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(54) Title: A SYSTEM AND METHOD FOR SIMULTANEOUSLY OBTAINING A PLURALITY OF IMAGES IN AN IMAGING SYSTEM

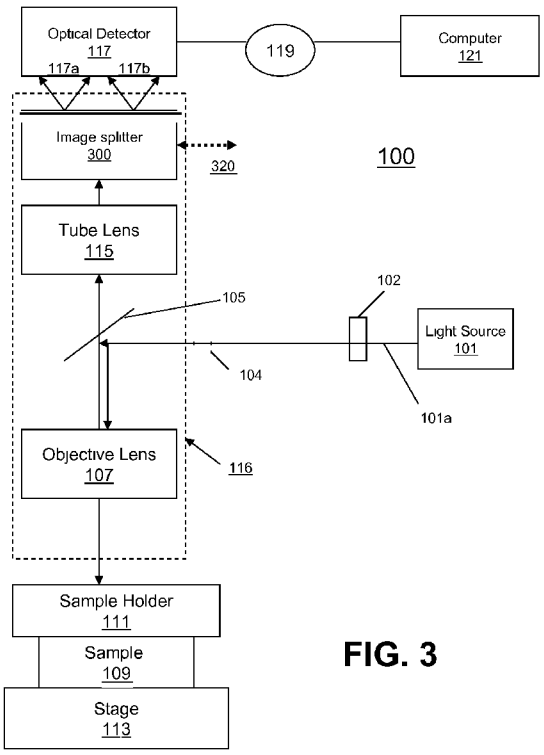

FIG. 3

(57) Abstract: A system for providing multiple images in an imaging unit is disclosed. A light source emits a beam of light to a sample. The sample receives the beam of light, wherein the sample emits a fluorescent beam of light in response to receiving the beam of light, where the fluorescent beam of light is split into a first wavelength beam and a second wavelength beam by a dichroic mirror. The dichroic mirror receives the first wavelength beam then transmits the first wavelength beam to at least one detector. The dichroic mirror receives the second wavelength beam that is transmitted through a first mirror, a second mirror and a third mirror to the at least one detector. The at least one detector simultaneously records and displays a first image from the first wavelength beam and a second image from the second wavelength beam.

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A SYSTEM AND METHOD FOR SIMULTANEOUSLY OBTAINING A PLURALITY OF IMAGES IN AN IMAGING SYSTEM

Field of the Invention

The present invention relates to a system and method for simultaneously obtaining a plurality of images in an imaging system.

Background of the Invention

Generally, when researching tiny regions of interest on a sample, researchers often employ a microscope to observe the sample. The microscope may be a conventional wide-field, fluorescence, epi-fluorescence or confocal microscope. The optical configuration of such a microscope typically includes a light source, illumination optics, objective lens, sample holder, imaging optics and a detector. Light emitted from the light source illuminates the region of interest on the sample after propagating through the illumination optics and the objective lens. Microscope objective forms a magnified image of the object that can be observed via eyepiece, or in case of a digital microscope, the magnified image is captured by the detector and sent to a computer for live observation, data storage and further analysis.

When using a microscope sometimes it becomes necessary to record fluorescence images to use for further studies. These fluorescent images may need to be recorded at two different wavelengths such as when performing fluorescence resonance energy transfer (FRET). FRET is a powerful and widely used method in cell biology for studying protein-protein interactions and also the conformational dynamics of proteins, enzymes and nucleic acids. The publications regarding FRET and its application in biology show the near exponential growth of this technology. The FRET efficiency can be measured by two popular methods, one is fluorescence intensity-based method, where fluorescence intensities of acceptor dye and donor dye are both measured while only the donor is excited; and the other method is fluorescence

lifetime-based method, where fluorescence lifetime times of donor dye are measured in the presence and absence of acceptor dye. Currently, the digital microscopes can only record fluorescence signals of donor and acceptor separately, not simultaneously, which certainly increases the difficulty of data interpretation of FRET experiments because of the photobleaching effect, and it limits the time resolution of dynamical studies that is very important in studying protein-protein interactions and conformational changes of the biological macromolecules, such as DNA, RNA, proteins and enzymes.

Therefore, there is a need for an imaging system that provides a user with a simple method for simultaneously obtaining a plurality of images from a sample and does not increase the difficulty of data interpretation of FRET experiments.

Summary of the Invention

The present invention has been accomplished in view of the above-mentioned technical background, and it is an objective of the present invention to provide a system for simultaneously obtaining a plurality of images from a sample.

In a preferred embodiment of the invention, a system for providing multiple images in an imaging unit are disclosed. A light source emits a beam of light to a sample. The sample receives the beam of light, wherein the sample emits a fluorescent beam of light in response to receiving the beam of light, where the fluorescent beam of light is split into a first wavelength beam and a second wavelength beam by a dichroic mirror. The dichroic mirror receives the first wavelength beam then transmits the first wavelength beam to at least one detector. The dichroic mirror receives the second wavelength beam that is transmitted through a first mirror, a second mirror and a third mirror to the at least one detector. The at least one detector simultaneously records and displays a first image from the first wavelength beam and a second image from the second wavelength beam.

In yet another preferred embodiment of the invention, a system for providing multiple

images in an imaging unit is disclosed. A light source emits a beam of light to a sample. The sample receives the beam of light, where the sample emits a fluorescent beam of light in response to receiving the beam of light, where the fluorescent beam of light is split into a first wavelength beam and a second wavelength beam by a dichroic mirror. The dichroic mirror receives the first wavelength beam then transmits the first wavelength beam to at least one detector. The dichroic mirror receives the second wavelength beam that is transmitted through a mirror and the dichroic mirror to the at least one detector. The detector simultaneously records and displays a first image from the first wavelength beam and a second image from the second wavelength beam.

Brief Description of the Drawings

These and other advantages of the present invention will become more apparent as the following description is read in conjunction with the accompanying drawings, wherein:

FIG.l is a block diagram of a typical imaging system in accordance with the invention;

FIG. 2 is a schematic of an image-receiving device of FIG. 1 in accordance with the invention;

FIG. 3 is a block-diagram of the imaging system of FIG. 1 comprising an image splitter in accordance with the invention;

FIG. 4 is a block-diagram of the imaging system of FIG. 1 coupled to dual view imaging system in accordance with the invention;

FIG. 5 shows a flow chart of how the dual view imaging microscope system of FIG. 3 operates in accordance with the invention;

FIG. 6 is another block diagram of the imaging system of FIG. 1 coupled to another dual view imaging system in accordance with the invention;

FIG. 7 shows another block diagram of the imaging system of FIG. 1 coupled to yet another dual view imaging microscope system in accordance with the invention; and

FIG. 8 is a flow chart that shows how the dual view imaging microscope system of FIGs. 5 and 6 operate in accordance with the invention.

Detailed Description of the Invention

The presently preferred embodiments of the invention are described with reference to the drawings, where like components are identified with the same numerals. The descriptions of the preferred embodiments are exemplary and are not intended to limit the scope of the invention.

FIG. 1 illustrates a block diagram of the essential components of a typical digital microscope system. This automated digital microscope system 100 includes the following components: a light source 101, a collimator 102, optionally aspherical optics 104 (in case of line scanning microscopy), beam folding optics 105, objective lens 107, a sample 109, a sample holder 111, a stage, 113, a tube lens 115, an optical detector 117, an optional communication link 119 and an optional computer 121.

Light source 101 may be a lamp, a laser, a plurality of lasers, a light emitting diode (LED), a plurality of LEDs, or any type of light source known to those of ordinary skill in the art that generates a light beam 101a. Light beam 101a is delivered by: the light source 101, collimator 102, optionally aspherical optics 104, beam-folding optics 105 and objective lens 107 to illuminate the sample 109. Sample 109 may be live biological organisms, biological cells, non-biological samples, or the like. Aspherical optics 104 is a typical Powell lens. Beam-folding optics 105 is a typical scanning mirror or a dichroic mirror. The light emitted or reflected from the sample 109 is collected by the objective lens 107, and then an image of the sample 109 is formed by the typical tube lens 115 on the optical detector 117. The optical detector 117 may be a charged coupled device (CCD), a complementary metal-oxide semiconductor (CMOS) image detector or any 2-D array optical detector utilized by those of ordinary skill in the art. Optical detector 117 is optionally, electrically or wirelessly, connected by the communication link 119 to the computer 121. Sample 109 is mounted on the sample

holder 111, which may be referred to as a typical microtiter plate, a microscope slide, a chip, plate of glass, Petri dish, or any type of sample holder.

In another embodiment, the microscope system 100 optionally, may be electrically or wirelessly, connected by a communication link 119 to the conventional computer 121. The communication link 119 may be any network that is able to facilitate the transfer of data between the automated microscope system 100 and the computer 121, such as a local access network (LAN), a wireless local network, a wide area network (WAN), a universal service bus (USB), an Ethernet link, fiber-optic or the like. The microscope may also have a plurality of objective lenses 107. The computer 121 may be referred to as an image detection device. In another embodiment of the invention, the image-detecting device 121 may be located inside of the digital microscope 100. The image detecting device 121 acts as a typical computer, which is capable of receiving an image of the sample 109 from the optical detector 117, then the image detecting device 121 is able to display, save or process the image by utilizing a standard image processing software program, algorithm or equation. Also, the computer 121 may be a personal digital assistant (PDA), laptop computer, notebook computer, mobile telephone, hard-drive based device or any device that can receive, send and store information through the communication link 119. Although, one computer is utilized in this invention a plurality of computers may be utilized in place of computer 121.

The microscope system 100 has been depicted schematically in Fig. 1 with only the essential components highlighted. It will be obvious to a person skilled in the art of microscopy that the block diagram describes all microscopes using an objective lens. Examples include, but are not limited to, conventional wide-field microscope, fluorescence microscope, epi-fluorescence microscope or line scanning confocal microscope. These types of microscope may be augmented with automation equipment to serve different applications, such as high-throughput screening. However, they are not precluded from the scope of this invention. Also, the microscope system 100 may be the IN Cell Analyzer 1000, IN Cell Analyzer 2000 or IN

Cell Analyzer 3000 manufactured by GE Healthcare in Piscataway, NJ.

FIG. 2 illustrates a schematic diagram of the image-receiving device of the digital microscope system of FIG. 1. Computer 121 may be known as an imaging receiving device 203 that includes the typical components associated with a conventional computer. Image receiving device 203 may also be stored on the image transmitting system 100. The image receiving device 203 includes: a processor 203a, an input/output (I/O) controller 203b, a mass storage 203c, a memory 203d, a video adapter 203e, a connection interface 203f and a system bus 203g that operatively, electrically or wirelessly, couples the aforementioned systems components to the processor 203a. Also, the system bus 203g, electrically or wirelessly, operatively couples typical computer system components to the processor 203a. The processor 203a may be referred to as a processing unit, a central processing unit (CPU), a plurality of processing units or a parallel processing unit. System bus 203g may be a typical bus associated with a conventional computer. Memory 203d includes a read only memory (ROM) and a random access memory (RAM). ROM includes a typical input/output system including basic routines, which assists in transferring information between components of the computer during start-up.

Input/output controller 203b is connected to the processor 203a by the bus 203g, where the input/output controller 203b acts as an interface that allows a user to enter commands and information into the computer through the GUI and input device 204, such as a keyboard and pointing devices. The typical pointing devices utilized are joysticks, mouse, game pads or the like. A display 206 is electrically or wirelessly connected to the system bus 203g by the video adapter 203e. Display 206 may be the typical computer monitor, plasma television, liquid crystal display (LCD) or any device capable of having characters and/or still images generated by a computer 121. Next to the video adapter 203e of the computer 203, is the connection interface 203f. The connection interface 203f may be referred to as a network interface that is connected, as described above, by the communication link 119 to the optical detector 117. Also, the image-receiving device 203 may include a network adapter or a modem, which enables the

image-receiving device 203 to be coupled to other computers.

Above the memory 203d is the mass storage 203c, which includes: 1. a hard disk drive component (not shown) for reading from and writing to a hard disk and a hard disk drive interface (not shown), 2. a magnetic disk drive (not shown) and a hard disk drive interface (not shown) and 3. an optical disk drive (not shown) for reading from or writing to a removable optical disk such as a CD- ROM or other optical media and an optical disk drive interface (not shown). The aforementioned drives and their associated computer readable media provide non-volatile storage of computer-readable instructions, data structures, program modules and other data for the computer 203. Also, the aforementioned drives include the technical effect of having an algorithm for obtaining fluorescent images at two or more wavelengths simultaneously, software or equation of this invention, which will be described in the flow chart of FIG. 4.

Within the software program for obtaining fluorescent images at two or more wavelengths simultaneously there is a graphical user interface (GUI). The dual view graphical user interface is a specially programmed GUI that has some of the same functionality as a typical GUI, which is a software program designed to allow a computer user to interact easily with the computer 203. The dual view GUI includes a screen shot that simultaneously displays: a first image from a first wavelength beam and a second image from a second wavelength beam. Even though only two images are discussed here the dual view imaging system may display two, three, four, five or more images.

According to one embodiment, schematically shown in fig. 3, there is provided a digital microscope system 100, comprising a light source 101 for illuminating a sample 109 to be imaged, imaging optics 116 for transmitting light originating from the sample 109 to form an image on a two dimensional detector array 117 for digitally registering said light, wherein the imaging optics 116 further comprises an image splitter 300 arranged to split the light originating from the sample into two or more wavelength ranges and to form a spatially separate sub-image

117a, 117b of each wavelength range on the two dimensional detector array 117.

As mentioned above, the digital microscope system 100 may be any suitable type of microscope such as a wide field fluorescence microscope, a confocal microscope or the like. In fig. 3 the imaging optics 116 is shown to comprise the same components as the microscope disclose in fig. 1, but depending on the type of microscope, it may comprise fewer or more components.

According to one embodiment, the digital microscope system 100 comprises a microscope control system 121 (computer), wherein the spatially separated sub images 117a, 117b are read out from the two dimensional detector array as one combined image, and wherein the microscope control system 121 is arranged to extract each sub-image 117a, 117b from the combined image. Alternatively the microscope control system 121 is arranged to selectively read out the spatially separated sub images 117a, 117b from the two dimensional detector array 117.

According to one embodiment, as is shown by way of example in figs 4, 6, 7, the image splitter 300 comprises one or more beam splitter for splitting the light originating from the sample into two or more light beams, two or more filters for defining the wavelength range of each light beam, and beam directing optics for defining the spatial position of each sub image. The beam splitter may be any suitable device capable of splitting an optical beam in one or more beams, potentially of a specific wavelength range. The filters for defining the wavelength range of each light beam may either be physically separate filters arranged in the beam path of each beam or they may be integrated with the beam splitter or a member of the beam directing optics. According to one embodiment, the image splitter comprises one or more dicroic mirrors arranged as an integrated beam splitter and filter, and optionally beam directing optics. According to another embodiment, the image splitter comprises one or more polarization beam

splitters arranged as beam splitter, and optionally beam directing optics.

According to one embodiment the image splitter 300 may be selectively arranged in the optical path of the imaging optics 116, as is indicated by arrow 320 in fig.3.

FIG. 4 illustrates the block diagram of the imaging system coupled to a dual view microscope system and a detector. For this invention, a dual view imaging device 300 is inserted in microscope system 100 in front of the optical detector 117. The insertion of the dual view imaging device 300 into microscope system 100 can be automically controlled by the computer 121, it can also be completed manually by the users themselves. Microscope system also includes additional mirror 123 and mirror 125 utilized to direct the excitation light 101a (FIG.l) and the emitted fluorescent beam from the sample 109 to the dual imaging device 300. The dual view imaging device 300 includes: a slit 301, a collimated lens 303, a second collimated lens 305, a dichroic mirror 307, a first mirror 309, a second mirror 311 and a third mirror 313. Slit 301 is directly across the first lens 303. First lens 303 is positioned directly opposite of second lens 305. The third mirror 313 is positioned slightly upwards from the dichroic mirror 307. Dichroic mirror 307 may be referred to as a polarization beam splitter 307. First mirror 309 and second mirror 311 are aligned vertically or slightly vertical towards each other and are above the dichroic mirror 307 in between the first lens 303 and the second lens 305. Slit 301 is wire/wirelessly connected to a typical mechanical controller 301a that is able to open or close the slit in a range of 0.01 to 5 centimeters. This controller 301a is connected to computer 121, which controls the operation of the controller 301a. Dual view imaging device 300 is adjacent to the detector 117 of FIG. 1. The combination of the digital microscope system 100, the dual imaging system 300 and the optical detector 117 forms the dual view imaging microscope system 302.

FIG. 5 depicts a flow chart of how a plurality of images is obtained by the dual view imaging microscope system. At block 401, the dual view imaging microscope system is

initialized, which results in inserting the dual view imaging device 300 into microscope system 100 either automatically or manually. The dual view imaging microscope system is initialized when a person uses a pointing device 204 of the computer 121 to start the software program of this system. The person goes to the Dual View imaging microscope system GUI to start the process in order to make the light source 101 emit a beam of light 101a onto a sample 109 (FIG. 1)

At 403, the sample 109 emits a fluorescent light in response to the beam of light 101a that is transmitted to the sample 109. The beam of light 101a is directed to the dual view imaging device 300 by the dichroic mirror or scanning mirror 105 that sends it through slit 301 and first lens 303 (FIG. 4).

At block 405, the fluorescent beam of light goes through the first lens 303 and hits the dichroic mirror 307. Dichroic mirror 307 splits the fluorescent beam of light into a first wavelength beam and a second wavelength beam. The dichroic mirror 307 act as a low pass filter or a high pass filter to split the fluorescent beam of light. When the dichroic mirror 307 (FIG. 4) is a low pass filter then any light from the fluorescent beam with a wavelength, for example, 530nanometers ,530nm is used here just for example, it can be any number, or less will be allowed to go directly through the dichroic mirror 307 and the second lens 305 to the optical detector 117 at block 407. Also, when the dichroic mirror 307 is a low pass filter then any light from the fluorescent beam with a wavelength, for example, above 530 nm will be deflected from the dichroic mirror 307 onto the first mirror 309, second mirror 311, third mirror 313 and the second lens 305 onto the optical detector at block 409.

However, when the dichroic mirror 307 is a high pass filter then any light from the fluorescent beam with a wavelength above 530nm,again 530 nm is used as an example here, will be allowed to go directly through the dichroic mirror 307 and the second lens 305 to the optical detector 117 at block 407. Also, when the dichroic mirror 307 is a high pass filter then any light from the fluorescent beam with a wavelength of 530 nm or less will be deflected from the

dichroic mirror 307 onto the first mirror 309, second mirror 311, third mirror 313 and the second lens 305 onto the optical detector 117 at block 409.

At block 411, the optical detector 117 simultaneously records and displays the image from the first wavelength and the second wavelength of the fluorescent beam. At block 413, the simultaneous images of the first wavelength beam and the second wavelength beam is transmitted through the communication link 119 to the optical computer 121 (FIG. 1) where the simultaneous images will be displayed on display 206 and this process ends.

FIG. 6 shows another block diagram of a dual imaging system. Dual imaging system 500 is placed in the digital microscope system 100 in front of optical detector 117 similar to FIG. 4. Dual imaging system 500 includes: a slit 501, a first collimated lens 503, a second collimated lens 505, a dichroic mirror 507 and a mirror 509. Slit 501 is equivalent to slit 301 discussed above, which is wire/ wirelessly connected to a controller 501a. Controller 501a is connected to and operated by computer 121. Mirror 509 is also connected to a typical controller 509a that moves the mirror 509 in a translational motion up, down, sideways and in a degree of rotation from 30 to 60 degrees etc. Controller 509a is wire/wirelessly connected to the computer 121. The dichroic mirror 507 has a position of 45 degrees relative to optical path of the fluorescent beam emitted from the microscope system 100. Dichroic mirror 507 is also equivalent to dichroic mirror 307 described above. - FIG. 7 is equivalent to FIG. 6, but just showing that the controller 509a enables the adjustment of the position of the mirror 509 relative to the dichroic mirror 507, which allows one to select one of the separated beams to pass the dichroic mirror 507 twice. This allows this invention to obtain a purer separation in the case of passing twice than passing only once.

FIG. 8 is a flow chart that shows how a dual view image is obtained by using the dual view imaging systems of FIG. 6 and 7. Blocks, 401, 403, 405, described above, are equivalent to blocks 701, 703 and 705 so a recitation of the operation of this process will not be recited herein.

At block 707, when the dichroic mirror 507 (FIG. 6) is a low pass filter then any light from the fluorescent beam with a wavelength of 530nm or less or first wavelength beam will be allowed to go directly through the dichroic mirror 507, the mirror 509 and the second lens 505 to the optical detector 117 at block 707. Also, when the dichroic mirror 507 is a low pass filter then any light from the fluorescent beam with a wavelength above 530 nm or second wavelength beam will be deflected from the dichroic mirror 507 through the second lens 505 onto the optical detector 117 at block 709. As stated above, the mirror 509 is controlled by controllers 509a in order to separate the first wavelength beam twice by the dichroic mirror 507 as shown in FIG. 6 while in FIG. 7 the first wavelength beam is separated only once by the dichroic mirror 507.

When the dichroic mirror 507 is a high pass filter then any light from the fluorescent beam with a wavelength above 530nm will be allowed to go directly through the dichroic mirror 507, the mirror 509 and the second lens 505 to the optical detector 117 at block 707. Also, when the dichroic mirror 307 is a high pass filter then any light from the fluorescent beam with a wavelength of 530 nm or less will be deflected from the dichroic mirror 507 to the mirror 509 onto the optical detector 117 at block 709.

At block 711, the optical detector 117 simultaneously records and displays the images from the first wavelength and the second wavelength of the fluorescent beam. At block 713, the simultaneous images of the first wavelength beam and the second wavelength beam is transmitted through the communication link 119 to the optical computer 121 (FIG. 1) where the simultaneous images will be displayed on display 206 and this process ends.

This invention provides a system and method for obtaining two simultaneous images of a sample on an optical detector. The user is able to obtain two simultaneous images of a sample on a detector by effectively splitting a first wavelength beam and a second wavelength beam from a fluorescent beam emitted from the sample. The user is able to simultaneously obtain and record a plurality of images from a sample that does not increase the difficult of data

interpretation of FRET experiments. In addition, this dual view imaging device helps to limit the time resolution of dynamical studies, which is very important in studying protein-protein interactions and conformational changes of the biological macromolecules, such as DNA, RNA, proteins and enzymes.

The presently preferred embodiments of the invention are described with reference to the drawings, where like components are identified with the same numerals. The descriptions of the preferred embodiments are exemplary and are not intended to limit the scope of the invention.

Although the present invention has been described above in terms of specific embodiments, many modification and variations of this invention can be made as will be obvious to those skilled in the art, without departing from its spirit and scope as set forth in the following claims.

What is claimed is:

1. A digital microscope system, comprising a light source for illuminating a sample to be imaged, imaging optics for transmitting light originating from the sample to form an image on a two dimensional detector array for digitally registering said light, wherein the imaging optics further comprises an image splitter arranged to split the light originating from the sample into two or more wavelength ranges and to form a spatially separate sub-image of each wavelength range on the two dimensional detector array.

2. Digital microscope system according to claim 1 comprising a microscope control system, wherein the spatially separated sub images are read out from the two dimensional detector array as one combined image, and wherein the microscope control system is arranged to extract each sub-image from the combined image, or wherein the microscope control system is arranged to selectively read out the spatially separated sub images from the two dimensional detector array.

3. Digital microscope system according to claim 1 or 2, wherein the image splitter comprises one or more beam splitter for splitting the light originating from the sample into two or more light beams, two or more filters for defining the wavelength range of each light beam, and beam directing optics for defining the spatial position of each sub image.

4. Digital microscope system according to claim 3 wherein the image splitter comprises one or more dicroic mirrors arranged as an integrated beam splitter and filter, and optionally beam directing optics.

5. Digital microscope system according to claim 3 wherein the image splitter comprises

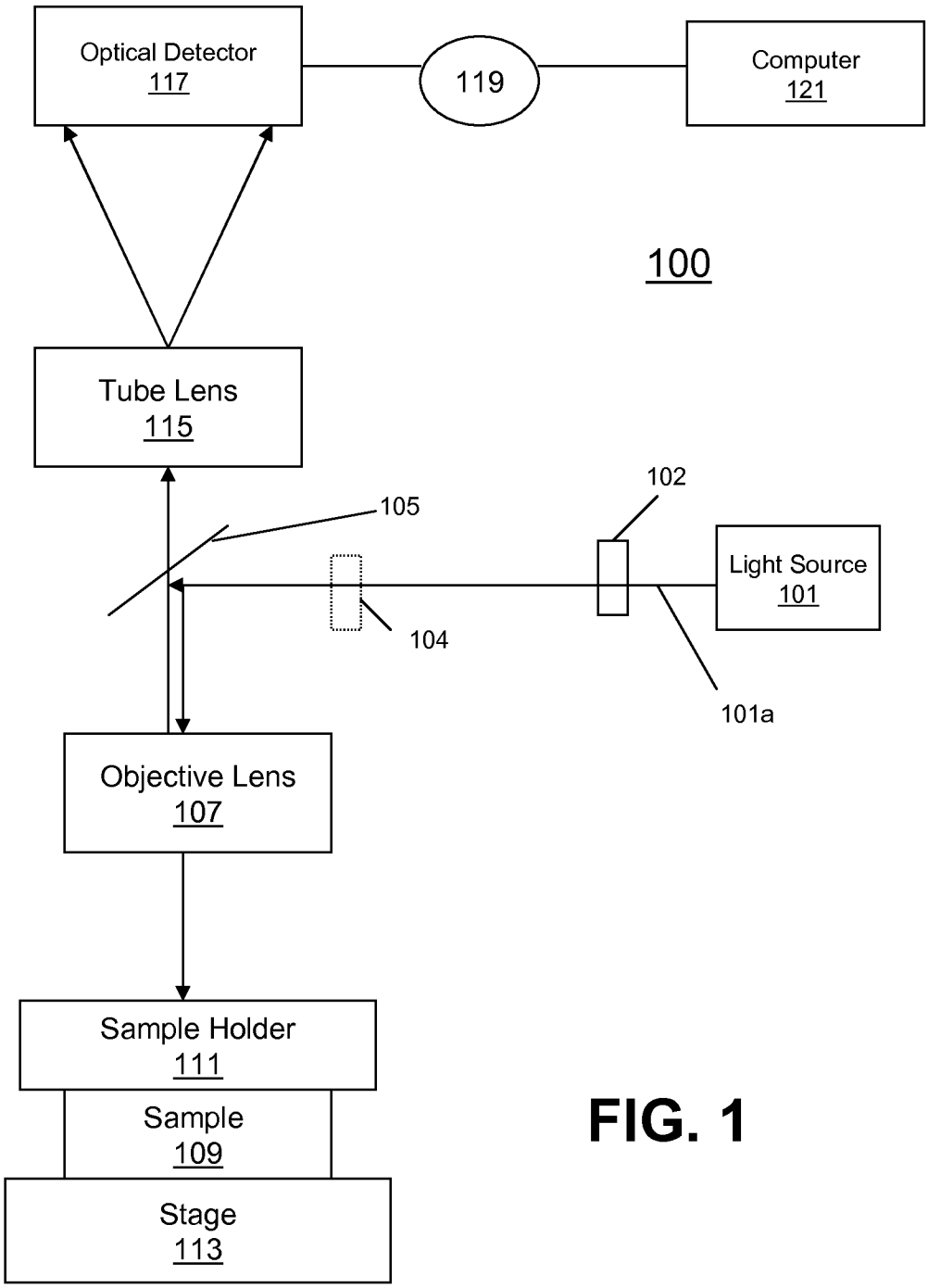
one or more polarization beam splitters arranged as beam splitter, and optionally beam directing; optics.

6. Digital microscope system according to anyone of claims 1 to 5, wherein the two dimensional detector array is a CCD detector or a CMOS detector.

7. Digital microscope system according to anyone of claims 1 to 6, wherein it is a wide field fluorescence microscope or a confocal microscope.

8. Digital microscope system according to anyone of claims 1 to 7, wherein the image splitter may be selectively arranged in the optical path of the imaging optics.

9. Digital microscope system according to anyone of claims 1 to 8, wherein the image splitter the dichroic mirror is a polarization beam splitter.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Computer
121
100
Tube Lens
115
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Light Source
101
104
101a
Objective Lens
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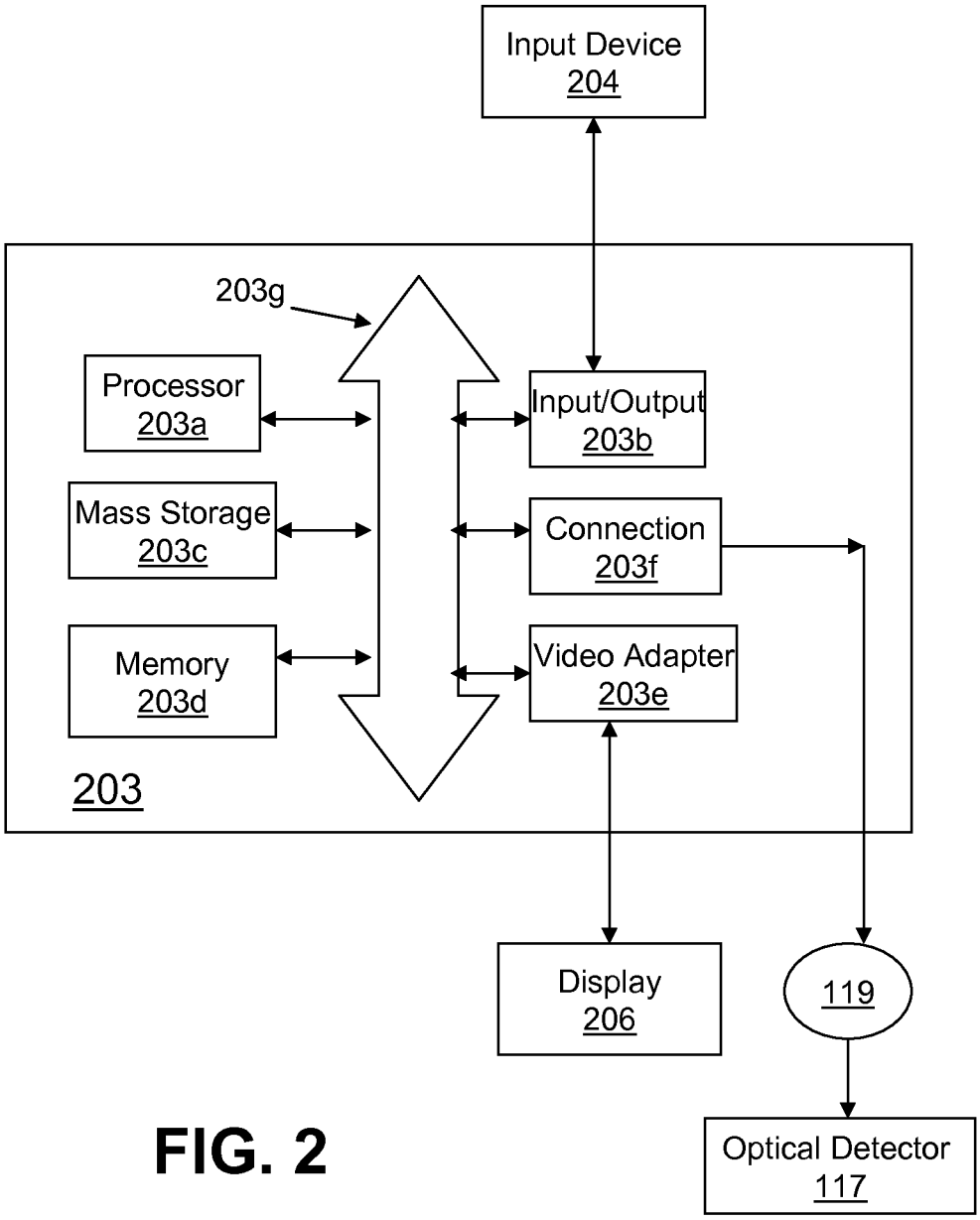
Sample Holder
111
Sample
109
Stage
113

FIG. 1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203g
Processor
203a
Input/Output
203b
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203f
Memory
203d
Video Adapter
203e
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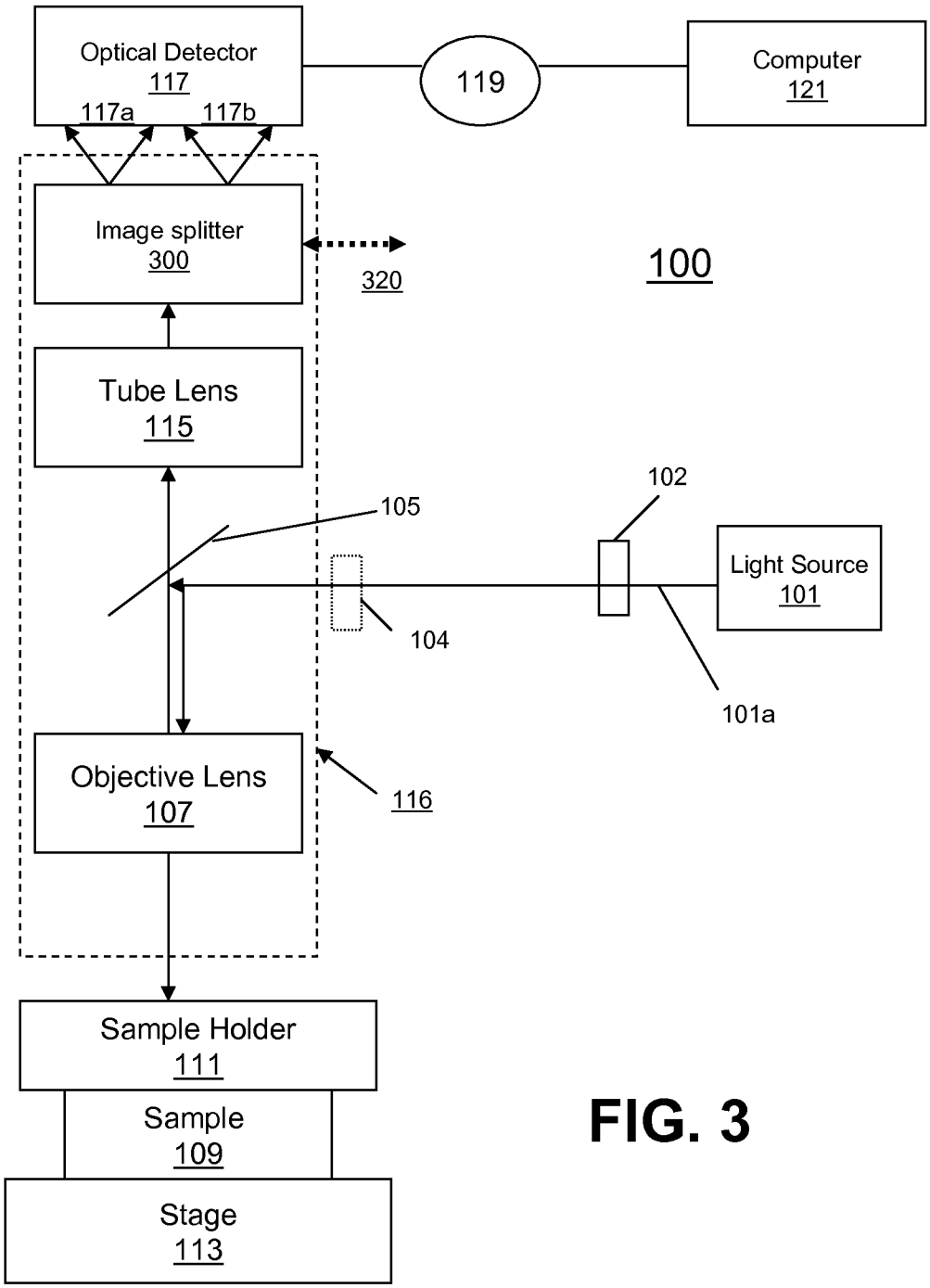
Display
206
119
Optical Detector
117

FIG. 2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117a
117b
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Computer
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320
100
Tube Lens
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Light Source
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Objective Lens
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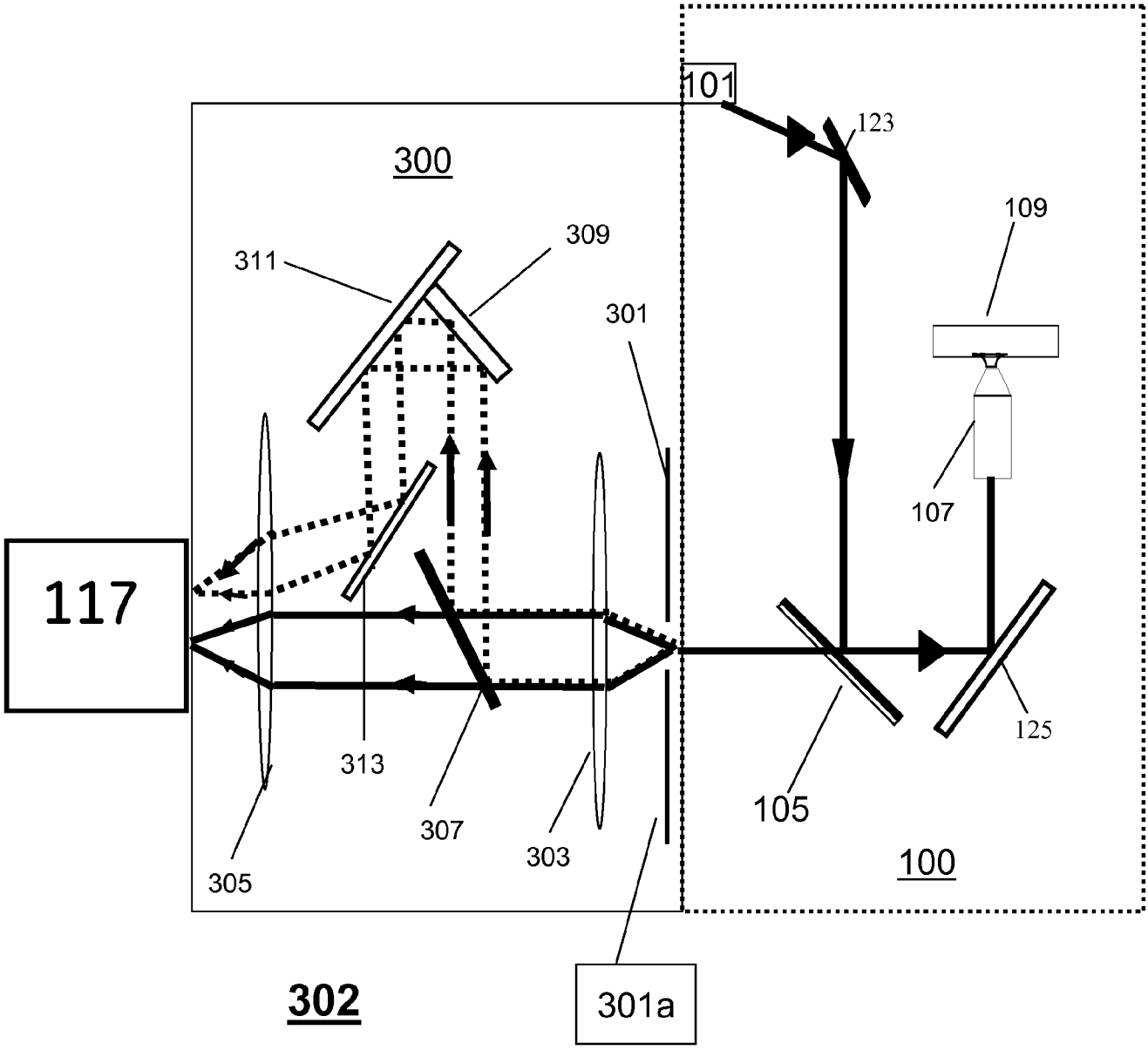
Sample Holder
111
Sample
109
Stage
113

FIG. 3


101
123
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301
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117
313
307
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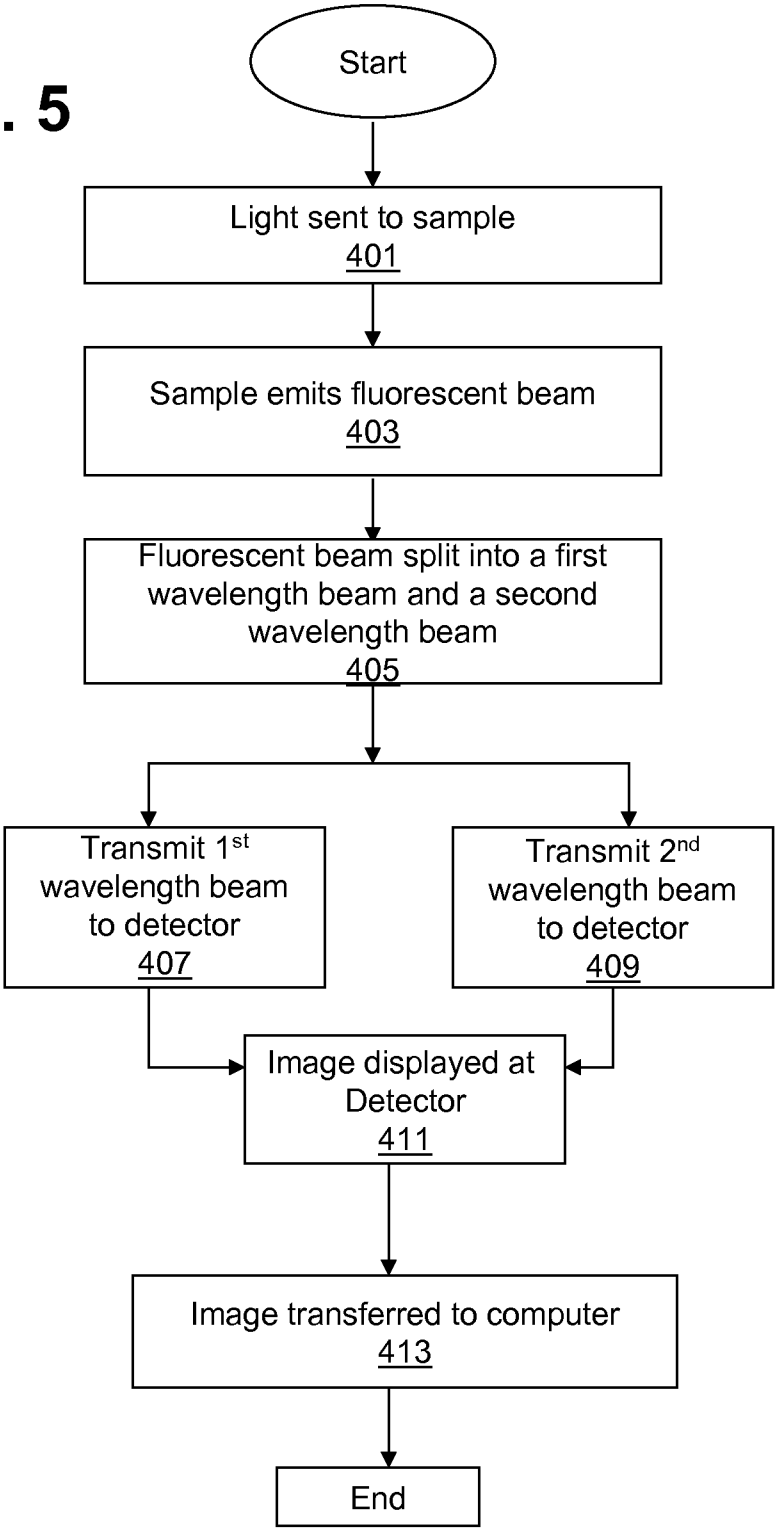
105
125
100
302
301a

FIG. 4

FIG. 5


Start
Light sent to sample
401
Sample emits fluorescent beam
403
Fluorescent beam split into a first wavelength beam and a second wavelength beam
405
Transmit 1st wavelength beam to detector
407
Transmit 2nd wavelength beam to detector
409
Image displayed at Detector
411
Image transferred to computer
413
End

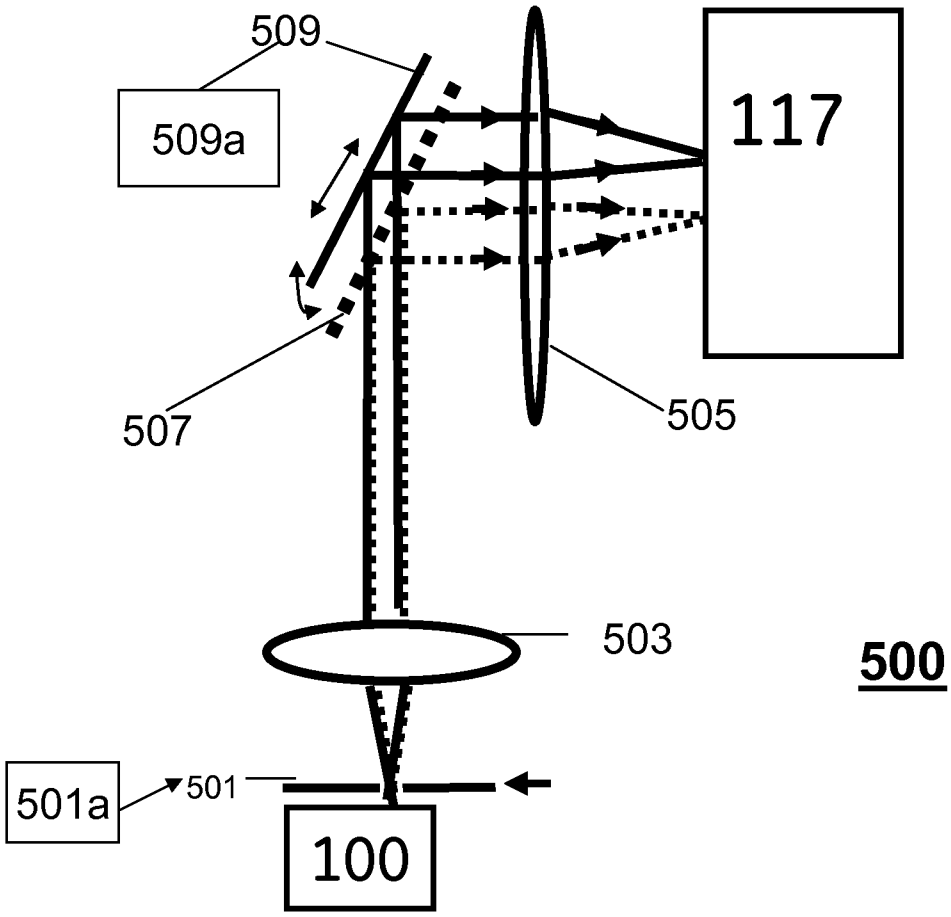


FIG. 6

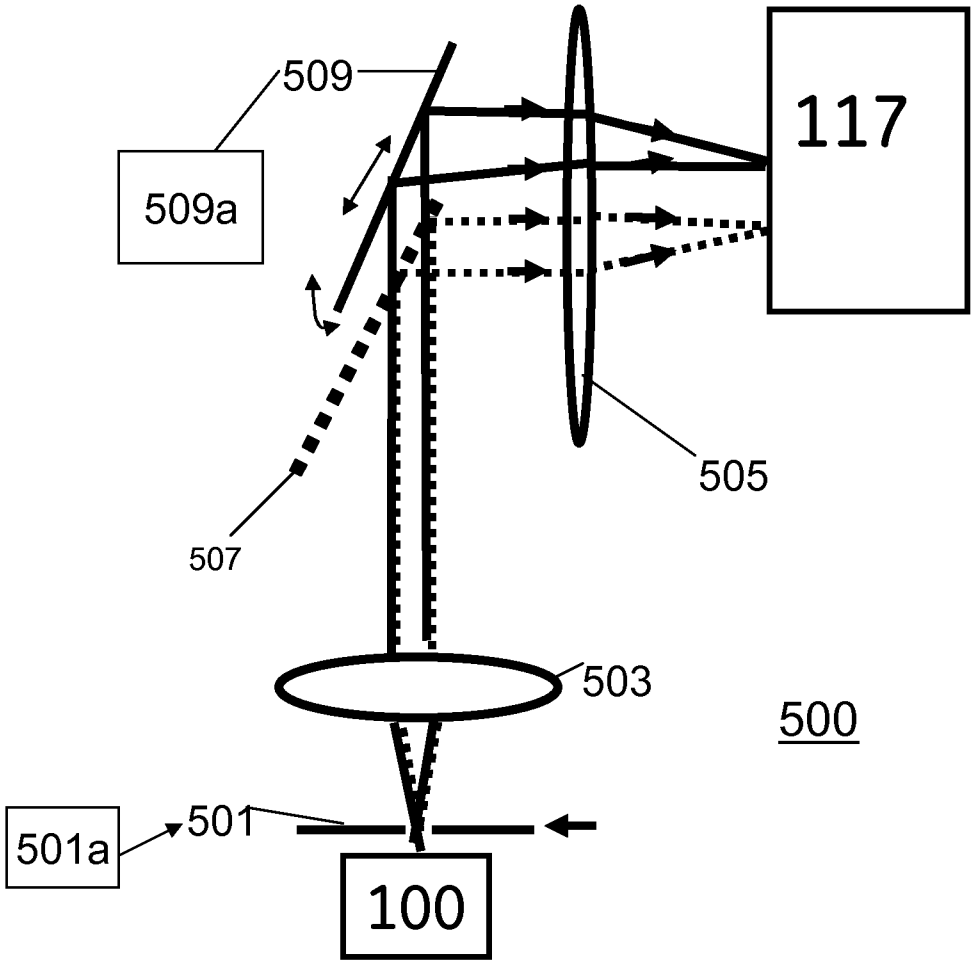
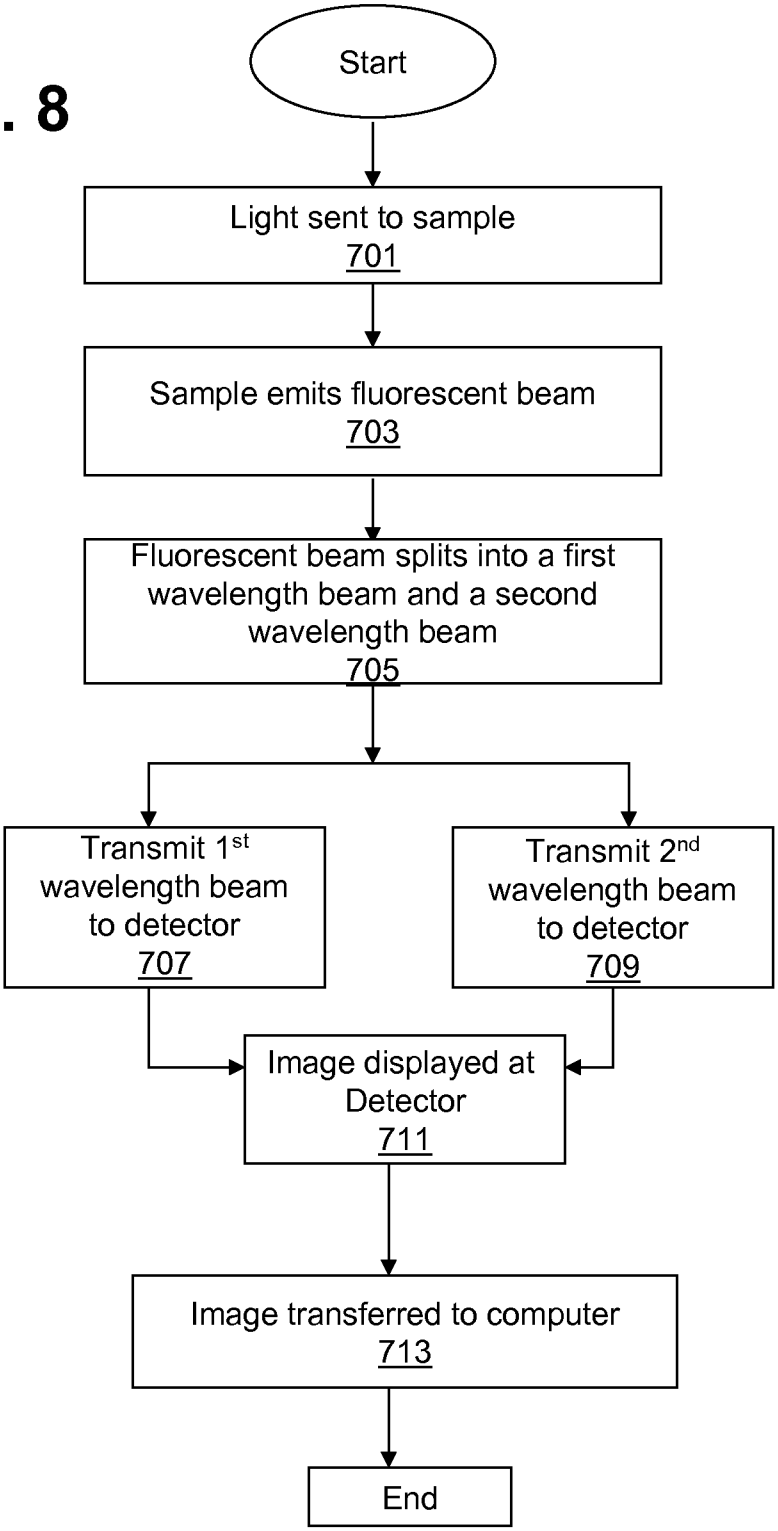


FIG 7

FIG. 8


Start
Light sent to sample
701
Sample emits fluorescent beam
703
Fluorescent beam splits into a first wavelength beam and a second wavelength beam
705
Transmit 1st wavelength beam to detector
707
Transmit 2nd wavelength beam to detector
709
Image displayed at Detector
711
Image transferred to computer
713
End

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/051506

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: G01N, G02B

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

SE, DK, FI, NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20040113059 A1 (Y. KAWANO ET AL), 17 June 2004 (17.06.2004), figure 17, claim 22, paragraph (0099)	1,3,4,6,7
A	as above	2,5,8
	--	
X	WO 2008125605 A2 (SCHWERTNER, M.), 23 October 2008 (23.10.2008), page 16, line 22; page 21, line 9 - line 21; page 23, line 21 - page 24, line 14, figures 9,10	1,3-8
	--	
X	US 20060073076 A1 (T. ICHIKI ET AL), 6 April 2006 (06.04.2006), figure 2, paragraphs (0007), (0045)	1,3,4
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents'
"A" document defining the general state of the art which is not considered to be of particular relevance
'E' earlier application or patent but published on or after the international filing date
L ' document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
'O" document referring to an oral disclosure, use, exhibition or other means
'P" document published prior to the international filing date but later than trie priority date claimed
"T" later document published after tne international Tiling date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
'Y" document of particular relevance: the claimed invention cannot be considered o involve an inventive step when the document is combined wiin one or more other such documents, such combination being obvious to a person skilled m the art
"&" document member of the same parent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 March 2010	18-03-2010
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Agneta Seidel / MRo Telephone No. +46 S 782 25 00

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/051506

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5926283 A (M.F. HOPKINS), 20 July 1999 (20.07.1999), column 6, line 50 - line 62; column 9, line 21 - line 26; column 11, line 35 - line 42, figures 1,2,4,5,8	1,2
A	US 20080305481 Al (D. F. WHITMAN ET AL), 11 December 2008 (11.12.2008), figure 10, paragraphs (0086)-(0088)	1-8
A	US 20040215134 Al (0. SOYKAN ET AL), 28 October 2004 (28.10.2004), figures 4,8, abstract	1-8
P,A	EP 2063257 A2 (JOHANNES KEPLER UNIVERSITAT LINZ), 27 May 2009 (27.05.2009), figure 2, abstract	1-8
A	US 20040150880 Al (T. NAKATA ET AL). 5 August 2004 (05.08.2004), figure 8, abstract, paragraphs (0109)-(0123)	1-8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/051506

International patent classification (IPC)

G01N 21/64 (2006.01)
G02B 21/36 (2006.01)

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Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85) .

Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/051506

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: 9
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

The text "wherein the image splitter the dichroic mirror is a polarization beam splitter" in claim 9 is unclear and leaves

See box II.2

3. [~~] Claims Nos.-
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. in Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. [~] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

Box II.2

the reader in doubt as to the meaning of the technical features of claim 9, thereby rendering the definition of the subject matter of said claim unclear (Article 6 PCT). Claim 9 refers to "the dichroic mirror", but no dichroic mirror is mentioned in claim 1, to which claim 9 refers. Further, there is no indication or embodiment in the description that clarifies the subject matter of claim 9.

US	20040113059	A1	17/06/2004	NONE	
WO	2008125605	A2	23/10/2008	DE 102007018048 A	16/10/2008
				EP 2137488 A	30/12/2009
US	20060073076	A1	06/04/2006	NONE	
US	5926283	A	20/07/1999	NONE	
US	20080305481	A1	11/12/2008	NONE	
US	20040215134	A1	28/10/2004	NONE	
EP	2063257	A2	27/05/2009	NONE	
US	20040150880	A1	05/08/2004	NONE	