



- (51) International Patent Classification:
G02B 27/14 (2006.01)
- (21) International Application Number:
PCT/EP2014/061040
- (22) International Filing Date:
28 May 2014 (28.05.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
201310280811.7 5 July 2013 (05.07.2013) CN
- (71) Applicant: **OSRAM GMBH** [DE/DE]; Marcel-Breuer-Straße 6, 80807 München (DE).
- (72) Inventor: **DING, Yi**; Kunshan Free Trade Zone, 3rd Avenue 5, Kunshan, Jiangsu 200 001 (CN).
- (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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,

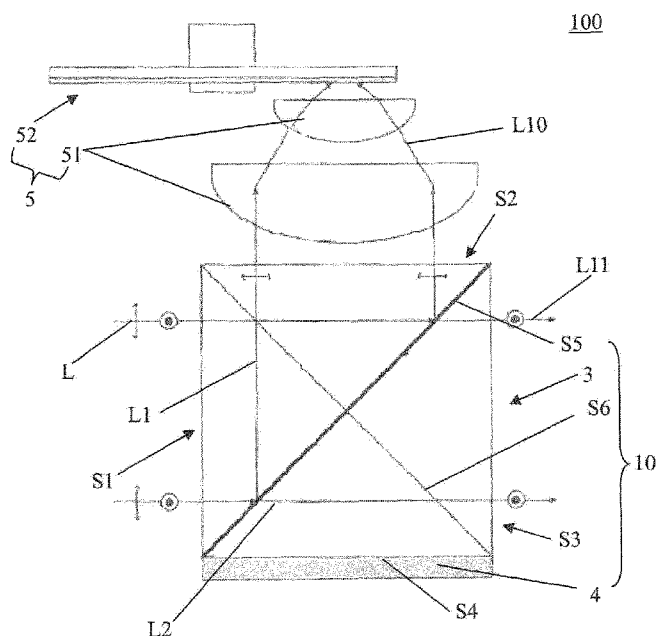
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

- (54) Title: PROJECTOR LIGHT SOURCE COMPRISING LIGHT CONVERSION WHEEL AND X-CUBE

**Figure 1a**

(57) Abstract: The present invention relates to a prism device 100 for a projector, the prism device comprising a light source and a prism box 3, the prism box comprising first, second, third and fourth surfaces, S1-S4 and an original light L from the light source entering the prism box through the first surface, wherein the prism device further comprises an optical path adjusting means 10 and at least one light conversion means (phosphor wheel) 5 provided downstream from at least one of the first, second, third and fourth surfaces, the optical path adjusting means is configured to guide a first part of the original light through at least one of the second, third and fourth surfaces to the light conversion means, and enable a second part of the original light to emerge through at least one further surface of the second, third and fourth surfaces as an emergent surface, and is configured to guide a converted light L11 from the light conversion means to emerge in a direction parallel to an emergent direction passing through the emergent surface, and guide at least a part of unconverted original light from the light conversion means to emerge in a direction parallel to an emergent direction passing through the emergent surface.

Description

PROJECTOR LIGHT SOURCE COMPRISING LIGHT CONVERSION WHEEL AND X-CUBE

5 **Technical Field**

The present invention relates to a prism device for light source.

Background Art

10 In the techniques used in the existing projectors, for instance, in the DLP, LCD or LCos type projector, the technique of enabling light with different wavelengths from a light source to emerge through an emergent aperture is used. However, in this process, for instance, in the technique used in the DLP type projector, in order to enable the light having
15 different wavelengths to emerge through the emergent aperture, the light is ejected to the emergent aperture in temporal order, instead of passing through the emergent aperture at the same time. In this situation, it will result in that we could not take full advantage of the triplet LCD or LCos
20 projector. Besides, since mechanism or means capable of effectively recovering the unconverted light is absent, during the emerging process, the unconverted light is wasted as it is not sufficiently used because it fails to emerge from the emergent aperture, and this also will significantly reduce
25 the optical efficiency of the light source of the projector.

Summary of the Invention

30 In order to solve the above technical problem, the present invention provides a prism device for a light source, which can form a compact optical system using an X-cube and realize light processing of the light source. Besides, upon processing of the prism device according to the present invention, the power ratio of formed light having different wavelengths can be properly controlled, and the converted light

and the unconverted light can be both used so that the usage efficiency of light of a light source system is improved and elevated. Moreover, light from the light source having different wavelengths can be ejected at the same time to an emergent aperture so as to successfully enter next possible optical system.

The first object of the present invention is accomplished via a prism device for a light source. The prism device comprises a light source and a prism box located downstream from the light source, the prism box comprises first, second, third and fourth surfaces, and an original light from the light source enters the prism box through the first surface, characterized in that the prism device further comprises an optical path adjusting means and at least one light conversion means provided downstream from at least one of the first, second, third and fourth surfaces, the optical path adjusting means is configured to guide a first part of the original light through at least one of the second, third and fourth surfaces to the light conversion means, and enable a second part of the original light to emerge through at least one further surface of the second, third and fourth surfaces as an emergent surface, and is configured to guide a converted light from the light conversion means to emerge in a direction parallel to an emergent direction passing through the emergent surface, and guide at least a part of unconverted original light from the light conversion means to emerge in a direction parallel to an emergent direction passing through the emergent surface. According to this configuration, the possibility of recovering and re-using part of the unconverted original light using this prism device is realized, based on the use of the converted light.

The term light source comprises all kinds of sources emitting radiation, which can be used to excite luminescent and/or phosphorescent materials ("excitation radiation"), thereby emitting converted radiation ("conversion radiation"). Preferably, the excitation radiation comprises polarized light

within a certain wavelength range, e.g. from 405 nm to 470 nm, but may also comprise other wavelengths and/or a combination of various wavelengths (including infrared and/or ultraviolet radiation). Preferably, one or more polarized light sources with small beam divergences are used as excitation sources, particularly laser diodes or superluminescent diodes.

According to a preferred solution of the present invention, the optical path adjusting means comprises a fifth surface having a first coating and a sixth surface having a second coating which are provided inside the prism box, and the fifth surface and the sixth surface are formed as internal surfaces of the prism box. The original light can be processed by using the two surfaces having coatings of different attributes, so as to realize the possibility of, for instance, splitting the light and changing the optical path.

Preferably, the optical path adjusting means further comprises a light recovery means in connection with the prism box, and the light recovery means is configured to at least guide a part of the unconverted original light to emerge in a direction parallel to the emergent direction passing through the emergent surface. Thus, it can be realized that the unconverted original light is guided to a direction consistent with that of the original emergent surface to emerge, so as to realize the possibility of re-using the unconverted original light.

Preferably, the light recovery means is provided downstream from the fifth surface and the sixth surface in optical path. Consequently, the converted light converted by the light conversion means and the unconverted original light both can be re-used and processed in the light recovery means provided downstream so as to realize the possibility of improving the efficiency of the light source.

Preferably, the light recovery means guides a part of the un-

converted original light, after conversion of polarization state, to emerge in a direction parallel to the emergent direction passing through the emergent surface. Therefore, the possibility of changing the polarization of the unconverted original light can be realized so as to meet the requirement of the emergent light in the aspect of the polarization state.

Preferably, one light conversion means is provided outside the second surface. Such configuration is beneficial for forming a compact and concise optical path so as to obtain eventually a compact prism device and the possibility of re-using the unconverted original light downstream the optical path.

Preferably, a normal of the fifth surface and a normal of the sixth surface are configured perpendicular to each other. Thus, according to demand of practical application circumstances, the two surfaces can be arranged inside the prism box perpendicularly in multiple different ways so as to realize, for instance, that the light of the original light is incident upon one of the surfaces at 45° and the converted light also is incident upon the other surface at 45° to finally achieve the object of guiding the light towards a particular direction and splitting the light.

Preferably, viewed from a cross section of the prism box, the fifth surface and the sixth surface extend from one corner to an opposite corner of the prism box, respectively, so as to be configured perpendicular to each other. Such configuration can satisfy the requirement of the above incident angle to achieve the object of guiding and splitting the light.

Preferably, the original light comprises a first original light having a first excited state and a second original light having a second excited state, the unconverted light comprises a first converted light having the first excited state and a second converted light having the second excited

state, wherein the light recovery means is at least configured to convert the first original light to the second original light or convert the second original light to the first original light; or, is configured to convert the first converted light to the second converted light or convert the second converted light to the first converted light. According to such configuration, the possibility of keeping consistent the excited state of the emergent light obtained by the light recovery device with the excited state of the emergent light obtained directly through the prism box can be realized, moreover, the emergent light in the desired excited state can be obtained according to different practical application circumstances.

Preferably, the first coating is configured to allow transmission of one of the first original light and the second original light and reflection of the other one of the first original light and the second original light; and the second coating is configured to allow transmission of the other one of the first original light and the second original light and reflection of the one of the first original light and the second original light. Consequently, the possibility of splitting and guiding the original light having different excited states can be realized.

Advantageously, the second coating is configured to reflect the first converted light and the second converted light for exiting. Thus, it can be realized that the desired converted light is directly guided to the emergent surface.

Preferably, the light recovery means is configured to be formed downstream from the fourth surface, wherein the fourth surface is opposite to the second surface. According to such configuration of the optical path, the converted light which originally may directly emerge can be re-used after guided to the light recovery means.

Preferably, the light recovery means is configured as a wave

plate. According to the specific requirement, the wave plate can change the polarization state of the incident light so as to realize the possibility of changing the excited state of the incident light after processing the incident light.

5 Preferably, the first original light and the second original light, and the polarization state of the first converted light and the second converted light is perpendicular to each other, respectively, and the wave plate is configured as a quarter wave plate. The half wave plate can change the polar-
10 ization state of the light passing therethrough, so as to realize the possibility of changing the excited states of the original light and the converted light between the first excited state and the second excited state.

Preferably, the first excited state and the second excited
15 state are P-polarization state and S-polarization state, or S-polarization state and P-polarization state, respectively. Therefore, the requirement to the polarization state of the emergent light can be met.

Preferably, emergent light passing through the emergent sur-
20 face comprises mixed light in different polarization states. Therefore, the requirement to the polarization state of the emergent light can be met, and the possibility of re-using the converted light in at least one polarization state is realized.

25 Preferably, the third surface opposite to the first surface acts as the emergent surface. Thus, while the simple and reasonable design of the optical path is satisfied, the third surface can be configured as the emergent aperture of the light of the light source after processing.

30 Preferably, the light recovery means comprises a first subunit and a second subunit, and the first subunit is configured to at least guide a part of the unconverted original light, after change of polarization state, to emerge through the se-

cond subunit. According to such configuration, while the converted light is changed of the polarization state and guided to the emergent surface, the same configuration also can be used for emergence of the unconverted original light after
5 suitable change of the polarization state.

Preferably, the second coating is configured to allow reflection of one of the first converted light and the second converted light and transmission of the other one of the first converted light and the second converted light to the light
10 recovery means. In this way, the possibility of maintaining consistent the polarization state of one of the two converted light, after processing by the light recovery means with that of the other converted light can be realized.

Advantageously, emergent light emerging through the emergent
15 surface and emergent light emerging through the second subunit have the same polarization state. Thus, it can be ensured that the emergent light having the same polarization state is provided.

Preferably, the first subunit comprises a third coating and a
20 third wave plate provided downstream from the third coating, and the second subunit is a fourth wave plate provided downstream from the third wave plate. By using the third coating, it can be realized that, while the converted light is reflected, for instance, the unconverted original light is
25 transmitted, and then after the polarization state of the unconverted original light is changed via the configuration of the wave plate, and upon the processing by the fourth wave plate, the polarization state of the unconverted original light can be consistent with that of the converted light re-
30 flected by the third coating.

Preferably, the third coating is configured to reflect the first converted light or the second converted light for exiting, and to transmit unconverted first original light or second original light to the third wave plate, the third wave

plate converts the first original light or the second original light to the second original light or the first original light and guides it to the fourth wave plate, and the fourth wave plate converts the second original light or the first original light to the first original light or the second original light. Therefore, the polarization state of the converted light emerging through the fourth wave plate can be kept consistent with that of the unconverted original light emerging through the fourth wave plate.

10 Preferably, the fourth wave plate is configured to extend from an end of the fourth surface along one end of the third surface to a direction away from the light conversion means, and the third wave plate is configured to join the other end of the fourth surface and an opening end of the fourth wave plate. Thus, the emergent direction of the converted light emerging through the light recovery means or the unconverted original light can be kept consistent with that of the emergent light emerging directly through, for instance, the third surface as the emergent surface, of the prism box.

20 Preferably, the fourth wave plate and the third wave plate are configured to form an angle of 45° with each other. Therefore, it can be satisfied that the unconverted original light entering the light recovery means and the converted light are guided to the desired emergent direction.

25 Preferably, the fourth wave plate is configured as a half wave plate. After the polarization state of the unconverted original light entering the light recovery means and the converted light can be changed by the half wave plate, the polarization state thereof is then changed.

30 Preferably, the first subunit comprises a seventh wave plate and a fifth wave plate both provided downstream from the fourth surface and a fourth coating provided downstream from the fifth wave plate, and the second subunit is a sixth wave plate. Therefore, the light entering the light recovery means

can be subject o corresponding change of the polarization state of the light successively by the fifth wave plate and the sixth wave plate, so that the possibility of keeping consistent the polarization state of the emergent light with the polarization state of the emergent light emerging through the prism box can be realized.

Preferably, the seventh wave plate performs primary conversion for one of the first converted light and the second converted light, and reflects it through the third coating to the sixth wave plate for secondary conversion, so as to obtain the other converted light of the emerging second converted light and first converted light. According to such configuration of the optical path, the polarization state of the first converted light or of the second converted light can be changed correspondingly successively by the fifth wave plate and the sixth wave plate so as to achieve the possibility of finally changing the polarization state of the light.

Preferably, the first original light and the second original light, and the polarization state of the first converted light and the second converted light is perpendicular to each other, and the fifth wave plate, the sixth wave plate and the seventh wave plate are configured as a quarter wave plate. The polarization state of the first original light and the second original light, and the first converted light and the second converted light is changed successively by the fifth wave plate and the sixth wave plate so as to finally achieve the same effect as, for instance, only using one half wave plate to change the polarization state of the light.

Preferably, the seventh wave plate is configured to be parallel with the fourth surface, the sixth wave plate is configured to extend from an end of the fourth surface along one end of the third surface to a direction away from the light conversion means, the fifth wave plate is configured to join the other end of the fourth surface and an opening end of the sixth wave plate, and the fourth coating is provided on the

fifth waveplate. Thus, the emergent direction of the converted light or the unconverted original light emerging through the light recovery means can be kept consistent with the emergent direction of the emergent light directly emerging through the prism box.

According to a preferred solution of the present invention, the light conversion means comprises one phosphor means having at least one types of phosphors. According to such configuration, the possibility of having the converted light simultaneously with different wavelengths can be realized.

The term phosphor comprises all kinds and/or mixtures of materials that are capable of emitting converted radiation (e.g. in the visible wavelengths range: "conversion light") upon irradiating with excitation radiation (e.g. blue light emitted by a laser diode). The excitation radiation may be converted by down-conversion or by up-conversion.

Preferably, the number of the light conversion means is two, and respective light conversion means is configured to comprise phosphor means having a single phosphor. Two light conversion means can be used simultaneously to achieve the same or similar effect as that of the phosphor means having at least two types of phosphors.

Advantageously, the optical path adjusting means is configured to divide the first part of the original light into two parts so as to guide it through each of two of the second, third and fourth surfaces to the phosphor means. Thus, after different parts of the original light can be guided to different phosphor means, it is realized that the wavelengths of different parts of the original light are changed correspondingly to finally obtain the converted light with different wavelengths.

Preferably, the optical path adjusting means comprises a fifth surface having a first coating and a sixth surface hav-

ing a second coating which are provided inside the prism box, the first coating is configured to reflect one part of the first part of the original light to one phosphor means, the first coating and the second coating are configured to transmit the other part of the first part of the original light to the other phosphor means; and the second coating is configured to reflect the second part of the original light to the emergent surface. According to the configuration of the two phosphor means, for instance, on the second surface and the third surface, it can be realized that the light after processing by the prism box and the phosphor means, emerges, e.g. from the fourth surface of the prism box.

Preferably, the first coating and the second coating are configured to allow transmission of converted light from the one phosphor means to the emergent surface, and allow transmission of converted light from the other phosphor means through the second coating to enter the emergent surface after reflected by the first coating. Therefore, light from the phosphor means located in different positions can emerge uniformly from the same emergent surface, for instance, the fourth surface.

Preferably, the optical path adjusting means comprises a fifth surface having a first coating and a sixth surface having a second coating which are provided inside the prism box, the first coating is configured to reflect one part of the first part of the original light to one phosphor means, the first coating and the second coating are configured to transmit the other part of the original light to the emergent surface; and the second coating is configured to reflect a second part of the original light to the other phosphor means. According to the configuration of the two phosphor means, for instance, on the second surface and the fourth surface, it can be realized that all light after processing by the prism box and the phosphor means emerges from, e.g. the third surface of the prism box.

Preferably, the first coating and the second coating are configured to allow transmission of converted light from one phosphor means and converted light from the other phosphor means through the second coating to enter the emergent surface after reflected by the first coating. Therefore, light from the phosphor means provided in different positions can uniformly emerge from the same emergent surface, e.g. the third surface.

According to a preferred solution of the present invention, the first, second, third and fourth surfaces of the prism device have an antireflective coating. As a result, decreasing of the light energy of light passing through the four surfaces can be avoided as much as possible so as to ensure the optical efficiency of the whole prism device.

Brief Description of the Drawings

The accompanying drawings constitute a part of the present Description and are used to provide further understanding of the present invention. Such accompanying drawings illustrate the embodiments of the present invention and are used to describe the principles of the present invention together with the Description. In the accompanying drawings the same components are represented by the same reference numbers. As shown in the drawings:

Fig. 1a - Fig. 1c are schematic diagrams of a prism device according to a first embodiment of the present invention;

Fig. 1d is a schematic diagram of the prism device according to a second embodiment of the present invention;

Fig. 2a - Fig. 2b are schematic diagrams of the prism device according to a third embodiment of the present invention;

Fig. 3 is a schematic diagram of the prism device according

to a fourth embodiment of the present invention;

Fig. 4 is a schematic diagram of a phosphor wheel of the prism device according to the embodiments of the present invention;

- 5 Fig. 5 is a schematic diagram of configuration of a fifth surface and a sixth surface of the prism device according to the present invention; and

Fig. 6 is a schematic diagram of the prism device according to a fifth embodiment of the present invention.

10 Detailed Description of the Embodiments

As shown in Fig. 1a - Fig. 1c, they are schematic diagrams of a prism device 100 according to a first embodiment of the present invention, wherein the prism device 100 comprises a prism box 3, of which four surfaces are coated with antire-
15 flective coatings so as to ensure that light energy of light passing through these surfaces will not be influenced, and a phosphor wheel 52 (to be explained in detailed later on) provided on a second surface S2 of the prism box 3 and at least one lens 51. Besides, the prism device 100 further comprises
20 an optical path adjusting means 10 which includes a quarter wave plate provided downstream from a fourth surface S4, and a fifth surface S5 having a first type of coating and a sixth surface S6 having a second type of coating provided inside the prism box 3. In the above, according to attributes of the
25 coatings, light having different polarization states will be reflected or transmitted by the surfaces having the coatings with corresponding attributes. Specifically, Fig. 1a to Fig. 1c show that the fifth surface S5 is configured in such as manner that a first original light L1 which is pump light and
30 has an S-polarization state passes through and a second original light L2 which is pump light in a P-polarization state is reflected, and meanwhile all converted light L' passes through; and the sixth surface S6 is configured in such a

manner that all light L which is pump light passes through, and meanwhile all converted light L' is reflected. According to such configuration, the light L which is the pump light from the light source enters from a first surface S1 of the prism box 3, the first original light L1 and the second original light L2 having the P-polarization state and the S-polarization state, respectively, directly passes through the sixth surface S6 and reaches the fifth surface S5, due to the second type of coating on the fifth surface S5, the first original light L1 having the P-polarization state is reflected and passes through the second surface S2 of the prism box 3 to arrive at a light conversion means 5, and at the same time, the second original light L2 having the S-polarization state directly passes through the fifth surface S5 and emerges through the third surface S3 of the prism box 3. In this way, after the light L from the light source has undergone processing of the prism box 3, the second original light L2 having the S-polarization state emerges from the prism device 100, and the first original light L1 having the P-polarization state strikes the phosphor wheel 52 after converged by the lens 51. The converted light L' converted by the light conversion means 5 and the unconverted original light L which is not converted are reflected and re-enter the prism box 3, which will be described in detail in Fig. 1b - Fig. 1c.

In reference to Fig. 1b - Fig. 1c, the converted light L' from a phosphor means 52 and the unconverted original light L enter the prism box 3 after passing through the lens 51. At this time, according to the configuration of the coatings of the fifth surface S5 and the sixth surface S6 described before, all converted light L' is reflected by the sixth surface S6 to the third surface S3 of the prism box 3 to emerge. Moreover, after the unconverted original light L enters the prism box 3 together with the converted light L', the first original light L1 having the P-polarization state, when confronted with the fifth surface S5, is reflected to the first surface S1 of the prism box 3, while the second original

light L2 having the S-polarization state directly passes through the fifth surface S5 and the sixth surface S6 and reaches the fourth surface S4 of the prism box 3. Since downstream from the fourth surface S4 is provided, e.g. a quarter wave plate as a light recovery unit 4, when the second original light L2 having the S-polarization state perpendicularly enters the fourth surface S4 and is reflected towards the prism box 3, the second original light L2 in the S-polarization state is changed into the first original light L1 in the P-polarization state, and then the second original light L2 as the first original light L1 undergone the change of the polarization state emerges from the fourth surface S4 into the prism box 3. Thereafter, the first original light L1 is emitted from the fourth surface S4 to the fifth surface S5, and is rejected on the fifth surface S5 to the third surface S3 of the prism box 3 to emerge. Consequently, in the prism device 100 according to the first embodiment, the light emerging from the third surface S3 as an emergent aperture includes the first and second converted light L1', L2' and the first original light L1 of the unconverted original light.

In addition, in the prism device 100 according to an embodiment of the present invention not shown, it is different from the first embodiment mentioned above in that the fifth surface S5 in the prism box 3 in this embodiment is configured to reflect the second original light L2 having the S-polarization state, while the first original light L1 having the P-polarization state can directly pass through the fifth surface S5.

That is, according to the above two embodiments, based on the difference of the configuration of the coatings on the fifth surface S5 and the sixth surface S6, the light finally emerging from the third surface S3 as the emergent aperture of the prism box 3 can include the unconverted first original light L1 in the P-polarization state or the unconverted second original light L2 in the S-polarization state. Besides, the

unconverted original light L emerging through the first surface S1 and returning back to the direction of the light source can be re-reflected into the prism box 3 to be reused so as to eventually realize the purpose of recovering the unconverted original light and achieving the effect of improving the optical efficiency of the light source.

Further, Fig. 1d is a schematic diagram of the prism device 100 according to the second embodiment of the present invention. As shown in Fig. 1d, according to this configuration, the difference from the above two embodiments lies in that the phosphor wheel 52 as shown can be provided on, for instance, a further surface different from the second surface S2, e.g. the third surface S3. At this time, the second surface S2 of the prism box 3 may be used as an emergent surface, the second original light L2 having the S-polarization state of the light L from the light source, for example, when confronted with the fifth surface S5 having a first coating C1, is reflected towards the second surface S2 to emerge, the second original light L2 of the light L having the P-polarization state, after directly passing through the fifth surface S5 having the first coating C1 and the sixth surface S6 having a second coating C2, directly arrives at the light conversion means 5 through the third surface S3. The converted light L' processed by the light conversion means 5 and the unconverted original light L will emerge through the second surface S2. It can thus be seen that, by providing the light conversion means 5 outside different surfaces of the prism box 3, one of the other surfaces can be used as the emergent surface.

Fig. 2a - Fig. 2b show schematic diagrams of the prism device 100 according to a third embodiment of the present invention. What differs from the above embodiments, such as the first and second embodiments, this prism device 100 is provided with a different light recovery unit 4 which has a first subunit 41 configured as, e.g. a quarter wave plate, and a second subunit 42 configured as, e.g. a half wave plate. In ad-

dition, Fig. 2a shows a schematic diagram of optical path of the converted light L' of the prism device 100 according to the third embodiment of the present invention, wherein the phosphor wheel 52 and the lens 51 are provided outside the second surface S2 of the prism box 3 as shown in the figure, and the light recovery unit 4 as a part of the optical path adjusting means 10 at this time receives the converted light L' from the phosphor wheel 52 and the unconverted original light L. The converted light L' after converted by the phosphor wheel 52, after converged by the lens 51, enters the prism box 3 through the second surface S2. According to the configuration of the fifth surface S5 having the first coating and the sixth surface S6 having the second coating, for example, when a part of a second converted light $L2'$ having the S-polarization state is confronted with the sixth surface S6, the second converted light $L2'$ is reflected and guided to emerge towards the third surface S3, and meanwhile, the other part of the second converted light $L2'$, after projecting through the fifth surface S5, is reflected when confronted with the sixth surface S6, and likewise is reflected and guided towards the third surface S3 to emerge. At the same time, a first converted light $L1'$ having the P-polarization state, after passing through the fifth surface S5 and the sixth surface S6, is confronted with a third wave plate P3 having a third coating C3, wherein a fourth wave plate P4 is provided downstream from the third wave plate P3, and the first converted light $L1'$ emerges through the fourth wave plate P4 after reflected by the third wave plate P3, wherein the fourth wave plate P4 is configured to extend along the third surface S3 towards a direction away from the second surface S2, and is configured as a half wave plate. When the first converted light $L1'$ passes through the fourth wave plate P4, the first converted light $L1'$ will be changed into the second converted light $L2'$ having the S polarization state-polarization state due to change of the polarization state. In this way, light emerging from the fourth wave plate P4 will maintain a polarization state consistent with that of the light emerging from the third surface S3, both being the

S-polarization state in this embodiment.

It should be indicated that, an angle between the third wave plate P3 and the fourth wave plate P4 can be adjusted, for instance, according to requirement to the optical distribution or optical angle of the emergent light. In the present embodiment, in order to maintain parallel the light emerging from the fourth wave plate P4 with the light emerging from the third surface S3, the angle between the third wave plate P3 and the fourth wave plate P4 can be 45° .

Fig. 2b shows a schematic diagram of an optical path of the unconverted original light L of the prism device 100 according to the third embodiment of the present invention. While having the optical path of the converted light L' as shown in Fig. 2a, after the unconverted original light L enters the prism box 3 from the second surface S2, a part of the unconverted first original light L1 having the P-polarization state, after confronted with the fifth surface S5, is reflected to the first surface S1 and emerges, after the unconverted second original light L2 having the S-polarization state passes through the fourth surface S4, as the first subunit 41 such as a quarter wave plate is provided downstream from the third wave plate P3, and the light passing through and reflected by this wave plate will be changed in polarization state, the light emerging from this wave plate therefore has a changed polarization state. In this embodiment, after the unconverted second original light L2 having the S-polarization state passes through the first subunit 41 and is reflected and re-emerges, the unconverted first original light L1 having the P-polarization state is formed, and then, the polarization state of the unconverted first original light L1 having the P-polarization state, after passing through the second subunit 42 configured as a half wave plate, is changed again, at which time, the polarization state after changed by the half wave plate is the S-polarization state. Thus, according to this configuration, the unconverted original light L emerging from the fourth

wave plate P4 as an emergent surface can keep a polarization state consistent with that of the converted light L' emerging from the third surface S3 and the fourth wave plate P4, both being the S-polarization state in the present embodiment.

5 In addition, in the prism device 100 according to a third embodiment of the present invention not shown, only by changing the attributes of the respective coatings of the fifth surface S5 and the sixth surface S6, the converted light L2' having the P-polarization state can directly pass through the
10 fifth surface S5 and the sixth surface S6, and the converted light L1' having the S-polarization state, when confronted with the sixth surface S6, can be directly reflected towards the third surface S3 as the emergent surface, and the unconverted original light L2 having the S-polarization state,
15 when confronted with the fifth surface S5, is directly reflected towards the first surface S1 to emerge, the unconverted first original L1 having the P-polarization state can directly pass through the fifth surface S5 and the sixth surface S6, and it can be realized, on the basis of the structure of the prism device 100 as shown in the third embodiment, to emerge from the third surface S3 and the fourth wave plate P4 the converted light L' having the P-polarization state and the unconverted original light L1 having the P-polarization state. Unnecessary details will not be given
20 herein.
25

Fig. 3 is a schematic diagram of the prism device 100 according to a fourth embodiment of the present invention. Similarly, with the aid of the optical path as shown in Fig. 1a, the light from the light source, upon guidance and processing by
30 the prism box 3, can strike the light conversion means 5. Thus, the converted light L' from the light conversion means 5 and the unconverted original light L pass through the second surface S2 as shown in the figure to enter the prism box 3. According to the configuration of the coatings on the
35 fifth surface S5 and the sixth surface S6, for example, the second converted light L2' having the S-polarization state,

when confronted with the sixth surface S6 having the second coating, is directly reflected towards the third surface S3, and emerges through the third surface S3 after passing through the fifth surface S5 having the first coating. Meanwhile, the first converted light L1' having the P-polarization state directly passes through the fifth surface S5 and the sixth surface S6, as a quarter wave plate, for instance, is provided downstream from the fourth surface S4, the converted light L' simultaneously having the P-polarization state and the S-polarization state will be formed after the first converted light L1' in the P-polarization state passes through the quarter wave plate. According to the fifth wave plate P5 provided downstream from the fourth surface S4 and the fourth coating C4 provided on the surface of the fifth wave plate P5, the converted light L' is directly reflected by the fourth coating C4 towards the sixth wave plate P6 provided downstream from the fifth wave plate P5. When the sixth wave plate P6 is configured as, for example, a quarter wave plate, the converted light L' reflected by the third coating C3 is completely converted to the converted light L2' having the S-polarization state.

In the prism device 100 according to the fourth embodiment of the present invention not shown, only by changing the attributes of the respective coatings on the fifth surface S5 and the sixth surface S6, it can be realized, on the basis of the structure of the prism device 100 as shown in the fourth embodiment, that the converted light L' having the P-polarization state and the unconverted original light L1 having the P-polarization state emerge from the third surface S3 and the fourth wave plate P4,. Unnecessary details will not be given herein. Besides, an angle between the fifth wave plate and the sixth wave plate can be adjusted, for instance, according to requirement to the optical distribution or optical angle of the emergent light. In the present embodiment, in order to maintain parallel the light emerging from the sixth wave plate with the light emerging from the third surface S3, the angle between the fifth wave plate and the sixth

wave plate can be 45° .

Fig. 4 is a schematic diagram of the phosphor wheel of the prism device 100 according to the embodiments of the present invention. In the present invention, processing such as conversion and recovery of the light L from the light source is realized by means of such phosphor wheel and the X-cube. Reference can be made to Fig. 1a for the basic structure of the prism device 100 according to the present invention, wherein the prism device 100 uses the phosphor wheel as shown in Fig. 1a, while phosphor wheel is configured with a round profile and has, for instance, a hollow circular center, for facilitating installation and connection. Besides, this wheel is also provided with at least one phosphor for converting, e.g. pump light from the light source. According to the embodiment as shown in Fig. 1a, the wheel has two types of phosphors, and the two types of phosphors are configured on the wheel in a manner of taking circular centers act as concentric circles, which can ensure uniform distribution of the light L from the light source in a circumferential direction of the wheel. Specifically, according to different places of the wheel where the light L strikes, control to the power ratio of the converted light converted by the phosphor and emerging from the wheel having different wavelengths can be realized. For example, when a proportion of the light L distributed on a phosphor 1 is greater than that of the light L distributed on a phosphor 2, the power of converted light converted by the phosphor 1 and having a first wavelength will be greater than the power of the converted light converted by the phosphor 2 and having a second wavelength, thus realizing regulation and control to the power ratio of the converted light having different wavelengths.

It should be noted in all of the above embodiments, for instance, in the first to the fourth embodiments, the phosphor means 52 can be implemented by the phosphor wheel as shown in Fig. 4 so as to realize the object of regulating and controlling the power ratio of the light of the converted light hav-

ing different wavelengths.

Fig. 5 is a schematic diagram of configuration of the fifth surface S5 and the sixth surface S6 of the prism device 100 according to the present invention. In reference to Fig. 1a to Fig. 3, the prism device 100 according to the present invention comprises the phosphor means 52 which is configured as, for instance, the phosphor wheel, the prism box 3 configured to process the light L from the light source, and a lens 51, wherein the lens 51 is configured to converge the light L passing through the prism box 3 or to diffuse the converted light from the phosphor means 52, and the prism box 3 is configured as, for instance, X-cube, which X-cube can serve functions such as splitting or steering light of the light L from the light source. Besides, the prism box 3 of the prism device 100 further comprises the fifth and sixth surfaces S5, S6 provided inside the box, for example, according to the lateral view of the prism box 3 as shown in Fig. 1a, the two surfaces S5 and S6 not only can be configured to be perpendicular to each other, but also can be configured in such a manner that normals of respective surfaces are perpendicular to each other as shown in the schematic diagram of Fig. 5, that is, the fifth surface S5 extends from the left side of the second surface to the right side of the fourth surface, and the sixth surface S6 extends from a diagonal of the first surface to the corresponding diagonal of the third surface, in other words, the fifth surface S5 and the sixth surface S6 are configured in such a manner that the light L can be incident upon the fifth surface S5 at 45° , and the converted light L' converted by the phosphor means 52 is incident upon the sixth surface at 45° .

It should be noted that the above configuration of the fifth surface S5 and the sixth surface S6 can be applied to the prism box 3 as shown in Fig. 1a to Fig. 3.

Fig. 6 is a schematic diagram of the prism device 100 according to a fifth embodiment of the present invention. The prism

device 100 can be configured with, for instance, two phosphor means 5, and four surfaces of the prism box 3 are all coated with antireflective coatings to ensure that the light energy of light passing through these surfaces will not be influenced. At this time, each phosphor means 5 is configured with a single phosphor, as shown in Fig. 6, each of two phosphor means 5 has a different phosphor. According to the fifth embodiment, the two phosphor means 5 are configured outside the second surface S2 and the third surface S3 of the prism box 3, respectively, at which time, the fourth surface S4 of the prism box 3 acts as an emergent surface. According to the fifth embodiment, a first part, for instance, of the pump light L from the light source after reflected by the fifth surface S5 having the first coating, passes through the second surface S2 to reach a first phosphor means 521; a second part of light from the light source, after directly passing through the fifth surface S5 and the sixth surface S6 having the second coating, reaches a second phosphor means 522; and a third part of light from the light source, after reflected by the sixth surface S6, will emerge through the fourth surface S4. In this way, all light from the light source can be sufficiently used, and the emergent light can be ensured to collectively emerge, for instance, from the fourth surface S4.

Of course, according to the requirement to selection of the emergent surface of the prism box 3, the two phosphor means 5 also can be provided, for instance, outside the second surface S2 and the fourth surface S4 of the prism box 3, respectively, at which time the third surface S3 of the prism box 3 acts as the emergent surface. In the prism device 100 according to the fifth embodiment of the present invention not shown, the first part of, for instance, the pump light from the light source, after reflected by the fifth surface S5 having the first coating, passes through the second surface S2 to reach the first phosphor means 521; the second part of light from the light source, after directly passing through the fifth surface S5 and the sixth surface S6 having the se-

cond coating, emerges through the third surface S3; the third part of light from the light source, after reflected by the sixth surface S6, will reach the second phosphor means 522 through the fourth surface S4. Thus, all light from the light source can be sufficiently used, and the emergent light can be ensured to collectively emerge from, for instance, the fourth surface S4.

The above is merely preferred embodiments of the present invention but not to limit the present invention. For the person skilled in the art, the present invention may have various alterations and changes. Any alterations, equivalent substitutions, improvements, within the spirit and principle of the present invention, should be covered in the protection scope of the present invention.

15

List of reference signs

3		prism box
4		light recovery means
5		light conversion means
5	10	optical path adjusting means
41		first subunit
42		second subunit
52		phosphor means
51		lens
10	100	prism device
521		first phosphor means
522		second phosphor means
S1		first surface
S2		second surface
15	S3	third surface
	S4	fourth surface
	S5	fifth surface
	S6	sixth surface
	P3	third wave plate

	P4	fourth wave plate
	P5	fifth wave plate
	P6	sixth wave plate
	L	original light
5	L10	first part of original light
	L11	second part of original light
	L1	first original light
	L2	second original light
	L'	converted light
10	L1'	first converted light
	L2'	second converted light

Patent claims

1. A prism device (100), comprising a light source and a prism box (3) located downstream from the light source, the prism box (3) comprising first, second, third and fourth surfaces (S1, S2, S3, S4), and an original light (L) from the light source entering the prism box (3) through the first surface (S1), characterized in that the prism device (100) further comprises an optical path adjusting means (10) and at least one light conversion means (5) provided downstream from at least one of the first, second, third and fourth surfaces, the optical path adjusting means (10) is configured to guide a first part (L10) of the original light (L) through at least one (S2; S2, S3; S2, S4) of the second, third and fourth surfaces to the light conversion means (5), and enable a second part (L11) of the original light (L) to emerge through at least one further surface (S3; S4; S3) of the second, third and fourth surfaces as an emergent surface, and is configured to guide a converted light (L') from the light conversion means (5) to emerge in a direction parallel to an emergent direction passing through the emergent surface, and guide at least a part of unconverted original light (L) from the light conversion means (5) to emerge in a direction parallel to an emergent direction passing through the emergent surface.
2. The prism device (100) according to Claim 1, characterized in that the optical path adjusting means (10) comprises a fifth surface (S5) having a first coating (C1) and a sixth surface (S6) having a second coating (C2) which are provided inside the prism box (3), and the fifth surface (S5) and the sixth surface (S6) are formed as internal surfaces of the prism box (3).
3. The prism device (100) according to Claim 2, characterized in that the optical path adjusting means (10) further comprises a light recovery means (4) in connection with the prism box (3), and the light recovery means (4) is configured to at least guide a part of the unconverted original light to emerge in a direction parallel to the emergent direction passing through the emergent surface.
4. The prism device (100) according to Claim 3, characterized in that the light recovery means (4) is provided downstream from the fifth surface (S5) and the sixth surface (S6) in optical path.
5. The prism device (100) according to Claim 4, characterized in that the light recovery means (4) guides a part of the unconverted original light (L), after conversion of polarization state, to emerge in a direction parallel to the emergent di-

rection passing through the emergent surface.

6. The prism device (100) according to any one of Claims 4-5, characterized in that one of the light conversion means (5) is provided outside the second surface (S2).

5 7. The prism device (100) according to Claim 6, characterized in that the original light (L) comprises a first original light (L1) having a first excited state and a second original light (L2) having a second excited state, the converted light (L') comprises a first converted light (L1') having the first excited state and a second converted light (L2') having the second excited state, wherein the light recovery
10 means (4) is at least configured to convert the first original light (L1) to the second original light (L2) or convert the second original light (L2) to the first original light (L1); or, is configured to convert the first converted light (L1') to the second converted light (L2') or convert the second converted light (L2') to the first converted light (L1').

15 8. The prism device (100) according to Claim 7, characterized in that the first coating (C1) is configured to allow transmission of one of the first original light (L1) and the second original light (L2) and reflection of the other one of the first original light (L1) and the second original light (L2); and the second coating (C2) is configured to allow transmission of the first original light (L1) and the second original
20 light (L2).

9. The prism device (100) according to any one of Claims 4-5, characterized in that the light recovery means (4) is configured to be formed downstream from the fourth surface (S4), wherein the fourth surface (S4) is opposite to the second surface (S2).

25 10. The prism device (100) according to any one of Claims 4-5, characterized in that the light recovery means (4) comprises a first subunit (41) and a second subunit (42), and the first subunit (41) is configured to at least guide a part of the unconverted original light (L), after change of polarization state, to emerge through the second subunit (42).

30 11. The prism device (100) according to Claim 10, characterized in that the second coating (C2) is configured to allow reflection of one of the first converted light (L1') and the second converted light (L2') and transmission of the other one of the

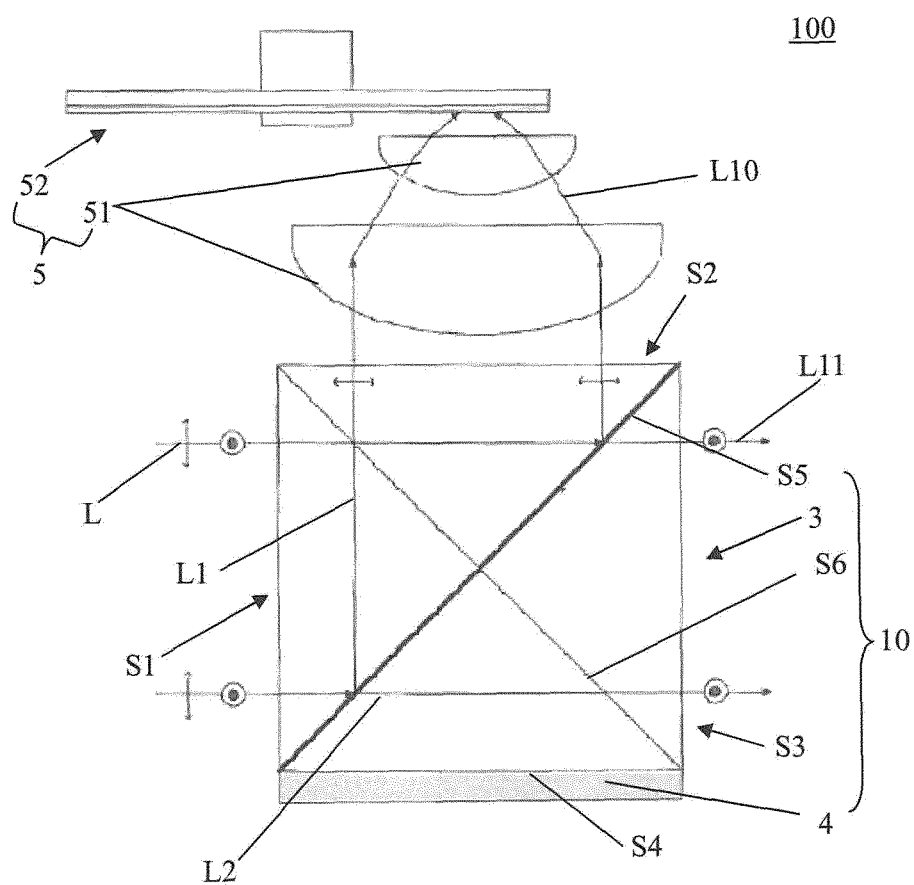
first converted light (L1') and the second converted light (L2') to the light recovery means (4).

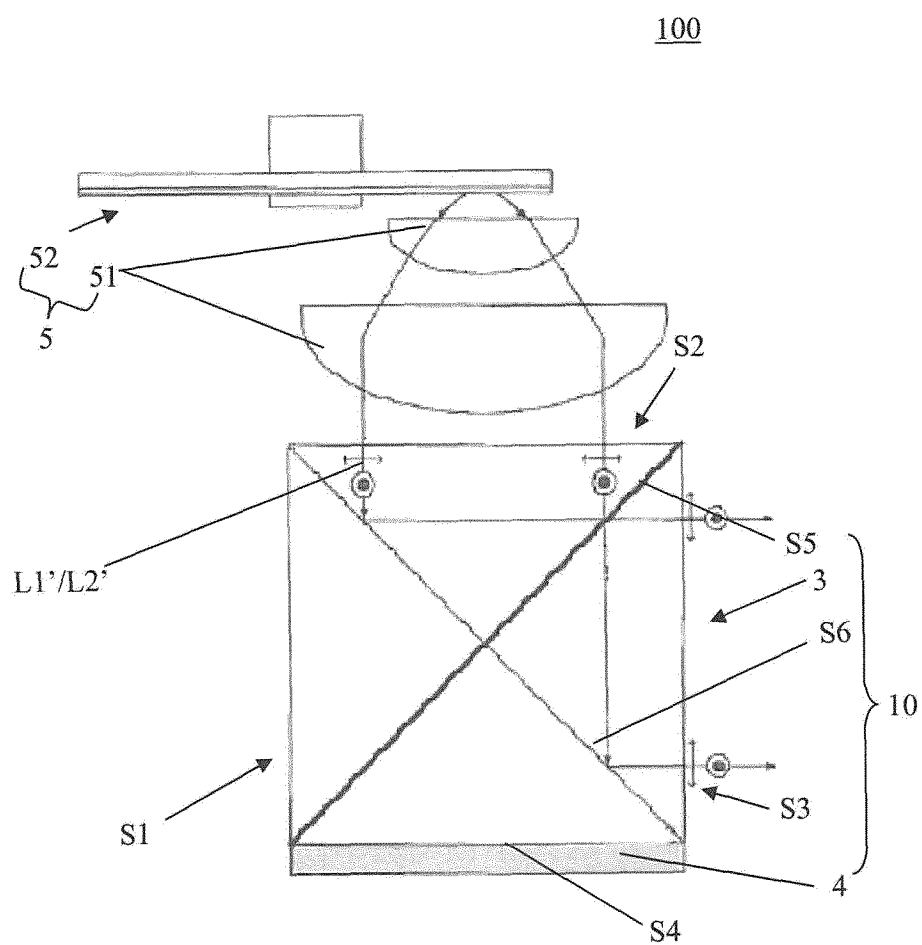
12. The prism device (100) according to Claim 11, characterized in that emergent light emerging through the emergent surface and emergent light emerging through the second subunit (42) have the same polarization state.

13. The prism device (100) according to Claim 12, characterized in that the first subunit (41) comprises a third coating (C3) and a third wave plate (P3) provided downstream from the third coating (C3), and the second subunit (42) is a fourth wave plate (P4) provided downstream from the third wave plate (P3).

14. The prism device (100) according to Claim 13, characterized in that the third coating (C3) is configured to reflect the first converted light (L1') or the second converted light (L2') for exiting, and to transmit unconverted first original light (L1) or second original light (L2) to the third wave plate (P3), the third wave plate (P3) converts the first original light (L1) or the second original light (L2) to the second original light (L2) or the first original light (L1) and guides it to the fourth wave plate (P4), and the fourth wave plate (P4) converts the second original light (L2) or the first original light (L1) to the first original light (L1) or the second original light (L2).

15. The prism device (100) according to Claim 10, characterized in that the first subunit (41) comprises a seventh wave plate (P7) and a fifth wave plate (P5) both provided downstream from the fourth surface (S4), and a fourth coating (C4) provided downstream from the fifth wave plate (P5), and the second subunit (42) is a sixth wave plate (P6).

**Figure 1a**

**Figure 1b**

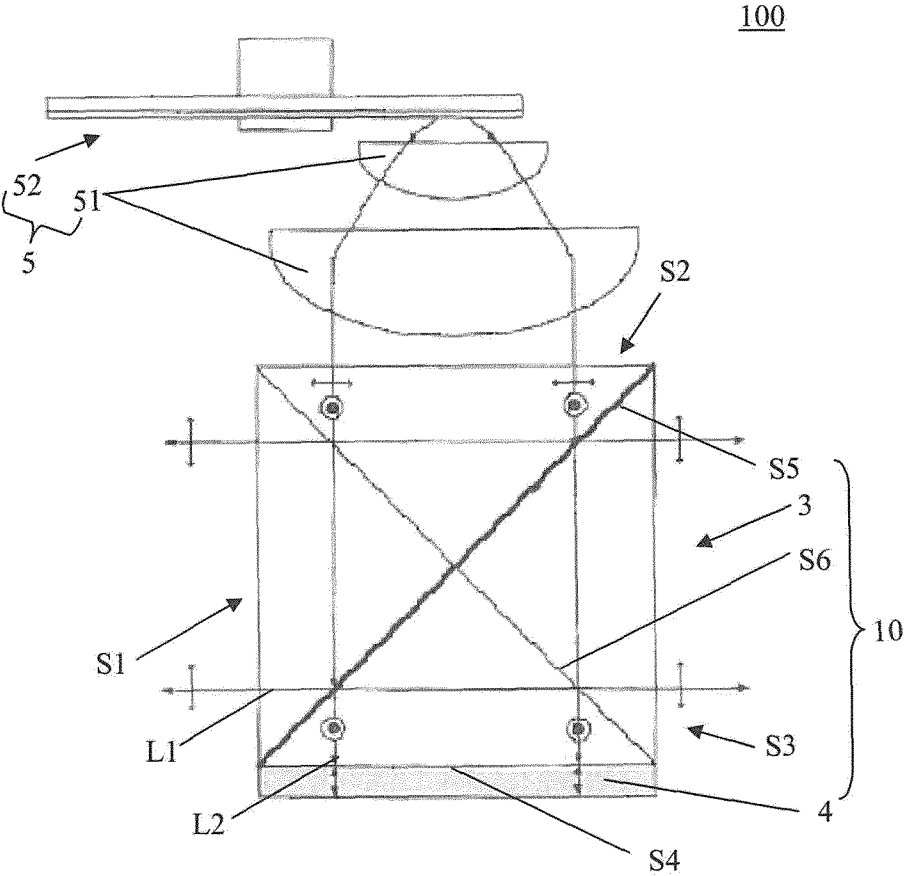


Figure 1c

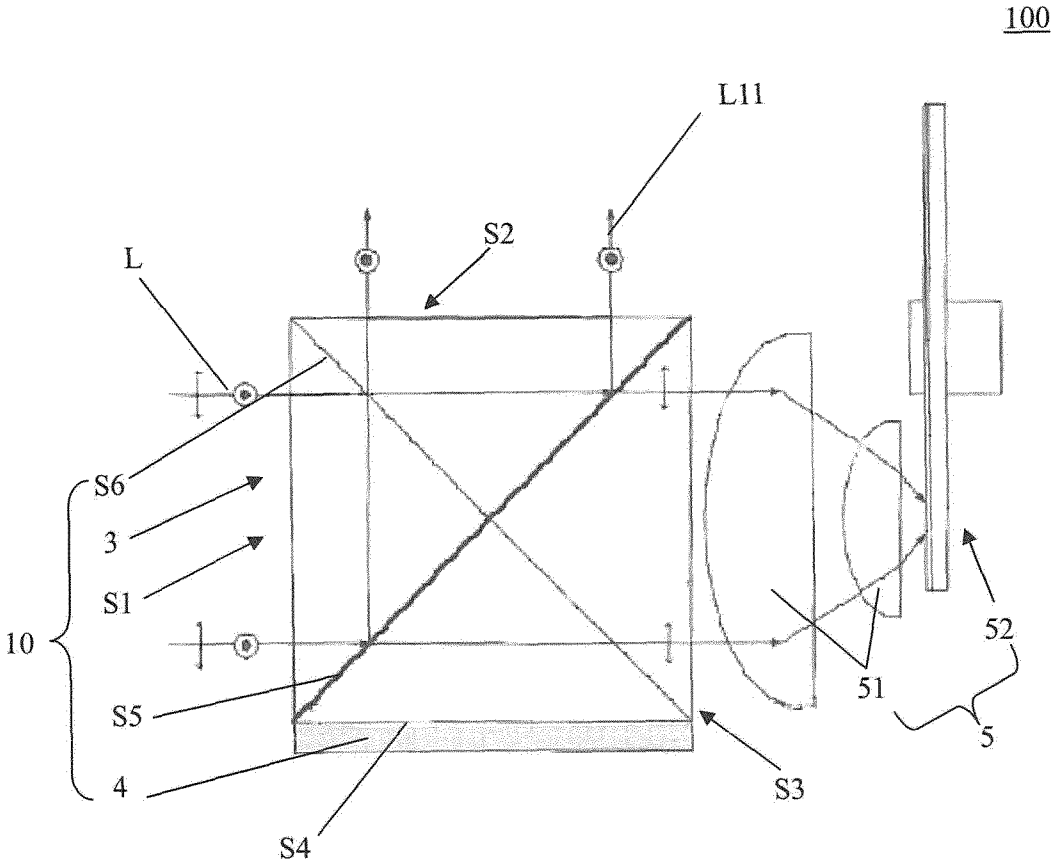


Figure 1d

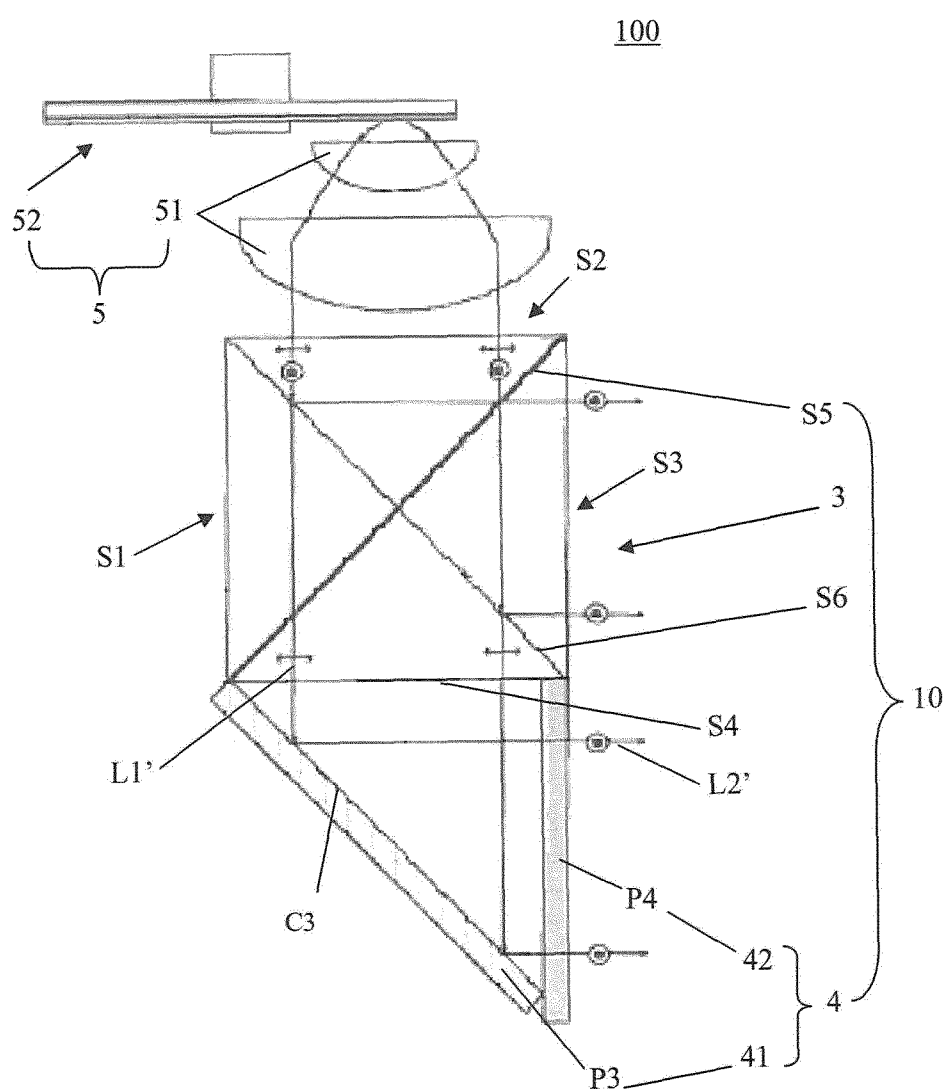
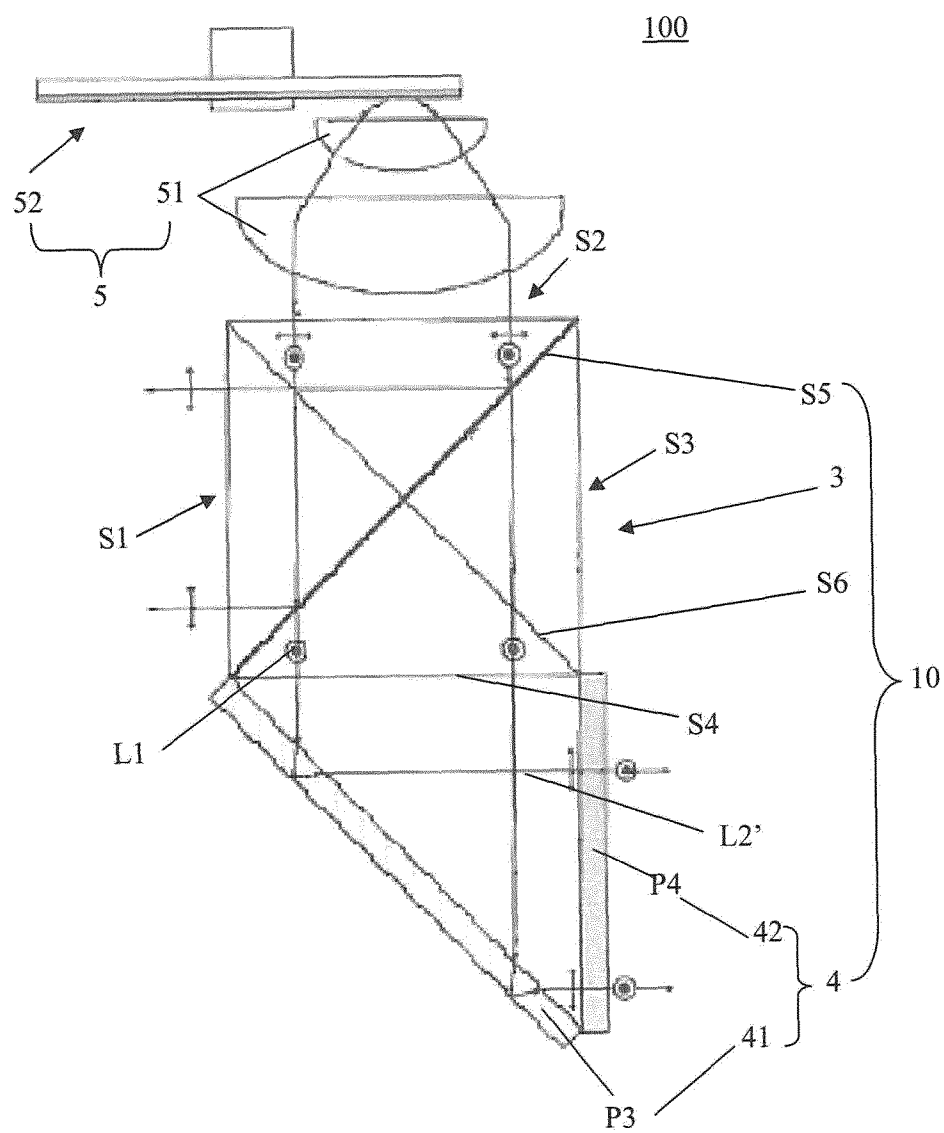
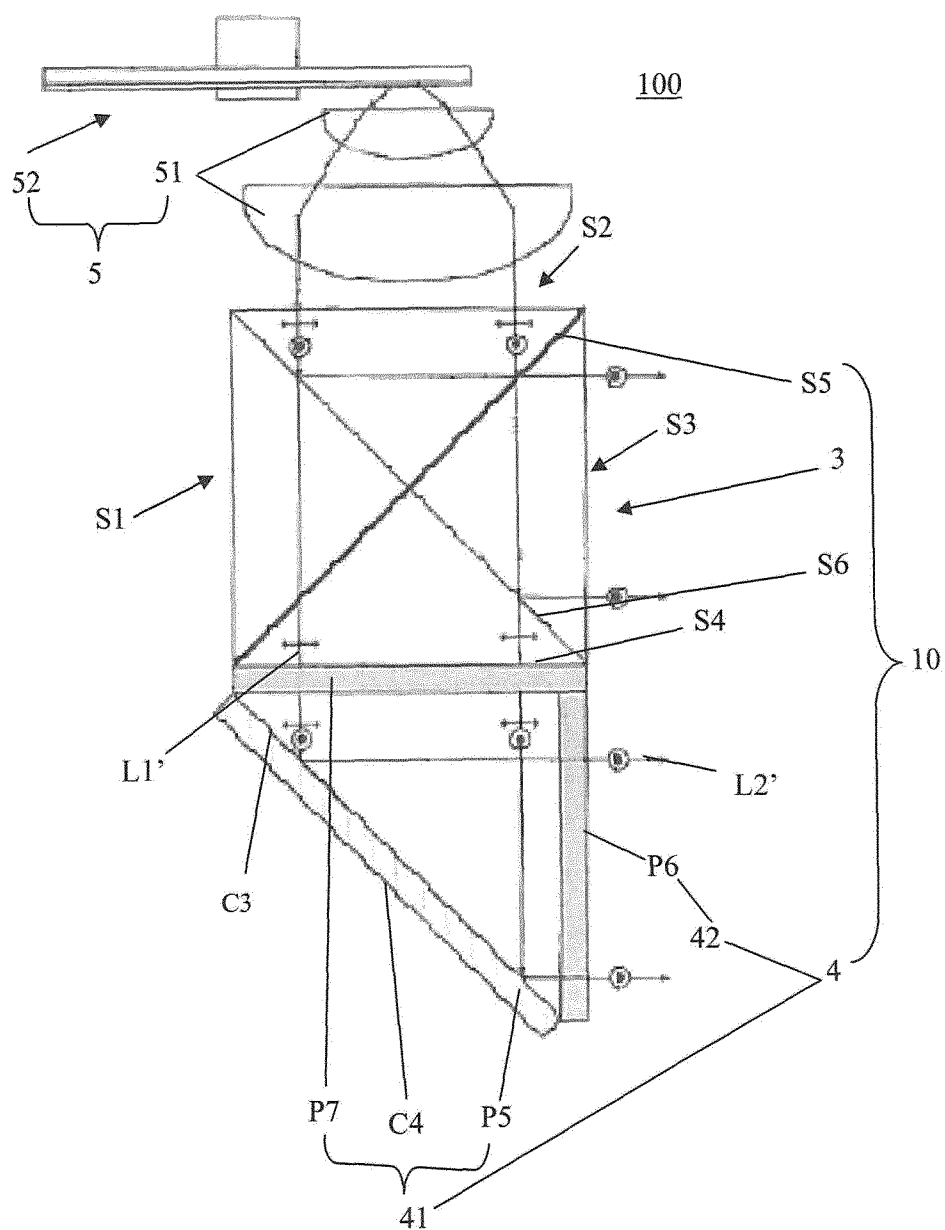


Figure 2a

**Figure 2b**

**Figure 3**

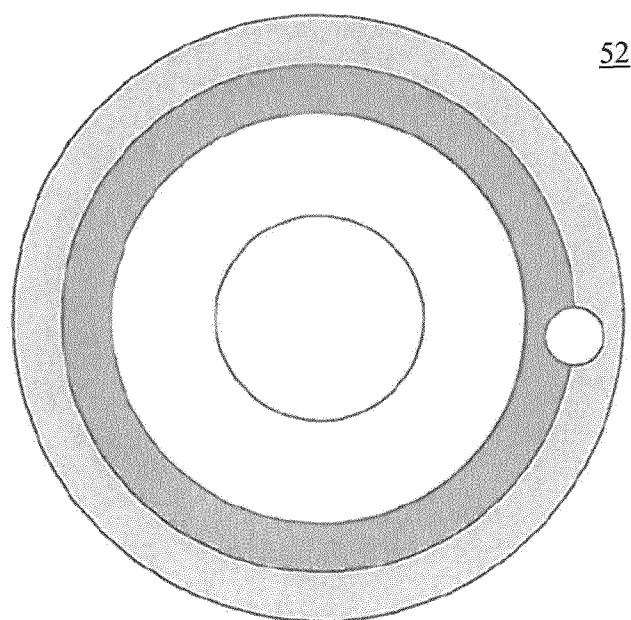


Figure 4

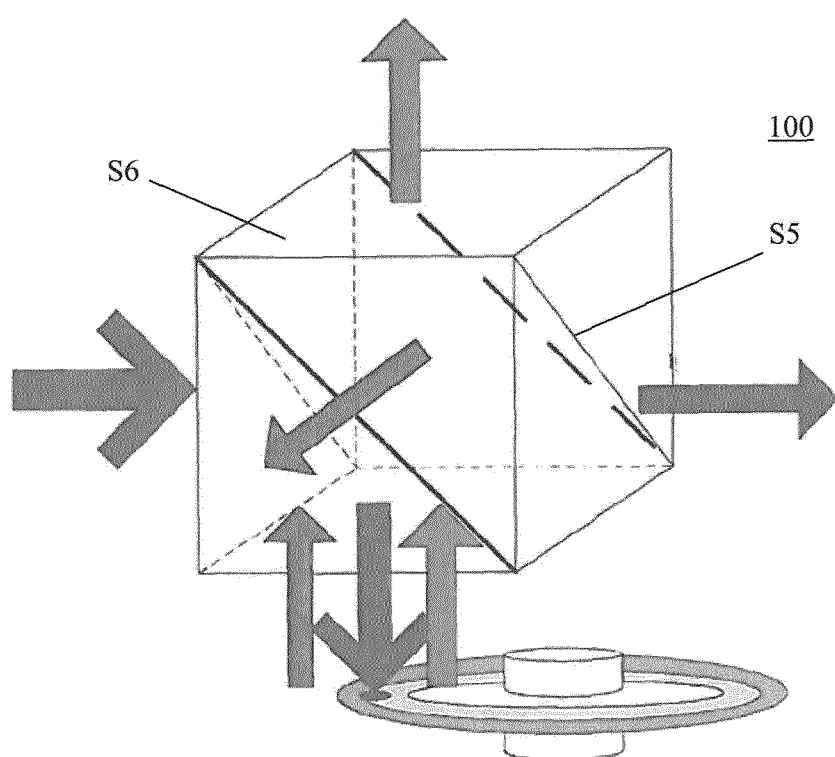
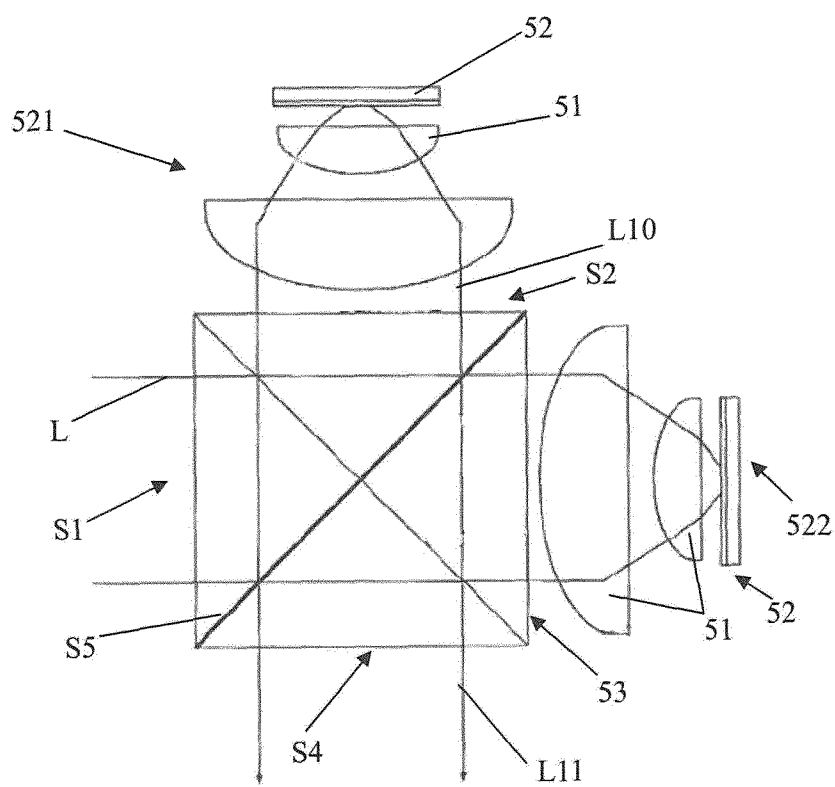


Figure 5

**Figure 6**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/061040

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B27/14
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)
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 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 2011/051095 A1 (NARIMATSU SHUJI [JP] ET AL) 3 March 2011 (2011-03-03) figure 4	1-15
A	----- US 2012/033185 A1 (CHANG KEH-SU [TW]) 9 February 2012 (2012-02-09) figure 4a	1-15
A	----- US 2013/083294 A1 (TSENG CHIH-NENG [TW]) 4 April 2013 (2013-04-04) paragraph [0029]; figure 1 -----	1-15



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 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

29 August 2014

Date of mailing of the international search report

04/09/2014

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Rödig, Christoph

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2014/061040

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011051095 A1	03-03-2011	CN 102004383 A	06-04-2011
		JP 5407664 B2	05-02-2014
		JP 2011048139 A	10-03-2011
		US 2011051095 A1	03-03-2011
US 2012033185 A1	09-02-2012	CN 102375314 A	14-03-2012
		TW 201207546 A	16-02-2012
		US 2012033185 A1	09-02-2012
US 2013083294 A1	04-04-2013	CN 103034035 A	10-04-2013
		US 2013083294 A1	04-04-2013