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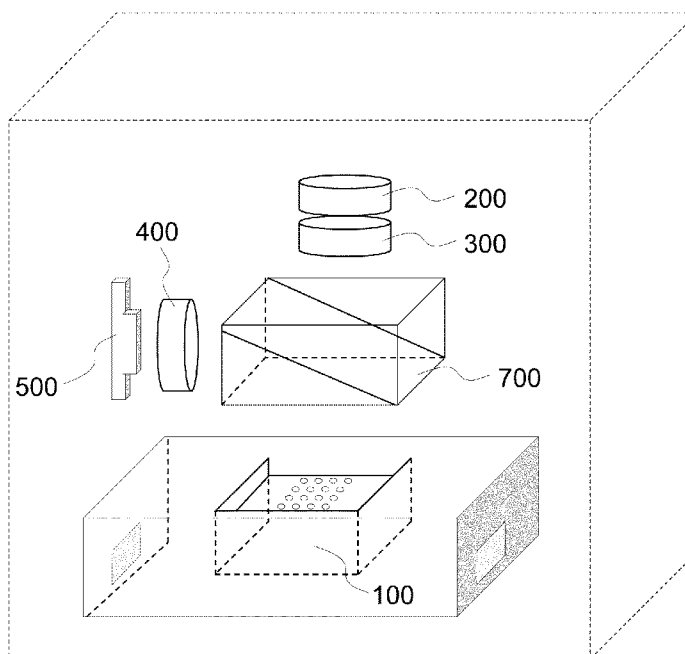
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(54) Title: OPTICAL SIGNAL DETECTION DEVICE FOR DETECTING MULTIPLE OPTICAL SIGNALS FOR MULTIPLE TARGET ANALYTES FROM SAMPLE

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(57) Abstract: The disclosure relates to an optical signal detection device. According to the disclosure, a device includes a sample holder configured to receive a plurality of samples, a light source module radiating excitation light to a plurality of sample areas on the sample holder, a detection module configured to detect emission light, and an excitation light filter module and an emission light filter module each including a dual bandpass filter unit. The device of the disclosure may detect more optical labels than the number of excitation light filter units included in the excitation light filter module using a dual bandpass filter unit. In particular, it is possible to perform detection using the dual bandpass filter which is used for both the excitation light filter module and the emission light filter module without moving the light source by adjusting the wavelength range of light which is transmitted through the dual bandpass filter.

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Description

Title of Invention: OPTICAL SIGNAL DETECTION DEVICE FOR DETECTING MULTIPLE OPTICAL SIGNALS FOR MULTIPLE TARGET ANALYTES FROM SAMPLE

Technical Field

- [1] The disclosure relates to a device for detecting a plurality of optical signals from a sample.

Background Art

- [2] Nucleic acid amplification reaction well known as polynucleotide chain reaction (PCR) includes repeated cycles of double-stranded DNA denaturation, annealing of the oligonucleotide primers to DNA templates, and extension/elongation of the primers with the DNA polymerase (Mullis et al., U.S. Patent Nos. 4,683,195, 4,683,202, and 4,800,159; Saiki et al., (1985) Science 230, 1350-1354). DNA denaturation is performed at about 95 °C and annealing and primer elongation are performed at a lower temperature ranging from 55 °C to 75 °C.
- [3] Real-time PCR is a PCR-based technique for detecting a target nucleic acid from a sample in real-time. To detect a particular target nucleic acid, a signal generator is used which radiates detectable optical signals in proportion to the amount of the target nucleic acid upon PCR. To that end, an intercalator may be used which emits an optical signal when combined with the dual-helix DNA, or oligonucleotides including molecules of an optical label as well as a quencher for suppressing fluorescent emissions therefrom may be used. An optical signal proportional to the amount of the target nucleic acid is detected through real-time PCR for each cycle and is measured to obtain an amplification curve or amplification profile curve which displays the intensity of the optical signal detected per cycle.
- [4] In general, an optical label has a unique excitation wavelength range and emission wavelength range. Two or more signal generating means may be used to detect two or more targets from one sample. The two or more signal generating means respectively emit fluorescent signals of different wavelengths corresponding to the presence of different targets. In order to detect each of a plurality of different optical labels in a sample, excitation light for each optical label have to be sequentially irradiated to the sample.
- [5] The fluorescent material, which is an optical label included in the samples, emits fluorescence, which is an optical signal. The light source emits excitation light to the samples, and the fluorescent material excited by the excitation light emits fluorescence. The light source may emit white light, and a filter may be disposed in the path of the

excitation light to emit a specific wavelength of excitation light to the samples.

- [6] Conventional devices require the same number of filters as the number of detection channels detectable in one sample. For example, in a device for measuring optical signals of four channels, at least 4 optical filters were used in one light emitting module. In the case of nucleic acid detection devices in which the number of filters and light sources that may be disposed on an optical part is limited due to the structure of the optical device, there is a problem in that channels cannot be secured sufficiently with the conventional structure in which one filter forms only one channel.

- [7] Therefore, a need exists for developing a target nucleic acid detection device including a new optical device capable of addressing such issues.

Disclosure of Invention

Technical Problem

- [8] The inventors have tried to develop a new optical detection structure capable of detecting more optical labels than the number of arranged filter units. As a result, the inventors found that it is possible to implement a device capable of detecting more optical labels than the number of arranged filter units by placing a multi-bandpass filter in each of: the excitation light filter module that filters the light from the light source; and the emission light filter module that filters the light from the sample. The inventors also found that it is possible to efficiently perform detection on the samples included in a plurality of sample areas by adjusting the arrangement of the filters of the emission light filter module and the excitation light filter module.
- [9] In light of the background, an object of the disclosure is to provide an optical signal detection device including a dual bandpass filter unit in each of an excitation light filter module and an emission light filter module.
- [10] Another object of the disclosure is to provide a method for detecting a plurality of optical signals from a sample using the optical signal detection device.

Solution to Problem

- [11] According to an embodiment of the disclosure, there is provided an optical signal detection device, comprising a sample holder configured to receive a plurality of samples, the sample holder divided into a plurality of sample areas including a first sample area and a second sample area, each of the sample areas receiving the plurality of samples, and the samples including at least three optical labels, a light source module configured to radiate excitation light to the plurality of sample areas, an excitation light path for each sample area formed between each sample area and the light source module, a detection module configured to detect emission light from the samples from the plurality of sample areas, a light emission path for each sample area formed between each sample area and the detection module, an excitation light filter

module configured to filter light generated from the light source module, the excitation light filter module including a plurality of excitation light filter units for different optical labels, and the excitation light filter module including a dual bandpass excitation light filter unit for a first optical label and a second optical label, and an emission light filter module configured to filter the emission light from the samples, the emission light filter module including a plurality of emission light filter units, each for different optical labels, and the emission light filter module including a dual bandpass emission light filter unit for two optical labels in which a third optical label is included.

- [12] According to an embodiment of the disclosure, there is provided a method for detecting a plurality of optical signal for a plurality of target analysis materials from a sample, comprising positioning the sample on a sample holder of an optical signal detection device, the optical signal detection device including the sample holder configured to receive a plurality of samples, the sample holder divided into a plurality of sample areas including a first sample area and a second sample area, a light source module configured to radiate excitation light to the plurality of sample areas, an excitation light path for each sample area formed between each sample area and the light source module, a detection module configured to detect emission light from the samples from the plurality of sample areas, a light emission path for each sample area formed between each sample area and the detection module, an excitation light filter module configured to filter light generated from the light source module, the excitation light filter module including a plurality of excitation light filter units, and the excitation light filter module including a dual bandpass excitation light filter unit for a first optical label and a second optical label and an excitation light filter unit for a third optical label, and an emission light filter module configured to filter the emission light from the sample, the emission light filter module including a plurality of emission light filter units, each for different optical labels, and the emission light filter module including a dual bandpass emission light filter unit for the second optical label and the third optical label and an emission light filter unit for the first optical label, and the detection module configured to detect light transmitted through the emission light filter module; detecting emission light for the first optical label, from the sample received in the first sample area by: positioning the dual bandpass excitation light filter unit for the first optical label and the second optical label on the excitation light path for the first sample area, positioning the emission light filter unit for the first optical label on the emission light path for the first sample area, and radiating light to the first sample area of the sample holder using the light source module; detecting emission light for the second optical label, from the sample received in the first sample area by: positioning the dual bandpass emission light filter unit for the second optical label and the third

optical label on the emission light path for the first sample area, and radiating light to the first sample area of the sample holder using the light source module; and detecting emission light for the third optical label, from the sample received in the first sample area by: positioning the excitation light filter unit for the third optical label on the excitation light path for the first sample area, and radiating light to the first sample area of the sample holder using the light source module.

Advantageous Effects of Invention

- [13] According to the embodiments of the disclosure, the optical signal detection device may detect more optical labels than the number of excitation light filter units included in the excitation light filter module using a dual bandpass filter unit. In particular, it is possible to perform detection using the dual bandpass filter which is used for both the excitation light filter module and the emission light filter module without moving the light source by adjusting the wavelength range of light which is transmitted through the dual bandpass filter.
- [14] In a device according to an embodiment of the disclosure, since at least two filter units: an excitation light filter unit and an emission light filter unit, may be formed to be positioned in the excitation light path and the emission light path for different sample areas, respectively, a plurality of sample areas may be detected with a common excitation light filter module and emission light filter module.
- [15] If a device according to an embodiment of the disclosure includes a plurality of thermally independent reaction areas, since the thermally independent reaction areas are reacted according to independent protocols, the timings of light detection in the reaction areas are independent from one another. In a device of an embodiment of the disclosure, since the plurality of excitation light filter units and emission light filter units may detect optical signals independently for each sample area, a device that performs an independent reaction protocol for each reaction area may efficiently detect the optical signal in an optimal reaction time.

Brief Description of Drawings

- [16] FIG. 1 is a view illustrating a device for detecting optical signals;
- [17] FIG. 2 is a schematic view illustrating a device including an optical module, an excitation light filter module, an emission light filter module, a detection module, and a sample holder;
- [18] FIG. 3 is a view illustrating a sample holder according to an embodiment;
- [19] FIG. 4 is a view illustrating an excitation light filter module and an emission light filter module according to an embodiment;
- [20] FIG. 5 is a view illustrating a light source module including a plurality of light source units and an excitation light filter module disposed corresponding to excitation light

paths formed between the light source units and sample areas;

[21] FIG. 6 is a view illustrating a relative arrangement of an excitation light filter module and a sample holder according to an embodiment;

[22] FIG. 7 is a view illustrating an example in which a plurality of excitation light filter units move to sequentially filter light radiated to a plurality of sample areas according to an embodiment; and

[23] FIG. 8 is a view illustrating an example in which a plurality of emission light filter units move to sequentially filter light radiated from a plurality of sample areas according to an embodiment.

Mode for the Invention

[24] The configuration and effects of the disclosure are now described in further detail in connection with embodiments thereof. The embodiments are provided merely to specifically describe the disclosure, and it is obvious to one of ordinary skill in the art that the scope of the disclosure is not limited to the embodiments.

[25] Such denotations as "first," "second," "A," "B," "(a)," and "(b)," may be used in describing the components of the disclosure. These denotations are provided merely to distinguish a component from another, and the essence of the components is not limited by the denotations in light of order or sequence. When a component is described as "connected," "coupled," or "linked" to another component, the component may be directly connected or linked to the other component, but it should also be appreciated that other components may be "connected," "coupled," or "linked" between the components.

[26] I. Optical signal detection device including dual bandpass filter

[27] FIGS. 1 and 2 are views for describing an optical signal detection device 10. Referring to FIGS. 1 and 2, an optical signal detection device 10 of the disclosure includes a light source module 200, a sample holder 100, an excitation light filter module 300, an emission light filter module 400, and a detection module 500. The optical signal detection device 10 may further include a beam splitter 700.

[28] The optical signal detection device 10 refers to a device that detects an optical signal generated from a sample. The optical signal may be luminescence, phosphorescence, chemiluminescence, fluorescence, polarized fluorescence, or other colored signal. The optical signal generated from the sample may be, e.g., a fluorescent signal. The optical signal may be an optical signal generated in response to an optical stimulus applied to the sample. The light source module 200 and the excitation light filter module 300 supply an appropriate optical stimulus to the sample, and the detection module 500 detects an optical signal generated from the sample in response to the optical stimulus. The emission light filter module 400 filters the optical signal generated from the

sample and transmits an accurate optical signal to the detection module 500.

- [29] The sample holder 100 positions the sample in a predetermined position so that the optical stimulus reaches the sample and the optical signal generated from the sample reaches the detection module 500. The sample holder 100 may also perform a process for detecting an optical signal from the sample, such as temperature control of the sample, if necessary.
- [30] The optical signal generated from the sample may be, e.g., an optical signal that is generated depending on the properties of the target analyte, such as activity, amount, or presence (or absence). Specifically, the optical signal generated from the sample may be an optical signal that is generated depending on the presence or absence of the target analyte in the sample. The magnitude or change of the optical signal serves as an indicator qualitatively or quantitatively indicating the properties, specifically the presence or absence, of the target analyte. As used herein, the term "target analyte" includes a variety of materials (e.g., biological and non-biological materials), specifically, biological materials, more specifically, materials including nucleic acid molecules (e.g., DNA and RNA), proteins, peptides, carbohydrates, lipids, amino acids, biological compounds, hormones, antibodies, antigens, metabolites, and cells. Most specifically, the target analyte may be a target nucleic acid sequence or a target nucleic acid molecule including the same.
- [31] The detection of an optical signal for the target analyte refers to detecting an optical signal generated by a signal generation reaction to the target analyte. It is possible to qualitatively or quantitatively detect or analyze the target analyte in the sample using a data set obtained through detection of an optical signal for the target analyte. Accordingly, the optical signal detection device of the disclosure may be a target nucleic acid sequence detection device.
- [32] The light source module 200 emits light to excite the optical label included in the sample. The light source module 200 includes a light source unit 210. The light emitted from the light source unit 210 may be denoted as excitation light. The light emitted from the sample may be denoted as emission light. The path of the excitation light from the light source unit 210 may be referred to as an excitation path. The path of the emission light from the sample may be referred to as an emission path. The light source unit 210 may include a light source element 215. One light source unit 210 may include one or more light source elements 215. According to an embodiment, the light source element 215 may be a light emitting diode (LED), including an organic LED, inorganic LED, and quantum dot LED, or a laser unit including a tunable laser, He-Ne laser, or Ar laser. According to an embodiment of the disclosure, the light source element 215 may be an LED.
- [33] The excitation light filter module 300 filters the light emitted from the light source

module so that light of a specific wavelength range reaches the sample. The excitation light filter module 300 includes a plurality of excitation light filter units 310. The excitation light filter unit 310 includes one or more filters.

[34] The emission light filter module 400 filters the light emitted from the sample received in the sample holder 100 so that light of a specific wavelength range reaches the detection module 500. The emission light filter module 400 includes a plurality of emission light filter units. The emission light filter unit includes one or more filters.

[35] The detection module 500 detects signals. Specifically, the detection module 500 detects fluorescence, which is an optical signal generated from samples. The detection module 500 includes a detection unit 510. The detection unit 510 includes a detector that detects light.

[36] The beam splitter 700 reflects and transmits the light incident from the light source unit 210. The light transmitted through the beam splitter 700 reaches the sample holder 100. The beam splitter 700 reflects and transmits the light emitted from the sample. The beam splitter 700 may be configured to allow the light reflected by the beam splitter 700 to reach the detection module 500.

[37] FIG. 2 is a schematic view illustrating a device including an optical module, an excitation light filter module, an emission light filter module, a detection module, and a sample holder. FIG. 3 is a view illustrating a sample holder according to an embodiment.

[38] The sample holder 100 receives a sample. All the substances that are received in the optical signal detection device of the disclosure and are subject to optical signal detection reaction are included in samples of the disclosure.

[39] For example, the samples include biological samples (e.g., cells, tissues, and body fluids) and non-biological samples (e.g., food, water and soil). The biological samples may include, e.g., viruses, bacteria, tissues, cells, blood (whole blood, plasma and serum), lymph, bone marrow, saliva, sputum, swab, aspiration, milk, urine, feces, eye fluid, semen, brain extract, cerebrospinal fluid, joint fluid, thymus fluid, bronchial lavage fluid, ascites and amniotic fluid.

[40] Products or materials obtained by treating or processing the biological sample and the non-biological sample are also included in the samples of the disclosure. Such processed products or materials include, e.g., products or materials obtained by physically or chemically processing the biological sample or non-biological sample, such as heat treatment, ultrasonic treatment, acid or base treatment, so as to expose an active ingredient, such as nucleic acid. Further, not only the biological sample or the non-biological sample but also extracts therefrom may be included in the processed products. For example, when a nucleic acid is separated from a sample and used in a detection reaction, the separated nucleic acid also belongs to the samples of the

disclosure. In this case, the sample may be subjected to a nucleic acid extraction process known in the art (see Sambrook, J. et al., *Molecular Cloning. A Laboratory Manual*, 3rd ed. Cold Spring Harbor Press(2001)). The nucleic acid extraction process may vary depending on the type of sample. Further, when the extracted nucleic acid is RNA, a reverse transcription process for synthesizing cDNA may be additionally performed (see Sambrook, J. et al., *Molecular Cloning. A Laboratory Manual*, 3rd ed. Cold Spring Harbor Press (2001)), and a synthetic product obtained by this process, such as cDNA, is also included in the processed product. Further, clones or products of nucleic acid amplification which are obtained by directly amplifying, e.g., extracted nucleic acid or cDNA obtained therefrom by, e.g., PCR, or by an amplification method that extracts nucleic acid after transforming and cultivating a microorganism are also included in the processed products. Mixtures of an additive for optical signal detection that may be performed in the device of the disclosure and the above-described biological sample, non-biological sample or a processed product thereof are also included in the scope of the sample of the disclosure. The additive includes, but is not limited to, e.g., a reaction solution, a buffer, a stabilizer, an enzyme, a salt, a nucleic acid fragment, dNTP, a detection probe, an optical label, a polymer bead for support or separation, and a resin.

- [41] The sample holder 100 of the disclosure is configured to receive a plurality of samples. According to the disclosure, the plurality of samples are not necessarily limited to a set of samples derived from different sources. Specifically, the plurality of samples are not limited to a plurality of specimens that are distinguished from each other. For example, when various tests are performed in separate tubes using a blood sample collected from one patient, the solution contained in each tube is a separate sample. Alternatively, when nucleic acid is extracted from a blood sample collected from one patient and applied to a plurality of reaction sites that are distinguished from each other, a separate sample is applied to each reaction site.
- [42] As such, the samples applied to the reaction sites in which the optical signal detection reactions distinguished from each other may proceed are separate samples that are distinguished from each other.
- [43] Thus, according to an embodiment of the disclosure, the sample holder 100 may be configured to include a plurality of reaction sites.
- [44] The sample holder 100 is configured to directly receive a plurality of samples or to receive a reaction vessel containing the samples. The reaction vessel of the disclosure includes a reaction vessel capable of containing one sample. The reaction vessel of the disclosure includes a reaction vessel capable of separately containing a plurality of samples. The reaction vessel of the disclosure includes a reaction vessel in which a plurality of distinct nucleic acid probes are fixed, such as a DNA array chip.

- [45] The sample holder 100 may be an electrically conductive material. When the sample holder 100 contacts the reaction vessels, heat may be transferred from the sample holder 100 to the reaction vessels. For example, the sample holder 100 may be formed of a metal, such as aluminum, gold, silver, nickel, or copper. Alternatively, a separate component from the sample holder may directly supply energy to the reaction vessel to control the temperature of the samples in the reaction vessel. In this case, the sample holder 100 may be configured to receive the reaction vessels but not to transfer heat to the reaction vessels.
- [46] An example of the sample holder 100 is a heating block. The heating block may include a plurality of holes, and reaction vessels may be positioned in the holes.
- [47] Another example of the sample holder 100 is a heating plate. The heating plate may be formed of a plate for receiving samples and a thin metal sheet attached to the plate. The heating plate may be operated in such a manner that the plate is heated by applying electric current to the thin metal sheet.
- [48] Another example of the sample holder 100 is a receiving unit capable of receiving one or more chips or cartridges. An example of the cartridge is a fluid cartridge including a flow channel.
- [49] The sample holder 100 is configured to receive a plurality of samples and to adjust the temperature of the plurality of samples to thereby cause a reaction for detection, such as a nucleic acid amplification reaction. For example, when the sample holder 100 is a heating block with a plurality of wells, the sample holder 100 is formed as a single heating block, and all of the wells of the heating block may not be formed to be thermally independent from each other. In this case, the temperatures of all the wells in which samples are received in the sample holder 100 are the same, and the temperature of the received samples cannot be adjusted separately according to different protocols.
- [50] As another example, the sample holder 100 may be configured to control the temperature of some of the samples received in the sample holder according to different protocols. In other words, the sample holder 100 may include two or more thermally independent reaction areas. The reaction areas are thermally independent from each other. No heat is transferred from one reaction area to another. For example, an insulating material or air gap may be present between the reaction areas. The temperature of each reaction area may be controlled independently. A reaction protocol including temperature and time may be set separately for each reaction area. Each reaction area may perform a reaction by an independent protocol. Since reactions are performed in the reaction areas according to independent protocols, the time points of light detection in the reaction areas are independent of each other. According to an embodiment of the disclosure, the plurality of reaction areas that are thermally independent from each other may be formed such that one sample plate may be received over the plurality of

reaction areas. Therefore, the user may perform reactions, with the samples processed by different protocols received in one sample plate.

[51] According to an embodiment of the disclosure, the sample holder of the disclosure is divided into a plurality of sample areas including a first sample area and a second sample area. FIG. 3 is a view illustrating a sample holder and sample areas according to an embodiment.

[52] As illustrated in FIG. 3, the sample holder 100 of the disclosure is divided into a plurality of sample areas 120. In the disclosure, the sample area 120 refers to an area on the sample holder 100 in which samples irradiated with excitation light for optical signal detection reaction by the same excitation light filter unit are located. In the disclosure, the sample area refers to a group of reaction sites irradiated with excitation light by the same excitation light filter unit among the plurality of reaction sites included in the sample holder. In other words, the sample area 120 is an area divided by each excitation light radiation area formed by a plurality of excitation light filter units. FIG. 3A illustrates a sample holder 100 divided into four sample areas 120a to 120d. FIG. 3B illustrates the sample holder of FIG. 3A together with an excitation light filter module 300 which includes a plurality of excitation light filter units 310 supplying excitation light to the sample holder. The excitation light filter module 300 of FIG. 3B includes four excitation light filter units 310a to 310d. The excitation light filtered by the excitation light filter unit 310a is radiated to the first sample area 120a, and the excitation light filtered by the excitation light filter unit 310b is radiated to the second sample area 120b. Even if the excitation light filter unit located in each sample area is changed by the rotation of the excitation light filter module, the excitation light filtered by the same excitation light filter unit is radiated to the samples located in the same sample area. Samples located in different sample areas are irradiated with excitation light filtered by different excitation light filter units. A shielding screen (not shown) may be formed between the sample areas 120 to prevent interference of excitation light between adjacent sample areas. The sample area 120 may be identified as the sample holder itself, as illustrated in FIG. 3C. Alternatively, as illustrated in FIGS. 3A and 3D, the sample area 120 may be a predetermined area on one sample holder that is divided into areas to which excitation light is radiated.

[53] When the sample holder 100 comprises two or more thermally independent reaction areas, rather than being defined over two or more reaction areas, each sample area 120 may be included in one reaction area and defined as a portion of the reaction area or as the same area as the reaction area. When the sample area 120 is defined as described above, two or more reaction areas whose light detection times are independent from each other and which are thermally independent from each other may be subjected to optical signal detection by different light source units and filter units. According to an

embodiment of the disclosure, the sample holder may include two or more reaction areas thermally independent from each other, and each sample area may be defined to be included in any one of the two or more reaction areas thermally independent from each other.

- [54] Although FIG. 3 illustrates an example in which the sample holder 100 is divided into 2, 4 or 6 sample areas, the sample holder and the sample areas of the disclosure are not limited thereto. The sample holder of the disclosure may be a sample holder including, e.g., 2, 3, 4, 5, 6, 8, 10, 12, 16, 20, or 24 sample areas. According to an embodiment of the disclosure, the number of reaction sites 110 included in each of the sample areas 120 may be the same. In other words, the sample areas 120 may have the same number of samples that may be received in each sample area. For example, as illustrated in FIG. 3, each sample area 120 may include 16 reaction sites 110. The number of reaction sites that may be included in each sample area 120, that is, the number of samples that may be received in each sample area, is not particularly limited, and may be, e.g., 2, 3, 4, 5, 6, 7, 8, 9, or more, and may be, e.g., 1000, 900, 800, 700, 600, 500, 400, 384, 300, 200, 100, 96, 48, 32, 24, 16 or less.
- [55] The light source module 200 is configured to radiate excitation light onto the plurality of sample areas 120. The light generated by the light source module 200 is radiated to the sample received in the sample area so that emission light is generated from the optical label included in the sample.
- [56] An excitation light path 610a and 610b for each sample area is formed between each of the sample areas and the light source module. Thus, excitation light is radiated to each of the sample areas through its own unique excitation light path.
- [57] The light source module may include one or more light source units. As illustrated in FIG. 2, the light source module 200 may include a plurality of light source units 210.
- [58] According to an embodiment of the disclosure, the light source module 200 includes a plurality of light source units, and the light source units 210 may be fixed. Specifically, the light source module 200 may include a light source support 220 and a plurality of light source units 210 fixed to the light source support 220.
- [59] The plurality of light source units 210 may be configured to individually radiate light to a plurality of sample areas of the sample holder. According to an embodiment of the disclosure, the light source module 200 includes a plurality of light source units 210, and the plurality of light source units may be configured such that one light source unit 210 may radiate light to one sample area. According to an embodiment, one dedicated individual light source unit may be allocated to each sample area. For example, referring to FIG. 2, the first light source unit 210a may be configured to radiate light to the first sample area 120a but not to radiate light to the other sample areas. The light emitted from the first light source unit 210a is radiated to the first sample area 120a

while the light from the other light source units is not radiated to the first sample area 120a.

- [60] According to an embodiment of the disclosure, the light source module 200 includes a plurality of light source units, and the plurality of light source units 210 may be light source units that emit light having the same wavelength characteristics. This means, e.g., that the plurality of light source units 210 emit light of the same wavelength range, and that the amount of light emitted for each wavelength range is the same. The term "same" here not only means exactly the same but also substantially the same. The term "substantially the same" means that when the light generated from the two light source units is radiated to the same optical label through the same filter, the same type of light is emitted in the same quantity from the optical label. Specifically, when the plurality of light source units have substantially the same wavelength characteristics, this means that the deviation in the amount of light or the wavelength range between the plurality of light source units is within 20%, 15%, or 10%.
- [61] For example, when the first light source unit 210a emits light in a visible light wavelength range, the second light source unit 210b may also be configured to emit light in the visible light wavelength range. As another example, when the first light source unit 210a emits light in a first wavelength range, the second light source unit 210b may also be configured to emit light in the first wavelength range. As another example, when the first light source unit 210a emits light in the first wavelength range and a second wavelength range, the second light source unit 210b may also be configured to emit light in the first wavelength range and the second wavelength range. The first light source unit 210a and the second light source unit 210b may be configured to have the same quantity of light in the first wavelength range and to have the same quantity of light in the second wavelength range.
- [62] According to an embodiment of the disclosure, the light source unit may include one or more light source elements. The number of light source elements included in the light source unit of the disclosure may be, e.g., one. In this case, one light source element may be one light source unit. According to an embodiment of the disclosure, the light source unit may include a plurality of light source elements. In this case, the light source elements may be uniformly arranged. The number of light source elements included in the light source unit of the disclosure is not limited thereto, but may be, e.g., 1000, 500, 100, 50, 40, 30, 20 or less.
- [63] The detection module 500 detects the optical signal emitted from the sample received in the sample holder 100. Referring to FIG. 2, the optical label is excited by the excitation light radiated from the light source module 200 through the excitation light filter module 300 to the sample, and an optical signal is emitted from the excited optical label. The optical signal may be detected by the detection module 500. Ac-

cordingly, emission light paths 620a and 620b for the sample area are formed between each sample area and the detection module 500. Thus, each of the sample areas radiates the emission light to the detection module 500 through its respective emission light path. For example, the emission light path 620 may be refracted by the beam splitter 700 so that the emission light may reach the detection module 500 during the detection process. When the detection module 500 is positioned in a straight emission optical path, the optical signal may be detected even without the use of the beam splitter 700.

- [64] The detection module 500 generates an electric signal according to the intensity of the optical signal to thereby detect the optical signal.
- [65] Like the light source module 200, the detection module 500 may be disposed in a fixed position to maintain an accurate optical path with respect to the sample holder 100. According to an embodiment, the detection module 500 includes a detection unit 510. In an embodiment, the detection module 500 may include a plurality of detection units 510, each of which may include a detector and be disposed to detect the emission light from each sample area.
- [66] According to an embodiment of the disclosure, the detection module 500 includes a plurality of detection units 510, and the detection unit 510 may be fixed. The plurality of detection units 510 may be configured to individually detect the emission light generated from the plurality of sample areas of the sample holder. According to an embodiment of the disclosure, the detection module 500 includes a plurality of detection units 510, and the plurality of detection units 510 may be configured such that one detection unit 510 may detect the light emitted from one sample area. According to an embodiment, one dedicated individual detection unit may be allocated to each sample area. For example, referring to FIG. 2, the first detection unit 510a may be configured to detect the emission light emitted from the first sample area 120a but not to detect the emission light emitted from the other sample areas. The emission light emitted from the first sample area 120a may be detected by the first detection unit 510a, and may not be detected by the other detection units.
- [67] The detection unit 510 may include a detector. The detector is configured to detect the emission light emitted from the optical label included in the sample. The detector may sense the amount of light per wavelength distinctively for light wavelengths or may sense the total amount of light regardless of wavelengths. Specifically, the detector may use, e.g., a photodiode, a photodiode array, a photo multiplier tube (PMT), a charge-coupled device (CCD) image sensor, a complementary metal-oxide-semiconductor (CMOS) image sensor, or an avalanche photodiode (APD).
- [68] The detection unit 510 is configured to detect the emission light emitted from the optical label included in the sample.

- [69] According to an embodiment of the disclosure, the detection unit 510 may be configured to be located in the emission light path 620a or 620b of the emission light generated from the sample holder. Specifically, the detection unit 510 may be formed toward the sample holder 100 so that the emission light generated from the sample may directly reach the detection unit, or the detection unit 510 may be formed toward a reflector or optical fiber so that the emission light may reach the detector. For example, as in the case of FIG. 2, the detection unit 510 may be formed toward the beam splitter 700 which reflects the emission light.
- [70] According to an embodiment of the disclosure, there may be provided a plurality of detection units 510. In this case, the plurality of detection units 510a and 510b each may be configured to detect emission light generated in a predetermined area of the sample holder. Referring to FIG. 2, the first detection unit 510a may be configured to detect the emission light 620a emitted from the first sample area 120a of the sample holder, and the second detection unit 510b may be configured to detect the emission light 620b emitted from the second sample area 120b of the sample holder. According to an embodiment of the disclosure, the device of the disclosure may detect a plurality of signals in the first sample area 120a of the sample holder, or may detect a plurality of signals in the second sample area 120b of the sample holder.
- [71] Although FIG. 2 illustrates that the plurality of detection modules 500 each include a detection unit 510, the device of the disclosure is not limited thereto, and as illustrated in FIG. 8, the plurality of detection units 510 may be formed in one detection module 510 to individually detect the emission light emitted from different sample areas.
- [72] Excitation light filter module including dual bandpass excitation light filter unit
- [73] The light generated from the light source module 200 is filtered by the excitation light filter module 300 and reaches the sample. Accordingly, excitation light filter units 310a and 310b may be positioned on the excitation light paths formed between the light source units 210a and 210b and each sample area.
- [74] FIG. 4 is a view illustrating an excitation light filter module 300 and an emission light filter module according to an embodiment.
- [75] The device of the disclosure includes an excitation light filter module 300. The excitation light filter module 300 filters the light generated from the light source module 200. Filtering or filtration means selectively transmitting or blocking a specific wavelength range of light of the light emitted from the light source unit. Selectively transmitting means transmitting 50%, 60%, 70%, 80%, or 90% or more of the amount of light in the desired wavelength range. Selectively blocking means blocking 50%, 60%, 70%, 80%, or 90% or more of the amount of light in the desired wavelength range.
- [76] The excitation light filter module 300 of the disclosure selectively transmits a

specific wavelength range of light of the light emitted from the light source unit 200 to the sample. Thus, among the optical labels included in the sample, only a specific optical label selectively generates an optical signal. As used herein, the term "optical label" refers to any label capable of emitting a specific wavelength of light when activated by another wavelength of light.

- [77] The optical label may be selected from the group consisting of Cy2™, YO-PRO™-1, YOYO™-1, Calcein, FITC, FluorX™, Alexa™, Rhodamine 110, Oregon Green™ 500, Oregon Green™ 488, RiboGreen™, Rhodamine Green™, Rhodamine 123, Magnesium Green™, Calcium Green™, TO-PRO™-1, TOTO1, JOE, BODIPY530/550, Dil, BODIPY TMR, BODIPY558/568, BODIPY564/570, Cy3™, Alexa™ 546, TRITC, Magnesium Orange™, Phycoerythrin R&B, Rhodamine Phalloidin, Calcium Orange™, Pyronin Y, Rhodamine B, TAMRA, Rhodamine Red™, Cy3.5™, ROX, Calcium Crimson™, Alexa™ 594, Texas Red, Nile Red, YO-PRO™-3, YOYO™-3, R-phycoerythrin, C-Phycocyanin, TO-PRO™-3, TOTO3, DiD DilC(5), Cy5™, Thiacarbocyanine, Cy5.5, HEX, TET, Bioscience Blue, CAL Fluor Gold 540, CAL Fluor Orange 560, CAL Fluor Red 590, CAL Fluor Red 610, CAL Fluor Red 635, FAM, Fluorescein, Fluorescein-C3, Pulsar 650, Quasar 570, Quasar 670, and Quasar 705. In particular, the optical label may be selected from the group consisting of FAM, CAL Fluor Red 610, HEX, Quasar 670, and Quasar 705.
- [78] The excitation light filter module 300 of the disclosure includes a plurality of excitation light filter units 310. FIG. 4A illustrates an excitation light filter module 300 including four excitation light filter units 310a to 310d according to an embodiment. FIG. 4B illustrates an excitation light filter module 300 including two excitation light filter units 310a and 310b according to an embodiment.
- [79] Each excitation light filter unit 310 includes a filter. Each excitation light filter unit 310 includes a filter that may transmit a wavelength range of light capable of exciting at least one of the optical labels. The filter included in the excitation light filter unit 310 of the disclosure may be a bandpass filter. The bandpass filter refers to a filter that selectively transmits a certain wavelength range of light. The wavelength range of light transmitted through the bandpass filter is referred to as the passband of the filter. The passband may be represented in the form of a wavelength range. A filter that transmits light of a specific passband refers to a filter that transmits light of a wavelength included in the specific passband. A filter having one passband is referred to as a single bandpass filter. Therefore, the single bandpass filter selectively transmits a certain wavelength range of light.
- [80] For example, in FIG. 4A, the third excitation light filter unit 310c may be a filter of passband EX-4, and the fourth excitation light filter unit 310d may be a filter of passband EX-5. Specifically, the third excitation light filter unit 310c transmits the

light of passband EX-4, and the fourth excitation light filter unit 310d transmits the light of passband EX-5. Accordingly, the light transmitted through the third excitation light filter unit 310c may excite the fourth optical label, and the light transmitted through the fourth excitation light filter unit 310d may excite the fifth optical label.

[81] In the disclosure, the passband identifier is defined as follows. The letters EX mean excitation light, and the letters EM mean emission light. The letters are followed by an optical label identifier. For example, passband EX-1 is a passband related to the excitation light of the first optical label, and passband EM-1 is a passband related to the emission light of the first optical label. Passband EX-FAM refers to a passband related to the excitation light of FAM, which is an optical label.

[82] Specifically, in the disclosure, passband EX-1 refers to a wavelength range including at least a partial wavelength range of the wavelength range of light capable of exciting the first optical label. More specifically, passband EX-1 may be an excitation wavelength range of the first optical label or a partial wavelength range thereof. The term "excitation wavelength range" refers to a wavelength range of light that excites a specific optical label to emit emission light. Accordingly, in the disclosure, the light transmitted through the filter of passband EX-1 may excite the first optical label.

[83] In the disclosure, passband EM-1 refers to a wavelength range including at least a partial wavelength range of the wavelength range of the emission light emitted from the first optical label. More specifically, passband EM-1 may be an emission wavelength range of the first optical label or a partial wavelength range thereof. In the disclosure, the term "emission wavelength range" refers to a wavelength range of energy or light emitted from a specific optical label. Accordingly, in the disclosure, the filter of passband EM-1 may transmit at least a portion of the emission light emitted from the first optical label.

[84] The specific types of optical labels have been described above. In particular, the optical label may be selected from the group consisting of FAM, CAL Fluor Red 610, HEX, Quasar 670, and Quasar 705. The first excitation light filter unit 310a and the second excitation light filter unit 310b may pass light capable of exciting different optical labels. Accordingly, according to an embodiment of the disclosure, the passbands of the first excitation light filter unit 310a and the second excitation light filter unit 310b may not overlap each other. The excitation light filter units included in the excitation light filter module 300 may be arranged to selectively excite different optical labels. Thus, according to an embodiment of the disclosure, each of the excitation light filter units is an excitation light filter unit for a different optical label.

[85] The excitation light filter unit for the first optical label refers to an excitation light filter unit that passes excitation light capable of exciting the first optical label. Referring to FIG. 4A, the numerals indicating the excitation light filter units 310a,

310b, 310c, and 310d in the drawings of the disclosure are used to identify which optical labels the excitation light filter units are intended for. For example, the second excitation light filter unit 310b of FIG. 4A is an excitation light filter unit for the third optical label, and the third excitation light filter unit 310c is an excitation light filter unit for the fourth optical label. This means that the second excitation light filter unit 310b is a filter unit that passes excitation light capable of exciting the third optical label, and the third excitation light filter unit 310c is a filter unit that passes excitation light capable of exciting the fourth optical label. The first excitation light filter unit 310a refers to a dual bandpass excitation light filter unit that passes both excitation light capable of exciting the first optical label and excitation light capable of exciting the second optical label.

- [86] According to an embodiment of the disclosure, the excitation light filter module of the disclosure includes a dual bandpass excitation light filter unit for the first optical label and the second optical label.
- [87] The dual bandpass excitation light filter unit is a filter unit including a first pass band and a second pass band. A filter having two or more passbands is referred to as a multi-bandpass filter, and a filter having two passbands is referred to as a dual bandpass filter. In other words, the dual bandpass excitation light filter unit selectively passes light of two predetermined wavelength ranges. In this case, the two passbands do not overlap each other.
- [88] The dual bandpass excitation light filter unit for the first optical label and the second optical label may transmit a wavelength range of light capable of exciting the first optical label and a wavelength range of light capable of exciting the second optical label.
- [89] According to an embodiment of the disclosure, the dual bandpass excitation light filter unit for the first optical label and the second optical label may transmit light of a passband EX-1 and a passband EX-2. The passband EX-1 may be a whole or part of an excitation wavelength range of the first optical label, and the passband EX-2 may be a whole or part of an excitation wavelength range of the second optical label. The passband EX-1 may not overlap the passband EX-2. Specifically, the maximum wavelength and the minimum wavelength of the passband EX-1 may be both smaller than the minimum wavelength of the passband EX-2, or both may be greater than the maximum wavelength of the second passband.
- [90] The dual bandpass excitation light filter unit for the first optical label and the second optical label according to the disclosure transmits both excitation light capable of exciting the first optical label and excitation light capable of exciting the second optical label. Accordingly, it is preferable that the excitation light passing through the passband EX-2 of one dual bandpass excitation light filter unit of the disclosure does

not excite the optical label excited by the excitation light passing through the passband EX-1 among the optical labels included in the sample. To this end, the wavelength ranges of the passband EX-1 and the passband EX-2 do not overlap each other, but may be spaced apart from each other. Specifically, the central wavelengths (CWL) of the passband EX-1 and the passband EX-2 may be spaced apart by a predetermined distance. The central wavelength refers to a wavelength corresponding to a mid-point between the minimum wavelength and the maximum wavelength of the corresponding passband. According to an embodiment of the disclosure, the central wavelengths of the passband EX-1 and the passband EX-2 may be spaced apart from each other by 10 nm, 20 nm, 30 nm, 40 nm, 50 nm, 60 nm, 70 nm or more. According to an embodiment of the disclosure, the central wavelengths of the passband EX-1 and the passband EX-2 may be spaced apart from each other in a range from 10 nm to 500 nm, from 20 nm to 400 nm, from 30 nm to 300 nm, from 30 nm to 200 nm, from 50 nm to 200 nm, from 60 nm to 200 nm or from 70 nm to 200 nm.

[91] Among the optical labels used to detect the target nucleic acid, FAM and CAL Fluor Red 610 are particularly suitable for selective excitation through one light source unit because their absorption wavelengths are spaced apart from each other. Therefore, according to an embodiment of the disclosure, the passband EX-1 and the passband EX-2 may include a wavelength range of light capable of exciting CAL Fluor Red 610 and FAM, respectively. Specifically, the passband EX-1 may have a central wavelength ranging from 550 nm to 600 nm, and the passband EX-2 may have a central wavelength ranging from 450 nm to 500 nm.

[92] Emission light filter module including dual bandpass emission light filter unit

[93] The emission light emitted from the sample received in the sample holder passes through the emission light filter module 400 and is detected by the detection module 500. Accordingly, emission light filter units 410a and 410b may be positioned on the emission light paths formed between each of the detection units 510 and the sample areas.

[94] Referring to FIG. 1, the device of the disclosure includes an emission light filter module 400. The emission light filter module 400 is configured to filter the emission light emitted from the sample. The term "filtering" or "filtration" has been described above in connection with the excitation light filter module.

[95] The emission light filter module 400 may be disposed in front of the detection unit 510. The emission light filter module 400 may include emission light filter units, and the emission light filter unit positioned in front of the detection unit 510 may be changed according to the wavelength of the emission light. The emission light filter unit of the emission light filter module is a filter for selectively passing the emission light emitted from the optical label included in the sample. When the detection unit

detects light of a wavelength range other than the emission light emitted from the optical label included in the sample, the optical signal may not be accurately detected. The emission light filter unit of the disclosure enables the target to be accurately detected by selectively passing the emission light emitted from the optical label. The emission light filter module 400 of the disclosure selectively passes a specific wavelength range of light, among the light emitted from the sample received in the sample area, to the detection module. Thus, only the emission light for a specific optical label among the emission light generated from the sample is selectively detected by the detection module.

- [96] Various types of optical labels have been described above. In particular, the optical label may be selected from the group consisting of FAM, CAL Fluor Red 610, HEX, Quasar 670, and Quasar 705. Referring to FIG. 4C, the first emission light filter unit 410a and the second emission light filter unit 410b may selectively pass emission light for different optical labels. Thus, according to an embodiment of the disclosure, the pass bands of the first emission light filter unit 410a and the second emission light filter unit 410b may not overlap each other. The emission light filter units included in the emission light filter module 400 may be arranged to selectively pass the emission light generated from different optical labels. Thus, according to an embodiment of the disclosure, each of the emission light filter units is an emission light filter unit for a different optical label.
- [97] The emission light filter module 400 of the disclosure includes a plurality of emission light filter units 410. FIGS. 4C and 4D illustrate an emission light filter module 400 according to an embodiment.
- [98] Each emission light filter unit 410 includes a filter. Each emission light filter unit 410 includes a filter that passes the emission light emitted from at least one of the optical labels. The filter included in the emission light filter unit 410 of the disclosure may be a bandpass filter. The bandpass filter has been described above.
- [99] For example, in FIG. 4C, the third emission light filter unit 410c may be a filter of passband EM-4, and the fourth emission light filter unit 410d may be a filter of passband EM-5. Specifically, the third emission filter unit 410c passes the light of the passband EM-4, and the fourth emission filter unit 410d passes the light of the passband EM-5. Accordingly, the third emission light filter unit 410c may pass the whole or part of the light emitted from the fourth optical label, and the fourth emission light filter unit 410d may pass the whole or part of the light emitted from the fifth optical label.
- [100] The emission light filter unit for the first optical label refers to an emission light filter unit that passes the emission light generated from the first optical label. Referring to FIG. 4C, the numerals indicating the emission light filter units 410a, 410b, 410c, and

410d in the drawings of the disclosure are used to identify which optical labels the emission light filter units are intended for. For example, the first emission light filter unit 410a of FIG. 4C is an emission light filter unit for the first optical label, and the third emission light filter unit 410c is an emission light filter unit for the fourth optical label. This means that the first emission light filter unit 410a is a filter unit that passes the emission light generated from the first optical label, and the third emission light filter unit 410c is a filter unit that passes the emission light generated from the fourth optical label. The second emission light filter unit 410b is a dual bandpass emission light filter unit that passes both the emission light generated from the second optical label and the emission light generated from the third optical label.

[101] According to an embodiment of the disclosure, the number of the plurality of excitation light filter units and the number of the plurality of emission light filter units may be the same.

[102] According to an embodiment of the disclosure, the emission light filter module of the disclosure includes a dual bandpass emission light filter unit for two optical labels in which the third optical label is included.

[103] The dual bandpass emission light filter unit for two optical labels including the third optical label of the disclosure may pass the whole or part of the emission light generated from the third optical label and the emission light generated from another optical label.

[104] As illustrated in FIG. 4C, the dual bandpass emission light filter unit 410b for two optical labels including the third optical label may be a dual bandpass emission light filter unit for the third optical label and the second optical label. In other words, the dual bandpass excitation light filter unit 310a and one optical label may be in common. Alternatively, as illustrated in FIG. 4D, the dual bandpass emission light filter unit 410c for two optical labels including the third optical label may be a dual bandpass emission light filter unit for the third optical label and the fourth optical label. In other words, the dual bandpass excitation light filter unit and the optical label may not be in common.

[105] Structure of excitation light filter module and arrangement of excitation light filter units

[106] FIG. 5 illustrates a light source module 200 including a plurality of light source units and an excitation light filter module 300 disposed corresponding to excitation light paths 610a and 610b formed between the light source units 210 and sample areas 120. Referring to FIG. 5, the excitation light filter module 300 of the disclosure includes a plurality of excitation light filter units 310a and 310b, and the excitation light filter module 300 is configured such that the excitation light filter units 310a and 310b may move to selectively filter the light emitted from the light source units 210a and 210b.

To this end, the device of the disclosure may include a first filter support 320. The plurality of excitation light filter units 310 may be disposed on the first filter support 320. According to an embodiment, the excitation light filter units 310 are fixed to the first filter support 320, and the first filter support 320 may be configured to be movable. The excitation light filter units 310 fixed to the first filter support 320 are moved by the movement of the first filter support 320. Although FIG. 5 illustrates the first filter support 320 which has a circular shape, the shape of the first filter support 320 is not limited thereto, and may have other various shapes, such as a circle, an ellipse, a quadrilateral, and an octagon. The first filter support 320 may be configured to be movable by a moving means 330. The moving means 330 may be, e.g., a motor.

[107] The moving means 330 may move the first filter support 320 through, e.g., a rotation shaft 340. The movement may be, e.g., rotation about the rotation shaft 340. Two opposite ends of the rotation shaft 340 may be directly connected to the first filter support 320 and the motor 330, respectively, transmitting power. Alternatively, one end of the rotation shaft may be connected to the first filter support 320, and the other end may be indirectly connected to the motor through another power transmission means, such as a gear, belt, or pulley. The position of the moving means is not particularly limited. For example, as illustrated in FIG. 5, when the light source module 200 is positioned between the moving means 330 and the first filter support 320, the light source module 200 may have a through hole 230 through which the rotation shaft 340 pass.

[108] Excitation light paths 610a and 610b for the sample areas are formed between the sample areas 120a and 120b and the light source units 210a and 210b, respectively. The excitation light filter module may be located in the excitation light path to filter the light generated from the light source module.

[109] According to an embodiment of the disclosure, the excitation light filter module may be configured such that at least two among the plurality of excitation light filter units are individually positioned in excitation light paths for different sample areas.

[110] For example, referring to FIG. 2, the excitation light filter module 300 includes a plurality of excitation light filter units including a first excitation light filter unit 310a and a second excitation light filter unit 310b and may be configured such that when the first excitation light filter unit 310a is located in the excitation light path 610a of the first sample area 120a, the second excitation light filter unit 310b is located in the excitation light path 610b of the second sample area 120b. The excitation light path 610a of the first sample area refers to an area through which the light radiated from the light source module and reaching the first sample area 120a passes. In other words, when the first excitation light filter unit 310a is positioned to be able to filter the light radiated from the light source module to the first sample area 120a, the second ex-

citation light filter unit 310b may be positioned to be able to filter the light radiated from the light source module to the second sample area 120b.

[111] According to an embodiment of the disclosure, the plurality of excitation light filter units may be arranged such that the plurality of light source units may radiate light to the sample areas through different excitation light filter units.

[112] FIG. 6 is a view illustrating a relative arrangement of excitation light filter units 310 of an excitation light filter module and sample areas 120 according to an embodiment. The excitation light filter unit 310 positioned on one sample area 120 is positioned in the excitation light path for the corresponding sample area. In FIG. 6, the light source module and the motor are omitted. As one of various structures for the excitation light generated from the light source module (not shown) to pass through the excitation light filter unit 310 to the sample area 120, the excitation light filter unit 310 may be configured to directly face the sample area. In other words, the excitation light filter unit 310 may be located above each sample area 120 of the sample holder.

[113] For example, the device of the disclosure may be configured such that at least two or more of the plurality of excitation light filter units included in the excitation light filter module are positioned in excitation light paths for different sample areas.

[114] FIG. 6A illustrates an example in which an excitation light filter module having four excitation light filter units 310a, 310b, 310c, and 310d filters the excitation light radiated to two sample areas 120a and 120b, which are partial areas of the sample holder including four sample areas. According to the structure of FIG. 6A, at least two of the plurality of excitation light filter units may be configured to be individually positioned in excitation light paths for different sample areas. Further, all of the excitation light filter units 310a to 310d included in the excitation light filter module may be located in the excitation light paths for the two sample areas 120a and 120b by rotating around the rotation shaft 340. FIG. 6B illustrates an example in which an excitation light filter module having four excitation light filter units filters the excitation light radiated to all the sample areas of the sample holder including two sample areas 120a and 120b.

[115] As another example, the device of the disclosure may be configured such that all of the plurality of excitation light filter units included in the excitation light filter module are positioned in excitation light paths for different sample areas.

[116] FIG. 6C illustrates an example in which an excitation light filter module having four excitation light filter units 310a, 310b, 310c, and 310d filters the excitation light radiated to all of the four sample areas 120a, 120b, 120c, and 120d of the sample holder including the four sample areas. FIG. 6D illustrates an example in which an excitation light filter module having two excitation light filter units filters the excitation light radiated to all of the two sample areas of the sample holder including the two

sample areas. According to an embodiment of the disclosure, the excitation light filter module may be configured such that all of the excitation light filter units included in the excitation light filter module are individually positioned in the excitation light paths for different sample areas. As described above, according to an embodiment of the disclosure, the plurality of excitation light filter units are four excitation light filter units, and the excitation light filter module may be configured such that the plurality of excitation light filter units are individually positioned in the excitation light paths for different sample areas.

[117] According to an embodiment of the disclosure, the plurality of excitation light filter units may be arranged in rotational symmetry on the first filter support 320. The rotationally symmetrical arrangement may be a rotationally symmetrical arrangement with respect to the rotational shaft 340. Specifically, the plurality of excitation light filter units may be arranged so that the distance between the rotation shaft 340 of the first filter support and each of the excitation light filter units 310 is the same, and the distances between adjacent excitation light filter units are all the same. This arrangement allows all of the excitation light filter units to be located in the same position when the excitation light filter module rotates around the rotation shaft.

[118] According to an embodiment of the disclosure, the excitation light filter module 300 may be configured to rotate about an axis 340 of the rotational symmetry, and the plurality of excitation light filter units may be arranged to be positioned one by one on the excitation light path for at least one sample area by one rotation of the excitation light filter module in a first direction.

[119] The excitation light filter module 300 according to the embodiment of FIG. 7 is configured to be movable. Specifically, referring to FIG. 7B, the first excitation light filter unit 310a which used to be located in the excitation light path of the first sample area 120a is moved to be located in the excitation light path of the fourth sample area 120d, and the second excitation light filter unit 310b may be positioned in the excitation light path of the first sample area 120a. Subsequently, the third excitation light filter unit 310c and the fourth excitation light filter unit 310d may be sequentially positioned in the excitation light path of the first sample area 120a by the movement of the excitation light filter module. By the movement, all of the excitation light filter units 310a, 310b, 310c, and 310d included in the excitation light filter module 300 may be positioned one-by-one in the excitation light path of the first sample area 120a by one rotation of the excitation light filter module.

[120] The positions of the plurality of excitation light filter units 310 may be simultaneously changed by the rotation of the first filter support 320. According to an embodiment of the disclosure, in the device of the disclosure, the excitation light filter unit 310 for filtering the excitation light path of the sample area may be synchronously

replaced by the movement of the first filter support 320. Thus, all the excitation light filter units included in the excitation light filter module are located on all the sample areas 120 allocated to the excitation light filter module 300, so that light filtered to have a specific wavelength range may be radiated to all the sample areas.

[121] When one excitation light filter module performs filtration on the excitation light paths of two sample areas as illustrated in FIG. 7A, all of the excitation light filter units included in the excitation light filter module may be sequentially positioned on the two sample areas.

[122] FIG. 7B illustrates an embodiment in which one excitation light filter module performs filtration on excitation light paths of four sample areas. By one rotation of the excitation light filter module including the four excitation light filter units, all the excitation light filter units may be sequentially positioned on each of the four sample areas allocated to the excitation light filter module.

[123] As illustrated in FIG. 7B, when the excitation light filter module includes four excitation light filter units 310a, 310b, 310c, and 310d, at least two or more filter units are positioned in the excitation light paths of different sample areas. Specifically, the first excitation light filter unit 310a is disposed on the first sample area 120a, the second excitation light filter unit 310b is disposed on the second sample area 120b, the third excitation light filter unit 310c is disposed on the third sample area 120c, and the fourth excitation light filter unit 310d is disposed on the fourth sample area 120d.

[124] When the first filter support 320 rotates and the excitation light filter units move, the second excitation light filter unit 310b is disposed on the first sample area 120a, the third excitation light filter unit 310b is disposed on the second sample area 120b, the fourth excitation light filter unit 310d is disposed on the third sample area 120c, and the first excitation light filter unit 310a is disposed on the fourth sample area 120d.

[125] When the first filter support 320 rotates again and the excitation light filter units move, the third excitation light filter unit 310c is disposed on the first sample area 120a, the fourth excitation light filter unit 310c is disposed on the second sample area 120b, the first excitation light filter unit 310a is disposed on the third sample area 120c, and the second excitation light filter unit 310b is disposed on the fourth sample area 120d.

[126] When the first filter support 320 rotates again and the excitation light filter units move, the fourth excitation light filter unit 310d is disposed on the first sample area 120a, the first filter unit 310d is disposed on the second sample area 120b, the second excitation light filter unit 310b is disposed on the third sample area 120c, and the third excitation light filter unit 310c is disposed on the fourth sample area 120d.

[127] As such, the excitation light filter unit 310 located in the excitation light path of each sample area 120 may be synchronously replaced by the movement of the first filter

support 320.

[128] For such synchronous replacement of the excitation light filter units 310, according to an embodiment of the disclosure, the first filter support is rotated $360/n$ degrees at a time, where n may be the number of excitation light filter units. In other words, the first filter support 320 includes n excitation light filter units 310, and the first filter support 320 is rotated $360/n$ degrees at a time, where n may be a natural number of 2 or more. As illustrated in FIG. 7A, in an embodiment, the first filter support 320 includes two excitation light filter units 310, and the first filter support 320 may be rotated 180 degrees at a time. In another example, the first filter support 320 includes three excitation light filter units 310, and the first filter support 320 may be rotated 120 degrees at a time. In another example, the first filter support 320 includes four excitation light filter units 310, and the first filter support 320 may be rotated 90 degrees at a time. FIG. 7B illustrates an example in which the first filter support 320 including four excitation light filter units 310 is rotated 90 degrees at a time, so that the excitation light filter unit 310 located on each sample area is synchronously replaced. By this synchronous movement, the excitation light corresponding to the wavelength range of each excitation light filter unit 310 may be sequentially radiated to each of the sample areas.

[129] According to an embodiment of the disclosure, the excitation light filter module includes a dual bandpass excitation light filter unit for the first optical label and the second optical label, an excitation light filter unit for the third optical label, an excitation light filter unit for the fourth optical label, and an excitation light filter unit for the fifth optical label; and the excitation light filter module may be configured such that the plurality of excitation light filter units are individually positioned in the excitation light paths for different sample areas. Referring to FIG. 6C, the four excitation light filter units 310a, 310b, 310c, and 310d included in the excitation light filter module 300 of the disclosure may be configured to be positioned in the excitation light paths for different sample areas. One of the four excitation light filter units is a dual bandpass excitation light filter unit 310a. Thus, five wavelength ranges of excitation light may be radiated to each of the sample areas using the four excitation light filter units.

[130] Although FIG. 4 or 7 illustrates an example in which one excitation light filter module is included, the device of the disclosure is not limited thereto. Referring to FIG. 3D, according to an embodiment of the disclosure, the device of the disclosure includes a sample holder 100 including sample wells 110 or reaction sites arranged in 8×12 , and the sample holder 100 is divided into a total of six sample areas each of which has a 4×4 array of sample wells 110 or reaction sites. The device may include a light source module including six light source units individually disposed on the

sample areas 120. The device may further include two excitation light filter modules including four excitation light filter units to be disposed in the excitation light paths of the six sample areas 120.

[131] Structure of emission light filter module and arrangement of emission light filter units

[132] Referring to FIG. 2, the emission light filter module 400 of the disclosure includes a plurality of emission light filter units 410a and 410b, and the emission light filter module 400 is configured to be movable to selectively filter the light emitted from the sample. To this end, the device of the disclosure may include a second filter support 420. The plurality of emission light filter units 410 may be disposed on the second filter support 420. According to an embodiment, the emission light filter units 410 are fixed to the second filter support 420, and the second filter support 420 may be configured to be movable. The emission light filter units 410 fixed to the second filter support 420 are moved by the movement of the second filter support 420. The second filter support 420 may have various shapes, such as a circle, an ellipse, a quadrilateral, and an octagon. The second filter support 420 may be configured to be movable by a moving means 430. The moving means 430 may be, e.g., a motor. The moving means 430 may move the second filter support 420 through, e.g., a rotation shaft 440. The movement may be, e.g., rotation about the rotation shaft 440. Two opposite ends of the rotation shaft 440 may be directly connected to the second filter support 420 and the motor 430, respectively, transmitting power. Alternatively, one end of the rotation shaft may be connected to the second filter support 420, and the other end may be indirectly connected to the motor through another power transmission means, such as a gear, belt, or pulley.

[133] Emission light paths 620a and 620b for each of the sample areas are formed between each of the sample areas and the detection module. The emission light filter module 400 may be located in the emission light path 620 to filter the light emitted from the sample.

[134] Referring to FIG. 2, the optical label in the sample is excited by the excitation light radiated from the light source unit 210 through the excitation light filter unit 310 to the sample, and an optical signal is emitted from the optical label in the sample. The optical signal may be detected by the detection unit 510 of the detection module 500. In this process, the emission light path 620 may be refracted by, e.g., the beam splitter 700 so that the emission light may reach the detection unit 510.

[135] FIG. 8 is a view illustrating an example in which a plurality of emission light filter units move to sequentially filter light radiated from a plurality of sample areas according to an embodiment. In FIG. 8, the beam splitter for refracting the emission light path 620 and a motor as a moving means for moving the emission light filter

module are omitted. The detection module 500 including the detection unit 510 is representatively illustrated only in step A1 of FIG. 8.

- [136] As illustrated in FIG. 8, according to an embodiment of the disclosure, the emission light filter module may be configured such that at least two of the plurality of emission light filter units 410 are individually positioned in the emission light paths 620a and 620b for different sample areas.
- [137] For example, the emission light filter module includes a plurality of emission light filter units including a first emission light filter unit 410a and a second emission light filter unit 410b, and may be configured such that when the first emission light filter unit 410a is positioned in the emission light path 620a of the first sample area 120a, the second emission light filter unit 410b is positioned in the excitation light path 620b of the second sample area 120b. The emission light path 620a of the first sample area 120a refers to an area through which the light that is emitted from the sample received in the first sample area 120a and reaches the detection unit 510 passes. In other words, when the first emission light filter unit 410a is positioned to be able to filter the light emitted from the first sample area 120a, the second emission light filter unit 410b may be positioned to be able to filter the light emitted from the sample area 120b.
- [138] According to an embodiment of the disclosure, the emission light filter module 400 includes the second filter support 420, and the plurality of emission light filter units 410 may be arranged in rotational symmetry on the second filter support 420. The rotationally symmetrical arrangement may be a rotationally symmetrical arrangement with respect to the rotational shaft. The rotationally symmetrical arrangement has been described above. This arrangement allows all of the emission light filter units to be located in the same position when the emission light filter module rotates around the rotation shaft.
- [139] According to an embodiment of the disclosure, the emission light filter module 400 is configured to rotate around the axis of rotational symmetry, and the plurality of emission light filter units 410 may be arranged to be sequentially positioned in the emission light path 620 for at least one sample area 120 by one rotation of the emission light filter module in a first direction.
- [140] Referring to FIG. 8, the second emission light filter unit 410b may be positioned in the emission light path 620a of the first sample area 120a where the first emission light filter unit 410a used to be positioned, by the movement of the emission light filter module 400. Subsequently, the third emission light filter unit 410c and the fourth emission light filter unit 410d may be sequentially positioned in the emission light path 620a of the first sample area 120a by the movement of the emission light filter module 400. As such, all the excitation light filter units 410 included in the emission light filter module may be sequentially located in the emission light path 620a of the first sample

area 120a by one rotation of the emission light filter module.

- [141] The positions of the plurality of emission light filter units 410 may be simultaneously changed by the rotation of the second filter support 420. According to an embodiment of the disclosure, in the device of the disclosure, the emission light filter unit 410 for filtering the emission light path of the sample area may be synchronously replaced by the movement of the second filter support 420. Thus, all the emission light filter units 410 included in the emission light filter module 400 may be located on all the sample areas 120 allocated to the emission light filter module 400 so that the detection unit 510 may detect the light filtered to have a specific wavelength range.
- [142] FIG. 8 illustrates an embodiment of the disclosure in which one emission light filter module 400 performs filtration on emission light paths 620a and 620b of two sample areas 120a and 120b. By one rotation of the emission light filter module including the four emission light filter units, all of the emission light filter units may be sequentially positioned on each of the two sample areas allocated to the emission light filter module.
- [143] As illustrated in FIG. 8, when the emission light filter module includes four emission light filter units 410a, 410b, 410c, and 410d, at least two or more filter units may be positioned in the emission light paths of different sample areas.
- [144] Specifically, the first emission light filter unit 410a is disposed on the first sample area 120a, and the second emission light filter unit 410b is disposed on the second sample area 120b.
- [145] When the second filter support 420 rotates and the emission light filter units move, the second emission light filter unit 410b is disposed on the first sample area 120a, and the third emission filter unit 410c is disposed on the second sample area 120b.
- [146] When the second filter support 420 rotates again and the emission light filter units move, the third emission light filter unit 410c is disposed on the first sample area 120a, and the fourth emission light filter unit 410d is disposed on the second sample area 120b.
- [147] When the second filter support 420 rotates again and the emission light filter units move, the fourth emission light filter unit 410d is disposed on the first sample area 120a, and the first emission light filter unit 410a is disposed on the second sample area 120b.
- [148] As such, the emission light filter unit 410 located in the emission light path of each sample area 120 may be synchronously replaced by the movement of the second filter support 420.
- [149] For synchronous replacement of the emission light filter units 410, according to an embodiment of the disclosure, the second filter support is rotated $360/n$ degrees at a time, where n may be the number of emission light filter units. In other words, the

second filter support 420 includes n emission light filter units 410, and the second filter support 420 is rotated $360/n$ degrees at a time, where n may be a natural number of 2 or more. In another example, when the second filter support 420 includes two emission light filter units 410, the second filter support 420 may rotate 180 degrees at a time. In another example, when the second filter support 420 includes three emission light filter units 410, the second filter support 420 may rotate 120 degrees at a time. In another example, the second filter support 420 includes four emission light filter units 410, and the second filter support 420 may rotate 90 degrees at a time. FIG. 8 illustrates an example in which the second filter support 420 including four emission light filter units 410 is rotated 90 degrees at a time, so that the emission light filter unit 410 located on each sample area is synchronously replaced. By this synchronous movement, the emission light emitted from the plurality of optical labels included in the sample received in the sample area may be filtered by each emission light filter unit 410 and detected by the detection unit.

[150] Combination of an arrangement of excitation light filter units and an arrangement of emission light filter units

[151] When a specific wavelength range of excitation light is radiated to the sample, a specific optical label is selectively excited to emit a specific wavelength range of emission light. Therefore, to detect an optical signal from the sample, the excitation light filter unit and the emission light filter unit for the same optical label need to be positioned in the respective excitation light path and the emission light path of the same sample area. For example, when the excitation light filter unit for the first optical label is located in the excitation light path of the first sample area, the emission light filter unit for the first optical label needs to be located in the emission light path of the first sample area.

[152] The plurality of emission light filter units may be independently arranged irrespective of the order of arrangement of the excitation light filter units. However, to effectively perform optical signal detection and analysis on the plurality of optical labels, it is preferable that the selection and arrangement of the emission light filter units are determined dependently on the type and arrangement order of the excitation light filter units.

[153] In the device of the disclosure, the arrangement of the filter units needs to be determined considering two points.

[154] First, the excitation light filter module and the emission light filter module of the disclosure each include a dual bandpass filter unit. Specifically, the excitation light filter module of the disclosure includes a dual bandpass excitation light filter unit for the first optical label and the second optical label.

[155] In this case, if the emission light filter module of the disclosure includes a dual

bandpass emission light filter unit for the first optical label and the second optical label, it may not separately detect the optical signal for the first optical label or the second optical label. Accordingly, the dual bandpass filter unit of the emission light filter module may be a filter unit that blocks both the emission light of the first optical label and the emission light of the second optical label, or passes only one of them while blocking the other.

[156] Accordingly, the emission light filter module of the device of the disclosure includes a dual bandpass emission light filter unit for two optical labels including the third optical label.

[157] FIG. 4A illustrates an excitation light filter module 300 according to an embodiment. The excitation light filter unit included in the excitation light filter module of FIG. 4A includes a dual bandpass excitation light filter unit 310a for the first and second optical labels.

[158] An embodiment of an emission light filter module applicable to the excitation light filter module is illustrated in FIGS. 4C and 4D.

[159] FIG. 4C includes a dual bandpass emission light filter unit 410b for the second optical label and the third optical label. When the dual bandpass excitation light filter unit 310a of FIG. 4A is positioned in the excitation light path of a specific sample area, light may reach the sample so that both the first optical label and the second optical label may be excited, and thus, both the first optical label and the second optical label in the sample may emit emission light. In this case, if the excitation light filter unit 410a for the first optical label of FIG. 4C is positioned in the emission light path of the corresponding sample area, the excitation light for the second optical label is blocked, so that selective optical signal detection for the first optical label is possible. By placing the dual bandpass excitation light filter unit 410b for the second optical label and the third optical label of FIG. 4C in the emission light path of the corresponding sample area, the excitation light for the first optical label may be blocked, so that selective optical signal detection for the second optical label is possible.

[160] FIG. 4D illustrates a dual bandpass emission light filter unit 410c for the third optical label and the fourth optical label. Since the emission light filter module of FIG. 4D includes the emission light filter unit 410a for the first optical label and the emission light filter unit 410b for the second optical label, it is possible to separately detect the optical signals for the first optical label and the second optical label.

[161] The excitation light filter module 300 illustrated in FIG. 4A includes four excitation light filter units 310a, 310b, 310c, and 310d, and may be used to detect five types of optical labels. The excitation light filter module illustrated in FIG. 4B includes two excitation light filter units, and may be used to detect three optical labels. As described above, the device of the disclosure may detect optical signals for more optical labels

than the number of excitation light filter units used for one sample area.

[162] Second, the excitation light filter module 300 and the emission light filter module 400 of the disclosure may be configured to simultaneously position the excitation light filter unit 310 and the emission light filter unit 410 in the optical paths of a plurality of sample areas.

[163] As illustrated in FIG. 6, according to the disclosure, the excitation light filter module 300 may be configured such that at least two of the plurality of excitation light filter units 310 are individually positioned in excitation light paths for different sample areas. In this case, a combination of the excitation light filter units located in the excitation light paths of the plurality of sample areas is determined depending on the order of arrangement of the plurality of excitation light filter units.

[164] For example, as illustrated in FIG. 7B, four excitation light filter units 310 may be arranged in the excitation light filter module 300 in rotational symmetry in the order shown in Table 1 below.

[165] [Table 1]

Arrangement order and number	First excitation light filter unit 310a		Second excitation light filter unit 310b	Third excitation light filter unit 310c	Fourth excitation light filter unit 310d
Name	Excitation light filter unit for first optical label and second optical mark		Excitation light filter unit for third optical label	Excitation light filter unit for fourth optical label	Excitation light filter unit for fifth optical label
Filter type	Dual bandpass filter		Single bandpass filter	Single bandpass filter	Single bandpass filter
Optical label in charge	First optical label	Second optical label	Third optical label	Fourth optical label	Fifth optical label

[166] In a case where the excitation light filter units are arranged in the order illustrated in Table 1, for example, when the excitation light filter unit 310b for the third optical label is positioned in the excitation light path of the first sample area 120a as in step B2 of FIG. 7B, the excitation light filter unit 310c for the fourth optical label is positioned in the excitation light path of the second sample area 120b. When the excitation light filter unit 310c for the fourth optical label is positioned in the excitation light path of the first sample area 120a as in step B3 of FIG. 7B, the excitation light

filter unit 310d for the fifth optical label is positioned in the excitation light path of the second sample area 120b.

[167] In the case of the emission light filter module 400 having the configuration as illustrated in FIG. 4C, the plurality of emission light filter units 410 of the emission light filter module may be arranged as shown in Table 2 below.

[168] [Table 2]

Arrangement order and number	First emission light filter unit 410a	Second emission light filter unit 410b		Third emission light filter unit 410c	Fourth emission light filter unit 410d
Name	Emission light filter unit for first optical label	Emission light filter unit for second and third optical labels		Emission light filter unit for fourth optical label	Emission light filter unit for fifth optical label
Filter type	Single bandpass filter	Dual bandpass filter		Single bandpass filter	Single bandpass filter
Optical label in charge	First optical label	Second optical label	Third optical label	Fourth optical label	Fifth optical label

[169] In the case of the emission light filter module 400 having the configuration as illustrated in FIG. 4D, the plurality of emission light filter units 410 of the emission light filter module may be arranged as shown in Table 3 below.

[170] [Table 3]

Arrangement order and number	First emission light filter unit 410a	Second emission light filter unit 410b	Third emission light filter unit 410c		Fourth emission light filter unit 410d
Name	Emission light filter unit for first optical label	Emission light filter unit for second optical label	Emission light filter unit for third and fourth optical labels		Emission light filter unit for fifth optical label
Filter type	Single bandpass filter	Single bandpass filter	Dual bandpass filter		Single bandpass filter
Optical label in charge	First optical label	Second optical label	Third optical label	Fourth optical label	Fifth optical label

[171] The order of arrangement of the filter units described herein is the order of the filter units when they are arranged clockwise from the direction in which light enters the filter module.

[172] It may be identified from comparison between Tables 1, 2, and 3 that the order of the optical labels in the charge of the excitation light filter module and the emission light filter module is the same. As such, when the plurality of emission light filter units have the same arrangement of the optical labels as the excitation light filter units, it is possible to detect the optical signals for all the optical labels in the charge of all the sample areas while the excitation light filter module and the emission light filter module each make one rotation.

[173] Thus, according to an embodiment of the disclosure, the plurality of excitation light filter units for different optical labels may be arranged in the excitation light filter module according to a first order for the optical labels, and the plurality of emission light filter units for different optical labels may be arranged in the emission light filter module according to the first order for the optical labels.

[174] The first order specifies an order in which the plurality of filter units are arranged but does not specify an arrangement direction. In other words, in a case where the filter units of the filter module are arranged in rotational symmetry, if the excitation light filter units are arranged clockwise according to the first order by the nature of rotational symmetry, the emission light filter units may be arranged clockwise or coun-

terclockwise according to the first order. The arrangement direction may be determined depending on an arrangement relationship between the emission light filter module and the sample area.

[175] FIG. 7B stepwise illustrates an example in which the excitation light filter module 300 moves while filtering the excitation light reaching the sample area 120. FIG. 8 stepwise illustrates an example in which the emission light filter module 400 moves while filtering the emission light emitted from the sample area 120. If the optical labels of the first sample area 120a and the second sample area 120b are detected by a combination of the excitation light filter module 300 and the emission light filter module 400 illustrated in FIGS. 7B and 8, five types of optical labels all may be detected in the first sample area 120a and the second sample area 120b by one rotation of the excitation light filter module and the emission light filter module as shown in Table 4.

[176] [Table 4]

Relative movement and detection order	1	2	3	4	5	6
Steps of rotation of excitation light filter module illustrated in FIG. 7B	B1	B1	B2	B3	B4	B4
Steps of rotation of emission light filter module illustrated in FIG. 8	A1	A2	A2	A3	A4	A1
Optical label detected in first sample area 120a	1	2	3	4	5	
Optical label detected in second sample area 120b	3		4	5	1	2

[177] If the arrangement of the excitation light filter units and the arrangement of the emission light filter units are not the same as those described herein, at least one of the excitation light filter module or the emission light filter module needs to be moved by one rotation or more or moved in the opposite direction so as to detect all of the optical labels. Therefore, the time required for detection increases. In particular, when optical signal detection is repeatedly performed several times, such as in a real-time PCR reaction, the overall detection time may significantly increase.

[178] Pass band combination of dual bandpass excitation light filter unit and dual bandpass emission light filter unit

[179] When the excitation light filter module of the device of the disclosure includes a dual bandpass excitation light filter unit for the first optical label and the second optical label, the emission light filter module includes a dual bandpass emission light filter unit for two optical labels including the third optical label. More specifically,

according to an embodiment of the disclosure, the emission light filter module may include a dual bandpass emission light filter unit for the second optical label and the third optical label.

- [180] As described above, when the dual bandpass excitation light filter unit and the dual bandpass emission light filter unit have pass bands of wavelength ranges of excitation light and emission light for one common optical label, an occasion may occur where the two dual bandpass filter units are simultaneously used, as like the combination of step B1 of FIG. 7B and step A2 of FIG. 8. In this case, bandpass adjustment is needed to prevent the generation of an error signal.
- [181] According to an embodiment of the disclosure, the dual bandpass emission light filter unit may be a dual bandpass emission light filter unit for the second optical label and the third optical label and transmit light of a passband EM-2 and a passband EM-3. The passband EM-2 may be a whole or part of an emission wavelength range of the second optical label, and the passband EM-3 may be a whole or part of an emission wavelength range of the third optical label. The passband EM-2 may not overlap the passband EM-3, and the passband EM-2 and the passband EM-3 may not overlap the passband EX-1 and the passband EX-2, respectively.
- [182] The dual bandpass emission light filter unit of the disclosure passes all of the emission light generated from two optical labels including the third optical label. To selectively detect the optical label, it is preferable that the passband EM-3 for detecting the emission light emitted from the third optical label does not pass the emission light emitted from the other optical label (e.g., the second optical mark). It is also preferable that the passband EM-2 for detecting the emission light generated from the second optical label does not pass the emission light generated from the third optical label.
- [183] To this end, the wavelength ranges of the passband EM-3 and the passband EM-2 do not overlap each other, but may be spaced apart from each other. Specifically, the central wavelengths (CWL) of the passband EM-3 and the passband EM-2 may be spaced apart by a predetermined distance. According to an embodiment of the disclosure, the central wavelengths of the passband EM-3 and the passband EM-2 may be spaced apart from each other by 10 nm, 20 nm, 30 nm, 40 nm, 50 nm, 60 nm, 70 nm or more. According to an embodiment of the disclosure, the central wavelengths of the passband EM-3 and the passband EM-2 may be spaced apart from each other in a range from 10 nm to 500 nm, from 20 nm to 400 nm, from 30 nm to 300 nm, from 30 nm to 200 nm, from 50 nm to 200 nm, from 60 nm to 200 nm or from 70 nm to 200 nm.
- [184] Further, the light passing through the emission light filter unit is detected by the detection module. In this case, the excitation light radiated to the sample to excite the optical label may be reflected and reach the emission light filter unit through the

emission light path. In this case, it is preferable that the emission light filter unit is configured not to pass the excitation light of the corresponding optical label. As in the above example, when the second optical label is detected with the dual bandpass excitation light filter unit for the first and second optical labels positioned in the excitation light path, and the dual bandpass emission light filter unit for the second and third optical labels positioned in the emission light path, the dual bandpass emission light filter unit may be configured to block the light passing through the bandpass EX-1 or the bandpass EX-2. Accordingly, the passband EM-2 and the passband EM-3 may not overlap the passband EX-1 and the passband EX-2, respectively.

[185] Among the optical labels used to detect the target nucleic acid, FAM and CAL Fluor Red 610 are particularly suitable for selective excitation through one light source unit because their absorption wavelengths are spaced apart from each other. Therefore, according to an embodiment of the disclosure, the passband EX-1 and the passband EX-2 of the dual bandpass excitation light filter unit may include a wavelength range of light capable of exciting CAL Fluor Red 610 and FAM, respectively. The dual bandpass emission light filter unit of the disclosure may be a dual bandpass emission light filter unit for two optical labels including FAM. More specifically, the dual bandpass emission light filter unit of the disclosure may be a dual bandpass emission light filter unit for FAM and Quasar 705. The passband EM-2 and passband EM-3 of the dual bandpass emission light filter unit of the disclosure may include wavelength ranges of emission light of FAM and Quasar 705, respectively. The passband EM-2 and passband EM-3 may not overlap the passband EX-1 and passband EX-2, respectively.

[186] If the filter unit is configured to meet the passband limitations as described above, it is possible to perform normal detection without generating an error signal even in the step of detecting the optical signal using the dual bandpass excitation light filter unit and the dual bandpass emission light filter unit simultaneously.

[187] According to an embodiment of the disclosure, in the device, the excitation light filter module may include the dual bandpass excitation light filter unit for the first optical label and the second optical label, an excitation light filter unit for the third optical label, an excitation light filter unit for a fourth optical label, and an excitation light filter unit for a fifth optical label.

[188] The excitation light filter module may include a first filter support. The plurality of excitation light filter units may be arranged on the first filter support in rotational symmetry in an order of: the dual bandpass excitation light filter unit for the first optical label and the second optical label, the excitation light filter unit for the third optical label, the excitation light filter unit for the fourth optical label, and the excitation light filter unit for the fifth optical label.

- [189] The excitation light filter module may be configured such that the four excitation light filter units are positioned on excitation light paths for different sample areas.
- [190] The emission light filter module may include a second filter support. The plurality of emission light filter units may be arranged on the second filter support based on the optical labels in the same order as the excitation light filter units.
- [191] The excitation light filter module and the emission light filter module may be configured to be synchronously rotated so that an excitation light filter unit and an emission light filter unit for the same optical label are positioned on an excitation light path and an emission light path, respectively, for the first sample area or the second sample area.
- [192] According to an embodiment of the disclosure, the device of the disclosure may include a sample holder including 8 X 12 wells, as illustrated in FIG. 3D, and the sample holder may be divided into six sample areas each of which includes 4 X 4 wells. The device of the disclosure may include a light source module including six light source units configured to individually radiate excitation light to the sample areas. An excitation light path for each sample area may be formed between each sample area and the light source module. The device of the disclosure may include a first excitation light filter module for filtering excitation light radiated to four sample areas among the six sample areas and a second excitation light filter module for filtering excitation light radiated to the remaining two sample areas. The first excitation light filter module may include four filter units including a dual bandpass excitation light filter unit, and the second excitation light filter module may have the same filter unit configuration as the first excitation light filter module. The first excitation light filter module may filter the excitation light radiated to four sample areas to excite the target optical label, and the second excitation light filter module may filter the excitation light radiated to the remaining two sample areas to excite the target optical label.
- [193] According to an embodiment of the disclosure, to detect the emission light generated from the six sample areas, the device may include three emission light filter modules and three detection modules. Each of the three emission light filter modules may include four emission light filter units including a dual bandpass emission light filter unit, and the three emission light filter modules have the same filter unit configuration. The three emission light filter modules and the three detection modules each may filter and detect the emission light emitted from two sample areas.
- [194] Controller
- [195] According to an embodiment of the disclosure, the device of the disclosure includes a controller configured to position an excitation light filter unit and an emission light filter unit for the same optical label on an excitation light path and an emission light path, respectively, for the same sample area.

- [196] The optical signal detection device of the disclosure may include a controller. The controller may be one or more controllers electrically connected to the sample holder, the light source module, the excitation light filter module, the emission light filter module, and the optical module. The controller may be, e.g., a computer, a micro-processor, or a programmable logic device.
- [197] The controller adjusts the temperature of the sample holder. The controller independently adjusts the temperature of each of two or more reaction areas that are thermally independent of each other included in the sample holder. Specifically, the controller receives each protocol for the sample located in each reaction area and adjusts the temperature of each reaction area according to the protocol for each reaction area.
- [198] The controller is configured to independently adjust the measurement of optical signal of the sample located in each sample area. Specifically, the controller may supply current to the light source unit to radiate a wavelength range of light, which is capable of generating an optical signal from the sample in the first sample area, to the first sample area. The controller may supply current to the moving means of the excitation light filter module and the emission light filter module, allowing the excitation light filter unit and the emission light filter unit for the optical label, which is the detection target, to be positioned in the excitation light path and the emission light path for the same sample area. The controller may apply power to the detection module to measure an optical signal.
- [199] **II. Optical signal detection method using dual bandpass filter**
- [200] According to the disclosure, there is provided a method for detecting a plurality of optical signal for a plurality of target analysis materials from a sample. The method may include the steps of:
- [201] (a) positioning the sample on a sample holder of an optical signal detection device, the optical signal detection device including:
- [202] the sample holder configured to receive a plurality of samples, the sample holder divided into a plurality of sample areas including a first sample area and a second sample area, a light source module configured to radiate excitation light to the plurality of sample areas, an excitation light path for each sample area formed between each sample area and the light source module, a detection module configured to detect emission light from the samples from the plurality of sample areas, a light emission path for each sample area formed between each sample area and the detection module, an excitation light filter module configured to filter light generated from the light source module, the excitation light filter module including a plurality of excitation light filter units, and the excitation light filter module including a dual bandpass excitation light filter unit for a first optical label and a second optical label and an ex-

citation light filter unit for a third optical label, and an emission light filter module configured to filter the emission light from the sample, the emission light filter module including a plurality of emission light filter units, each for different optical labels, and the emission light filter module including a dual bandpass emission light filter unit for the second optical label and the third optical label and an emission light filter unit for the first optical label, and the detection module configured to detect light transmitted through the emission light filter module;

[203] (b) detecting emission light for the first optical label, from the sample received in the first sample area by: positioning the dual bandpass excitation light filter unit for the first optical label and the second optical label on the excitation light path for the first sample area, positioning the emission light filter unit for the first optical label on the emission light path for the first sample area, and radiating light to the first sample area of the sample holder using the light source module;

[204] (c) detecting emission light for the second optical label, from the sample received in the first sample area by: positioning the dual bandpass emission light filter unit for the second optical label and the third optical label on the emission light path for the first sample area and radiating light to the first sample area of the sample holder using the light source module; and

[205] (d) detecting emission light for the third optical label, from the sample received in the first sample area by: positioning the excitation light filter unit for the third optical label on the excitation light path for the first sample area and radiating light to the first sample area of the sample holder using the light source module.

[206] The method of the disclosure is a method for detecting a plurality of optical signals for a plurality of target analytes from a sample.

[207] The method of the disclosure includes (a) positioning a sample in a sample holder of an optical signal detection device. The optical signal detection device is an optical signal detection device provided according to the disclosure. The optical signal detection device has been described above.

[208] The sample may be a sample including a plurality of optical labels. Specifically, the sample may be a sample including a first optical label, a second optical label, and a third optical label. Each of the optical labels is activated by excitation light for the optical label when a specific target analyte is present in the sample, and emits a specific wavelength of emission light.

[209] The method of the disclosure includes the step of sequentially radiating light capable of activating the first optical label, the second optical label, and the third optical label to thereby detect whether the optical label generates emission light.

[210] First, in step (b), a dual bandpass excitation light filter unit for the first optical label and the second optical label is positioned in the excitation light path for the first

sample area, and the emission light filter unit for the first optical label is positioned in the emission light path for the first sample area (see step B1 of FIG. 7B and step A1 of FIG. 8). The light source module is used to radiate light to the first sample area of the sample holder, and the emission light for the first optical label, emitted from the sample received in the first sample area, is detected. Thus, the optical signal for the target analyte reacting with the first optical label is detected.

[211] The detection may be performed by the detection module of the device of the disclosure.

[212] Since the dual bandpass excitation light filter unit for the first optical label and the second optical label also passes the excitation light for the second optical label, the excitation light for the second optical label may also be radiated to the sample but, since the emission light emitted from the second optical label cannot pass through the emission light filter unit for the first optical label, it is not detected in step (b).

[213] Next, in step (c), to detect the emission light of the second optical label, the dual bandpass emission light filter unit for the second optical label and the third optical label is positioned in the emission light path for the first sample area (see step B1 of FIG. 7B and step A2 of FIG. 8). The light source module is used to radiate light to the first sample area of the sample holder, and the emission light for the second optical label, emitted from the sample received in the first sample area, is detected. Thus, the optical signal for the target analyte reacting with the second optical label is detected.

[214] Since the dual bandpass excitation light filter unit for the first optical label and the second optical label also passes the excitation light for the first optical label, the excitation light for the first optical label may also be radiated to the sample but, since the emission light emitted from the first optical label cannot pass through the dual bandpass emission light filter unit for the second optical label and the third optical label, it is not detected in step (c).

[215] Next, in step (d), to detect the emission light of the third optical label, the excitation light filter unit for the third optical label is positioned in the excitation light path for the first sample area (see step B2 of FIG. 7B and step A2 of FIG. 8). The light source module is used to radiate light to the first sample area of the sample holder, and the emission light for the third optical label, emitted from the sample received in the first sample area, is detected. Thus, the optical signal for the target analyte reacting with the third optical label is detected.

[216] The method of the disclosure may further include the steps of positioning an excitation light filter unit for a fourth optical label in the excitation light path for the first sample area, positioning an emission light filter unit for the fourth optical label in the emission light path for the first sample area, radiating light to the first sample area of the sample holder using the light source module, and detecting emission light for the

fourth optical label, emitted from the sample received in the first sample area (see step B3 of FIG. 7B and step A3 of FIG. 8).

[217] The method of the disclosure may further include the steps of positioning an excitation light filter unit for a fifth optical label in the excitation light path for the first sample area, positioning an emission light filter unit for the fifth optical label in the emission light path for the first sample area, radiating light to the first sample area of the sample holder using the light source module, and detecting emission light for the fifth optical label, emitted from the sample received in the first sample area (see step B4 of FIG. 7B and step A4 of FIG. 8).

[218] The method of the disclosure may further include the step of detecting the emission light for each optical label in the second sample area in parallel with the step of detecting the emission light for each optical label in the first sample area. Referring to step B1 of FIG. 7 and step A1 of FIG. 8, the method may further include the step of detecting emission light for the third optical label emitted from the sample received in the second sample area by: positioning an excitation light filter unit for the third optical label and a dual bandpass emission light filter unit for the second optical label and the third optical label in the excitation light path and the emission light path of the second sample area, respectively, and radiating light to the second sample area of the sample holder using the light source module, in parallel with detecting the emission light for the first optical label in the first sample area in step (b).

[219] According to the method of the disclosure, it is possible to detect optical signals for a larger number of target analytes than the number of excitation light filter units.

[220] The method of the disclosure may be applied even where the first sample area and the second sample area are individually located in two reaction areas that are thermally independent from each other. Accordingly, the method of the disclosure may simultaneously detect optical signals for a plurality of samples by different protocols.

[221] When an element "comprises," "includes," or "has" another element, the element may further include, but rather than excluding, the other element, and the terms "comprise," "include," and "have" should be appreciated as not excluding the possibility of presence or adding one or more features, numbers, steps, operations, elements, parts, or combinations thereof. All the scientific and technical terms as used herein may be the same in meaning as those commonly appreciated by a skilled artisan in the art unless defined otherwise. It will be further understood that terms, such as those defined in dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[222] The above-described embodiments are merely examples, and it will be appreciated by one of ordinary skill in the art various changes may be made thereto without

departing from the scope of the disclosure. Accordingly, the embodiments set forth herein are provided for illustrative purposes, but not to limit the scope of the disclosure, and should be appreciated that the scope of the disclosure is not limited by the embodiments. The scope of the disclosure should be construed by the following claims, and all technical spirits within equivalents thereof should be interpreted to belong to the scope of the disclosure.

[223] While embodiments of the disclosure have been described above, it will be easily appreciated by one of ordinary skill in the art that the perform is not limited thereto. Thus, the scope of the invention is defined by the appended claims and equivalents thereof.

[224] **[CROSS-REFERENCE TO RELATED APPLICATIONS]**

[225] This application claims priority from Korean Patent Application No. 10-2020-0067206, filed on June 03, 2020, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference in its entirety.

Claims

- [Claim 1] An optical signal detection device, comprising:
a sample holder configured to receive a plurality of samples, the sample holder divided into a plurality of sample areas comprising a first sample area and a second sample area, each of the sample areas receiving the plurality of samples, and the samples comprising at least three optical labels;
a light source module configured to radiate excitation light to the plurality of sample areas, an excitation light path for each sample area formed between each sample area and the light source module;
a detection module configured to detect emission light from the samples from the plurality of sample areas, a light emission path for each sample area formed between each sample area and the detection module;
an excitation light filter module configured to filter light generated from the light source module, the excitation light filter module comprising a plurality of excitation light filter units, each for different optical labels, and the excitation light filter module comprising a dual bandpass excitation light filter unit for a first optical label and a second optical label; and
an emission light filter module configured to filter the emission light from the samples, the emission light filter module comprising a plurality of emission light filter units, each for different optical labels, and the emission light filter module comprising a dual bandpass emission light filter unit for two optical labels in which a third optical label is comprised.
- [Claim 2] The optical signal detection device of claim 1, wherein the excitation light filter module is configured such that at least two of the plurality of excitation light filter units are separately positioned on excitation light paths for different sample areas.
- [Claim 3] The optical signal detection device of claim 1, wherein the emission light filter module is configured such that at least two of the plurality of emission light filter units are separately positioned on emission light paths for different sample areas.
- [Claim 4] The optical signal detection device of claim 1, wherein the excitation light filter module comprises a first filter support, and wherein the plurality of excitation light filter units are arranged in rotational

symmetry on the first filter support.

[Claim 5] The optical signal detection device of claim 4, wherein the excitation light filter module is configured to rotate about an axis of the rotational symmetry, and wherein the plurality of excitation light filter units are arranged to be positioned one by one on the excitation light path for at least one sample area by one rotation of the excitation light filter module in a first direction.

[Claim 6] The optical signal detection device of claim 1, wherein the emission light filter module comprises a second filter support, and wherein the plurality of emission light filter units are arranged in rotational symmetry of the second filter support.

[Claim 7] The optical signal detection device of claim 6, wherein the emission light filter module is configured to rotate about an axis of the rotational symmetry, and wherein the plurality of emission light filter units are arranged to be positioned one by one on the emission light path for at least one sample area by one rotation of the emission light filter module in a first direction.

[Claim 8] The optical signal detection device of claim 1, wherein the plurality of excitation light filter units, each for different optical labels are arranged in the excitation light filter module according to a first order for the optical labels, and the plurality of emission light filter units, each for different optical labels are arranged in the emission light filter module according to the first order for the optical labels.

[Claim 9] The optical signal detection device of claim 1, wherein the number of the plurality of excitation light filter units is the same as the number of the plurality of emission light filter units.

[Claim 10] The optical signal detection device of claim 1, further comprising a controller configured to position an excitation light filter unit and an emission light filter unit for the same optical label on an excitation light path and an emission light path, respectively, for the same sample area.

[Claim 11] The optical signal detection device of claim 1, wherein the emission light filter module comprises a dual bandpass emission light filter unit for the second optical label and the third optical label.

[Claim 12] The optical signal detection device of claim 1, wherein the dual bandpass excitation light filter unit for the first optical label and the second optical label transmits light of a passband EX-1 and a passband EX-2, wherein the passband EX-1 is a whole or part of an excitation wavelength range of the first optical label, and the passband EX-2 is a

whole or part of an excitation wavelength range of the second optical label, and wherein the passband EX-1 does not overlap the passband EX-2.

- [Claim 13] The optical signal detection device of claim 12, wherein the dual bandpass emission light filter unit is a dual bandpass emission light filter unit for the second optical label and the third optical label and transmits light of a passband EM-2 and a passband EM-3, wherein the passband EM-2 is a whole or part of an emission wavelength range of the second optical label, and the passband EM-3 is a whole or part of an emission wavelength range of the third optical label, wherein the passband EM-2 does not overlap the passband EM-3, and wherein the passband EM-2 and the passband EM-3 do not overlap the passband EX-1 and the passband EX-2, respectively.
- [Claim 14] The optical signal detection device of claim 1, wherein the sample holder comprises two or more reaction areas thermally independent from each other, and wherein each sample area is defined to be comprised in any one of the two or more reaction areas thermally independent from each other.
- [Claim 15] The optical signal detection device of claim 1, wherein the light source module comprises a plurality of light source units emitting light having the same wavelength characteristic.
- [Claim 16] The optical signal detection device of claim 5, wherein the first filter support rotates $360/n$ degrees at a time, and wherein n is the number of the excitation light filter units.
- [Claim 17] The optical signal detection device of claim 7, wherein the second filter support rotates $360/n$ degrees at a time, and wherein n is the number of emission light filter units.
- [Claim 18] The optical signal detection device of claim 1, wherein the plurality of excitation light filter units are four excitation light filter units, and wherein the excitation light filter module is configured such that the plurality of excitation light filter units are separately positioned on excitation light paths for different sample areas.
- [Claim 19] The optical signal detection device of claim 1, wherein the excitation light filter module comprises the dual bandpass excitation light filter unit for the first optical label and the second optical label, an excitation light filter unit for the third optical label, an excitation light filter unit for a fourth optical label, and an excitation light filter unit for a fifth optical label, wherein

the excitation light filter module comprises a first filter support, wherein the plurality of excitation light filter units are arranged on the first filter support in rotational symmetry in an order of the dual bandpass excitation light filter unit for the first optical label and the second optical label, the excitation light filter unit for the third optical label, the excitation light filter unit for the fourth optical label, and the excitation light filter unit for the fifth optical label, wherein the excitation light filter module is configured such that each of the four excitation light filter units are positioned on excitation light paths for different sample areas, wherein the emission light filter module comprises a second filter support, wherein the plurality of emission light filter units are arranged on the second filter support in the same order as the excitation light filter units, and wherein the excitation light filter module and the emission light filter module are configured to be synchronously rotated so that an excitation light filter unit and an emission light filter unit for the same optical label are positioned on an excitation light path and an emission light path, respectively, for the first sample area or the second sample area.

[Claim 20]

A method for detecting a plurality of optical signal for a plurality of target analysis materials from a sample, the method comprising: positioning the sample on a sample holder of an optical signal detection device, the optical signal detection device comprising: the sample holder configured to receive a plurality of samples, the sample holder divided into a plurality of sample areas comprising a first sample area and a second sample area, a light source module configured to radiate excitation light to the plurality of sample areas, an excitation light path for each sample area formed between each sample area and the light source module, a detection module configured to detect emission light from the samples from the plurality of sample areas, a light emission path for each sample area formed between each sample area and the detection module, an excitation light filter module configured to filter light generated from the light source module, the excitation light filter module comprising a plurality of excitation light filter units, and the excitation light filter module comprising a dual bandpass excitation light filter unit for a first optical label and a second optical label and an excitation light filter unit for a third optical label, and an emission light filter module configured to filter the emission

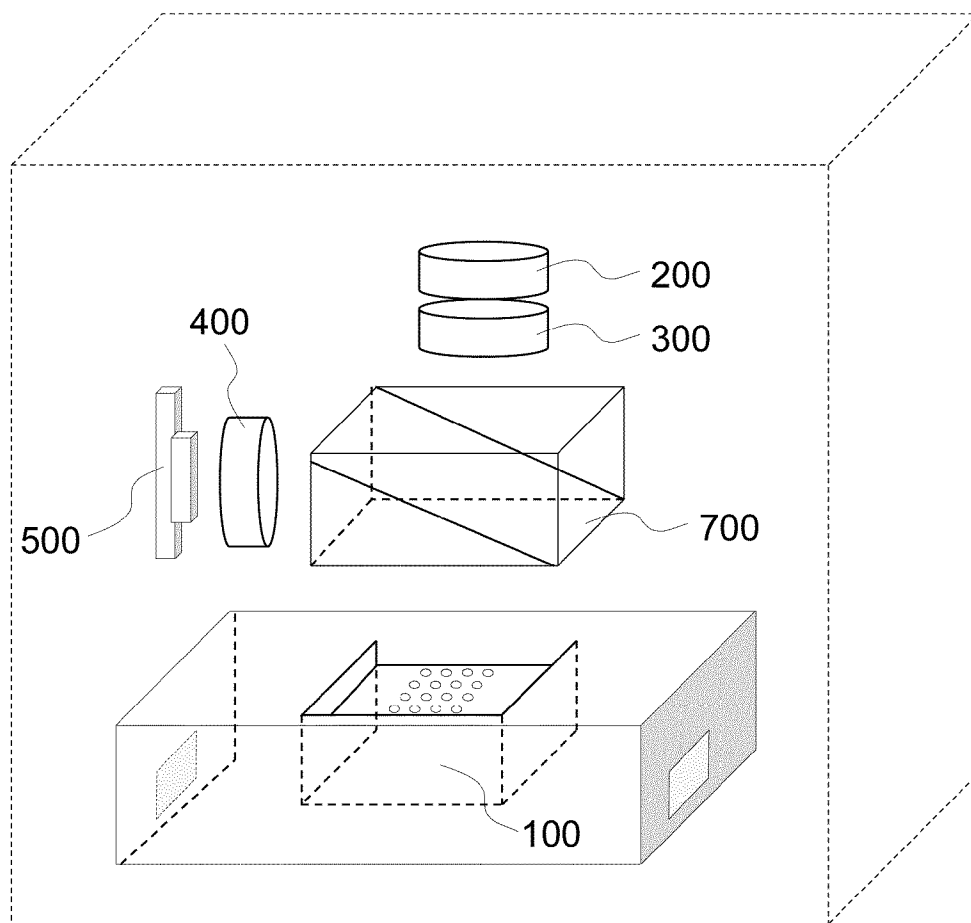
light from the sample, the emission light filter module comprising a plurality of emission light filter units, each for different optical labels, and the emission light filter module comprising a dual bandpass emission light filter unit for the second optical label and the third optical label and an emission light filter unit for the first optical label, and the detection module configured to detect light transmitted through the emission light filter module;

detecting emission light for the first optical label, from the sample received in the first sample area by: positioning the dual bandpass excitation light filter unit for the first optical label and the second optical label on the excitation light path for the first sample area, positioning the emission light filter unit for the first optical label on the emission light path for the first sample area, and radiating light to the first sample area of the sample holder using the light source module;

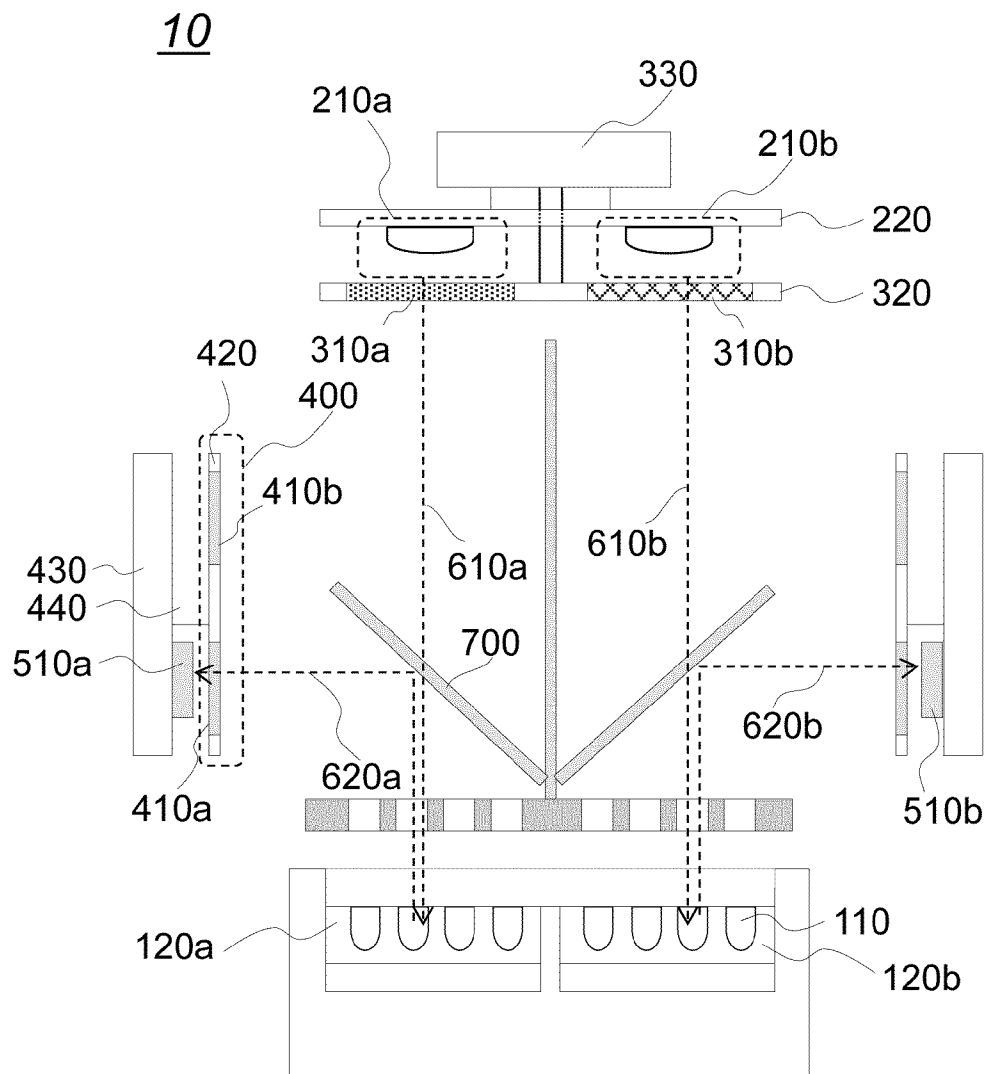
detecting emission light for the second optical label, from the sample received in the first sample area by: positioning the dual bandpass emission light filter unit for the second optical label and the third optical label on the emission light path for the first sample area, and radiating light to the first sample area of the sample holder using the light source module; and

detecting emission light for the third optical label, from the sample received in the first sample area by: positioning the excitation light filter unit for the third optical label on the excitation light path for the first sample area, and radiating light to the first sample area of the sample holder using the light source module.

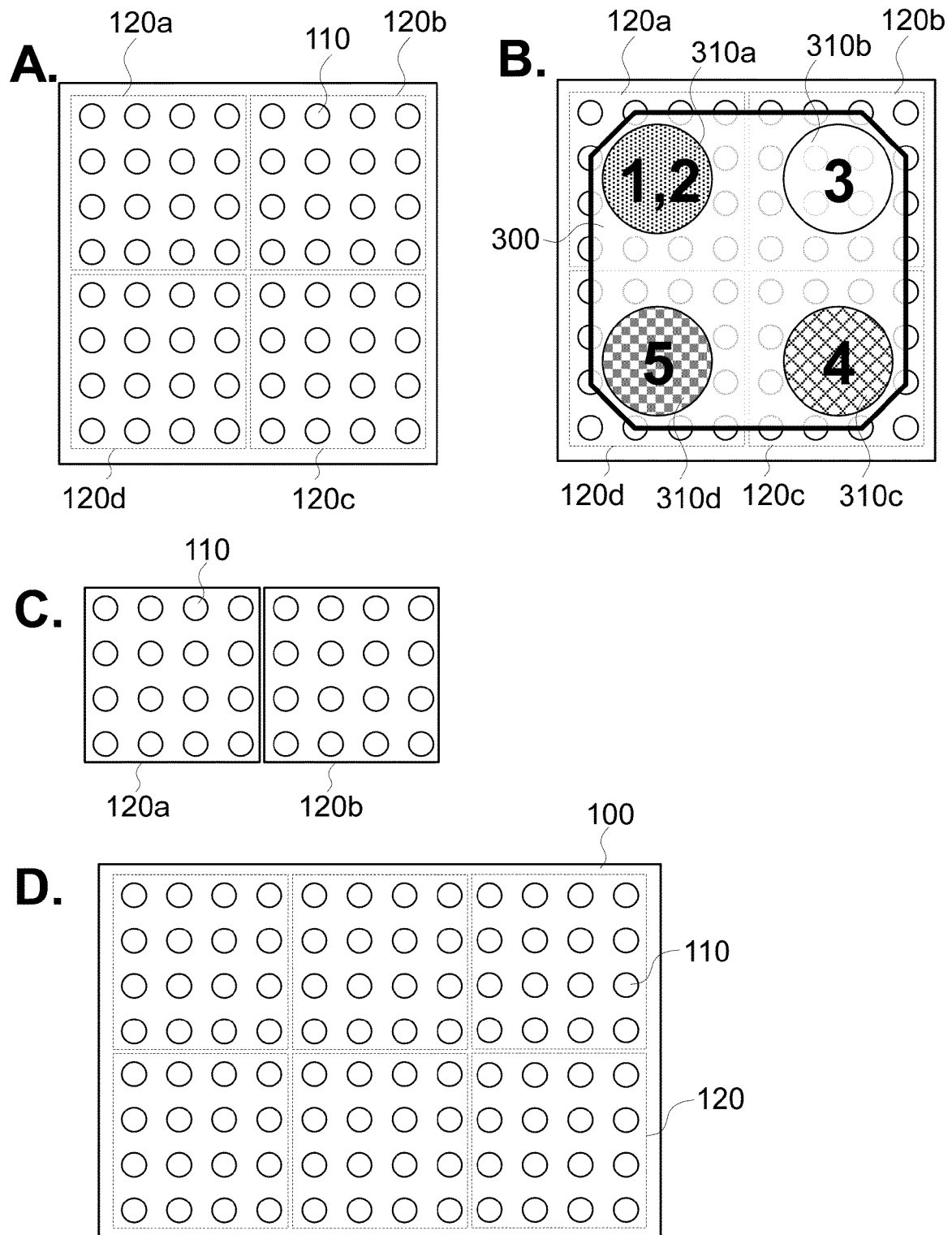
[Fig. 1]

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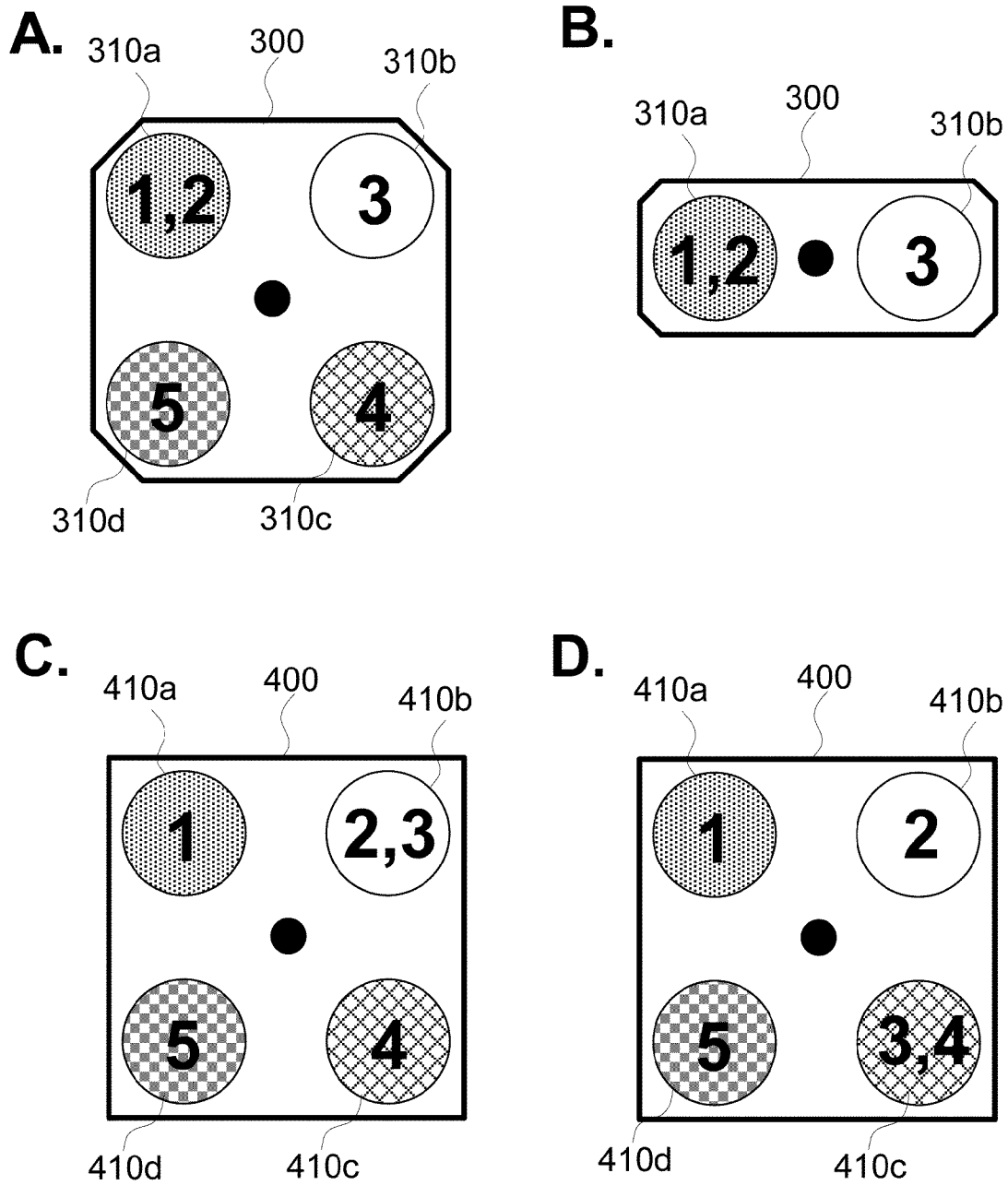
[Fig. 2]



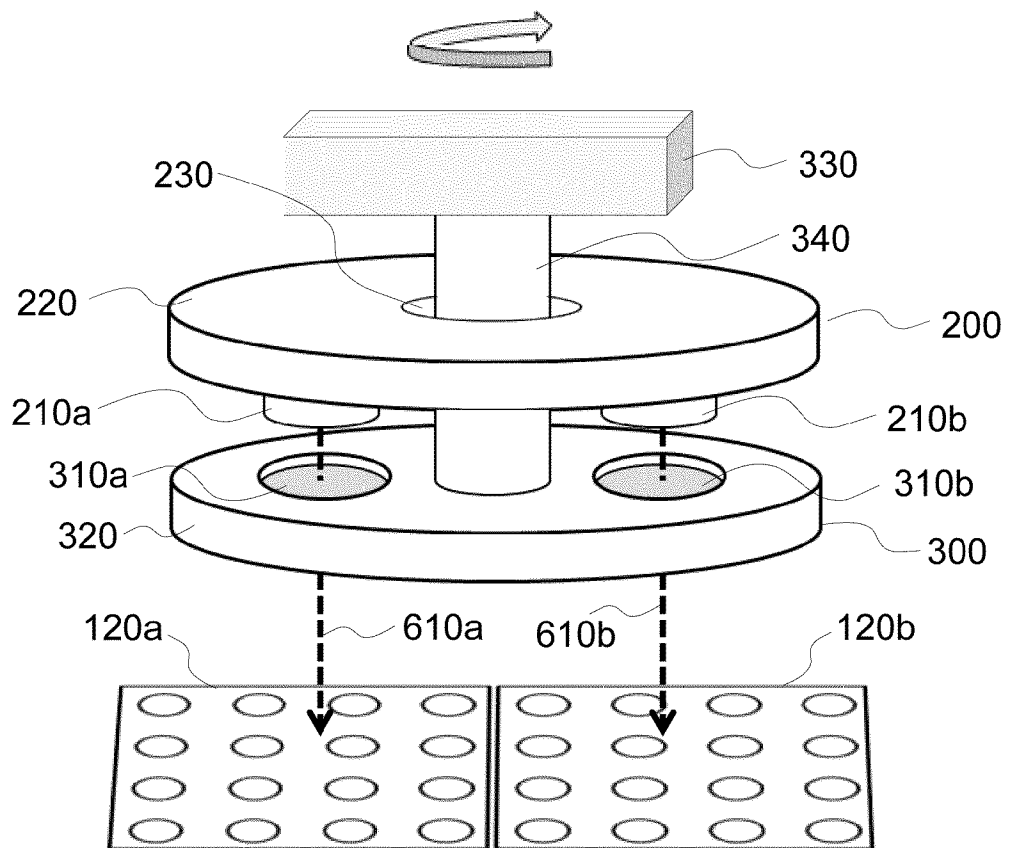
[Fig. 3]



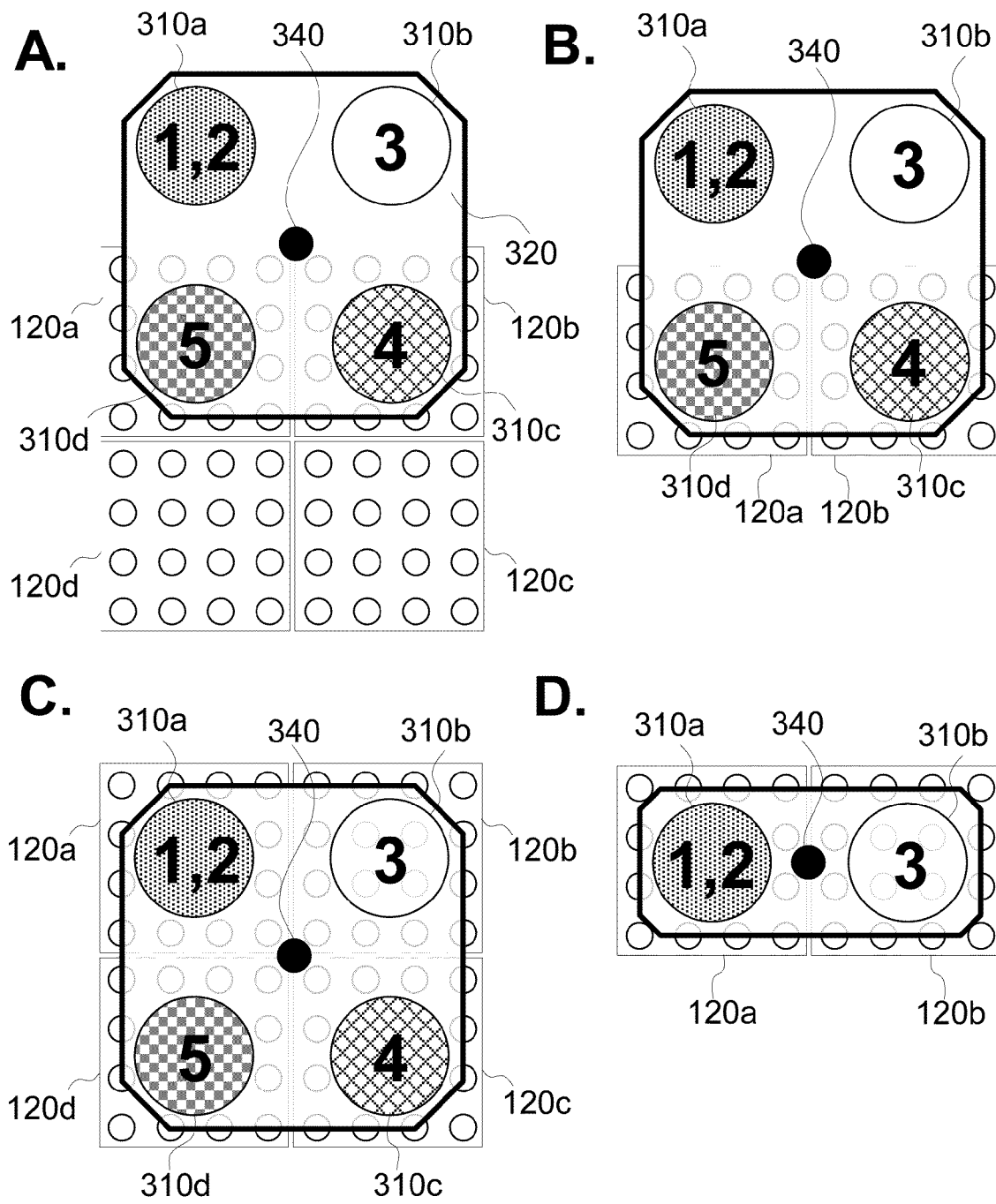
[Fig. 4]



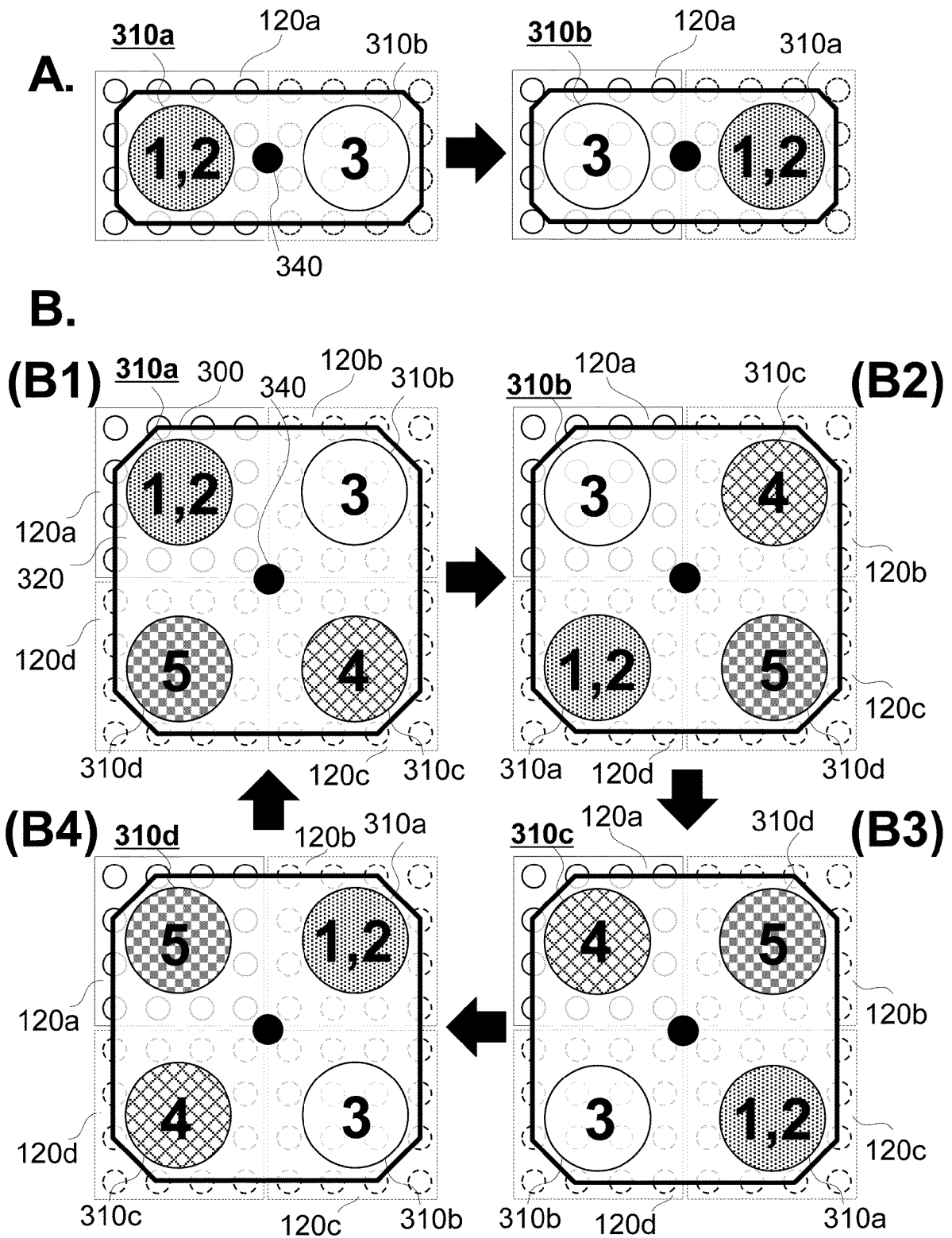
[Fig. 5]



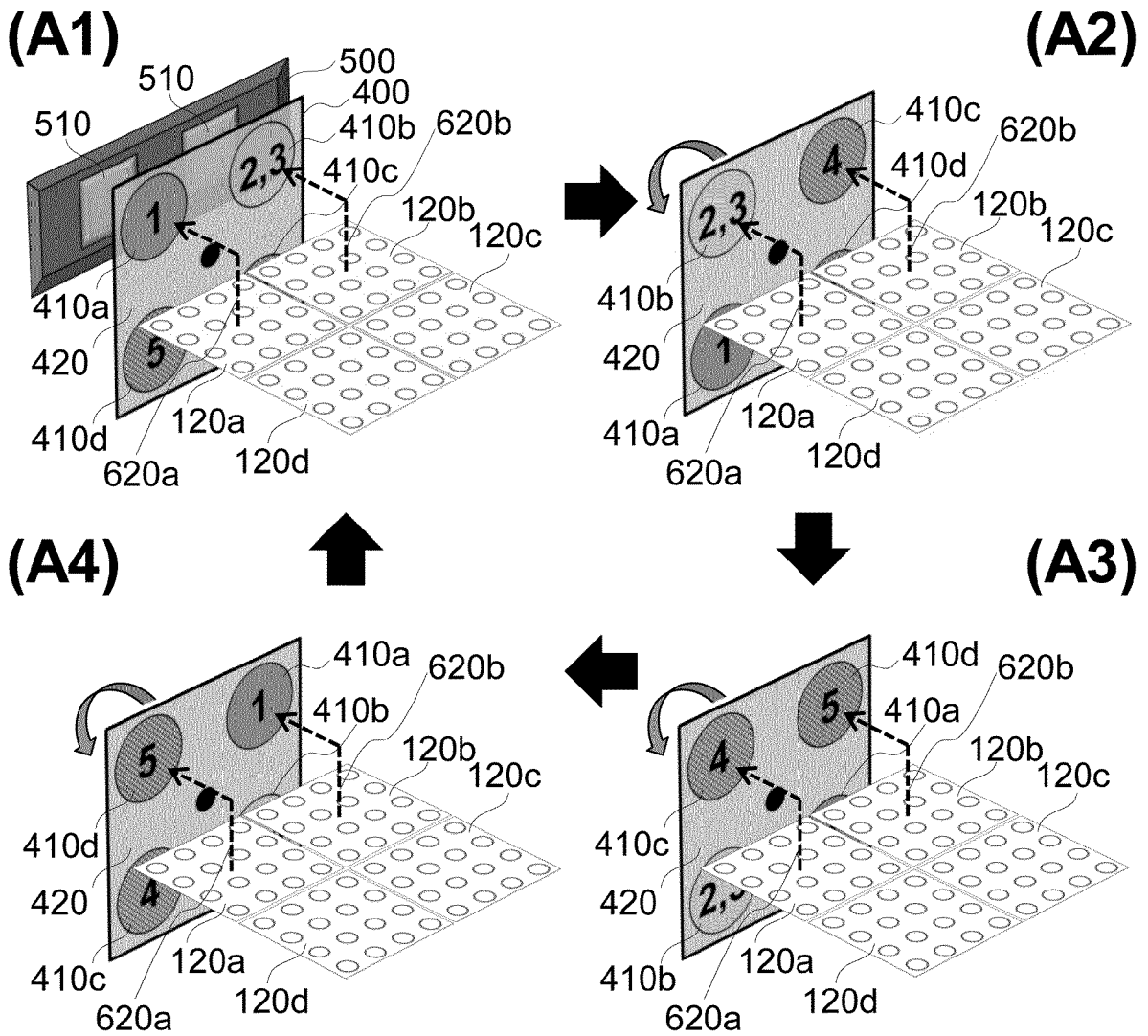
[Fig. 6]



[Fig. 7]



[Fig. 8]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2021/006769

A. CLASSIFICATION OF SUBJECT MATTER G01N 21/64(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) G01N 21/64(2006.01); B01L 7/00(2006.01); C12Q 1/68(2006.01); C12Q 1/6848(2018.01); G01N 21/25(2006.01); G01N 35/00(2006.01); G02B 21/00(2006.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models Japanese utility models and applications for utility models Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS(KIPO internal) & Keywords: target, dye, fluorescence, dual bandpass excitation light filter, dual bandpass emission light filter		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 25 August 2021		Date of mailing of the international search report 26 August 2021
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea Facsimile No. +82-42-481-8578		Authorized officer BAHNG, SEUNG HOON Telephone No. +82-42-481-5560

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International application No.

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KR	10-1821637	B1	09 March 2018	None		