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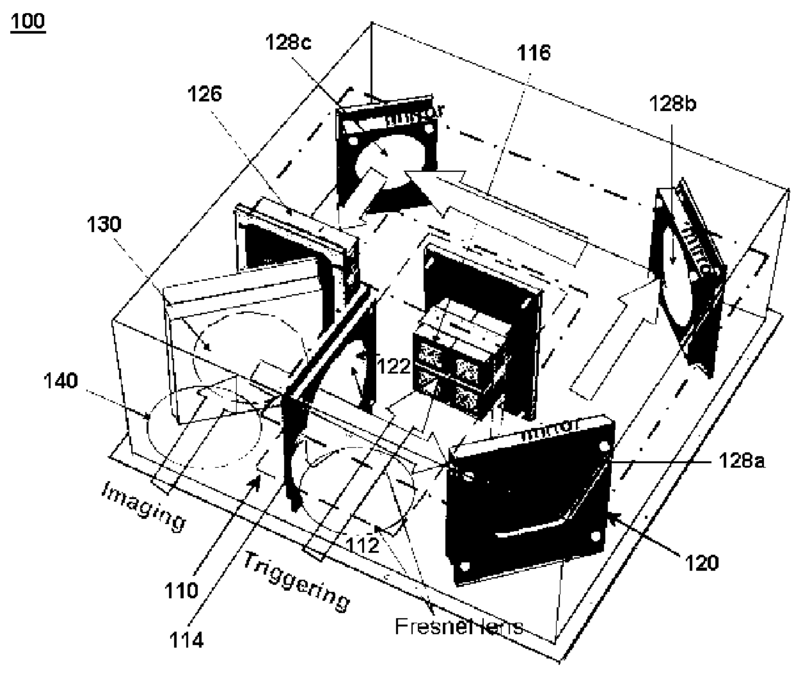
(54) **Title:** AN OPTICAL SYSTEM USING A MIRROR WHICH HAS THE POSSIBILITY OF FAST CONTROL OF THE ANGLE OF REFLECTION

[Fig. 1]



(57) **Abstract:** An optical system using a mirror is disclosed. The optical system includes: (1) a triggering optical module for detecting an object of observation in a wide area, the triggering optical module having a wide field of view (FOV); (2) an imaging optical module for observing the object of observation in detail, the imaging optical module having a high resolving power and a FOV which is narrower than the wide FOV of the triggering optical module; (3) a mirror for controlling a reflection angle at a high speed, the mirror being located in front of the imaging optical module; and (4) a controller for determining whether the object of observation detected by the triggering optical module is a target of observation, and for controlling the mirror, so that the imaging optical module can input an optical signal from the detected object, form an image, and observe the detected object in detail, when it is determined that the detected object is a target of observation. The optical system allows a triggering optical module to detect an object of observation in a wide FOV and allows an imaging optical module with a high resolution to observe in detail the detected object of observation using a mirror, which can rapidly tilt the reflection angle. Therefore, the optical system has both a wide FOV function and a high resolution and can effectively observe a rapidly moving object.

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Description

AN OPTICAL SYSTEM USING A MIRROR WHICH HAS THE POSSIBILITY OF FAST CONTROL OF THE ANGLE OF REFLECTION

Technical Field

[1] The present invention relates to optical systems. More particularly, this invention relates to an optical system that allows a triggering optical module to detect an object of observation in a wide field of view (FOV) and allows an imaging optical module with a high resolution to observe, in detail, the detected object of observation using a mirror, which can rapidly tilt the reflection angle, so the optical system has both a wide FOV function and a high resolution and can effectively observe a rapidly moving object.

Background Art

[2] If an optical module (or an optical system) includes all of the following features: a wide field of view (FOV), high resolution, and a high speed tracking function, it can be utilized in a variety of applications. That is, if an optical module can detect an object of observation over a wide range of area through a wide FOV function, observe the detected object of observation in detail through a high resolving power function, and even track a rapidly moving object, it can become an ideal optical module.

[3] However, it is difficult to implement all of these functions in one optical module. Since there is a trade off between the wide FOV and the high resolving power, when one of them is improved, the other is deteriorated. The optical module has a relatively short focal length to provide a wide FOV, but a relatively long focal length to provide a high resolving power. In order to compatibly and simultaneously exert a wide FOF and a high resolving power, both an optical module with a wide FOV (hereinafter referred to as a 'wide FOV optical module') and an optical module with a high resolving power (hereinafter referred to as a 'high resolution optical module') are implemented in the same system. To this end, the optical signal receiving direction of the wide FOV optical module must be controlled to be consistent with that of the high resolution optical module so that the wide FOV optical module and the high resolution optical module can receive an optical signal from the same source.

[4] This is gradually increased to observe transient events or phenomena, such as a gamma-ray burst (GRB) or transient luminous events (TLE). This is because the GRB

or TLE include a great amount of information about the earth and space. Observing these transient phenomena helps researchers understand global electrical phenomena in the atmosphere, so the transient phenomena can be used for study related to weather and activities of the sun and earth. However, these transient phenomena emerged at random over a relatively wide area. In particular, since these transient phenomena last a very short time and occur sporadically, it is difficult to observe them. In order to observe phenomena such as a GRB or TLE, monitoring an object, capturing a high resolution image, and tracking the object at a high speed, in a wide FOV, are conditions all needed simultaneously. Also, the optical signal receiving direction of the high resolution optical module must be controlled to be consistent with that of the wide FOV optical module so that the detected phenomena using a wide FOV optical module can be observed by the high resolution optical module. That is, in order to observe rapidly moving phenomena, such as a GRB or TLE, etc., the optical signal receiving direction of the high resolution optical module must be controlled at a high speed so as not to miss, i.e., in order to track, rapidly moving phenomena detected by the wide FOV optical module.

[5] Recently, micro-electro-mechanical systems (MEMS) have received widespread attention. MEM technology that combines a computer with a small mechanism, such as a sensor valve, a gear, a reflector and a semiconductor chip manipulator, etc. MEMS, also referred to as a smart meter, are devices composed of a micro-circuit in a small silicon chip, installed into mechanical devices such as a reflector or a sensor. For example, MEMS are utilized in a variety of applications, such as a device for inflating an air bag to match a passenger's weight with a vehicle's speed as detected by the air bag, a global positioning system (GPS) sensor that reads a continuous track and a treatment process for freight transportation, an interactive sensor for sensing changes in the air flow on the surface of airplane wings according to the air resistance and performing a corresponding operation according to the sensing result, an optical switch for outputting an optical signal at 20 nanometers per second, a sensor-manipulated heating/cooling device, and a sensor installed in a building for changing the flexibility of matter that reacts to atmospheric pressure. Since a mirror using MEMS technology, i.e., an MEMS mirror, can rapidly change its reflection angle to a certain direction, the MEMS mirror needs to be applied to an optical module to observe and track a rapidly moving object.

Disclosure of Invention

Technical Problem

[6] The present invention solves the above problems, and provides an optical system that allows a triggering optical module to detect an object of observation in a wide field of view (FOV) and allows an imaging optical module with a high resolving power to capture an image and observe in detail the detected object of observation using a mirror, which can rapidly tilt the reflection angle, so the optical system has both a wide FOV function and a high resolving power and can effectively observe a rapidly moving object.

Technical Solution

[7] In accordance with an exemplary embodiment of the present invention, the present invention provides an optical system including: (1) a triggering optical module for detecting an object of observation in a wide area, the triggering optical module having a wide field of view (FOV); (2) an imaging optical module for observing the object of observation in detail, the imaging optical module having a high resolving power and a FOV which is narrower than the wide FOV of the triggering optical module; (3) a mirror for controlling a reflection angle at a high speed, the mirror being located in front of the imaging optical module; and (4) a controller for determining whether the object of observation detected by the triggering optical module is a target of observation, and for controlling the mirror, so that the imaging optical module can input an optical signal from the detected object, form an image, and observe the detected object in detail, when it is determined that the detected object is a target of observation.

[8] Preferably, the triggering optical module includes: (a) a first lens part or mirror part with a wide FOV; (b) a first aperture for the first lens part or mirror part; and (c) a first optical signal detector for detecting an optical signal from the first lens part or mirror part.

[9] Preferably, the imaging optical module includes: (a) a second lens part or mirror part with a focal length, which is longer than that of the first lens part of the mirror part, and a high resolving power; and (b) a second optical signal detector for detecting an optical signal from the second lens part or mirror part. Here, the imaging optical module further comprises a second aperture for the second lens part or mirror part.

[10] Preferably, the imaging optical module further includes at least one or more mirrors for altering an optical path between the second lens part and the second optical signal detector.

[11] Preferably, the first aperture is identical to the second aperture.

[12] Preferably, the first optical signal detector is identical to the second optical signal detector.

[13] Preferably, the mirror includes an MEMS micro-mirror or an MEMS micro-mirror array, with a tilting angle can be changed at a high speed to control the reflection angle in an analog method, and whose reflection angle is relatively large.

Advantageous Effects

[14] As described above, the optical system, according to the present invention, allows a triggering optical module to detect an object of observation in a wide field of view (FOV) and allows an imaging optical module with a high resoling power to image and observe in detail the detected object of observation using a mirror, which can tilt the reflection angle at a high speed, so the optical system has both a wide FOV function and a high resolving power and can effectively observe a rapidly moving object.

Brief Description of the Drawings

[15] The features and advantages of the present invention will be more apparent from the following detailed description in conjunction with the accompanying drawings, in which:

[16] Figure 1 is a schematic perspective view illustrating an optical system according to an embodiment of the present invention;

[17] Figure 2 is a plan view illustrating the optical system of Figure 1;

[18] Figure 3 is a schematic plan view illustrating an optical system that shares one optical signal detector, according to an embodiment of the present invention;

[19] Figure 4 is a view illustrating a simulation where an optical module is performing a tracking process;

[20] Figure 5 is a view illustrating a spot formed on an optical signal detector by an on-axis optical signal and an optical signal whose incident angle is 10°in an optical system whose F number is 1;

[21] Figure 6 is a view illustrating a simulation result of an image formed on a pixel side of an optical signal detector when an on-axis optical signal and an optical signal whose incident angle is ±9° are incident on the optical signal detector;

[22] Figure 7 is a plan view illustrating a schematic structure of an image optical module used for simulation;

[23] Figure 8 shows spots formed on the surface of an optical signal detector of an image optical module according to the incident angle of optical signals, in which Figures 8A,

8B, and 8C show spots when incident angles of an optical signal are 0°, 5°, and 10° respectively;

[24] Figure 9 shows spots formed on the surface of an optical signal detector of an image optical module according to the incident angle of optical signals, in comparison with the spot of an optical signal whose incident angle is 0.5° in which Figures 9A, 9B, and 9C show spots when incident angles of an optical signal are 0°, 5°, and 10° respectively; and

[25] Figure 10 is ±0.7°are incident on the optical signal detector.

[26]

[27] <Brief Description of Symbols in the Drawings>

[28] 100: optical system (an embodiment of the present invention)

[29] 110: triggering optical module

[30] 112, 212: first lens part or mirror part

[31] 114: first aperture

[32] 116: first optical signal detector

[33] 120: imaging optical module

[34] 122, 222: second lens part or mirror part

[35] 126: second optical signal detector

[36] 128a, 128b, 128c, 128: normal reflection mirror

[37] 130, 230: mirror (which can rapidly change its reflection angle)

[38] 140: second aperture

[39] 300: an optical system sharing an optical signal detector (another embodiment of the present invention)

[40] 350: optical signal detector

[41] 360a, 360b: translucent mirror or micro-shutter

Best Mode for Carrying Out the Invention

[42] Now, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[43] Figure 1 is a schematic perspective view illustrating an optical system according to an embodiment of the present invention. As shown in Figure 1, the optical system 100 is configured in such way that: a triggering optical module 110 with a wide field of view (FOV) detects an object of observation in a wide area; an imaging optical module 120 has a high resolving power and a FOV, which is narrower than the wide FOV of the triggering optical module, and observes the object of observation in detail; and a mirror 130 is located in front of the imaging optical module 120 and controls a

reflection angle at a high speed. Although not shown clearly in Figure 1, the optical system 100, according to an embodiment of the present invention, includes a controller that determines whether the object of observation detected by the triggering optical module 110 is a target of observation, and controls the mirror 130, so that the imaging optical module 120 can input an optical signal from the detected object, form an image, and observe the detected object in detail, when it is determined that the detected object is a target of observation. Also, the optical system 100 further includes an aperture 140 for the mirror 130, which is hereinafter referred as a 'second aperture.' Each of the elements described above is explained in detail as follows.

[44] The triggering optical module 110 includes: a first lens part or mirror part 112 that has a relatively short focal length, which causes a wide FOV; a first aperture 114 for the first lens part or mirror part 112; and a first optical signal detector 116 for detecting an optical signal from the first lens part or mirror part 112. As shown in Figure 1, the first lens part or mirror part 112 is implemented by a spherical or parabolic lens or mirror. The first lens part or mirror part 112 may be implemented with a double Fresnel lens to secure a much wider field of view.

[45] The imaging optical module 120 includes: a second lens part or mirror part 122 that has a focal length longer than that of the first lens part of mirror part 112 of the triggering optical module 110, which causes a narrow field of view but a high resolving power; and a second optical signal detector 126 for detecting an optical signal from the second lens part or mirror part 122. As shown in Figure 1, the second lens part or mirror part 122 is implemented by a spherical or parabolic lens or mirror. The imaging optical module 120, as shown in Figure 1, further includes at least one or more mirrors 128a, 128b, and 128c to establish a relatively long optical path between the second lens part or mirror part 122 and the second optical signal detector 126, which reduce the system size. The mirrors 128a, 128b, and 128c are implemented by a normal reflection mirror.

[46] The mirror 130 allows the imaging optical module 120 to form an image from an optical signal of an object of observation, under the control of the controller. To this end, the reflection angle of the mirror 130 must be altered or controlled at a high speed. It is preferable that the mirror 130 is implemented by an MEMS micro-mirror or an MEMS micro-mirror array whose tilting angle can be altered at a high speed to control the reflection angle in an analog method and whose tilting angle is relatively large, so as to effectively track and observe an object of observation, although the object moves rapidly.

[47] Although not shown in Figure 1, the optical system 100 of the present invention is connected to a data storage unit, an interface unit, and a power supply. The data storage unit stores detected optical signals. The storage unit is implemented by a flash memory or a hard disc. The interface unit serves to interface between elements in the system. The interface unit is implemented by a bus interface unit. The power supply provides power to elements in the system.

[48] In the following description, the triggering optical module 110 and the imaging optical module 120 of the optical system 100 according to the present invention will be explained in detail through a specific example.

[49] The triggering optical module 110 serves as an optical module for searching for an object (event) of observation, and thus may have a relatively low resolution and a wide FOV. That is, since the triggering optical module 110 does not require a precise imaging ability, ultraviolet photons may be incident on the optical signal detector, possessing a relatively large possibility of aberration.

[50] The imaging optical module 120 forms an image for a triggered object of observation at a narrow FOV but at a high resolution. The second lens part or mirror part 122 of the imaging optical module 120 is implemented by a Fresnel lens whose focal length is 1 m and whose aperture is 10 cm. It should be understood that the second lens part or mirror part 122 may be implemented by a spherical lens or mirror. The mirror 130, located in front of the second lens part or mirror part 122, is implemented by an MEMS micro-mirror array which is a planar array and has an aperture of 10 cm. Although an event occurs anywhere, the MEMS micro-mirror array is operated in such a way as to face the object of observation detected by the triggering optical module and then provide an on-axis beam to the imaging optical module. The MEMS micro-mirror array must be responded to within a response time that includes a processing time and transformation time for all signals since the object of observation has been detected, preferably 100 μm, so that the MEMS micro-mirror array can determine whether an object which moves at an approximate light speed on the ground is a target of observation and can track the detected object. As well, the MEMS micro-mirror array can detect and track transient events that emerge at random, such as astronomical phenomena, cosmic phenomena, and atmospheric phenomena, etc., for example a gamma ray bursts (GRB) and transient luminous events (TLE).

[51] Figure 2 is a plan view illustrating the optical system of Figure 1.

[52] According to the design of an optical system, the second optical signal detector 126 and the first optical signal detector 116 can be implemented in such a way to be

formed as a single optical signal detector; and also the mirror 130 and the triggering optical module 110 can be implemented in such way to share a single aperture, instead the mirror 130 and the triggering optical module 110 utilizes the second aperture 140 and the first aperture 114, individually and respectively. Figure 3 is a schematic plan view illustrating an optical system that shares one optical signal detector, according to an embodiment of the present invention. As shown in Figure 3, the optical system 300 includes: a first lens part or mirror part 312 of a triggering optical module; a second lens part or mirror 322 and a reflection mirror 328, included in an imaging optical module; an MEMS micro-mirror 330; and an optical signal detector 350. Also, the optical system 300 further includes a translucent mirror or micro-shutter 360a and 360b for providing an optical path to the imaging optical module. The optical system 300 is the same as the optical system 100 except that the triggering optical module and the imaging optical module share a single optical signal detector 350. Therefore, the following description will omit explanation regarding the same elements and their operations between the optical systems 100 and 300.

[53] In the following, the simulation result for an optical system of the present invention is described according to the triggering optical module and the imaging optical module.

[54] Regarding the simulation result according to the triggering optical module: The field of view of the triggering optical module are calculated as ±10°, ±8.5°, and ±6.8° when F number (f/D) are 1, 1.2, and 1.5, correspondingly and respectively. The triggering optical module for the simulation is configured to include a Fresnel lens and an optical signal detector. Using this configuration, simulation is performed for each F number. Figure 4 is a view illustrating a simulation for an triggering optical module, and Figure 5 is a view illustrating a spot formed on an optical signal detector by an on-axis optical signal and an optical signal whose incident angle is 10 in an optical system whose F number is 1. The rectangle around the spot, as shown in Figure 5, is twice as large as the pixel of the detector. When the incident angle is 10°, a peak is formed at a position spaced apart from the chief ray by 2~3 mm. The chief ray of an optical signal whose incident angle is 10 is formed at a position spaced apart from the center of the detection surface of the detector by 15.6 mm, which is shown in Figure 5. In order to check the shape of image formed at the pixels of the optical signal detector, a track optical module is simulated assuming that it is composed of four optical signal detectors with 64 channels. Figure 6 is a view illustrating a simulation result of an image formed on a pixel side of an optical signal detector when an on-axis optical

signal and an optical signal whose incident angle is ±9° are incident on the optical signal detector. Referring to Figure 6, the FOV of the optical system according to the present invention becomes ±9° above in a trigger optical system whose F number is 1; and also, the optical signal incident within the FOV of the triggering optical module is detected by the optical signal detector and is used as a trigger signal.

[55] Regarding the simulation result according to the imaging optical module: The triggering optical module reads a position where an object of observation (for example, a GRB or TLE) occurs and then transmits the occurrence position of an object of observation to the controller in order to operate the mirror. The controller changes the tilt angle of the mirror to face the occurrence position of the object of observation. Therefore, the optical signal can be always transmitted, in on-axis, to the optical signal detector of the imaging optical module through the mirror, although an event occurs anywhere within the FOV of the triggering optical module. For the simulation, the imaging optical module is used where F number (=f/D) is 10, the FOV is 0.7°, and the FOV per pixel is approximately 0.08°. For the simulation, the second lens of the imaging optical module uses a Fresnel lens whose focal length 1 m and whose aperture is 10 cm. Figure 7 is a plan view illustrating a schematic structure of an imaging optical module used for simulation. Through the simulation of Figure 7, optical signals incident at other angles are monitored to ensure that they are always focused at a preset point by tilting the mirror. The simulation is performed after the detection surface of the optical signal detector is located at the focus of a lens. The mirror is tilted 45 with respect to the surface direction of the aperture of the optical system at the initial state. The optical signal incident orthogonally to the surface direction of the aperture passes through the lens by the mirror and then is focused on the center portion of the optical signal detector, and this case is defined as the optical signal incident angle is 0°.

[56] Figure 8 shows spots formed on the surface of an optical signal detector of an image optical module according to the incident angle of optical signals, in which Figures 8A, 8B, and 8C show spots when incident angles of an optical signal are 0°, 5°, and 10° respectively. Through the simulation of Figure 8, when the mirror is tilted by 2.5° and 5°, respectively, it is checked that the optical system can be controlled so that optical signals incident at other directions can be focused at the same spot of the optical signal detector. That is, as shown in Figure 8, the simulation ensures that the optical system of the present invention can constantly maintain the focus surface by tilting the mirror. In the simulation, the entire surface of the mirror is set to be tilted, so that the image is extended up and down as shown in the simulation result. This is because the tilt angle

of the mirror is increased and thus the effective reflection area of the mirror transmitted to the Fresnel lens is changed. However, this phenomenon can be reduced when a micro-mirror array, which can be divided into small-sized mirrors and tilted, is used in the system. To this end, as described above, it is preferable that the mirror of the optical system is implemented by an MEMS mirror array whose tilting angle is changed at a high speed so that the reflection angle can be rapidly controlled in an analog method. As established through the simulation results, tilting micro-mirrors make it possible to establish an on-axis optical system for the optical signals incident at other different angles and also to perform a magnification and an accurate measurement with respect to a wide FOV according to tiling angles of micro-mirrors.

[57] Figure 9 shows spots formed on the surface of an optical signal detector of an image optical module according to the incident angle of optical signals, in comparison with a spot of an optical signal whose incident angle is 0.5°, in which Figures 9A, 9B, and 9C show spots when incident angles of an optical signal are 0°, 5°, and 10° respectively. This simulation is performed for the shape formed when an optical signal with a tilting angle of 0.5° is incident on the optical signal detector. This simulation is performed after the mirror is tilted according to incident angles of optical signals, respectively, and thus the focus of the incident light is formed on the center of the optical signal detector. This simulation is performed to predict the shape of imaging an object of observation. In Figure 9, the center of the rectangle is a traveling point of the chief ray. For an optical signal of a tilting angle of 0.5°, the chief ray deviates from the center of the rectangle by a pixel unit, which causes an aberration. This aberration is created because the Fresnel lens is not optimized and the image plane is curved. When the FOV is widened using two Fresnel lenses, an optical system with a relatively small aberration can be used for an optical signal incident at a relatively large angle. Such an aberration can also be improved by optimizing the structure of the entire optical system. Figure 10 is a view illustrating a simulation to check an image formed on a pixel side of an optical signal detector. More specifically, Figure 10 is a view illustrating a simulation result of an image formed on a pixel side of an optical signal detector when an on-axis optical signal and an optical signal whose incident angle is ±0.7° are incident on the optical signal detector. From the simulation as shown in Figure 10, the imaging optical module can observe a magnified image of an event.

[58] Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of

the invention as disclosed in the accompanying claims.

Claims

[1] An optical system comprising:
(1) a triggering optical module for detecting an object of observation in a wide area, the triggering optical module having a wide field of view (FOV);
(2) an imaging optical module for observing the object of observation in detail, the imaging optical module having a high resolving power and a FOV which is narrower than the wide FOV of the triggering optical module;
(3) a mirror for controlling a reflection angle at a high speed, the mirror being located in front of the imaging optical module; and
(4) a controller for determining whether the object of observation detected by the triggering optical module is a target of observation, and for controlling the mirror, so that the imaging optical module can input an optical signal from the detected object, form an image, and observe the detected object in detail, when it is determined that the detected object is a target of observation.

[2] The optical system according to claim 1, wherein the triggering optical module comprises:
(a) a first lens part or mirror part with a wide FOV;
(b) a first aperture for the first lens part or mirror part; and
(c) a first optical signal detector for detecting an optical signal from the first lens part or mirror part.

[3] The optical system according to claim 2, wherein the imaging optical module comprises:
(a) a second lens part or mirror part with a focal length, which is longer than that of the first lens part of the mirror part, and a high resolving power; and
(b) a second optical signal detector for detecting an optical signal from the second lens part or mirror part,
wherein the imaging optical module further comprises a second aperture for the second lens part or mirror part.

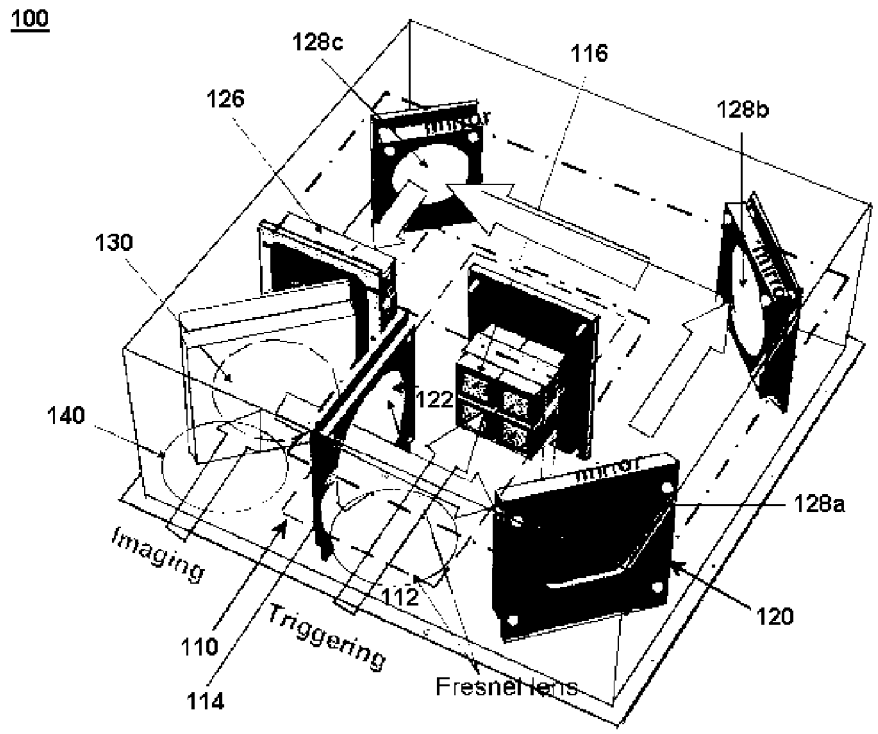
[4] The optical system according to claim 3, wherein the imaging optical module further comprises:
at least one or more mirrors for altering an optical path between the second lens part and the second optical signal detector.

[5] The optical system according to claim 3, wherein the first aperture is identical to the second aperture.

[6] The optical system according to claim 3, wherein the first optical signal detector is identical to the second optical signal detector.

[7] The optical system according to any one of claims 1 to 6, wherein the mirror comprises an MEMS micro-mirror or an MEMS micro-mirror array, with a tilting angle can be changed at a high speed to control the reflection angle in an analog method, and whose reflection angle is relatively large.

[Fig. 1]


100
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128b
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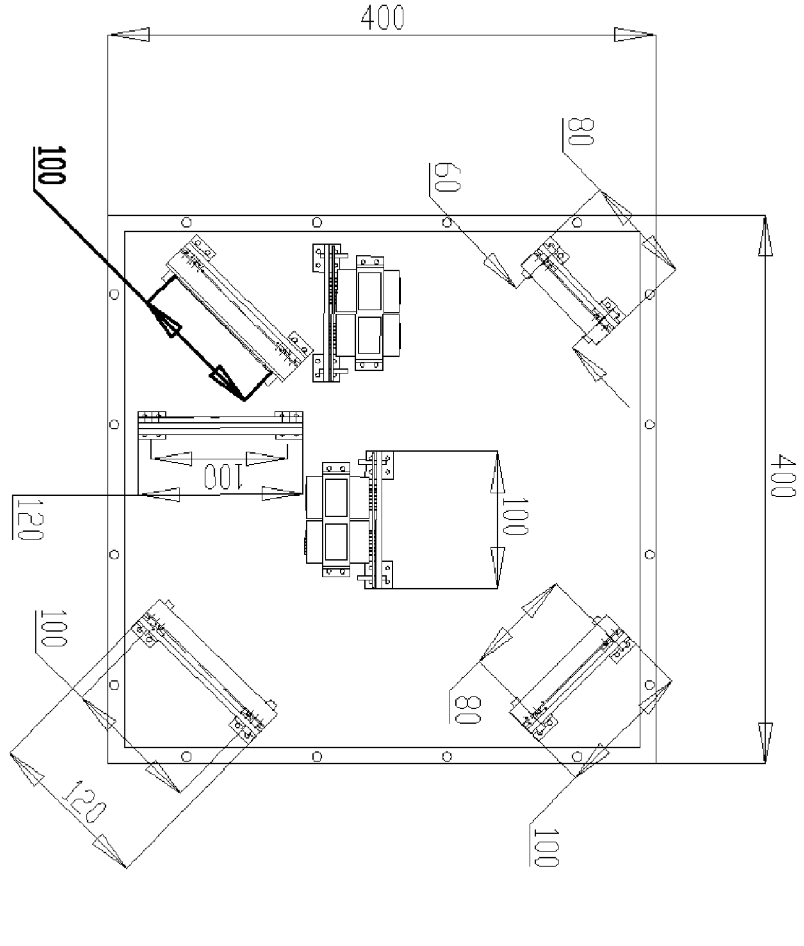
122
140
128a
Imaging
110
Triggering
112
120
114
Fresnel lens

[Fig. 2]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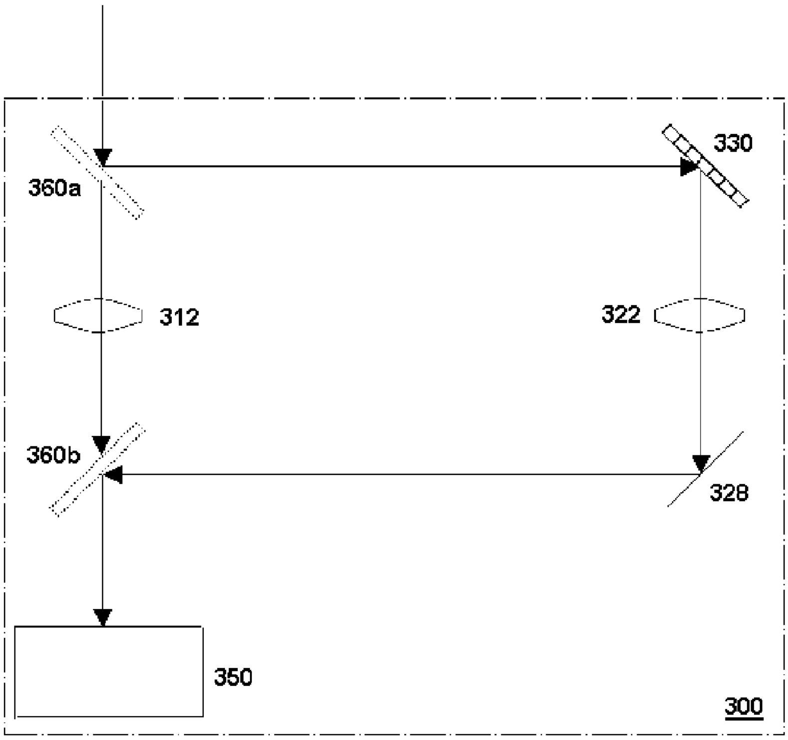
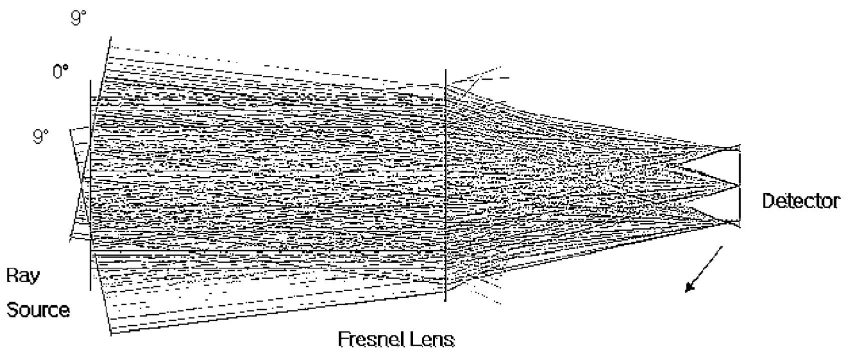
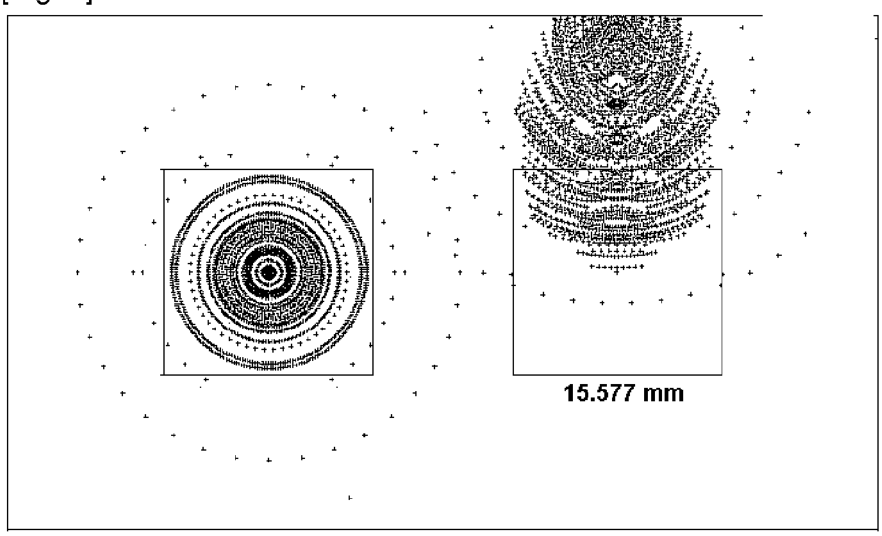
[Fig. 3]



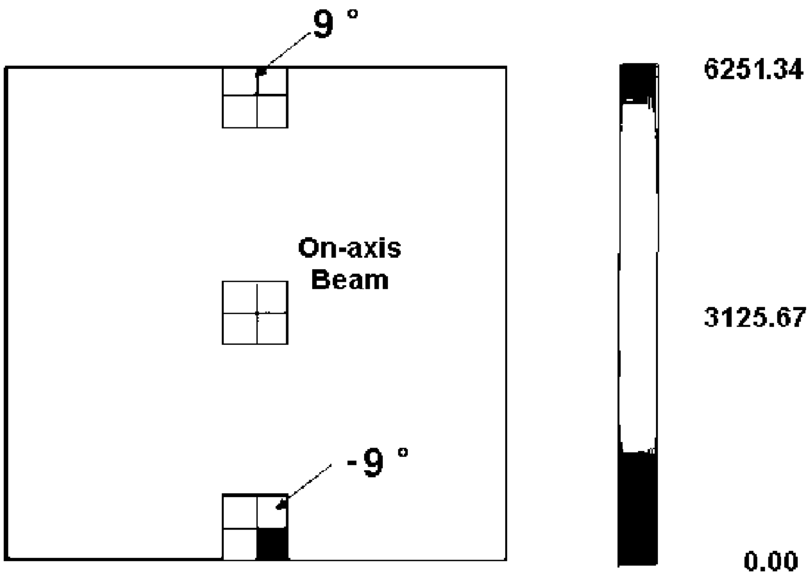
[Fig. 4]



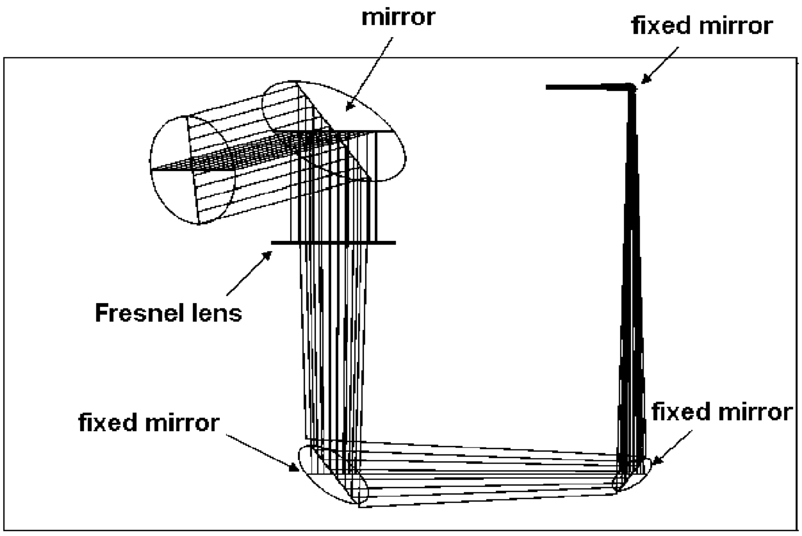
[Fig. 5]



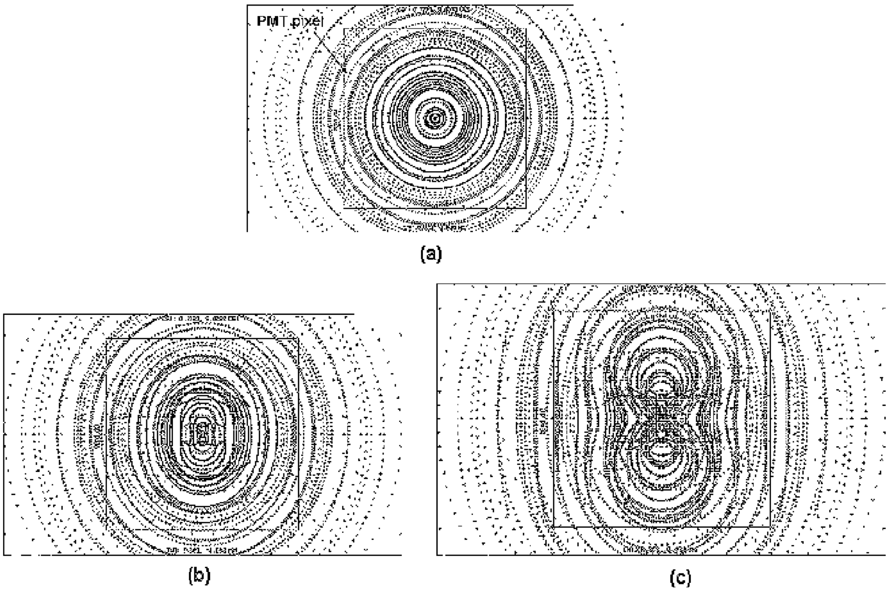
[Fig. 6]


9 °
On-axis
Beam
-9 °
6251.34
3125.67
0.00

[Fig. 7]


mirror
fixed mirror
Fresnel lens
fixed mirror
fixed mirror

[Fig. 8]


PMT pixel
(a)
(b)
(c)

[Fig. 9]

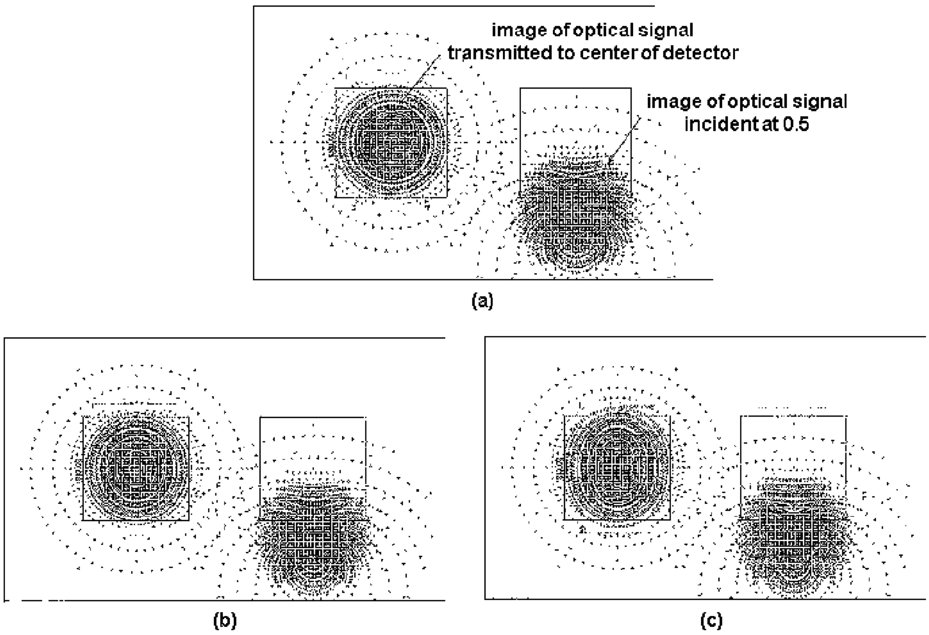
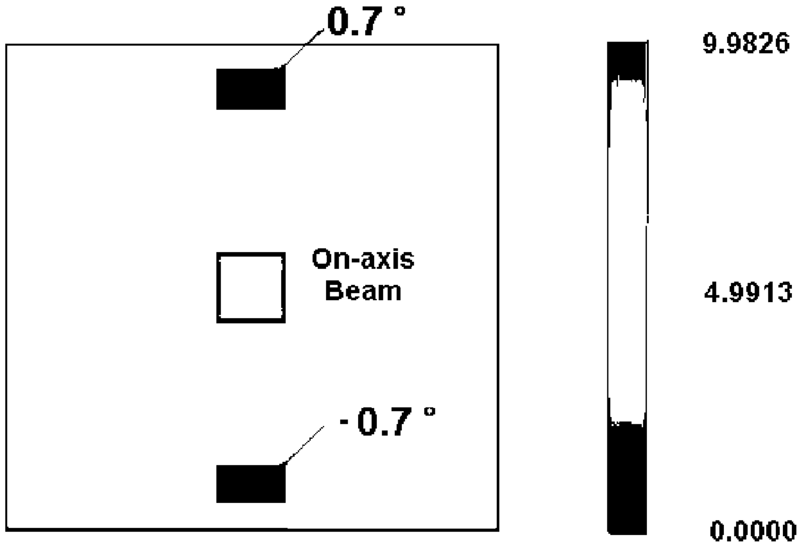


image of optical signal
transmitted to center of detector
image of optical signal
incident at 0.5
(a)
(b)
(c)

[Fig. 10]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2008/000934

A. CLASSIFICATION OF SUBJECT MATTER

G02B 27/02(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)
IPC 8 : G02B

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 model since 1975.
Japanese utility models and applications for utility model since 1975.

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US7,158,180 B2 (JASON MICHAEL NEIDRICH) 02 January 2007 See abstract and fig1.	1-7
A	JP09-265655 A (MATSUSHITA ELECTRIC IND., CO., LTD.) 07 October 1997 See abstract and fig1.	1-7
A	US6,359,681 B1 (BRIEN J. HOUSAND et al.) 19 March 2002 See abstract and fig4.	1-7
A	KR10-0715236 B1 (EHWA UNIVERSITY INDUSTRY COLLABORATION FOUNDATION) 11 May 2007 See abstract and fig2.	1-7

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

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 MAY 2008 (28.05.2008)	**28 MAY 2008 (28.05.2008)**

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Facsimile No. 82-42-472-7140

Authorized officer
KOH, JAE HYUN
Telephone No. 82-42-481-5687

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2008/000934

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