

Description

This invention relates to a visible laser source as described in the preamble of claim 1.

"Miniature light source of coherent blue radiation" by T. Taniuchi and K. Yamato, CLEO '87, WP 6, 1987 discloses a visible laser source which has some problems as described hereinafter. A further visible laser source is described in JP-A-61 189 524.

In common with the visible laser source of the present invention, the laser source of JP-A-61 189 524 comprises a semiconductor laser and an optical nonlinear device which are both mounted on a common sub mount, the semiconductor laser having an active layer which is associated with one surface of the semiconductor laser and the optical nonlinear device being provided on one surface with a waveguide.

However, in contrast to the visible laser source of the present invention, the optical nonlinear device of JP-A-61 189 524 is mounted on the sub mount so that the surface with the waveguide on it lies remote, i.e. faces away from the sub mount. Moreover, the mounting surfaces for the semiconductor laser and the nonlinear device are offset, the sub mount comprises namely a first mounting surface for the optical nonlinear device and a second mounting surface for the laser parallel to the first surface, this second surface being provided on an elevated, projecting base portion of the sub mount.

The projecting base of the sub mount is necessary for aligning the optical axis of the active layer with the optical axis of the waveguide but, however, complicates the sub mount manufacture. Further, due to the design of the known laser source, an accurate alignment between the optical axis of the active layer and the optical axis of the waveguide tends to be difficult.

It is an object of this invention to provide a further visible laser source which can be easily manufactured, in particular, without any, or with a considerably reduced amount of positive alignment being necessary.

This object is achieved by the laser source according to claim 1.

In accordance with the present invention, the semiconductor laser and the optical nonlinear device are so mounted on the sub mount that both the surface of the semiconductor laser associated with the active layer and the surface of the optical nonlinear device associated with the waveguide face the sub mount. Consequently, both the semiconductor laser and the optical nonlinear device can be mounted on a flat surface of the sub mount so that the optical axis of the active layer can be accurately aligned with the optical axis of the waveguide without any, or with a considerably reduced amount of positive alignment being necessary.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of a prior art visible laser source.

Fig. 2 is a perspective view of the optical nonlinear device of Fig. 1.

Fig. 3 is a sectional view of the optical nonlinear device of Fig. 1.

Fig. 4 is a sectional view of a visible laser source according to a first embodiment of this invention.

Figs. 5(a), 5(b), and 5(c) are sectional views of the visible laser source of the first embodiment during the assembly thereof.

Fig. 6 is a sectional view of portions of the optical nonlinear device and the sub mount of Fig. 4.

Fig. 7 is a sectional view of a visible laser source according to a second embodiment of this invention.

Fig. 8 is a sectional view of portions of the semiconductor laser, the optical nonlinear device, and the sub mount of Fig. 7.

Fig. 9 is a perspective view of the optical nonlinear device of Fig. 7.

Figs. 10(a), 10(b), 10(c), and 10(d) are sectional views of the optical nonlinear device of the second embodiment during the fabrication thereof.

Fig. 11 is a sectional view of an optical information recording and reproducing system which includes a visible laser source of this invention.

Like and corresponding elements are denoted by the same reference characters throughout the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Before the description of this invention, a prior art visible laser source will be described hereinafter for a better understanding of this invention. Fig. 1 shows a prior art visible laser source disclosed in "Miniaturized light source of coherent blue radiation" by T. Taniuchi and K. Yamamoto, CLEO '87, WP6, 1987.

As shown in Fig. 1, the prior art visible laser source includes a semiconductor laser 2, an optical nonlinear device 3, lenses 31 and 32, and a half wave plate 33. Fundamental wave P1 from the semiconductor laser 2 is applied via the lenses 31 and 32 to a light input surface 7 (a light incident surface) of a waveguide 5 formed in the optical nonlinear device 3. The half wave plate 33 extends between the lenses 31 and 32. The half wave plate 33 rotates a direction of polarization of the fundamental wave P1 through 90° to match the direction of polarization to polarization characteristics of the waveguide 5 to allow the fundamental wave P1 to be guided along the waveguide 5.

Figs. 2 and 3 show the prior art optical nonlinear device 3 which is disclosed in "Second harmonic generation by Cherenkov radiation in proton-exchanged

"LiNbO₃ optical waveguide" by T. Taniuchi and K. Yamamoto, CLEO '86, WR3, 1986.

As shown in Figs. 2 and 3, the prior art optical nonlinear device 3 includes a LiNbO₃ substrate 4 on which the buried-type waveguide 5 is formed. In cases where the fundamental wave P1 is applied to the light input surface 7 of the waveguide 5, when the effective refractive index N1 related to the guide mode of the fundamental wave P1 equals the effective refractive index N2 related to harmonic wave P2, the harmonic wave P2 is effectively radiated into the substrate 4 via the waveguide 5 so that a desired optical nonlinear function is available.

A method of forming such a prior art buried-type waveguide 5 is disclosed in "Proton exchange for high-index waveguides in LiNbO₃" by J.L. Jackel, C.E. Rice, and J.J. Veselka, Appl. Phys. Lett., Vol 41, No. 7, pp 607-608, 1982. In this prior art method, a layer of Cr or Al is formed on a ferroelectric LiNbO₃ substrate 4 by vapor deposition, and a photo process and an etching process are used to provide a slit in the substrate 4. The slit has a width of about several micrometers. Then, the substrate 4 is thermally processed in benzoic acid to form a high refractive index layer corresponding to a waveguide 5. The refractive index difference between the high refractive index layer and the main body of the substrate 4 is about 0.13.

During the assembly of the prior art visible laser source of Fig. 1, the lenses 31 and 32, the half wave plate 33, and the optical nonlinear device 3 are fixedly located on a mount 34. After the alignment is made on a package 35 of the semiconductor laser 2 in directions of three axes X, Y, and Z with an accuracy of 1 micrometer, the package 35 is fixed to a position at which the intensity of the obtained harmonic wave is maximized.

The total length of the prior art visible laser source of Fig. 1 is 30 mm under conditions where the semiconductor laser 2 emits light having a wavelength of 0.84 micrometer and the length of the optical nonlinear device 3 is 6 mm. It was experimentally found that when the power output of the fundamental wave P1 from the semiconductor laser 2 was 120 mW, the portion of the output fundamental wave P1 which corresponds to 65 mW was coupled to the optical nonlinear device 3 and the harmonic wave P2 of 1.05 mW was obtained. In this case, the conversion efficiency (P1/P2) in the optical nonlinear device 3 was 0.9% and the coupling efficiency was 54%.

The prior art visible laser source of Fig. 1 has problems as follows. The alignment of the optical axes of the lenses 31, 32 and the optical nonlinear device 3 tends to be difficult since an accuracy of 1 micrometer or less is required in this alignment. The number of necessary parts is large. The large number of the parts tends to cause a mis-alignment of the optical axes. Furthermore, the large number of the parts

causes the visible laser source to be easily affected by a temperature variation and a vibration. The lenses produce a considerable loss of the fundamental wave. The lenses are large so that the visible laser source is also large. It is generally difficult to stably generate harmonic wave of 1 mW or greater.

Fig. 4 shows a visible laser source according to a first embodiment of this invention. As shown in Fig. 4, the visible laser source includes a sub mount 1 of Si on which a semiconductor laser 2 and an optical nonlinear device 3 are located. The semiconductor laser 2 emits light having a wavelength of 0.84 micrometer. The power output of the semiconductor laser 2 is 100 mW. The optical nonlinear device 3 includes a LiNbO₃ substrate 4. A waveguide 5 is formed on the substrate 4 by proton exchange performed within phosphoric acid. The waveguide 5 has a large variation in refractive index and effectively traps the light. In addition, the waveguide 5 has a high efficiency of the conversion of fundamental wave into harmonic wave. An active layer 8 of the semiconductor laser 2 is formed at the surface 10 of the semiconductor laser 2 which faces the sub mount 1. The waveguide 5 is formed at the surface 14 of the optical nonlinear device 3 which faces the sub mount 1. The active layer 8 of the semiconductor laser 2 and the waveguide 5 have a common optical axis so that the semiconductor laser 2 and the waveguide 5 are directly coupled with respect to fundamental wave P1.

When the fundamental wave P1 which has a wavelength of 0.84 micrometer is directly applied from the semiconductor laser 2 into the waveguide 5 via a light input surface 7 (a light incident surface) of the optical nonlinear device 3, the fundamental wave P1 propagates in a single mode and is converted within the waveguide 5 into harmonic wave P2 having a wavelength of 0.42 micrometer. The harmonic wave P2 is emitted from a light output surface 12 of the optical nonlinear device 3.

The visible laser source of Fig. 4 was manufactured as follows. As shown in Fig. 5(a), the sub mount 1 of Si had a flat surface extending parallel to directions X and Z. A projection 9 extending along a direction Y was formed on the sub mount 1 by a known photo process and a known dry etching process. It should be noted that the directions X, Y, and Z are perpendicular to each other. The projection 9 had a width of 2 micrometers and a height of 5 micrometers. Subsequently, as shown in Fig. 5(b), the semiconductor laser 2 was bonded to the flat region of the sub mount 1 which extended leftward of the projection 9 as viewed in Fig. 5(b). Specifically, the surface 10 of the semiconductor laser 2 at which the active layer 8 was formed was faced to the sub mount 1. During the bonding of the semiconductor laser 2, a light output surface of the semiconductor laser 2 was pressed against a left-hand side 9a of the projection 9. Subsequently, as shown in Fig. 5(c), the optical nonlinear

device 3 was fixed to the sub mount 1 after a drive electric current was passed through the semiconductor laser 2 to generate the fundamental wave P1. Specifically, the optical nonlinear device 3 was located on the flat region of the sub mount 1 which extended rightward of the projection 9. In addition, the surface 14 of the optical nonlinear device 3 at which the waveguide 5 was formed was faced to the sub mount 1. During the fixing of the optical nonlinear device 3, a light input surface of the optical nonlinear device 3 was pressed against a right-hand side 9b of the projection 9. As shown in Fig. 6, the light input surface 7 of the optical nonlinear device 3 formed an angle θ of 90° or less with respect to the surface 14 of the optical nonlinear device 3 at which the waveguide 5 was formed. This angular design of the light incoming surface 7 of the optical nonlinear device 3 prevents mechanical contact between the semiconductor laser 2 and the optical nonlinear device 3 which could damage the devices 2 and 3. In addition, this angular design of the light input surface 7 allows a smaller portion of the light to be reflected at the light input surface 7 back to the active layer 8 of the semiconductor laser 2. When the optical nonlinear device 3 was fixed to the sub mount 1, the optical nonlinear device 3 was aligned with the semiconductor laser 2 in the direction X so that the power of the generated harmonic wave P2 was maximized. Since the projection 9 separates the semiconductor laser 2 and the optical nonlinear device 3 from each other by a gap of 2 micrometers in the direction Z, a positive process of aligning the devices 2 and 3 in the direction Z is unnecessary. During the bonding of the semiconductor laser 2 and the fixing of the optical nonlinear device 3, since the devices 2 and 3 are placed on the flat surfaces of the sub mount 1 which having the same level and since the active layer 8 of the device 2 and the waveguide 5 of the device 3 are in the same height, a positive process of aligning the devices 2 and 3 in the direction Y is unnecessary. Specifically, a protective layer 13 of SiO₂ covering the waveguide 5 was formed on the optical nonlinear device 3 to equalize the heights of the active layer 8 of the device 2 and the waveguide 5 of the device 3. The height of the waveguide 5 which was measured from the surface of the sub mount 1 was 6.5 micrometers. A light input end of the waveguide 5 was heated to form a taper waveguide 6. The thickness of the taper waveguide 6 was greater than the thickness of the remainder of the waveguide 5. The taper waveguide 6 ensures a higher coupling efficiency with respect to the fundamental wave P1 and allows easier matching between the heights of the active layer 8 of the device 2 and the waveguide 5 of the device 3.

When the semiconductor laser 2 was operated at a power output of 100 mW, the power of the obtained harmonic wave P2 (whose wavelength is 0.42 micrometer) was 2 mW. In this case, the conversion effi-

ciency was 2%. In this way, the conversion efficiency in this embodiment was higher than the conversion efficiency in the prior art visible laser source of Fig. 1. The higher conversion efficiency results from the following fact. The coupling efficiency in this embodiment is greater than that in the prior art visible laser source of Fig. 1 by a factor of 1.5 so that 76% of the output fundamental wave from the semiconductor laser 2 enters the optical nonlinear device 3. Specifically, an antireflection film of SiO₂ was formed on the light input surface 7 of the optical nonlinear device 3. The antireflection film causes a 15% increase in the efficiency of the coupling between the active layer 8 of the semiconductor laser 2 and the waveguide 5 of the optical nonlinear device 3 with respect to the fundamental wave P1. In addition, the antireflection film decreases the quantity of the return of the fundamental wave P1 to the semiconductor laser 2 which could cause unstable operation of the device 2.

The visible laser source of this embodiment is smaller than the prior art visible laser source of Fig. 1. Specifically, the visible laser source of this embodiment is 4X4X10 mm in size. In the visible laser source of this embodiment, a mis-alignment between the optical axes remains effectively prevented. Therefore, the visible laser source of this embodiment is less affected by a temperature variation and a vibration than the prior art visible laser source of Fig. 1.

The light outgoing surface 12 of the optical nonlinear device 3 is polished and is vertical (perpendicular) with respect to the direction of the travel of the harmonic wave P2. This design allows a smaller variation in the output angle of the harmonic wave P2 due to a temperature variation.

It should be noted that the sub mount 1 may be made of material other than Si. In cases where the sub mount 1 is made of MgO-doped material, it is possible to prevent an optical damage by short wave light and thus to prevent a variation in the power of the generated harmonic wave.

It was experimentally confirmed that the visible laser source of this embodiment generated harmonic wave with respect to fundamental wave whose wavelength was in the range of 0.65-1.3 micrometers.

Figs. 7 and 8 show a second embodiment of this invention which is similar to the embodiment of Figs. 4-6 except for the design changes indicated hereinafter.

In the embodiment of Figs. 7 and 8, a projection 9 (see Fig. 4) is removed from a sub mount 1. A light output surface 11 of a semiconductor laser 2 contacts a light input surface 7 of an optical nonlinear device 3.

The embodiment of Figs. 7 and 8 was assembled as follows. After the optical nonlinear device 3 was bonded to the sub mount 1, the semiconductor laser 2 was bonded to the sub mount 1 while being pressed against the optical nonlinear device 3. As shown in

Fig. 8, the light input surface 7 of the optical nonlinear device 3 formed an angle θ of 90° or greater with respect to a surface 14 of the optical nonlinear device 3 at which waveguides 5 were formed. During the bonding of the semiconductor laser 2, the light output surface 11 of the semiconductor laser 2 was pressed against the light input surface 7 of the optical nonlinear device 3 so that the semiconductor laser 2 was correctly located in a direction Z. The length of the manufactured visible laser source was 6 mm.

As shown in Fig. 9, the optical nonlinear device 3 has a plurality of parallel waveguides 5 extending along the direction Z. Light input ends of the respective waveguides 5 form taper waveguides 6. At the light input surface 7 of the optical nonlinear device 3, the taper waveguides 6 align along a direction X. A strip region of the light incoming surface 7 which extending along the direction X is substantially continuously occupied by the taper waveguides 6. This design ensures reliable coupling between an active layer 8 of the semiconductor laser 2 and at least one of the waveguides 5.

It was experimentally found that visible laser sources of the embodiment of Figs. 7-9 were manufactured at a yield of 30% without any positive alignment.

The optical nonlinear device 3 in the embodiment of Figs. 7-9 were fabricated as follows. A substrate 4 included a +X plate (a "+" side of a substrate cut along a plane perpendicular to a direction X) of MgO-doped LiNbO_3 . The X plate was used to match the directions of polarization of the semiconductor laser 2 and the waveguides 5. As shown in Fig. 10(a), one surface of the substrate 4 was coated with a protective mask 18 of Ta by electron beam vapor deposition. The thickness of the mask 18 was 300 angstroms. As shown in Fig. 10(b), a pattern of photo resist 19 was formed on the protective mask 18 by a general photo process. The thickness of the photo resist 19 was 0.5 micrometers. Then, the protective mask 18 was exposed to dry etching using CF_4 . After the photo resist 19 was removed from the substrate 4, the substrate 4 with the protective mask 18 was exposed to a heating process or a proton exchange process within pyrophosphoric acid to form a waveguide 5 as shown in Fig. 10(c). Specifically, the substrate 4 was heated to 230°C and remained heated at 230°C for 8 minutes. The thickness of the waveguide 5 was 0.37 micrometer. It should be noted that, for clarity, Figs. 10(b) and 10(c) show a case where a single waveguide is formed. After the formation of the waveguide 5, the protective mask 18 was removed from the substrate 4. Then, a light input portion of the substrate 4 was thermally processed at a temperature of 300°C so that the thickness of the waveguide 5 at the light incoming portion was 1.5 micrometer. As shown in Fig. 10(d), the substrate 4 and the waveguide 5 were coated with a protective layer 13 of SiO_2 . Opposite surfaces of the sub-

strate 4 which extended substantially perpendicular to the waveguide 5 were polished to form a light input surface 7 (see Figs. 7-9) and a light output surface 12. Subsequently, the edge of the light output surface 12 through which fundamental wave passed was made rough to scatter the fundamental wave. The light input surface 7 was coated with an antireflection film acting on the fundamental wave. The antireflection film on the light input surface 7 serves to prevent the return of the fundamental wave to the semiconductor laser 2. The light output surface 12 was coated with an antireflection film acting on harmonic wave. The antireflection film on the light output surface 12 ensures that the harmonic wave is effectively output via the light output surface 12.

When the fundamental wave P1 which has a wavelength of 0.84 micrometer is applied from the semiconductor laser 2 to the waveguide 5 via the light input surface 7 of the optical nonlinear device 3, the fundamental wave P1 propagates in a single mode and is converted within the waveguide 5 into harmonic wave P2 having a wavelength of 0.42 micrometer. The harmonic wave P2 is emitted from the light output surface 12 of the optical nonlinear device 3.

It was experimentally found that when the power output of the fundamental wave P1 from the semiconductor laser 2 was 70 mW, the harmonic wave P2 of 1 mW was obtained. In addition, since the portion of the fundamental wave which returned to the semiconductor laser 2 was greatly decreased, the semiconductor laser 2 operated stably and the power output of the harmonic wave fluctuated in the range of $\pm 3\%$.

Fig. 11 shows an optical information recording and reproducing system which includes a visible laser source 21 similar to the visible laser source of Figs. 4-6. The visible laser source 21 is used in a reproducing section of the system.

As shown in Fig. 11, the visible laser source 21 includes a sub mount 1 on which a semiconductor laser 2 and an optical nonlinear device 3 are fixedly located. Fundamental wave P1 emitted from the semiconductor laser 2 is converted by the optical nonlinear device 3 into harmonic wave P2. A beam of the harmonic wave P2 output from the visible laser source 21 is shaped by a lens 22 into parallel light. The parallel harmonic wave P2 passes through a beam splitter 23 and is then focused by a lens 24 into a spot on an optical disk 25. The diameter of the light spot is 0.62 micrometer which equals approximately a half of the diameter of a light spot available in a prior art system. The smaller diameter of the light spot enables a larger recording density related to the optical disk 25. The harmonic wave P2 is reflected by the optical disk 25 and carries information recorded on the optical disk 25. Then, the reflected harmonic wave P2 enters the beam splitter 23. After the harmonic wave P2 is reflected by the beam splitter 23, the wave P2 enters

an optical detector 26 which generates an electric signal representative of the information.

In the embodiments of this invention, light absorbing material may be applied to the light output surface 12 of the optical nonlinear device 3 to absorb the fundamental wave. In addition, the substrate 4 of the optical nonlinear device 3 may be made of ferroelectric material such as LiTaO₃, MgO-doped LiTaO₃ or KNbO₃, organic material such as MNA, or a compound semiconductor such as ZnS.

Claims

1. A visible laser source comprising:

a sub mount (1) ;

a semiconductor laser (2) located on the sub mount (1) and having an active layer (8) displaced from a surface (10) of the semiconductor laser (2),

an optical nonlinear device (3) for converting a fundamental wave (P1) into a corresponding harmonic wave (P2) located on the sub mount (1) and having a substrate (4), a waveguide (5) formed at a surface (14) of the substrate (4) and a protective layer (13) covering said waveguide (5),

wherein the semiconductor laser (2) and the waveguide (5) are directly optically coupled to each other for direct application of a fundamental wave from the semiconductor laser (2) to the optical nonlinear device (3),

characterized in that

the semiconductor laser (2) is mounted on said sub mount (1) such that the surface (10) of the semiconductor laser from which the active layer (8) is displaced faces a flat surface of the sub mount (1) ;

in that the optical non-linear device (3) is mounted on said sub mount (1) such that the surface (14) of the optical non-linear device at which the protective layer (13) is formed faces said flat surface of the sub mount (1) ;

and in that said protective layer (13) is of a thickness corresponding to the displacement of the active layer (8) from said surface (10) of the semiconductor laser (2).

2. A visible laser source according to claim 1, characterized in that the active layer (8) of the semiconductor laser (2) and the waveguide (5) of the optical nonlinear device (3) have a common optical axis.

3. A visible laser source according to claim 1, characterized in that the sub mount (1) has a projection (9) extending between the semiconductor laser (2) and the optical nonlinear device (3).

4. A visible laser source according to claim 1, characterized in that the sub mount (1) is made of Si.

5. A visible laser source according to claim 1, characterized in that the optical nonlinear device (3) includes a substrate (4) of LiNbO₃ or LiTaO₃.

6. A visible laser source according to claim 1, characterized in that the optical nonlinear device (3) includes a substrate (4) of MgO-doped LiNbO₃ or MgO-doped LiTaO₃.

7. A visible laser source according to claim 1, characterized in that the waveguide (5) includes a proton exchange waveguide.

8. A visible laser source according to claim 1, characterized in that a light input end of the waveguide (5) includes a tapered waveguide (6).

9. A visible laser source according to claim 1, characterized in that the optical nonlinear device (3) has a light output surface via which a harmonic wave travels from the optical nonlinear device (3), the light output surface being perpendicular to a direction of the travel of the harmonic wave from the optical nonlinear device (3).

10. A visible laser source according to claim 1, characterized by means for scattering a fundamental wave from the semiconductor laser (2) at a light output surface (12) of the waveguide (5).

11. A visible laser source according to claim 1, characterized by means for absorbing a fundamental wave from the semiconductor laser (2) at a light output surface (12) of the waveguide (5).

12. A visible laser source according to claim 1, characterized by an anti-reflection film extending on a light input surface (7) of the optical nonlinear device (3).

13. A visible laser source according to claim 1, characterized in that a light input surface (7) of the optical nonlinear device (3) forms an angle θ greater than 90° with respect to a surface of the sub mount (1) on which the optical nonlinear device (3) is located, wherein the light input surface (7) of the optical non-linear device (3) is tilted towards the semiconductor laser (2) such that it partially touches the light output surface (11) of the semiconductor laser.

Patentansprüche

1. Eine sichtbare Laserquelle mit:

an optical detector 26 which generates an electric signal representative of the information.

In the embodiments of this invention, light absorbing material may be applied to the light output surface 12 of the optical nonlinear device 3 to absorb the fundamental wave. In addition, the substrate 4 of the optical nonlinear device 3 may be made of ferroelectric material such as LiTaO₃, MgO-doped LiTaO₃ or KNbO₃, organic material such as MNA, or a compound semiconductor such as ZnS.

Claims

1. A visible laser source comprising:
 - a sub mount (1);
 - a semiconductor laser (2) located on the sub mount (1) and having an active layer (8) displaced from a surface (10) of the semiconductor laser (2),
 - an optical nonlinear device (3) for converting a fundamental wave (P1) into a corresponding harmonic wave (P2) located on the sub mount (1) and having a substrate (4), a waveguide (5) formed at a surface (14) of the substrate (4) and a protective layer (13) covering said waveguide (5),
 - wherein the semiconductor laser (2) and the waveguide (5) are directly optically coupled to each other for direct application of a fundamental wave from the semiconductor laser (2) to the optical nonlinear device (3),
 - characterized in that
 - the semiconductor laser (2) is mounted on said sub mount (1) such that the surface (10) of the semiconductor laser from which the active layer (8) is displaced faces a flat surface of the sub mount (1);
 - in that the optical non-linear device (3) is mounted on said sub mount (1) such that the surface (14) of the optical non-linear device at which the protective layer (13) is formed faces said flat surface of the sub mount (1);
 - and in that said protective layer (13) is of a thickness corresponding to the displacement of the active layer (8) from said surface (10) of the semiconductor laser (2).
2. A visible laser source according to claim 1, characterized in that the active layer (8) of the semiconductor laser (2) and the waveguide (5) of the optical nonlinear device (3) have a common optical axis.
3. A visible laser source according to claim 1, characterized in that the sub mount (1) has a projection (9) extending between the semiconductor laser (2) and the optical nonlinear device (3).
4. A visible laser source according to claim 1, characterized in that the sub mount (1) is made of Si.
5. A visible laser source according to claim 1, characterized in that the optical nonlinear device (3) includes a substrate (4) of LiNbO₃ or LiTaO₃.
6. A visible laser source according to claim 1, characterized in that the optical nonlinear device (3) includes a substrate (4) of MgO-doped LiNbO₃ or MgO-doped LiTaO₃.
7. A visible laser source according to claim 1, characterized in that the waveguide (5) includes a proton exchange waveguide.
8. A visible laser source according to claim 1, characterized in that a light input end of the waveguide (5) includes a tapered waveguide (6).
9. A visible laser source according to claim 1, characterized in that the optical nonlinear device (3) has a light output surface via which a harmonic wave travels from the optical nonlinear device (3), the light output surface being perpendicular to a direction of the travel of the harmonic wave from the optical nonlinear device (3).
10. A visible laser source according to claim 1, characterized by means for scattering a fundamental wave from the semiconductor laser (2) at a light output surface (12) of the waveguide (5).
11. A visible laser source according to claim 1, characterized by means for absorbing a fundamental wave from the semiconductor laser (2) at a light output surface (12) of the waveguide (5).
12. A visible laser source according to claim 1, characterized by an anti-reflection film extending on a light input surface (7) of the optical nonlinear device (3).
13. A visible laser source according to claim 1, characterized in that a light input surface (7) of the optical nonlinear device (3) forms an angle Θ greater than 90° with respect to a surface of the sub mount (1) on which the optical nonlinear device (3) is located, wherein the light input surface (7) of the optical non-linear device (3) is tilted towards the semiconductor laser (2) such that it partially touches the light output surface (11) of the semiconductor laser.

Patentansprüche

1. Eine sichtbare Laserquelle mit:



- einem Subhalter (1);
 einem Halbleiterlaser (2), der auf dem Subhalter (1) angeordnet ist und eine aktive Schicht (8) aufweist, die von einer Oberfläche (10) des Halbleiterlasers (2) versetzt ist,
 einem optischen nichtlinearen Gerät (3) zum Wandeln einer Fundamentalwelle (P1) in eine entsprechende harmonische Welle (P2), das auf dem Subhalter (1) angeordnet ist und ein Substrat (4), eine Wellenführung (5), die an einer Oberfläche (14) des Substrates (4) gebildet ist, und eine Schutzschicht (13) aufweist, die die Wellenführung (5) bedeckt,
 worin der Halbleiterlaser (2) und die Wellenführung (5) für die direkte Anlegung einer Fundamentalwelle aus dem Halbleiterlaser (2) an das optische nichtlineare Gerät (3) optisch direkt aneinander gekoppelt sind,
 dadurch gekennzeichnet, daß
 der Halbleiterlaser (2) auf dem Subhalter (1) derart angebracht ist, daß die Oberfläche (10) des Halbleiterlasers, von welcher die aktive Schicht (8) versetzt ist, auf eine flache Oberfläche des Subhalters (1) weist; dadurch, daß das optische nichtlineare Gerät (3) auf dem Subhalter (1) derart angebracht ist, daß die Oberfläche (14) des optischen nichtlinearen Gerätes, bei welcher die Schutzschicht (13) gebildet ist, auf die flache Oberfläche des Subhalters (1) weist;
 und dadurch, daß die Schutzschicht (13) von einer Dicke ist, die dem Versatz der aktiven Schicht (8) von der Oberfläche (10) des Halbleiterlasers (2) entspricht.
2. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß die aktive Schicht (8) des Halbleiterlasers (2) und die Wellenführung (5) des optischen nichtlinearen Gerätes (3) eine gemeinsame optische Achse aufweisen.
 3. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß der Subhalter (1) einen Vorsprung (9) aufweist, der sich zwischen dem Halbleiterlaser (2) und dem optischen nichtlinearen Gerät (3) erstreckt.
 4. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß der Subhalter (1) aus Si hergestellt ist.
 5. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß das optische nichtlineare Gerät (3) ein Substrat (4) aus LiNbO_3 oder LiTaO_3 umfaßt.
 6. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß das optische nichtlineare Gerät (3) ein Substrat (4) aus MgO -dotiertem LiNbO_3 oder MgO -dotiertem LiTaO_3 umfaßt.

7. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß die Wellenführung (5) eine Protonaustauschwellenführung umfaßt.
8. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß ein Lichteingangsende der Wellenführung (5) eine sich verjüngende Wellenführung (6) umfaßt.
9. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß das optische nichtlineare Gerät (3) eine Lichtausgangsoberfläche aufweist, über welche eine harmonische Welle sich aus dem optischen nichtlinearen Gerät (3) fortpflanzt, wobei die Lichtausgangsoberfläche senkrecht zu einer Richtung der Ausbreitung der harmonischen Welle aus dem optischen nichtlinearen Gerät (3) steht.
10. Eine sichtbare Laserquelle nach Anspruch 1, gekennzeichnet durch ein Mittel zum Streuen einer Fundamentalwelle aus dem Halbleiterlaser (2) bei einer Lichtausgangsoberfläche (12) der Wellenführung (5).
11. Eine sichtbare Laserquelle nach Anspruch 1, gekennzeichnet durch ein Mittel zum Absorbieren einer Fundamentalwelle aus dem Halbleiterlaser (2) bei einer Lichtausgangsoberfläche (12) der Wellenführung (5).
12. Eine sichtbare Laserquelle nach Anspruch 1, gekennzeichnet durch einen Antirefleksionsfilm, der sich auf einer Lichteingangsoberfläche (7) des optischen nichtlinearen Gerätes (3) erstreckt.
13. Eine sichtbare Laserquelle nach Anspruch 1, dadurch gekennzeichnet, daß eine Lichteingangsoberfläche (7) des optischen nichtlinearen Gerätes (3) einen Winkel θ größer als 90° mit Bezug auf eine Oberfläche des Subhalters (1) bildet, auf welchem das optische nichtlineare Gerät (3) angeordnet ist, worin die Lichteingangsoberfläche (7) des optischen nichtlinearen Gerätes (3) in Richtung auf den Halbleiterlaser (2) gekippt ist, so daß sie die Lichtausgangsoberfläche (11) des Halbleiterlasers partiell berührt.

Revendications

1. Source à laser visible comprenant:
 - une monture auxiliaire (1);
 - un laser à semi-conducteur (2) situé sur la monture auxiliaire (1) et présentant une couche active (8) déplacée par rapport à



- une surface (10) du laser à semi-conducteur (2),
- un dispositif optique non linéaire (3) pour convertir une onde fondamentale (P1) en une onde harmonique correspondante (P2), situé sur la monture auxiliaire (1) et comportant un substrat (4), un guide d'ondes (5) formé à une surface (14) du substrat (4) et une couche protectrice (13) qui couvre ledit guide d'ondes (5), dans laquelle le laser à semi-conducteur (2) et le guide d'ondes (5) sont couplés optiquement directement l'un à l'autre afin d'appliquer directement une onde fondamentale depuis le laser à semi-conducteur (2) au dispositif optique non linéaire (3), caractérisée en ce que
 - le laser à semi-conducteur (2) est monté sur ladite monture auxiliaire (1) de telle manière que la surface (10) du laser à semi-conducteur, depuis laquelle la couche active (8) est déplacée, fait face à une surface plane de la monture auxiliaire (1);
 - en ce que le dispositif optique non linéaire (3) est monté sur ladite monture auxiliaire (1) de telle manière que la surface (14) du dispositif optique non linéaire sur laquelle est formée la couche protectrice (13) fait face à ladite surface plane de la monture auxiliaire (1); et en ce que ladite couche protectrice (13) a une épaisseur qui correspond au déplacement de la couche active (8) depuis ladite surface (10) du laser à semi-conducteur (2).
2. Source laser visible selon la revendication 1, caractérisée en ce que la couche active (8) du laser à semi-conducteur (2) et le guide d'ondes (5) du dispositif optique non linéaire (3) ont un axe optique commun.
 3. Source laser visible selon la revendication 1, caractérisée en ce que la monture auxiliaire (1) possède une projection (9) qui s'étend entre le laser à semi-conducteur (2) et le dispositif optique non linéaire (3).
 4. Source laser visible selon la revendication 1, caractérisée en ce que la monture auxiliaire (1) est réalisée en Si.
 5. Source laser visible selon la revendication 1, caractérisée en ce que le dispositif optique non linéaire (3) comprend un substrat (4) en LiNbO_3 ou LiTaO_3 .
 6. Source laser visible selon la revendication 1, caractérisée en ce que le dispositif optique non linéaire (3) comprend un substrat (4) en LiNbO_3 dopé au MgO , ou en LiTaO_3 dopé au MgO .
 7. Source laser visible selon la revendication 1, caractérisée en ce que le guide d'ondes (5) comprend un guide d'ondes à échange de protons.
 8. Source laser visible selon la revendication 1, caractérisée en ce qu'une extrémité d'entrée de lumière du guide d'ondes (5) comprend un guide d'ondes (6) qui va en se rétrécissant.
 9. Source laser visible selon la revendication 1, caractérisée en ce que le dispositif optique non linéaire (3) comporte une surface de sortie de lumière à travers laquelle une onde harmonique se déplace depuis le dispositif optique non linéaire (3), la surface de sortie de lumière étant perpendiculaire à une direction de déplacement de l'onde harmonique depuis le dispositif optique non linéaire (3).
 10. Source laser visible selon la revendication 1, caractérisée par des moyens pour diffracter une onde fondamentale depuis le laser à semi-conducteur (2) au niveau d'une surface de sortie de lumière (12) du guide d'ondes (5).
 11. Source laser visible selon la revendication 1, caractérisée par des moyens pour absorber une onde fondamentale depuis le laser à semi-conducteur (2) au niveau d'une surface de sortie de lumière (12) du guide d'ondes (5).
 12. Source laser visible selon la revendication 1, caractérisée par un film anti-réflexion qui s'étend sur une surface d'entrée de lumière (7) du dispositif optique non linéaire (3).
 13. Source laser visible selon la revendication 1, caractérisée en ce qu'une surface d'entrée de lumière (7) du dispositif optique non linéaire (3) forme un angle θ supérieur à 90° par rapport à une surface de la monture auxiliaire (1) sur laquelle est placé le dispositif optique non linéaire (3), dans laquelle la surface d'entrée de lumière (7) du dispositif optique non linéaire (3) est inclinée en direction du laser à semi-conducteur (2) de telle manière qu'elle touche partiellement la surface de sortie de lumière (11) du laser à semi-conducteur.

