(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 August 2007 (02.08.2007)

PCT

(10) International Publication Number
WO 2007/086292 A1

(51) International Patent Classification:
H01L 27/146 (2006.01) *G01T 1/24* (2006.01) *G01T 1/20* (2006.01)

(21) International Application Number: PCT/JP2007/050629

(22) International Filing Date: 11 January 2007 (11.01.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2006-019032 27 January 2006 (27.01.2006) JP

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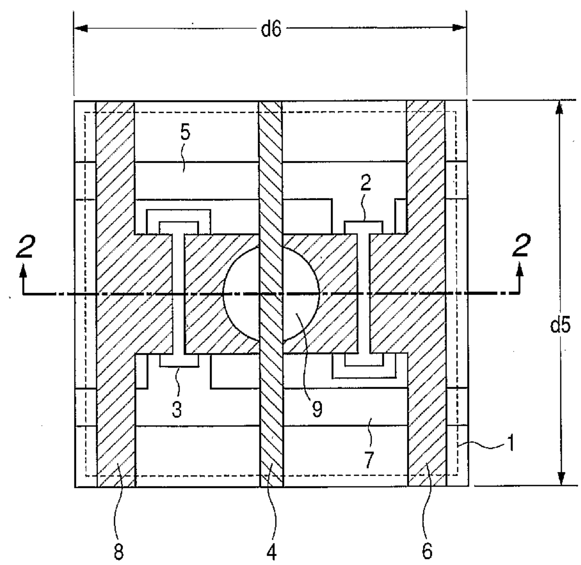
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

[Continued on next page]

(54) Title: IMAGING APPARATUS AND RADIATION IMAGING APPARATUS



(57) Abstract: Pixels including a photoelectric conversion element 1, a signal transfer TFT (thin film transistor) 2 electrically connected to the photoelectric conversion element, and a reset TFT 3 electrically connected to the photoelectric conversion element and for applying a bias to the photoelectric conversion element are two-dimensionally disposed on the insulating substrate, and the photoelectric conversion element 1, signal transfer TFT 2, and reset TFT 3 are electrically connected through a common contact hole 9. A source or drain electrode of the signal transfer TFT 2 and the source or drain electrode of the reset TFT 3 are formed from a common electroconductive layer.

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DESCRIPTION

IMAGING APPARATUS AND RADIATION IMAGING APPARATUS

TECHNICAL FIELD

The present invention relates to an optical imaging apparatus and a radiation imaging apparatus applied to an analyzing instrument and the like that use a medical diagnostic imaging apparatus, a non-destructive inspection apparatus, and radiation. Incidentally, in the present specification, the radiation is referred to as radiation including corpuscular rays such as X-rays, γ-rays or α-rays and β-rays. Further, a conversion element is referred to as a semiconductor element that converts at least a light signal or the radiation into an electrical signal.

BACKGROUND ART

In recent years, manufacturing technology of a liquid crystal display panel using a thin film transistor (TFT) has been advancing, and upsizing of the panel and the display unit screen is going on. This manufacturing technology is applied to a large area sensor having a conversion element (photoelectric conversion element) including a semiconductor and a switching element such as the TFT. Such an area sensor (radiation imaging sensor panel) is combined with a scintillator that converts the radiation into light such as visible light, and is used in the field of the radiation imaging apparatus such as a medical X-ray imaging apparatus.

Heretofore, an imaging method used by medical image diagnosis has been roughly classified into plain radiography for obtaining a still image and fluoroscopic radiography for obtaining a moving image. However, for the moment, the above described radiation imaging apparatus begins to be used mainly for plain radiography. At the same time, the situation is such that the reading speed is not sufficient for fluoroscopic radiography.

Hence, in US 2005/145800 (Japanese Patent Application Laid-Open No. 2003-218339), one pixel of the area sensor includes the conversion element, a transfer switch (transfer TFT and the like) for transferring a signal from the conversion element, and a reset switch (reset TFT) for resetting the conversion element. By this configuration, the radiation imaging apparatus that shortens a reading seed is proposed.

In general, the structure of the pixel of the area sensor (radiation imaging sensor panel) is roughly classified into two of a flat type which disposes the conversion element and the switching element on the same flat surface and a lamination type which disposes the conversion element over the upper side of the switching element. The former can simplify a manufacturing process since the conversion element and the switching element can be formed by the same semiconductor manufacturing process. The later can form the area of the conversion element larger in one pixel as compared to the flat type since the conversion element is disposed over the switching element. Therefore, an aperture ratio of the pixel can be made large, so that the pixel becomes highly sensitive. For this reason, in Patent Document 1, the lamination type sensor is also described.

Fig. 11 is a plan view of the radiation imaging apparatus using a conventional lamination type structure. Although the scintillator is disposed over the pixel of the radiation imaging apparatus, it is omitted in Fig. 11.

The conventional radiation imaging apparatus includes, within one pixel as shown in Fig. 11, a conversion element (photoelectric conversion element) 101, a transfer switch (transfer TFT) 102, and a reset switch (reset TFT) 103.

An under-electrode of the conversion element and a source or drain electrode of the transfer switch are connected through a contact hole. Similarly, the under-electrode of the conversion element and the source or drain electrode of the reset switch are also connected through the contact hole. Hence, the contact hole is provided for each switching element.

DISCLOSURE OF THE INVENTION

In US2005/145800 (Japanese Patent Application Laid-Open No. 2003-218339), as shown in Fig. 11, the transfer switch 102 and the reset switch 103 are independently disposed, respectively, and the photoelectric conversion element including the conversion element 101 and a contact hole 109 for connecting the switching element are independently provided within one pixel, respectively. Hence, for example, even when a connection failure occurs in the contact hole 109 of the reset switch 103 in a certain pixel, if the transfer switch 102 is normal, the signal of some kind of the conversion element can be read, and therefore, there are often the cases where it is difficult to specify a defect pixel in a defect inspection process.

Further, though the size of the contact hole is usually to the extent of 10 μm to 20 μm, for example, when pixel pitches d1 and d2 are larger to the extent of 200 μm, as shown in Fig. 11, such a size of this contact hole does not cause any big problem and each switching element can be freely disposed.

In contrast to this, when a high definition image similarly to a mammogram is required, the image pitch becomes smaller, but pixel pitches d3 and d4 to the extent of 100 μm are the limit in which two switching elements can be disposed within one pixel, as shown in Fig. 12. Further, when the pixel pitches d3 and d4 becomes smaller such as 80 μm and 50 μm, there is the possibility that the contact hole 109 ends up being superposed with each wiring such as the gate wiring 105 and the signal wiring 106.

When a fluctuation occurs in film thickness of an interlayer insulating layer within a radiation imaging sensor panel, the size of the contact hole 109 fluctuates. As a result, a parasitic capacitance between each wiring and conversion element 101 fluctuates within the radio imaging sensor panel, and this causes sensitivity fluctuation. To prevent this fluctuation, for example, when the gate wiring 105 is made thin, the resistance of the gate wiring 105 becomes larger. Hence, a gate driving pulse applied to the gate wiring 105 becomes smaller. Therefore, to perform transfer of sufficient signals by the transfer switch 102, the electricity conduction time of the transfer switch 102 is increased and the reading speed is reduced. Further, for example, when the signal wiring 106 is made thin, the resistance of the signal wiring 106 becomes larger, and this increases noises, so that the S/N, that is, sensitivity ends up being reduced. That is, in either case, deterioration of characteristics is likely to be caused.

From the above, it will be clear that an object of the present invention is to prevent deterioration of characteristics in the imaging apparatus and radiation imaging apparatus having small pixel pitches and capable of easily specifying the defect pixel in the defect inspection process.

As means for solving the above described problems, the present invention provides a photoelectric conversion apparatus in which pixels including a conversion element that converts at least an optical signal into an electric signal, a signal transfer switch that is electrically connected to the conversion element, and a reset switch that is electrically connected to the conversion element and applies a bias to the conversion element are two-dimensionally disposed on an insulating substrate, and wherein the conversion element, the signal transfer switch, and the reset switch are electrically connected through a common contact hole.

A scintillator converting, into light, radiation of corpuscular rays such as X-rays, γ-rays or α-rays and β-rays may be disposed over the above described conversion element, to constitute a radiation imaging apparatus.

Further, the present invention provides a radiation imaging apparatus in which pixels including a conversion element that converts at least a radiation into an electric signal, a signal transfer switch that is electrically connected to the conversion element, and a reset switch that is electrically connected to the conversion element and applies a bias to the conversion element are two-dimensionally disposed on an insulating substrate, and wherein the conversion element, the signal transfer switch, and the reset switch are electrically connected through a common contact hole.

According to the present invention, it is easy to specify defect pixels in a defect inspection process. Further, it is possible to prevent deterioration of characteristics even in the imaging apparatus and radiation imaging apparatus having small pixel pitches.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the Figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Fig. 1 is a top plan view to explain a radiation imaging apparatus which is a first embodiment of the present invention;

Fig. 2 is a sectional view cut along the line 2-2 in Fig. 1 to explain the radiation imaging apparatus which is the first embodiment of the present invention;

Fig. 3 is a top plan view to explain the radiation imaging apparatus which is a second embodiment of the present invention;

Fig. 4 is a sectional view cut along the line 4-4 in Fig. 3 to explain the radiation imaging apparatus which is a third embodiment of the present invention;

Fig. 5 is a sectional view to explain the radiation imaging apparatus which is a third embodiment of the present invention;

Fig. 6 is a sectional view to explain the radiation imaging apparatus which is a fourth embodiment of the present invention;

Fig. 7 is a top plan view of the radiation imaging apparatus of a comparison example in the case where a pixel pitch is 50 μm;

Fig. 8 is a sectional view cut along the line 8-8 in Fig. 7;

Fig. 9 is a top plan view of a flat type radiation imaging apparatus according to a fifth embodiment of the present invention;

Fig. 10 is a schematic diagram to explain an application example to an X-ray diagnosis system of the radiation imaging apparatus of the present invention;

Fig. 11 is a top plan view to explain a conventional radiation imaging apparatus; and

Fig. 12 is a top plan view to explain a problem of the conventional radiation imaging apparatus.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the best mode to execute the present invention will be described in detail with reference to the drawings. In the following description, a radiation imaging apparatus will be taken up. The radiation imaging apparatus using a scintillator and a photoelectric conversion element is disposed with the scintillator that converts corpuscular rays such as X-rays, γ-rays or α-rays and β-rays into visible light, and this imaging apparatus is the best mode of the imaging apparatus of the present invention. In the following description, an example of a radiation detector that detects the X-rays will be shown. Further, the present invention is also suitably applied to an imaging apparatus that detects infra-red rays.

(First Embodiment)

An radiation imaging apparatus according to a first embodiment of the present invention will be described by using the drawings. Fig. 1 is a top plan view of one pixel of the radiation imaging apparatus of the present invention, and Fig. 2 is a sectional view cut along the line 2-2 in Fig. 1.

The radiation imaging apparatus in the present embodiment includes a lamination type radiation imaging sensor panel forming a MIS type photoelectric conversion element that includes a conversion element on the upper part of a transfer switch (transfer TFT) and a reset switch (reset TFT). Further, this apparatus is an indirect type radiation imaging apparatus including a scintillator for converting the X rays into light such as a visible light located over these switches.

A configuration of the radiation detector of the present embodiment will be described by using Figs. 1 and 2.

In Fig. 1, reference numeral 1 denotes a conversion element such as photoelectric conversion element that converts the light such as an incident visible light into an electric charge. Reference numeral 2 denotes a transfer switch for transferring the electric charge converted by the conversion element 1. Reference numeral 3 denotes a reset switch for resetting the conversion element 1. Over the conversion element 1, a scintillator that converts unillustrated incident X-rays into light such as visible light is disposed. Here, the transfer switch is a transfer TFT, and the reset switch is a rest TFT. Reference numeral 4 denotes a bias wiring for applying a bias to the conversion element 1, and reference numeral 5 denotes a gate wiring for giving a gate drive pulse from a drive device (not shown) to the transfer switch 2. Reference numeral 6 denotes a signal wiring for transferring the electric charge transferred by the transfer switch 2 to a reading device (not shown). Reference numeral 7 denotes a gate wiring for giving the gate drive pulse from a drive device (not shown) to the reset switch 3, and reference numeral 8 denotes a reset wiring for giving a bias for resetting the conversion element 1. Reference numeral 9 denotes a contact hole that electrically connects the source or drain electrode of the conversion element 1 and the transfer switch 2 or the source or the drain electrode of the reset switch 3.

As shown in Fig. 2, the transfer switch 2 and the reset switch 3 include a first electroconductive layer 11, a first insulating layer 12, a first semiconductor layer 13, a first impurity semiconductor layer 14, and a second electroconductive layer 15, which are all formed on an insulating substrate 10, respectively. Here, the first electroconductive layer 11 is used as gate electrodes and gate wirings 5 and 7 of the transfer switch 2 and the reset switch 3, and the first insulating layer 12 is used as a gate insulating film. Further, the first semiconductor layer 13 is used as a channel of the transfer switch 2 and the reset switch 3, and the first impurity semiconductor 14 is used as an ohmic contact layer. Further, the second electroconductive layer 15 is used as a source or drain electrode of the transfer switch 2 and the reset switch 3, the signal wiring 6, and the reset wiring 8. Over that layer, an interlayer insulating layer 16 is provided, and further over that interlayer insulating layer 16, a MIS type photoelectric conversion element including the conversion element 1 is laminated. The MIS type photoelectric conversion element including the conversion element 1 is fabricated from a third electroconductive layer 17, a second insulating layer

18, a second semiconductor layer 19, a second impurity conductor layer 20, a fourth electroconductive layer 21, and a fifth electroconductive layer 26. Here, the third electroconductive layer 17 is used as an under-electrode of the MIS type photoelectric conversion element, and the second insulating layer 18 is used as an insulating layer of the MIS type photoelectric conversion element. Further, the second semiconductor layer 19 is used as a photoelectric conversion layer of the MIS type photoelectric conversion element, and the second impurity semiconductor layer 20 is used as an ohmic contact layer having a hole blocking effect of the MIS type photoelectric conversion element and an upper-electrode. Further, the fourth electroconductive layer 21 is used as a bias wiring 4 of the MIS type photoelectric conversion element, and the fifth electroconductive layer 26 is used as the upper electrode of the MIS type photoelectric conversion element. Further, over that layer, a third insulating layer (protective layer) 22, a passivation layer 23, an adhesive layer 24, and a scintillator 25 such as CsI that converts the X-rays into light such as visible light are formed. The scintillator 25 is provided on a carbon plate or a film (not shown), which is glued together to the radiation imaging sensor panel through the adhesive layer 24.

One of the source and drain electrodes of the transfer switch 2 and one of the source and drain electrodes of the reset switch 3 include a common second electroconductive layer 15, and the second electroconductive layer 15 is a common electrode. However, it is conceivable that the common second electroconductive layer 15 includes ea wiring that connects together one of the source and drain electrodes of the transfer switch 2, one of the source and drain electrodes of the reset switch 3, and one of the electrodes of the transfer switch 2 and the reset switch 3. In that case, a part of the common second electroconductive layer 15 includes one of the source and drain electrodes of the transfer switch and one of the source and drain electrodes of the reset switch 3.

Here, in the present embodiment, the third electroconductive layer 17 which is the under electrode of the photoelectric conversion element and one of the source and drain electrodes (second electroconductive layer 15) of the transfer switch 2 are connected by the contact hole 9. Further, the under-electrode (third electroconductive layer 17) of the photoelectric conversion element and one of the source and drain electrodes (second electroconductive layer 15) of the reset switch 3 are connected by the contact hole 9. That is, by the one common contact hole 9, the conversion element 1 which becomes the photoelectric conversion element, the transfer switch 2, and the reset switch 3 are connected.

Hence, when a connection failure occurs in the contact hole 9, the signal of the photoelectric conversion element is not read, and therefore, it is easy to specify a defect pixel in the defect inspection process.

Further, though the pixel pitches d5 and d6 of the radiation imaging apparatus of the present embodiment are 80 μm each, even when the diameter of the contact hole 9 is made 20 μm in order to realize the lamination type by disposing the photoelectrical conversion element through the interlayer insulating layer, two switching elements can be disposed. That is, in the present embodiment, since only one contact hole exists within one pixel, two TFTs can be disposed within one pixel without making the wire width of the gate wires 5 and 7 and the signal wire 6 thin. That is, the contact hole 9 for connecting to the photoelectrical conversion element is commonly used for two switching elements, so that a ratio of area occupying the contact hole within one pixel is reduced, and the area to dispose two switching elements can be easily secured even in the pixel of small pitch.

From the above, the radiation imaging apparatus of the present embodiment can easily specify the defect pixel in the defect pixel inspection process, and can prevent deterioration of the characteristics even in the case of the radiation imaging apparatus having small pixel pitches.

Incidentally, though one pixel only is shown in Fig. 1, in reality, for example, 2000 × 2000 pixels are disposed on the insulating substrate 10, and configures the photoelectric imaging sensor panel. Further, in the present embodiment, the indirect radiation imaging apparatus combining the photoelectric conversion element and scintillator has been shown. However, in place of the photoelectric conversion element, the same effect can be obtained in the direct type radiation imaging apparatus using the conversion element (hereinafter, referred to as direct conversion type element) sandwiching the semiconductor layer such as amorphous selenium that directly converts the corpuscular rays such as X-rays, γ-rays or α-rays and β-rays into the electrical charge between the electrodes. Further, the conversion element of the indirect type radiation imaging apparatus may use another type photoelectric conversion element of the MIS type photoelectric conversion element, for example, a PIN type photoelectric conversion element. Further, with respect to the structure of the pixel of the indirect radiation imaging apparatus, a flat type in which the photoelectric conversion element and switching element are included in the same layer or a lamination type in which the photoelectric conversion element is formed over the switching element may be provided. Furthermore, in the present embodiment, though an example has been shown in which the carbon plate and the film are provided with the scintillator layer such as the CsI so as to be glued together to the radiation imaging sensor panel through the adhesive layer 24, the scintillator material such as the CsI may be laminated directly over the passivation layer 23.

(Second Embodiment)

Hereinafter, a radiation imaging apparatus according to a second embodiment of the present invention will be described by using the drawings. Fig. 3 is a top plan view of one pixel of the radiation imaging apparatus of the present embodiment, and Fig. 4 is a sectional view cut along the line 4-4 in Fig. 3.

The radiation imaging apparatus in the present embodiment has a lamination type radiation imaging apparatus substrate disposed with a MIS type photoelectric conversion element including a conversion element on the upper part of a transfer switch (transfer TFT) and a reset switch (reset TFT). Further, located over the lamination type radiation imaging apparatus substrate, it is an indirect radiation imaging apparatus having a scintillator for converting X-rays into light such as visible light. An equivalent circuit diagram of the radiation imaging apparatus of the present embodiment is the same as Fig. 13, and its operation principle is the same as the conventional radiation imaging apparatus described by using Figs. 11 to 14, and therefore, the description thereof will be omitted here.

The configuration of the radiation imaging apparatus of the present embodiment will be described by using Figs. 3 and 4.

In Fig. 3, reference numeral 1 denotes a conversion element such as photoelectric conversion element that converts a light such as an incident visible light into an electric charge. Reference numeral 2 denotes a transfer switch for transferring the electric charge converted by the conversion element 1. Reference numeral 3 denotes a reset switch for resetting the conversion element 1. Over the conversion element 1, a scintillator that converts unillustrated incident X-rays into light such as visible light is disposed. Here, the transfer switch is a transfer TFT, and the reset switch is a reset TFT. Reference numeral 4 denotes a bias wiring for applying a bias to the conversion element 1, and reference numeral 5 denotes a gate wiring for giving a gate-drive pulse from a drive device (not shown) to the transfer switch 2. Reference numeral 6 denotes a signal wiring for transmitting the electric charge transferred by the transfer switch 2 to a reading device (not shown). Reference numeral 7 denotes a gate wiring for giving the gate drive pulse from a drive device (not shown) to the reset switch 3, and reference numeral 8 denotes a reset wiring for giving a bias for resetting the conversion element 1. Reference numeral 9 denotes a contact hole that electrically connects the source or drain electrode of the conversion element 1 and the transfer switch 2 and the source or the drain electrode of the reset switch 3.

As shown in Fig. 4, the transfer switch 2 and the reset switch 3 include a first electroconductive layer 11, a first insulating layer 12, a first semiconductor layer 13, a fourth insulating layer 28, a first impurity semiconductor layer 14, and a second electroconductive layer 15, which are all formed on an insulating substrate 10. Here, the first electroconductive layer 11 is used as gate electrodes and gate wirings 5 and 7 of the transfer switch 2 and the reset switch 3, and the first insulating layer 12 is used as a gate insulating film. Further, the first semiconductor layer 13 is used as a channel of the transfer switch 2 and the reset switch 3, and the first impurity semiconductor layer 14 is used as an ohmic contact layer. Further, the second electroconductive layer 15 is used as source or drain electrode of the transfer switch 2 and the reset switch 3, the signal wiring 6, and the reset wiring 8. Over that layer, a fifth insulating layer (protective layer) 27 and an interlayer insulating layer 16 are provided, and further over that interlayer insulating layer 16, a MIS type photoelectric conversion element including the conversion element 1 is laminated. The MIS type photoelectric conversion element including the conversion element 1 is fabricated from a third electroconductive layer 17, a second insulating layer 18, a second semiconductor layer 19, a second impurity semiconductor layer 20, a fourth electroconductive layer 21, and a fifth electroconductive layer 26. Here, the third electroconductive layer 17 is used as an under-electrode of the MIS type photoelectric conversion element, and the second insulating layer 18 is used as an insulating layer of the MIS type photoelectric conversion element. Further, the second semiconductor layer 19 is used as a photoelectric conversion layer of the MIS type photoelectric conversion element, and the second impurity semiconductor layer 20 is used as an ohmic contact layer having a hole blocking effect of the MIS type photoelectric conversion element. Further, the fourth electroconductive layer 21 is used as an upper electrode or a bias wiring 4 of the MIS type photoelectric conversion element, and the fifth electroconductive layer 26 is used as the upper electrode of the MIS type photoelectric conversion element. Further, over that layer, a third insulating layer 22, a passivation 23, and a scintillator layer 25 such as CsI that converts the X-rays into light such as visible light are formed. The scintillator layer 25 is directly laminated and formed over the passivation 23.

One of the source and drain electrodes of the transfer switch 2, and one of the source and drain electrodes of the reset switch 3 include the common second electroconductive layer 15, and the second electroconductive layer 15 is a common electrode. However, it is conceivable that the common second electroconductive layer 15 includes a wiring that connects together one of the source and drain electrodes of the transfer switch 2, one of the source and drain electrodes of the reset switch 3, and one of the electrodes of the transfer switch 2 and the reset switch 3. In that case, a part of the common second electroconductive layer 15 includes one of the source and drain electrodes of the transfer switch 2 and one of the source and drain electrodes of the reset switch 3.

Here, in the present embodiment, the third electroconductive layer 17 which is the under electrode of the photoelectric conversion element and one of the source and drain electrodes (second electroconductive layer 15) of the transfer switch 2 are connected by the contact hole 9. Further, the under-electrode (third electroconductive layer 17) of the photoelectric conversion element and one of the source and drain electrodes (second electroconductive layer 15) of the reset switch 3 are connected by the contact hole 9. That is, by the one common contact hole 9, the conversion element 1 which becomes the photoelectric conversion element, the transfer switch 2, and the reset switch 3 are connected.

Hence, when a connection failure occurs in the contact hole 9, the signal of the photoelectric conversion element can not be read, and therefore, it is easy to specify a defect pixel in the defect inspection process.

Further, though the pixel pitches d5 and d6 of the radiation imaging apparatus of the present embodiment are 80 μm each, even when the size of the contact hole 9 is made 20 μm in order to realize the lamination type by disposing the photoelectric conversion element through the interlayer insulating layer, two switching elements can be disposed. That is, in the present embodiment, since only one contact hole exists within one pixel, two TFTs can be disposed within one pixel without making the wire width of the gate wires 5 and 7 and the signal wire 6 thin. That is, the contact hole for connecting to the photoelectric conversion element is used commonly for two switching elements, so that a ratio of the area occupied by the contact hole within one pixel is reduced, and the area to dispose two switching elements can be easily secured even in the pixel of small pitch.

Further, different from the first embodiment, the bias wiring 4 is not allowed to be disposed over the contact hole 9. As a result, even when the contact hole 9 is deep, a patterning of the bias wiring 4 is possible in a region where a resist film thickness is uniform, and therefore, more stability of the process can be realized. Here, while a disposing direction of the bias wiring 4 is in parallel with the gate wirings 5 and 7, if the bias wiring 4 is disposed on a position where it is not disposed over the contact hole 9, it may be disposed in parallel with the signal wiring 6.

From the above, the radiation imaging apparatus of the present embodiment can easily specify a defect pixel in the defect pixel inspection process, and can prevent deterioration of the characteristics even in the case of the radiation imaging apparatus having small pixel pitches.

Incidentally, though one pixel only is shown in Fig. 3, in reality, for example, 2000 × 2000 pixels are disposed on the insulating substrate 10, and configures the photoelectric imaging sensor panel. Further, in the present embodiment, the indirect radiation imaging apparatus combining the conversion element with the photoelectric conversion element and scintillator has been shown. However, in place of the photoelectric conversion element, the same effect can be obtained in the direct type radiation imaging apparatus using the conversion element sandwiching the semiconductor layer such as amorphous selenium that directly converts the corpuscular rays such as X-rays, γ-rays or α-rays and β-rays into the electrical charge between the electrodes. Further, the conversion element of the indirect type radiation imaging apparatus may use another type photoelectric conversion element of the MIS type photoelectric conversion element, for example, a PIN type photoelectric conversion element. Further, with respect to the structure of the pixel of the indirect radiation imaging apparatus, a flat type in which the semiconductor conversion element and switching element are included in the same layer or a lamination type in which the photoelectric conversion element is formed over the switching element may be provided.

Further, in the present embodiment, though a scintillator material such as the CsI is directly laminated over the passivation layer 23, the scintillator layer such as the CsI may be provided on a carbon plate and a film so as to be adhered together to the radiation imaging sensor panel through the adhesive layer.

Further, in the above described first and second embodiments, when the contact hole is made common, the common electrodes may be not necessarily used (this holds true for the third to fifth embodiments to be described later). This is because even when one of the source or drain electrode of the transfer switch 2 and one of the source or drain electrode of the reset switch 3 are not common electrode, if the end portions of the source or drain electrodes of the transfer switch 2 and the reset switch 3 are formed within the contact hole, the common connection can be made.

(Third Embodiment)

Hereinafter, a radiation imaging apparatus according to a third embodiment will be described by using the drawings. Fig. 5 is a sectional view of the radiation imaging apparatus of the present embodiment, and is a sectional view equivalent to the line 2-2 in Fig. 1. The same component parts as those of Fig. 2 will be attached with the same reference number, and the description thereof will be omitted.

The present embodiment relates to a direct type radiation imaging apparatus using a conversion element that sandwiches a semiconductor layer such as amorphous selenium directly converting corpuscular rays such as X-rays, γ-rays or α-rays and β-rays into light such as a visible ray between electrodes in place of the photoelectric conversion element of Fig. 2 showing the first embodiment. The present embodiment describes the case where the X-rays are allowed to enter a radiation detector similarly to the first and second embodiments.

The points of difference between the radiation imaging apparatus of the present embodiment of Fig. 5 and the radiation imaging apparatus of the first embodiment shown in Fig. 2 are as follows. The first point of difference is that the radiation imaging apparatus of the present embodiment shown in Fig. 5 is configured to use the conversion element that directly converts the X-rays into electric charges, and therefore, is not provided with a scintillator 25 and an adhesive layer 24. The second point of difference is that, since the semiconductor layer such as amorphous selenium that directly converts the radiation into the electric charges is sandwiched between the electrodes, a second insulating layer 18 is replaced by a third impurity semiconductor layer 30.

In the first to third embodiments as describe above, an example has been described, in which, as shown in Figs. 1 and 3, on an approximately square region in which a transfer switch 2 and a reset switch 3 are formed, the conversion element is disposed such that it is exactly accommodated in that region through an interlayer insulating layer 16. However, the region in which the conversion element (including the conversion element of the direct conversion type of the third embodiment) 1 is disposed does not necessary need to be disposed over the region in which the transfer switch 2 and the reset switch 3 are formed. That is, the lamination type radiation imaging apparatus may be such that the conversion element 1, the transfer switch 2, and the reset switch 3 are connected through the contact hole. Further, the conversion element may be of another shape such as a honeycomb shape instead of a square shape. Moreover, though the disposition of the pixels including the conversion element, transfer switch, and reset switch has been shown as a matrix-pattern in Fig. 13, it may be of a two-dimensional pattern, for example, a honeycomb pattern.

(Fourth Embodiment)

Hereinafter, a radiation imaging apparatus according to a fourth embodiment of the present invention will be described by using the drawings. Fig. 6 is a sectional view of the radiation imaging apparatus of the present embodiment. The same component parts as those of Fig. 2 will be attached with the same reference number, and the description thereof will be omitted.

The first to third embodiments are provided with lamination type radiation imaging substrates disposed with the MIS type photoelectric conversion element including the conversion element on the upper portion of the transfer switch and the reset switch. The present embodiment forms the photoelectric conversion element by removing the upper portion of the transfer switch and reset switch. In such configuration, after having formed the photoelectric conversion element, even when the defect such as short-circuit between the source and drain electrodes of the transfer switch and reset switch is discovered, a repairing of removing the defect portion by laser can be performed.

(Fifth Embodiment)

Next, when describing a fifth embodiment of the present invention, it will be described by comparing with a comparison example in which two contact holes are provided for a transfer switch and a reset switch in one pixel.

Fig. 7 is a top plan view of a radiation imaging apparatus of the comparison example where a pixel pitch is 50 μm, and Fig. 8 is a sectional view cut along the line 8-8 in Fig. 7. Fig. 9 is a top plan view of a flat type radiation imaging apparatus according to the fifth embodiment of the present invention. The same component parts as those of Figs. 1 and 2 will be attached with the same reference number, and the description thereof will be omitted.

As shown in Fig. 8, in the case of the flat type, a conversion element 1 which is a photoelectric conversion element, a transfer switch (here, transfer TFT) 2, and a reset switch (here, reset TFT) 3 can be simultaneously formed by the same layer. That is, a photoelectric conversion layer of the photoelectric conversion element 1, and channel layers of the transfer switch 2 and the reset switch 3 are formed by the same first semiconductor layer 13. Further, an ohmic contact layer having a hole blocking effect of the conversion element 1, the transfer switch 2, and the ohmic contact layer of the reset switch 3 are formed by the same first impurity semiconductor layer

14.

Here, since the flat type does not dispose the interlayer insulating film 16, the contact holes 91 and 92 can be formed with a diameter to the extent of 10 μm.

However, as shown in Fig. 7, when the pixel pitch d6 is made 50 μm, the bias wiring 4 is often disposed not being connected by the upper and under pixels.

In contrast to this, in the flat type radiation imaging apparatus of the present embodiment, even when the pixel pitch is 50 μm, as shown in Fig. 9, a ratio of the area occupied by the contact hole 9 within one pixel is reduced, and therefore, the disposition of the bias wiring 4 is made easy. Further, the same effect similarly to other embodiments can be obtained.

(Application Example)

Fig. 10 shows an example of applying the radiation imaging apparatus according to the present invention to an X ray diagnosis system.

As shown in Fig. 10, X-rays 6060 generated by an X-ray tube 6050 transmit a chest 6062 of a patient or a test subject 6061, and are incident on a radiation imaging apparatus 6040 that mounts a scintillator (phosphor) on the upper portion. The incident X rays contain information on an internal body of the patient 6061. Corresponding to the incidence of the X-rays, the scintillator emits light, and this is subjected to photoelectric conversion, thereby obtaining electrical information. This information is converted into digital information, and is subjected to image processing by an image processor 6070 which is signal processing means, and can be observed by a display 6080 which is display means of a control chamber.

Further, this information can be transferred to a remote location by transmission processing means such as a telephone line 6090, and can be displayed in the display 6081 which becomes display means installed in a doctor room of another location or can be stored in recording means such as an optical disk, enabling the doctor of the remote location to give a diagnosis. Further, this information can be recorded also in a film 6110 which becomes recording medium by a film processor 6100 which becomes recording means.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the claims.

This application claims priority from Japanese Patent Application No. 2006-019032 filed on January 27, 2006, which is hereby incorporated by reference herein.

CLAIMS

1. An imaging apparatus, comprising,

an insulating substrate; and

a pixel being disposed on said insulating substrate, and comprising:

a conversion element for converting an optical signal into an electrical signal;

a signal transfer switch electrically connected to said conversion element; and

a reset switch electrically connected to said conversion element and for applying a bias to said conversion element;

wherein said conversion element, said signal transfer switch, and said reset switch are electrically connected through a common contact hole.

2. The imaging apparatus according to claim 1, wherein one electrode of said signal transfer switch is electrically connected to said conversion element, and one electrode of said reset switch is electrically connected to said conversion element, and

wherein an electroconductive layer, at least a part of which forms said one electrode of said signal transfer switch, and an electroconductive layer, at least a part of which forms said one electrode of said reset switch are formed from a common electroconductive layer, and an electrical connection between said common electroconductive layer and said conversion element is formed through said common contact hole.

3. The imaging apparatus according to claim 2, wherein said signal transfer switch and said reset switch are thin film transistors, and said one electrode of said signal transfer switch and said one electrode of said reset switch are the source electrode or drain electrode of said thin film transistor.

4. The imaging apparatus according to claim 1, wherein said signal transfer switch and said reset switch are disposed over said insulating substrate, and

wherein said conversion element is disposed in a region on said insulating substrate excluding at least a part of the region in which said signal transfer switch and said reset switch are formed.

5. The imaging apparatus according to claim 1, wherein said signal transfer switch and said rest switch are disposed over said insulating substrate, and

wherein said conversion element is disposed through an insulating layer in the region over said insulating substrate including the region in which said signal transfer switch and said rest switch are disposed.

6. The imaging apparatus according to claim 1, wherein a scintillator that converts radiation into light is disposed over said conversion element.

7. A radiation imaging apparatus, comprising:

an insulating substrate; and

a pixel being disposed on said insulating substrate and comprising:

a conversion element converting radiation into an electrical signal;

a signal transfer switch electrically connected to said conversion element; and

a reset switch electrically connected to said conversion element and for applying a bias to said conversion element;

wherein said conversion element, said signal transfer switch, and said reset switch are electrically connected through a common contact hole.

8. The radiation imaging apparatus according to claim 7, wherein one electrode of said signal transfer switch is electrically connected to said conversion element, and one electrode of said reset switch is electrically connected to said conversion element, and

wherein an electroconductive layer at least a part of which forms said one electrode of said signal transfer switch, and an electroconductive layer at least a part of which forms said one electrode of said reset switch comprise a common electroconductive layer, and an electrical connection beteen said common electroconductive layer and said conversion element is formed through said common contact hole.

9. The radiation imaging apparatus according to claim 8, wherein said signal transfer switch and said reset switch are thin film transistors, and said one electrode of said signal transfer switch and said one electrode of said reset switch are the source electrode or drain electrode of said thin film transistor.

10. The imaging apparatus according to claim 7, wherein said signal transfer switch and said reset switch are disposed over said insulating substrate, and

wherein said conversion element is disposed in a region over said insulating substrate excluding at least a part of the region in which said signal transfer switch and said reset switch are formed.

11. The imaging apparatus according to claim 7, wherein said signal transfer switch and said rest switch are disposed over said insulating substrate, and

wherein said conversion element is disposed through an insulating layer in the region over said insulating substrate including the region in which said signal transfer switch and said rest switch are disposed.

12. A radiation imaging system, comprising:

the radiation imaging apparatus according to claim 6 or 7;

signal processing means that processes the signal from said radiation detector;

recording means for recording the signal from said signal processing means;

display means for displaying the signal from said signal processing means;

transmission processing means for transmitting the signal from said signal processing means; and

a radiation source for generating said radiation.

FIG. 1

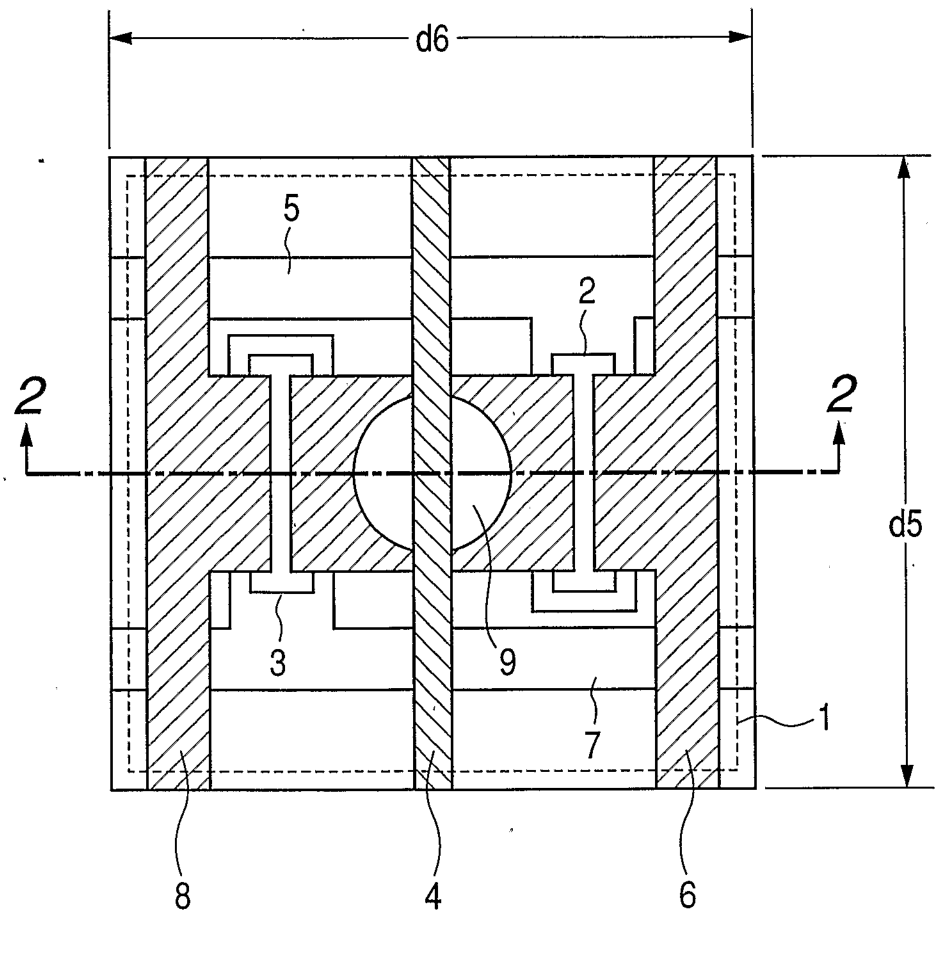


FIG. 2

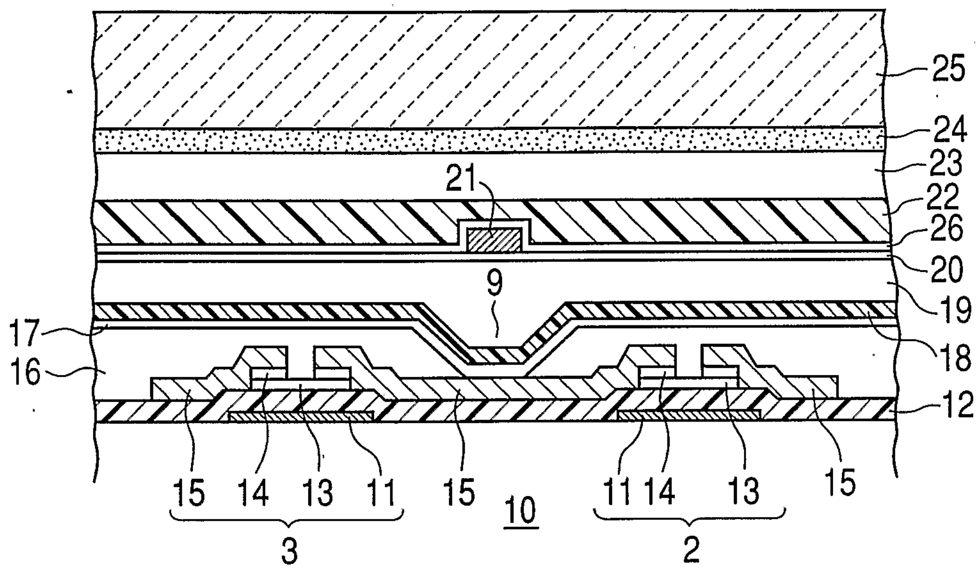


FIG. 3

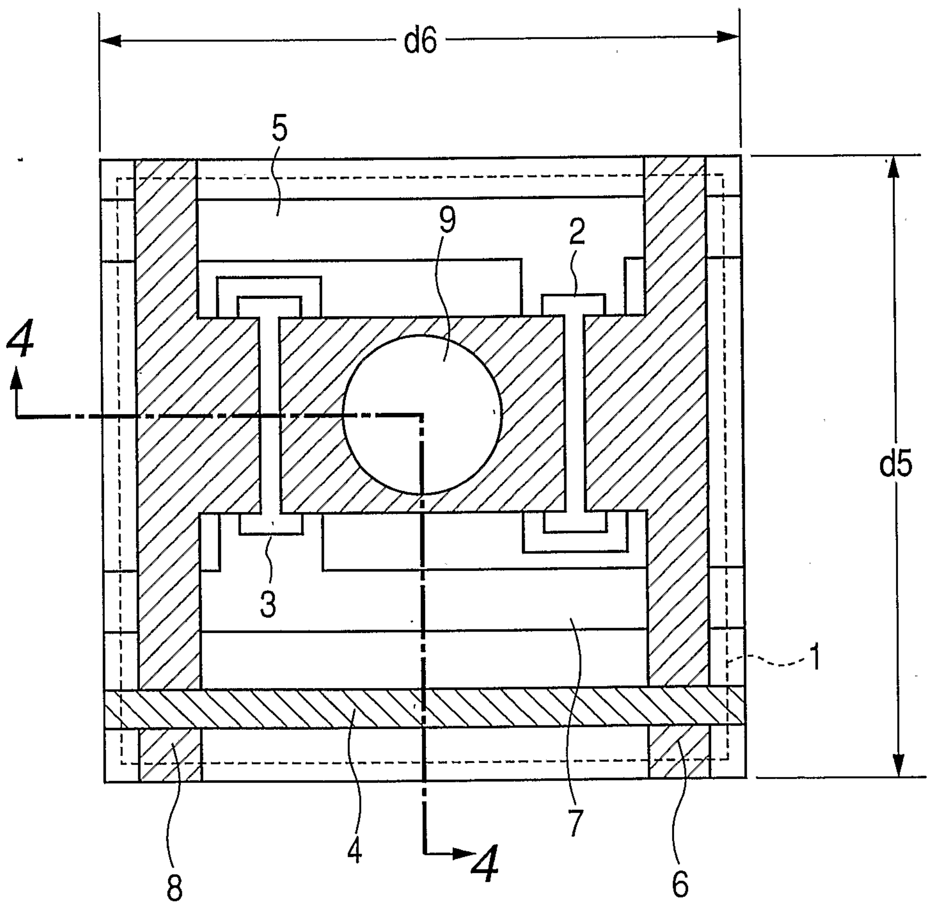


FIG. 4

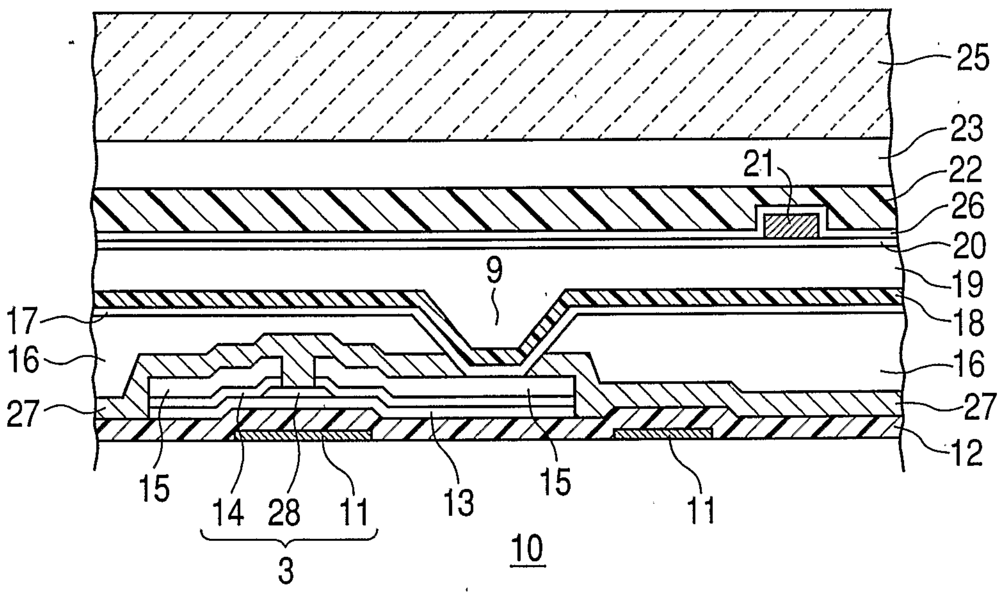


FIG. 5

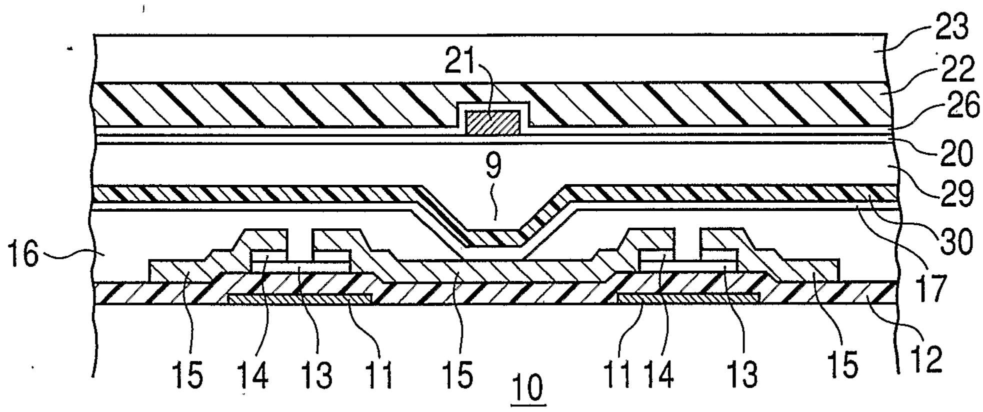


FIG. 6

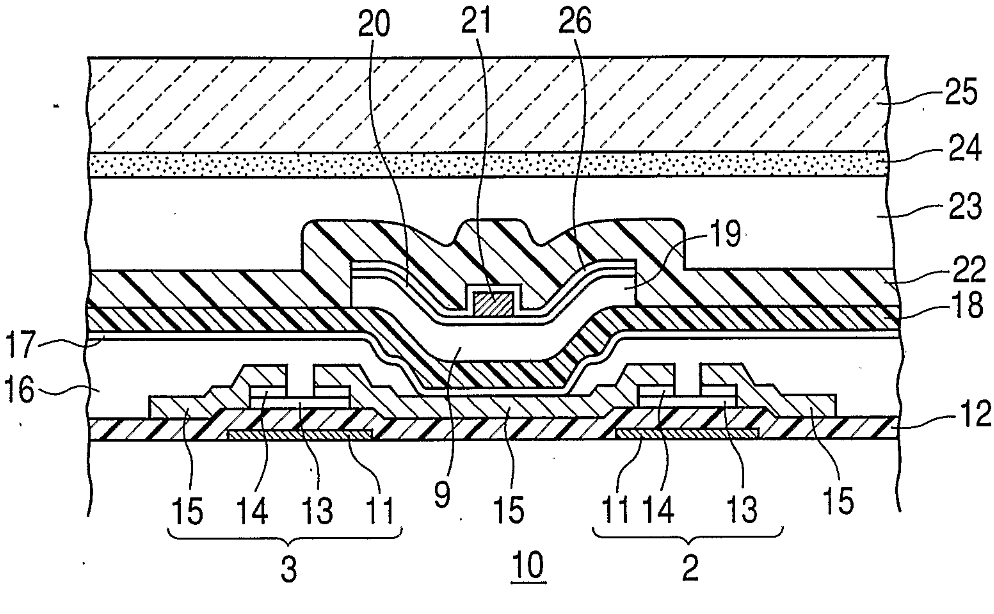


FIG. 7

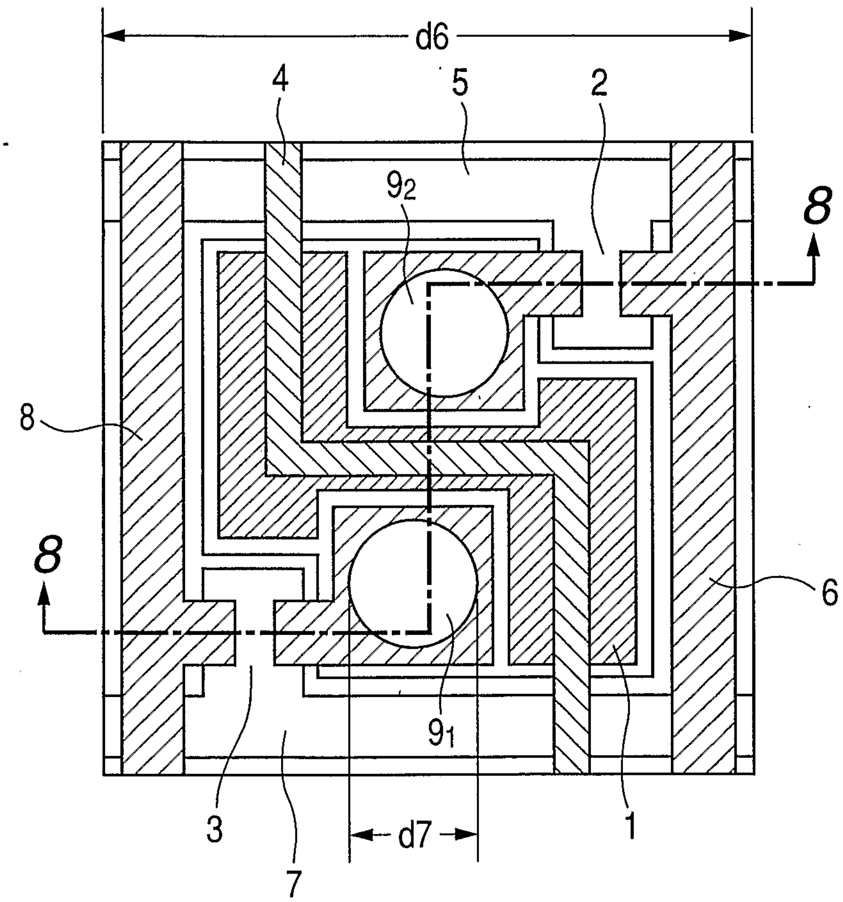


FIG. 8

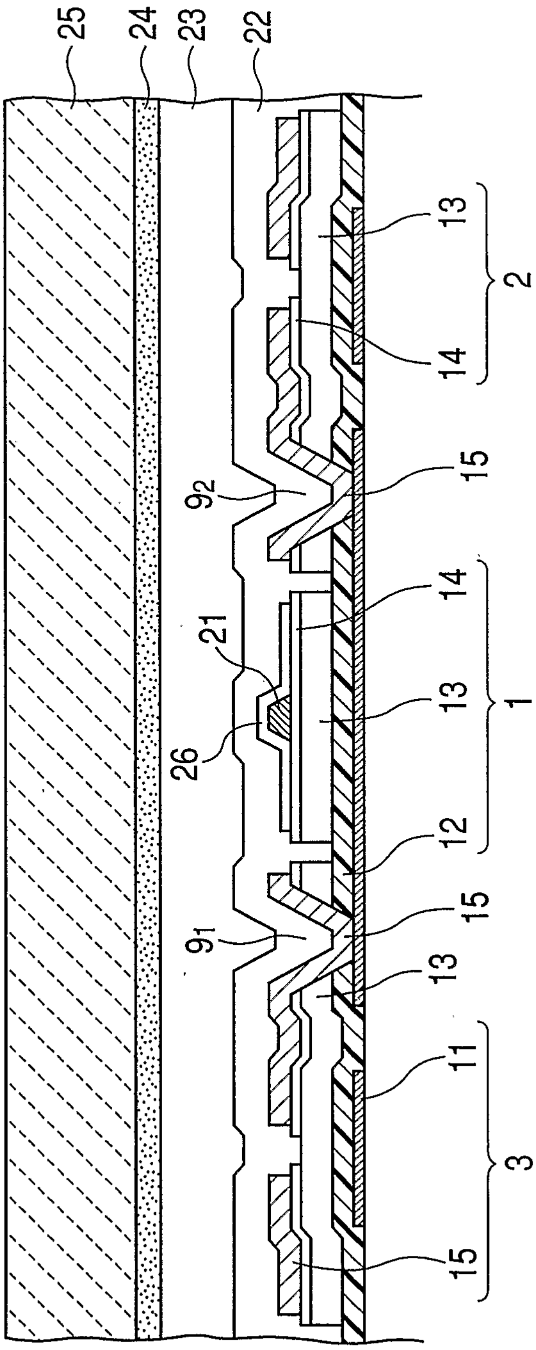


FIG. 9

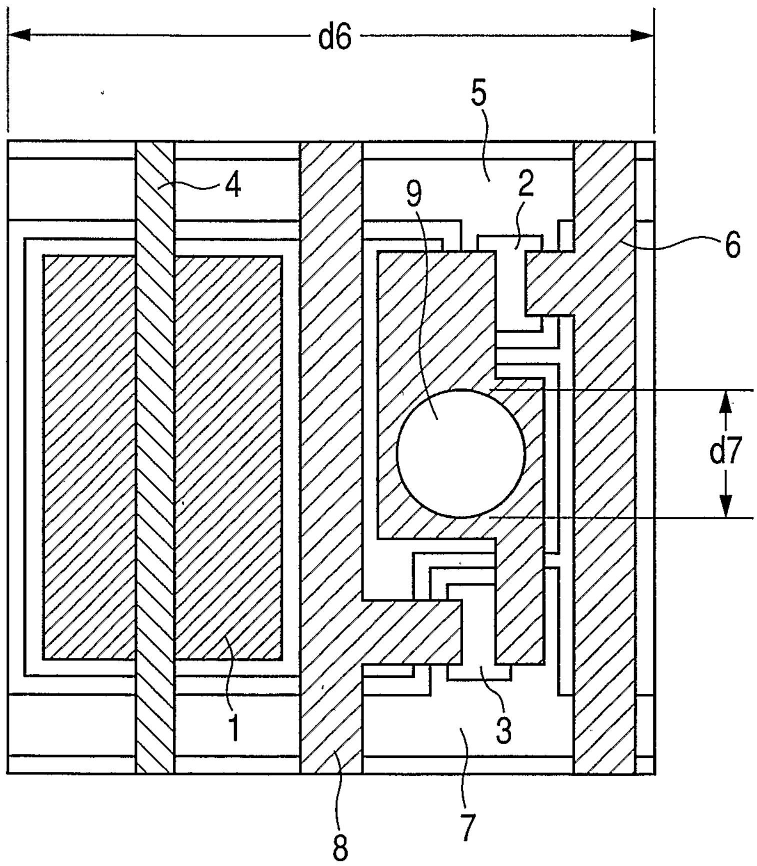


FIG. 10

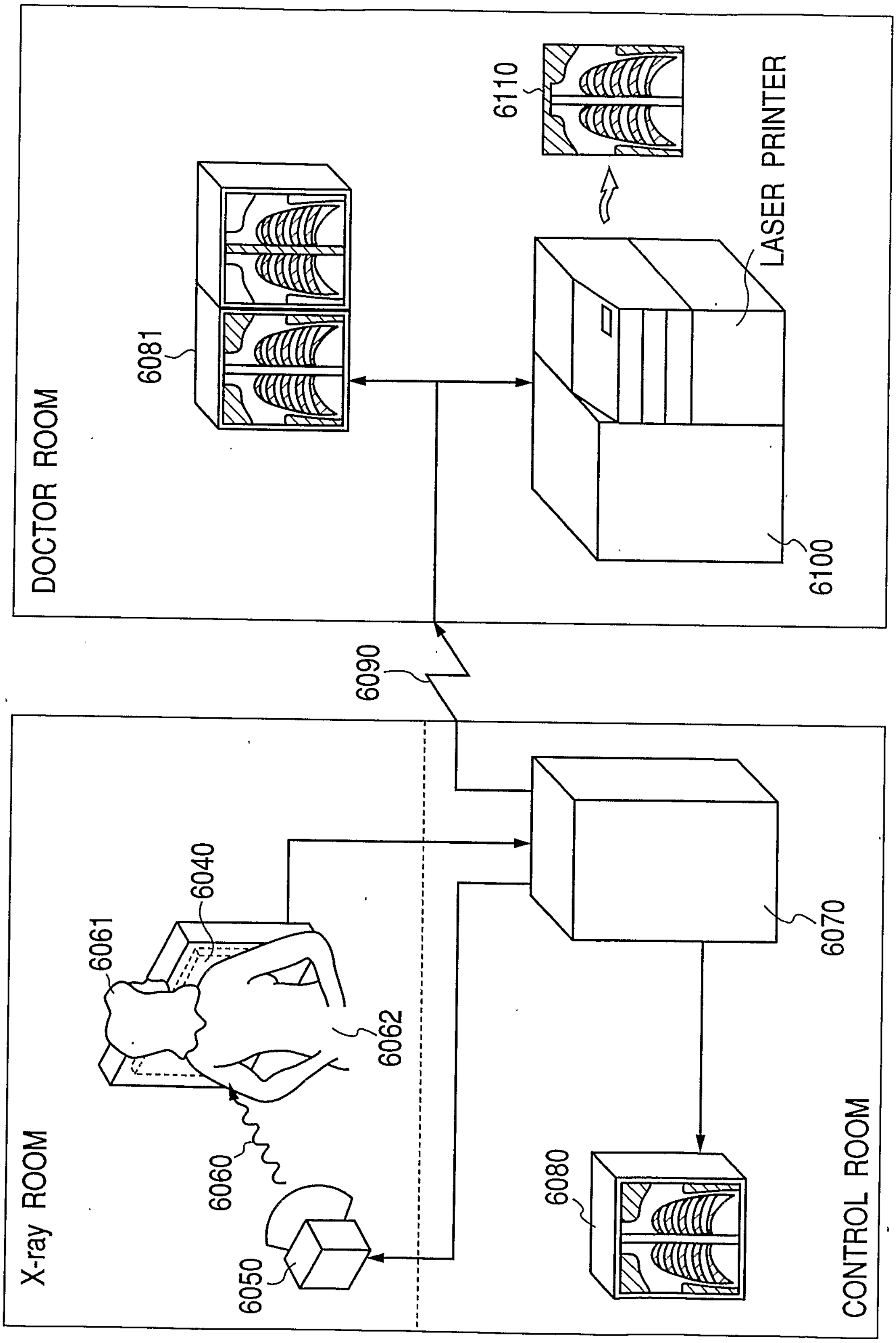

DOCTOR ROOM
6081
6110
LASER PRINTER
6100
6090
X-ray ROOM
6061
6040
6062
6060
6050
6070
6080
CONTROL ROOM

FIG. 11

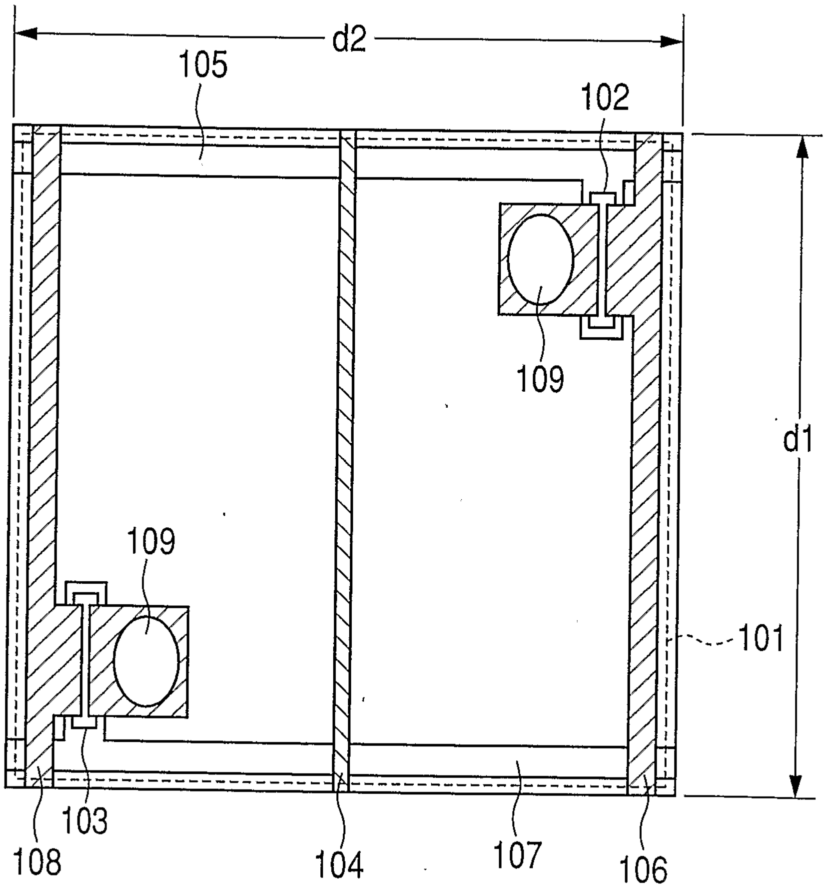
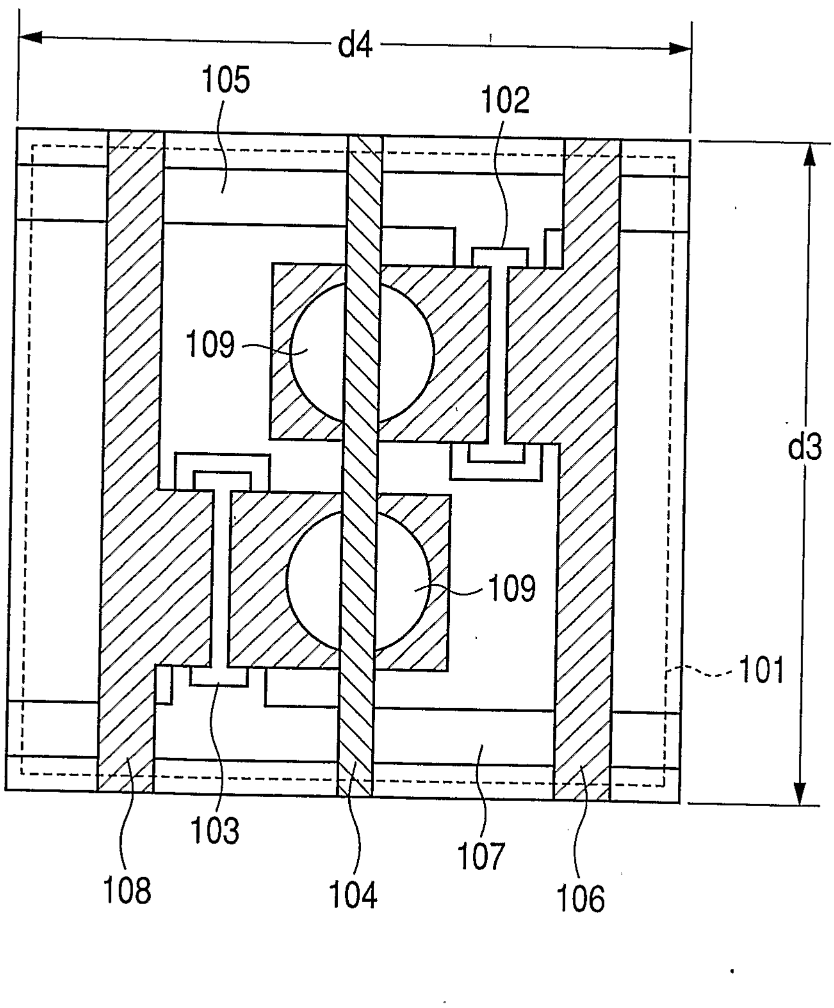


FIG. 12



INTERNATIONALSEARCHREPORT

International application No.
PCT/JP2007/050629

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H01L27/146(2006.01)i, G01T1/20(2006.01)i, G01T1/24(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H01L27/146, G01T1/20, G01T1/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2007
Registered utility model specifications of Japan 1996-2007
Published registered utility model applications of Japan 1994-2007

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2003-218339 A (CANON KABUSHIKI KAISHA) 2003.07.31,【0051】-【0052】,【0054】-【0055】,Fig12, 15 & US 2005/0145800 A1	1-3,5,7-9,11 4,6,10,12
Y	JP 2004-179645 A (CANON KABUSHIKI KAISHA) 2004.06.24,【0018】-【0039】,【0119】-【0122】,Fig1-4, 23,24 & US 2004/0159794 A1 & EP 1420453 A2	4,6,10,12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13.04.2007	24.04.2007

Name and mailing address of the ISA/JP	Authorized officer
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