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(54) **SURFACE-EMITTING LASER**

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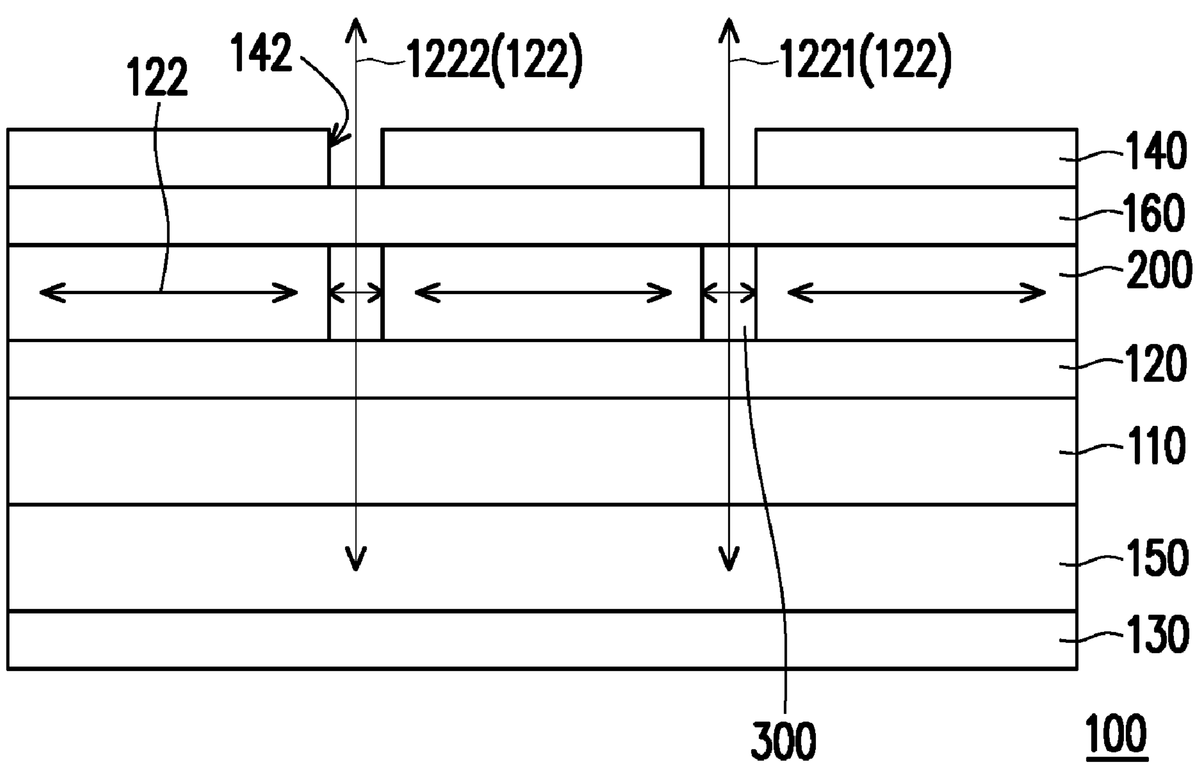
(57) **ABSTRACT**

A surface-emitting laser including a cladding layer, an active region, a first grating, a plurality of second gratings, a first electrode, and a second electrode is provided. The active region is disposed on the cladding layer. The first grating is disposed on the active region. The second gratings are disposed on the active region and separately distributed among the first grating. A diffraction order of the first grating is different from a diffraction order of the second gratings. The first electrode is electrically connected to the cladding layer. The second electrode covers at least the first grating.



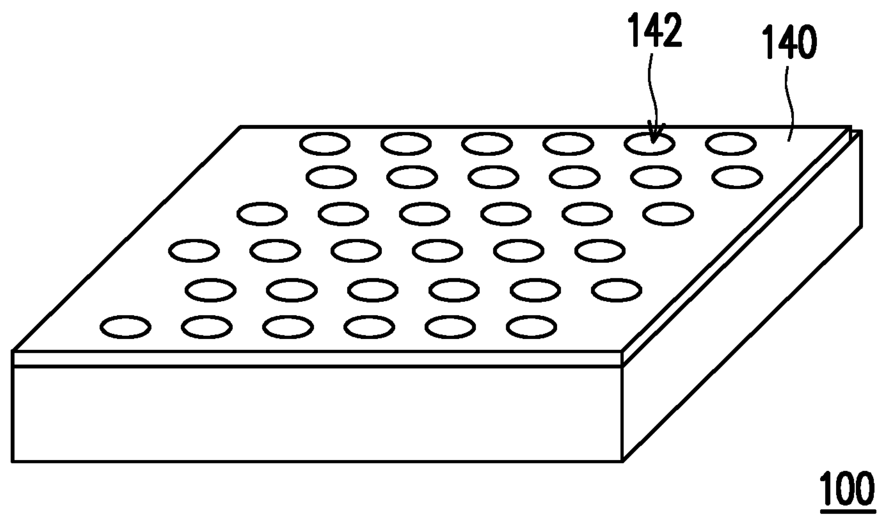

142
140
100

FIG. 1A

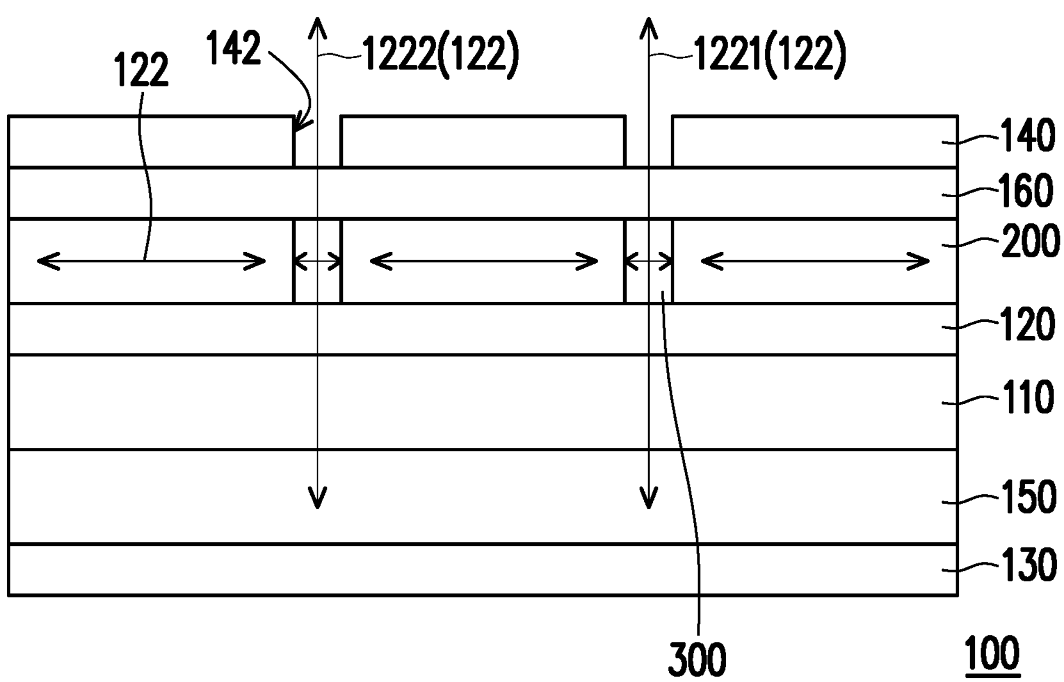

122
142
1222(122)
1221(122)
140
160
200
120
110
150
130
300
100

FIG. 1B

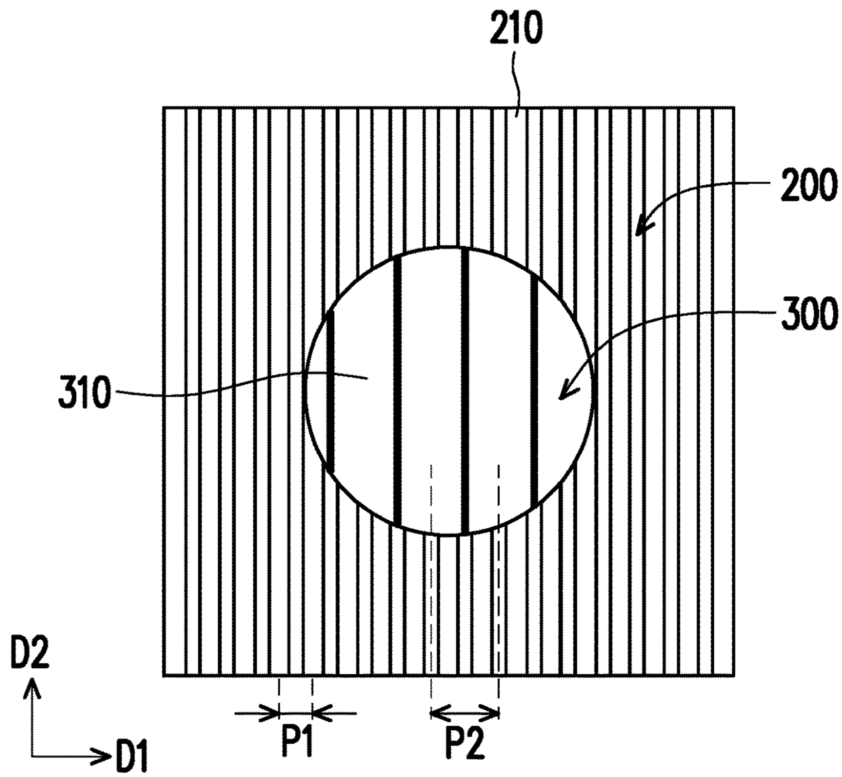

210
200
300
310
D2
D1
P1
P2

FIG. 2A

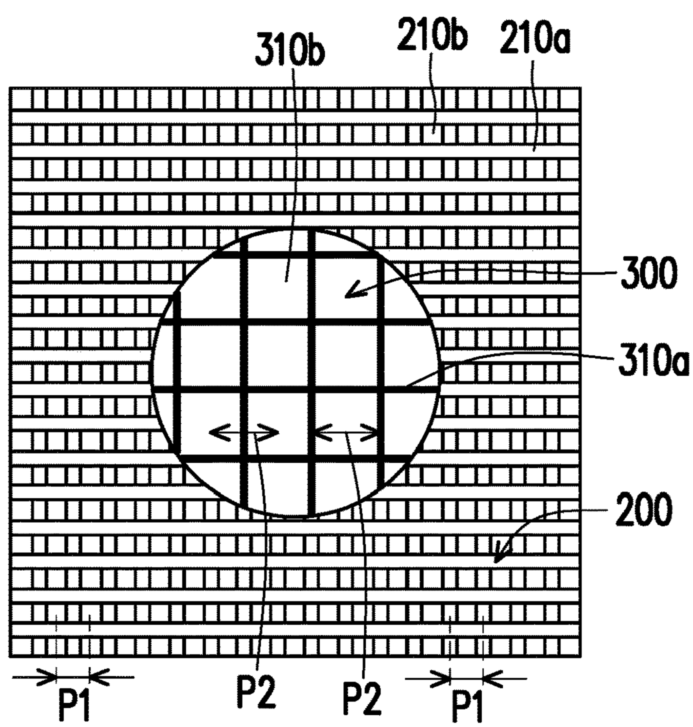

310b
210b
210a
300
310a
200
P1
P2
P2
P1

FIG. 2B

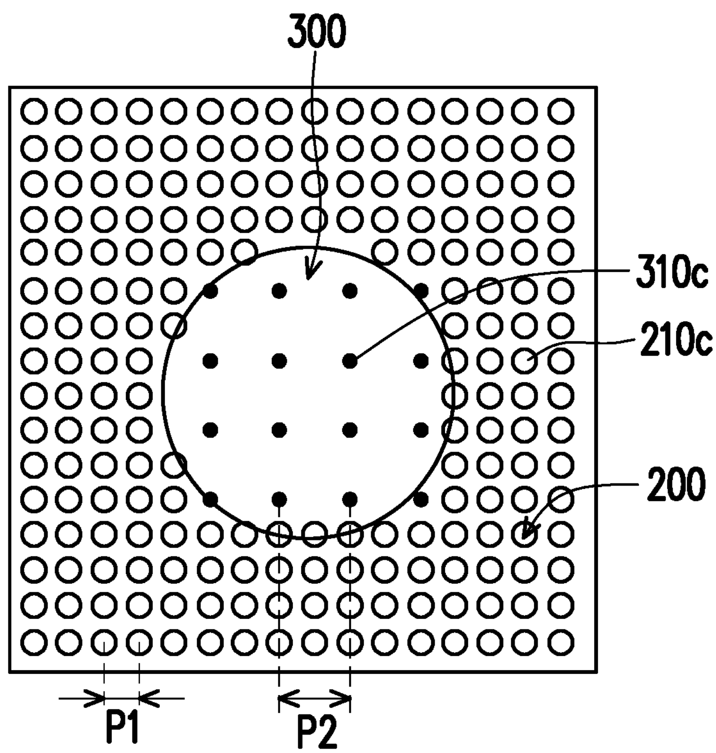


FIG. 2C

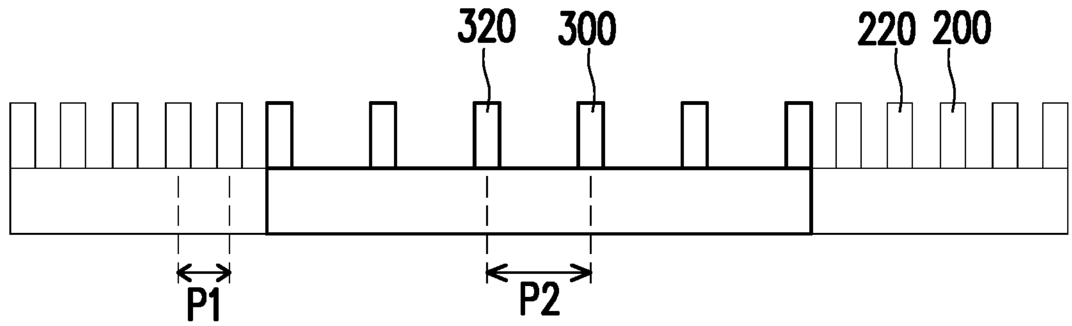


FIG. 3A

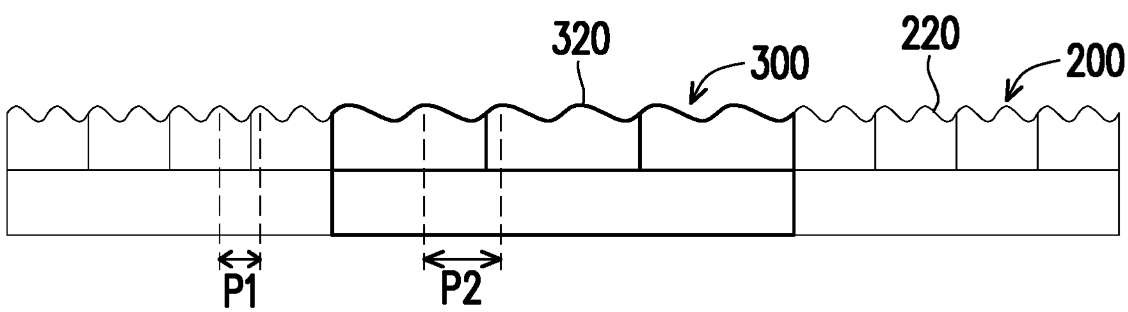


FIG. 3B

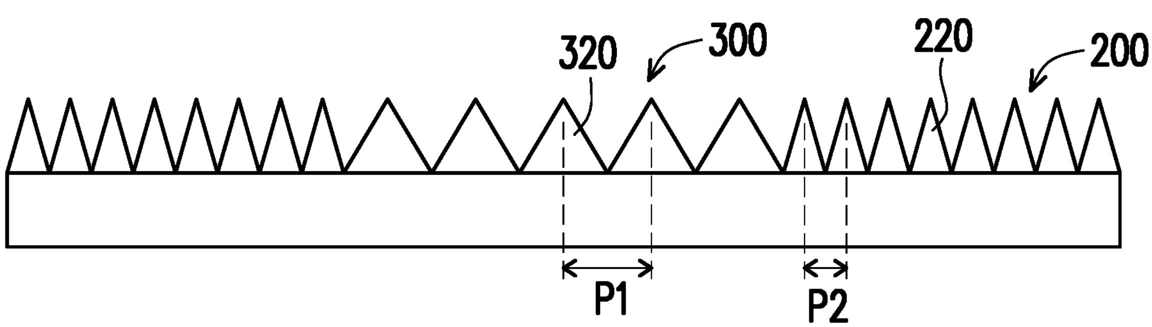


FIG. 3C

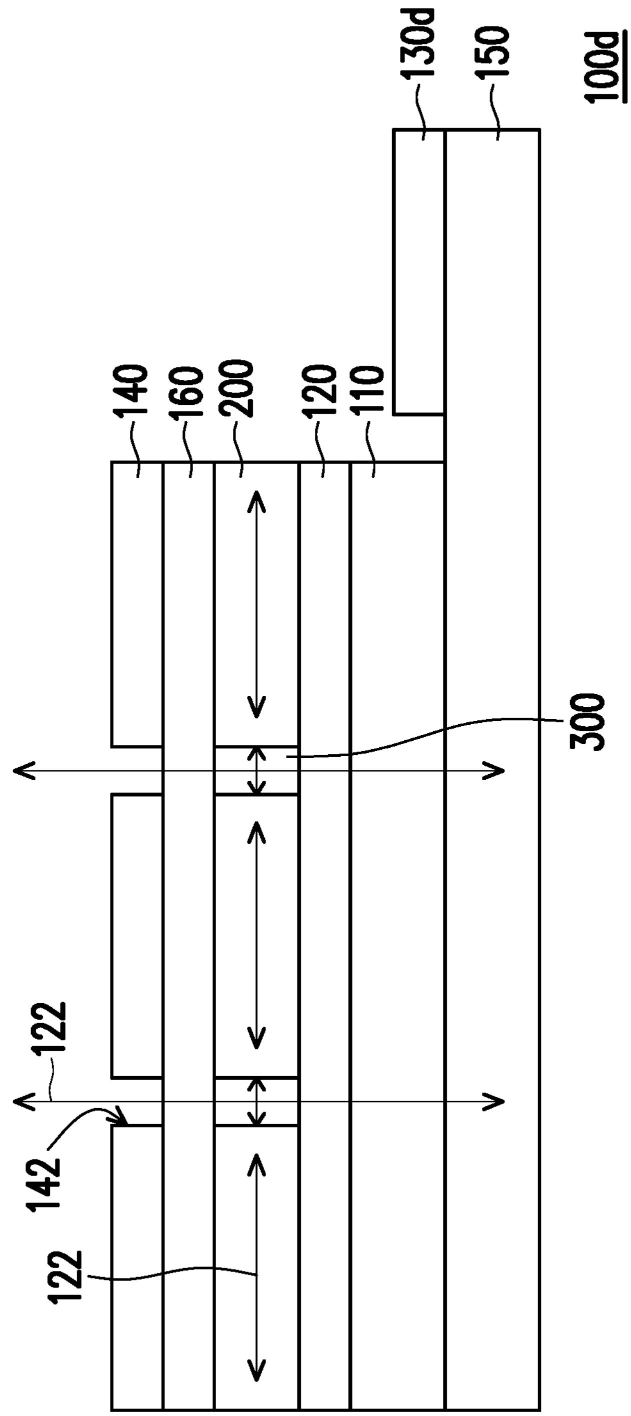


FIG. 4

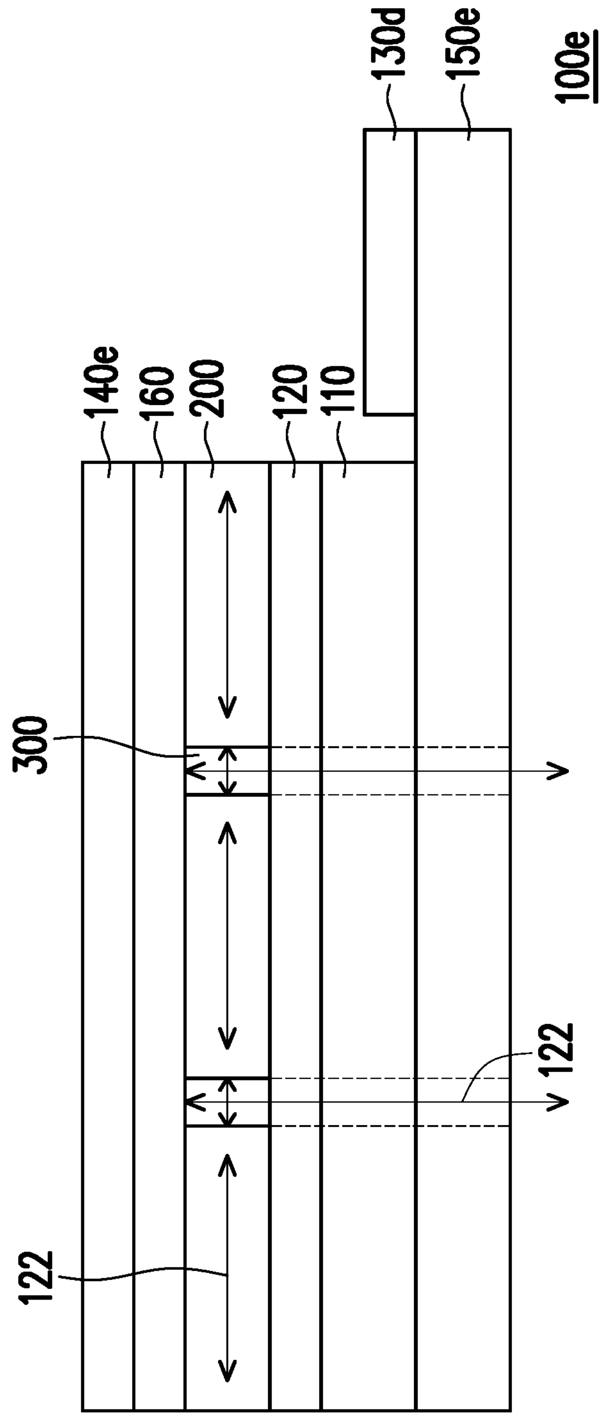


FIG. 5

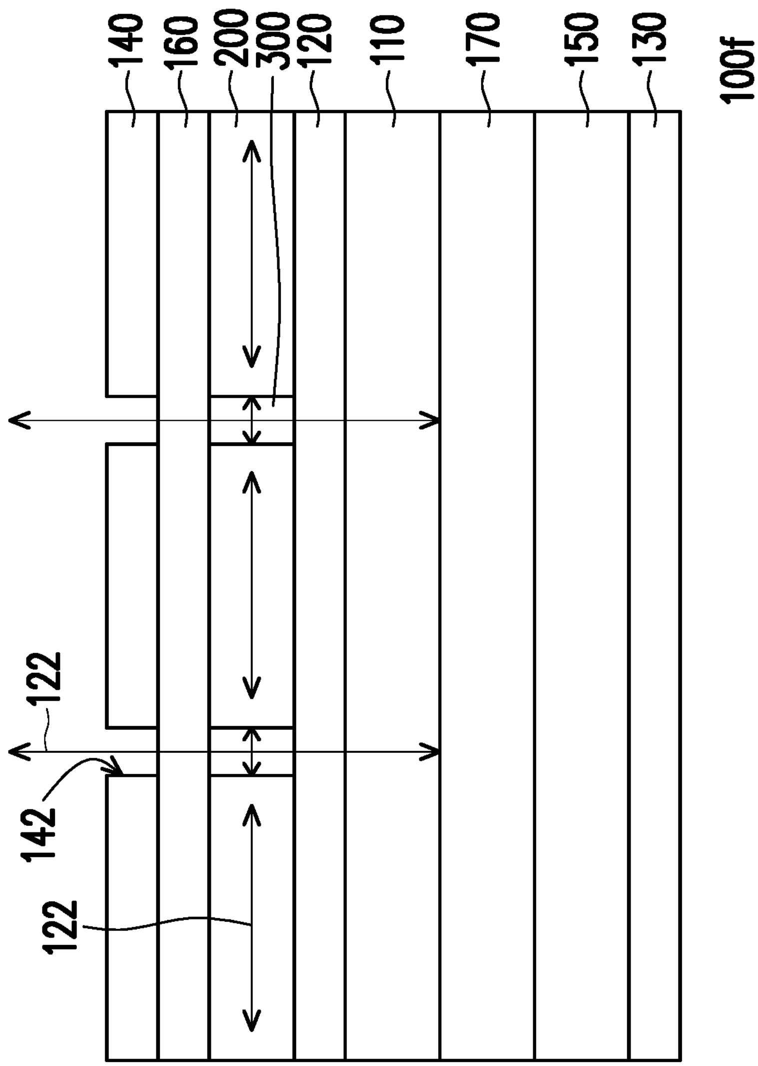


FIG. 6

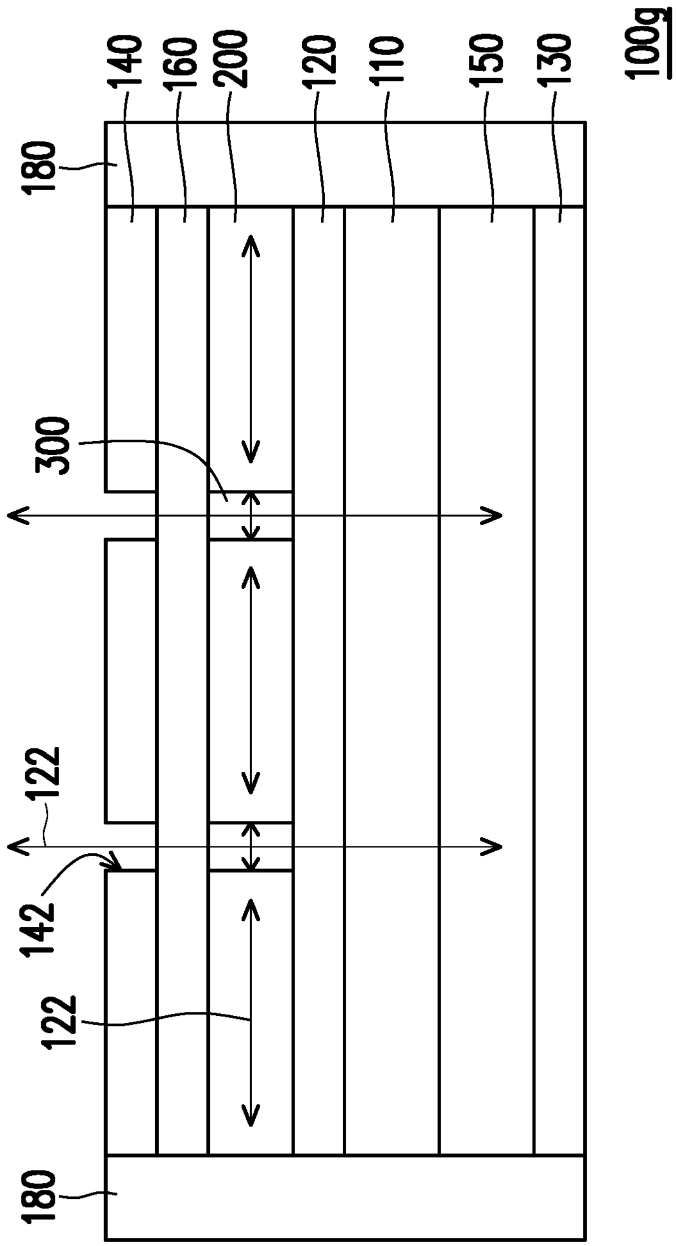


FIG. 7

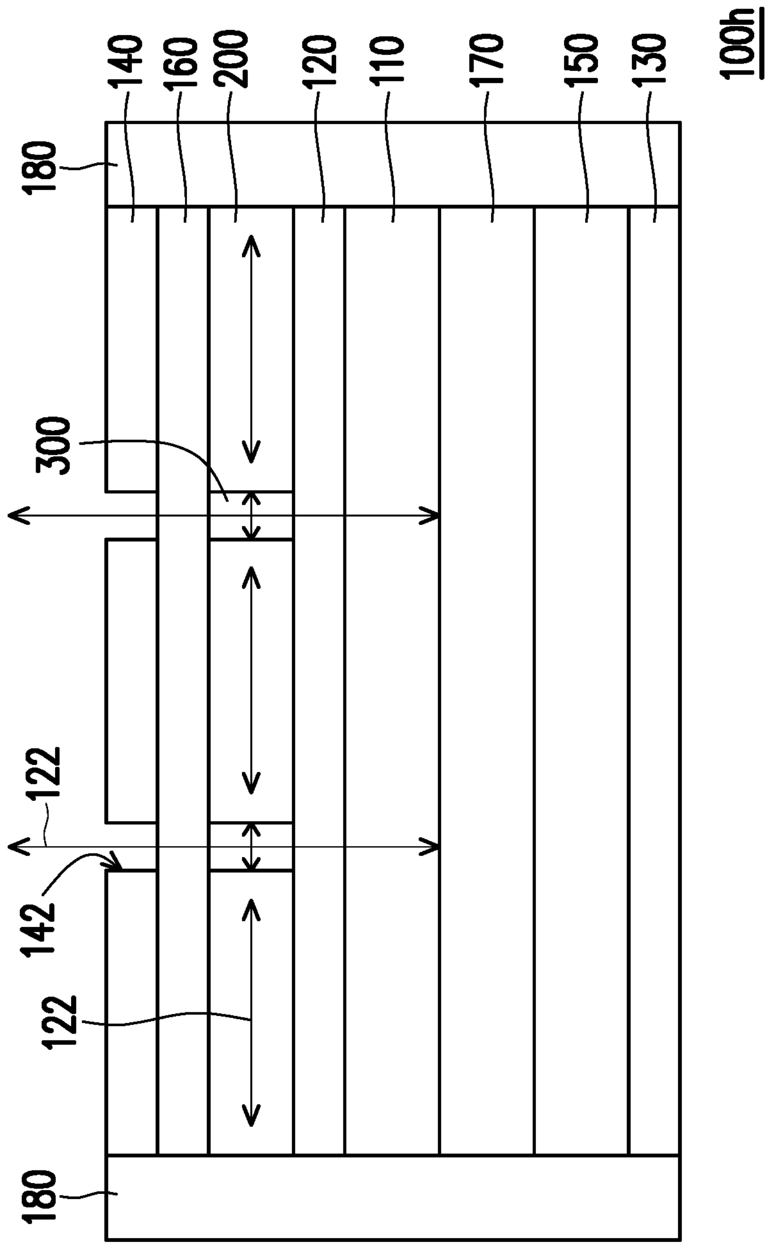


FIG. 8

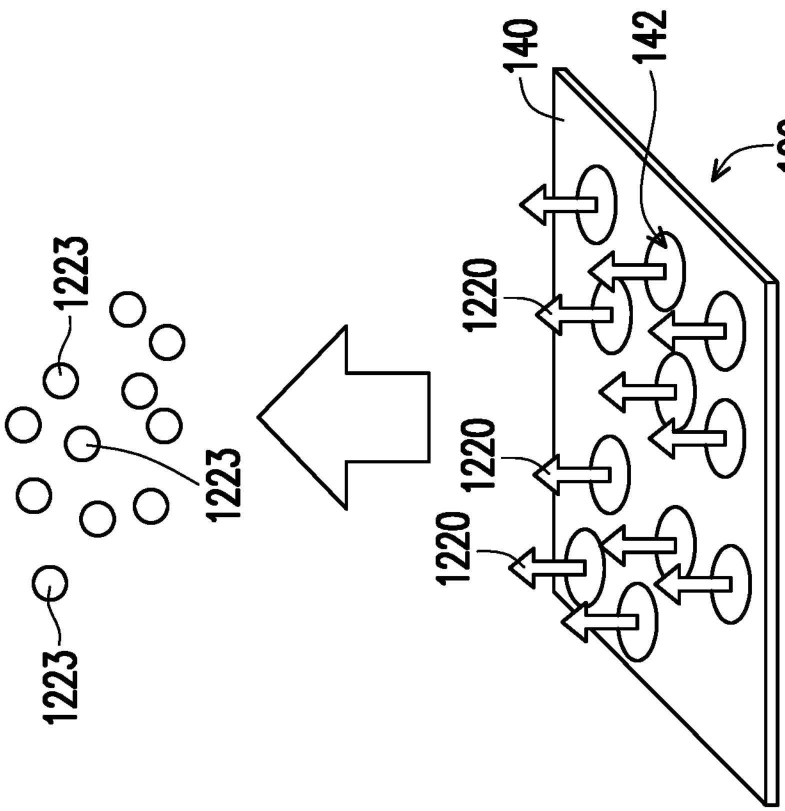


FIG. 9

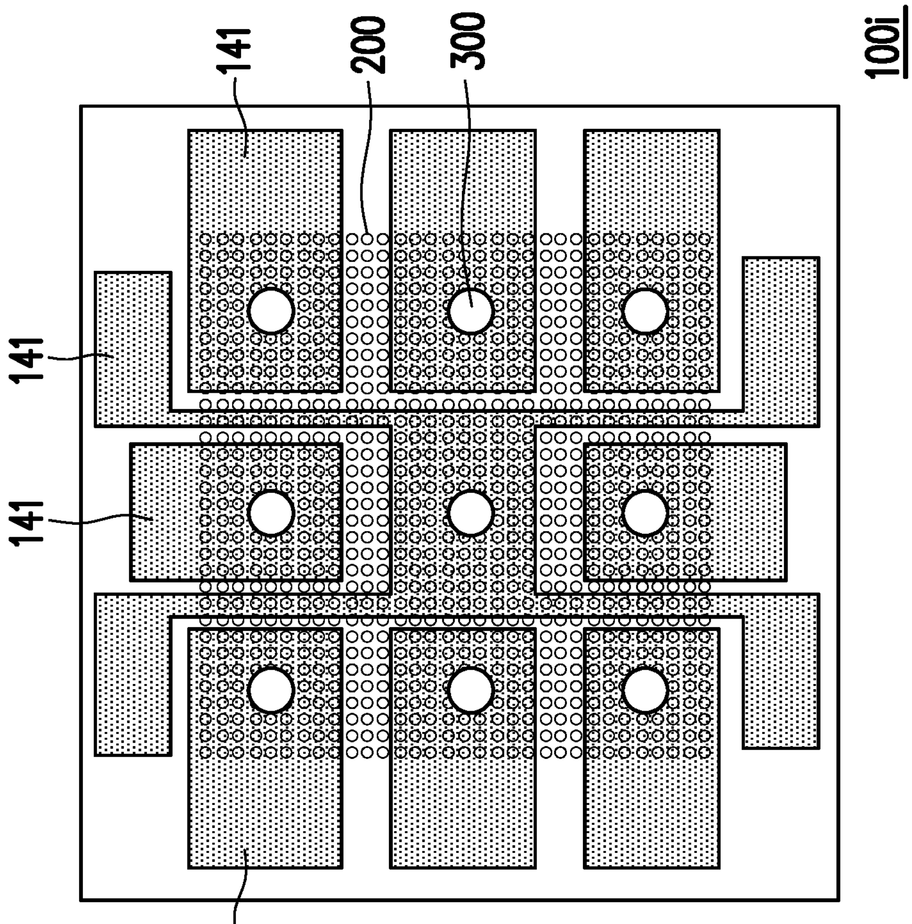


FIG. 10

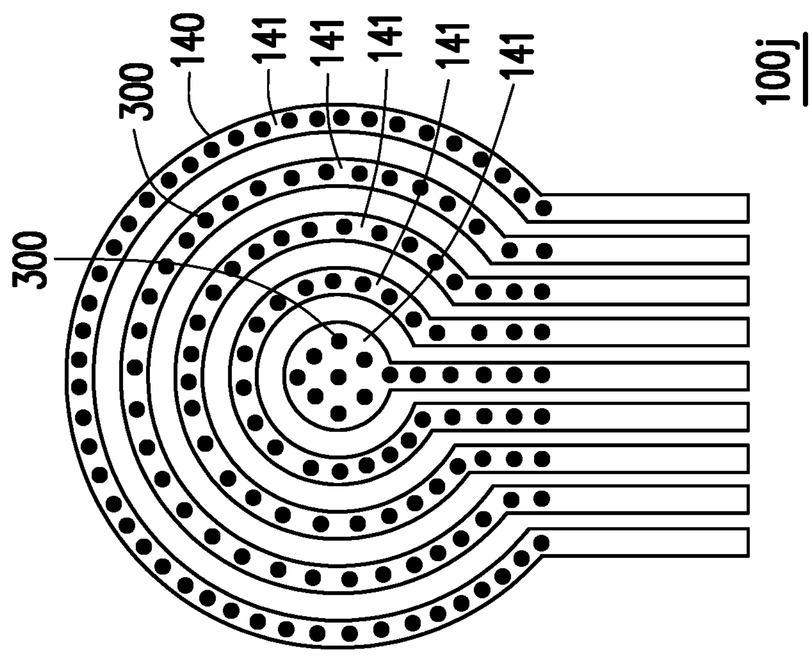


FIG. 11A

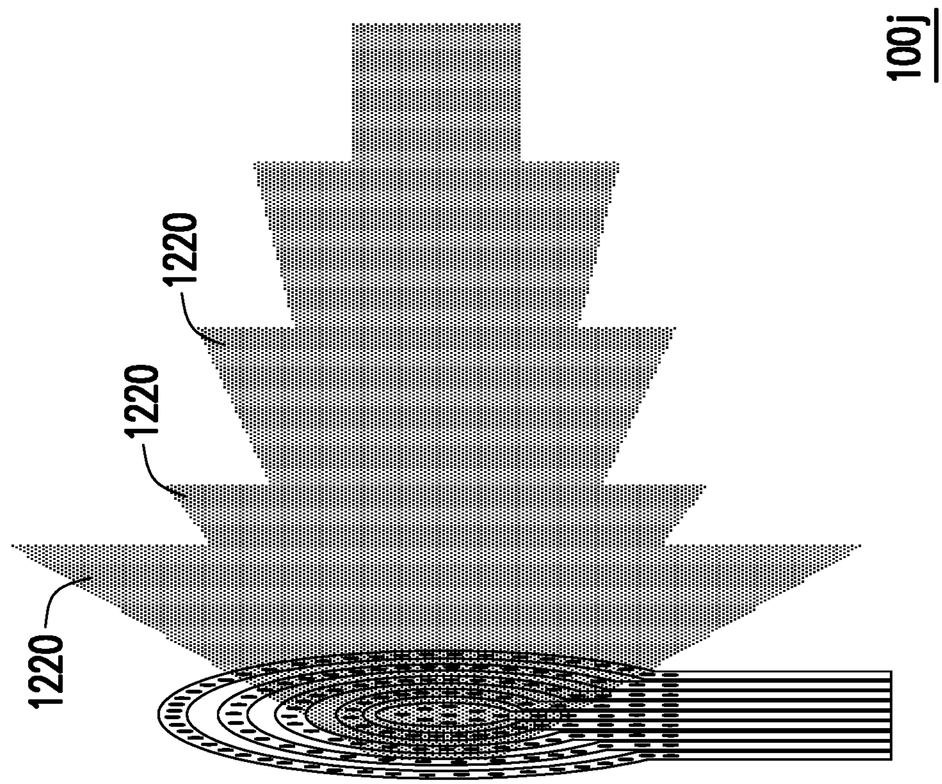


FIG. 11B

SURFACE-EMITTING LASER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of U.S. Provisional Application No. 63/136,206, filed on Jan. 12, 2021, and U.S. Provisional Application No. 63/143,927, filed on Jan. 31, 2021. The entirety of each of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention generally relates to a light-emitting device and, in particular, to a surface-emitting laser.

2. Description of Related Art

[0003] A semiconductor laser can be classified into a surface-emitting laser and an edge-emitting laser. The surface-emitting laser has various types, including a vertical cavity surface-emitting laser (VCSEL), a photonic crystal surface-emitting laser, a distributed feedback surface-emitting laser, etc.

[0004] In a distributed laser, a grating and reflection are generally continuous along a resonance cavity, instead of just being at two opposite ends of the resonance cavity. This changes the modal behavior considerably and makes the laser more stable.

[0005] However, for a distributed feedback surface-emitting laser or a photonic crystal surface-emitting laser, a metal electrode at the light-emitting side of the laser has an opening for light output, so that current is not spread uniformly in an active region below the opening and current crowding effect is thus formed. Therefore, the beam quality and beam control of the laser are adversely affected.

SUMMARY OF THE INVENTION

[0006] Accordingly, the invention is directed to a surface-emitting laser, which has good current spreading, good beam quality, and good beam control.

[0007] An embodiment of the invention provides a surface-emitting laser including a cladding layer, an active region, a first grating, a plurality of second gratings, a first electrode, and a second electrode. The active region is disposed on the cladding layer. The first grating is disposed on the active region. The second gratings are disposed on the active region and separately distributed among the first grating. A diffraction order of the first grating is different from a diffraction order of the second gratings. The first electrode is electrically connected to the cladding layer. The second electrode covers at least the first grating.

[0008] In the surface-emitting laser according to the embodiment of the invention, since the second gratings are separately distributed among the first grating, the first grating is used for laser feedback for more efficient reflection of the light emitted by the active region, and the second gratings are used for output coupling by diffraction. Therefore, the laser characteristics of the surface-emitting laser are better controlled. As a result, the surface-emitting laser has good beam quality and good beam control. Moreover, in the surface-emitting laser according to the embodiment of the invention, the second electrode covers at least the first grating, so that the surface-emitting laser has good and uniform current spreading, and current crowding effect is effectively reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

[0010] FIG. **1**A is a schematic perspective view of a surface-emitting laser according to an embodiment of the invention.

[0011] FIG. **1**B is a schematic cross-sectional view of the surface-emitting laser in FIG. **1**A.

[0012] FIG. **2**A, FIG. **2**B, and FIG. **2**C are schematic local top views of three embodiments of the first grating and the second gratings of the surface-emitting laser in FIG. **1**B.

[0013] FIG. **3**A, FIG. **3**B, and FIG. **3**C are schematic local cross-sectional views of three embodiments of the first grating and the second gratings of the surface-emitting laser in FIG. **1**B.

[0014] FIG. **4** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention.

[0015] FIG. **5** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention.

[0016] FIG. **6** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention.

[0017] FIG. **7** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention.

[0018] FIG. **8** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention.

[0019] FIG. **9** is a schematic view showing light spots of the sub-beams and the openings of the surface-emitting laser in FIG. **1**A and FIG. **1**B respectively in a far-field and a near-field.

[0020] FIG. **10** is a schematic top transparent view of the surface-emitting laser showing the second electrode, the first grating, and the second gratings according to another embodiment of the invention.

[0021] FIG. **11**A is a schematic top transparent view of the surface-emitting laser showing the second electrode and the second gratings according to another embodiment of the invention.

[0022] FIG. **11**B is a perspective view of the surface-emitting laser in FIG. **11**A showing different sub-beams due to different sub-electrodes.

DESCRIPTION OF THE EMBODIMENTS

[0023] Reference will now be made in detail to the present embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0024] FIG. **1**A is a schematic perspective view of a surface-emitting laser according to an embodiment of the invention, and FIG. **1**B is a schematic cross-sectional view of the surface-emitting laser in FIG. **1**A. Referring to FIG. **1**A and FIG. **1**B, the surface-emitting laser **100** in this embodiment includes a cladding layer **110**, an active region **120**, a first grating **200**, a plurality of second gratings **300**, a first electrode **130**, and a second electrode **140**. The active region **120** is disposed on the cladding layer **110**. The first grating **200** is disposed on the active region **120**. The second gratings **300** are disposed on the active region **120** and separately distributed among the first grating **200**. A diffraction order of the first grating **200** is different from a diffraction order of the second gratings **300**. The first electrode **130** is electrically connected to the cladding layer **110**. The second electrode **140** covers at least the first grating **200**.

[0025] In this embodiment, the second electrode **140** covers the first grating **200** and has a plurality of openings **142** above the second gratings **200**. The second electrode **140** is, for example, a metal electrode layer. Moreover, the diffraction order of the first grating **200** is greater than or equal to 1, and the diffraction order of the second gratings **300** is greater than or equal to 2. In this embodiment, the first grating **200** is a first order grating, and the second gratings **300** are second order gratings. When the first electrode **130** and the second electrode **140** are applied with a forward voltage, the active region **120** emits light **122**. The first grating **200** transmits and reflects the light **122** in a horizontal direction parallel to the active region **120** to form distributed feedback, i.e. laser feedback. The second gratings **300** diffracts the light **122** in a vertical direction perpendicular to the active region to form output coupling. The light **122** diffracted by the second gratings **300** passes through the openings **142** to travel out of the surface-emitting laser **100**. In other embodiments, when the second gratings **300** are third order gratings, the second gratings **300** diffract the light **122** along inclined directions. For example, the inclined directions and a normal direction of the active region **120** have an included angle of 60 degrees. When the diffraction order of the second gratings **300** is greater than or equal to 4, the second gratings **300** have other different inclined directions.

[0026] In the surface-emitting laser **100**, the laser feedback and output coupling are separated for better control of laser characteristics. The first grating **200** (i.e. the first order grating) is used for distributed feedback for more efficient reflection, and the second gratings **300** (i.e. the second order grating) is used below the openings **142** (i.e. output windows) for output coupling. Therefore, the surface-emitting laser **100** has good beam quality and good beam control. Moreover, the second electrode **140** (i.e. a metal electrode layer) covers the first grating **200**, so that current can be spread horizontally and uniformly in the second electrode **140**. As a result, the surface-emitting laser **100** has good and uniform current spreading, and current crowding effect is effectively reduced.

[0027] In this embodiment, the surface-emitting laser **100** further includes a substrate **150** disposed between the cladding layer **110** and the first electrode **130**. The first electrode **130** is, for example, a metal electrode layer covering a bottom surface of the substrate **150**. In this embodiment, the surface-emitting laser **100** further includes a contact layer **160** disposed between the first grating **200** and the second electrode **140** and covers the second gratings **300**. The contact layer **160** form good electrical contact for the first grating **200** and the second electrode **140**.

[0028] In this embodiment, the cladding layer **110** is an n-type semiconductor layer, and the first grating **200** and the second gratings **300** form a p-type semiconductor layer. However, in other embodiments, the cladding layer **110** is a p-type semiconductor layer, and the first grating **200** and the second gratings **300** form an n-type semiconductor layer.

[0029] In this embodiment, the second gratings **300** diffract light **122** emitted by the active region **120** into a plurality of sub-beams (e.g. the sub-beams **1221** and **1222** shown in FIG. **1**B) traveling out of the surface-emitting laser **100**, and adjacent sub-beams **1221** and **1222** interfere with each other. For example, the sub-beam **1221** and the sub-beam **1222** may form constructive interference, so as to form a light spot in a far-field having good beam quality. The first grating **200** transmits and strongly couples light **122** between the second gratings **300** so as to ensure the coherence between the sub-beams.

[0030] FIG. **2**A, FIG. **2**B, and FIG. **2**C are schematic local top views of three embodiments of the first grating and the second gratings of the surface-emitting laser in FIG. **1**B. Referring to FIG. **1**B and FIG. **2**A first, in this embodiment, the first grating **200** and the second gratings **300** are one-dimensional gratings. In this embodiment, each of the first grating **200** and the second gratings **300** includes a plurality of straight strips **210**, **310** parallel to each other. Specifically, the first grating **200** includes a plurality of straight strips **210** arranged in a first direction D**1**, and the second grating **300** includes a plurality of straight strips **310** arranged in the first direction D**1**. Each of the straight strips **210** extends along a second direction D**2**, and Each of the straight strips **310** extends along the second direction D**2**. The first direction D**1** may be perpendicular to the second direction D**2**. In this embodiment, a pitch P**2** of the straight strips **310** of the second gratings **300** is greater than a pitch P**1** of the straight strips **210** of the first grating **200**.

[0031] Referring to FIG. **1**B and FIG. **2**B, in this embodiment, the first grating **200** and the second gratings **300** are two-dimensional gratings. Each of the first grating **200** and the second gratings **300** includes two-dimensional line array or two-dimensional pillar array. Specifically, the first grating **200** may include two-dimensional line array **210***a*, and the second gratings **300** may include two-dimensional line array **310***a*. Alternatively, in another embodiment, the first grating **200** may include two-dimensional pillar array **210***b*, and the second gratings **300** may include two-dimensional pillar array **310***b*. In other embodiments, Each of the first grating **200** and the second gratings **300** may include two-dimensional polygon array.

[0032] Referring to FIG. **1**B and FIG. **2**C, in this embodiment, each of the first grating **200** and the second gratings **300** includes two-dimensional hole array. Specifically, the first grating **200** includes two-dimensional hole array **210***c*, and the second grating **300** includes two-dimensional hole array **310***c*.

[0033] In FIG. **2**A, FIG. **2**B, and FIG. **2**C, a pitch P**2** of the two-dimensional hole, line, or pillar array **310***c*, **210***a*, **210***b* of the second gratings **300** is greater than a pitch P**1** of the two-dimensional hole, line, or pillar array **210***c*, **210***a*, **210***b* of the first grating **200**.

[0034] FIG. **3**A, FIG. **3**B, and FIG. **3**C are schematic local cross-sectional views of three embodiments of the first grating and the second gratings of the surface-emitting laser in FIG. **1**B. Referring to FIG. **1**B, FIG. **3**A, FIG. **3**B, and FIG. **3**C, each of the first grating **200** and the second gratings

300 includes a plurality of periodical units periodically arranged. Specifically, the first grating **200** includes a plurality of periodical units **220** periodically arranged, and the second grating **300** includes a plurality of periodical units **320** periodically arranged. A profile of each of the periodical units **220** and **320** in a cross-section perpendicular to the active region **120** is a step shape (as shown in FIG. **3**A), a wave shape (as shown in FIG. **3**B), or a triangular shape (as shown in FIG. **3**C). In these embodiments, a pitch P**2** of the periodical units **320** of the second gratings **300** is greater than a pitch P**1** of the periodical units **220** of the first grating **200**.

[0035] In this embodiment, the material of the substrate includes gallium nitride (GaN), gallium arsenide (GaAs), indium phosphide (InP), gallium antimonide (GaSb), indium arsenide (InAs), sapphire, any other suitable material, or a combination thereof. The material of the cladding layer **110** may include GaN, aluminum gallium arsenide (AlGaAs), aluminum gallium arsenic antimonide (AlGaAsSb), any other suitable material, or a combination thereof. The active region **120** may have quantum structure, for example, quantum wells, quantum dots, etc. The material of the active region **120** may include indium arsenide (InAs) and gallium arsenide (GaAs); indium gallium arsenide (InGaAs) and gallium aluminum arsenide (GaAlAs); indium gallium arsenic antimonide (InGaAsSb) and aluminum gallium arsenic antimonide (AlGaAsSb); indium gallium nitride (InGaN) and gallium nitride (GaN); indium gallium nitride (InGaN) and gallium aluminum nitride (GaAlN); indium arsenide (InAs) and indium phosphide (InP); indium arsenic antimonide (InAsSb) and indium phosphide (InP); other suitable materials or a combination thereof. The material of the first grating **200** and the second gratings **300** may include GaAs, InP, GaSb, AlGaAs, AlGaAsSb, any other suitable material, or a combination thereof. The material of the contact layer **160** may include GaAs, InP, GaN, GaSb, gallium phosphide (GaP), InAs, AlGaAs, AlGaAsSb, transparent conductive material, any other suitable material, or a combination thereof, wherein the transparent conductive material may include indium tin oxide (ITO), indium zinc oxide (IZO), aluminum doped zinc oxide (AZO), any other suitable material, or a combination thereof.

[0036] FIG. **4** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention. Referring to FIG. **4**, the surface-emitting laser **100*d*** in this embodiment is similar to the surface-emitting laser **100** in FIG. **1**B, and the main difference therebetween is as follows. In the surface-emitting laser **100*d*** according to this embodiment, the cladding layer **110** and the first electrode **130*d*** are disposed on the substrate **150**, and the cladding layer **110** and the first electrode **130*d*** are disposed on the same side of the substrate **150**.

[0037] FIG. **5** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention. Referring to FIG. **5**, the surface-emitting laser **100*e*** in this embodiment is similar to the surface-emitting laser **100*d*** in FIG. **4**, and the main difference therebetween is as follows. In the surface-emitting laser **100*d*** in FIG. **4**, the second gratings **300** diffract the light **122** emitted by the active region **120** to pass through the openings **142**, so that the light **122** travels out of the surface-emitting laser **100*d*** through the openings **142**. However, in the surface-emitting laser **100*e*** in FIG. **5**, the second electrode **140*e*** covers the first grating **200** and the second gratings **300**; that is, the second electrode **140*e*** does not have openings **142** as shown in FIG. **4**. Moreover, the substrate **150*e*** is pervious to the light **122** emitted by the active region **120**. That is to say, the second gratings **300** diffract the light **122** upwards and downwards. The upward light **122** is then reflected by the second electrode **140*e*** (e.g. a metal electrode layer) downwards. The downward light **122** passes through the substrate **150*e*** and then travels out of the surface-emitting laser **100*e***. Therefore, the surface-emitting laser **100*e*** is a bottom emitting laser.

[0038] FIG. **6** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention. Referring to FIG. **6**, the surface-emitting laser **100*f*** in this embodiment is similar to the surface-emitting laser **100** in FIG. **1**B, and the main difference therebetween is as follows. The surface-emitting laser **100*f*** according to this embodiment further includes a distributed Bragg reflection (DBR) layer **170**, wherein the cladding layer **110** is disposed between the active region **120** and the DBR layer **170**. In this embodiment, the DBR layer **170** is disposed between the cladding layer **110** and the substrate **150**. The second gratings **300** diffract the light **122** upwards and downwards. The downward light **122** is reflected by the DBR layer **170** upwards. The upward light **122** passes through the openings **142** and travels out of the surface-emitting laser **100*f***. The DBR layer **170** prevents the light **122** from leaking from the bottom of the surface-emitting laser **100*f***, so that the light efficiency of the surface-emitting laser is improved.

[0039] FIG. **7** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention. Referring to FIG. **7**, the surface-emitting laser **100*g*** in this embodiment is similar to the surface-emitting laser **100** in FIG. **1**B, and the main difference therebetween is as follows. The surface-emitting laser **100*g*** according to this embodiment further includes a mirror layer **180** disposed on side surfaces of the cladding layer **110**, the active region **120**, and the first grating **200**. In this embodiment, the mirror layer **180** is also disposed on side surfaces of the first electrode **130**, the substrate **150**, the contact layer **160**, and the second electrode **140**. When the first grating **200** transmits and reflects the light **122** in a horizontal direction, the mirror layer **180** serves as a facet mirror to reflects the light **122** back to the first grating **200** and prevents the light **122** from leaking out from the side surface of the first grating **200**. Therefore, the light efficiency of the surface-emitting laser **100** is improved.

[0040] FIG. **8** is a schematic cross-sectional view of the surface-emitting laser according to another embodiment of the invention. Referring to FIG. **8**, the surface-emitting laser **100*h*** in this embodiment is similar to the surface-emitting laser **100*g*** in FIG. **7**, and the main difference therebetween is as follows. The surface-emitting laser **100*h*** according to this embodiment further includes a DBR layer **170**, wherein the cladding layer **110** is disposed between the active region **120** and the DBR layer **170**. In this embodiment, the DBR layer **170** is disposed between the cladding layer **110** and the substrate **150**. Besides, in this embodiment, the mirror layer **180** is also disposed on a side surface of the DBR layer **170**.

[0041] FIG. **9** is a schematic view showing light spots of the sub-beams and the openings of the surface-emitting laser in FIG. **1**A and FIG. **1**B respectively in a far-field and a near-field. Referring to FIG. **1**B and FIG. **9**, in the surface-emitting laser **100**, the openings **142** may be in an order arrangement or in a random arrangement. The second gratings **300** diffract the light **122** emitted by the active region **120** into a plurality of sub-beams **1220**. The sub-beams **1220** pass through the openings **142** in the near-field, respectively, and travel out of the surface-emitting laser **100** to the far-field, so as to form a plurality of light spots **1223** in the far-field, respectively. According to the pattern design of the openings **142** in the near-field and the diffraction order of the second gratings **300**, the pattern of the light spots **1223** in the far-field may be designed. Sub-beams **1220** from adjacent openings **142** may interfere with each other to form beam shaping so as to form a different light spot pattern in the far-field. The pattern of the light spots **1223** may be in an order arrangement, a random arrangement. In another embodiment, due to beam shaping, the sub-beams **1220** may form order or random bright lines in the far-field. In another embodiment, multiple sub-beams **1220** interference with properly designed openings **142** arrangement can result very small beam divergence and excellent beam quality.

[0042] FIG. **10** is a schematic top transparent view of the surface-emitting laser showing the second electrode, the first grating, and the second gratings according to another embodiment of the invention. Referring to FIG. **10**, the surface-emitting laser **100*i*** in this embodiment is similar to the surface-emitting laser **100** in FIG. **1**A and FIG. **1**B, and the main difference therebetween is as follows. In the surface-emitting laser **100*i***, the second electrode **140** includes a plurality of separate sub-electrodes **141** respectively covering different sets of the second gratings **300**, wherein the sub-electrodes **141** are independently driven. In this embodiment, the sub-electrodes **141** may be independently driven by a driver. For example, when the surface-emitting laser **100*i*** needs to emit a light beam to an object in a long distance, all sub-electrodes **141** may be driven, and all second gratings **300** diffract the light **122** into the sub-beams **1220** to form a light beam with high intensity. When the surface-emitting laser **100*i*** needs to emit a light beam to an object in a short distance, one or some of the sub-electrodes may be driven, and the other sub-electrodes may not be driven. For example, the middle one or five second gratings may diffract the light **122** into one sub-beam **1220** or five sub-beams **1220** to form a light beam with lower intensity, which may save the power consumption of the surface-emitting laser **100*i***. In another embodiment, the diffraction order of the second gratings **300** may be 2, 3 or more, or a combination thereof, so that the light patterns provided by the surface-emitting laser **100*i*** may have more variations. In another embodiment, the first electrode **130** may include a plurality of separate sub-electrodes respectively under different sets of the second gratings **300**, wherein the sub-electrodes are independently driven. The surface-emitting laser **100*i*** in this embodiment may achieve flexible application in three-dimensional sensing field, better spatial resolution. Moreover, the sub-beams **1220** may be separately designed for better output coupling and beam control. Additionally, the sub-beams **1220** may be separately turned on for power adjustment or beam steering.

[0043] FIG. **11**A is a schematic top transparent view of the surface-emitting laser showing the second electrode and the second gratings according to another embodiment of the invention. FIG. **11**B is a perspective view of the surface-emitting laser in FIG. **11**A showing different sub-beams due to different sub-electrodes. Referring to FIG. **11**A and FIG. **11**B, the surface-emitting laser **100*j*** in this embodiment is similar to the surface-emitting laser **100*i*** in FIG. **10**, and the main difference therebetween is as follows. In the surface-emitting laser **100*j***, the sub-electrodes **141** are concentrically arranged. Different sub-electrodes **141** may cover different sets of second gratings **300** having different diffraction orders. For example, the set of second gratings **300** covered by the middle sub-electrode **141** may have the second diffraction order, so that the second gratings **300** covered by the middle sub-electrode **141** may emit the sub-beams **1220** in the front direction. The set of second gratings **300** covered by the first inner ring of the sub-electrodes **141** may have the third diffraction order, and emit sub-beams **1220** in a divergent direction. When the sets of second gratings **300** covered by different rings of the sub-electrodes have different diffraction orders, the sets of second gratings **300** may respectively emit sub-beams **1220** with different divergent angle. The sub-electrodes **141** are independently driven. Therefore, by driving one, some, or all of the sub-electrodes **141**, the divergent angle of a light beam of the surface-emitting laser **100*j*** may be adjusted. Moreover, when the sub-electrodes **141** are separately turned on, the surface-emitting laser **100*i*** may achieve power adjustment, beam steering, or large angle sweeping.

[0044] In conclusion, in the surface-emitting laser according to the embodiments of the invention, since the second gratings are separately distributed among the first grating, the first grating is used for laser feedback for more efficient reflection of the light emitted by the active region, and the second gratings are used for output coupling by diffraction. Therefore, the laser characteristics of the surface-emitting laser are better controlled. As a result, the surface-emitting laser has good beam quality and good beam control. Moreover, in the surface-emitting laser according to the embodiments of the invention, the second electrode covers at least the first grating, so that the surface-emitting laser has good and uniform current spreading, and current crowding effect is effectively reduced.

[0045] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the invention covers modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A surface-emitting laser comprising:

a cladding layer;

an active region disposed on the cladding layer;

a first grating disposed on the active region;

a plurality of second gratings disposed on the active region and separately distributed among the first grating, wherein a diffraction order of the first grating is different from a diffraction order of the second gratings;

a first electrode electrically connected to the cladding layer; and

a second electrode covers at least the first grating.

2. The surface-emitting laser according to claim **1**, wherein the first grating is a first order grating, and the second gratings are second order gratings.

3. The surface-emitting laser according to claim **1**, wherein the second electrode covers the first grating and has a plurality of openings above the second gratings.

4. The surface-emitting laser according to claim **1** further comprising a contact layer disposed between the first grating and the second electrode and covers the second gratings.

5. The surface-emitting laser according to claim **1**, wherein the diffraction order of the first grating is greater than or equal to 1, and the diffraction order of the second gratings is greater than or equal to 2.

6. The surface-emitting laser according to claim **1** further comprising a substrate disposed between the cladding layer and the first electrode.

7. The surface-emitting laser according to claim **1** further comprising a substrate, wherein the cladding layer and the first electrode are disposed on a same side of the substrate.

8. The surface-emitting laser according to claim **1** further comprising a substrate, wherein the cladding layer and the first electrode are disposed on the substrate, the second electrode covers the first grating and the second gratings, and the substrate is pervious to light emitted by the active region.

9. The surface-emitting laser according to claim **1** further comprising a mirror layer disposed on side surfaces of the cladding layer, the active region, and the first grating.

10. The surface-emitting laser according to claim **1** further comprising a distributed Bragg reflection layer, wherein the cladding layer is disposed between the active region and the distributed Bragg reflection layer.

11. The surface-emitting laser according to claim **1**, wherein the first grating and the second gratings are one-dimensional gratings.

12. The surface-emitting laser according to claim **11**, wherein each of the first grating and the second gratings includes a plurality of straight strips parallel to each other.

13. The surface-emitting laser according to claim **12**, wherein a pitch of the straight strips of the second gratings is greater than a pitch of the straight strips of the first grating.

14. The surface-emitting laser according to claim **1**, wherein the first grating and the second gratings are two-dimensional gratings.

15. The surface-emitting laser according to claim **14**, wherein each of the first grating and the second gratings includes two-dimensional hole array, two-dimensional line array, or two-dimensional pillar array.

16. The surface-emitting laser according to claim **15**, wherein a pitch of the two-dimensional hole, line, or pillar array of the second gratings is greater than a pitch of the two-dimensional hole, line, or pillar array of the first grating.

17. The surface-emitting laser according to claim **1**, wherein each of the first grating and the second gratings includes a plurality of periodical units periodically arranged, and a profile of each of the periodical units in a cross-section perpendicular to the active region is a step shape, a wave shape, or a triangular shape.

18. The surface-emitting laser according to claim **1**, wherein each of the first grating and the second gratings includes a plurality of periodical units periodically arranged, a pitch of the periodical units of the second gratings is greater than a pitch of the periodical units of the first grating.

19. The surface-emitting laser according to claim **1**, wherein the second gratings diffract light emitted by the active region into a plurality of sub-beams traveling out of the surface-emitting laser, and adjacent sub-beams interfere with each other.

20. The surface-emitting laser according to claim **1**, wherein the second electrode comprises a plurality of separate sub-electrodes respectively covering different sets of the second gratings, wherein the sub-electrodes are independently driven.

21. The surface-emitting laser according to claim **20**, wherein the sub-electrodes are concentrically arranged.

22. The surface-emitting laser according to claim **1**, wherein the second electrode is a metal electrode layer.

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