FIG. 7, one on-chip lens **131** on the first photoelectric converter **101** having an L shape can be disposed.

[0122] As illustrated in FIGS. 5 to 7, the present technology can be applied to a case where the number of the on-chip lenses **131** on the first photoelectric converter **101** is three, two, or one. Note that, although not illustrated, in a case where the size of the first photoelectric converter **101** is increased, the number of on-chip lenses **131** to be disposed can be increased in accordance with the size and shape, and a case where the number of on-chip lenses **131** is four or more is also in a range to which the present technology can be applied.

Shape of Slit in First Embodiment

[0123] In order to improve the sensitivity of the unit pixel **100**, a slit is provided in the unit pixel **100**. Embodiments such as a shape and an arrangement position of the slit will be described.

[0124] FIGS. 8 to 10 are diagrams for describing the shape and arrangement of a slit in a first embodiment. FIG. 8 is a plan view illustrating a configuration in a case where three on-chip lenses **131** are disposed on the first photoelectric converter **101** in the unit pixel **100** described with reference to FIG. 5 (in FIG. 7, a unit pixel **100a**). FIG. 9 is a sectional view of the unit pixel **100a** along a line segment A-A' in the plan view of FIG. 8. FIG. 10 is a sectional view of the unit pixel **100a** along a line segment B-B' in the plan view of FIG. 8.

[0125] Referring to FIGS. 8 and 9, since the line segment A-A' is located in the first photoelectric converter **101-2** and the first photoelectric converter **101-3**, the on-chip lens **131-2** and the on-chip lens **131-3** are provided. Referring to FIGS. 8 and 10, since the line segment B-B' is located in the first photoelectric converter **101-3** and the second photoelectric converter **102**, the on-chip lens **131-1** and the on-chip lens **131-4** are provided.

[0126] A color filter layer **171** is formed below the on-chip lens **131-2** and the on-chip lens **131-3** (FIG. 9). Similarly, a color filter layer **171** is formed under the on-chip lens **131-1** and the on-chip lens **131-4** (FIG. 10). Since a basic configurations of the unit pixel **100a** illustrated in FIGS. 9 and 10 are the same, the description will be given with reference to the sectional configuration example

illustrated in FIG. 9, and if necessary, the sectional configuration example illustrated in FIG. 10 will also be referred to.

[0127] The color filter layer **171** can be, for example, a filter having colors of red (R), green (G), and blue (B). White (W) may be included. The color filter layer **171** may be omitted, for example, in a case where infrared light is received.

[0128] A light shielding film **172** is formed between the adjacent unit pixels **100a** in the same layer as the color filter layer **171**. The light shielding film **172** is a film provided so that light incident on the on-chip lens **131** of the unit pixel **100a** does not enter the adjacent unit pixel **100a**, and includes a material having a light shielding property.

[0129] The inter-pixel isolator **173** is formed in a region where the light shielding film **172** is formed. The inter-pixel isolator **173** is a film provided so that light incident on the first photoelectric converter **101** or the second photoelectric converter **102** of the unit pixel **100a** does not leak into the adjacent unit pixel **100a**. The inter-pixel isolator **173** is configured by a trench penetrating the silicon substrate **174**. An oxide film of SiO₂ or the like may be formed in the trench. A film including a material that reflects light, for example, a metal such as aluminum or tungsten, may be formed in the trench.

[0130] In a planar configuration example illustrated in FIG. 8, an L-shaped slit **151** is formed in the first photoelectric converter **101**. The L-shaped slit **151** is formed in a central portion of the first photoelectric converter **101** having an L shape. The slit **151** is formed in a region where light is condensed by the L-shaped on-chip lens **131**.

[0131] When viewed in the sectional view taken along the line segment A-A' illustrated in FIG. 9, the slit **151** is formed with a predetermined depth from near a center of the on-chip lens **131-2** to near a center of the on-chip lens **131-3**. When viewed in the sectional view taken along the line segment B-B' illustrated in FIG. 10, the slit **151** having a predetermined thickness is formed with a predetermined depth near the center of the on-chip lens **131-3**.

[0132] Note that, although the slit **151** is described here, the slit **151** may be referred to as a trench or a groove, and is formed as a trench that does not penetrate the silicon substrate **174**. The inter-pixel isolator **173** is formed by a trench penetrating the silicon substrate **174**, and the slit **151** is formed by a trench not penetrating the silicon substrate **174**.

[0133] The slit **151** is formed with a predetermined depth from an interface of an oxide film **175** formed between the color filter layer **171** and the silicon substrate **174** toward the first photoelectric converter **101**. The slit **151** is provided to scatter and reflect light incident on the first photoelectric converter **101** via the on-chip lens **131** and the color filter layer **171**. This aspect is now described with reference to FIG. 11.

[0134] FIG. 11 is a sectional view illustrated in FIG. 10, and is a diagram in which traveling directions of light are indicated by arrows. A part of the light incident on the on-chip lens **131-1** is incident on the slit **151**. Due to a difference in refractive index between the slit **151** and the silicon substrate **174**, the light incident on the slit **151** is refracted and travels from the slit **151** into the silicon substrate **174**, that is, into the first photoelectric converter **101**. In other words, the incident light is scattered by the slit **151**. The light scattered by the slit **151** reaches the inter-pixel isolator **173** and is reflected. In this way, by providing the slit **151**, the incident light can be confined in the first photoelectric converter **101**, and an optical path length can be extended.

[0135] The slit **151** may include a material that reflects light, for example, metal. For example, a metal film may be formed in a trench constituting the slit **151**. In such a configuration, a part of the light incident on the on-chip lens **131-1** is reflected by the slit **151**, reaches the inter-pixel isolator **173**, and is reflected. In such a configuration, by providing the slit **151**, the incident light can be also confined in the first photoelectric converter **101**, and the optical path length can be extended.

[0136] As described above, the slit **151** can include metal or a material such as SiO₂. The material filled in the trench constituting each of the slit **151** and the inter-pixel isolator **173** may be the same material, for example, SiO₂, or may be different materials.

[0137] In this way, the unit pixel **100a** can be formed such that the first photoelectric converter **101** having an L shape is provided with the slit **151** having the same shape as the first photoelectric converter **101**, in this case, an L shape. By providing the slit **151** in the first photoelectric converter **101**, the sensitivity of the first photoelectric converter **101** can be improved.

Second Embodiment

[0138] FIG. **12** is a diagram illustrating a configuration of a unit pixel **100b** according to a second embodiment. The unit pixel **100b** illustrated in FIG. **12** has a configuration in which two on-chip lenses **131** are disposed on the first photoelectric converter **101** described with reference to FIG. **6**, and is a plan view illustrating a configuration of the unit pixel **100b** provided with the slit **151**.

[0139] In the unit pixel **100b** illustrated in A of FIG. **12**, the on-chip lens **131-5** and the on-chip lens **131-6** are disposed on the first photoelectric converter **101**, and the slit **151** having an L shape is provided under the two on-chip lenses **131**.

[0140] In the unit pixel **100b** illustrated in B of FIG. **12**, the on-chip lens **131-7** and the on-chip lens **131-8** are disposed on the first photoelectric converter **101**, and the slit **151** having an L shape is provided under the two on-chip lenses **131**.

[0141] The shape, size, and the like of the slit **151** illustrated in A of FIG. **12** and B of FIG. **12** are the same as the shape, size, and the like of the slit **151** provided in the unit pixel **100a** according to the first embodiment.

[0142] The L-shaped slit **151** can be provided regardless of the shape and arrangement of the on-chip lens **131**, and the sensitivity can be improved by providing the slit **151**.

Third Embodiment

[0143] FIGS. **13** and **14** are diagrams illustrating a configuration of a unit pixel **100c** according to a third embodiment. The unit pixel **100c** illustrated in FIG. **13** has a configuration in which one on-chip lenses **131** are disposed on the first photoelectric converter **101** described with reference to FIG. **7**, and is a plan view illustrating a configuration of the unit pixel **100c** provided with the slit **151**.

[0144] In the unit pixel **100c** illustrated in FIG. **13**, the on-chip lens **131-9** is disposed on the first photoelectric converter **101**, and the slit **151** having an L shape is provided under the on-chip lenses **131-9**.

[0145] The shape, size, and the like of the slit **151** illustrated in FIG. **13** are the same as the shape, size, and the like of the slit **151** provided in the unit pixel **100a** according to the first embodiment.

[0146] FIG. **14** is a sectional view of the unit pixel **100c** along a line segment A-A' in the plan view of FIG. **13**. Since a basic configuration is similar to the basic configuration of the unit pixel **100a** illustrated in FIGS. **9** and **10**, the same components are denoted by the same reference signs, and will not be described accordingly. The sectional view of the unit pixel **100c** taken along a line segment B-B' in the plan view of FIG. **13** is similar to the sectional view of the unit pixel **100a** illustrated in FIG. **10**, and thus will not be described.

[0147] Referring to FIG. **14**, the on-chip lens **131-9** is disposed on the line segment A-A'. In a case where the on-chip lens **131-9** is divided into four equal parts, the slit **151** is formed in a portion corresponding to two regions located at the center.

[0148] The L-shaped slit **151** can be provided regardless of the shape and arrangement of the on-chip lens **131**, and the sensitivity can be improved by providing the slit **151**.

Fourth Embodiment

[0149] FIGS. **15** and **16** are diagrams illustrating a configuration of a unit pixel **100d** according to a fourth embodiment. The unit pixel **100d** illustrated in FIG. **15** has a configuration in which one on-chip lens **131** is disposed on the first photoelectric converter **101** described with reference to FIG. **7**, is provided with the slit **151**, and is a plan view illustrating a configuration of the unit pixel **100d** in which a slit **152** is also provided in the second photoelectric converter **102** which is a small pixel.

[0150] In the unit pixel **100d** illustrated in FIG. **15**, the on-chip lens **131-9** is disposed on the first

photoelectric converter **101**, and the slit **151** having an L shape is provided under the on-chip lenses **131-9**. This configuration is similar to the configuration of the unit pixel **100c** (FIG. **13**) according to the third embodiment.

[0151] In the unit pixel **100d** illustrated in FIG. **15**, the on-chip lens **131-4** is disposed on the second photoelectric converter **102**, and a slit **152** having a quadrangular shape in plan view and a rectangular shape in the example illustrated in FIG. **15** is provided under the on-chip lens **131-4**. The slit **152** is formed in an oblique direction of the second photoelectric converter **102** in the drawing. Although details will be described later, formation in an oblique direction can prevent light scattered by the slit **152** in the second photoelectric converter **102** from advancing toward the first photoelectric converter **101** and entering the first photoelectric converter **101**.

[0152] FIG. **16** is a sectional view of the unit pixel **100d** along a line segment B-B' in the plan view of FIG. **15**. Since a basic configuration is similar to the basic configuration of the unit pixel **100a** illustrated in FIGS. **9** and **10**, the same components are denoted by the same reference signs, and will not be described accordingly. The sectional view of the unit pixel **100d** taken along a line segment A-A' in the plan view of FIG. **15** is similar to the sectional view of the unit pixel **100c** illustrated in FIG. **14**, and thus will not be described.

[0153] Referring to FIG. **16**, the on-chip lens **131-9** and the on-chip lens **131-4** are disposed on the line segment B-B'. The slit **151** is formed near the center of the first photoelectric converter **101** below the on-chip lens **131-9**. The slit **152** is formed near the center of the second photoelectric converter **102** below the on-chip lens **131-4**.

[0154] In this way, the slit **152** may also be provided in the second photoelectric converter **102**. By providing the slit **152** in the second photoelectric converter **102**, the sensitivity of the second photoelectric converter **102** can be also improved.

[0155] FIG. **15** illustrates an example in which an embodiment in which the slit **152** is also provided in the second photoelectric converter **102** is applied to the unit pixel **100c** according to the third embodiment. However, the example can be also applied to the unit pixel **100a** (FIG. **8**) according to the first embodiment and the unit pixel **100b** (FIG. **12**) according to the second embodiment.

Fifth Embodiment

[0156] FIGS. **17** to **19** are diagrams illustrating a configuration of a unit pixel **100e** according to a fifth embodiment. In the unit pixel **100e** illustrated in FIG. **17**, a case will be described as an example where the fifth embodiment is applied to a configuration in which one on-chip lens **131-9** is disposed on the first photoelectric converter **101** described with reference to FIG. **7**.

[0157] In the unit pixel **100e** illustrated in FIGS. **17** to **19**, the slit **151e** and the slit **152e** have different shapes from, for example, the slit **151** and the slit **152** of the unit pixel **100d** illustrated in FIG. **15**, and are similar to the slit **151** and the slit **152** in terms of the other points.

[0158] The slit **151e** formed in the first photoelectric converter **101** of the unit pixel **100e** is formed so as to be in contact with the inter-pixel isolator **173**. The slit **151e** includes a slit **151e-1** provided in the lateral direction in the drawing and a slit **151e-2** provided in the longitudinal direction in the drawing.

[0159] The slit **151e-1** is formed in a quadrangular shape (a rectangle in FIG. **17**) from the inter-pixel isolator **173** on the left side in the drawing to the inter-pixel isolator **173** on the right side in the drawing in the region of the first photoelectric converter **101-2** and the first photoelectric converter **101-3**. The slit **151e-2** is formed in a quadrangular shape (a rectangle in FIG. **17**) from the inter-pixel isolator **173** on the lower side in the drawing to the inter-pixel isolator **173** on the upper side in the drawing in the region of the first photoelectric converter **101-1** and the first photoelectric converter **101-2**.

[0160] The slit **151e-1** and the slit **151e-2** are disposed at positions intersecting with each other at the center of the first photoelectric converter **101-2**.

[0161] The slit **152e** is formed in a quadrangular shape (a rectangle in FIG. **17**) in the region of the

second photoelectric converter **102** from a corner of the inter-pixel isolator **173** on the upper left side in the drawing to a corner of the inter-pixel isolator **173** on the lower right side in the drawing. [0162] Referring to the sectional view taken along a line segment A-A' illustrated in FIG. **18**, the slit **151e-1** is formed from the inter-pixel isolator **173** on the left side in the drawing to the inter-pixel isolator **173** on the right side in the drawing under the on-chip lens **131-9**.

[0163] Referring to the sectional view taken along a line segment B-B' illustrated in FIG. **19**, the slit **151e-2** is formed in the first photoelectric converter **101** near the center below the on-chip lens **131-9**, and the slit **152e** is formed in the second photoelectric converter **102** near the center below the on-chip lens **131-4**.

[0164] In this way, in a case where the slit **151e** is configured to be in contact with the inter-pixel isolator **173**, the slit **151e** and the inter-pixel isolator **173** may be integrated. For example, the slit **151e** and the inter-pixel isolator **173** can include the same material, for example, SiO₂. Of course, the slit **151e** and the inter-pixel isolator **173** can include different materials. For example, the slit **151e** can include SiO₂, and the inter-pixel isolator **173** can include metal (a metal film can be formed in the inter-pixel isolator **173**).

[0165] In this way, the shape of the slit **151e** may be a shape obtained by extending each side of an L shape. By providing the slit **151e** having such a shape in the first photoelectric converter **101**, the sensitivity of the first photoelectric converter **101** can be improved. In addition, by providing the slit **152e** having such a shape in the second photoelectric converter **102**, the sensitivity of the second photoelectric converter **102** can be improved.

[0166] FIG. **17** illustrates an example in which the fifth embodiment is applied to the unit pixel **100d** according to the fourth embodiment. However, the fifth embodiment can be applied to the unit pixel **100a** (FIG. **8**) according to the first embodiment, the unit pixel **100b** (FIG. **12**) according to the second embodiment, and the unit pixel **100c** (FIG. **13**) according to the third embodiment, and the slit **151** provided in the first photoelectric converter **101** can have a shape in which each side of an L shape is extended.

Sixth Embodiment

[0167] FIG. **20** is a diagram illustrating a configuration of a unit pixel **100f** according to a sixth embodiment. In the embodiment described below, unless otherwise specified, the description will be continued assuming that the embodiment can be applied to the configuration in which three on-chip lenses **131** are provided on the first photoelectric converter **101** illustrated in FIG. **5**, the configuration in which two on-chip lenses **131** are provided on the first photoelectric converter **101** illustrated in FIG. **6**, and the configuration in which one on-chip lens **131** is provided on the first photoelectric converter **101** illustrated in FIG. **7**.

[0168] In the unit pixel **100f** illustrated in FIG. **20**, three slits of a slit **153-1**, a slit **153-2**, and a slit **153-3** are formed in the first photoelectric converter **101**. The slit **153-1** is formed in a quadrangular shape in the lateral direction in the drawing in the region of the first photoelectric converter **101-1**. The slit **153-2** is formed in a quadrangular shape in an oblique direction in the drawing in the region of the first photoelectric converter **101-2**. The slit **153-3** is formed in a quadrangular shape in the longitudinal direction in the drawing in the region of the first photoelectric converter **101-3**.

[0169] Although details will be described later, each of the slits **153-1** to **153-3** is formed in such a position, direction, and shape that light travels in such a direction as to be confined in the first photoelectric converter **101**. Each of the slits **153-1** to **153-3** is formed in such a position, direction, and shape that light does not travel toward the second photoelectric converter **102**.

[0170] Each of the slits **153-1** to **153-3** is formed at a position where light incident by the on-chip lens **131** is condensed. For example, in a case where the configuration in which three on-chip lenses **131** are on the first photoelectric converter **101** illustrated in FIG. **5** is applied to the sixth embodiment, for example, the slit **153-1** provided in the region of the on-chip lens **131-1** is formed in a region where light is condensed by the on-chip lens **131-1**, that is, near the center of the first

photoelectric converter **101-1**.

[0171] All of the slits **153-1** to **153-3** may be formed with the same depth, or different depths. In a case where the slits **153-1** to **153-3** are formed with different depths, for example, the slit **153-2** may be deeper than the slits **153-1** and **153-3**. In such a case, for example, out of the light scattered by the slit **153-1**, the light traveling toward the slit **153-2** may be scattered again at the slit **153-2**.

[0172] In this way, in a case where the plurality of slits **153** is provided in the first photoelectric converter **101**, the sensitivity of the first photoelectric converter **101** can be also improved.

Seventh Embodiment

[0173] FIG. **21** is a diagram illustrating a configuration of a unit pixel **100g** according to a seventh embodiment.

[0174] The unit pixel **100g** illustrated in FIG. **21** is different from the unit pixel **100f** (FIG. **20**) according to the sixth embodiment in that the unit pixel **100g** includes two slits **153-1-1** and **153-1-2** in the region of the first photoelectric converter **101-1** and two slits **153-3-1** and **153-3-2** in the region of the first photoelectric converter **101-3**, and is similar to the unit pixel **100f** in terms of the other points.

[0175] In the first photoelectric converter **101-1**, the quadrangular slits **153-1-1** and **153-1-2** having a long side in the lateral direction in the drawing are disposed at positions parallel to each other. The first photoelectric converter **101-2** is provided with one quadrangular slit **153-2** having a long side in an oblique direction in the drawing. In the first photoelectric converter **101-3**, the quadrangular slits **153-3-1** and **153-3-2** having a long side in the longitudinal direction in the drawing are disposed at positions parallel to each other.

[0176] As in the first photoelectric converter **101-1** and the first photoelectric converter **101-3**, a plurality of slits **153** may be provided in a predetermined region.

[0177] Note that, although, in the example illustrated in FIG. **21**, an example has been illustrated in which the two slits **153** are formed in a region of a predetermined size of the first photoelectric converter **101**, three or more slits **153** may be formed.

[0178] Note that a plurality of slits **153-2** disposed in the first photoelectric converter **101-2** may be also disposed in the first photoelectric converter **101-2**. For example, two slits **153-2** disposed in an oblique direction may be formed in the first photoelectric converter **101-2**.

[0179] Note that, in a case where the plurality of slits **153** is provided in one predetermined region of the first photoelectric converter **101**, the lengths of the plurality of slits **153** may be the same or different. For example, the slit **153-1-1** and the slit **153-1-2** disposed in the first photoelectric converter **101-1** may have the same length or different lengths. The slits **153** may be formed with the same depth or different depths.

[0180] In this way, in a case where the plurality of slits **153** is provided in the first photoelectric converter **101**, the sensitivity of the first photoelectric converter **101** can be also improved.

Eighth Embodiment

[0181] FIG. **22** is a diagram illustrating a configuration of a unit pixel **100h** according to an eighth embodiment.

[0182] The unit pixel **100h** illustrated in FIG. **22** is different from the unit pixel **100g** (FIG. **21**) according to the seventh embodiment in that the unit pixel **100h** includes two slits **153-2-1** and a slit **153-2-2** in the region of the first photoelectric converter **101-2**, and similar to the unit pixel **100g** in terms of the other points.

[0183] In the first photoelectric converter **101-2**, the quadrangular slits **153-2-1** and **153-2-2** having a long side in the longitudinal direction in the drawing are disposed at positions parallel to each other with an equal length.

[0184] As illustrated in FIG. **22**, a plurality of slits **153** provided in the first photoelectric converter **101-2** may be provided in the longitudinal direction. Note that, although, in the example illustrated in FIG. **22**, an example has been illustrated in which the two slits **153** are formed in a region of a predetermined size of the first photoelectric converter **101**, three or more slits **153** may be formed.

[0185] In a case where the plurality of slits **153** is provided in one predetermined region of the first photoelectric converter **101**, the lengths of the plurality of slits **153** may be the same or different.

[0186] In this way, in a case where the plurality of slits **153** is provided in the first photoelectric converter **101**, the sensitivity of the first photoelectric converter **101** can be also improved.

Ninth Embodiment

[0187] FIG. **23** is a diagram illustrating a configuration of a unit pixel **100i** according to a ninth embodiment.

[0188] The unit pixel **100i** illustrated in FIG. **23** is different from the unit pixel **100g** (FIG. **21**) according to the seventh embodiment in that the unit pixel **100i** includes a cross-shaped slit **154** in the region of the first photoelectric converter **101-2**, and similar to the unit pixel **100g** in terms of the other points.

[0189] In the first photoelectric converter **101-2**, the cross-shaped slit **154** is disposed near the center of the first photoelectric converter **101-2**. Note that the cross-shaped slit **154** illustrated in FIG. **23** is formed such that a longitudinal long side and a lateral long side have an equal length, but may have a shape in which one of the longitudinal long side or the lateral long side is longer.

[0190] Note that the cross-shaped slit **154** may be disposed in both or either the first photoelectric converter **101-1** or the first photoelectric converter **101-3**. That is, a plurality of cross-shaped slits **154** may be disposed in the first photoelectric converter **101**.

[0191] In this way, in a case where the plurality of slits **153** or **154** is provided in the first photoelectric converter **101**, the sensitivity of the first photoelectric converter **101** can be also improved.

Tenth Embodiment

[0192] FIG. **24** is a diagram illustrating a configuration of a unit pixel **100j** according to a tenth embodiment.

[0193] The unit pixel **100j** illustrated in FIG. **24** is different from the unit pixel **100g** (FIG. **21**) according to the seventh embodiment in that an L-shaped slit **155** is provided in the region of the first photoelectric converter **101-2**, and is similar to the unit pixel **100g** in terms of the other points.

[0194] In the first photoelectric converter **101-2**, a slit **155-1** and a slit **155-2** having an L shape are disposed. The slit **155-1** is formed on the side close to the inter-pixel isolator **173** and has a shape smaller than the slit **155-2**. Note that the L-shaped slit **155** illustrated in FIG. **24** is formed such that a longitudinal long side and a lateral long side have an equal length, but may have a shape in which one of the longitudinal long side or the lateral long side is longer.

[0195] Note that the L-shaped slit **155** may be disposed in both or either the first photoelectric converter **101-1** or the first photoelectric converter **101-3**. That is, a plurality of L-shaped slits **155** may be disposed in the first photoelectric converter **101**.

[0196] In this way, in a case where the plurality of slits **153** or **155** is provided in the first photoelectric converter **101**, the sensitivity of the first photoelectric converter **101** can be also improved.

Eleventh Embodiment

[0197] FIG. **25** is a diagram illustrating a configuration of a unit pixel **100k** according to an eleventh embodiment.

[0198] The unit pixel **100k** illustrated in FIG. **25** is different from the unit pixels **100** in the other embodiments in that a slit **156** is provided in the region of the second photoelectric converter **102**, and no slit is formed in the first photoelectric converter **101**.

[0199] The second photoelectric converter **102** is provided with a slit **156** having a quadrangular shape and having a long side in an oblique direction in the drawing. In the example illustrated in FIG. **25**, the rectangular slit **156** is illustrated, but the cross-shaped slit **154** illustrated in FIG. **23** or the L-shaped slit **155** illustrated in FIG. **24** can be disposed in the second photoelectric converter **102**. In the example illustrated in FIG. **25**, one slit **156** is provided in the second photoelectric converter **102**, but a plurality of slits **156** may be provided in the second photoelectric converter

102.

[0200] In this way, in a case where the slit **156** is provided in the second photoelectric converter **102**, the sensitivity of the second photoelectric converter **102** can be also improved.

Twelfth Embodiment

[0201] FIGS. **26** and **27** are diagrams illustrating a configuration of a unit pixel **100m** according to a twelfth embodiment.

[0202] The unit pixel **100m** illustrated in FIG. **26** has a configuration in which a unit pixel **f** (FIG. **20**) according to the sixth embodiment and the unit pixel **100k** (FIG. **25**) according to the eleventh embodiment are combined.

[0203] The unit pixel **100m** has slits the **153-1**, **153-2**, and **153-3** in the first photoelectric converter **101** and the slit **156** in the second photoelectric converter **102**.

[0204] FIG. **27** is a diagram illustrating a sectional configuration of the unit pixel **100m** taken along the line segment A-A' illustrated in FIG. **26**. FIG. **27** illustrates a sectional configuration example in a case where the unit pixel **100** (FIG. **5**) in which three on-chip lenses **131** are disposed on the first photoelectric converter **101** is applied. The on-chip lens **131-1** and the on-chip lens **131-4** are disposed in the unit pixel **100m**.

[0205] The slit **153-1** is formed under the on-chip lens **131-1** disposed on the first photoelectric converter **101**. The slit **153-1** is formed with a predetermined depth at a position not in contact with the inter-pixel isolator **173**. The slit **156** is formed under the on-chip lens **131-4** disposed on the second photoelectric converter **102**. The slit **156** is formed with a predetermined depth near the center of the on-chip lens **131-4**.

[0206] In this way, the slits **153** and **156** can be provided in both the first photoelectric converter **101** and the second photoelectric converter **102**. Note that, in the description with reference to FIGS. **26** and **27**, an example has been illustrated as described above in which the unit pixel **f** (FIG. **20**) according to the sixth embodiment and the unit pixel **100k** (FIG. **25**) according to the eleventh embodiment are combined as described above. However, a mode may be adopted in which any of the unit pixels **100g** to **100j** (FIGS. **21** to **24**) according to the seventh to tenth embodiments and the unit pixel **100k** (FIG. **25**) according to the eleventh embodiment are combined.

[0207] In this way, in a case where the slits **153** and **156** are provided in the first photoelectric converter **101** and the second photoelectric converter **102**, respectively, the sensitivity of the first photoelectric converter **101** and the second photoelectric converter **102** can be improved.

Control of Traveling Direction of Light by Slit

[0208] The control of the traveling direction of the incident light by providing the slits **151** to **156** will be described with reference to FIG. **28**. The unit pixel **100m** illustrated in FIG. **28** is the unit pixel **100m** according to the twelfth embodiment illustrated in FIG. **26**, and here, the description will be continued by using the unit pixel **100m** as an example.

[0209] The light incident on the slit **153-1** formed in the first photoelectric converter **101** is scattered in a direction a or a direction b. The direction a and the direction b are directions perpendicular to the long side of the slit **153-1**. The direction a is a direction toward the inter-pixel isolator **173** located on the lower side in the drawing of the unit pixel **100m**, and the direction b is a direction toward the inter-pixel isolator **173** located on the upper side in the drawing of the unit pixel **100m**. The light scattered by the slit **153-1** travels into the first photoelectric converter **101** and does not travel toward the second photoelectric converter **102**.

[0210] The light incident on the slit **153-2** formed in the first photoelectric converter **101** is scattered in a direction c or a direction d. The direction c and the direction d are directions perpendicular to the long side of the slit **153-2**. The direction c is a direction toward the inter-pixel isolator **173** located on the left side in the drawing of the unit pixel **100m**, and the direction d is a direction toward the inter-pixel isolator **173** located on the upper side in the drawing of the unit pixel **100m**. The light scattered by the slit **153-2** travels into the first photoelectric converter **101** and does not travel toward the second photoelectric converter **102**.

[0211] The light incident on the slit **153-3** formed in the first photoelectric converter **101** is scattered in a direction e or a direction f. The direction e and the direction f are directions perpendicular to the long side of the slit **153-3**. The direction e is a direction toward the inter-pixel isolator **173** located on the left side in the drawing of the unit pixel **100m**, and the direction f is a direction toward the inter-pixel isolator **173** located on the right side in the drawing of the unit pixel **100m**. The light scattered by the slit **153-3** travels into the first photoelectric converter **101** and does not travel toward the second photoelectric converter **102**. In this way, the slit **153** formed in the first photoelectric converter **101** is disposed such that the long side faces the inside of the first photoelectric converter **101** and the short side faces the second photoelectric converter **102**.

[0212] The slit **153** provided in the first photoelectric converter **101** scatters the incident light into the first photoelectric converter **101**, but does not scatter the incident light toward the second photoelectric converter **102**. Therefore, the light scattered by the slit **153** can be prevented from leaking into the second photoelectric converter **102**.

[0213] The slit **156** formed in the second photoelectric converter **102** is disposed such that the long side faces the inside of the second photoelectric converter **102** and the short side faces the first photoelectric converter **101**.

[0214] The light incident on the slit **156** formed in the second photoelectric converter **102** is scattered in a direction g or a direction h. The direction g and the direction h are directions perpendicular to the long side of the slit **156**. The direction g is a direction toward the inter-pixel isolator **173** located on the lower side in the drawing of the unit pixel **100m**, and the direction h is a direction toward the inter-pixel isolator **173** located on the right side in the drawing of the unit pixel **100m**. The light scattered by the slit **156** travels into the second photoelectric converter **102** and less light travels toward the first photoelectric converter **101**.

[0215] In this way, the slit **156** provided in the second photoelectric converter **102** scatters the incident light into the second photoelectric converter **102**, and reduces the light traveling toward the first photoelectric converter **101**. It is therefore possible to reduce leakage of the light scattered by the slit **156** into the first photoelectric converter **101**.

[0216] In this way, by arranging the slit **153** provided in the first photoelectric converter **101** so that the short side faces the second photoelectric converter **102**, it is possible to reduce leakage of light from the first photoelectric converter **101** to the second photoelectric converter **102**. Similarly, by arranging the slit **156** provided in the second photoelectric converter **102** so that the short side faces the first photoelectric converter **101**, it is possible to reduce leakage of light from the second photoelectric converter **102** to the first photoelectric converter **101**.

[0217] In the sixth to twelfth embodiments described above, basically, the short side of the slit is disposed to face the first photoelectric converter **101** (large pixel) or the second photoelectric converter **102** (small pixel). Therefore, in the unit pixels **100f** to **100m** according to the sixth to twelfth embodiments, it is possible to prevent light from leaking from the large pixel to the small pixel and from the small pixel to the large pixel.

Thirteenth Embodiment

[0218] FIGS. **29** and **30** are diagrams illustrating a configuration of a unit pixel **100n** according to a thirteenth embodiment. The unit pixel **100n** according to the thirteenth embodiment illustrated in FIGS. **29** and **30** exemplifies a case where the thirteenth embodiment is applied to the unit pixel **100m** (FIG. **26**, FIG. **27**) according to the twelfth embodiment.

[0219] In the unit pixel **100n** illustrated in FIGS. **29** and **30**, the shapes of the slit **153** and a slit **156n** are different from the shapes of the slit **153** and the slit **156** of the unit pixel **100m** illustrated in FIGS. **26** and **27**, and the other points are similar.

[0220] A slit **153-1n** formed in the first photoelectric converter **101-1** of the unit pixel **100n** is formed so as to be in contact with the inter-pixel isolator **173**. The short side of the slit **153-1n** on the left side in the drawing is in contact with the inter-pixel isolator **173** on the left side in the drawing, and the short side of the slit **153-1n** on the right side in the drawing is formed at such a

position and has such a size as to be in contact with the inter-pixel isolator **173** formed between the first photoelectric converter **101** and the second photoelectric converter **102**.

[0221] A slit **153-2n** formed in the first photoelectric converter **101-2** of the unit pixel **100n** is formed so as to be in contact with the inter-pixel isolator **173**. A short side of the slit **153-2n** on the upper left side in the drawing is in contact with a portion where the inter-pixel isolator **173** on the upper left side in the drawing intersects, and the short side of the slit **153-2n** on the lower right side in the drawing is formed at such a position and has such a size as to be in contact with the inter-pixel isolator **173** formed between the first photoelectric converter **101** and the second photoelectric converter **102**.

[0222] A slit **153-3n** formed in the first photoelectric converter **101-3** of the unit pixel **100n** is formed so as to be in contact with the inter-pixel isolator **173**. The short side of the slit **153-3n** on the upper side in the drawing is in contact with the inter-pixel isolator **173** on the upper side in the drawing, and the short side of the slit **153-3n** on the lower side in the drawing is formed at such a position and has such a size as to be in contact with the inter-pixel isolator **173** formed between the first photoelectric converter **101** and the second photoelectric converter **102**.

[0223] The slit **156n** formed in the second photoelectric converter **102** of the unit pixel **100n** is formed so as to be in contact with the inter-pixel isolator **173**. The short side of the slit **156n** on the upper left side in the drawing is in contact with the inter-pixel isolator **173** formed between the first photoelectric converter **101** and the second photoelectric converter **102**, and the short side of the slit **156n** on the lower right side in the drawing is formed at such a position and has such a size as to be in contact with a portion where the inter-pixel isolator **173** on the lower right side in the drawing intersects.

[0224] Referring to FIG. **30** which is a sectional view taken along a line segment A-A' illustrated in FIG. **29**, the slit **153-1n** is formed from the inter-pixel isolator **173** on the left side in the drawing to the inter-pixel isolator **173** on the right side in the drawing under the on-chip lens **131-1**. Under the on-chip lens **131-4**, the slit **156n** is formed in a region corresponding to a vicinity of the center of the on-chip lens **131-4**.

[0225] In this way, in a case where the slits **153-1n** to **153-3n** and **156n** are configured to be in contact with the inter-pixel isolator **173**, each of the slits **153-1n** to **153-3n** and **156n** and the inter-pixel isolator **173** may be integrated. For example, the slits **153-1n** to **153-3n** and **156n** and the inter-pixel isolator **173** can include the same material, for example, SiO₂.

[0226] Of course, the slits **153-1n** to **153-3n** and **156n** and the inter-pixel isolator **173** can include different materials. For example, the slits **153-1n** to **153-3n** and **156n** may include SiO₂, and the inter-pixel isolator **173** can include metal (a metal film may be formed in the inter-pixel isolator **173**).

[0227] By providing the slits **153-1n** to **153-3n** having such a shape in the first photoelectric converter **101**, the sensitivity of the first photoelectric converter **101** can be improved. In addition, by providing the slit **156n** having such a shape in the second photoelectric converter **102**, the sensitivity of the second photoelectric converter **102** can be improved.

[0228] Note that, in the description with reference to FIGS. **29** and **30**, an example has been illustrated as described above in which the unit pixel **m** (FIG. **26**) according to the twelfth embodiment and the thirteenth embodiment are combined as described above. However, it is also possible to combine the thirteenth embodiment with any of the unit pixels **100f** to **100j** (FIGS. **20** to **24**) according to the sixth to eleventh embodiments so that the slit provided in the unit pixel **100** is in contact with the inter-pixel isolator **173**.

Fourteenth Embodiment

[0229] FIG. **31** is a schematic diagram illustrating a configuration example of a pixel array unit **11a** according to a fourteenth embodiment. In a case where the color filter layer **171** is provided, a unit pixel provided with a slit or a unit pixel provided with no slit can be set in accordance with the color of the color filter layer **171**. In the following description, a case will be described as an

example where the unit pixel **100m** according to the twelfth embodiment is disposed in the unit pixel **100** provided with a slit. However, any of the unit pixels **100a** to **100n** according to the first to thirteenth embodiments described above can be applied.

[0230] FIG. **31** illustrates four unit pixels **100** in 2×2 disposed in the pixel array unit **11a**. A unit pixel **100GB** on the upper left side in the drawing is a unit pixel provided with a green color filter layer **171**. A unit pixel **100B** on the upper right side in the drawing is a unit pixel provided with a blue color filter layer **171**. A unit pixel **100R** on the lower left side in the drawing is a unit pixel provided with a red color filter layer **171**. A unit pixel **100GR** on the lower right side in the drawing is a unit pixel provided with a green color filter layer **171**.

[0231] The example illustrated in FIG. **31** is an example in which slits are provided in all the unit pixels **100** disposed in the pixel array unit **11a**. Slits are provided in both the first photoelectric converter **101** and the second photoelectric converter **102** included in the unit pixel **100GB**, the unit pixel **100B**, the unit pixel **100R**, and the unit pixel **100GB**.

[0232] In this way, by providing slits in the first photoelectric converters **101** and the second photoelectric converters **102** of all the unit pixels **100** disposed in the pixel array unit **11a**, the sensitivity of all the unit pixels **100** can be improved.

Fifteenth Embodiment

[0233] FIG. **32** is a schematic diagram illustrating a configuration example of a pixel array unit **11b** according to a fifteenth embodiment.

[0234] In a pixel array unit **11b-1** illustrated in A of FIG. **32**, slits are provided in both the first photoelectric converter **101** and the second photoelectric converter **102** of the unit pixel **100R** in which the red color filter layer **171** is disposed, and no slit is provided in the unit pixel **100GB**, the unit pixel **100B**, and the unit pixel **100GR**. In this case, the sensitivity of the unit pixel **100R**, which is an R pixel, can be improved as compared with the other unit pixels **100**.

[0235] In a pixel array unit **11b-2** illustrated in B of FIG. **32**, slits are provided in both the first photoelectric converter **101** and the second photoelectric converter **102** of each of the unit pixel **100GB** and the unit pixel GR in which the green color filter layer **171** is disposed, and no slit is provided in the unit pixel **100B** and the unit pixel **100R**. In this case, the sensitivity of the unit pixel GB and the unit pixel **100GR**, which are G pixels, can be improved as compared with the other unit pixels **100**.

[0236] In a pixel array unit **11b-3** illustrated in C of FIG. **32**, slits are provided in both the first photoelectric converter **101** and the second photoelectric converter **102** of the unit pixel **100B** in which the blue color filter layer **171** is disposed, and no slit is provided in the unit pixel **100GB**, the unit pixel **100R**, and the unit pixel **100GR**. In this case, the sensitivity of the unit pixel **100B**, which is a B pixel, can be improved as compared with the other unit pixels **100**.

[0237] In this way, the slit may be provided in the unit pixel **100** in which the color filter layer **171** of a color desired to have higher sensitivity than the other unit pixels **100** is disposed.

Sixteenth Embodiment

[0238] FIG. **33** is a schematic diagram illustrating a configuration example of a pixel array unit **11c** according to a sixteenth embodiment.

[0239] In a pixel array unit **11c-1** illustrated in A of FIG. **33**, slits are provided in the first photoelectric converter **101** of the unit pixel **100R** in which the red color filter layer **171** is disposed, and no slit is provided in the second photoelectric converter **102**. No slit is provided in the unit pixel **100GB**, the unit pixel **100B**, and the unit pixel **100GR**. In this case, the sensitivity of the first photoelectric converter **101** (large pixel) of the unit pixel **100R**, which is an R pixel, can be improved as compared with the first photoelectric converters **101** of the other unit pixels **100**.

[0240] In a pixel array unit **11c-2** illustrated in B of FIG. **33**, slits are provided in the first photoelectric converter **101** of each of the unit pixel **100GB** and the unit pixel GR in which the green color filter layer **171** is disposed, and no slit is provided in the second photoelectric converter **102**. No slit is provided in the unit pixel **100B** and the unit pixel **100R**. In this case, the sensitivity

of the first photoelectric converter **101** (large pixel) of the unit pixel GB and the unit pixel **100GR**, which are G pixels, can be improved as compared with the first photoelectric converters **101** of the other unit pixels **100**.

[0241] In a pixel array unit **11c-3** illustrated in C of FIG. **33**, slits are provided in the first photoelectric converter **101** of the unit pixel **100B** in which the blue color filter layer **171** is disposed, and no slit is provided in the second photoelectric converter **102**. No slit is provided in the unit pixel **100GB**, the unit pixel **100R**, and the unit pixel **100GR**. In this case, the sensitivity of the first photoelectric converter **101** (large pixel) of the unit pixel **100B**, which is a B pixel, can be improved as compared with the first photoelectric converters **101** of the other unit pixels **100**.

[0242] In this way, the slit may be provided in the first photoelectric converter **101** of the unit pixel **100** in which the color filter layer **171** of a color desired to have higher sensitivity than the other unit pixels **100** is disposed.

Seventeenth Embodiment

[0243] FIG. **34** is a schematic diagram illustrating a configuration example of a pixel array unit **11d** according to a seventeenth embodiment.

[0244] In a pixel array unit **11d-1** illustrated in A of FIG. **34**, slits are provided in the second photoelectric converter **102** of the unit pixel **100R** in which the red color filter layer **171** is disposed, and no slit is provided in the first photoelectric converter **101**. No slit is provided in the unit pixel **100GB**, the unit pixel **100B**, and the unit pixel **100GR**. In this case, the sensitivity of the second photoelectric converter **102** (small pixel) of the unit pixel **100R**, which is an R pixel, can be improved as compared with the second photoelectric converters **102** of the other unit pixels **100**.

[0245] In a pixel array unit **11d-2** illustrated in B of FIG. **34**, slits are provided in the second photoelectric converter **102** of each of the unit pixel **100GB** and the unit pixel GR in which the green color filter layer **171** is disposed, and no slit is provided in the first photoelectric converter **101**. No slit is provided in the unit pixel **100B** and the unit pixel **100R**. In this case, the sensitivity of the second photoelectric converter **102** (small pixel) of the unit pixel GB and the unit pixel **100GR**, which are G pixels, can be improved as compared with the second photoelectric converters **102** of the other unit pixels **100**.

[0246] In a pixel array unit **11d-3** illustrated in C of FIG. **34**, slits are provided in the second photoelectric converter **102** of the unit pixel **100B** in which the blue color filter layer **171** is disposed, and no slit is provided in the first photoelectric converter **101**. No slit is provided in the unit pixel **100GB**, the unit pixel **100R**, and the unit pixel **100GR**. In this case, the sensitivity of the second photoelectric converter **102** (small pixel) of the unit pixel **100B**, which is a B pixel, can be improved as compared with the second photoelectric converters **102** of the other unit pixels **100**.

[0247] In this way, the slit may be provided in the second photoelectric converter **102** of the unit pixel **100** in which the color filter layer **171** of a color desired to have higher sensitivity than the other unit pixels **100** is disposed.

[0248] In the present technology, the unit pixel **100** can include the first photoelectric converter **101** and the second photoelectric converter **102** having different sizes. The first photoelectric converter **101** and the second photoelectric converter **102** can be disposed without generating an unnecessary gap between the first photoelectric converter **101** and the second photoelectric converter **102**.

[0249] By providing the slit in the unit pixel **100**, incident light can be scattered and confined in the photoelectric converter. Therefore, the sensitivity can be improved.

[0250] A slit can be provided in both or either the first photoelectric converter **101** or the second photoelectric converter **102**, or a slit can be provided only in a desired photoelectric converter whose sensitivity is desired to be improved, and sensitivity adjustment such as improving the sensitivity of the entire unit pixel **100** or improving only the sensitivity of the desired photoelectric converter can be performed.

[0251] By adjusting the position and direction of the slit, it is possible to prevent light from leaking into the first photoelectric converter **101** or the second photoelectric converter **102**, and color

mixing between large and small pixels can be suppressed.

Example Applications to Electronic Devices

[0252] The present technology can be applied to all electronic devices using an imaging element in an image capturer (photoelectric converter), such as an imaging apparatus like a digital still camera or a video camera, a mobile terminal device having an imaging function, and a copying machine using an imaging element in an image reader. An imaging element may be formed as one chip, or may be in a modular form having an imaging function in which an imaging unit and a signal processor or an optical system are packaged together.

[0253] FIG. 35 is a block diagram illustrating a configuration example of an imaging apparatus as an electronic device to which the present technology is applied.

[0254] An imaging apparatus **1000** in FIG. 35 is provided with an optical unit **1001** including a lens group and the like, an imaging element (imaging device) **1002** to which the configuration of the imaging apparatus **10** in FIG. 1 is adopted, and a digital signal processor (DSP) circuit **1003** being a camera signal processing circuit. Furthermore, the imaging apparatus **1000** also includes a frame memory **1004**, a display unit **1005**, a recording unit **1006**, an operation unit **1007**, and a power supply unit **1008**. The DSP circuit **1003**, the frame memory **1004**, the display unit **1005**, the recording unit **1006**, the operation unit **1007**, and the power supply unit **1008** are connected to one another via a bus line **1009**.

[0255] The optical unit **1001** captures incident light (image light) from an object, and forms an image on the imaging surface of the imaging element **1002**. The imaging element **1002** converts the amount of the incident light the image of which is formed on the imaging surface by the optical unit **1001**, into an electric signal on a pixel basis, and outputs the electric signal as a pixel signal. As the imaging element **1002**, the imaging apparatus **10** in FIG. 1 can be used.

[0256] The display unit **1005** is formed with a flat-panel display such as a liquid crystal display (LCD) or an organic electro luminescence (EL) display, for example, and displays a video image or a still image formed by the imaging element **1002**. The recording unit **1006** records the video image or the still image captured by the imaging element **1002** in a recording medium such as a hard disk or a semiconductor memory.

[0257] The operation unit **1007** issues an operation command regarding various functions of the imaging apparatus **1000** under operation by a user. The power supply unit **1008** appropriately supplies various kinds of power that is the operating power supply for the DSP circuit **1003**, the frame memory **1004**, the display unit **1005**, the recording unit **1006**, and the operation unit **1007**, to these supply targets.

Practical Application Example to Mobile Body

[0258] The technology of the present disclosure (present technology) can be applied to various products. For example, the technology of the present disclosure may be achieved in a form of an apparatus to be mounted to a mobile body of any kind such as an automobile, an electric vehicle, a hybrid electric vehicle, a motorcycle, a bicycle, a personal mobility, an airplane, a drone, a vessel, and a robot.

[0259] FIG. 36 is a block diagram illustrating a schematic configuration example of a vehicle control system as an example of a mobile body control system to which the technology of the present disclosure is applied.

[0260] The vehicle control system **12000** includes a plurality of electronic control units connected to each other via a communication network **12001**. In the example illustrated in FIG. 36, the vehicle control system **12000** includes a driving system control unit **12010**, a body system control unit **12020**, an outside-vehicle information detecting unit **12030**, an in-vehicle information detecting unit **12040**, and an integrated control unit **12050**. In addition, a microcomputer **12051**, a sound/image output section **12052**, and a vehicle-mounted network interface (I/F) **12053** are illustrated as a functional configuration of the integrated control unit **12050**.

[0261] The driving system control unit **12010** controls the operation of devices related to the

driving system of the vehicle in accordance with various kinds of programs. For example, the driving system control unit **12010** functions as a control device for a driving force generating device for generating the driving force of the vehicle, such as an internal combustion engine, a driving motor, or the like, a driving force transmitting mechanism for transmitting the driving force to wheels, a steering mechanism for adjusting the steering angle of the vehicle, a braking device for generating the braking force of the vehicle, and the like.

[0262] The body system control unit **12020** controls the operation of various kinds of devices provided to a vehicle body in accordance with various kinds of programs. For example, the body system control unit **12020** functions as a control device for a keyless entry system, a smart key system, a power window device, or various kinds of lamps such as a headlamp, a backup lamp, a brake lamp, a turn signal, a fog lamp, or the like. In this case, radio waves transmitted from a mobile device as an alternative to a key or signals of various kinds of switches can be input to the body system control unit **12020**. The body system control unit **12020** receives these input radio waves or signals, and controls a door lock device, the power window device, the lamps, or the like of the vehicle.

[0263] The outside-vehicle information detecting unit **12030** detects information about the outside of the vehicle including the vehicle control system **12000**. For example, the outside-vehicle information detecting unit **12030** is connected with an imaging section **12031**. The outside-vehicle information detecting unit **12030** makes the imaging section **12031** image an image of the outside of the vehicle, and receives the imaged image. On the basis of the received image, the outside-vehicle information detecting unit **12030** may perform processing of detecting an object such as a human, a vehicle, an obstacle, a sign, a character on a road surface, or the like, or processing of detecting a distance thereto.

[0264] The imaging section **12031** is an optical sensor that receives light, and which outputs an electric signal corresponding to a received light amount of the light. The imaging section **12031** can output the electric signal as an image, or can output the electric signal as information about a measured distance. In addition, the light received by the imaging section **12031** may be visible light, or may be invisible light such as infrared rays or the like.

[0265] The in-vehicle information detecting unit **12040** detects information about the inside of the vehicle. The in-vehicle information detecting unit **12040** is, for example, connected with a driver state detecting section **12041** that detects the state of a driver. The driver state detecting section **12041**, for example, includes a camera that images the driver. On the basis of detection information input from the driver state detecting section **12041**, the in-vehicle information detecting unit **12040** may calculate a degree of fatigue of the driver or a degree of concentration of the driver, or may determine whether the driver is dozing.

[0266] The microcomputer **12051** can calculate a control target value for the driving force generating device, the steering mechanism, or the braking device on the basis of the information about the inside or outside of the vehicle which information is obtained by the outside-vehicle information detecting unit **12030** or the in-vehicle information detecting unit **12040**, and output a control command to the driving system control unit **12010**. For example, the microcomputer **12051** can perform cooperative control intended to implement functions of an advanced driver assistance system (ADAS) which functions include collision avoidance or shock mitigation for the vehicle, following driving based on a following distance, vehicle speed maintaining driving, a warning of collision of the vehicle, a warning of deviation of the vehicle from a lane, or the like.

[0267] In addition, the microcomputer **12051** can perform cooperative control intended for automated driving, which makes the vehicle to travel automatically without depending on the operation of the driver, or the like, by controlling the driving force generating device, the steering mechanism, the braking device, or the like on the basis of the information about the outside or inside of the vehicle which information is obtained by the outside-vehicle information detecting unit **12030** or the in-vehicle information detecting unit **12040**.

[0268] In addition, the microcomputer **12051** can output a control command to the body system control unit **12020** on the basis of the information about the outside of the vehicle which information is obtained by the outside-vehicle information detecting unit **12030**. For example, the microcomputer **12051** can perform cooperative control intended to prevent a glare by controlling the headlamp so as to change from a high beam to a low beam, for example, in accordance with the position of a preceding vehicle or an oncoming vehicle detected by the outside-vehicle information detecting unit **12030**.

[0269] The sound/image output section **12052** transmits an output signal of at least one of a sound and an image to an output device capable of visually or auditorily notifying information to an occupant of the vehicle or the outside of the vehicle. In the example of FIG. **36**, an audio speaker **12061**, a display section **12062**, and an instrument panel **12063** are exemplified as the output device. The display section **12062** may, for example, include at least one of an on-board display and a head-up display.

[0270] FIG. **37** is a diagram illustrating an example of an installation position of the imaging section **12031**.

[0271] In FIG. **37**, the imaging section **12031** includes imaging sections **12101**, **12102**, **12103**, **12104**, and **12105**.

[0272] The imaging sections **12101**, **12102**, **12103**, **12104**, and **12105** are, for example, disposed at positions on a front nose, sideview mirrors, a rear bumper, and a back door of the vehicle **12100** as well as a position on an upper portion of a windshield within the interior of the vehicle. The imaging section **12101** provided to the front nose and the imaging section **12105** provided to the upper portion of the windshield within the interior of the vehicle obtain mainly an image of the front of the vehicle **12100**. The imaging sections **12102** and **12103** provided to the sideview mirrors obtain mainly an image of the sides of the vehicle **12100**. The imaging section **12104** provided to the rear bumper or the back door obtains mainly an image of the rear of the vehicle **12100**. The imaging section **12105** provided to the upper portion of the windshield within the interior of the vehicle is used mainly to detect a preceding vehicle, a pedestrian, an obstacle, a signal, a traffic sign, a lane, or the like.

[0273] Note that FIG. **37** illustrates an example of imaging ranges of the imaging sections **12101** to **12104**. An imaging range **12111** represents the imaging range of the imaging section **12101** provided to the front nose. Imaging ranges **12112** and **12113** respectively represent the imaging ranges of the imaging sections **12102** and **12103** provided to the sideview mirrors. An imaging range **12114** represents the imaging range of the imaging section **12104** provided to the rear bumper or the back door. A bird's-eye image of the vehicle **12100** as viewed from above is obtained by superimposing image data imaged by the imaging sections **12101** to **12104**, for example.

[0274] At least one of the imaging sections **12101** to **12104** may have a function of obtaining distance information. For example, at least one of the imaging sections **12101** to **12104** may be a stereo camera constituted of a plurality of imaging elements, or may be an imaging element having pixels for phase difference detection.

[0275] For example, the microcomputer **12051** can determine a distance to each three-dimensional object within the imaging ranges **12111** to **12114** and a temporal change in the distance (relative speed with respect to the vehicle **12100**) on the basis of the distance information obtained from the imaging sections **12101** to **12104**, and thereby extract, as a preceding vehicle, a nearest three-dimensional object in particular that is present on a traveling path of the vehicle **12100** and which travels in substantially the same direction as the vehicle **12100** at a predetermined speed (for example, equal to or more than 0 km/hour). Further, the microcomputer **12051** can set a following distance to be maintained in front of a preceding vehicle in advance, and perform automatic brake control (including following stop control), automatic acceleration control (including following start control), or the like. It is thus possible to perform cooperative control intended for automated driving that makes the vehicle travel automatically without depending on the operation of the driver

or the like.

[0276] For example, the microcomputer **12051** can classify three-dimensional object data on three-dimensional objects into three-dimensional object data of a two-wheeled vehicle, a standard-sized vehicle, a large-sized vehicle, a pedestrian, a utility pole, and other three-dimensional objects on the basis of the distance information obtained from the imaging sections **12101** to **12104**, extract the classified three-dimensional object data, and use the extracted three-dimensional object data for automatic avoidance of an obstacle. For example, the microcomputer **12051** identifies obstacles around the vehicle **12100** as obstacles that the driver of the vehicle **12100** can recognize visually and obstacles that are difficult for the driver of the vehicle **12100** to recognize visually. Then, the microcomputer **12051** determines a collision risk indicating a risk of collision with each obstacle. In a situation in which the collision risk is equal to or higher than a set value and there is thus a possibility of collision, the microcomputer **12051** outputs a warning to the driver via the audio speaker **12061** or the display section **12062**, and performs forced deceleration or avoidance steering via the driving system control unit **12010**. The microcomputer **12051** can thereby assist in driving to avoid collision.

[0277] At least one of the imaging sections **12101** to **12104** may be an infrared camera that detects infrared rays. The microcomputer **12051** can, for example, recognize a pedestrian by determining whether or not there is a pedestrian in imaged images of the imaging sections **12101** to **12104**. Such recognition of a pedestrian is, for example, performed by a procedure of extracting characteristic points in the imaged images of the imaging sections **12101** to **12104** as infrared cameras and a procedure of determining whether or not it is the pedestrian by performing pattern matching processing on a series of characteristic points representing the contour of the object. When the microcomputer **12051** determines that there is a pedestrian in the imaged images of the imaging sections **12101** to **12104**, and thus recognizes the pedestrian, the sound/image output section **12052** controls the display section **12062** so that a square contour line for emphasis is displayed so as to be superimposed on the recognized pedestrian. The sound/image output section **12052** may also control the display section **12062** so that an icon or the like representing the pedestrian is displayed at a desired position.

[0278] In the present specification, the system represents the entire device including a plurality of devices.

[0279] Note that the effects described in the present specification are merely examples and are not limited, and there may be other effects.

[0280] Note that the embodiments of the present technology are not limited to the above-described embodiments, and various changes can be made without departing from the gist of the present technology.

[0281] Note that the present technology may also have the following configurations.

[0282] (1)

[0283] An imaging element includes

[0284] a first photoelectric converter that generate a charge corresponding to a light amount, and

[0285] a second photoelectric converter having a smaller light receiving area than the first photoelectric converter, in which

[0286] the first photoelectric converter has an L shape in plan view,

[0287] the second photoelectric converter has a quadrangular shape, and

[0288] a shape obtained by combining the first photoelectric converter and the second photoelectric converter is a quadrangular shape.

[0289] (2)

[0290] In the imaging element according to (1),

[0291] a plurality of on-chip lenses is disposed on the first photoelectric converter.

[0292] (3)

[0293] In the imaging element according to (1) or (2),

[0294] the light receiving area of the first photoelectric converter is about three times the light receiving area of the second photoelectric converter,

[0295] three on-chip lenses are disposed on the first photoelectric converter, and

[0296] one on-chip lens having the same type as the on-chip lenses is disposed on the second photoelectric converter.

[0297] (4)

[0298] In the imaging element according to (1) or (2),

[0299] an on-chip lens of the same type of the first photoelectric converter is disposed on the first photoelectric converter.

[0300] (5)

[0301] In the imaging element according to any of (1) to (4),

[0302] the first photoelectric converter is provided with a slit on a light receiving surface side.

[0303] (6)

[0304] In the imaging element according to (5),

[0305] the slit is formed in a quadrangular shape under the on-chip lens.

[0306] (7)

[0307] In the imaging element according to (5),

[0308] the slit has the same type as the on-chip lens.

[0309] (8)

[0310] In the imaging element according to (5) or (6),

[0311] a plurality of the slit is formed under the on-chip lens.

[0312] (9)

[0313] In the imaging element according to any of (5) to (8),

[0314] the slit has a quadrangular shape, and a short side of the slit having the quadrangular shape faces the second photoelectric converter.

[0315] (10)

[0316] In the imaging element according to any of (1) to (9),

[0317] the second photoelectric converter is provided with a slit on a light receiving surface side.

[0318] (11)

[0319] In the imaging element according to (10),

[0320] the slit has a quadrangular shape, and a short side of the slit having the quadrangular shape faces the first photoelectric converter.

[0321] (12)

[0322] In the imaging element according to any of (5) to (11),

[0323] an inter-pixel isolator is formed between a first pixel including the first photoelectric converter and the second photoelectric converter and a second pixel adjacent to the first pixel, and

[0324] the slit is formed up to a position to be in contact with the inter-pixel isolator.

[0325] (13)

[0326] The imaging element according to any of (5) to (12) further includes

[0327] a color filter layer, in which

[0328] the slit is provided in the first photoelectric converter in which a predetermined color of the color filter layer is disposed.

[0329] (14)

[0330] The imaging element according to any of (5) to (13) further includes

[0331] a color filter layer, in which

[0332] the slit is provided in the second photoelectric converter in which a predetermined color of the color filter layer is disposed.

[0333] (15)

[0334] An electronic device includes

[0335] an imaging element, and

[0336] a processor that processes a signal from the imaging element,
[0337] the imaging element including
[0338] a first photoelectric converter that generate a charge corresponding to a light amount, and
[0339] a second photoelectric converter having a smaller light receiving area than the first photoelectric converter, in which
[0340] the first photoelectric converter has an L shape in plan view,
[0341] the second photoelectric converter has a quadrangular shape, and
[0342] a shape obtained by combining the first photoelectric converter and the second photoelectric converter is a quadrangular shape.

REFERENCE SIGNS LIST

[0343] **10** Imaging apparatus [0344] **11** Pixel array unit [0345] **12** Vertical drive unit [0346] **13** Column processor [0347] **14** Horizontal drive unit [0348] **15** System controller [0349] **16** Pixel drive line [0350] **17** Vertical signal line [0351] **18** Signal processor [0352] **19** Data storage [0353] **100** Unit pixel [0354] **101** First photoelectric converter [0355] **102** Second photoelectric converter [0356] **103** First transfer transistor [0357] **104** Second transfer transistor [0358] **105** Third transfer transistor [0359] **106** Fourth transfer transistor [0360] **107** FD unit [0361] **108** Reset transistor [0362] **109** Amplification transistor [0363] **110** Selection transistor [0364] **111** Charge accumulator [0365] **112** Node [0366] **113** Node [0367] **121** Current source [0368] **131** On-chip lens [0369] **151** to **156** Slit [0370] **171** Color filter layer [0371] **172** Light shielding film [0372] **173** Inter-pixel isolator [0373] **174** Silicon substrate [0374] **175** Oxide film

Claims

1. An imaging element, comprising: a first photoelectric converter that generate a charge corresponding to a light amount; and a second photoelectric converter having a smaller light receiving area than the first photoelectric converter, wherein the first photoelectric converter has an L shape in plan view, the second photoelectric converter has a quadrangular shape, and a shape obtained by combining the first photoelectric converter and the second photoelectric converter is a quadrangular shape.
2. The imaging element according to claim 1, wherein a plurality of on-chip lenses is disposed on the first photoelectric converter.
3. The imaging element according to claim 1, wherein the light receiving area of the first photoelectric converter is about three times the light receiving area of the second photoelectric converter, three on-chip lenses are disposed on the first photoelectric converter, and one on-chip lens having a same type as the on-chip lenses is disposed on the second photoelectric converter.
4. The imaging element according to claim 1, wherein an on-chip lens of a same type of the first photoelectric converter is disposed on the first photoelectric converter.
5. The imaging element according to claim 1, wherein the first photoelectric converter is provided with a slit on a light receiving surface side.
6. The imaging element according to claim 5, wherein the slit is formed in a quadrangular shape under the on-chip lens.
7. The imaging element according to claim 5, wherein the slit has a same type as the on-chip lens.
8. The imaging element according to claim 5, wherein a plurality of the slits is formed under the on-chip lens.
9. The imaging element according to claim 5, wherein the slit has a quadrangular shape, and a short side of the slit having the quadrangular shape faces the second photoelectric converter.
10. The imaging element according to claim 1, wherein the second photoelectric converter is provided with a slit on a light receiving surface side.
11. The imaging element according to claim 10, wherein the slit has a quadrangular shape, and a short side of the slit having the quadrangular shape faces the first photoelectric converter.

12. The imaging element according to claim 5, wherein an inter-pixel isolator is formed between a first pixel including the first photoelectric converter and the second photoelectric converter and a second pixel adjacent to the first pixel, and the slit is formed up to a position to be in contact with the inter-pixel isolator.

13. The imaging element according to claim 5, further comprising a color filter layer, wherein the slit is provided in the first photoelectric converter in which a predetermined color of the color filter layer is disposed.

14. The imaging element according to claim 5, further comprising a color filter layer, wherein the slit is provided in the second photoelectric converter in which a predetermined color of the color filter layer is disposed.

15. An electronic device, comprising: an imaging element; and a processor that processes a signal from the imaging element, the imaging element including a first photoelectric converter that generate a charge corresponding to a light amount, and a second photoelectric converter having a smaller light receiving area than the first photoelectric converter, wherein the first photoelectric converter has an L shape in plan view, the second photoelectric converter has a quadrangular shape, and a shape obtained by combining the first photoelectric converter and the second photoelectric converter is a quadrangular shape.
