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(54) **LIGHT SOURCE SYSTEM AND LIGHTING DEVICE**

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F21V 29/10 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F21V 29/10*** (2015.01); ***F21V 7/05*** (2013.01); ***F21V 9/30*** (2018.02); ***G02B 27/126*** (2013.01); ***G02B 27/283*** (2013.01)

(58) **Field of Classification Search**
CPC ... F21V 29/10; F21V 7/05; F21V 9/30; G02B 27/126; G02B 27/283
See application file for complete search history.

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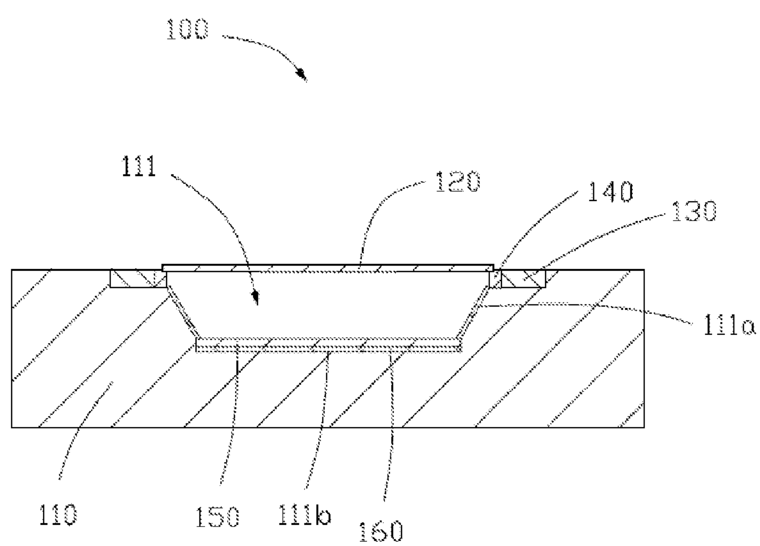
(57) **ABSTRACT**

The present disclosure provides a light source system and a lighting device including the same. The light source system includes at least one laser configured to emit excitation light, a substrate, a reflective layer, a wavelength conversion layer, and a light guiding element. The substrate is made of material with a high thermal conductivity and provided with a notch. The laser is received in a sidewall of the notch. The reflective layer covers walls of the notch and is configured to reflect the excitation light. The wavelength conversion layer is provided on a part of the reflective layer and configured to perform wavelength conversion on the excitation light to obtain excited light. The light guiding element covers an opening of the notch and configured to guide the excitation light and the excited light, to obtain light to be emitted by the light source system.

21 Claims, 4 Drawing Sheets



(51) **Int. Cl.**

F21V 7/05	(2006.01)
G02B 27/12	(2006.01)
G02B 27/28	(2006.01)

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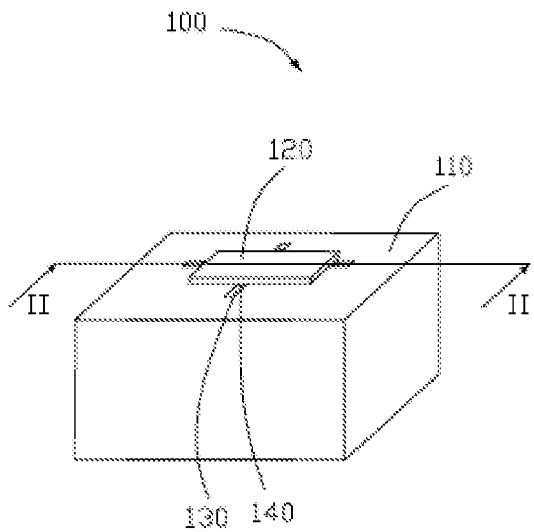
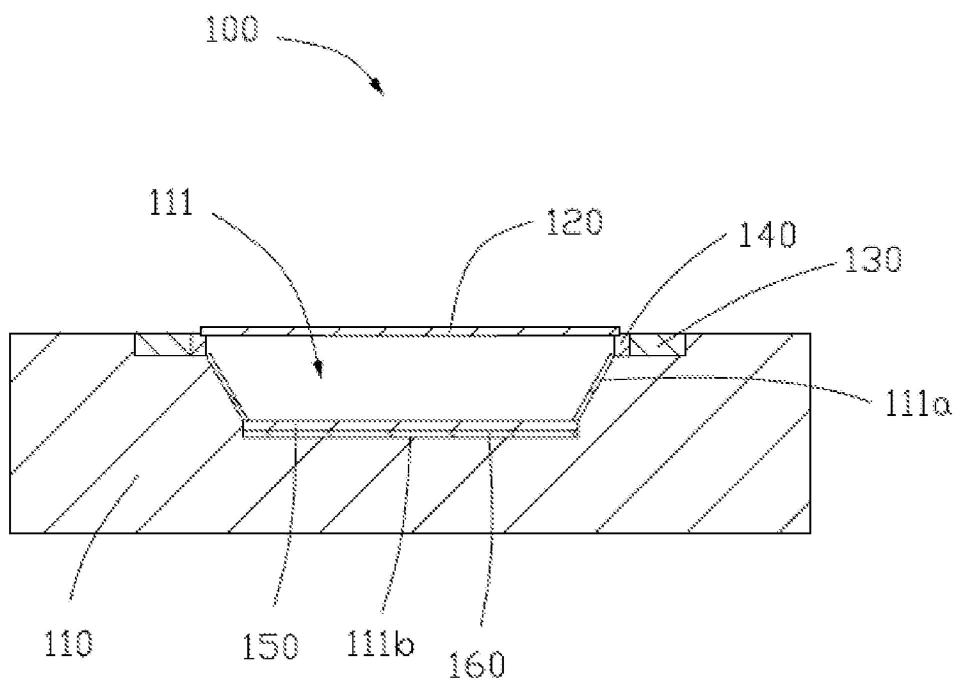

100
120
110
II
II
130
140

FIG. 1


100
111
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111a
110
150
111b
160

FIG. 2

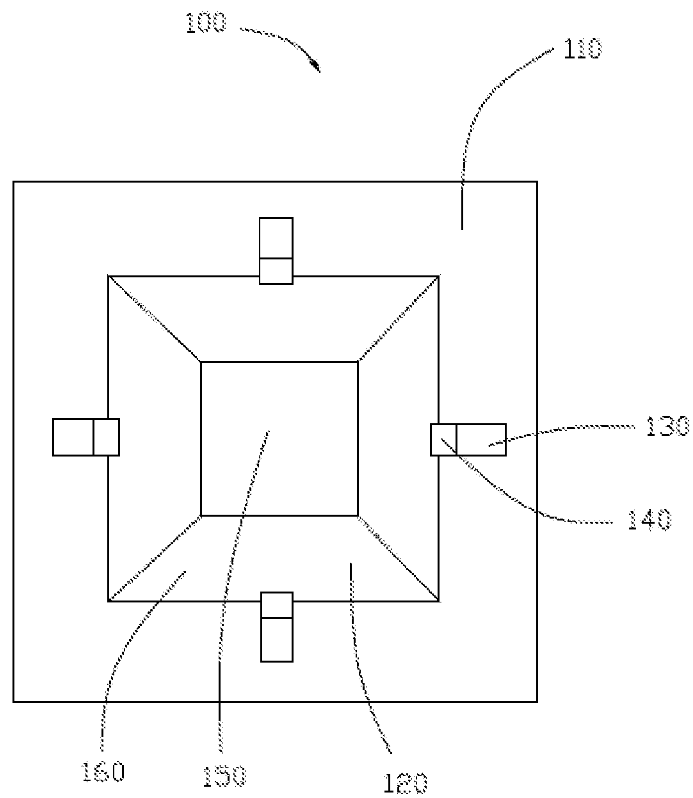

FIG. 3

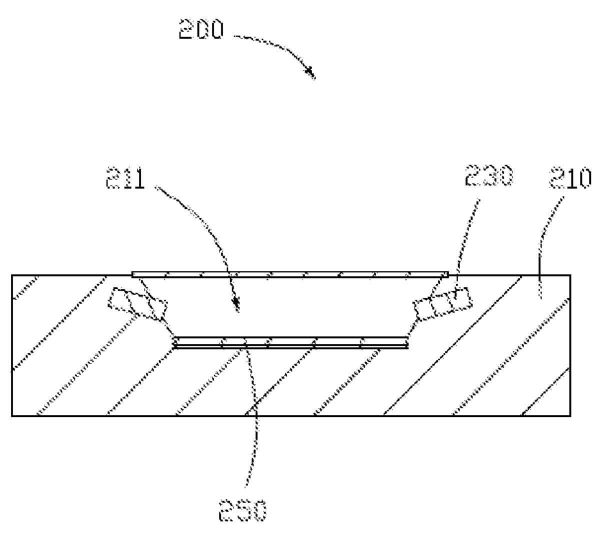

FIG. 4

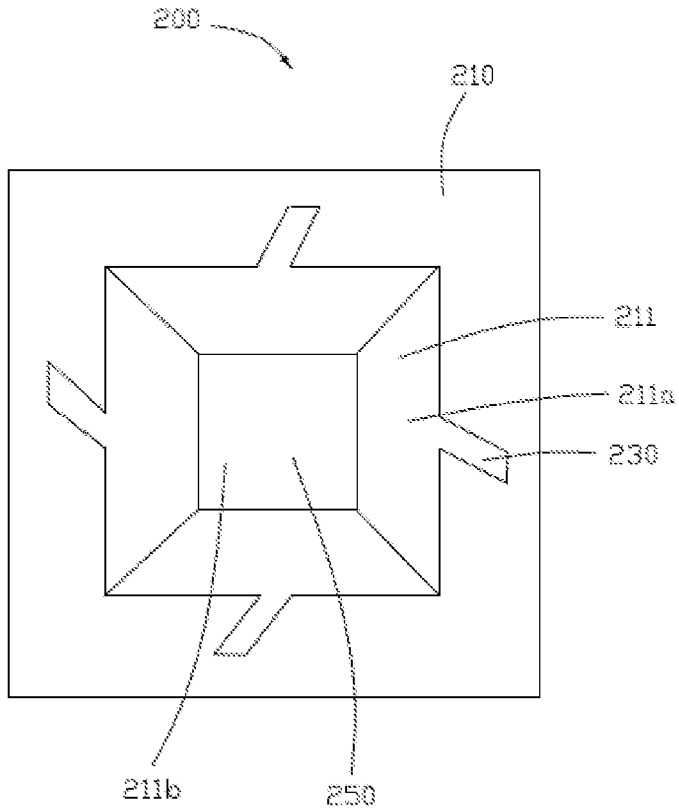

FIG. 5

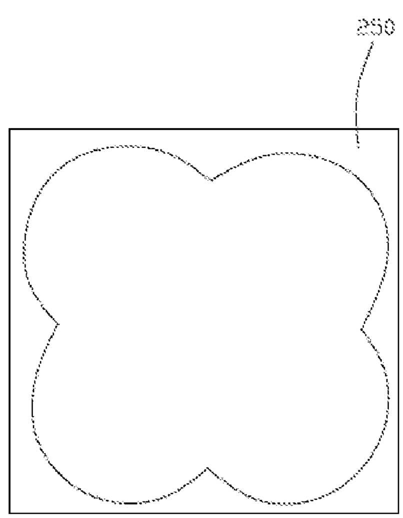

FIG. 6

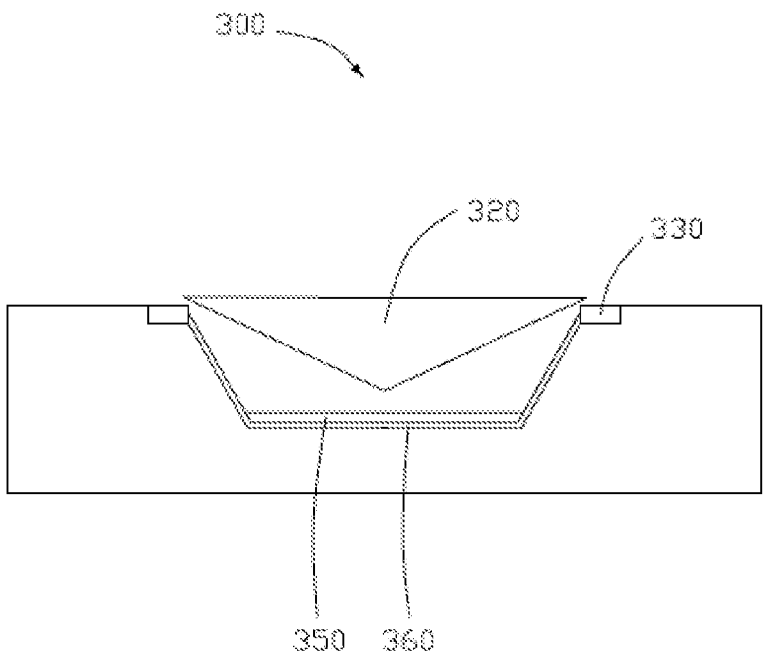

FIG. 7

LIGHT SOURCE SYSTEM AND LIGHTING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. national phase application of International Application No. PCT/CN2018/088524, filed on May 25, 2018, which claims priority to and the benefit of Chinese Patent Application No. 201711466234.5, filed on Dec. 28, 2017. The disclosures of the above applications are incorporated herein by reference.

FIELD

The present disclosure relates to the technical field of light sources, and in particular, to a light source system and a lighting device.

BACKGROUND

This section is intended to provide a background or context for specific forms or variations of the present disclosure recited in the claims. The description here is not admitted to be prior art just because it is included in this section.

At present, a solid-state light source used in the lighting field uses a blue laser and phosphors to output white light. The blue laser can operate at high drive power densities and produce relatively high luminous flux. A light source using the blue laser can have brightness which is dozens of times higher than that of an LED. For applications with strict restrictions in volume and etendue, the blue laser has inherent advantages as light sources.

At present, the solid-state light sources with the blue laser have aspects such as heat dissipation of a blue laser chip and a wavelength conversion layer.

SUMMARY

According to one form of the present disclosure, a light source system includes:

at least one laser configured to emit excitation light;

a substrate made of material with a high thermal conductivity and provided with a notch, where the at least one laser is received in at least one sidewall of the notch;

a reflective layer covering a wall of the notch and configured to reflect the excitation light;

a wavelength conversion layer provided on a part of the reflective layer and configured to perform wavelength conversion on the excitation light to obtain excited light; and

a light guiding element covering an opening of the notch and configured to guide the excitation light and the excited light, to obtain light to be emitted by the light source system.

In some variations of the present disclosure, a lighting device includes the above light source system.

In the light source system and the lighting device including the light source system provided by the teachings of the present disclosure, the substrate in the light source system is made of material with a high thermal conductivity, the laser is received in the substrate, and heat of the wavelength conversion layer is transferred to the substrate through the reflective layer, thereby enhancing the heat dissipation of the laser and the wavelength conversion layer in the light source system. In addition, since the laser and the wavelength conversion layer are located in the same notch, the light source system and the lighting device each have a small volume and each have a simple and compact structure.

DRAWINGS

In order that the disclosure may be well understood, there will now be described various forms thereof, given by way of example, reference being made to the accompanying drawings, in which:

FIG. **1** is a three-dimensional schematic diagram of a light source system provided by a first form of the present disclosure.

FIG. **2** is a cross-sectional view of a light source system shown in FIG. **1** taken along a line II-II.

FIG. **3** is a top view of a light source system shown in FIG. **2**.

FIG. **4** is a cross-sectional view of a light source system provided by a second form of the present disclosure.

FIG. **5** is a top view of the light source system shown in FIG. **4**.

FIG. **6** is a schematic diagram of spots on a wavelength conversion layer shown in FIG. **4**.

FIG. **7** is a cross-sectional view of a light source system provided by a third form of the present disclosure.

SYMBOL DESCRIPTION OF MAIN COMPONENTS

Light source system	100, 200, 300
Substrate	110, 210
Notch	111, 211
Sidewall	111a, 211a
Bottom wall	111b, 211b
Light guiding element	120, 320
Laser	130, 230, 330
Beam deflecting device	140
Wavelength conversion layer	150, 250, 350
Reflective layer	160, 360

The following specific forms will further illustrate the present disclosure with reference to the above drawings.

The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

DETAILED DESCRIPTION

The present disclosure provides a light source system and a lighting device which can solve the heat dissipation problems of an internal laser and a wavelength conversion layer.

Referring to FIG. **1** to FIG. **3**, FIG. **1** is a three-dimensional schematic diagram of a light source system **100** provided by a first form of the present disclosure, FIG. **2** is a cross-sectional view of the light source system **100** shown in FIG. **1** taken along a line II-II, and FIG. **3** is a top view of the light source system **100** shown in FIG. **2**. The light source system **100** provided by the teachings of the present disclosure includes a substrate **110**, a light guiding element **120**, at least one laser **130**, a beam deflecting device **140**, a wavelength conversion layer **150**, and a reflective layer **160**.

The light source system **100** in this form includes the at least one laser **130** configured to emit excitation light. The substrate **110** is made of material with a high thermal conductivity, and the material with a high thermal conductivity can be aluminum nitride, silicon nitride, silicon carbide, boron nitride, and/or a metal such as copper or aluminum, combinations thereof, among others. The substrate **110** is provided with a notch **111**, and the laser **130** is received in a sidewall of the notch **111**, thereby solving a heat dissipation problem of the laser **130**. In addition, the laser **130** and the wavelength conversion layer **150** are located in a same notch **111**, and the light source system **100** and a lighting device to which the light source system **100** is applied have a small volume and a simple and compact structure.

The beam deflecting device **140** and the at least one laser **130** are provided in one-to-one correspondence, and the beam deflecting device **140** is configured to guide the excitation light emitted by the at least one laser **130** corresponding to the beam deflecting device **140** to be irradiated to the wavelength conversion layer **150**. The beam deflecting device **140** can be a prism, an aspheric lens, a free arc-shaped surface, a reflective mirror, and so on.

The reflective layer **160** can be a diffuse reflective layer or a metal reflective layer, covers a wall of the notch **111** and is configured to reflect light, to improve a light emission efficiency of the light source system **100**.

The wavelength conversion layer **150** is provided on a part of the reflective layer **160** and is configured to perform wavelength conversion on the excitation light to obtain excited light. The wavelength conversion layer **150** transfers heat to the substrate **110** via the reflective layer **160** and dissipates the heat through the substrate **110**, thereby solving the heat dissipation problem of the wavelength conversion layer **150**.

The light guiding element **120** covers an opening of the notch **111** and is configured to reflect the excitation light and transmit the excited light, and the excited light is emitted from the light guiding element **120** to obtain light to be emitted by the light source system **100**.

The substrate **110** of the light source system **100** is made of material with a high thermal conductivity, and the at least one laser **130** is received in the wall of the substrate **110**. The heat generated by the wavelength conversion layer **150** is transferred to the substrate **110** via the reflective layer **160**, thereby solving the heat dissipation problems of the at least one laser **130** and the wavelength conversion layer **150** of the light source system.

In addition, the light source system **100** adopts the at least one laser **130**, and the at least one laser **130** and the wavelength conversion layer **150** are received in the notch **111** of the same substrate **110**, so that the light source system **100** not only has high light emission brightness, but also has a small volume. The light source system **100** can also be applied to a lighting equipment, and the lighting device provided by the teachings of the present disclosure can be applied in the fields of automobile lamp devices, stage lights, and laser headlights.

In the first form, the light source system **100** includes four identical lasers **130**. In some variations, the at least one laser **130** is a blue laser configured to emit blue excitation light. It should be understood that the at least one laser **130** is not limited to a blue laser, and the at least one laser **130** can include an ultraviolet laser, a red laser, a green laser, or the like. It should also be understood that the light source system **100** can include one or two blue lasers or a blue laser array, and the specific number of the lasers **130** of the light source system **100** can be selected according to actual needs.

The notch **111** has a shape of a frustum, and the wall of the notch **111** includes four sidewalls **111***a* and one bottom wall **111***b*. The at least one laser **130** is exposed at a surface of the substrate **110**, and any two lasers **130** are received in different sidewalls **111***a* of the notch **111**. Each beam deflecting device **140** is disposed between the at least one laser **130** corresponding to the beam deflecting device **140** and the light guiding element **120**.

It should be understood that, in some variations of the present disclosure, the light source system **100** includes less than four lasers **130**, for example, three lasers **130**. Each of any three sidewalls **111***a* of the notch **111** can be provided with a laser **130**. Alternatively, two of the three lasers **130** are disposed on one sidewall **111***a* and the remaining one laser **130** is disposed on another sidewall **111***a*. Alternatively, the three lasers **130** are all disposed on any one sidewall **111***a* if heat dissipation conditions allow. Due to a reflective effect of the reflective layer **160** and filtering characteristics of the light guiding element **120**, the excitation light can excite the wavelength conversion layer **150** to generate the excited light, and the excited light is emitted from the light source system **100** to obtain the light.

In some variations of the present disclosure, the wavelength conversion layer **150** is provided with yellow phosphors and configured to generate yellow excited light. The yellow excited light is emitted from the light guiding element **120** to obtain yellow light.

The wavelength conversion layer **150** is provided on the reflective layer **160** at the bottom wall **111***b*. The yellow excited light emitted by the wavelength conversion layer **150** and unconverted blue excitation light are directly incident onto the light guiding element **120**. Under the reflection of the light guiding element **120** and the reflective layer **160**, the unconverted part of the excitation light can excite the wavelength conversion layer **150** multiple times until it is converted into excited light and emitted through the light guiding element **120**. It should be understood that the wavelength conversion layer **150** can be disposed on the reflective layer **160** at any position of the sidewall **111***a*, or any positions provided on multiple walls or a partial region of any wall of the notch **111**. In addition, the wavelength conversion layer **150** can be configured to generate excited light of other colors under the excitation of the excitation light, such as red and green excited light. That is, in some variations the wavelength conversion layer **150** is provided with a red fluorescent material and a green fluorescent material in sections, so that optical power of the generated red excited light and that of the green excited light can reach a preset ratio. It should be understood that, in other forms, the wavelength conversion layer **150** can also be provided with yellow and green fluorescent materials, or yellow and red fluorescent materials, or yellow, red, and green fluorescent materials, and it is not limited to this.

In addition, in some variations the wavelength conversion layer **150** has a rough surface, to improve the light emission efficiency of the wavelength conversion layer **150** and reduce reflection loss when the excitation light glides at a large angle.

In some variations, the reflective layer **160** is disposed on the wall, that is, the reflective layer **160** covers four sidewalls **111***a* and one bottom wall **111***b*, so as to reflect the light therein from various directions in the light source system **100**, thereby increasing the number of the light reflection and improving a conversion efficiency of the excitation light. In addition, the light in the notch **111** can only be emitted from the light guiding element **120**, which enhances the light emission efficiency of the light source system **100**.

In this form, the light guiding element **120** is configured to reflect the excitation light and transmit the excited light, and the light guiding element **120** can be a beam-splitting filter plated with a blue-reflective and yellow-transmissive film. It should be understood that in some variations, the light guiding element **120** is a prism provided with an optical film, and the prism facilitates multiple reflections of the excitation light in the light source system **100**. In other variations, the light guiding element **120** can be coated according to the colors of the excitation light and the excited light.

It should be understood that, in some variations, the notch **111** can have a shape with which its opening and the bottom wall **111***b* have different areas. For example, in at least one variation an area of the bottom wall **111***b* is smaller than the area of the opening, such as a circular frustum shape, a circular cone shape, a pyramid shape, or other irregular shapes such as a shape having a U-shaped or V-shaped cross-section, in order to enhance the unconverted part of the excitation light emitted from the wavelength conversion layer **150** to be reflected back to the wavelength conversion layer **150** and converted into excited light. That is, the unconverted part of the excitation light emitted from the wavelength conversion layer **150** and incident on the light guiding element **120** is reflected back to the reflective layer **160**, reflected by the reflective layer **160** to the wavelength conversion layer **150** and converted into excited light and emitted from the light guiding element **120**. It should be understood that the laser **130** can be disposed on any sidewall of the notch **111**. In some variations, the wavelength conversion layer **150** is disposed on the bottom wall of a U-shaped notch, or the wavelength conversion layer **150** is disposed on one sidewall of a V-shaped notch, and the wavelength conversion layer **150** and the laser **130** can be located on a same sidewall or opposite sidewalls.

Referring to FIG. **4** to FIG. **6**, FIG. **4** is a cross-sectional view of a light source system **200** provided by a second form of the present disclosure, FIG. **5** is a top view of the light source system **200** shown in FIG. **4**, and FIG. **6** is a schematic diagram of spots on a wavelength conversion layer **250** shown in FIG. **4**.

The cross-sectional view of the light source system **200** provided in the form as shown in FIG. **4** is obtained in the same manner as the light source system **100**.

A difference between the light source system **200** and the light source system **100** mainly lies in that the at least one laser **230** in the light source system **200** is received in the sidewall **211***a* of the notch **211** of the substrate **210** at a preset angle. In such a manner, the excitation light emitted by the at least one laser **230** propagates along a straight line to and irradiated by the wavelength conversion layer **250**, and the beam deflecting device is omitted. It should be noted that, within the scope of the spirit or basic features of the present disclosure, various specific solutions applicable to the first form can also be correspondingly applied to the second form and will not be repeated herein to save space and avoid duplication.

Specifically, as shown in FIG. **4** and FIG. **5**, the at least one laser **230** is at a certain angle with respect to the bottom wall **211***b* in a perpendicular direction, in such a manner that the excitation light emitted by the at least one laser **230** propagates along a straight line to and irradiated by the wavelength conversion layer **250**, thereby omitting the beam deflecting device; as shown in FIG. **5**, the at least one laser **230** is at a certain angle with respect to the sidewall **211***a* in a horizontal direction, in such a manner that spots formed on the wavelength conversion layer **250** by any two lasers **230** partially overlap and partially do not overlap, and then spots emitted by the lasers **230** can be more uniformly irradiated on the wavelength conversion layer **250**, which can avoid a problem that a conversion efficiency of the wavelength conversion layer **250** is reduced due to excessive local heat of the wavelength conversion layer **250**. The laser spots irradiated on the wavelength conversion layer **250** are as shown in FIG. **6**.

The light source system **200** provided in the second form can solve the heat dissipation problems of the at least one laser **230** and the wavelength conversion layer **250**, and the light source system **200** and a lighting device to which the light source system **200** is applied have a small volume and a simple and compact structure. In addition, the number of optical devices used in the light source system **200** is reduced, an internal space of the light source system **200** is saved, and the cost is lower.

Referring to FIG. **7**, which is a cross-sectional view of a light source system **300** provided by a third form of the present disclosure as shown in FIG. **1**.

The cross-sectional view of the light source system **300** provided in the form as shown in FIG. **7** is obtained in the same manner as the light source system **100**.

A difference between the light source system **300** and the light source system **100** mainly lies in that the at least one laser **330** of the light source system **300** emits excitation light in a first polarization state and the wavelength conversion layer **350** changes a polarization state of the excitation light. Also, the light guiding element **320** is a polarizing prism plated with an optical film and the polarizing prism is configured to reflect light of the first polarization state and transmit light of another polarization state. That is, the polarization state of the excitation light of the first polarization state is changed by the wavelength conversion layer **350**, and the excitation light of the first polarization state is finally emitted from the light guiding element **320** in forms of other polarization states. Also, excited light of other polarization states is also emitted from the light guiding element **320**, and blue excitation light and yellow excited light that are emitted from the light guiding element **320** are combined to obtain white light. It should be noted that, within the scope of the spirit or basic features of the present disclosure, various specific solutions applicable to the first form can also be correspondingly applied to the third form and will not be repeated herein in order to save space and avoid duplication.

The light source system **300** provided in the third form can solve the heat dissipation problems of the laser **330** and the wavelength conversion layer **350** of the light source system **300**, and the light source system **300** and a lighting device to which the light source system **300** is applied have a small volume and a simple and compact structure.

The above are only the forms or variations of the present disclosure and do not limit the patent scope of the present disclosure. Any equivalent structure or equivalent process transformation made by using the description and drawings of the present disclosure, or those directly or indirectly used in other related technical fields are similarly included in the patent protection scope of the present disclosure.

What is claimed is:

1. A light source system, comprising:

at least one laser configured to emit excitation light;

a substrate made of material with a high thermal conductivity, wherein the substrate is provided with a notch, and the at least one laser is received in a sidewall of the notch;

a reflective layer covering a wall of the notch and configured to reflect the excitation light;

a wavelength conversion layer provided on a part of the reflective layer and configured to perform wavelength conversion on the excitation light to obtain excited light; and

a light guiding element covering an opening of the notch and configured to guide the excitation light and the excited light, to obtain light to be emitted by the light source system.

2. The light source system according to claim **1**, wherein the light guiding element comprises a beam-splitting filter.

3. The light source system according to claim **1**, wherein the wall comprises a bottom wall and the sidewall, and the bottom wall has an area different from the opening.

4. The light source system according to claim **3**, wherein the reflective layer covers both the bottom wall and the sidewall of the notch, and the wavelength conversion layer is disposed on a part of the reflective layer covering the bottom wall.

5. The light source system according to claim **1**, further comprising:

at least one beam deflecting device in one-to-one correspondence with the at least one laser, wherein each of the at least one beam deflecting device is configured to guide excitation light emitted by corresponding one of the at least one laser to irradiate the wavelength conversion layer.

6. The light source system according to claim **5**, wherein the notch has a shape of a frustum, the at least one laser is exposed out of a surface of the substrate, any two lasers of the at least one laser are received in different sidewalls of the notch, and each of the at least one beam deflecting device is disposed between the corresponding one of the at least one laser and the light guiding element.

7. The light source system according to claim **4**, wherein the at least one laser comprises a plurality of lasers, and each of the plurality of lasers is received in the sidewall of the notch at a preset angle, in such a manner that excitation light emitted by the laser propagates in a straight line to irradiate the wavelength conversion layer.

8. The light source system according to claim **6**, wherein spots formed on the wavelength conversion layer by any two of the at least one laser partially overlap.

9. The light source system according to claim **1**, wherein the light guiding element is a prism.

10. The light source system according to claim **9**, wherein the at least one laser emits excitation light in a first polarization state, the wavelength conversion layer is configured to change the polarization state of the excitation light, and the prism is configured to reflect light of the first polarization state and transmit light of another polarization state.

11. A lighting device, comprising:

a light source system, wherein the light source system comprises:

at least one laser configured to emit excitation light;

a substrate made of material with a high thermal conductivity, wherein the substrate is provided with a notch, and the at least one laser is received in a sidewall of the notch;

a reflective layer covering a wall of the notch and configured to reflect the excitation light;

a wavelength conversion layer provided on a part of the reflective layer and configured to perform wavelength conversion on the excitation light to obtain excited light; and

a light guiding element covering an opening of the notch and configured to guide the excitation light and the excited light, to obtain light to be emitted by the light source system.

12. The lighting device according to claim **11**, wherein the light guiding element comprises a beam-splitting filter.

13. The lighting device according to claim **11**, wherein the wall comprises a bottom wall and the sidewall, and the bottom wall has an area different from the opening.

14. The lighting device according to claim **13**, wherein the reflective layer covers both the bottom wall and the sidewall of the notch, and the wavelength conversion layer is disposed on a part of the reflective layer covering the bottom wall.

15. The lighting device according to claim **11**, further comprising:

at least one beam deflecting device in one-to-one correspondence with the at least one laser, wherein each of the at least one beam deflecting device is configured to guide excitation light emitted by corresponding one of the at least one laser to irradiate the wavelength conversion layer.

16. The lighting device according to claim **15**, wherein the notch has a shape of a frustum, the at least one laser is exposed out of a surface of the substrate, any two lasers of the at least one laser are received in different sidewalls of the notch, and each of the at least one beam deflecting device is disposed between the corresponding one of the at least one laser and the light guiding element.

17. The lighting device according to claim **14**, wherein the at least one laser comprises a plurality of lasers, and each of the plurality of lasers is received in the sidewall of the notch at a preset angle, in such a manner that excitation light emitted by the laser propagates in a straight line to irradiate the wavelength conversion layer.

18. The lighting device according to claim **16**, wherein spots formed on the wavelength conversion layer by any two of the at least one laser partially overlap.

19. The lighting device according to claim **11**, wherein the light guiding element is a prism.

20. The lighting device according to claim **19**, wherein the at least one laser emits excitation light in a first polarization state, the wavelength conversion layer is configured to change the polarization state of the excitation light, and the prism is configured to reflect light of the first polarization state and transmit light of another polarization state.

21. A light source system, comprising:

at least one laser configured to emit excitation light;

a substrate made of material with a high thermal conductivity, wherein the substrate is provided with a notch, and the at least one laser is received in a sidewall of the notch;

a reflective layer covering a wall of the notch and configured to reflect the excitation light;

a wavelength conversion layer provided on a part of the reflective layer and configured to perform wavelength conversion on the excitation light to obtain excited light; and

a light guiding element covering an opening of the notch and configured to guide the excitation light and the excited light, to obtain light to be emitted by the light source system,

wherein the at least one laser emits excitation light in a first polarization state, the wavelength conversion layer is configured to change the polarization state of the excitation light, and the light guiding element is configured to reflect light of the first polarization state and transmit light of another polarization state.

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