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DETECTION DEVICE

Abstract

According to an aspect, a detection device includes: a light source device; an object placement member; an electrochromic shutter having a plurality of divided regions arranged in a plane; and an optical sensor having a plurality of detection regions arranged in a plane. One of the detection regions includes one or more photodetection elements. The divided regions in the electrochromic shutter are capable of being switched between a light-transmitting state and a non-light-transmitting state for each of the divided regions, and the light-emitting elements are each capable of being switched between a lit state and an unlit state. The respective light-emitting elements, the respective divided regions of the electrochromic shutter, and the respective detection regions overlap when viewed in the first direction.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority from Japanese Patent Application No. 2024-020776 filed on Feb. 15, 2024, the entire contents of which are incorporated herein by reference.

BACKGROUND

1. Technical Field

[0002] What is disclosed herein relates to a detection device.

2. Description of the Related Art

[0003] Japanese Patent Publication No. 6830593 (JP-B-6830593) discloses a biosensor that includes an optical sensor including a photosensor (photodetection element), a culture vessel placed on the upper side of an imaging surface of the photosensor, and a point light source disposed above the culture vessel. The culture vessel accommodates therein a culture medium and a plurality of objects to be detected (microorganisms). In the biosensor of JP-B-6830593, light emitted from the point light source passes through the culture medium and the objects to be detected (microorganisms), and enters the photodiode. The biosensor of JP-B-6830593 may, however, have difficulty in detecting the objects to be detected if the culture medium in the culture vessel has low light transmittance.

[0004] Detection devices with higher accuracy of detection of the objects to be detected are required.

[0005] For the foregoing reasons, there is a need for a detection device that improves accuracy of detection of objects to be detected.

SUMMARY

[0006] According to an aspect, a detection device includes: a light source device including a plurality of light-emitting elements arranged in a plane; an object placement member with a light-transmitting property that is disposed overlapping the light source device on a first side in a first direction and on which an object to be detected is placed; an electrochromic shutter that is disposed overlapping the object placement member on the first side in the first direction and has a plurality of divided regions arranged in a plane; and an optical sensor that is disposed overlapping the electrochromic shutter on the first side in the first direction and has a plurality of detection regions arranged in a plane. One of the detection regions includes one or more photodetection elements. The divided regions in the electrochromic shutter are capable of being switched between a light-transmitting state and a non-light-transmitting state for each of the divided regions, and the light-emitting elements are each capable of being switched between a lit state and an unlit state. The respective light-emitting elements, the respective divided regions of the electrochromic shutter, and the respective detection regions overlap when viewed in the first direction.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a perspective view schematically illustrating a detection device according to an embodiment of the present disclosure;

[0008] FIG. **2** is a perspective view of a state where a top plate is removed from FIG. **1**;

[0009] FIG. **3** is a schematic view of the detection device according to the embodiment;

[0010] FIG. **4** is a schematic view illustrating a section of an electrochromic shutter;
[0011] FIG. **5** is a schematic diagram illustrating an example of the configuration of the electrochromic shutter;
[0012] FIG. **6** is a schematic circuit diagram illustrating the configuration of a switching element in the electrochromic shutter;
[0013] FIG. **7** is a block diagram illustrating an example of the configuration of the detection device;
[0014] FIG. **8** is a schematic view illustrating projection regions of light emitted from light-emitting elements;
[0015] FIG. **9** is a schematic view of the detection device according to the embodiment;
[0016] FIG. **10** is a schematic plan view of a light source device according to the embodiment;
[0017] FIG. **11** is a schematic plan view of the electrochromic shutter according to the embodiment;
[0018] FIG. **12** is a schematic plan view of an optical sensor according to the embodiment;
[0019] FIG. **13** is a schematic diagram illustrating an operating state of two light-emitting elements and two divided regions of the electrochromic shutter adjacent to each other in an X direction;
[0020] FIG. **14** is a flowchart illustrating a detection operation example of the detection device according to the embodiment;
[0021] FIG. **15** is a schematic view illustrating the order in which the light-emitting elements are turned on;
[0022] FIG. **16** is a schematic view illustrating the order in which the divided regions of the electrochromic shutter open; and
[0023] FIG. **17** is a schematic view illustrating the order in which photodetection elements of the detection device perform detection.

DETAILED DESCRIPTION

[0024] The following describes a mode (embodiment) for carrying out the present disclosure in detail with reference to the drawings. The present disclosure is not limited to the description of the embodiment given below. Components described below include those easily conceivable by those skilled in the art or those substantially identical thereto. In addition, the components described below can be combined as appropriate. What is disclosed herein is merely an example, and the present disclosure naturally encompasses appropriate modifications easily conceivable by those skilled in the art while maintaining the gist of the present disclosure.
[0025] To further clarify the description, the drawings may schematically illustrate, for example, widths, thicknesses, and shapes of various parts as compared with actual aspects thereof. However, they are merely examples, and interpretation of the present disclosure is not limited thereto. The same component as that described with reference to an already mentioned drawing is denoted by the same reference numeral through the present disclosure and the drawings, and detailed description thereof may not be repeated where appropriate.
[0026] In XYZ coordinates in the drawings, a Z direction (first direction) corresponds to the up-down direction; an X direction (second direction) corresponds to the right-left direction; and a Y direction (third direction) corresponds to the front-rear direction. The X direction intersects (at right angles) the Y and Z directions; the Y direction intersects (at right angles) the X and Z directions; and the Z direction intersects (at right angles) the X and Y directions. A Z1 side is one side in the first direction, and a Z2 side is the other side in the first direction. An end on an X2 side in the X direction is referred to as a first end, and the end on an X1 side is referred to as a second end. A plan view indicates a state viewed in the Z direction (first direction).
[0027] FIG. **1** is a perspective view schematically illustrating a detection device according to an embodiment of the present disclosure. FIG. **2** is a perspective view of a state where a top plate is removed from FIG. **1**.
[0028] As illustrated in FIGS. **1** and **2**, a detection device **100** has a substantially box shape, for

example. The detection device **100** includes a housing **3** and a holding member **4**. The housing **3** includes a top plate **31** and side plates **32** and **33**. The holding member **4** includes a plate **41** and a base plate **42**. An object placement member **110** is placed on the plate **41**. The four corners of the base plate **42** are provided with front-side holders **42**_c_ and rear-side holders **42**_d_. The front-side holders **42**_c_ and the rear-side holders **42**_d_ are biased to the upper side (Z1 side) by springs **5**. The object placement member **110** is placed on the plate **41**, whereby the plate **41** and the object placement member **110** are biased to the upper side (Z1 side) by the springs **5**.
[0029] FIG. **3** is a schematic view of the detection device according to the embodiment. As illustrated in FIG. **3**, the detection device **100** includes a light source device **7**, the object placement member **110**, an electrochromic shutter **82**, an optical sensor **81**, and the springs **5**.
[0030] The light source device **7** includes a light source substrate **72** and a plurality of light-emitting elements **71**. The light-emitting element **71** is a light-emitting diode (LED), for example. Thus, the light source device **7** includes a plurality of light-emitting elements **71** arranged in a plane.
[0031] The object placement member **110** includes a placement substrate **111** and a cover member **112**. The object placement member **110** is a Petri dish, for example. The object placement member **110** has a light-transmitting property. The placement substrate **111** is a light-transmitting substrate disposed overlapping the light source device **7** on the Z1 side and on which objects to be detected **114** are placed.
[0032] The object placement member **110** according to the present embodiment is placed upside down with respect to a conventional object placement member. In other words, in the conventional object placement member, the placement substrate is placed on the lower side, and the cover member is placed on the upper side. By contrast, in the object placement member **110** according to the present embodiment, the placement substrate **111** is placed on the upper side, and the cover member **112** is placed on the lower side. The optical sensor **81** and the electrochromic shutter **82** are provided on top of (on the Z1 side of) the object placement member **110** placed upside down, and the light source device **7** is provided under (on the Z2 side of) the object placement member **110**. A culture medium **113** (e.g., agar) is provided on the lower side of the placement substrate **111**, and the objects to be detected **114** are applied to the culture medium **113** (lower surface of the culture medium **113**). The object to be detected **114** is a microorganism, such as a bacterium, or a sample containing a microorganism and forms colonies on the culture medium **113** over time. The object to be detected **114** is not limited to the bacteria, and may be other micro-objects such as cells.
[0033] The optical sensor **81** includes an array substrate **811** and sensor pixels **812** (photodetection elements **813** or photodiodes). The optical sensor **81** is disposed overlapping the electrochromic shutter **82** on the Z1 side. The sensor pixels **812** are provided on the surface of the array substrate **811** on the Z2 side. The electrochromic shutter **82** will be described later.
[0034] Light L emitted from the light-emitting element **71** passes through the cover member **112**, the culture medium **113**, the placement substrate **111**, and a divided region of the electrochromic shutter **82** in a light-transmitting state (open state) and travels toward the optical sensor **81**. The amount of light incident on the photodetection element **813** (photodiode) of the optical sensor **81** differs between a region overlapping the object to be detected **114** and a region not overlapping the object to be detected **114**. As a result, the optical sensor **81** can image the objects to be detected **114**. Thus, the detection device **100** is a device that monitors changes in the objects to be detected **114** by placing the objects to be detected **114** accommodated in the object placement member **110** between the light source device **7** and the optical sensor **81** and imaging the objects to be detected **114** by the optical sensor **81**.
[0035] FIG. **4** is schematic view illustrating a section of the electrochromic shutter. FIG. **5** is a schematic diagram illustrating an example of the configuration of the electrochromic shutter.
[0036] The electrochromic shutter **82** is described below. In the following description,

“electrochromic” in the electrochromic shutter may be abbreviated simply as “EC”. In other words, for example, the electrochromic shutter may be referred to as an EC shutter, and an electrochromic material may be referred to as an EC material. EC is an abbreviation for electrochromic.

[0037] As illustrated in FIG. **4**, the electrochromic shutter **82** includes a first substrate **8211**, a second substrate **8212**, and an electrochromic material **8215**. The EC material **8215** is sandwiched between the first substrate **8211** and the second substrate **8212** in the Z direction. The EC shutter **82** is a device that uses the EC material **8215** that can be reversibly controlled to be brought into a light-transmitting state or a non-light-transmitting state by controlling applied voltage. The EC material **8215** is an ion-insertion metal oxide, such as chromium oxide (Cr.sub.2O.sub.3) and tungsten oxide (WO.sub.3), but it is not limited thereto and may be another material that produces similar phenomena.

[0038] The first substrate **8211** and the second substrate **8212** are light-transmitting substrates, such as glass substrates. The surface of the first substrate **8211** facing the EC material **8215** is provided with first electrodes **8213**. The surface of the second substrate **8212** facing the EC material **8215** is provided with a second electrode **8214**. The first electrode **8213** is coupled to a switching element **8240**. The potential difference between the first electrode **8213** and the second electrode **8214** determines the voltage applied to the EC material **8215**. The second electrode **8214** according to the embodiment is supplied with a constant potential.

[0039] As illustrated in FIG. **5**, the EC shutter **82** includes an active area **82**AA and a switching circuit area **82**SA. In the active area **82**AA, a plurality of switching elements **8240** are arranged in a matrix (row-column configuration). The switching elements **8240** correspond to respective divided regions **820** of the EC shutter **82**. Some of the divided regions **820** are indicated by dashed lines. Specifically, out of the switching elements **8240** illustrated in FIG. **5**, “1-1” corresponds to a divided region **82-1**, “2-1” corresponds to a divided region **82-2**, and “3-1” corresponds to a divided region **82-3**. The divided regions **820** of the EC shutter **82** will be described later in detail.

[0040] In the EC shutter **82**, signals input via wiring **8231** are supplied to the active area **82**AA as drive signals via a gate driver **8221** and wiring **8235**. Signals input via wiring **8232** are supplied to the switching circuit area **82**SA via a decoder **8222** and wiring **8236**. The potential of a signal input via a wiring line **8233** is supplied to the active area **82**AA as an applied potential via the switching circuit area **82**SA and wiring **8237**. The potential of a signal input via a wiring line **8234** is supplied to the active area **82**AA as a reset potential via the switching circuit area **82**SA and the wiring **8237**.

[0041] FIG. **6** is a schematic circuit diagram illustrating the configuration of the switching element in the electrochromic shutter. The switching element **8240** illustrated in FIG. **6** is a field effect transistor (FET). The gate of the switching element **8240** is coupled to a scanning line **8350**. One of the source and the drain of the switching element **8240** is coupled to a transmission line **8370**. The other of the source and the drain of the switching element **8240** is coupled to the first electrode **8213**. In other words, at the timing when the signal (drive signal) is supplied to the gate via the scanning line **8350**, the switching element **8240** supplies the first electrode **8213** with a potential corresponding to the potential (e.g., applied or reset potential) according to the signal transmitted via the transmission line **8370**.

[0042] The transmission line **8370** illustrated in FIG. **6** is one of transmission lines Data_1, Data_2, Data_3, . . . , and Data_n illustrated in FIG. **5**. The wiring **8237** includes a plurality of transmission lines, such as the transmission lines Data_1, Data_2, Data_3, . . . , and Data_n illustrated in FIG. **5**. The transmission lines are coupled to the wiring **8233** via the switching circuit area **82**SA. n is a natural number of 2 or larger indicating the number of the switching elements **8240** arranged in the Y direction and the number of transmission lines. The switching elements **8240** arranged in the X direction share a single transmission line with one another.

[0043] A plurality of transmission lines, such as the transmission lines Data_1, Data_2, Data_3, . . . , and Data_n, are coupled to the wiring line **8233** via individual first switches **8251**, **8252**, **8253**, . . . , and **825***n*, respectively. As illustrated in FIG. **5**, the transmission line Data_1 is coupled to the wiring **8233** via the first switch **8251**. The transmission line Data **2** is coupled to the wiring line **8233** via the first switch **8252**. The transmission line Data **3** is coupled to the wiring line **8233** via the first switch **8253**. Similarly, the transmission line Data_n is coupled to the wiring line **8233** via the first switch **825***n*.

[0044] A plurality of transmission lines, such as the transmission lines Data_1, Data_2, Data_3, . . . , and Data_n, are coupled to the wiring **8234** via individual second switches **8261**, **8262**, **8263**, . . . , and **826***n*, respectively. As illustrated in FIG. **5**, the transmission line Data_1 is coupled to the wiring **8234** via the second switch **8261**. The transmission line Data_2 is coupled to the wiring **8234** via the second switch **8262**. The transmission line Data_3 is coupled to the wiring **8234** via the second switch **8263**. Similarly, the transmission line Data_n is coupled to the wiring **8234** via the second switch **826***n*. The positions where the transmission lines are coupled to the second switches **8261**, **8262**, **8263**, . . . , and **826***n* are closer to the active area **82**AA than the positions where the transmission lines are coupled to the first switches **8251**, **8252**, **8253**, . . . , and **825***n*.

[0045] The first switches **8251**, **8252**, **8253**, . . . , and **825***n* and the second switches **8261**, **8262**, **8263**, . . . , and **826***n* operate under the control of the decoder **8222**.

[0046] The decoder **8222** is coupled to wiring lines ASW1, ASW2, ASW3, . . . , and ASWn that transmit signals to individually control the first switches **8251**, **8252**, **8253**, . . . , and **825***n*. As illustrated in FIG. **5**, the wiring line ASW1 couples the decoder **8222** to the first switch **8251**. The wiring line ASW2 couples the decoder **8222** to the first switch **8252**. The wiring line ASW3 couples the decoder **8222** to the first switch **8253**. Similarly, the wiring line ASWn couples the decoder **8222** to the first switch **825***n*. The wiring **8236** includes the wiring lines ASW1, ASW2, ASW3, . . . , and ASWn.

[0047] The decoder **8222** is also coupled to a wiring line ASW0 that transmits signals to collectively control the second switches **8261**, **8262**, **8263**, . . . , and **826***n*. The wiring line ASW0 couples the decoder **22** to the second switches **8261**, **8262**, **8263**, . . . , and **826***n*. Besides the wiring lines ASW1, ASW2, ASW3, . . . , and ASWn, the wiring **8236** also includes the wiring line ASW0.

[0048] The decoder **8222** operates according to signals supplied from a host **8225** via the wiring **8232** and controls the operations of the first switches **8251**, **8252**, **8253**, . . . , and **825***n* and the second switches **8261**, **8262**, **8263**, . . . , and **826***n*. More specifically, the decoder **8222** functions as what is called a combinational logic circuit and can control the operations of the first switches **8251**, **8252**, **8253**, . . . , and **825***n* and the second switches **8261**, **8262**, **8263**, . . . , and **826***n* according to signals supplied via the wiring **8232** including a smaller number of wiring lines than the number of wiring lines included in the wiring **8236**.

[0049] The scanning line **8350** illustrated in FIG. **6** is one of scanning lines Gate_1, Gate_2, Gate_3, . . . , and Gate_m illustrated in FIG. **5**. The wiring **8235** includes a plurality of scanning lines, such as the scanning lines Gate_1, Gate_2, Gate_3, . . . , and Gate_m illustrated in FIG. **5**. The gate driver **8221** operates according to signals supplied from the host **8225** via the wiring **8231** and sequentially supplies drive signals to the scanning lines Gate_1, Gate_2, Gate_3, . . . , and Gate_m. m is a natural number of 2 or larger indicating the number of the switching elements **8240** arranged in the X direction and the number of scanning lines. The switching elements **8240** arranged in the Y direction share a single scanning line with one another.

[0050] FIG. **7** is a block diagram illustrating an example of the configuration of the detection device. As illustrated in FIG. **7**, the detection device **100** includes the optical sensor **81**, the electrochromic shutter **82**, the light source device **7**, and a host IC **75**. The optical sensor **81** includes the array substrate **811**, the sensor pixels **812** (photodetection elements **813** or photodiodes) formed on the array substrate **811**, gate line drive circuits **814**A and **814**B, a signal line drive circuit **815**A, and a detection control circuit (ROIC) **816**.

[0051] The array substrate **811** is formed using a substrate as a base. Each of the sensor pixels **812** is configured with a corresponding one of the photodetection elements **813**, a plurality of transistors, and various types of wiring.

[0052] The array substrate **811** has a detection region AA and a peripheral region GA. The detection region AA is a region provided with the sensor pixels **812** (photodetection elements **813**). The peripheral region GA is a region between the outer periphery of the detection region AA and the outer ends of the array substrate **811** and is a region not provided with the sensor pixels **812**. The gate line drive circuits **814**A and **814**B, the signal line drive circuit **815**A, and the detection control circuit **816** are provided in the peripheral region GA.
[0053] Each of the sensor pixels **812** is an optical sensor that includes the photodetection element (photodiode) **813** as a sensor element. Each of the photodetection elements **813** outputs an electrical signal corresponding to light emitted thereto.
[0054] The detection control circuit **816** is a circuit that supplies control signals Sa, Sb, and Sc to the gate line drive circuits **814**A and **814**B and the signal line drive circuit **815**A, respectively, to control operations of these circuits. The detection control circuit **816** includes a signal processing circuit that performs signal processing on detection signals Vdet from the photodetection elements **813**.
[0055] The detection control circuit **816** performs signal processing on the detection signals Vdet from the photodetection elements **813** and outputs sensor values So based on the detection signals Vdet to the host IC **75**. Thus, the detection device **100** detects information on the object to be detected **114**.
[0056] The electrochromic shutter **82** includes a plurality of divided regions **820** and a second light-emitting element control circuit (DDIC-2) **822**. Each of the divided regions **820** is arranged overlapping a plurality of (e.g., four) photodetection elements **813**. The second light-emitting element control circuit **822** supplies control signals Sg to the respective divided regions **820** and controls operations of these regions.
[0057] The light source device **7** includes the light source substrate **72**, the light-emitting elements **71** formed on the light source substrate **72**, gate line drive circuits **814**C and **814**D, a signal line drive circuit **815**B, and a first light-emitting element control circuit (DDIC-1) **74**.
[0058] The light-emitting elements **71** are arranged in a matrix (row-column configuration) in a region of the light source substrate **72** overlapping the detection region AA. The light source substrate **72** is a drive circuit substrate that drives each of the light-emitting elements **71** so as to switch the element between on (lit state) and off (unlit state). The light-emitting elements **71** are disposed overlapping the respective divided regions **820** of the electrochromic shutter **82**.
[0059] The first light-emitting element control circuit **74** supplies control signals Sd, Se, and Sf to the gate line drive circuits **814**C and **814**D and the signal line drive circuit **815**B, respectively, to control operations of these circuits.
[0060] The host IC **75** includes, as a control circuit for the optical sensor **81**, a sensor value storage circuit **751**, a sensor value calculation circuit **752**, a light intensity setting circuit **753**, and a target value storage circuit **759**. The sensor value storage circuit **751** stores therein the sensor values So output from the detection control circuit **816** of the optical sensor **81**. The sensor value calculation circuit **752** performs a predetermined calculation process on the sensor values So of the photodetection elements **813**.
[0061] In a light intensity setting mode, the light intensity setting circuit **753** compares the sensor values So detected by the photodetection elements **813** with a preset target sensor value So-t acquired from the target value storage circuit **759** to set light intensities of the light-emitting elements **71** for detection. The target value storage circuit **759** stores therein the preset target sensor value So-t.
[0062] The host IC **75** includes, as a control circuit for the light source device **7**, a lighting pattern generation circuit **754** and a lighting pattern storage circuit **755**. The lighting pattern storage circuit **755** stores therein information on the light intensity of each of the light-emitting elements **71** in the light intensity setting mode.
[0063] The lighting pattern generation circuit **754** generates various control signals based on the

information on the light intensity in the lighting pattern storage circuit **755**.

[0064] The host IC **75** includes an image generation circuit **756** and a storage circuit **757**. In a detection mode, the image generation circuit **756** generates an image of the object to be detected **114**, based on the sensor values So output from the photodetection elements **813**. The storage circuit **757** stores therein image data generated by the image generation circuit **756**. The host IC **75** is coupled to a host computer (PC) **758** and transfers the image data to the host PC **758**.

[0065] FIG. **8** is a schematic view illustrating projection regions of light emitted from the light-emitting elements. FIG. **9** is a schematic view of the detection device according to the embodiment. FIG. **10** is a schematic plan view of the light source device according to the embodiment. FIG. **11** is a schematic plan view of the electrochromic shutter according to the embodiment. FIG. **12** is a schematic plan view of the optical sensor according to the embodiment.

[0066] As illustrated in FIG. **8**, a total of 16 light-emitting elements **71** according to the present embodiment are provided. In other words, the following describes the embodiment where n and m described with reference to FIG. **5** are 4. The 16 light-emitting elements **71** are arranged in a matrix (row-column configuration) at regular intervals in the X direction (second direction) and the Y direction (third direction). In the 16 light-emitting elements **71**, the distance between the light-emitting elements **71** adjacent to each other in the X direction is a distance d, and the distance between the light-emitting elements **71** adjacent to each other in the Y direction is also the distance d.

[0067] As illustrated in FIG. **9**, light emitted from one light-emitting element **71** spreads radially as the light travels toward the upper side (Z1 side). Therefore, as illustrated in FIG. **8**, a projection region IA of light projected onto the optical sensor **81** without the electrochromic shutter **82** is a circle with a radius r centered on the light-emitting element **71**. As illustrated in FIG. **8**, the projection regions IA adjacent in the X or Y direction have an overlapping portion P indicated by hatching. This overlapping portion P causes the image of the object to be detected **114** to be blurred or hazy.

[0068] As illustrated in FIG. **10**, a total of 16 light-emitting elements **71** according to the present embodiment are provided. The light-emitting elements **71** are turned on one by one. Specifically, for example, in a unit period when one light-emitting element **71-1** is on, the light-emitting elements **71** other than the light-emitting element **71-1** are off. In other words, the light-emitting elements **71** can be switched between the lit state and the unlit state for each of the light-emitting elements **71**.

[0069] The 16 light-emitting elements **71** are arranged in a matrix (row-column configuration) at regular intervals in the X and Y directions as described above. Specifically, four rows along the X direction are arranged, and four columns along the Y direction are arranged. As for the rows, for example, the first row is positioned on the most Y2 side. In the first row, four light-emitting elements **71** are arranged at regular intervals from the X2 side to the X1 side. Specifically, light-emitting elements **71-1**, **71-2**, **71-3**, and **71-4** are arranged from the X2 side to the X1 side. In the second row, four light-emitting elements **71** are arranged at regular intervals from the X2 side to the X1 side. Specifically, light-emitting elements **71-5**, **71-6**, **71-7**, and **71-8** are arranged from the X2 side to the X1 side. In the third row, four light-emitting elements **71** are arranged at regular intervals from the X2 side to the X1 side. Specifically, light-emitting elements **71-9**, **71-10**, **71-11**, and **71-12** are arranged from the X2 side to the X1 side. In the fourth row, four light-emitting elements **71** are arranged at regular intervals from the X2 side to the X1 side. Specifically, light-emitting elements **71-13**, **71-14**, **71-15**, and **71-16** are arranged from the X2 side to the X1 side.

[0070] As for the columns, for example, the first column is positioned on the most X2 side. In the first column, four light-emitting elements **71** are arranged at regular intervals from the Y2 side to the Y1 side. Similarly, in the second, the third, and the fourth columns, four light-emitting elements **71** are arranged at regular intervals from the Y2 side to the Y1 side.

[0071] As illustrated in FIG. **11**, the electrochromic shutter **82** according to the present embodiment is divided into a total of 16 parts in plan view seen in the Z direction. In other words, the electrochromic shutter **82** has 16 divided regions **820** divided in the X and Y directions.

[0072] The divided regions **820** are brought into a light-transmitting state one by one. In other words, one divided region **820** overlapping one lit light-emitting element **71** when viewed in the Z direction is brought into a light-transmitting state, and the divided regions **820** other than the one divided region **820** are brought into a non-light-transmitting state. Specifically, the divided regions **820** in the electrochromic shutter **82** can be switched between the light-transmitting state and the non-light-transmitting state for each of the divided regions **820**. In the period during which one divided region **820** is in the light-transmitting state, the other divided regions **820** are in a closed (non-light-transmitting) state. In other words, the period during which one divided region **820** is in the light-transmitting state is different from the periods during which the other divided regions **820** are in the light-transmitting state.

[0073] The divided regions **820** adjacent to each other in the X or Y direction are arranged without a gap or with a slight gap interposed therebetween. All the divided regions **820** each have a square shape when viewed in the Z direction. The divided regions **820** are arranged in a matrix (row-column configuration) at regular intervals in the X and Y directions when viewed in the Z direction. The 16 divided regions **820** are arranged in a lattice pattern at regular intervals in the X and Y directions. Specifically, in the same manner as the arrangement of the light-emitting elements, four rows along the X direction are arranged, and four columns along the Y direction are arranged. As for the rows, for example, the first row is positioned on the most Y2 side. In the first row, four divided regions **820** are arranged at regular intervals from the X2 side to the X1 side. Specifically, divided regions **82-1**, **82-2**, **82-3**, and **82-4** are arranged from the X2 side to the X1 side. In the second row, four divided regions **820** are arranged at regular intervals from the X2 side to the X1 side. Specifically, divided regions **82-5**, **82-6**, **82-7**, and **82-8** are arranged from the X2 side to the X1 side. In the third row, four divided regions **820** are arranged at regular intervals from the X2 side to the X1 side. Specifically, divided regions **82-9**, **82-10**, **82-11**, and **82-12** are arranged from the X2 side to the X1 side. In the fourth row, four divided regions **820** are arranged at regular intervals from the X2 side to the X1 side. Specifically, divided regions **82-13**, **82-14**, **82-15**, and **82-16** are arranged from the X2 side to the X1 side.

[0074] As for the columns, for example, the first column is positioned on the most X2 side. In the first column, four divided regions **820** are arranged at regular intervals from the Y2 side to the Y1 side. Similarly, in the second, the third, and the fourth columns, four divided regions **820** are arranged at regular intervals from the Y2 side to the Y1 side.

[0075] The divided region **820** according to the present disclosure does not necessarily have a square shape in plan view. Thus, the divided region **820** may have, for example, an equilateral triangular shape or a polygonal shape with five or more sides in plan view.

[0076] As illustrated in FIG. **12**, the optical sensor **81** has a plurality of detection regions **810**. One detection region **810** includes one or more photodetection elements **813** (photodiodes). While one detection region **810** according to the present embodiment includes four photodetection elements **813**, the present disclosure is not limited thereto, and one detection region **810** may include three or less or five or more photodetection elements **813**. The detection region **810** is arranged correspondingly to the divided region **820** of the electrochromic shutter **82**. Specifically, the outline of the detection region **810** overlaps the outline of the divided region **820** of the electrochromic shutter **82** when viewed in the Z direction. Therefore, four photodetection elements **813** are disposed overlapping one divided region **820** of the electrochromic shutter **82** when viewed in the Z direction.

[0077] The detection regions **810** are arranged in a matrix (row-column configuration) at regular intervals in the X and Y directions when viewed in the Z direction. The 16 detection regions **810** are arranged in a lattice pattern at regular intervals in the X and Y directions. Specifically, in the same manner as the arrangement of the light-emitting elements **71** and the divided regions **820** of the electrochromic shutter **82**, four rows along the X direction are arranged, and four columns along the Y direction are arranged. As for the rows, for example, the first row is positioned on the most Y2 side. In the first row, four detection regions **810** are arranged at regular intervals from the X2 side to the X1 side. In the second row, four detection regions **810** are arranged at regular intervals from the X2 side to the X1 side. In the third row, four detection regions **810** are arranged at regular intervals from the X2 side to the X1 side. In the fourth row, four detection regions **810** are arranged at regular intervals from the X2 side to the X1 side.

[0078] Referring back to FIG. **7**, the light-emitting elements **71** overlap the respective divided regions **820** of the electrochromic shutter **82** when viewed in the Z direction. The divided region **820** of the electrochromic shutter **82** overlaps the photodetection elements **813** when viewed in the Z direction. Therefore, the respective light-emitting elements **71**, the respective divided regions **820** of the electrochromic shutter **82**, and the respective detection regions **810** overlap when viewed in the Z direction. In the present embodiment, the number of light-emitting elements **71** overlapping one divided region **820** of the electrochromic shutter **82** may be two or more. The light-emitting element **71** is a light-emitting diode (LED), for example.

[0079] Also in FIG. **9**, the divided region **82-1** overlaps the light-emitting element **71-1**, the divided region **82-2** overlaps the light-emitting element **71-2**, the divided region **82-3** overlaps the light-emitting element **71-3**, and the divided region **82-4** overlaps the light-emitting element **71-4** when viewed in the Z direction. Light L1 emitted from the light-emitting element **71-1** is incident on the entire area of the divided region **82-1** and part of the divided region **82-2**. Similarly, light L2 is incident on the entire area of the divided region **82-2**, part of the divided region **82-1**, and part of the divided region **82-3**. Light L3 is incident on the entire area of the divided region **82-3**, part of the divided region **82-2**, and part of the divided region **82-4**. Light L4 is incident on the entire area of the divided region **82-4** and part of the divided region **82-3**. The irradiation angle of light emitted from the light-emitting element **71** is an angle θ1, and **114**A denotes a captured image of the object to be detected.

[0080] The following describes the operating timing of the electrochromic shutter **82** and the turning-on and -off timings of the light-emitting elements in comparison. FIG. **13** is a schematic diagram illustrating an operating state of two light-emitting elements and two divided regions of the electrochromic shutter adjacent to each other in the X direction.

[0081] In FIG. **13**, the upper left diagram illustrates the turning-on and -off timings of the light-emitting element **71-1** (refer to FIG. **10**) and the operating state of the divided region **82-1** (refer to FIG. **11**) of the EC shutter **82**. The light-emitting element **71-1** and the divided region **82-1** overlap when viewed in the Z direction. In FIG. **13**, the lower right diagram illustrates the turning-on and -off timings of the light-emitting element **71-2** (refer to FIG. **10**) and the operating state of the divided region **82-2** (refer to FIG. **11**) of the EC shutter **82**. The light-emitting element **71-2** and the divided region **82-2** overlap when viewed in the Z direction.

[0082] The control signal Sg (refer to FIG. **7**) for instructing the shutter to open and close is indicated by a solid line, and the transmittance of the shutter is indicated by a dashed line. The highest transmittance of the EC shutter **82** is 100%, and the lowest transmittance is 0%. In the present embodiment, a transmittance of 95% is indicated by an alternate long and two short dashes line because a predetermined transmittance at which satisfactory detection accuracy can be obtained is 95% or higher.

[0083] First, the divided region **82-1** of the EC shutter **82** receives the control signal Sg (refer to FIG. **7**) to open (turn on) the shutter at time T1 as indicated by the solid line. After the control signal Sg is received, the transmittance of the divided region **82-1** of the EC shutter **82** gradually increases. The transmittance reaches 95% at time T2 and is saturated near 100% at time T3. In the embodiment, a state where the transmittance is 95% or higher is the state where the EC shutter **82** is in the light-transmitting state (open state), and a state where the transmittance is lower than 5%, for example, is the non-light-transmitting state (closed state). Therefore, the divided region **82-1** of the EC shutter **82** comes into the light-transmitting state (open state) at time T2. The time length from time T1 to time T2 is determined in advance by experiment, for example. Thus, it is determined that the transmittance of the EC shutter **82** reaches 95% at the time when (time T2−time T1) has elapsed since time T1.

[0084] At time T3, the light-emitting element **71-1** shifts from the unlit state (off state) to the lit state. The light-emitting element **71-1** remains in the lit state from time T3 to time T4. At time T4, the light-emitting element **71-1** shifts to the unlit state.

[0085] When the control signal Sg to close (turn off) the shutter is received at time T5 after time T4, the transmittance of the divided region **82-1** of the EC shutter **82** gradually decreases from time T5. The transmittance of the divided region **82-1** reaches 95% at time T6 and is saturated near 0% at time T7. The transmittance reaches 95% at time T6, whereby the divided region **82-1** of the EC shutter **82** comes into the closed state at time T6.

[0086] After time T7, the light-emitting element **71-2** is brought into the lit and unlit states, and the divided region **82-2** of the EC shutter **82** is brought into the open state. The changes between the lit and unlit states of the light-emitting element **71-2** are the same as those in the light-emitting element **71-1**, and the open and closed states of the divided region **82-2** of the EC shutter **82** are the same as those in the divided region **82-1**.

[0087] Specifically, the divided region **82-2** of the EC shutter **82** first receives the control signal Sg to open (turn on) the shutter at time T8 as indicated by the solid line. After the control signal Sg is received, the transmittance of the divided region **82-2** of the EC shutter **82** gradually increases. The transmittance reaches 95% at time T9 and is saturated near 100% at time T10.

[0088] At time T10, the light-emitting element **71-2** shifts from the unlit state (off state) to the lit state. The light-emitting element **71-2** remains in the lit state from time T10 to time T11. At time T11, the light-emitting element **71-2** shifts to the unlit state.

[0089] When the control signal Sg to close (turn off) the shutter is received at time T12 after time T11, the transmittance of the divided region **82-2** gradually decreases from time T12. The transmittance reaches 95% at time T13 and is saturated near 0% at time T14.

[0090] After this, the light-emitting elements **71-3** and **71-4** are sequentially brought into the lit state in the same manner, and the divided regions **82-3** and **82-4** are brought into the open state in the same manner.

[0091] The following describes a detection operation example of the detection device. FIG. **14** is a flowchart illustrating the detection operation example of the detection device according to the embodiment.

[0092] First, the lighting pattern generation circuit **754** (refer to FIG. **7**) brings all the light-emitting elements **71** into the unlit (off) state and turns off (closes) all the divided regions **820** of the electrochromic shutter **82** at Step S**101**. As a result, all the 16 light-emitting elements **71** illustrated in FIG. **10** are in the unlit state, and all the 16 divided regions **820** illustrated in FIG. **11** are in the off state.

[0093] Subsequently, the host IC **75** (refer to FIG. **7**) sets the number n of the light-emitting element **71** to 1 (n=1) (Step S**102**).

[0094] Then, the lighting pattern generation circuit **754** turns on the control signal for the divided region **820** of the electrochromic shutter **82** corresponding to the number n (Step S**103**). As a result, the divided region **82-1** of the EC shutter **82** receives the control signal Sg to open (turn on) the shutter at time T1 as described with reference to FIG. **13**, for example.

[0095] Subsequently, after the transmittance of the divided region **820** of the electrochromic shutter **82** reaches 95% or higher by the processing at Step S**103**, the lighting pattern generation circuit **754** turns on the light-emitting element **71** corresponding to the number n (Step S**104**). As a result, the light-emitting element **71-1** shifts from the unlit state (off state) to the lit state at time T3 as described with reference to FIG. **13**, for example.

[0096] Then, the image generation circuit **756** (refer to FIG. **7**) generates divided image data corresponding to the number n and stores it in the storage circuit **757** (Step S**105**). As a result, the divided image data corresponding to the divided region **82-1** illustrated in FIG. **11** is generated and stored.

[0097] Subsequently, the lighting pattern generation circuit **754** brings the light-emitting element **71** corresponding to the number n into the unlit state (Step S**106**). As a result, the light-emitting element **71-1** shifts from the lit state to the unlit state at time T4 as described with reference to FIG. **13**, for example.

[0098] After the light-emitting element **71** is brought into the unlit state at Step S**106**, the lighting pattern generation circuit **754** turns off the control signal for the divided region **820** of the electrochromic shutter **82** corresponding to the number n (Step S**107**). As a result, when the control signal Sg to close (turn off) the shutter is received at time T5 after time T4, the transmittance of the divided region **82-1** of the EC shutter **82** gradually decreases from time T5 as described with reference to FIG. **13**, for example.

[0099] The host IC **75** determines whether the number n is the final value (Step S**108**). If the number n is not determined to be the final value, the host IC updates the number n of the light-emitting element to n+1 (n=n+1) (Step S**109**). For example, the host IC **75** updates n=1 to n=2, and the lighting pattern generation circuit **754** performs the processing at Step S**103** again.

[0100] Then, the processing from Step S**103** to Step S**107** is performed, and the host IC **75** determines whether the number n is the final value again (Step S**108**), and the processing is repeated until the number n is determined to be the final value.

[0101] The following specifically describes the order in which the light-emitting elements **71** are turned on, the order in which the divided regions **820** of the electrochromic shutter **82** are brought into the light-transmitting state, and the order in which the photodetection elements **813** in the detection regions **810** of the optical sensor **81** perform detection, with reference to FIGS. **15**, **16**, and **17**. FIG. **15** is a schematic view illustrating the order in which the light-emitting elements are turned on. FIG. **16** is a schematic view illustrating the order in which the divided regions of the electrochromic shutter open. FIG. **17** is a schematic view illustrating the order in which the photodetection elements of the detection device perform detection.

[0102] As illustrated in FIG. **15**, as for the light-emitting elements **71**, the light-emitting elements **71** of the first row are turned on one by one toward the X1 side. As illustrated in FIG. **16**, as for the divided regions **820** of the electrochromic shutter **82**, the divided regions **820** of the first row are brought into the light-transmitting state one by one toward the X1 side. As illustrated in FIG. **17**, as for the photodetection elements **813**, detection is sequentially performed on the detection regions **810** of the first row, for each of the detection regions **810**. As described above, the “light-transmitting state” or the “open state” of the divided region **820** of the electrochromic shutter **82** means that the light transmittance is 95% or higher.

[0103] For example, when the light-emitting element **71-1** illustrated in FIG. **15** is turned on as indicated by halftone dot, the divided region **82-1** of the electrochromic shutter **82** illustrated in FIG. **16** is brought into the light-transmitting state, and detection is performed by the four photodetection elements **813** included in the detection region **810** in the first row and the first column illustrated in the FIG. **17**. Subsequently, the light-emitting element **71-2** at the position shifted by one toward the X1 side is turned on, the divided region **82-2** is brought into the light-transmitting state, and detection is performed by one detection region **810** overlapping the divided region **82-2**. After the lighting and detection are performed one by one on the first row, the processing is performed on the second row. Specifically, the light-emitting element **71-5** in the second row and the first column is turned on, the divided region **82-5** is brought into the light-transmitting state, and detection is performed by one detection region **810** overlapping the divided region **82-5**. Detection is performed thereafter by the detection regions **810** at the positions shifted one by one toward the X1 side. When the processing on the second row is completed, detection is repeatedly performed from the third row to the fourth row in the same manner, and detection by the detection region **810** positioned in the fourth row and the fourth column is the final detection.

[0104] Referring back to the flowchart in FIG. **14**, if the host IC **75** determines that the number n is the final value (Step S**108**), the image generation circuit **756** combines all the divided image data to generate composite image data (Step S**110**). Thus, the composite image data in all the regions illustrated in FIG. **17** is generated. The image generation circuit **756** transfers the composite image data to the host PC **758** (Step S**111**).

[0105] As described above, the detection device **100** includes the light source device **7**, the object placement member **110** with a light-transmitting property, the electrochromic shutter **82** having a plurality of divided regions **820**, and the optical sensor **81** having a plurality of detection regions **810**. One detection region **810** includes one or more photodetection elements **813**. The divided regions **820** in the electrochromic shutter **82** can be switched between the light-transmitting state and the non-light-transmitting state for each of the divided regions **820**, and the light-emitting elements **71** can be switched between the lit state and the unlit state for each of the light-emitting elements **71**. The respective light-emitting elements **71**, the respective divided regions **820** of the electrochromic shutter **82**, and the respective detection regions **810** overlap when viewed in the Z direction.

[0106] As described above, if a plurality of light-emitting elements **71** are provided, light rays in different directions are emitted from the light-emitting elements **71** to one object to be detected **114**, which may blur an image captured by the optical sensor **81**.

[0107] By contrast, in the present embodiment, the respective light-emitting elements **71**, the respective divided regions **820** of the electrochromic shutter **82**, and the respective detection regions **810** of the optical sensor **81** overlap when viewed in the Z direction. Therefore, by turning on one light-emitting element **71** and bringing the divided region **820** overlapping the light-emitting element **71** into the light-transmitting state, the detection device **100** reduces a plurality of light rays incident on the detection region **810** overlapping the divided region **820** in the light-transmitting state. This configuration can reduce blurring of the image captured by the optical sensor **81**.

[0108] The divided region **820** that overlaps the light-emitting element **71** in the lit state when viewed in the Z direction is brought into the light-transmitting state, and the divided region **820** overlapping the light-emitting element **71** in the unlit state when viewed in the Z direction is brought into the non-light-transmitting state.

[0109] This configuration can turn on one light-emitting element **71**, bring only the divided region **820** overlapping the light-emitting element **71** into the light-transmitting state, and bring the divided regions **820** other than the one divided region **820** into the non-light-transmitting state. Therefore, the light L transmitted through the divided region **820** in the light-transmitting state is limited to the light L emitted from the light-emitting element **71**. This configuration can further reduce blurring of the image captured by the optical sensor **81**.

[0110] The light-emitting elements **71**, the divided regions **820**, and the detection regions **810** are arranged in a matrix (row-column configuration) along the X direction (second direction) intersecting the Z direction (first direction) and the Y direction (third direction) intersecting the Z and X directions. When N is a natural number, the light-emitting elements **71** arranged in the N-th row are sequentially brought into the lit state from the end (first end) on the X2 side in the X direction to the end (second end) on the X1 side, and the divided regions **820** arranged in the N-th row are sequentially brought into the light-transmitting state from the first end on the X2 side in the X direction to the second end on the X1 side. After the lit state and the light-transmitting state in the N-th row are ended, the light-emitting elements **71** arranged in the N+1-th row are brought into the lit state, and the divided regions **820** arranged in the N+1-th row are brought into the light-transmitting state.

[0111] Thus, each of the divided regions **820** is brought into the lit state, and each of the detection regions **810** is brought into the light-transmitting state, whereby the detection regions **810** can sequentially detect the light L. Therefore, an image with higher detection accuracy can be obtained by combining the images detected by all the detection regions **810**.

[0112] The light-emitting elements **71** include, for example, the light-emitting element **71-1** (first light-emitting element) and the light-emitting element **71-2** (second light-emitting element) adjacent to the light-emitting element **71-1** on the X1 side with respect to the light-emitting element **71-1**. The divided regions **820** include, for example, the divided region **82-1** (first divided region) overlapping the light-emitting element **71-1** (first light-emitting element) when viewed in the Z direction and the divided region **82-2** (second divided region) overlapping the light-emitting element **71-2** (second light-emitting element) when viewed in the Z direction. The light-emitting element **71-1** is brought into the unlit state and the divided region **82-1** is brought into the non-light-transmitting state before the light-emitting element **71-2** is brought into the lit state and the divided region **82-2** is brought into the light-transmitting state.

[0113] Specifically, as described with reference to FIG. **13**, the period during which the light-emitting element **71-2** is in the lit state and the divided region **82-2** is in the light-transmitting state is the period from time T10 to time T11. Therefore, before time T10, the light-emitting element **71-1** is brought into the unlit state, and the divided region **82-1** is brought into the non-light-transmitting state. In other words, after the divided region **82-1** is brought into the non-light-transmitting state, the light-emitting element **71-2** is brought into the lit state and the divided region **82-2** is brought into the light-transmitting state. Therefore, the light L from the light-emitting element **71-2** can be detected by only one detection region **810** overlapping the divided region **82-2** when viewed in the Z direction. As a result, an image with higher detection accuracy can be obtained.

[0114] The transmittance of the divided region **82-1** (first divided region) is controlled to start to increase before the light-emitting element **71-1** (first light-emitting element) is turned on.

[0115] Specifically, referring to FIG. **13**, the time at which the light-emitting element **71-1** (first light-emitting element) is turned on is time T3. The time at which the transmittance of the divided region **82-1** (first divided region) starts to increase is time T1. In other words, time T1 comes before time T3. The response speed of the electrochromic shutter **82** is slower than that of a liquid crystal shutter, for example. Therefore, by setting the time (timing) at which the transmittance of the divided region starts to increase earlier, the detection device **100** can reduce a plurality of light rays incident on one detection region **810**. This configuration can further reduce blurring of the image captured by the optical sensor **81**.

[0116] The light-emitting element **71-1** (first light-emitting element) is controlled to be in the lit state when the transmittance of the divided region **82-1** (first divided region) is equal to or higher than a predetermined value with respect to the maximum transmittance. The predetermined value is, for example, 95%.

[0117] Specifically, as described with reference to FIG. **13**, the period during which the transmittance of the divided region **82-1** (first divided region) is equal to or higher than a predetermined value of 95% is from time T2 to time T6. In the period from time T2 to time T6, the light-emitting element **71-1** is in the lit state. In other words, whenever the light-emitting element **71-1** is in the lit state, the divided region **82-1** is in the light-transmitting state. This configuration reduces a plurality of light rays incident on one detection region **810**, thereby further reducing blurring of the image captured by the optical sensor **81**.

[0118] The transmittance of the divided region **82-1** (first divided region) is controlled to start to decrease after the light-emitting element **71-1** (first light-emitting element) is brought into the unlit state.

[0119] Specifically, referring to FIG. **13**, the time at which the light-emitting element **71-1** (first light-emitting element) is brought into the unlit state is time T4. The time at which the transmittance of the divided region **82-1** (first divided region) starts to decrease is time T5. Time T5 comes after time T4. In other words, whenever the light-emitting element **71-1** is in the unlit state, the divided region **82-1** is in the non-light-transmitting state. This configuration reduces a plurality of light rays incident on one detection region **810**, thereby further reducing blurring of the image captured by the optical sensor **81**.

Claims

1. A detection device comprising: a light source device comprising a plurality of light-emitting elements arranged in a plane; an object placement member with a light-transmitting property that is disposed overlapping the light source device on a first side in a first direction and on which an object to be detected is placed; an electrochromic shutter that is disposed overlapping the object placement member on the first side in the first direction and has a plurality of divided regions arranged in a plane; and an optical sensor that is disposed overlapping the electrochromic shutter on the first side in the first direction and has a plurality of detection regions arranged in a plane, wherein one of the detection regions includes one or more photodetection elements, the divided regions in the electrochromic shutter are capable of being switched between a light-transmitting state and a non-light-transmitting state for each of the divided regions, and the light-emitting elements are each capable of being switched between a lit state and an unlit state, and the respective light-emitting elements, the respective divided regions of the electrochromic shutter, and the respective detection regions overlap when viewed in the first direction.
2. The detection device according to claim 1, wherein a divided region overlapping a light-emitting element in a lit state when viewed in the first direction out of the divided regions is brought into the light-transmitting state, and a divided region overlapping the light-emitting element in an unlit state when viewed in the first direction is brought into a non-light-transmitting state.
3. The detection device according to claim 2, wherein the light-emitting elements, the divided regions, and the detection regions are arranged in a matrix having a row-column configuration along a second direction intersecting the first direction and a third direction intersecting the first direction and the second direction, and when N is a natural number, the light-emitting elements arranged in an N-th row are sequentially brought into the lit state from a first end in the second direction to a second end, and the divided regions arranged in the N-th row are sequentially brought into the light-transmitting state from the first end in the second direction to the second end, and after the lit state and the light-transmitting state in the N-th row are ended, the light-emitting elements arranged in an N+1-th row are brought into the lit state, and the divided regions arranged in the N+1-th row are brought into the light-transmitting state.
4. The detection device according to claim 3, wherein the light-emitting elements include a first light-emitting element and a second light-emitting element adjacent to the first light-emitting element on the second end side in the second direction with respect to the first light-emitting element, the divided regions include a first divided region overlapping the first light-emitting element when viewed in the first direction and a second divided region overlapping the second light-emitting element when viewed in the first direction, and the first light-emitting element is brought into the unlit state and the first divided region is brought into the non-light-transmitting state before the second light-emitting element is brought into the lit state and the second divided region is brought into the light-transmitting state.
5. The detection device according to claim 4, wherein the transmittance of the first divided region is controlled to start to increase before the first light-emitting element is turned on.
6. The detection device according to claim 4, wherein the first light-emitting element is controlled to be in the lit state when the transmittance of the first divided region is equal to or higher than a predetermined value with respect to a maximum transmittance.
7. The detection device according to claim 4, wherein the transmittance of the first divided region

is controlled to start to decrease after the first light-emitting element is brought into the unlit state.
8. The detection device according to claim 6, wherein the predetermined value is 95%.