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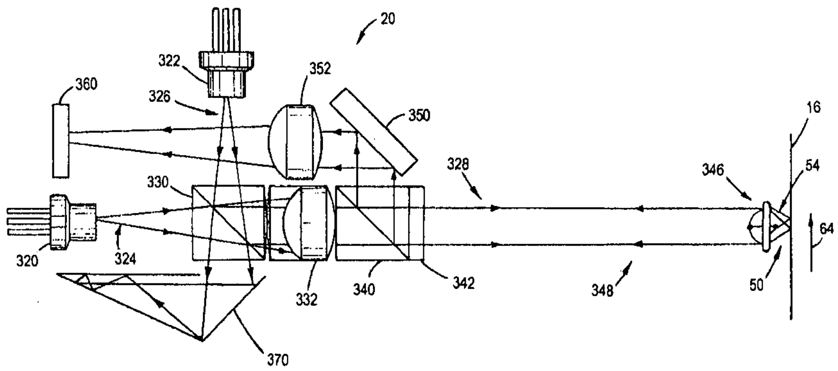

(57) Abstract: A system and method for providing direct read after write functionality in an optical data storage device include an optical head having a first coherent light source modulated at higher power during writing of data to the optical medium and a second coherent light source operating in a continuous wave mode at lower power while the first coherent light source is writing data. Optic components combine light from the first and second light sources and focus light from the first coherent light source to a first spot of a selected track on the optical medium and focus light from the second coherent light source to a second spot on the selected track downstream from the first spot relative to movement direction of the optical medium to read and verify the data directly after writing during the write process rather than in a separate verification process.

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OPTICAL STORAGE DEVICE WITH DIRECT READ AFTER WRITE

TECHNICAL FIELD

[0001] The present disclosure relates to an optical data storage device that reads data directly after writing the data to a storage medium.

BACKGROUND

[0002] Optical recording devices, such as optical disk and optical tape drives, commonly use an Optical Pickup Unit (OPU) or read/write head to store and retrieve data from associated optical media. Conventional OPUs may utilize different wavelength semiconductor laser diodes with complex beam path optics and electromechanical elements to focus and track the optical beam within one or more preformatted tracks on the optical storage medium to write or store the data and subsequently read the data. Data written to the medium with a laser at higher power may be verified in a separate verification operation or process after writing using a lower laser power, or may be verified during the write operation by another laser or laser beam. The ability to read and verify the data during the write operation may be referred to as Direct Read After Write (DRAW). One strategy for providing DRAW functionality is to use multiple independent OPUs with one OPU writing the data as a second OPU reads the data for write verification, such as disclosed in U.S. Pat. No. 6,141,312, for example, where two separate OPUs are placed side-by-side to achieve DRAW functionality. While this approach may be suitable for some applications, it increases the cost and complexity of the storage device.

[0003] Present OPUs may use a diffraction grating or similar optics in the laser path to generate two or more beams from a single laser element including a higher power beam used for reading/writing data and for focusing, and one or more lower power satellite beams used for tracking. The beams are focused to corresponding spots on the surface of the optical storage medium by the various optical and electromechanical elements of the OPU(s). In addition to writing data and focus control, the center spot may also be used for tracking operations in some applications. The lower power satellite spot(s) generated from one or more lower-power side-beams may be used for another type of tracking operation for specific types of media.

SUMMARY

[0004] In one embodiment of the present disclosure, an optical storage system that receives an optical medium having a plurality of tracks for storing data includes an optical head having a first coherent light source modulated at higher power during writing of data to the optical medium and a second coherent light source operating in a continuous wave mode at lower power while the first coherent light source is writing data, optics that combine light from the first and second light sources and focus light from the first coherent light source to a first spot of a selected track on the optical medium and focus light from the second coherent light source to a second spot on the selected track downstream from the first spot relative to movement direction of the optical medium, the optics directing reflected light from the optical medium to a photodetector. A controller coupled to the optical head selectively positions the optical head for writing data along the selected track using the first coherent light source while reading data directly after writing from the selected track using reflected light from the second coherent light source detected by the photodetector.

[0005] In one embodiment, an optical data storage system includes an optical pickup unit, a first laser disposed within the optical pickup unit, a second laser disposed within the optical pickup unit, and an amplitude beam splitter disposed within the optical pickup unit and positioned to combine light from the first and second lasers and direct combined light toward an optical storage medium. A collimating lens positioned downstream of the amplitude beam splitter collimates the combined light. The system also includes a polarizing beam splitter positioned downstream of the collimating lens, a quarter-wave plate positioned downstream of the polarizing beam splitter, an objective lens positioned downstream of the quarter wave plate and configured to focus light from the first laser to a first spot on a selected track of the optical storage medium, and to focus light from the second laser to a second spot on the selected track downstream of the first spot, a photodetector and associated optics configured to receive light reflected from the optical medium through the objective lens and polarizing beam splitter, and a controller in communication with the first and second lasers and the photodetector to modulate light from the first laser to write data to the selected track of the optical storage medium and read data from the selected track of the optical storage medium using the second laser to provide a direct read after write capability.

[0006] Embodiments of the present disclosure include a method for providing direct read after write functionality for an optical storage device that reads and writes data to an optical storage medium includes combining light from a first laser modulated at higher power during writing of data to the optical storage medium and light from a second laser operated in a continuous wave mode at lower power, focusing light from the first laser to a first spot within a selected track on the optical storage medium, focusing light from the second laser to a second spot within the selected track on the optical storage medium downstream relative to the first spot in the direction of travel of the optical storage medium, and directing light reflected from the second spot to a photodetector to provide direct read after write functionality.

[0007] Embodiments according to the present disclosure may provide various advantages. For example, an optical storage device according to one embodiment of the present disclosure provides direct read after right functionality for data verification using a single OPU or optical head, which reduces complexity and associated costs.

[0008] The above advantages and other advantages and features associated with various embodiments of the present disclosure will be readily apparent from the following detailed description when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figures 1A and 1B are diagrams illustrating operation of an optical data storage system or method with direct read after write (DRAW) functionality according to various embodiments of the present disclosure;

[0010] Figure 2 is a block diagram illustrating operation of an optical pickup unit (OPU) having a writing laser source and integrated DRAW laser source forming a main beam and side beam to provide DRAW functionality according to various embodiments of the present disclosure;

[0011] Figure 3 is a block diagram illustrating a representative OPU having integrated write and DRAW laser sources according to various embodiments of the present disclosure; and

[0012] Figure 4 is a block diagram illustrating operation of a system or method for optical data storage with DRAW functionality according to various embodiments of the present disclosure.

DETAILED DESCRIPTION

[0013] Various embodiments of the present disclosure are described herein. However, the disclosed embodiments are merely exemplary and other embodiments may take various and alternative forms that are not explicitly illustrated or described. The Figures are not necessarily to scale; some features may be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one of ordinary skill in the art to variously employ the present invention. As those of ordinary skill in the art will understand, various features illustrated and described with reference to any one of the Figures may be combined with features illustrated in one or more other Figures to produce embodiments that are not explicitly illustrated or described. The combinations of features illustrated provide representative embodiments for representative applications. However, various combinations and modifications of the features consistent with the teachings of this disclosure may be desired for particular applications or implementations.

[0014] The processes, methods, logic, or strategies disclosed may be deliverable to and/or implemented by a processing device, controller, or computer, which may include any existing programmable electronic control unit or dedicated electronic control unit. Similarly, the processes, methods, logic, or strategies may be stored as data and instructions executable by a controller or computer in many forms including, but not limited to, information permanently stored on various types of articles of manufacture that may include persistent non-writable storage media such as ROM devices, as well as information alterably stored on writeable storage media such as optical and magnetic disks and tapes, solid state devices, and other magnetic and optical media. The processes, methods, logic, or strategies may also be implemented in a software executable object. Alternatively, they may be embodied in whole or in part using suitable hardware components, such as Application Specific Integrated Circuits (ASICs), Field-Programmable Gate Arrays (FPGAs), state machines, controllers or other hardware components or devices, or a combination of hardware, software and firmware components.

[0015] Referring now to Figures 1A and 1B, block diagrams illustrating operation of an optical data storage system or method with direct read after write (DRAW) capability according to various embodiments of the present disclosure are shown. Figure 1A is a side view diagram and Figure 1B is a top or plan view diagram. In the representative embodiment illustrated in Figures 1A and 1B, optical data storage system 10 is implemented by an optical tape drive 12 that receives an optical data storage medium 14 implemented by an optical tape 16. While illustrated and described with reference to an optical tape drive, those of ordinary skill in the art will recognize that the teachings of the present disclosure may also be applied to various other types of optical data storage devices that may use various types of write-once or re-writable optical media, such as optical discs, for example. In one embodiment, optical tape 16 is a ½ inch (12.7mm) wide tape having a plurality of tracks generally extending across the width of the tape and may vary in length depending on the desired storage capacity and performance characteristics as illustrated and described in greater detail herein. Optical tape 16 may be wound on an associated spool 30 contained within a protective case or cartridge 18 that is manually or automatically loaded or mounted in optical tape drive 12. Transport mechanism 24 moves optical tape 16 through a carriage and past at least one optical pickup unit (OPU) or optical head 20 to a take-up spool 22 that typically remains within tape drive 12. OPU 20 writes data to, and reads data from, optical tape 16 as transport mechanism 24 moves optical tape 16 between cartridge 18 and take-up spool 22 in response to at least one controller and associated electronics 26. As explained in greater detail below, data may be read/written to optical tape 16 in one or more of the plurality of tracks in a serpentine fashion as the tape travels in either direction past OPU 20, i.e. either from cartridge 18 to take-up spool 22, or from take-up spool 22 to cartridge 18.

[0016] Optical head 20 may include associated optics and related electromechanical servo controlled devices, represented generally by reference numeral 30, that direct a higher power modulated write beam and a lower power continuous wave (cw) read beam to an objective lens that focuses the beams to corresponding spots on the storage medium for writing/reading data as illustrated and described in greater detail with reference to Figure 2. Various servo mechanisms (not specifically illustrated) may be used to position/align the beams with a selected one of the plurality of tracks 36 on optical tape 16.

[0017] Figure 2 is a block diagram illustrating operation of a system or method for direct read after write according to the present disclosure. In the representative embodiment of Figure 2, an optical pickup unit (OPU) 20 having a first coherent light beam 40 and a second coherent light beam 44 provide DRAW functionality using only a single head or OPU. Beams 40 and 44 may be generated by corresponding coherent light sources such as laser diodes (best illustrated in Figure 3), for example. Alternatively, a single or common coherent light source may be used with associated optics to split the beam. However, as described in greater detail herein, use of a single or common light source to generate both the read and the write beams may require more sophisticated processing of the reflected beam used to read the data and filter the effects of the modulation associated with writing the data to the storage medium.

[0018] In various embodiments according to the present disclosure, OPU 20 includes a first laser 320 (Figure 3) to generate first coherent light beam 40 and a second laser 322 (Figure 3) to generate second coherent light beam 44. Associated optics (best illustrated in Figure 3) combine the first and second beams and focus the beams to associated spots 50 and 54, respectively, within a selected track "n" of a plurality of tracks 36 on the optical tape 16. Optical spots 50, 54 may be manipulated by various optical and electromechanical elements of OPU 20 to write and retrieve data from optical tape 16.

[0019] Referring now to Figures 2 and 3, the first and second light sources or lasers 320, 322 may operate at different power levels and in different modes to provide DRAW functionality. For example, the first light source 320 that generates beam 40 and spot 50 may be operated at higher power and modulated to write corresponding data impressions 60 on optical tape 16, while the second light source 322 may be operated at lower power in a continuous wave (cw) mode to provide beam 44 and spot 54 to read the data impressions 60 directly after writing by beam 40. The second (DRAW) spot 54 is positioned a sufficient distance downstream in the direction of travel 64 of tape 16 relative to write spot 50 to allow the data impressions 60 sufficient time to stabilize before being read. In one embodiment, center spot 50 may have an average power of 10-20 times more than the average power of DRAW spot 54. For example, center spot 50 may have an average power of about

8 mW to write data, while DRAW spot 54 may only have an average power of about 0.35 mW to read data directly after writing. The lower power of DRAW spot 54 assures that it will contain sufficiently low energy to not alter the previously written data on optical storage medium or tape 16.

[0020] In one representative embodiment, spots 50 and 54 are mechanically aligned in the OPU manufacturing process to correspond to the axes of data tracks 36 on preformatted optical tape media 16. In addition, spots 50 and 54 are generally positioned so that transit distance (d) of tape 16 between center spot 50 and satellite/side spot 54 provides sufficient time for the data written to optical tape media 16 to stabilize based on the fastest anticipated linear tape speed and the characteristics of the optical tape media 16. In one embodiment, OPU 20 is manufactured to provide a distance (d) of between about 10-20 μm.

[0021] Some conventional optical storage devices use center spot 50 from the higher power emitting beam 40 for reading, writing, and focusing in addition to one type of tracking operation. Satellite spots may be used for another type of tracking for specific types of media. In these applications, the satellite spots may not be aligned with one another, or with center spot 50 along a single selected track 36 of optical tape 16. In contrast to the conventional function of typical satellite beams, various embodiments according to the present disclosure use satellite spot 54 to provide direct read after write (DRAW) functionality.

[0022] As previously described, first laser beam 40 is operated at a higher power and modulated to alter the structure of the optically active layer of optical tape 16 and write data marks 60 on a selected one of the plurality of tracks 36. Satellite DRAW beam 44 has much lower power when it reaches optical tape 16 so that it does not alter the optically active layer of optical tape 16. However, satellite DRAW beam 44 is designed to have enough power after being reflected from optical tape 16 to detect data marks 60 to provide DRAW functionality.

[0023] Figure 3 is a block diagram illustrating operation of a DRAW system or method for optical data storage according to various embodiments of the present disclosure. In the representative embodiment illustrated, the optical components including first coherent light source 320 and second coherent light source 322 are contained within a single optical head or OPU. Coherent light sources 320, 322 may be implemented by diode lasers, for example. Depending on the particular implementation, an optical storage device, such as device 10 (Figure 1), may include multiple optical heads to write/read data simultaneously to corresponding tracks 36 of optical tape 16. In addition to coherent light sources 320, 322, OPU 20 may include an amplitude beam splitter 330 that operates to combine diverging beams 324 and 326 into a combined beam 328 that passes through a collimating lens 332 positioned downstream of the amplitude beam splitter 330. Lens 332 collimates the combined light 328, which then passes through polarizing beam splitter 340, which is positioned downstream relative to collimating lens 332. A wave retarder, such as quarter wave plate 342 is positioned downstream of polarizing beam splitter 340 to change polarization of light 328 directed to the optical storage medium 16 relative to reflected light 348 from the optical storage medium 16 to facilitate redirection of reflected light 348 by polarizing beam splitter 340 to mirror 350. Reflected light 348 from spot 44 is then directed by mirror 350 through DRAW focusing lens 352 to photodetector 360, implemented by a photodiode array in one embodiment.

[0024] Combined light 328 passing through quarter wave plate 342 is focused by objective lens 346 to form spots 50, 54 within a selected track on optical tape 16. Various strategies may be used to provide an overlapping or common beam path while focusing the light from laser source 320 to first spot 50 and light from laser source 322 to second spot 54 using a single objective lens 346. For example, different wavelengths of light may be generated by laser sources 320, 322, or the beam paths may not directly overlap and have slightly different angles of incidence relative to one another.

[0025] As illustrated in the representative embodiment of Figure 3, photodetector 360 includes associated optics, such as DRAW lens 352, mirror 350, and quarter wave plate 342, configured to receive light reflected from the optical storage medium 16 through the objective lens 346 and polarizing beam splitter 340. A controller 26 (Figure 1) in communication with first laser 320, second laser 322, and photodetector 360 includes control logic to modulate light 324 from first laser 320 to write data to a selected track 36 of optical storage medium 16 and operate second laser 322 in a continuous wave (cw) mode to read data from the selected track 36 of optical storage medium 16 to provide direct read after write functionality. Controller 26 may use various strategies to compare the data read using beam 326 with the data written using beam 324 to provide data verification and storage device diagnostics.

[0026] In various embodiments, amplitude beam splitter 330 is configured to transmit more than about 90% of incident light 324 from first laser 320 through to collimating lens 332 with the remaining light (not considering losses) reflected toward an optical absorber or beam dump 370. As such, amplitude beam splitter 330 will therefore also transmit about 90% of incident light 326 from second laser 322 to beam dump 370 and redirect less than about 10% of the incident light 326 from second laser 322 to collimating lens 332. In one embodiment, amplitude beam splitter 330 transmits about 95% of light 324 with the remaining 5% of light redirected to optical absorber 370. Similarly, about 95% of light 326 is transmitted to beam dump 370 with the remaining 5% of light redirected to collimating lens 332. As illustrated in Figure 3, optional beam dump 370 is positioned or configured to absorb a relatively small portion of light from first laser 320 redirected by amplitude beam splitter 330 and a relatively large portion of light from second laser 322 transmitted through amplitude beam splitter 330. In this embodiment, to provide an average write power of 8 mW (ignoring optical losses associated with all other components) to the optical tape 16, write laser 320 would operate at approximately 8.4 mW transmitting 95% through amplitude beam splitter 330. Similarly, DRAW laser 322 would operate at a relatively lower power of 7 mW to provide 0.35 mW of average read power at optical tape 16 with only 5% redirected by amplitude beam splitter 330 toward optical tape 16.

[0027] Figure 4 is a block diagram illustrating operation of a system or method for optical data storage with DRAW functionality according to various embodiments of the present disclosure. Those of ordinary skill in the art will recognize that the functions represented in Figure 4 may be performed by various optical components with an associated programmed microprocessor that compares data written to the optical storage medium with the data read directly after writing to provide direct read after write functionality. Whether performed by one or more optical components alone or in combination with a programmed microprocessor-based controller, various steps or functions illustrated may be performed in the sequence illustrated, in parallel, or in some cases omitted. Although not explicitly illustrated, one of ordinary skill in the art will recognize that one or more of the illustrated steps or functions may be repeatedly performed depending upon the particular implementation. Similarly, the order illustrated in the representative embodiment is not necessarily required to achieve the features and advantages described herein, but is provided for ease of illustration and description.

[0028] Various control functions, such as spot focusing and alignment with a selected track, for example, may be performed by a controller or processor using logic or code represented by one or more functions of the simplified flow chart of Figure 4 to control associated components or devices within the optical storage device. Control logic may be implemented in software with instructions executed by a microprocessor-based controller. Of course, the control logic may be implemented in software, hardware, or a combination of software and hardware in one or more controllers or equivalent electronics depending upon the particular implementation. When implemented in software, the control logic may be stored in one or more computer-readable storage media having stored data representing code or instructions executed by a computer to control one or more components of the optical storage device. The computer-readable storage media may include one or more of a number of known physical devices which utilize electric, magnetic, optical, and/or hybrid storage to keep executable instructions and associated data.

[0029] Operation of a representative system or method for optical storage with DRAW functionality may include combining light from a first laser modulated at higher power during writing of data to the optical storage medium and light from a second laser operated in a continuous wave mode at lower power as represented by block 410. Associated optics may be used to focus light from the first laser to a first spot within a selected track on the optical storage medium as represented by block 420. Similarly, one or more optical devices may be used to focus light from the second laser to a second spot within the selected track on the optical storage medium downstream relative to the first spot in the direction of travel of the optical storage medium as represented by block 420. As previously illustrated and described, the first and second lasers may use one or more of the same/common optical components/devices to direct the beams toward the optical storage medium and focus the beams to corresponding spots within a selected track.

[0030] As also illustrated in Figure 4, a system or method according to the present disclosure may include directing light reflected from the second spot to a photodetector within the OPU to provide direct read after write functionality as generally represented by block 440. Depending on the particular implementation, a system or method according to the present disclosure may also include changing polarization of light directed to the optical storage medium relative to light reflected from the optical storage medium to facilitate redirection of the light reflected from the optical storage medium to the photodetector as represented by block 435. As described above with reference to Figure 3, this may be accomplished using a quarter-wave plate or similar wave retarder, for example, in combination with a polarizing beam splitter.

[0031] Various embodiments may optionally include one or more devices that are positioned or configured to direct light from the first and second lasers that is not directed to the optical storage medium to an optical absorber or beam dump as represented by block 450.

[0032] Light reflected from the second spot back to the photodetector as represented by block 440 may be used to compare read data with write data to provide write data verification as represented by block 460. As those of ordinary skill in the art will recognize, the read data will be time shifted by the optical medium transit delay relative to the write data. Compensation may also be provided for beam path differences and/or processing delays depending on the particular implementation.

[0033] As such, various embodiments according to the present disclosure provide a system and method for direct read after write (DRAW) functionality for an optical data storage device using a single OPU or optical head, which reduces complexity and associated costs.

[0034] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms encompassed by the claims. The words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the disclosure and claims. As previously described, the features of various embodiments may be combined to form further embodiments that may not be explicitly described or illustrated. While various embodiments may have been described as providing advantages or being preferred over other embodiments or prior art implementations with respect to one or more desired characteristics, those of ordinary skill in the art recognize that one or more features or characteristics may be compromised to achieve desired overall system attributes, which depend on the specific application and implementation. These attributes include, but are not limited to: cost, strength, durability, life cycle cost, marketability, appearance, packaging, size, serviceability, weight, manufacturability, ease of assembly, etc. As such, embodiments described as less desirable than other embodiments or prior art implementations with respect to one or more characteristics are not outside the scope of the disclosure and may be desirable for particular applications.

WHAT IS CLAIMED IS:

1. An optical storage system comprising:

an optical pickup unit;

a first laser disposed within the optical pickup unit;

a second laser disposed within the optical pickup unit;

an amplitude beam splitter disposed within the optical pickup unit and positioned to combine light from the first and second lasers and direct combined light toward an optical storage medium;

a collimating lens positioned downstream of the amplitude beam splitter to collimate the combined light;

a polarizing beam splitter positioned downstream of the collimating lens;

a quarter-wave plate positioned downstream of the polarizing beam splitter;

an objective lens positioned downstream of the quarter wave plate and configured to focus light from the first laser to a first spot on a selected track of the optical storage medium, and to focus light from the second laser to a second spot on the selected track downstream of the first spot;

a photodetector and associated optics configured to receive light reflected from the optical medium through the objective lens and polarizing beam splitter; and

a controller in communication with the first and second lasers and the photodetector to modulate light from the first laser to write data to the selected track of the optical storage medium and read data from the selected track of the optical storage medium using the second laser to provide a direct read after write capability.

2. The system of claim 1 wherein the associated optics comprise:

a mirror positioned to redirect the light reflected from the optical storage medium from the polarizing beam splitter toward the photodetector; and

a lens positioned to focus light reflected from the mirror onto the photodetector.

3. The system of claim 1 or 2 wherein the amplitude beam splitter is configured to transmit more than about 90% of incident light from the first laser to the collimating lens and to redirect less than about 10% of incident light from the second laser to the collimating lens.

4. The system of any preceding claim further comprising:

a beam dump configured to absorb light from the first laser redirected by the amplitude beam splitter and light from the second laser transmitted through the amplitude beam splitter.

5. The system of any preceding claim wherein the first and second lasers comprise diode lasers.

6. The system of any preceding claim wherein the controller operates the second laser in a continuous wave (CW) mode.

7. The system of any preceding claim wherein the controller operates the first laser at higher power than the second laser.

8. An optical storage system that receives an optical storage medium having a plurality of tracks for storing data, the system comprising:

an optical head having a first coherent light source modulated at higher power during writing of data to the optical medium and a second coherent light source operating in a continuous wave mode at lower power while the first coherent light source is writing data, optics that combine light from the first and second light sources and focus light from the first coherent light source to a first spot of a selected track on the optical storage medium and focus light from the second coherent light source to a second spot on the selected track downstream from the first spot relative to movement direction of the optical storage medium, the optics directing reflected light from the optical storage medium to a photodetector; and

a controller coupled to the optical head that selectively positions the optical head for writing data along the selected track using the first coherent light source while reading data directly after writing from the selected track using reflected light from the second coherent light source detected by the photodetector.

9. The system of claim 8 wherein the optics comprise:

an amplitude beam splitter that transmits more than about 90% of incident light from the first coherent light source and redirects less than about 10% of light from the second coherent light source toward the optical storage medium.

10. The system of claim 9 wherein the optics further comprise a collimating lens positioned to receive light from the first and second coherent light sources passing through the amplitude beam splitter.

11. The system of claim 10 wherein the optics further comprise a polarizing beam splitter positioned to transmit light from the collimating lens toward the optical storage medium and to direct light reflected from the optical storage medium away from the collimating lens.

12. The system of claim 11 wherein the optics further comprise a device to modify polarization of incident light, the device positioned between the polarizing beam splitter and the optical storage medium.

13. The system of claim 12 wherein the device comprises a quarter-wave plate.

14. The system of claim 12 or 13 wherein the optics further comprise an objective lens disposed between the device to modify polarization and the optical storage medium.

15. The system of any of claims 11 to 14 wherein the optics further comprise a mirror positioned to redirect light reflected from the optical storage medium and redirected by the polarizing beam splitter toward the photodetector.

16. The system of any preceding claim wherein the optical storage medium comprises an optical tape.

17. A method for providing direct read after write functionality for an optical storage device that reads and writes data to an optical storage medium, comprising:

combining light from a first laser modulated at higher power during writing of data to the optical storage medium and light from a second laser operated in a continuous wave mode at lower power;

focusing light from the first laser to a first spot within a selected track on the optical storage medium;

focusing light from the second laser to a second spot within the selected track on the optical storage medium downstream relative to the first spot in the direction of travel of the optical storage medium;

directing light reflected from the second spot to a photodetector to provide direct read after write functionality.

18. The method of claim 17 further comprising changing polarization of light directed to the optical storage medium relative to light reflected from the optical storage medium to facilitate redirection of the light reflected from the optical storage medium to the photodetector.

19. The method of claim 17 or 18 further comprising directing light from the first and second lasers that is not directed to the optical storage medium to an optical absorber.

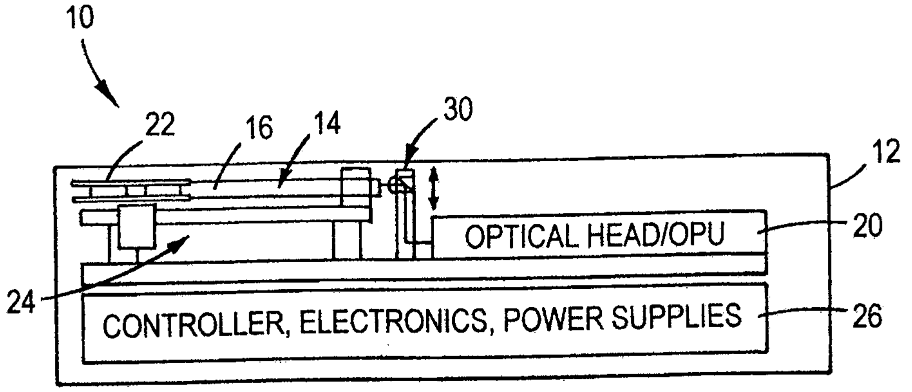

FIG.1A

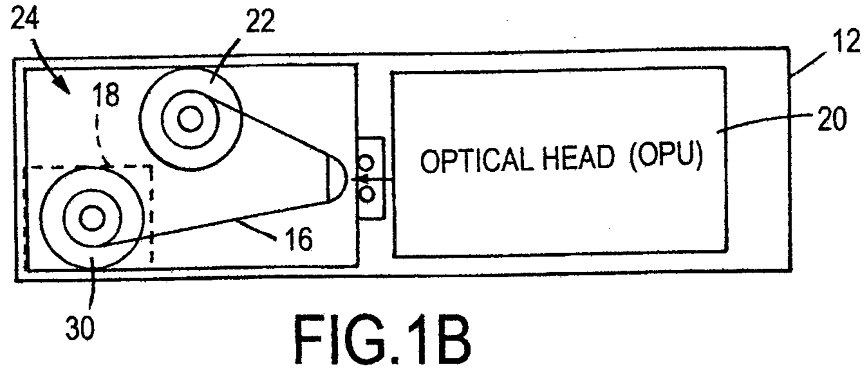

FIG.1B

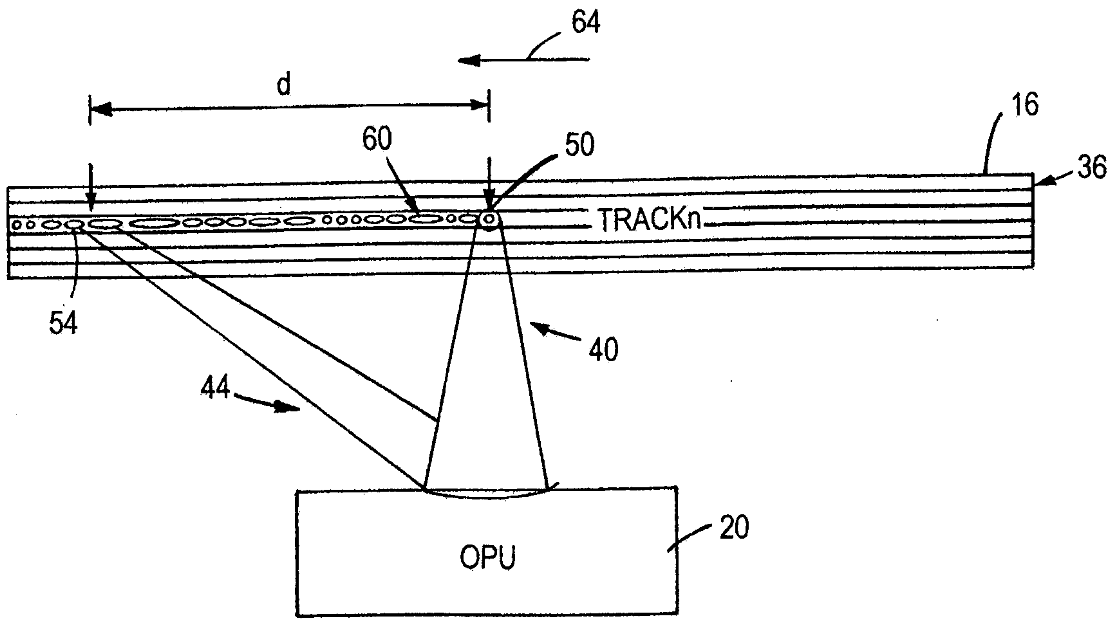

FIG.2

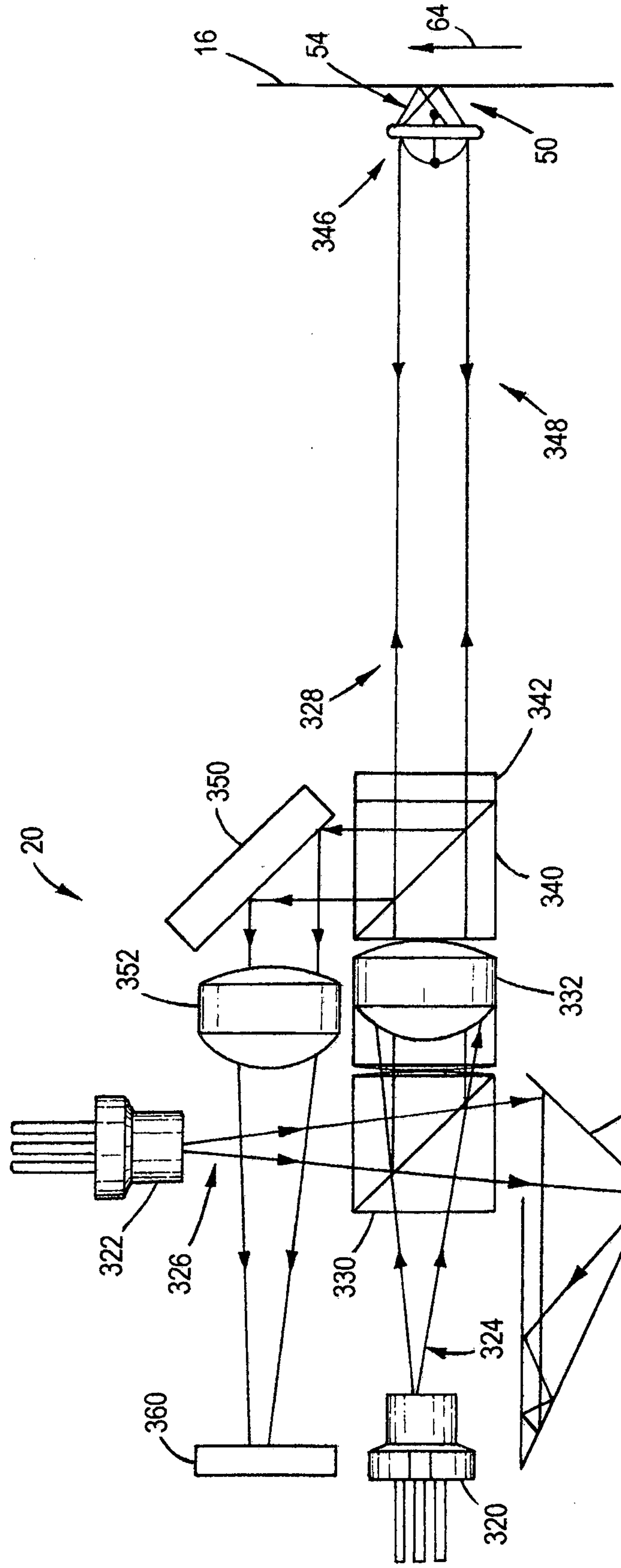
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FIG.3

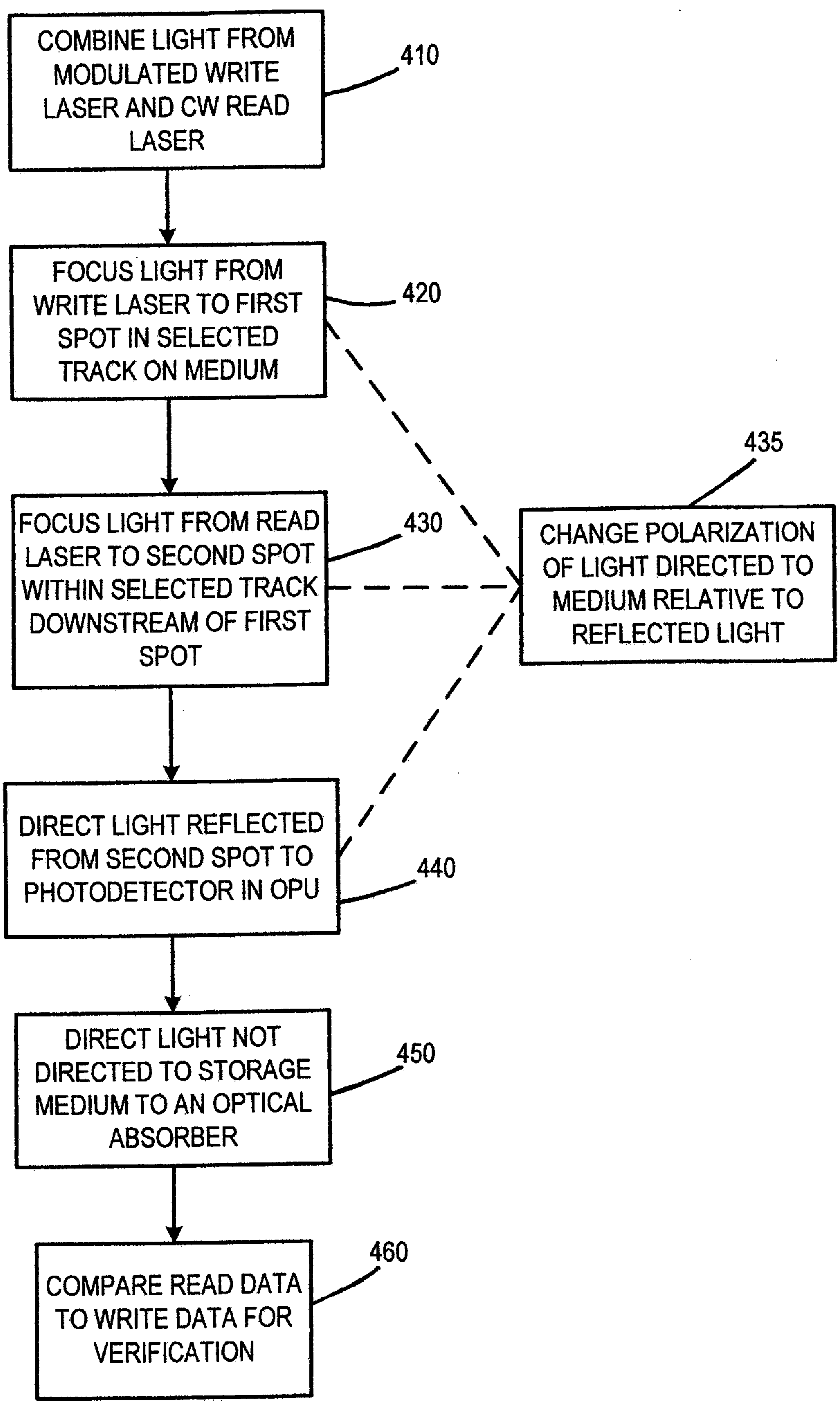
COMBINE LIGHT FROM MODULATED WRITE LASER AND CW READ LASER
410
FOCUS LIGHT FROM WRITE LASER TO FIRST SPOT IN SELECTED TRACK ON MEDIUM
420
435
CHANGE POLARIZATION OF LIGHT DIRECTED TO MEDIUM RELATIVE TO REFLECTED LIGHT
FOCUS LIGHT FROM READ LASER TO SECOND SPOT WITHIN SELECTED TRACK DOWNSTREAM OF FIRST SPOT
430
DIRECT LIGHT REFLECTED FROM SECOND SPOT TO PHOTODETECTOR IN OPU
440
DIRECT LIGHT NOT DIRECTED TO STORAGE MEDIUM TO AN OPTICAL ABSORBER
450
COMPARE READ DATA TO WRITE DATA FOR VERIFICATION
460

FIG.4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/025498

A. CLASSIFICATION OF SUBJECT MATTER
INV. G11B7/0045 G11B7/1356 G11B7/1395
ADD.

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)
G11B

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 694 447 A (COHEN DONALD K [US] ET AL) 15 September 1987 (1987-09-15) the whole document	1-19
X	US 6 442 126 B1 (MARCHANT ALAN B [US] ET AL) 27 August 2002 (2002-08-27) the whole document	1-19
X	US 6 034 933 A (ROKUTAN TAKAO [JP]) 7 March 2000 (2000-03-07) the whole document	1-19
X	US 6 314 071 B1 (ALON AMIR [US] ET AL) 6 November 2001 (2001-11-06) column 8, line 1 - column 9, line 20; figures 5a, 5b	1-19

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[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 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
23 April 2013	02/05/2013

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	Skaropoulos, N

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/025498

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 2011/141868 A1 (MAHNAD FARAMARZ [US]) 16 June 2011 (2011-06-16) paragraph [0189] - paragraph [0216]; figures 29-40	1-19

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/025498

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4694447	A	15-09-1987	CA	1232353	A1	02-02-1988
			DE	3587054	D1	18-03-1993
			DE	3587054	T2	12-08-1993
			EP	0167910	A2	15-01-1986
			JP	H0619848	B2	16-03-1994
			JP	S6126947	A	06-02-1986
			US	4694447	A	15-09-1987
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US 2011141868	A1	16-06-2011	AU	2010340125	A1	26-07-2012
			CN	102934167	A	13-02-2013
			EP	2513902	A1	24-10-2012
			US	2011141868	A1	16-06-2011
			WO	2011084351	A1	14-07-2011

(19) 中华人民共和国国家知识产权局

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代理人 罗亚男

(51) Int.Cl.

G11B 7/0045(2006.01)

G11B 7/1356(2006.01)

G11B 7/1395(2006.01)

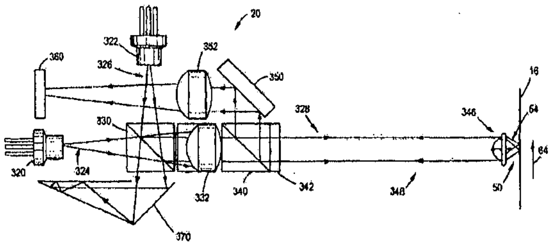
权利要求书2页 说明书6页 附图3页

(54) 发明名称

具有写后直接读的光学存储设备

(57) 摘要

用于在光学数据存储设备中提供写后直接读功能性的系统和方法包括具有在把数据写到光学介质期间以较高功率调制的第一相干光源和当第一相干光源写数据时在较低功率以连续波模式工作的第二相干光源的光学头。光学元件组合来自第一和第二光源的光并且把来自第一相干光源的光聚焦到光学介质上选定轨道的第一个点并且把来自第二相干光源的光聚焦到该选定轨道上相对于光学介质的运动方向在第一个点下游的第二个点，以便在写过程期间，而不是在单独的验证过程中，在写后直接读取并验证数据。



CN 104160446 A

1. 一种光学存储系统，包括：

光学拾取单元；

第一激光器，位于光学拾取单元中；

第二激光器，位于光学拾取单元中；

振幅分束器，位于光学拾取单元中并且定位成组合来自第一和第二激光器的光并且把组合后的光指向光学存储介质；

准直透镜，位于振幅分束器下游，以使组合后的光准直；

偏振分束器，位于准直透镜下游；

四分之一波片，位于偏振分束器下游；

物镜，位于四分之一波片下游并且配置为把来自第一激光器的光聚焦到光学存储介质的选定轨道上的第一个点，并且把来自第二激光器的光聚焦到该选定轨道上第一个点下游的第二个点；

光探测器及关联的光学器件，配置为通过物镜和偏振分束器接收从光学介质反射的光；及

控制器，与第一和第二激光器及光探测器通信，以便调制来自第一激光器的光以把数据写到光学存储介质的选定轨道并且利用第二激光器从光学存储介质的该选定轨道读数据，以提供写后直接读能力。

2. 如权利要求1所述的系统，其中关联的光学器件包括：

反射镜，定位成把从光学存储介质反射的光从偏振分束器朝光探测器重定向；及

透镜，定位成把从反射镜反射的光聚焦到光探测器上。

3. 如权利要求1或2所述的系统，其中振幅分束器配置为把来自第一激光器的入射光的多于大约90%传送到准直透镜并且把来自第二激光器的入射光的少于大约10%重定向到准直透镜。

4. 如前面任何一项权利要求所述的系统，还包括：

射束收集器，配置为吸收由振幅分束器重定向的来自第一激光器的光和通过振幅分束器传送的来自第二激光器的光。

5. 如前面任何一项权利要求所述的系统，其中第一和第二激光器包括二极管激光器。

6. 如前面任何一项权利要求所述的系统，其中控制器以连续波(CW)模式操作第二激光器。

7. 如前面任何一项权利要求所述的系统，其中控制器以比第二激光器高的功率操作第一激光器。

8. 一种容纳具有用于存储数据的多条轨道的光学存储介质的光学存储系统，该系统包括：

光学头，具有在把数据写到光学介质期间以较高功率调制的第一相干光源和当第一相干光源写数据时在较低功率以连续波模式工作的第二相干光源、组合来自第一和第二光源的光并且把来自第一相干光源的光聚焦到光学存储介质上的选定轨道的第一个点并且把来自第二相干光源的光聚焦到该选定轨道上相对于光学存储介质的运动方向在第一个点下游的第二个点的光学器件，该光学器件把来自光学存储介质的反射光指向光探测器；及

耦合到光学头的控制器，选择性地定位光学头，用于利用第一相干光源沿选定的轨道

写数据，同时在写之后利用由光探测器检测到的来自第二相干光源的反射光从所述选定的轨道直接读数据。

9. 如权利要求 8 所述的系统，其中光学器件包括：

振幅分束器，朝着光学存储介质传送来自第一相干光源的入射光的多于大约 90％并且重定向来自第二相干光源的光的少于大约 10％。

10. 如权利要求 9 所述的系统，其中光学器件还包括准直透镜，该准直透镜定位成接收经过振幅分束器的来自第一和第二相干光源的光。

11. 如权利要求 10 所述的系统，其中光学器件还包括偏振分束器，该偏振分束器定位成从准直透镜朝着光学存储介质传送光并且把从光学存储介质反射的光指向远离准直透镜。

12. 如权利要求 11 所述的系统，其中光学器件还包括修改入射光的偏振的设备，该设备位于偏置分束器和光学存储介质之间。

13. 如权利要求 12 所述的系统，其中所述设备包括四分之一波片。

14. 如权利要求 12 或 13 所述的系统，其中光学器件还包括位于修改偏振的所述设备和光学存储介质之间的物镜。

15. 如权利要求 11 至 14 中任何一项所述的系统，其中光学器件还包括反射镜，该反射镜定位成朝光探测器重定向从光学存储介质反射并由偏振分束器重定向的光。

16. 如前面任何一项权利要求所述的系统，其中光学存储介质包括光带。

17. 一种用于为读和写数据到光学存储介质的光学存储设备提供写后直接读功能性的方法，包括：

组合在把数据写到光学存储介质期间来自以较高功率调制的第一激光器的光和来自以较低功率工作在连续波模式的第二激光器的光；

把来自第一激光器的光聚焦到光学存储介质上选定轨道内的第一个点；

把来自第二激光器的光聚焦到光学存储介质上该选定轨道内在光学存储介质行进方向相对于第一个点在其下游的第二个点；及

把从第二个点反射的光指向光探测器，以提供写后直接读功能性。

18. 如权利要求 17 所述的方法，还包括相对于从光学存储介质反射的光改变指向光学存储介质的光的偏振，以便于从光学存储介质反射的光到光探测器的重定向。

19. 如权利要求 17 或 18 所述的方法，还包括把没有指向光学存储介质的来自第一和第二激光器的光指向光吸收器。

具有写后直接读的光学存储设备

技术领域

[0001] 本公开内容涉及在把数据写到存储介质之后直接读数据的光学数据存储设备。

背景技术

[0002] 光学记录设备，诸如光盘和光带驱动器，通常使用光学拾取单元（OPU）或读／写头来存储并从关联的光学介质取回数据。常规的 OPU 可以利用具有复杂射束路径光学器件和机电元件的不同波长的半导体激光二极管来聚焦并跟踪光学存储介质上一条或多条预先格式化的轨道内的光束，以便写或存储数据并且随后读取数据。利用处于较高功率的激光写到介质的数据可以在写之后利用较低的激光功率在单独的验证操作或过程中被验证，或者可以在写操作期间通过另一个激光或激光束验证。在写操作期间读取并验证数据的能力可以被称为写后直接读（DRAW）。用于提供 DRAW 功能性的一种策略是使用多个独立的 OPU，其中一个 OPU 在另一个 OPU 读数据进行写验证的时候写数据，例如像在美国专利 No.6,141,312 中所公开的，其中两个独立的 OPU 并排放置，以实现 DRAW 功能性。虽然这种方法会适于有些应用，但是它增加了存储设备的成本和复杂性。

[0003] 目前的 OPU 可以在激光路径中使用衍射光栅或类似的光学器件来从单个激光元件生成两个或更多射束，包括用于读／写和用于聚焦的较高功率的射束，以及用于跟踪的一个或多个较低功率的卫星射束。通过 OPU 的各种光学器件和机电元件，射束聚焦到光学存储介质的表面上对应的点。在有些应用中，除了写数据和聚焦控制之外，中心点还可用于跟踪操作。从一个或多个较低功率的侧束生成的较低功率的卫星点可以用于对特殊介质类型的另一种类型的跟踪操作。

发明内容

[0004] 在本公开内容的一个实施例中，一种容纳具有用于存储数据的多条轨道的光学介质的光学存储系统包括光学头，该光学头具有在把数据写到光学介质期间以较高功率调制的第一相干光源和当第一相干光源写数据时在较低功率以连续波模式工作的第二相干光源、组合来自第一和第二光源的光并且把来自第一相干光源的光聚焦到光学介质上选定轨道的第一个点并且把来自第二相干光源的光聚焦到该选定轨道上相对于光学介质的运动方向在第一个点下游的第二个点的光学器件，该光学器件把来自光学介质的反射光指向光探测器。耦合到光学头的控制器选择性地定位光学头，用于利用第一相干光源沿选定的轨道写数据，同时在写之后利用由光探测器检测到的来自第二相干光源的反射光从选定的轨道直接读数据。

[0005] 在一个实施例中，一种光学数据存储系统包括光学拾取单元、位于光学拾取单元中的第一激光器、位于光学拾取单元中的第二激光器，以及位于光学拾取单元中并且定位成组合来自第一和第二激光器的光并且把组合后的光朝着光学存储介质指引的振幅分束器。位于振幅分束器下游的准直透镜使组合后的光准直。该系统还包括位于准直透镜下游的偏振分束器、位于偏振分束器下游的四分之一波片、位于四分之一波片下游并且配置为

把来自第一激光器的光聚焦到光学存储介质的选定轨道上第一个点并且把来自第二激光器的光聚焦到该选定轨道上第一个点下游的第二个点的物镜、配置为接收通过物镜和偏振分束器从光学介质反射的光的光探测器及关联的光学器件，以及与第一和第二激光器及光探测器通信以便调制来自第一激光的光以向光学存储介质的选定轨道写数据并且利用第二激光器从光学存储介质的该选定轨道读数据以提供写后直接读能力的控制器。

[0006] 本公开内容的实施例包括一种用于为读取并把数据写到光学存储介质上的光学存储设备提供写后直接读功能性的方法，包括组合在把数据写到光学存储介质期间来自以较高功率调制的第一激光器的光和来自以较低功率工作在连续波模式的第二激光器的光、把来自第一激光器的光聚焦到光学存储介质上选定轨道内的第一个点、把来自第二激光器的光聚焦到光学存储介质上该选定轨道内在光学存储介质行进方向相对于第一个点在其下游的第二个点，并且把从第二个点反射的光指向光探测器，以提供写后直接读功能性。

[0007] 根据本公开内容的实施例可以提供各种优点。例如，根据本公开内容一个实施例的光学存储设备利用单个 OPU 或光学头提供了用于数据验证的写后直接读功能性，该设备降低了复杂性和相关的成本。

[0008] 当联系附图理解时，与本公开内容的各种实施例关联的以上优点和其它优点及特征将从以下具体描述显而易见。

附图说明

[0009] 图 1A 和 1B 是根据本公开内容各种实施例说明具有写后直接读 (DRAW) 功能性的光学数据存储系统或方法的操作的图；

[0010] 图 2 是根据本公开内容各种实施例说明光学拾取单元 (OPU) 的操作的框图，其中 OPU 具有形成主射束和侧射束的写激光源和集成的 DRAW 激光源以便提供 DRAW 功能性；

[0011] 图 3 是根据本公开内容各种实施例说明具有集成的写和 DRAW 激光源的代表性 OPU 的框图；及

[0012] 图 4 是根据本公开内容各种实施例说明用于具有 DRAW 功能性的光学数据储存器的系统或方法的操作的框图。

具体实施方式

[0013] 这里描述本公开内容的各种实施例。但是，所公开的实施例仅仅是示例性的并且其它实施例可以采取未明确说明或描述的各种不同的和备选形式。附图不一定是按比例的；有些特征可以夸大或最小化，以示出特定组件的细节。因此，这里所公开的具体结构和功能细节不应当解释为限制，而仅仅是作为教本领域普通技术人员以各种方式使用本发明的代表性基础。如本领域普通技术人员将理解的，参考任一附图所说明和描述的各种特征可以与一个或多个其它附图中所说明的特征组合，以产生未明确说明或描述的实施例。所说明的特征的组合提供了用于代表性应用的代表性实施例。但是，与本公开内容的示教一致的特征的各种组合和修改对于特定的应用或实现来说会是期望的。

[0014] 所公开的过程、方法、逻辑或策略可以交付给和 / 或由处理设备、控制器或计算机实现，这些设备可以包括任何现有的可编程电子控制单元或专用电子控制单元。类似地，过程、方法、逻辑或策略可以作为可以由控制器或计算机执行的数据和指令以许多形式存

储，包括但不限于永久性地存储在可以包括诸如 ROM 设备的持久性不可写存储介质的各种类型制造品上的信息，以及可修改地存储在诸如光和磁盘和带、固态设备及其它磁性和光学介质的可写存储介质上的信息。过程、方法、逻辑或策略还可以在软件可执行的对象中实现。或者，它们可以完全或部分地利用合适的硬件组件来体现，诸如专用集成电路 (ASIC)、现场可编程门阵列 (FPGA)、状态机、控制器或者其它硬件组件或设备，或者硬件、软件和固件组件的组合。

[0015] 现在参考图 1A 和 1B，示出了根据本公开内容各种实施例说明具有写后直接读 (DRAW) 能力的光学数据存储系统或方法的操作的框图。图 1A 是侧视图，而图 1B 是顶视或俯视图。在图 1A 和 1B 中所说明的代表性实施例中，光学数据存储系统 10 由光带驱动器 12 实现，其中光带驱动器 12 容纳由光带 16 实现的光学数据存储介质 14。虽然是参考光带驱动器来说明和描述的，但是本领域普通技术人员将认识到，本公开内容的示教还可以应用到可以使用各种类型写一次或可重写光学介质的各种其它类型的光学数据存储设备，例如像光盘。在一个实施例中，光带 16 是 1/2 英寸 (12.7mm) 宽的带，具有多条一般来说跨带的宽度延伸的轨道并且其长度可以依赖期望的存储能力和性能特征而变化，如这里更具体地说明和描述的。光带 16 可以缠绕在保护性外壳或托架 18 中所包含的关联的卷轴 30 上，其中托架 18 手动或自动地加载或安装在光带驱动器 12 中。传输机制 24 移动光带 16 通过托架并经过至少一个光学拾取单元 (OPU) 或光学头 20，到达通常留在带驱动器 12 中的收带轴 22。当传输机制 24 在托架 18 和收带轴 22 之间移动光带 16 时，响应于至少一个控制器和关联的电子器件 26，OPU 20 把数据写到光带 16，和从其读取数据。如以下更具体解释的，当带在任一方向经过 OPU 20 时，即，从托架 18 到收带轴 22，或者从收带轴 22 到托架 18，数据可以以蛇形方式被读取 / 写到光带 16 中多条轨道当中的一条或多条。

[0016] 光学头 20 可以包括把较高功率调制的写射束和较低功率的连续波 (cw) 读射束指向物镜的关联的光学器件和相关的机电伺服受控设备，总体上由标号 30 表示，其中物镜把射束聚焦到存储介质上对应的点 (spot)，用于写 / 读数据，如参考图 2 更具体地说明和描述的。各种伺服机制 (未具体说明) 可以用来定位 / 对准射束与光带 16 上多条轨道 36 中选定的一条。

[0017] 图 2 是根据本公开内容说明用于写后直接读的系统或方法的操作的框图。在图 2 的代表性实施例中，具有第一相干光束 40 和第二相干光束 44 的光学拾取单元 (OPU)20 只用单个头或 OPU 提供 DRAW 功能性。例如，射束 40 和 44 可以由对应的相干光源，诸如激光二极管 (在图 3 中最好地说明)，生成。或者，单个或公共的相干光源可以与关联的光学器件一起使用，以分离射束。但是，如这里更具体描述的，用单个或公共光源既生成读射束又生成写射束会需要对反射射束的更复杂的处理，以便读取数据并过滤掉与把数据写到存储介质相关联的调制的影响。

[0018] 在根据本公开内容的各种实施例中，OPU 20 包括生成第一相干光束 40 的第一激光器 320(图 3) 和生成第二相干光束 44 的第二激光器 322(图 3)。关联的光学器件 (在图 3 中最好地说明) 组合第一和第二射束并且把射束分别聚焦到光带 16 上多条轨道 36 的选定轨道“n”当中关联的点 50 和 54。光点 50、54 可以由 OPU 20 的各种光学和机电元件来操纵，以便从光带 16 写和取回数据。

[0019] 现在参考图 2 和 3，第一和第二光源或激光器 320、322 可以在不同的功率水平并以

不同的模式工作，以提供 DRAW 功能性。例如，生成射束 40 和点 50 的第一光源 320 可以在较高的功率工作并且被调制成在光带 16 上写对应的数据印象 60，而第二光源 322 可以以连续波 (cw) 模式在较低的功率工作，以提供射束 44 和点 54，以便通过射束 40 在写后直接读数据印象 60。第二 (DRAW) 点 54 位于带 16 行进的方向 64 中相对于写点 50 在其下游有足够的距离处，以允许数据印象 60 在被读取之前有足够的时间稳定。在一个实施例中，中心点 50 可以具有比 DRAW 点 54 的平均功率大 10-20 倍的平均功率。例如，中心点 50 可以具有大约 8mW 的平均功率来写数据，而 DRAW 点 54 可以只具有大约 0.35mW 的平均功率来在写后直接读数据。DRAW 点 54 较低的功率确保它将包含足够低的能量，以不改变之前在光学存储介质或带 16 上被写的数据。

[0020] 在一种代表性实施例中，点 50 和 54 在 OPU 制造过程中机械对准成对应于预先格式化的光带介质 16 上的数据轨道 36 的轴。此外，基于最快预期线性带速度和光带介质 16 的特点，点 50 和 54 一般来说定位成使得带 16 在中心点 50 和卫星 / 侧点 54 之间的传输距离 (d) 为写到光带介质 16 的数据提供足够的时间来稳定。在一个实施例中，OPU 20 制造成提供大约 10-20μm 之间的距离 (d)。

[0021] 除一种类型的跟踪操作之外，有些常规的光学存储设备还使用来自较高功率射束 40 的中心点 50 用于读、写和聚焦。对于特殊类型的介质，卫星点可用于另一种类型的跟踪。在这些应用中，卫星点不能彼此对准，或者沿光带 16 的单个选定轨道 36 与中心点 50 对准。与典型卫星射束的常规功能相反，根据本公开内容的各种实施例使用卫星点 54 来提供写后直接读 (DRAW) 功能性。

[0022] 如前面描述过的，第一激光束 40 工作在较高功率并且被调制成改变光带 16 的光活性层的结构并且在多条轨道 36 中选定的一条上写数据标记 60。当它到达光带 16 时，卫星 DRAW 射束 44 有低得多的功率，因此它不改变光带 16 的光活性层。但是，卫星 DRAW 射束 44 设计成在从光带 16 反射之后有足够的功率来检测数据标记 60，以提供 DRAW 功能性。

[0023] 图 3 是根据本公开内容各种实施例说明用于光学数据储存器的 DRAW 系统或方法的操作的框图。在所说明的代表性实施例中，包括第一相干光源 320 和第二相干光源 322 的光学组件包含在单个光学头或 OPU 中。例如，相干光源 320、322 可以由激光二极管实现。依赖于特定的实现，诸如设备 10(图 1) 的光学存储设备可以包括多个光学头，以便对光带 16 的对应轨道 36 同时写 / 读数据。除了相干光源 320、322，OPU 20 还可以包括振幅分束器 330，它操作成把分叉的射束 324 和 326 组合成穿过位于振幅分束器 330 下游的准直透镜 332 的组合射束 328。透镜 332 使组合后的光 328 准直，然后该光穿过位于准直透镜 332 下游的偏振分束器 340。波减速器，诸如四分之一波片 342，位于偏振分束器 340 下游，以相对于来自光学存储介质 16 的反射光 348 改变指向光学存储介质 16 的光 328 的偏振，以方便反射光 348 通过偏振分束器 340 到反射镜 350 的重定向。然后，来自点 44 的反射光 348 被反射镜 350 指引通过 DRAW 聚焦透镜 352 到达光探测器 360，在一个实施例中，光探测器 360 由光电二极管阵列实现。

[0024] 经过四分之一波片 342 的组合光 328 被物镜 346 聚焦，以便在光带 16 上选定的轨道内形成点 50、54。当利用单个物镜 346 把来自激光源 320 的光聚焦到第一个点 50 并且把来自激光源 322 的光聚焦到第二个点 54 时，各种策略可以用来提供重叠或公共的射束路径。例如，不同波长的光可以由激光源 320、322 生成，或者射束路径不能直接重叠并且相对

于彼此具有稍不同的入射角。

[0025] 如在图 3 的代表性实施例中所说明的，光探测器 360 包括关联的光学器件，诸如 DRAW 透镜 352、反射镜 350 和四分之一波片 342，配置为通过物镜 346 和偏振分束器 340 接收从光学存储介质 16 反射的光。与第一激光器 320、第二激光器 322 和光探测器 360 通信的控制器 26（图 1）包括控制逻辑，该控制逻辑把来自第一激光器 320 的光 324 调制成把数据写到光学存储介质 16 的选定轨道 36 并且以连续波（cw）模式操作第二激光器 322 以便从光学存储介质 16 的选定轨道 36 读数据，以提供写后直接读功能性。控制器 26 可以使用各种策略来比较利用射束 326 读取的数据和利用射束 324 写入的数据，以提供数据验证和存储设备诊断。

[0026] 在各种实施例中，振幅分束器 330 配置为传送来自第一激光器 320 的入射光 324 的大约 90％以上到准直透镜，剩余的光（不考虑损耗）朝着光吸收器或射束收集器 370 反射。照此，振幅分束器 330 还将传送来自第二激光器 322 的入射光 326 的大约 90％到射束收集器 370 并且把来自第二激光器 322 的入射光 326 的大约 10％以下重定向到准直透镜 332。在一个实施例中，振幅分束器 330 传送光 324 的大约 95％，剩余的 5％的光重定向到光吸收器 370。类似地，光 326 的大约 95％传送到射束收集器 370，剩余的 5％的光重定向到准直透镜 332。如图 3 中所说明的，可选的射束收集器 370 定位成或配置为吸收由振幅分束器 330 重定向的、来自第一激光器 320 的相当小部分的光和通过振幅分束器 330 传送的、来自第二激光器 322 的相当大部分的光。在这种实施例中，为了向光带 16 提供 8mW 的平均写功率（忽略与所有其它组件相关联的光损耗），写激光器 320 将工作在大约 8.4mW，从而把 95％传送通过振幅分束器 330。类似地，DRAW 激光器 322 将工作在 7mW 的相对较低的功率，以便在光带 16 提供 0.35mW 的平均读功率，只有 5％被振幅分束器 330 朝着光带 16 重定向。

[0027] 图 4 是根据本公开内容各种实施例说明用于具有 DRAW 功能性的光学数据储存器的系统或方法的操作的框图。本领域普通技术人员将认识到，图 4 中所代表的功能可以由具有关联的被编程微处理器的各种光学元件执行，该光学元件比较写到光学存储介质的数据和写后直接读取的数据，以提供写后直接读功能性。不管是由一个或多个光学元件单独地执行，还是结合基于被编程微处理器的控制器执行，所说明的各个步骤或功能都可以以所说明的顺序、并行地执行，或者在有些情况下可以被省略。虽然没有明确地说明，但是本领域普通技术人员将认识到，依赖于特定的实现，所说明的步骤或功能当中的一个或多个可以重复执行。类似地，在代表性实施例中所说明的次序不一定是实现这里所述特征和优点所必需的，而是为便于说明和描述提供的。

[0028] 各种控制功能，例如像点聚焦和与选定轨道的对准，可以由控制器或处理器利用由图 4 简化流程图的一个或多个功能表示的逻辑或代码执行，以控制光学存储设备中关联的组件或设备。控制逻辑可以在软件中利用由基于微处理器的控制器执行的指令来实现。当然，依赖于特定的实现，控制逻辑可以在一个或多个控制器或等效电子器件中以软件、硬件或软件和硬件的组合实现。当以软件实现时，控制逻辑可以存储在一个或多个计算机可读存储介质中，该介质存储了代表由计算机执行的、用来控制光学存储设备的一个或多个组件的代码或指令的数据。计算机可读存储介质可以包括利用电、磁、光和／或混合储存器来保持可执行指令和关联数据的多种已知物理设备当中的一种或多种。

[0029] 用于具有 DRAW 功能性的光学储存器的代表性系统或方法的操作可以包括组合在数据写到光学存储介质期间以较高功率调制的第一激光器的光和来自以较低功率工作在连续波模式的第二激光器的光，如由方框 410 表示的。关联的光学器件可以用来把来自第一激光器的光聚焦到光学存储介质上选定轨道中的第一个点，如由方框 420 表示的。类似地，一个或多个光学设备可以用来把来自第二激光器的光聚焦到光学存储介质上该选定轨道中在光学存储介质行进的方向相对于第一个点在其下游的第二个点，如由方框 430 表示的。如前面所说明和描述的，第一和第二激光器可以使用相同 / 公共光学元件 / 设备当中的一个或多个来朝着光学存储介质指引射束并且把射束聚焦到选定轨道中对应的点。

[0030] 如也在图 4 中说明的，根据本公开内容的系统或方法可以包括把从第二个点反射的光指向 OPU 中的光探测器，以提供写后直接读功能性，如总体上由方框 440 表示的。依赖于特定的实现，根据本公开内容的系统或方法还可以包括相对于从光学存储介质反射的光改变指向光学存储介质的光的偏振，以方便从光学存储介质反射的光重定向到光探测器，如由方框 435 表示的。如以上参考图 3 所描述的，例如，这可以利用四分之一波片或类似的波减速器结合偏振分束器来实现。

[0031] 各种实施例可以可选地包括定位成或者配置为把来自第一和第二激光器的、未指向光学存储介质的光指向光吸收器或射束收集器的一个或多个设备，如由方框 450 表示的。

[0032] 从第二个点反射回光探测器的光，如由方框 440 表示的，可以用来比较读数据与写数据，以提供写数据验证，如由方框 460 表示的。如本领域普通技术人员将认识到的，读数据将相对于写数据时间偏移光学介质的传输延迟。依赖于特定的实现，也可以为射束路径差和 / 或处理延迟提供补偿。

[0033] 照此，根据本公开内容的各种实施例利用单个 OPU 或光学头为光学数据存储设备提供了用于写后直接读 (DRAW) 功能性的系统和方法，该系统和方法降低了复杂性和相关联的成本。

[0034] 虽然以上描述了示例性实施例，但是这些实施例不是要描述由权利要求涵盖的全部可能形式。说明书中所使用的词是描述性而不是限制性的词，并且应当理解，在不背离本公开内容和权利要求主旨和范围的情况下，可以进行各种改变。如前面所描述的，各种实施例的特征可以组合，以形成可能没有明确描述或说明的更多实施例。虽然各种实施例可以描述为关于一个或多个期望的特点比其它实施例或现有技术实现提供优点或更优，但是本领域普通技术人员应当认识到，为了实现依赖于具体应用和实现的期望的整体系统属性，一个或多个特征或特点会受损。这些属性包括，但不限于：成本、强度、耐久性、生命周期成本、可销售性、外观、包装、尺寸、可维护性 (serviceability)、重量、可制造性、组装的容易性，等等。照此，关于一个或多个特点描述为没有其它实施例或现有技术实现那么可取的实施例不在本公开内容范围之外并且对于特定应用会是期望的。

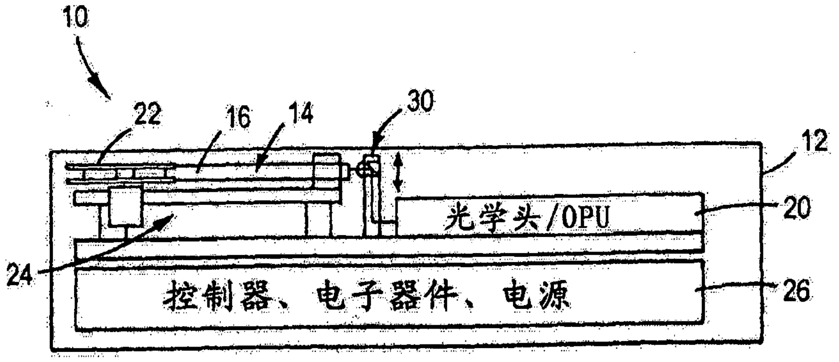

10
22
16
14
30
12
光学头/OPU
20
24
控制器、电子器件、电源
26

图 1A

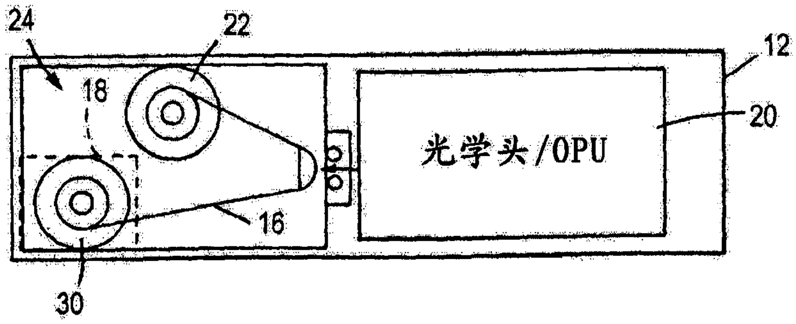

24
22
12
18
20
光学头/OPU
16
30

图 1B

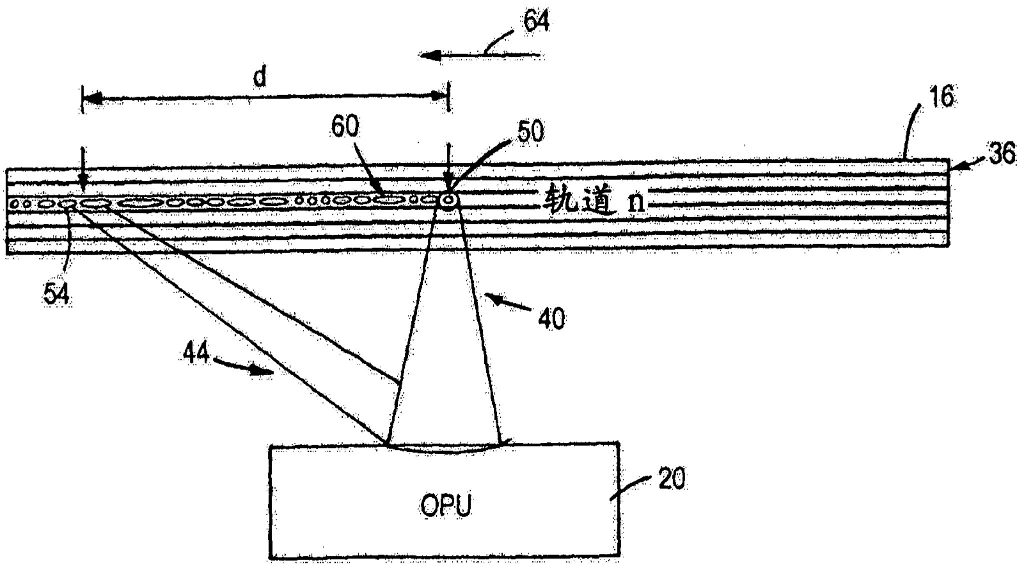

64
d
16
60
50
36
轨道 n
54
40
44
OPU
20

图 2

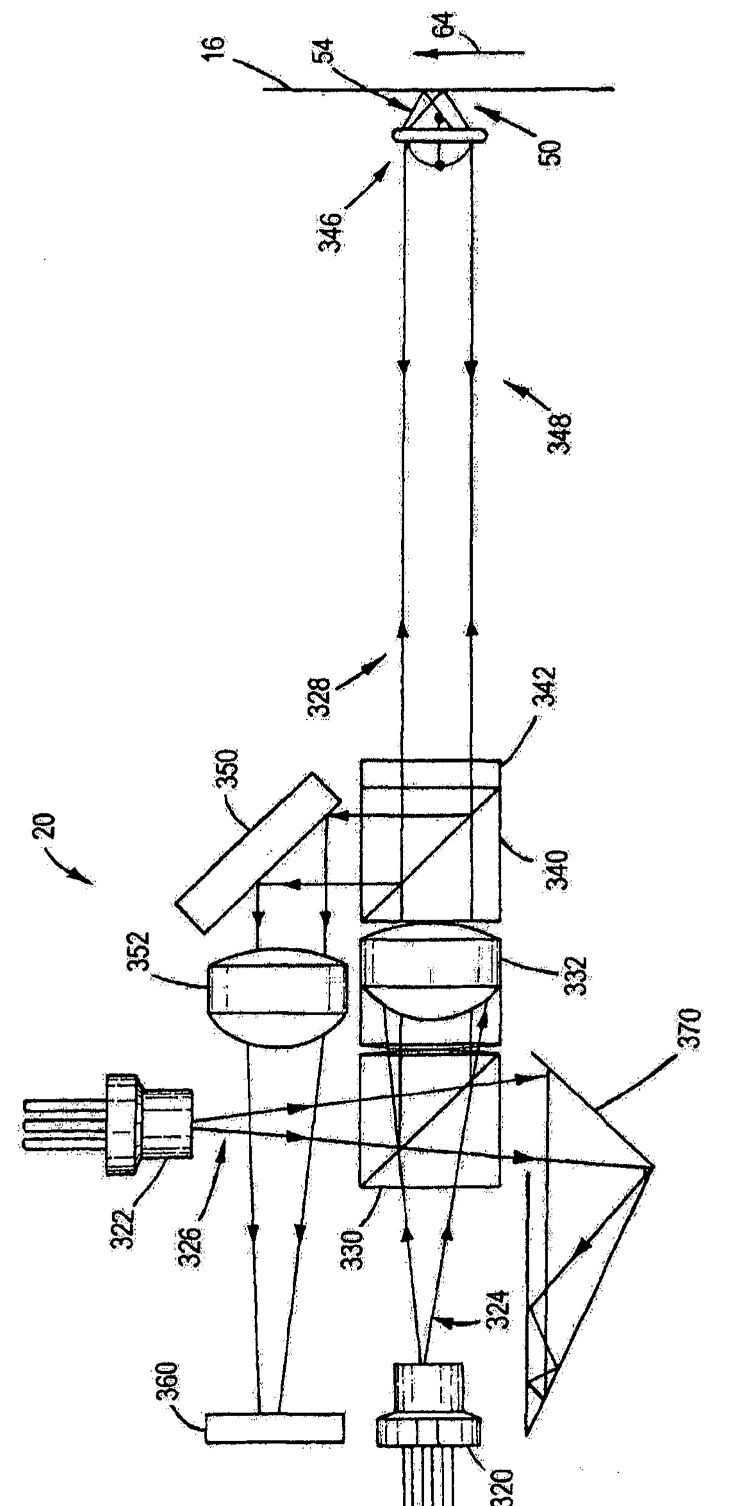
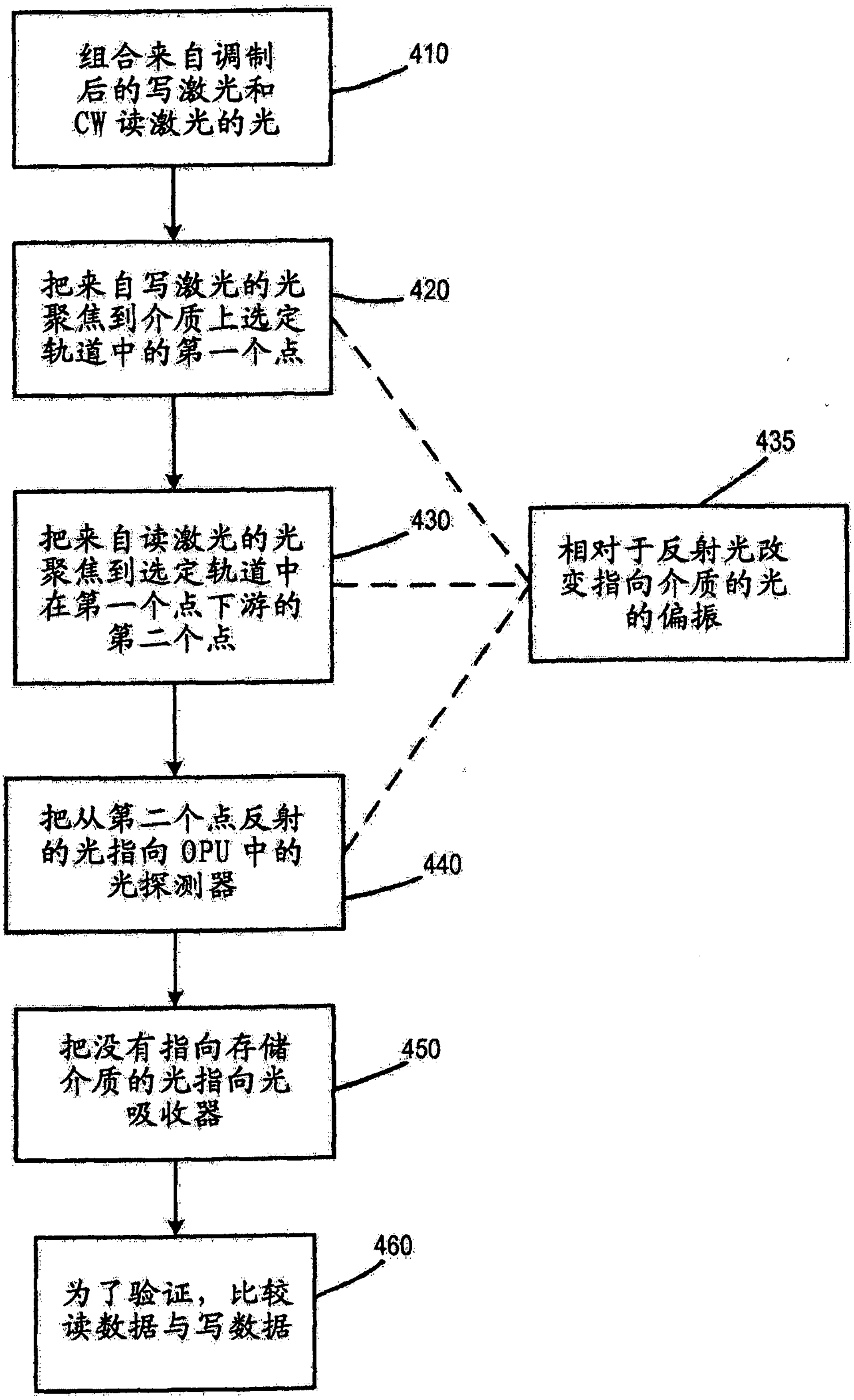

16
54
64
50
346
348
328
342
350
20
340
352
332
370
322
326
330
324
360
320

图 3



组合来自调制后的写激光和CW读激光的光
410
把来自写激光的光聚焦到介质上选定轨道中的第一个点
420
把来自读激光的光聚焦到选定轨道中在第一个点下游的第二个点
430
435
相对于反射光改变指向介质的光的偏振
把从第二个点反射的光指向OPU中的光探测器
440
把没有指向存储介质的光指向光吸收器
450
为了验证，比较读数据与写数据
460

图 4