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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 December 2008 (24.12.2008)

PCT

(10) International Publication Number
WO 2008/157758 A1

(51) International Patent Classification:
G02B 26/10 (2006.01) *G02B 27/00* (2006.01)

(21) International Application Number:
PCT/US2008/067661

(22) International Filing Date: 20 June 2008 (20.06.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/945,302 20 June 2007 (20.06.2007) US
12/142,661 19 June 2008 (19.06.2008) US

(71) Applicant *(for all designated States except US)*: **CUBIC CORPORATION** [US/US]; 9333 Balboa Avenue, San Diego, California 92123 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MARYFIELD, Tony** [US/US]; 14121 Los Nietos Avenue, Poway, California 92064 (US). **DADKHAH, Mahyar** [US/US]; 12465 Carmel Park Drive, San Diego, California 92130 (US).

(74) Agents: **SANDERS, Jason, A.** et al.; Townsend and Townsend and Crew LLP, 1200 Seventeenth Street, Suite 2700, Denver, CO 80202 (US).

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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,

[Continued on next page]

(54) Title: COMBINATION PZT AND MEMS BEAM STEERING

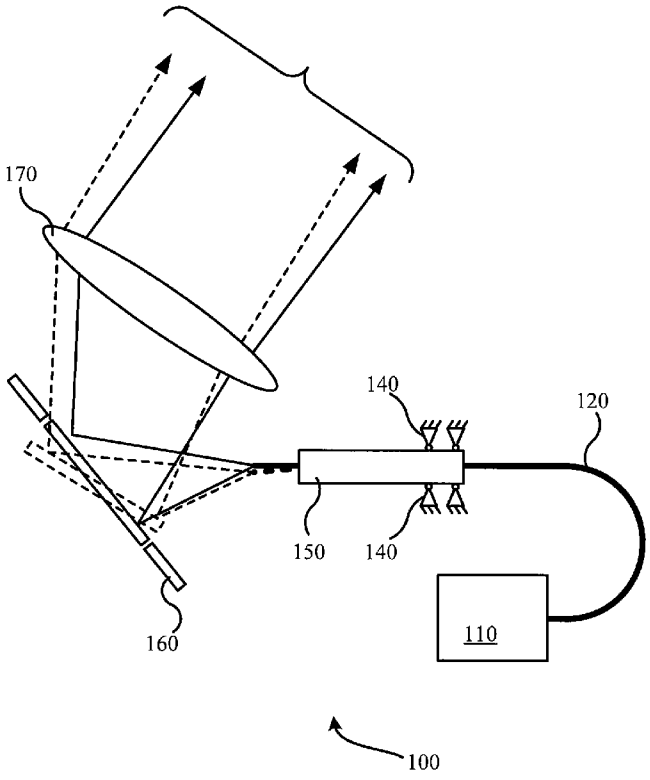


FIG. 1

(57) Abstract: Beam steering systems and methods are disclosed according to various embodiments. A beam steering system may include a laser (110) that produces a beam of light. The beam of light may then be directed through a piezoelectric tube (150) that includes a light guide (120) and one or more piezoelectric elements (140). The piezoelectric tube is coupled with the light source, such that the beam of light is conducted through the light guide. The piezoelectric tube is coupled with a scanning optical element (160) that includes an optical element and a steering device. A controller may be communicatively coupled with the light source, the piezoelectric tube and the scanning optical element. The controller may include instructions to dither the beam of light with the piezoelectric tube and/or instructions to steer the beam of light with the scanning optical element.

WO 2008/157758 A1

NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

COMBINATIONAL PZT AND MEMS BEAM STEERING

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application is a non-provisional, and claims the benefit, of commonly assigned U.S. Provisional Patent Application No. 60/945,302, filed June 20, 2007, entitled "Combinational PZT And MEMS Beam Steering," the entirety of which is herein incorporated by reference for all purposes.

BACKGROUND

[0002] This disclosure relates in general to piezoelectric light guides and, but not by way of limitation, to piezoelectric light guides as a dithering tool in a beam steering application among other things.

[0003] Atmospheric conditions often cause beam spreading and/or beam wander in a light beam. In some applications, light beams are used to communicate between a transmitter and a receiver. Due to such atmospheric affects, communication signals directed toward a receiver may be off target. Moreover, because these atmospheric affects are often transient, transmitters often employ beam steering and/or beam dithering protocols to track a receiver and/or adjust the beams transmission.

BRIEF SUMMARY

[0004] In one embodiment, the present disclosure provides for a beam steering system that includes an illumination means, a dithering means, and a scanning means. The illumination means provides a beam of light and may comprise a laser, a laser diode, or another light source. The dithering means, for example, a light guide and at least one piezoelectric element, may be used to dither the beam of light. The scanning means, for example, a microelectromechanical mirror, may be independent from said dithering means and may scan the dithered beam of light toward a target. Moreover, the scanning means may scan at a frequency lower than the frequency of the dithering means. For example, the dithering means may dither the beam of light at a frequency greater than about 10 KHz. In another embodiment the dithering means may dither the beam of light at a frequency between 5 KHz and 50 KHz. As another example, the scanning means may scan the beam of light at a

frequency between 50 Khz and 100 KHz. In another embodiment, the scanning means may scan the beam of light at a frequency between 100 KHz and 1 MHz.

[0005] In another embodiment, the disclosure provides for another beam steering system comprising a light source that provides a beam of light, a piezoelectric tube, a scanning optical element, and a controller. The light source may be a laser. The piezoelectric tube may include a light guide and one or more piezoelectric elements. The piezoelectric tube may be coupled with the light source, such that at least a portion of the beam of light is conducted through the light guide. The scanning optical element may be coupled with the piezoelectric tube. The scanning optical element may include an optical element and a steering device. The controller may be communicatively coupled with the light source, the piezoelectric tube and the scanning optical element; and may include instructions to dither the beam of light with the piezoelectric tube and/or instructions to steer the beam of light with the scanning optical element.

[0006] In various embodiments, the steering device may include a microelectromechanical device. In various other embodiments, the optical element may include a mirror. The light source may include a laser or laser diode. In some embodiments, the light guide is cylindrical and/or comprises fiber optics. In some embodiments the light guide may include four piezoelectric elements distributed radially about the light guide and/or substantially equidistant from one another. The instructions to dither the beam of light may include instructions to deflect the beam of light such that the beam of light maps out a substantially circular pattern.

[0007] Another beam steering system is also provided according to another embodiment. The beam steering system may include a laser that provides a beam of laser light, a piezoelectric tube, a scanning microelectromechanical mirror, and a controller. The piezoelectric tube may be cylindrically shaped. The light guide may be housed within the piezoelectric tube and at least four piezoelectric elements may be coupled radially around the piezoelectric tube. The piezoelectric tube may be coupled with the laser such that at least a portion of a beam of laser light from the laser may be conducted through the light guide. The scanning microelectromechanical mirror may include a steering device coupled with the piezoelectric tube. The beam of light may be incident on the scanning microelectromechanical mirror after exiting the piezoelectric tube. The controller may be communicatively coupled with and control the operation of the light source, the piezoelectric

tube, and the scanning microelectromechanical mirror. The controller may includes instructions to dither the beam of light with the piezoelectric tube and/or instructions to steer the beam of light with the scanning microelectromechanical mirror.

[0008] A beam steering method is also provided according to another embodiment. A beam of light is directed toward a light guide. One or more piezoelectric elements coupled with the light guide is activated. The activating dithers the beam of light according to a dither pattern. The dithered light may then be directed toward a steering optical element. The beam of light may then be steered toward a target with the steering optical element.

[0009] Further areas of applicability of the present disclosure will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating various embodiments, are intended for purposes of illustration only and do not limit the scope of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 shows a beam steering device that includes microelectromechanical mirror and a piezoelectric light guide according to one embodiment.

[0011] FIG. 2A shows a steering and dithering plan according to one embodiment.

[0012] FIG. 2B shows the resulting steering and dithering pattern according to one embodiment.

[0013] FIG. 3 shows an end view of a piezoelectric light guide including four piezoelectric elements according to one embodiment.

[0014] FIG. 4 provides a schematic representation of a computer system that may be used to implement various methods of the invention.

[0015] FIG. 5 shows a flowchart of another embodiment.

[0016] In the appended figures, similar components and/or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

DETAILED DESCRIPTION

[0017] The ensuing description provides preferred exemplary embodiment(s) only, and is not intended to limit the scope, applicability or configuration of the disclosure. Rather, the ensuing description of the preferred exemplary embodiment(s) will provide those skilled in the art with an enabling description for implementing a preferred exemplary embodiment. It should be understood that various changes may be made in the function and arrangement of elements without departing from the spirit and scope as set forth in the appended claims.

[0018] Various embodiments of the invention provide for a decoupled beam dithering and beam steering device. That is, the dithering mechanism and the beam steering mechanisms are separated and can be independently controlled. This decoupling may allow for high frequency dithering with lower frequency steering, and/or provide low beam deviation dithering with higher beam deviation steering. A piezoelectric light guide may be used as the dithering mechanism. Such devices may have quick response times and may operate at high frequencies. One or more piezoelectric elements, for example, may provide a directional force on the light guide that deviates the beam of light. A microelectromechanical mirror, for example, may be used to steer the dithered beam of light.

[0019] Referring first to FIG. 1, a beam steering device 100 that includes microelectromechanical mirror 160 and piezoelectric tube 150 is shown according to one embodiment. The beam steering device 100 also includes a lens 170, a laser 110 and a fiber optic (Please remove tube) 120. The piezoelectric tube 150 may include a light guide and one or more piezoelectric elements 140. The light guide may include fiber optics, crystal fibers, or any other type of waveguide. The laser 110 may include any type of laser operating with any wavelength. Indeed, the embodiments provided herein, do not require a specific wavelength and/or laser type. The lens 170 may include any type of optical element for focusing and/or collimating light. The piezoelectric tube 150 or piezoelectric tube, may include one or more piezoelectric elements 140. In one embodiment, the piezoelectric tube 150 includes four piezoelectric elements 140. The dithering and beam steering may be decoupled using the microelectromechanical mirror 160 for beam steering, and the piezoelectric tube 150 for dithering and/or nutation.

[0020] When a beam of light is conducted through the piezoelectric tube 150, the piezoelectric elements 140 may be activated to deflect the light guide in any direction depending on the placement of the piezoelectric elements 140 about the light guide and/or

depending on the applied voltage on the piezoelectric elements 140. In some embodiments, the piezoelectric elements 140 may be used to deflect the light guide small distances at high frequencies. For example, in one embodiment, the piezoelectric elements 140 may deflect the light guide about ±5 μm. In another embodiment, the piezoelectric elements 140 may deflect the light guide between about ±1 μm and ±10 μm. As another example, in another embodiment, piezoelectric elements 140 may deflect the light guide between about ±10 μm and ±100 μm. In another embodiment, the piezoelectric elements 140 may deflect the light guide at a frequency greater than 1 kHz. In another embodiment, the piezoelectric elements 140 may deflect the light guide at a frequency between 10 kHz and 100 KHz. In another embodiment, the piezoelectric elements 140 may deflect the light guide at a frequency between about 100 kHz and 1 MHz. In another embodiment the piezoelectric elements 140 may deflect the light guide 150 at a frequency greater than 1 MHz.

[0021] The piezoelectric tube 150 may dither the beam of light according to various dithering patterns. For example, the piezoelectric tube 150 may dither the beam of light in a circular, oval, polygon-shaped and/or rectangular pattern. FIG. 2A shows an example of a circular dithering pattern 210.

[0022] Returning to FIG. 1, dithered light from the piezoelectric tube 150 is incident on the microelectromechanical mirror 160. The microelectromechanical mirror 160 may be used to steer or scan the light beam. This steering may occur over large angles and at slow frequencies. For example, in one embodiment, the microelectromechanical mirror 160 may steer a beam of light ±1°. In another embodiment, the microelectromechanical mirror 160 may steer a beam of light between ±1° and ±5°. In another embodiment, the microelectromechanical mirror 160 may steer a beam of light between ±5° and ±10°. In another embodiment, the microelectromechanical mirror 160 may steer a beam of light at a frequency of about 100 Hz. In another embodiment, the microelectromechanical mirror 160 may steer a beam of light at a frequency between about 10 Hz and 500 Hz.

[0023] FIG. 2A shows a raster scan steering pattern 220. While a fixed steering pattern is shown, the steering pattern may also be random, a linear pattern or vary over time. By combining the steering and the dithering, a pattern of moving circles is produced as shown in FIG. 2B. This decoupling of the steering and dithering by using a separate device for each, may allow for higher dithering speeds, lighter weight components, higher steering angles, greater portability, simplified controls, etc. Moreover, the controls can be designed to

resonate with the piezoelectric elements and/or the microelectromechanical mirror in order reduce power consumption.

[0024] FIG. 3 shows an end view of a piezoelectric light guide 315 that includes four piezoelectric elements 305 according to one embodiment. The four piezoelectric elements 305 are arrayed approximately 90° from each other around the piezoelectric light guide 315. Each piezoelectric element 305 may provide a directional force to the piezoelectric light guide 315, and thus deflect the light guide 315 a small amount. Moreover, opposing piezoelectric elements, such as, 305-D and 305-B as well as 305-A and 305-C, may coordinate by simultaneously applying positive and negative directional forces. Using these piezoelectric elements 305, the light guide 315 may be deflected according to any time varying functions. For example, the piezoelectric light guide 315 may be deflected in a circular pattern by varying the electric charge incident on the piezoelectric elements 305 over time using time varying sinusoidal functions.

[0025] Operation of a beam steering device may be coordinated with a computational system like that shown schematically in FIG. 4. The drawing broadly illustrates how individual system elements may be implemented in a separated or more integrated manner. The computational device 400 is shown comprised of hardware elements that are electrically coupled via bus 426, which is also coupled with the portions of the beam steering device that may include, for example, a microelectromechanical mirror 452, a laser, and piezoelectric element(s) 454. The hardware elements include a processor 402, an input device 404, an output device 406, a storage device 408, a computer-readable storage media reader 410a, a communications system 414, a processing acceleration unit 416 such as a DSP or special-purpose processor, and a memory 418. The computer-readable storage media reader 410a is further connected to a computer-readable storage medium 410b, the combination comprehensively representing remote, local, fixed, and/or removable storage devices plus storage media for temporarily and/or more permanently containing computer-readable information. The communications system 414 may comprise a wired, wireless, modem, and/or other type of interfacing connection and permits data to be exchanged with external devices.

[0026] The computational device 400 also comprises software elements, shown as being currently located within working memory 420, including an operating system 424 and other code 422, such as a program designed to implement methods of the invention. It will be

apparent to those skilled in the art that substantial variations may be used in accordance with specific requirements. For example, customized hardware might also be used and/or particular elements might be implemented in hardware, software (including portable software, such as applets), or both. Further, connection to other computing devices such as network input/output devices may be employed.

[0027] FIG. 5 shows a flowchart of another embodiment. A beam of light is directed toward a piezoelectric light guide as shown in block 505. For example, a laser beam may be directed toward a piezoelectric light guide. The piezoelectric light guide may then dither the beam of light according to a dithering pattern at block 510. For example the pattern may be made using a time varying function. As one example, the time varying function may produce a circular or oval dither pattern. The dithered light may then be directed toward a microelectromechanical (MEM) mirror at block 515. The dithered light may then be steered with the microelectromechanical mirror at block 520. As described in other embodiments the dithering may occur at high frequencies and produce small deviations in the beam of light, where as the steering may occur at lower frequencies and produce larger deviations in the beam of light.

[0028] Specific details are given in the above description to provide a thorough understanding of the embodiments. However, it is understood that the embodiments may be practiced without these specific details. For example, circuits, structures, and/or components may be shown in block diagrams in order not to obscure the embodiments in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures, components, and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

[0029] Implementation of the techniques, blocks, steps and means described above may be done in various ways. For example, these techniques, blocks, steps and means may be implemented in hardware, software, or a combination thereof. For a hardware implementation, the processing units may be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described above and/or a combination thereof.

[0030] Also, it is noted that the embodiments may be described as a process which is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be rearranged. A process is terminated when its operations are completed, but could have additional steps not included in the figure. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination corresponds to a return of the function to the calling function or the main function.

[0031] Furthermore, embodiments may be implemented by hardware, software, scripting languages, firmware, middleware, microcode, hardware description languages and/or any combination thereof. When implemented in software, firmware, middleware, scripting language and/or microcode, the program code or code segments to perform the necessary tasks may be stored in a machine readable medium, such as a storage medium. A code segment or machine-executable instruction may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a script, a class, or any combination of instructions, data structures and/or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters and/or memory contents. Information, arguments, parameters, data, etc., may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

[0032] For a firmware and/or software implementation, the methodologies may be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. Any machine-readable medium tangibly embodying instructions may be used in implementing the methodologies described herein. For example, software codes may be stored in a memory. Memory may be implemented within the processor or external to the processor. As used herein the term "memory" refers to any type of long term, short term, volatile, nonvolatile, or other storage medium and is not to be limited to any particular type of memory or number of memories, or type of media upon which memory is stored.

[0033] Moreover, as disclosed herein, the term "storage medium" may represent one or more devices for storing data, including read only memory (ROM), random access memory (RAM), magnetic RAM, core memory, magnetic disk storage mediums, optical storage

mediums, flash memory devices and/or other machine readable mediums for storing information. The term "machine-readable medium" includes, but is not limited to portable or fixed storage devices, optical storage devices, wireless channels and/or various other mediums capable of storing, containing or carrying instruction(s) and/or data.

[0034] While the principles of the disclosure have been described above in connection with specific apparatuses and methods this description is made only by way of example and not as limitation on the scope of the disclosure.

WHAT IS CLAIMED IS:

1. A beam steering system comprising:

illumination means for providing a beam of light;

dithering means for dithering the beam of light provided by the illumination means; and

scanning means independent from said dithering means for scanning the dithered beam of light, wherein the scanning means scans at a frequency lower than the frequency of the dithering means.

2. The beam steering system according to claim 1, wherein the dithering means dithers the beam of light at a frequency greater than about 10 KHz.

3. The beam steering system according to claim 1, wherein the scanning means scans the beam of light at a frequency less than about 100 Hz.

4. The beam steering system according to claim 1, wherein the dithering means comprises a light guide and at least one piezoelectric element.

5. The beam steering system according to claim 1, wherein the scanning means includes a microelectromechanical mirror.

6. The beam steering system according to claim 1, wherein the illumination means includes a laser.

7. A beam steering system comprising:

a light source providing a beam of light;

a piezoelectric tube including a light guide and one or more piezoelectric elements, wherein the piezoelectric tube is coupled with the light source, such that at least a portion of the beam of light is conducted through the light guide;

a scanning optical element coupled with the piezoelectric tube, wherein the scanning optical element comprises an optical element and a steering device; and

a controller communicatively coupled with the light source, the piezoelectric tube and the scanning optical element, wherein the controller includes instructions to dither the beam of light with the piezoelectric tube and instructions to steer the beam of light with the scanning optical element.

8. The beam steering system according to claim 7, wherein the steering device comprises a microelectromechanical device.

9. The beam steering system according to claim 7, wherein the optical element comprises a mirror.

10. The beam steering system according to claim 7, wherein the light source comprises a laser.

11. The beam steering system according to claim 7, wherein the light source comprises a laser diode.

12. The beam steering system according to claim 7, wherein the light guide is cylindrical.

13. The beam steering system according to claim 7, wherein the piezoelectric tube includes four piezoelectric elements distributed radially about the light guide and substantially equidistant from one another.

14. The beam steering system according to claim 7, wherein the instructions to dither the beam of light comprises instructions to deflect the beam of light such that the beam of light maps out a substantially circular pattern.

15. The beam steering system according to claim 7, wherein the light guide comprises a fiber-optic.

16. A beam steering system comprising:

a laser providing a beam of laser light;

a piezoelectric tube including a cylindrical light guide and at least four piezoelectric elements coupled radially around the piezoelectric tube, wherein the piezoelectric tube is coupled with the laser such that at least a portion of a beam of laser light from the laser is conducted through the light guide;

a scanning microelectromechanical mirror including a steering device coupled with the piezoelectric tube, wherein a beam of light is incident on the scanning microelectromechanical mirror after exiting the piezoelectric tube ; and

a controller communicatively coupled with the light source, the piezoelectric tube and the scanning microelectromechanical mirror, wherein the controller is configured to control the operation of the light source, the piezoelectric tube , and the scanning microelectromechanical mirror, wherein the controller includes instructions to dither the beam of light with the piezoelectric tube and instructions to steer the beam of light with the scanning microelectromechanical mirror.

17. The beam steering system according to claim 16, wherein the light guide comprises a fiber-optic.

18. A method of beam steering comprising:

directing a beam of light toward a light guide;

activating one or more piezoelectric elements coupled with the light guide, wherein said activating dithers the beam of light according to a dither pattern;

toward a steering optical element; and

steering the beam of light toward a target with the steering optical element.

19. The method according to claim 18, wherein the dither pattern is a substantially circular pattern.

20. The method according to claim 18, wherein said activating further comprises substantially oppositely activating two opposed piezo-optical elements.

21. The method according to claim 18, wherein the steering further includes directing a steering device to steer the beam of light toward the target.

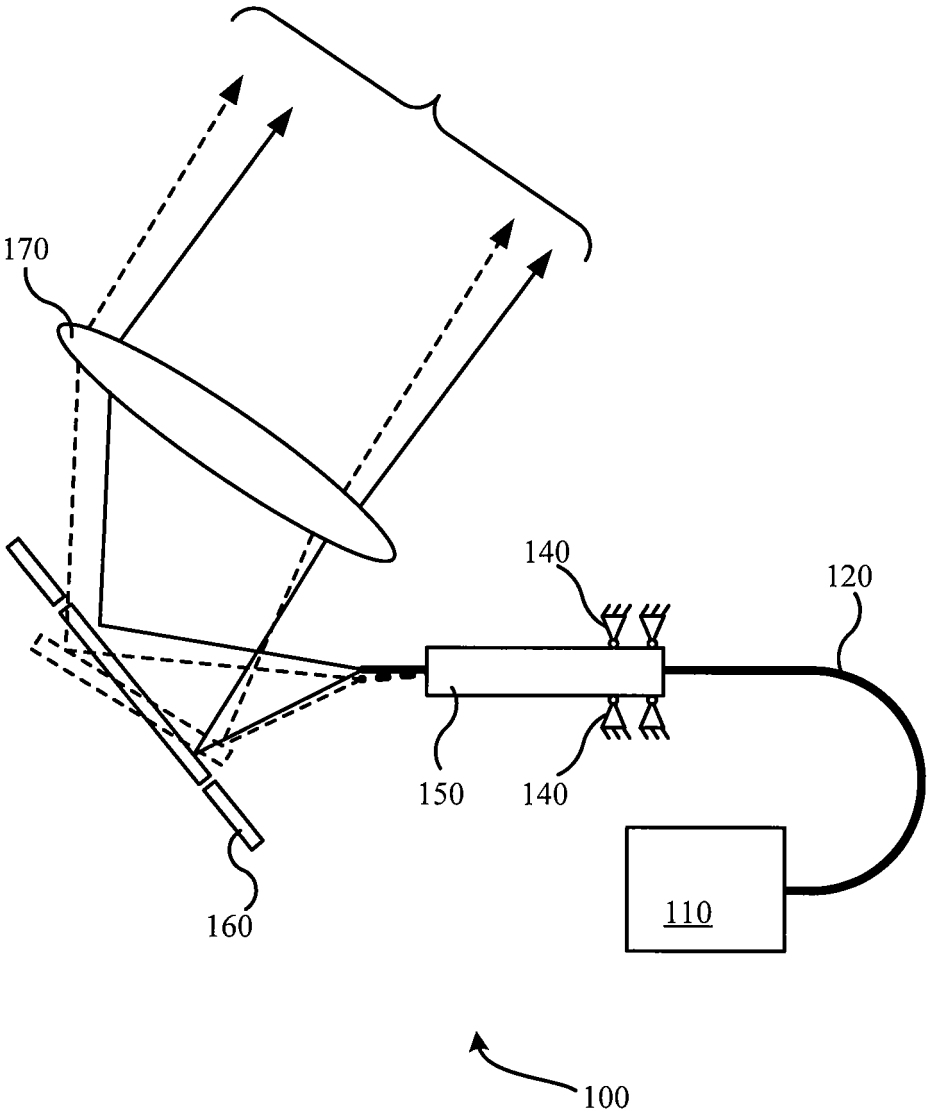


FIG. 1

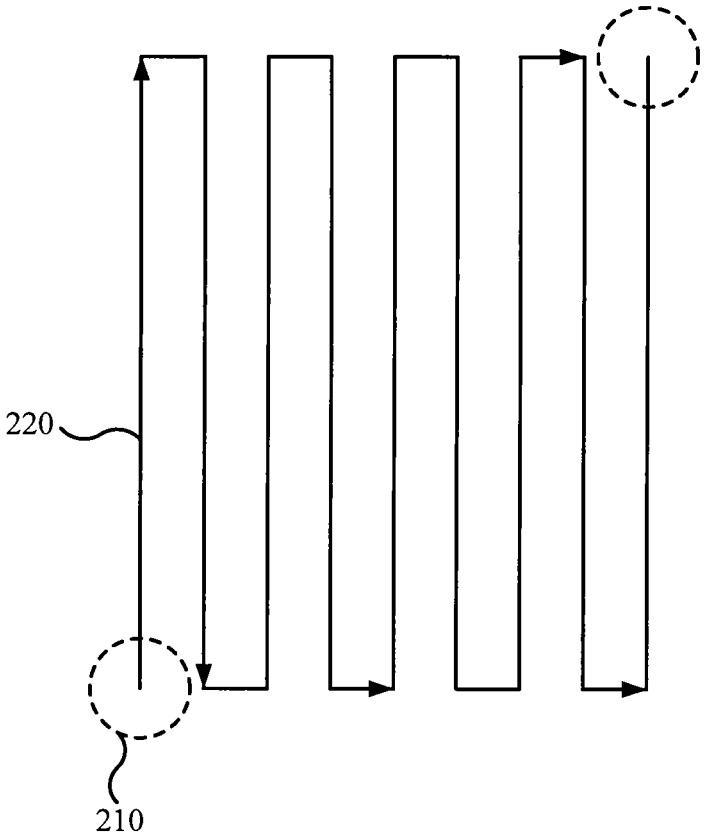


FIG. 2A

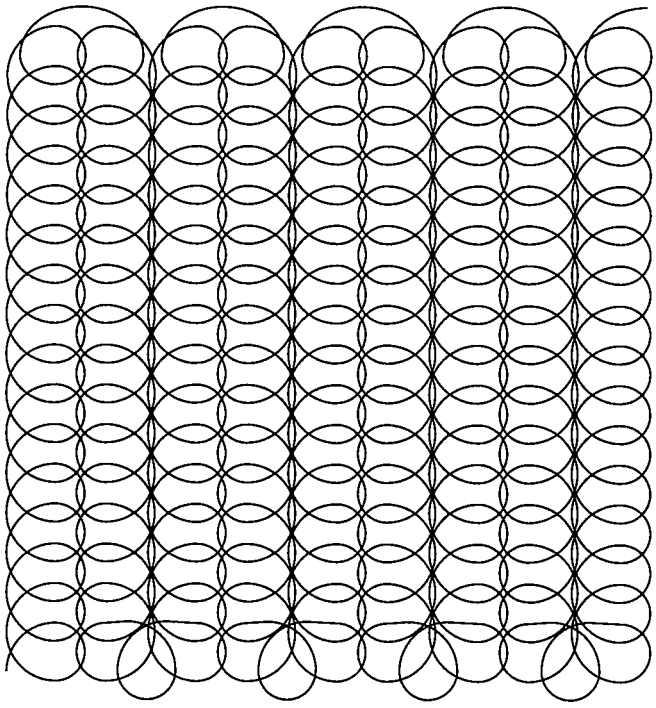


FIG. 2B

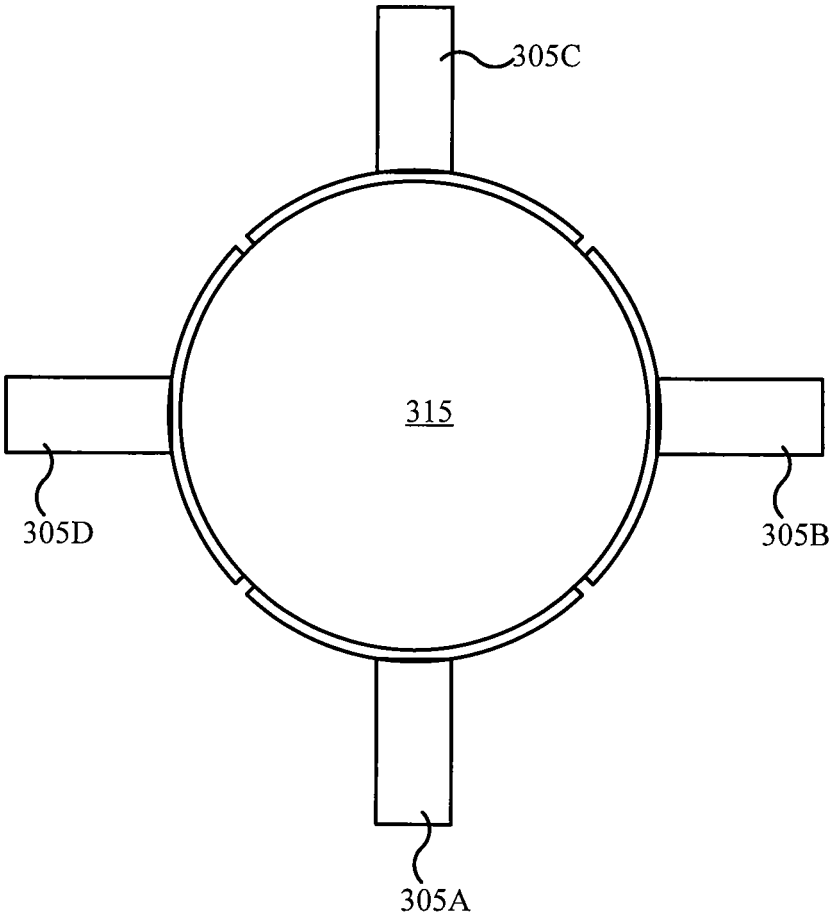


FIG. 3

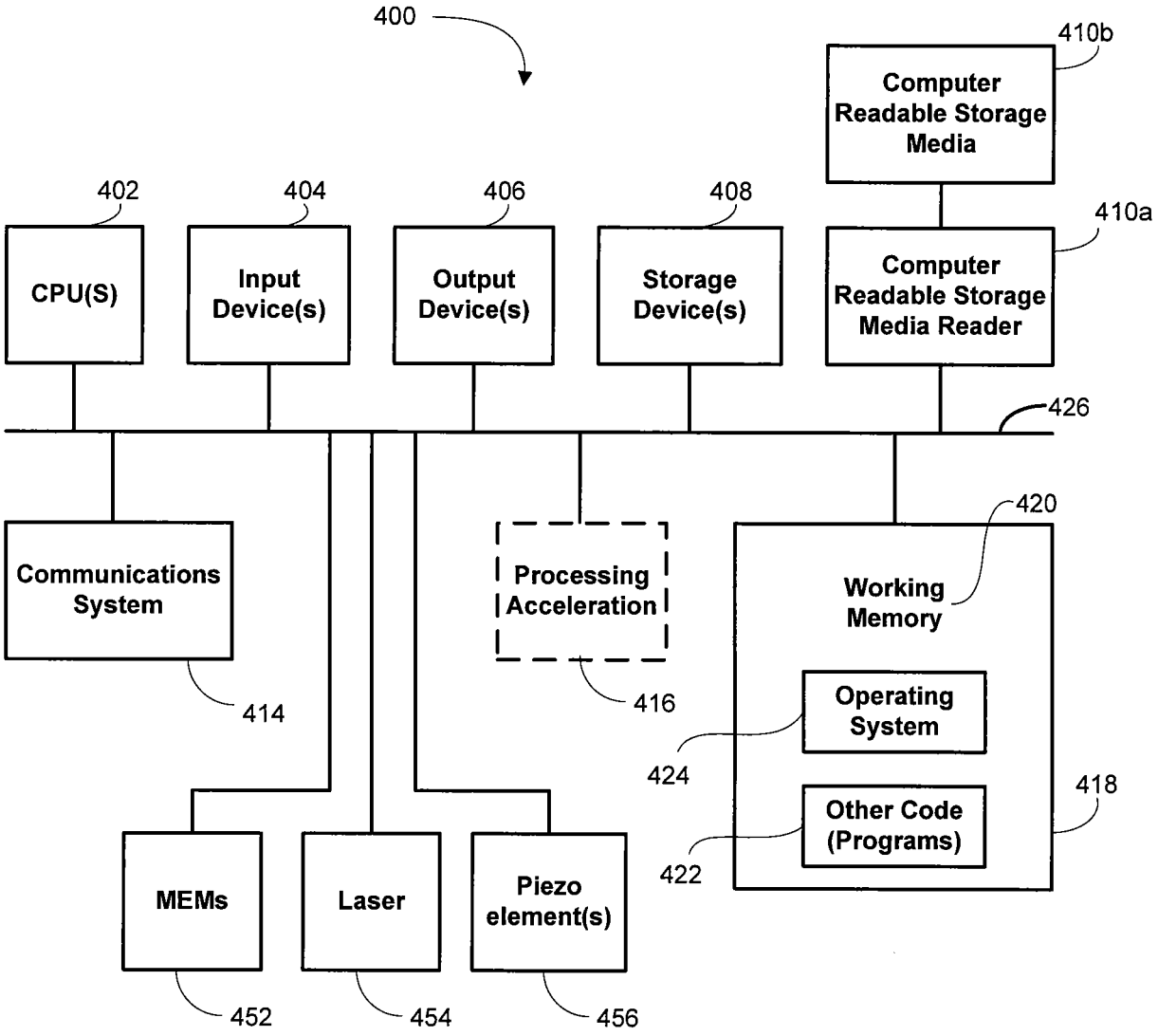

400
410b
Computer Readable Storage Media
402
404
406
408
410a
CPU(S)
Input Device(s)
Output Device(s)
Storage Device(s)
Computer Readable Storage Media Reader
426
420
Communications System
Processing Acceleration
Working Memory
414
416
Operating System
424
418
Other Code (Programs)
422
MEMs
Laser
Piezo element(s)
452
454
456

FIG. 4

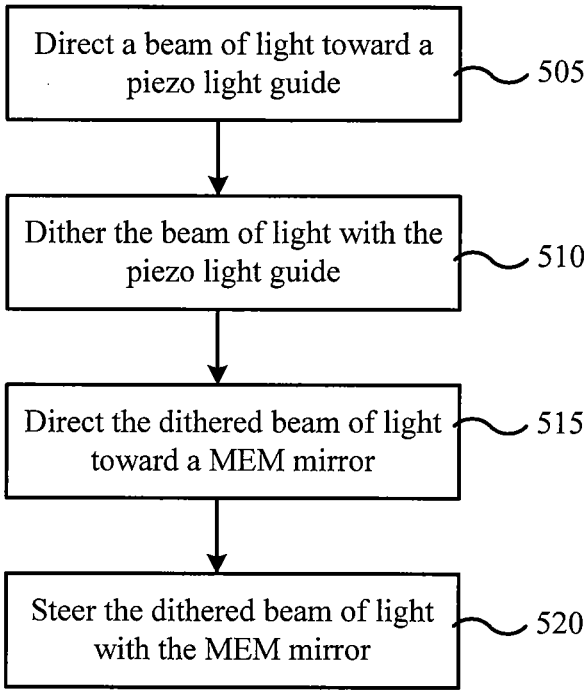

Direct a beam of light toward a piezo light guide
505
Dither the beam of light with the piezo light guide
510
Direct the dithered beam of light toward a MEM mirror
515
Steer the dithered beam of light with the MEM mirror
520

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/067661

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B26/10 G02B27/00

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)
G02B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 626 292 A (ROSEMOUNT AEROSPACE INC [US]) 15 February 2006 (2006-02-15) paragraphs [0059] - [0061], [0075] - [0078]; figures 1,7a-b,8a-b	1-3,6
X	US 2006/284790 A1 (TEGREENE CLARENCE T [US] ET AL) 21 December 2006 (2006-12-21)	1,4,5, 7-12,14, 15,18-21
A	paragraphs [0096], [0097], [0120], [0171] - [0179]; figures 8,21-23	16
X	WO 96/02823 A (SCIENT GENERICS LTD [GB]; GREEN ALAN EDWARD [GB]; PETTIGREW ROBERT MAR) 1 February 1996 (1996-02-01) page 2, line 29 - page 3, line 16; figures 1,2 page 5, line 32 - page 6, line 19	1,6

☐ Further documents are listed in the continuation of Box C.

☒ 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 document 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 the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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 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
5 November 2008	13/11/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Andreassen, Jon

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2008/067661

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1626292 A	15-02-2006	NONE	
US 2006284790 A1	21-12-2006	NONE	
WO 9602823 A	01-02-1996	AU 2987395 A	16-02-1996