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Semiconductor laser light source and solid-state laser apparatus
Halbleiterlaser-Lichtquelle und Festkörperlaser
Source de lumière à laser à semi-conducteur et laser à l’état solide

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Description

SPECIFICATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a semiconductor laser light source designed to integrate a plurality of laser beams, and a solid-state laser apparatus using the same.

2. Description of the Related Art

[0002] A semiconductor laser, which is small in size, highly reliable, and easy to maintain as compared with a gas laser, a solid-state laser or the like, is widely used in the optical communication field, optical disk devices and so on. However, the semiconductor laser is still under development in fields which require high-output laser beams such as laser welding and laser scalpel field. The optical output obtained from one semiconductor laser is limited to approximately several milliwatts to several hundreds of milliwatts in CW (constant wave) operation. It is thus quite difficult to apply the semiconductor laser to the aforementioned fields. To deal with this problem, it has been researched to increase the output of laser beam by integrating laser beams from a plurality of semiconductor lasers.

[0003] On the other hand, since the laser beam of the semiconductor laser has a great divergent angle, high accuracy is required for the configuration and arrangement of optical elements, so that it is technically quite difficult to integrate a plurality of laser beams. However, in the case where it is made possible that a plurality of laser beams are joined, for example, to one optical fiber, the application range of the semiconductor laser will increase.

[0004] As a prior art, Japanese Unexamined Patent Publication JP-A 60-76707 (1985) discloses a semiconductor laser duplex module for optical communication, directed to improve the reliability by multiplexing with the following features. An optical system is used which, in order that beams from two semiconductor lasers are caused to enter one optical fiber, rotates the polarization plane of one laser beam 90 degrees and then merges the two laser beams by the birefringence effect, and when one suffers a breakdown, the other continues operation.

[0005] However, in the arrangement of JP-A 60-76707, when a semiconductor laser having a great divergent angle is used, since the incident angle on the birefringent element greatly differs between the light in the vicinity of the optical axis and the light diverging outward, the birefringence effect is not uniform, with the result that it is difficult to merge the laser beams. In addition, since the wave fronts of the laser beams are disturbed due to the large variation in the incident angle, it is difficult to converge the beams onto an optical fiber having a small core diameter.

[0006] In a semiconductor laser for optical communication which places emphasis on wave length stability and longevity, the above problem does not arise because the divergent angle is not very great. However, in a semiconductor laser for processing which places emphasis on high output and high intensity, the above problem arises because the divergent angle is generally great.

[0007] Furthermore, in the prior art, since the optical element for merging the laser beams and the optical element for joining the laser beams to the optical fiber are separately provided, the passage loss of light increases and the overall structure is complicated and increased in size, with the result that the reliability and the productivity decrease.

SUMMARY OF THE INVENTION

[0008] An object of the invention is to provide a semiconductor laser light source, as defined in claims 1-7, with which the efficiency of merging laser beams and the efficiency of joining the laser beams to the succeeding optical system are greatly improved.

[0009] Another object of the invention is to provide a solid-state laser apparatus, as defined in claim 8, in which the output of the excitation beam can be increased by improving the efficiency of merging laser beams and the efficiency of joining the laser beams to the succeeding optical system.

[0010] The invention provides a semiconductor laser light source as defined in claim 1.

[0011] According to the invention, by disposing the cylindrical optical element in the rear of the first and second semiconductor lasers and converging the laser beams in the direction where the divergent angle θ decreases, the light use efficiency is enhanced and the variation in incident angle on the succeeding birefringent optical element can be decreased. Accordingly, the variation in birefringent effect of the laser beams is narrowed, whereby the efficiency of merging the laser beams is enhanced.

[0012] Furthermore, by providing the converging optical element, for example, a cylindrical lens and a spherical lens, for converging the laser beams merged by the birefringent optical element in the direction where the divergent angle θ decreases, the light use efficiency is enhanced and the two divergent angles θa and θb are independently controlled by the cylindrical optical element and the converging optical element, so that a small circular convergent light spot can be realized. As a result, the efficiency of joining the laser beams to the succeeding optical system such as an optical fiber can be greatly enhanced.

[0013] In the invention it is preferable that the first and second semiconductor lasers respectively oscillate in a
transverse multimode.

[0014] According to the invention, the transverse multimode semiconductor lasers, which can produce high output even when used alone, contribute to enhancing the output of the laser beam.

[0015] In the invention it is preferable that the first and second semiconductor lasers constitute a transverse multimode semiconductor laser array in which a plurality of light emitting regions are formed on a single chip.

[0016] According to the invention, by using the semiconductor laser array having a plurality of light emitting regions, light emission characteristics of the respective light emitting regions such as divergent angle, polarization ratio, oscillation wavelength and output are substantially uniform, so that the characteristics of the merged laser beams becomes uniform. Moreover, the transverse multimode semiconductor laser array, which produce high output even when used alone, contribute to enhancing the output of laser beam.

[0017] In the invention it is preferable that the converging optical element is constructed of a curved surface formed integrally with a light emitting surface of the birefringent optical element.

[0018] According to the invention, by integrating the converging optical element and the birefringent optical element, the interfacial reflection loss is reduced as compared with the case where the converging optical element and the birefringent optical element are separately formed. Moreover, the assembly and the adjustment are facilitated, with the result that the reliability and the productivity are improved.

[0019] In the invention it is preferable that convergence positions of the cylindrical optical element and the converging optical element coincide with each other, and an incident end surface of an optical fiber is situated at the convergence positions.

[0020] According to the invention, the spot diameter at the convergence positions can be decreased, whereby the coupling efficiency of the laser beams with the optical fiber is extremely enhanced.

[0021] In the invention, it is preferable that the semiconductor laser light source further comprises an optical fiber bundle constructed of a plurality of optical fibers and is arranged so that, on an incident end surface of each optical fiber, laser beams from a couple of light emitting regions of the light emitting regions of the semiconductor laser array enter after being merged with each other.

[0022] According to the invention, since the light emitting end surface of the optical fiber bundle is formed as a plane-shaped light source having a predetermined area, a high-output and high-intensity light source can be realized. Thus, the invention is effective for use as an excitation light source of an optically excited solid-state laser and for other uses such as processing, illumination and display.

[0023] The invention provides a solid-state laser apparatus as defined in claim 8.

[0024] According to the invention, by disposing the cylindrical optical element in the rear of the first and second semiconductor lasers and converging the laser beams in the direction where the divergent angle of the laser beams is decreased, the use efficiency of light is increased and the change in incident angle on the succeeding birefringent optical element is decreased. Accordingly, the variation in the birefringent effect of the laser beams is narrowed, with the result that the efficiency of merging the laser beams is improved.

[0025] Furthermore, by providing the converging optical element, for example, a cylindrical or spherical lens, for converging the laser beams merged by the birefringent optical element in the direction where the divergent angle of the laser beams is decreased, the use efficiency of light is increased. In addition, the two divergent angles of the laser beams are separately controlled by the cylindrical optical element and the converging optical element, whereby a small circular convergent light spot can be realized. As a result, the efficiency of coupling the laser beams with the succeeding optical system can be greatly enhanced.

[0026] By using the laser beam whose output has been thus increased as the excitation beam of the solid-state laser medium, the laser output of the solid-state laser medium is extremely increased.

[0027] Herein a cylindrical optical element indicates an element which is composed of curved or plane surfaces where light incomes and outgoes, which curved or plane surfaces have generating line parallel to each other, and has a focusing power in a direction perpendicular to the generating lines and no focusing power in a direction parallel to the generating lines. Such a lens is given as an example that has one side which is cylindrically shaped and the other side which is shaped into a plane (a semicylindrical lens). A cylindrical lens in which a cross section perpendicular to the generating line is circular can be also given as an example.

[0028] In the invention, for the purpose of downsizing the apparatus, it is preferable to use a cylindrical lens as the cylindrical optical element. Since the cylindrical lens has a larger refractive power than a semicylindrical lens, it is possible to reduce the interval between the light emitting portions of the semiconductor laser array and reduce the length of the birefringent optical element in the laser beam transmission direction. As a result, it is possible to reduce the distance to the optical fiber without increasing the NA (numerical aperture) of the optical fiber. For deriving this effect to a larger extent, the upper limit of the diameter of the cylindrical lens is preferably 1 mm, and more preferably 500 μm. Though the lower limit of the diameter depends on the divergent angle and the divergent distance of the semiconductor laser, from the view of adjustment it is preferably 10 μm and more preferably 30 μm.

[0029] Furthermore, in the invention, a graded index type cylindrical lens is more preferable in which a refractive index of the periphery is smaller than that of the center portion. By using the graded index type cylindri-
BRIEF DESCRIPTION OF THE DRAWINGS

FIGs. 1A to 1C show the structure of an embodiment of the invention. FIG. 1A is a plan view, FIG. 1B is a partial front view, and FIG. 1C is a view showing the configuration of an end surface on the light emitting side; FIG. 2 is a view showing the structure of a solid-state laser apparatus according to the invention; and FIGs. 3A and 3B show the structure of another embodiment of the invention. FIG. 3A being a plan view, FIG. 3B being a partial front view.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGs. 1A to 1C show the structure of an embodiment of the invention. FIG. 1A is a plan view, FIG. 1B is a partial front view, and FIG. 1C is a view showing the configuration of an end surface on the light emitting side. A semiconductor laser light source 9 comprises a semiconductor laser array 2 having a plurality of light emitting regions 3, a cylindrical lens 4 for converging in the Z direction laser beams LA and LB from the light emitting regions 3, a wave plate 5 for controlling the polarization direction which is vertical to the active layer formed parallel to the XY plane. For example, the divergent angle 4θ in the Z direction is 34 degrees and the divergent angle 6θ in the X direction is 10 degrees. The laser beams LA and LB are substantially linearly polarized immediately after the laser beams LA and LB were emitted from the light emitting regions 3, and the polarization planes of the laser beams LA and LB are parallel to the active layer.

The cylindrical lens 4 includes a light entering surface which is formed to be a cylindrical surface having a generatrix parallel to the X direction, and a flat light emitting surface. The cylindrical lens 4 converges the laser beams LA and LB from the light emitting regions 3 only in the Z direction and does not converge the laser beams LA and LB in the X direction. By disposing the cylindrical lens 4 in the rear of the semiconductor laser array 2, the light use efficiency is increased and the variation in the angle of incidence on the succeeding birefringent optical element 6 can be reduced, thereby the nonuniformity in the birefringent effect is decreased and the efficiency of merging the laser beams into one is improved.

As the cylindrical lens 4, for example, a cylindrical lens made of molten quartz can be used in which the radius of curvature of the light entering surface is 500 μm, the numerical aperture (NA) is 0.4 and the central thickness is 0.5 mm.

The wave plate 5 is made of a uniaxial crystal or a biaxial crystal in which the refractive index of light differs between in the X direction and in the Z direction. The light emitting surface of the wave plate 5 is formed to have a level difference so that a portion 5a through which the laser beam LA passes and a portion 5b through which the laser beam LB passes are different in thickness. This configuration causes a light phase difference due to a difference in an optical distance, thereby controlling the rotation angle between the polarization planes of the adjoining laser beams LA and LB to
parallel to the Y direction. The laser beams LA and LB thus overlap with each other to exit in a direction parallel to the Z direction and does not converge the laser beams LA and LB. The light emitting surface 7 converges the laser beams LA and LB only in the X direction, so that the polarization planes of the laser beams LA and LB become perpendicular to each other. A wave plate can be used in which the polarization plane of the laser beam LA is rotated 90 degrees and the polarization plane of the laser beam LB is maintained as it is by adjusting the thickness of the portions 5a and 5b. Moreover, the wave plate 5 can be designed so that the polarization plane of one laser beam is rotated +45 degrees and the polarization plane of the other laser beam is rotated -45 degrees.

The birefringent optical element 6 is made of a birefringent crystal, for example, YVO₄ crystal (having an extraordinary ray refractive index ne of 2.20 and an ordinary ray refractive index no of 2.0) which is cut out as an extraordinary ray because a beam walkoff of approximately 5.8 degrees to the Y direction is caused within the XY plane. The divergent angles of the laser beams LA and LB in the birefringent optical element 6 are both approximately 2.5 degrees.

Thus, the optical paths of the laser beams LA and LB which are separated by a predetermined space at the light entering surface are crossed by the travel of the laser beam LB in the slanting direction. The length of the birefringent optical element 6 is adjusted so that the crossing position coincides with the light emitting surface. In this embodiment, the length thereof is 5 mm.

The light emitting surface 7 has a generatrix parallel to the Z direction and is provided with a function equal to that of a cylindrical lens as a result of being formed to be a cylindrical surface having a radius of curvature of, for example, 5 mm. The light emitting surface 7 converges the laser beams LA and LB only in the X direction and does not converge the laser beams LA and LB in the Z direction. At the light emitting surface 7, the beam walkoff in the laser beam LB is dissolved by approximately 5.8 degrees, whereby the laser beams LA and LB overlap with each other to exit in a direction parallel to the Y direction. The laser beams LA and LB thus merged enter one optical fiber 10.

It is preferable that the convergence position in the X direction by the light emitting surface 7 and the convergence position in the Z direction by the cylindrical lens 4 coincide with each other. For example, the imaging magnification βx of the light emitting surface 7 is set to substantially equal magnification and the imaging magnification βz of the cylindrical lens 4 is set to 10 to 30 magnification. With this configuration, even when the laser beams are different in the divergent angle in the orthogonal directions, a small circular convergent light spot can be realized at the convergence position, with the result that the efficiency of joining the laser beams to the optical fiber 10 which is a succeeding optical system can be improved. Moreover, by incorporating the function of the converging lens into the light emitting surface 7 of the birefringent optical element 6, the interfacial reflection loss is reduced compared with the case where the light emitting surface 7 and the function of the converging lens are separately provided. Accordingly, the assembly and the adjustment are facilitated, and the reliability and the productivity are improved.

The optical fiber 10 comprises a core 11 having a diameter of, for example, 60 μm and a cladding 12 covering the core 11. The numerical aperture NA is 0.14. The light incident end surface of the optical fiber 10 is situated approximately 7 mm in the rear of the light emitting surface 7 of the birefringent optical element 6.

Thus, a plurality of optical fibers 10 are disposed which are joined by the adjoining laser beams LA and LB. The light emitting ends of the optical fibers 10 are bundled by a ring-form bundling member 13 so that the optical fibers 10 constitute one optical fiber bundle as shown in FIG. 1C. The optical fiber bundle is used as a single plane light source for generating a laser beam LC. For example, by using the semiconductor laser array 2 having twenty light emitting regions 3 with an output of 1 W, and using ten semiconductor optical fibers, a light source is obtained which generates the laser beam LC with an output of approximately 14 W even when the optical loss on the way is considered. This constitution improves the applicability of the semiconductor laser in the laser beam machining.

FIG. 2 is a view showing the structure of a solid-state laser apparatus according to the invention. The solid-state laser apparatus comprises the semiconductor laser device described with reference to FIG. 1, a lens 14 for converging the laser beam LC generated from the semiconductor laser device 9, and a solid-state laser unit 20 which performs laser oscillation as a result of being optically excited by the laser beam LC.

The solid-state laser unit 20 includes a solid-state laser medium 22 which forms inverted population as a result of being optically excited by the laser beam LC serving as the excitation beam, a concave mirror 21 exhibiting a high transmittance for the wavelength of the laser beam LC and a high reflectance for the oscillation wavelength of the solid-state laser medium 22, a plane mirror 24 exhibiting a reflectance of 95% for the oscillation wavelength of the solid-state laser medium 22, and
an aperture 23 which limits the lateral mode of the oscillation beam.

[0048] For instance, a laser beam LP having a wavelength of 1,064 nm and an output of approximately 7.5 W can be obtained when the wavelength of the laser beam LC is 810 nm, the solid-state laser medium 22 comprises Nd:YAG crystal which is doped with 1.1 at% (atomic percent) of Nd and has an oscillation wavelength of 1,064 nm, the aperture diameter of the aperture 23 is 250 μm and the length of the optical resonator comprising the concave mirror 21 and the plane mirror 24 is 100 mm.

[0049] It is clear that, by merging a plurality of laser beams emitted from the semiconductor laser array 2 from two into one by the birefringent effect and bundling the optical fibers 10, a single high-output excitation light source can be obtained. By optically exciting the solid-state laser medium 22, the laser oscillation output of the solid-state laser medium 22 is greatly increased.

[0050] FIG. 3 shows the structure of another embodiment of the invention. FIG. 3A is a plan view, and FIG. 3B is a partial front view. The whole structure of this embodiment is similar to that explained in FIG. 1, while in this embodiment a cylindrical lens 4a of graded index type (e.g. Doric lens having a diameter of 300 μm, manufactured by Doric Lenses Inc., Canada) is used as the cylindrical optical element in place of the cylindrical lens 4 of FIG. 1. Since the cylindrical lens is used as the cylindrical lens, as shown in FIG. 3B, it is possible to reduce the distance between the optical fiber 10 and the semiconductor laser array 2 without increasing the NA of the optical fiber 10. To achieve the structure of this embodiment, the interval between the light emitting portions 3 is set to 250 μm, the length of the birefringent optical element 6 is set to 2.5 mm, the radius of curvature of the cylindrical surface of the light emitting surface 7 is set to 2.5 mm, and the distance between the birefringent optical element 6 and the optical fiber 10 is set to 3.5 mm. Because other conditions and operations are similar to those in FIG. 1, explanations thereof will be omitted. With the use of the cylindrical lens 4a as described above, it is possible to reduce the length of the semiconductor laser along the light transmission direction to a half of that in FIG. 1 while holding the NA of the optical fiber 10 at 0.14 the same as that in FIG. 1.

[0051] Further, in the case of using such cylindrical lens 4a, merging of the laser beams LA and LB in the birefringent optical element 6 can be further efficiently carried out by converging the laser beams LA and LB from the light emitting regions 3 of the semiconductor laser array 2 in the Z direction.

[0052] The invention may be embodied in other specific forms without departing from the essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and the range of equivalency of the claims are therefore intended to be embraced therein.

Claims

1. A semiconductor laser source comprising

   first and second semiconductor lasers (3) for emitting laser beams (LA, LB) whose polarization planes are parallel to each other and whose divergent angles θa and θb in two orthogonal directions satisfy an inequality condition θa > θb; a birefringent optical element (6) for merging by a birefringent effect, optical paths of the respective laser beams (LA, LB) having passed through a polarization rotating element (5), and a converging optical element (7) for converging the laser beams merged by the birefringent optical element in a direction where the divergent angle θb of the laser beams decreases;

   characterized in that

   a cylindrical optical element (4) is provided between the semiconductor lasers (3) and the polarization rotating element (5), for converging the laser beams emitted from the first and second semiconductor lasers (3) in a direction where the divergent angle θa of the laser beams decreases;

   said polarization rotating element (5) is provided for controlling the polarization direction of at least one of said laser beams (LA, LB) so that the polarization planes of the respective laser beams (LA, LB) form an angle of 90 degrees when said laser beams (LA, LB) having passed through said cylindrical optical element (4).

2. The semiconductor laser source of claim 1, wherein said polarization rotating element (5) is integrally formed with optical paths of the respective laser beams (LA, LB), having a different length from each other.

3. The semiconductor laser source of claim 1 or 2, wherein said first and second semiconductor lasers (3) respectively oscillate in a transverse multimode.

4. The semiconductor laser source of claim 1 or 2, wherein said first and second semiconductor lasers (3) constitute a transverse multimode semiconductor laser array (2) in which a plurality of light emitting regions are formed on a single chip.

5. The semiconductor laser source of any of the preceding claims, wherein the converging optical element (7) is constructed of a curved surface formed
6. The semiconductor laser source of any of the preceding claims, wherein convergence positions of said cylindrical optical element (4) and the converging optical element (7) coincide with each other, and an incident end surface of an optical fiber (10) is situated at the convergence positions.

7. The semiconductor laser source of claim 6, wherein said optical fiber (10) is an optical fiber bundle constructed of a plurality of optical fibers and arranged so that, on an incident end surface of each optical fiber, laser beams from a couple of light emitting regions of the light emitting regions of said semiconductor array enter after being merged with each other.

8. A solid state laser apparatus comprising

   the semiconductor laser source of any of the preceding claims; and

   a solid state medium (22) which is optically excited by the merged laser beam to perform laser oscillation.

Patentansprüche

1. Halbleiterlaserquelle, enthaltend:

   einen ersten und zweiten Halbleiterlaser (3) zum Emittieren von Laserstrahlen (LA, LB) mit parallel zueinander ausgebildeten Polarisationsebenen und Streuwinkeln $\theta_a$ und $\theta_b$ entlang zweier orthogonalen Richtungen unter Erfüllung der Ungleichheitsbedingung $\theta_a > \theta_b$; ein doppelbrechendes optisches Element (6) zum Verschmelzen - durch einen Doppelbrechungseffekt - optischer Pfade der jeweiligen Laserstrahlen (LA, LB), die durch ein Polarisationsrotationselement (5) passiert sind; und ein konvergierendes optisches Element (7) zum Konvergieren der durch das doppelbrechende optische Element verschmolzenen Laserstrahlen entlang einer Richtung, bei der sich der Streuwinkel $\theta_b$ der Laserstrahlen verringert;

   dadurch gekennzeichnet, dass

   ein zylindrisches optisches Element (4) zwischen den Halbleiterlasern (3) und dem Polarisationsrotationselement (5) vorgesehen ist, zum Konvergieren der von dem ersten und zweiten Halbleiterlaser (3) emittierten Laserstrahlen entlang einer Richtung, entlang der sich der Streuwinkel $\theta_a$ der Laserstrahlen verringert, derart, dass das Polarisationsrotationselement (5) zum Steuern der Polarisationsrichtung zumindest der Laserstrahlen (LA, LB) so vorgesehen ist, dass die Polarisationsebenen der jeweiligen Laserstrahlen (LA, LB) einen Winkel von 90° dann bilden, wenn die Laserstrahlen (LA, LB) das zylindrische optische Element (4) passiert haben.

2. Halbleiterlaserquelle nach Anspruch 1, dadurch gekennzeichnet, dass das Polarisationsrotationselement (5) integral mit den optischen Pfaden der jeweiligen Laserstrahlen (LA, LB) gebildet ist, mit einer unterschiedlichen Länge zueinander.

3. Halbleiterlaserquelle nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass der erste und zweite Halbleiterlaser (3) jeweils in einem Quermehrfachmodus oszilliert.

4. Halbleiterlaserquelle nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass der erste und zweite Halbleiterlaser (3) ein Quermehrmoden-Halbleiterlaserfeld (2) bilden, bei dem mehrere Licht emittierende Gebiete auf einem einzelnen Chip gebildet sind.

5. Halbleiterlaserquelle nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, dass das konvergierende optische Element (7) aus einer gekrümmten Oberfläche konstruiert ist, die als Einheit mit einer Licht emittierenden Oberfläche des doppelparen optischen Elements (6) ausgebildet ist.

6. Halbleiterlaserquelle nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, dass die Konvergenzpositionen des zylindrischen optischen Elements (4) und des konvergierenden optischen Elements (7) miteinander übereinstimmen und eine Eintrittsendoberfläche einer Lichtleitfaser (10) bei den Konvergenzpositionen vorliegt.

7. Halbleiterlaserquelle nach Anspruch 6, dadurch gekennzeichnet, dass die Lichtleitfaser (10) ein aus mehreren Lichtleitfasern aufgebautes Lichtleitfaserbündel ist, das so ausgebildet ist, dass bei einer Eintrittsendoberfläche jeder Lichtleitfaser Laserstrahlen von einem Paar der Licht emittierenden Gebiete der Licht emittierenden Gebiete des Halbleiterfelde ntreten, nachdem sie miteinander verschmolzen sind.
8. Festkörperlasergerät, enthaltend:

eine Halbleiterlaserquelle nach einem der vorangehenden Ansprüche; und
ein Festkörpermedium (22), das optisch durch den verschmolzenen Laserstrahl zum Durchführen der Laseroszillation erregt ist.

Revendications

1. Source laser à semi-conducteur comprenant

un premier et un deuxième lasers à semi-conducteur (3) pour émettre des faisceaux laser (LA, LB) dont les plans de polarisation sont mutuellement parallèles et dont les angles divergents \( \Theta_a \) et \( \Theta_b \) dans deux directions orthogonales satisfont la condition d'inégalité \( \Theta_a > \Theta_b \); un élément optique biréfringent (6) pour faire fusionner par un effet de biréfringence, les trajets optiques des faisceaux laser respectifs (LA, LB) ayant passé à travers un élément rotatif de polarisation (5) ; et un élément optique convergent (7) pour faire converger les faisceaux laser fusionnés par l'élément optique biréfringent dans une direction selon laquelle l'angle divergent \( \Theta_b \) des faisceaux laser diminue ;

caractérisé en ce que

un élément optique cylindrique (4) est prévu entre les lasers à semi-conducteurs (3) et l'élément rotatif de polarisation (5), pour faire converger les faisceaux laser émis par le premier et le deuxième lasers à semi-conducteur (3) dans une direction où l'angle divergent \( \Theta_a \) des faisceaux laser diminue ;

ledit élément rotatif de polarisation (5) est prévu pour commander la direction de polarisation d'au moins un desdits faisceaux laser (LA, LB) de sorte que les plans de polarisation des faisceaux laser respectifs (LA, LB) forment un angle de 90 degrés lorsque lesdits faisceaux laser (LA, LB) ont passé à travers ledit élément optique cylindrique (4).

2. Source laser à semi-conducteur selon la revendication 1, dans laquelle ledit élément rotatif de polarisation (5) est formé de façon intégrée avec les trajets optiques des faisceaux laser respectifs (LA, LB), possédant une longueur différente l'un de l'autre.

3. Source laser à semi-conducteur selon la revendication 1 ou 2, dans laquelle lesdits premier et deuxième lasers à semi-conducteurs (3) oscillent respectivement en multimode transversal.

4. Source laser à semi-conducteur selon la revendication 1 ou 2, dans laquelle lesdits premier et deuxième lasers à semi-conducteur (3) constituent une matrice de lasers à semi-conducteur à multimode transversal (2) dans laquelle une pluralité de régions émettrices de lumière est formée sur une seule puce.

5. Source laser à semi-conducteur selon l'une quelconque des revendications précédentes, dans laquelle l'élément optique convergent (7) est construit à partir d'une surface courbe formée de façon intégrée avec une surface émettrice de lumière dudit élément optique biréfringent (6).

6. Source laser à semi-conducteur selon l'une quelconque des revendications précédentes, dans laquelle les positions de convergence dudit élément optique cylindrique (4) et dudit élément optique convergent (7) coincident l'une avec l'autre, et où une surface d'extrémité d'incidence d'une fibre optique (10) est située aux positions de convergence.

7. Source laser à semi-conducteur selon la revendication 6, dans laquelle ladite fibre optique (10) est un faisceau de fibres optiques construit à partir d'une pluralité de fibres optiques et disposé de sorte que, sur une surface d'extrémité d'incidence de chaque fibre optique, les faisceaux laser provenant d'un couple de régions émettrices de lumière parmi les régions émettrices de lumière de ladite matrice de semi-conducteurs entrent après avoir fusionné l'un avec l'autre.

8. Laser à l'état solide comprenant

la source laser à semi-conducteur selon l'une quelconque des revendications précédentes ; un support à l'état solide (22) qui est excité de façon optique par le faisceau laser fusionné pour exécuter l'oscillation laser.