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(54) **SEMICONDUCTOR LASER DIODE AND SEMICONDUCTOR LASER DIODE ASSEMBLY CONTAINING THE SAME**

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(57) **ABSTRACT**

Provided is a semiconductor laser diode. The semiconductor laser diode includes a first material layer, an active layer, and a second material layer, characterized in that the semiconductor laser diode includes: a ridge waveguide, which is formed in a ridge shape over the second material layer to define a channel defined so that a top material layer of the second material layer is limitedly exposed, and in which a second electrode layer which is in contact with the top material layer of the second material layer via the channel is formed; and a first protrusion, which is positioned at one side of the ridge waveguide and has not less height than that of the ridge waveguide.

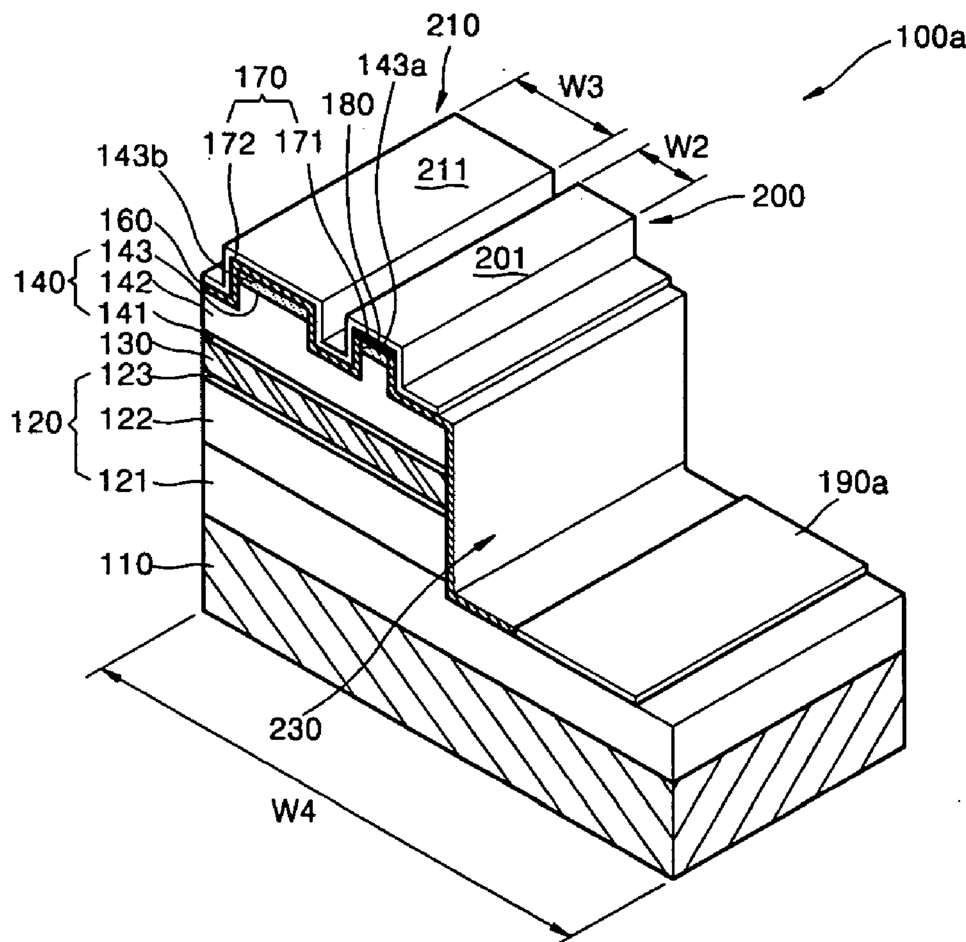


FIG. 1 (PRIOR ART)

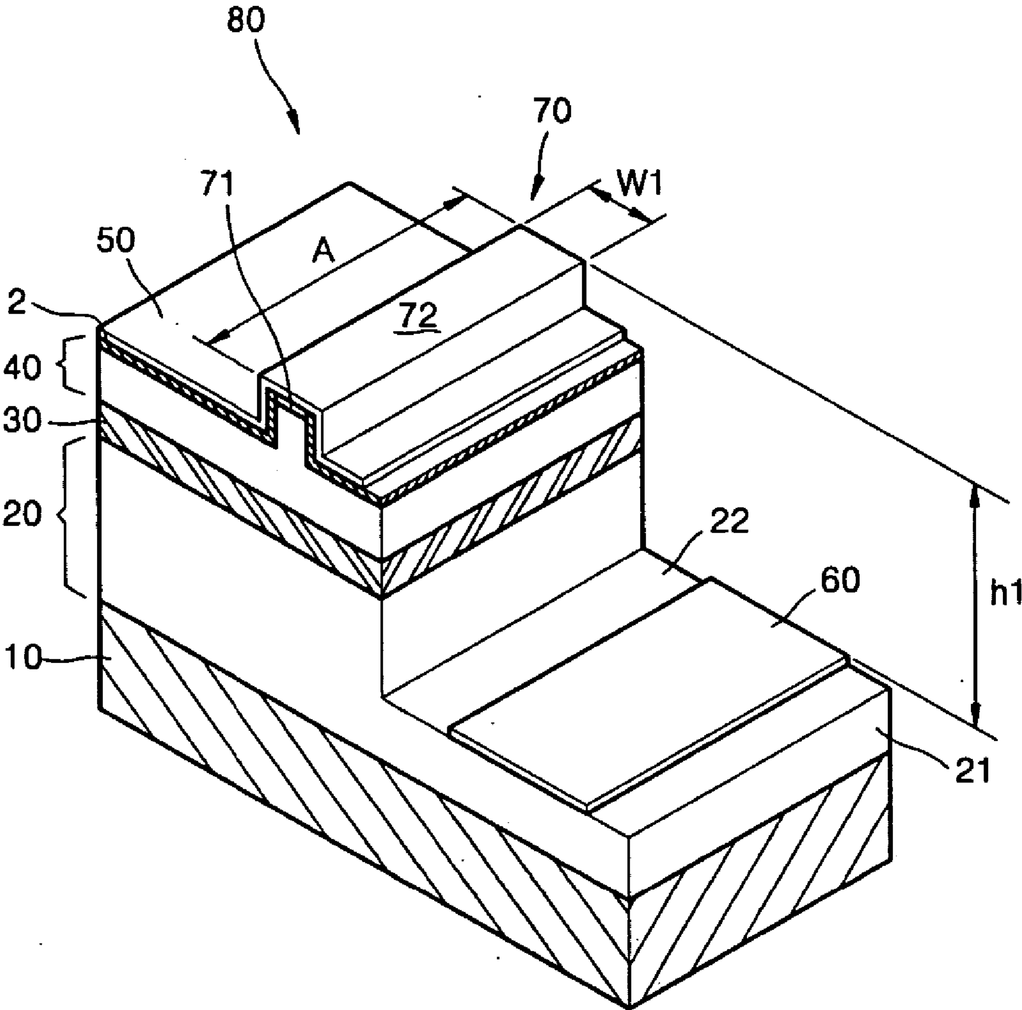


FIG. 2 (PRIOR ART)

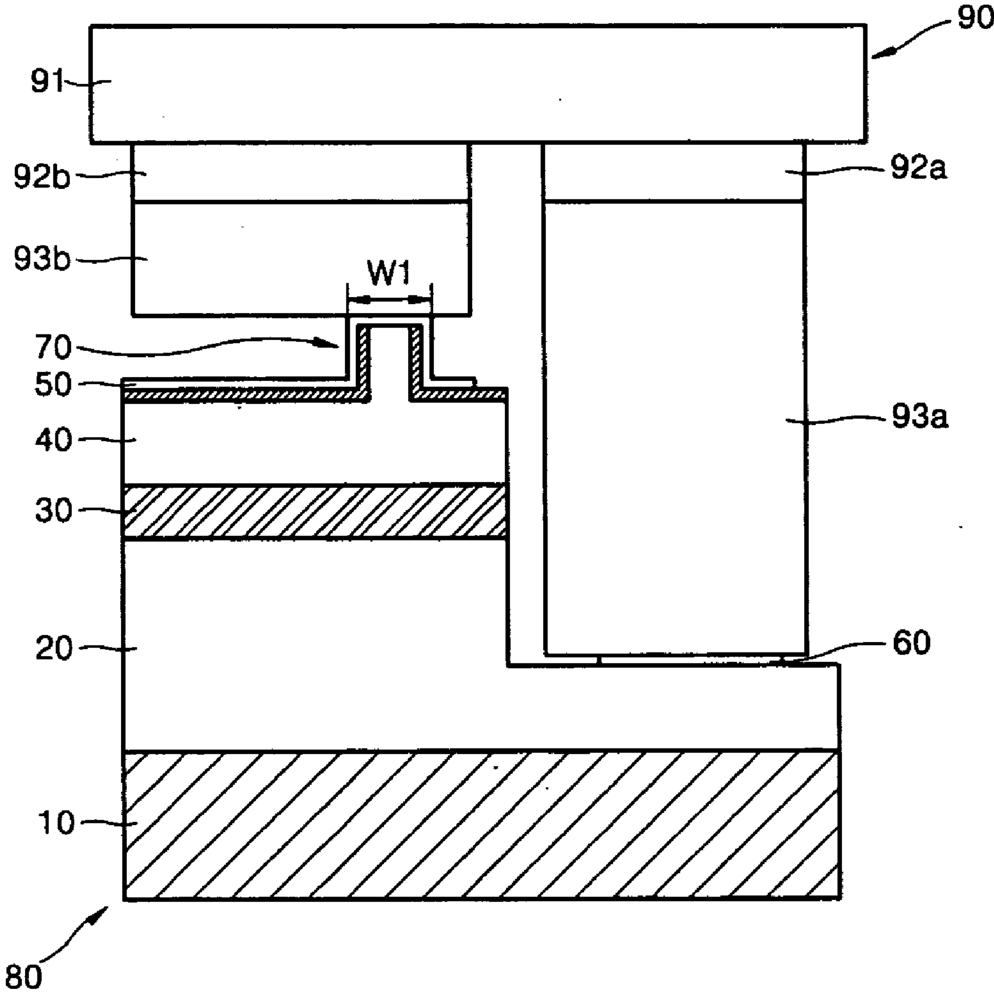


FIG. 3 (PRIOR ART)

FIG. 4

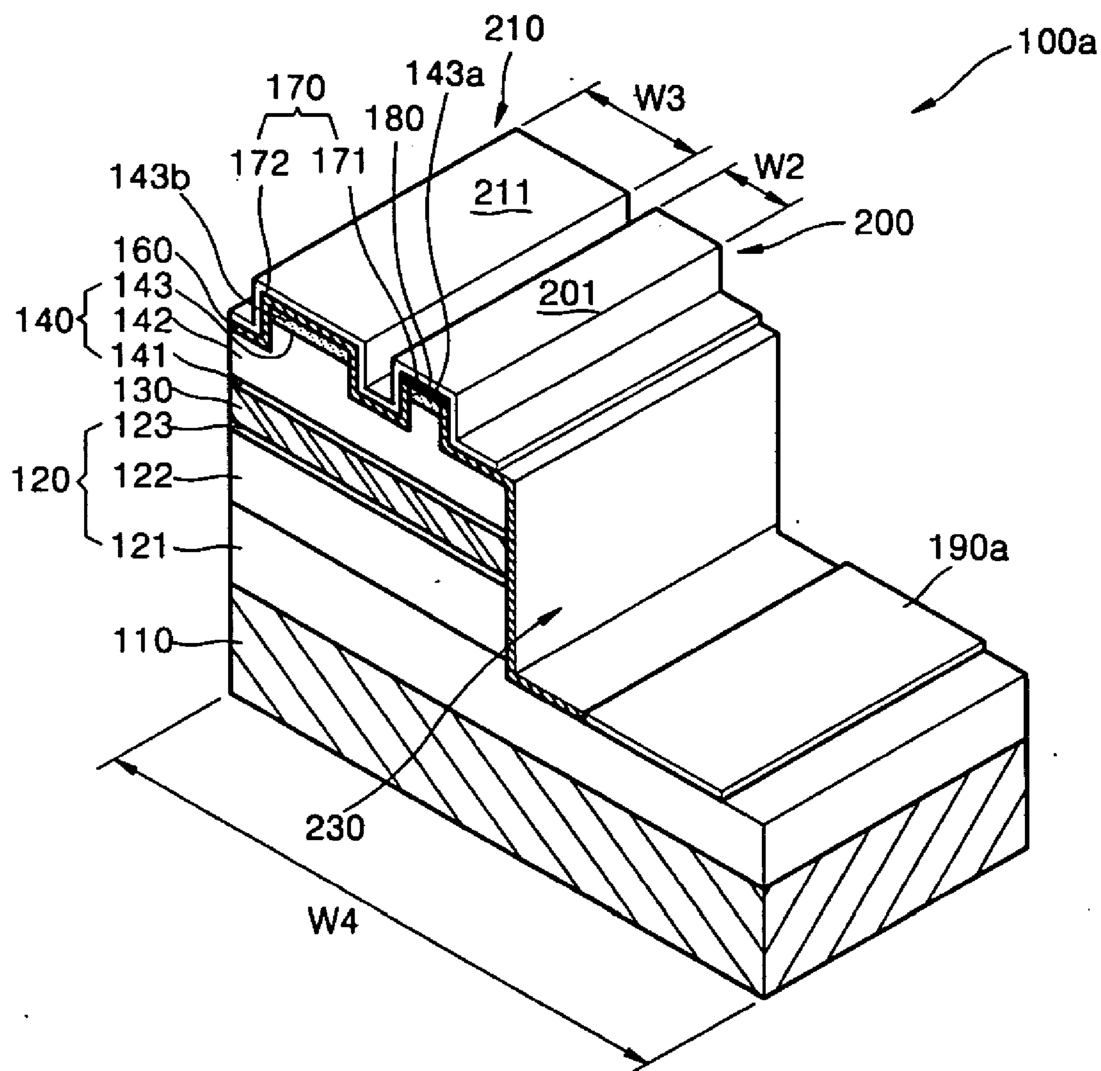


FIG. 5

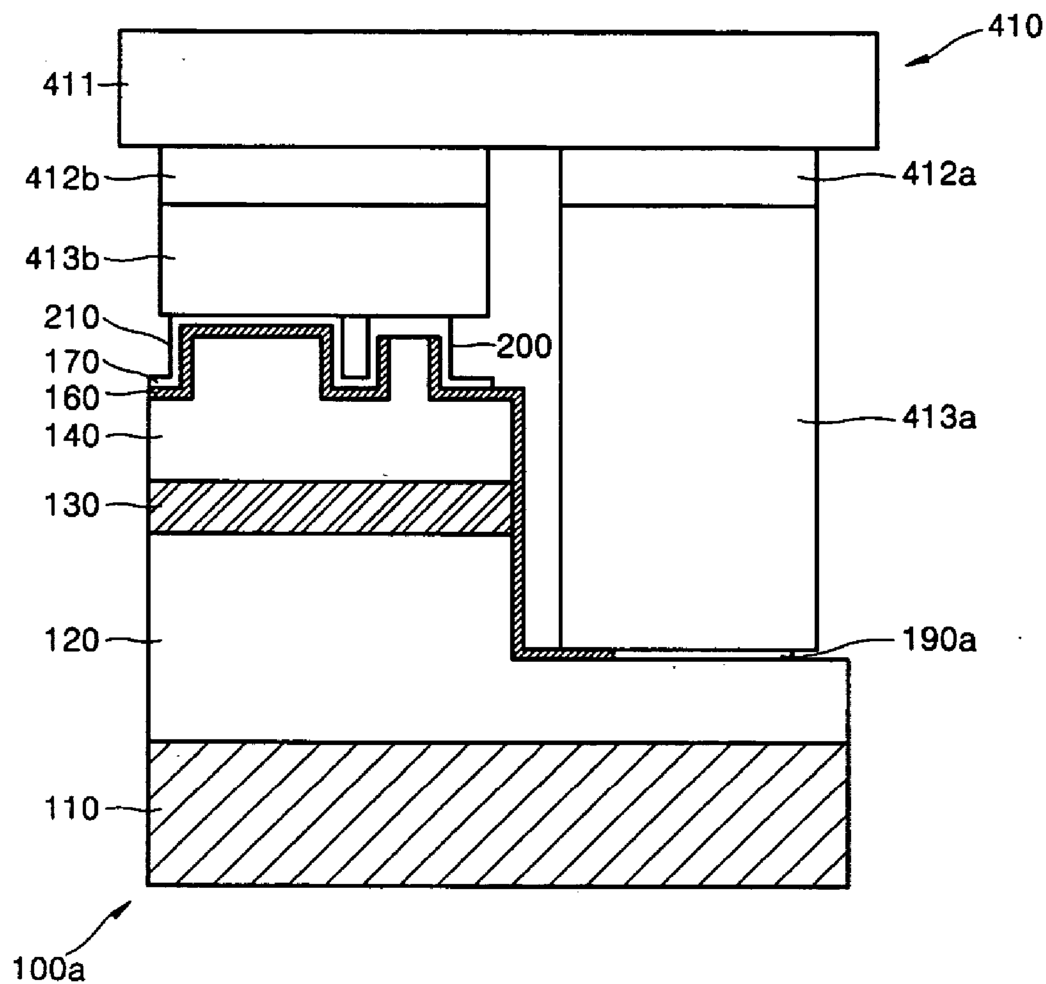


FIG. 6

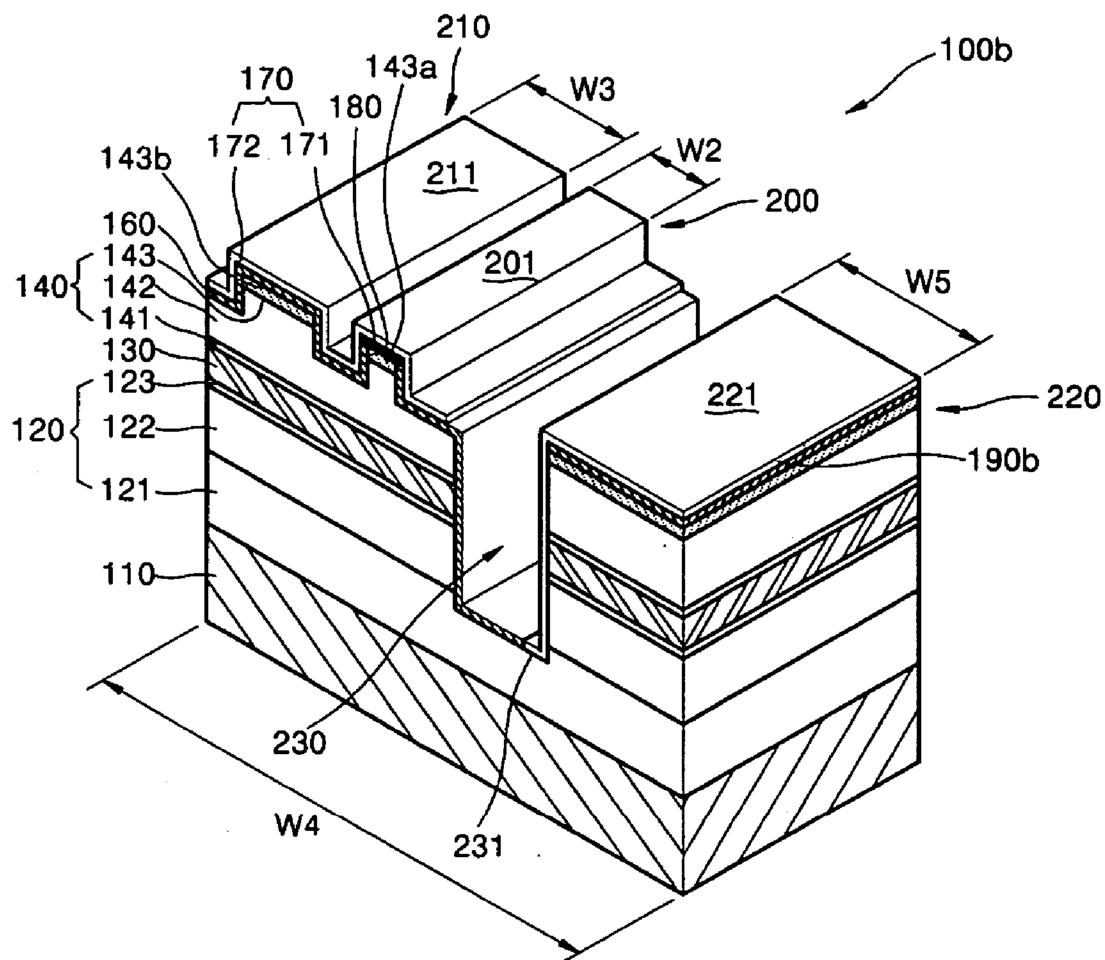


FIG. 7

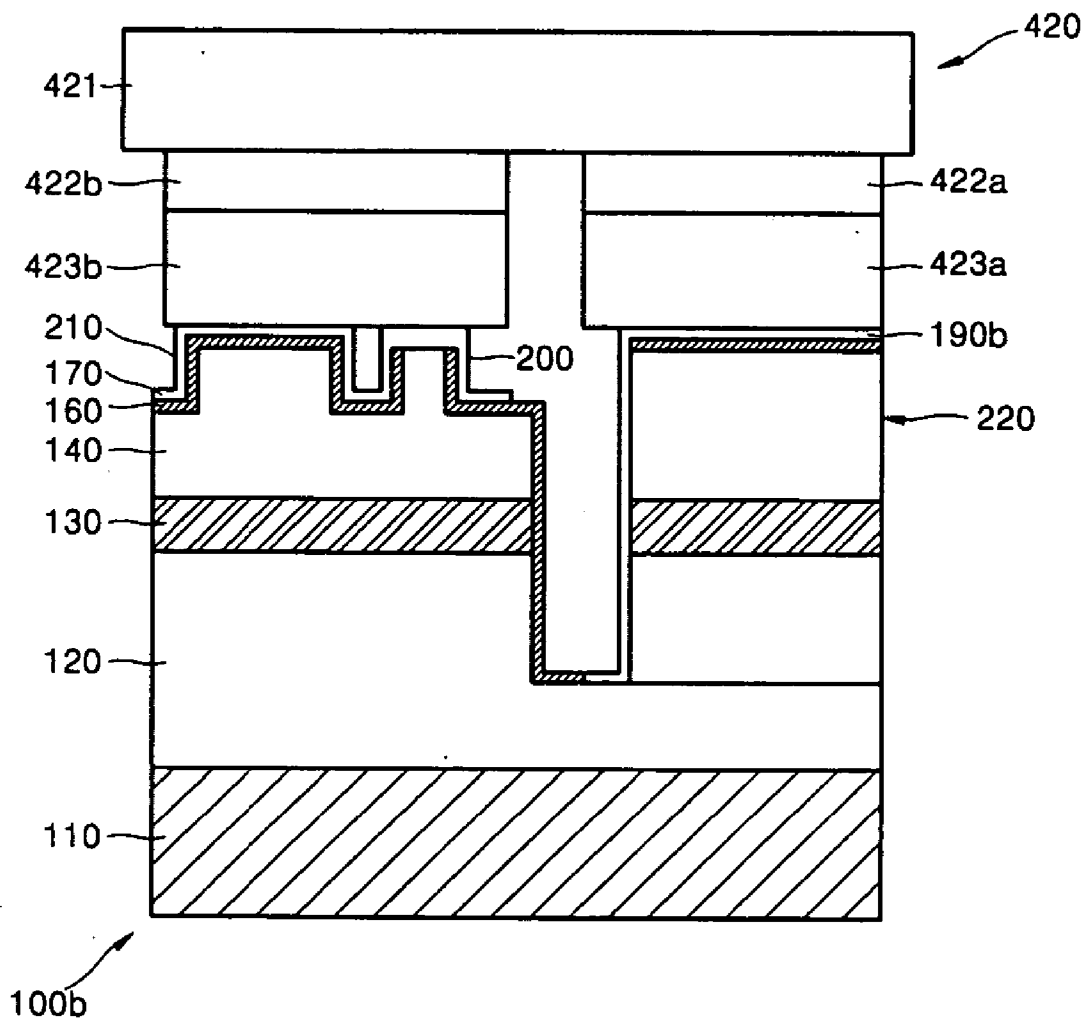


FIG. 8

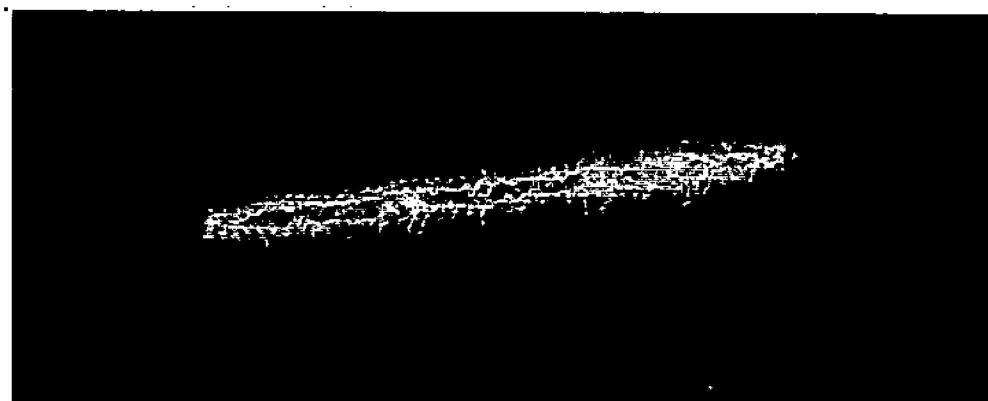
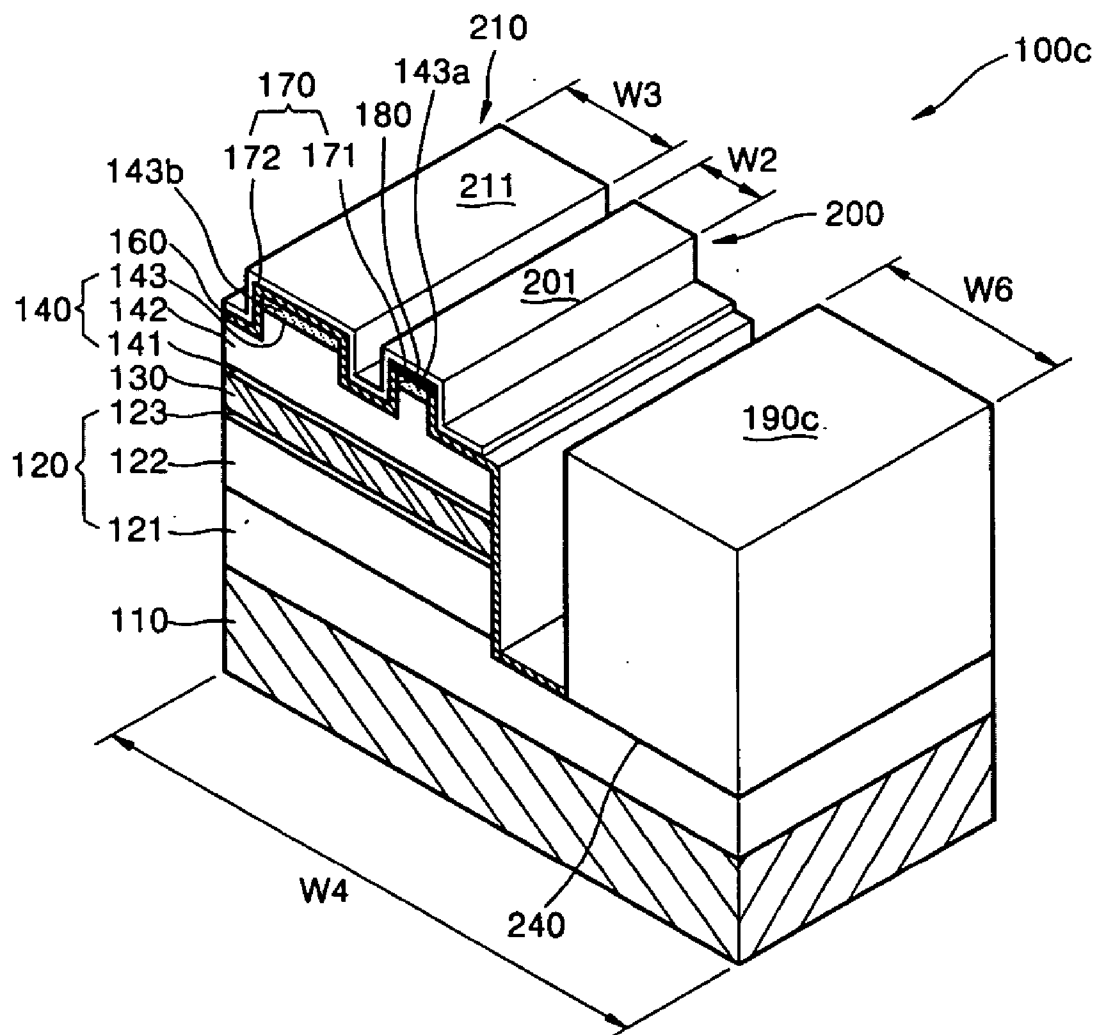


FIG. 9



SEMICONDUCTOR LASER DIODE AND SEMICONDUCTOR LASER DIODE ASSEMBLY CONTAINING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of prior U.S. application Ser. No. 10/732,240 filed on Dec. 11, 2003 and claims priority under 35 U.S.C. § 120 to such prior application, the entire content of which is incorporated herein by reference. This application also claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 2003-14614, filed on Mar. 8, 2003, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a semiconductor laser diode and more particularly, to a semiconductor laser diode having a ridge waveguide.

[0004] 2. Description of the Related Art

[0005] As high density information recording is increasingly in demand, the need for a visible light semiconductor laser diode is increasing. Therefore, semiconductor laser diodes made of various compounds capable of emitting a visible light laser are being developed. In particular, much attention has been paid to a group III-V nitride semiconductor laser diode because its optical transition is a direct transition type that induces high frequency laser emission and because it emits a blue light laser.

[0006] FIG. **1** shows a perspective view of a conventional GaN-based, group III-V nitride semiconductor laser diode having n-type and p-type electrodes, which are formed on the same side, and a ridge waveguide.

[0007] Referring to FIG. **1**, an n-type material layer **20**, a light emitting active layer **30**, and a p-type material layer **40** are sequentially formed on a sapphire substrate **10**. The upper surface of the p-type material layer **40** is formed with a ridge waveguide **70**. The ridge waveguide **70** is slightly protruded from the upper surface of the p-type material layer **40**. The ridge waveguide **70** comprises a channel **71** formed so that the p-type material layer **40** is exposed in a narrow stripe-type configuration, and a p-type electrode layer **50**, which is in contact with the p-type material layer **40** via the channel **71**. Strictly speaking, a reference numeral **2** is not the p-type material layer **40** but is a current restricting layer formed for defining the channel **71**.

[0008] An n-type electrode layer **60** serves to feed an electric current into a bottom material layer **21** of the n-type material layer **20** and is formed on an exposed surface **22** of the bottom material layer **21** of the n-type material layer **20**.

[0009] In this structure, the upper surface of the p-type electrode layer **50**, that is, the upper surface **72** of the ridge waveguide **70**, and the upper surface of the n-type electrode layer **60** are separated by a step height, h**1**.

[0010] Generally, a temperature has an effect on a critical current and laser mode stability for laser emission of semiconductor laser diodes. As a temperature increases, both of the characteristics are lowered. Therefore, there is a need to remove heat generated in an active layer during laser emission to thereby prevent overheating of laser diodes. In the structure of the aforementioned conventional GaN-based, group III-V semiconductor laser diode, most heat is discharged only through a ridge because of very low thermal conductivity of a substrate (for a sapphire substrate, about 0.5 W/cmK). However, because heat discharge through a ridge occurs limitedly, it is difficult to carry out efficient heat discharge. Therefore, lowering of characteristics of semiconductor devices by overheating of laser diodes is not efficiently prevented.

[0011] In this regard, a flip-chip bonding technology shown in FIG. **2** can be applied to the structure of a conventional semiconductor laser diode shown in FIG. **1** to discharge heat generated in an active layer.

[0012] Referring to FIG. **2**, a reference numeral **80** indicates a conventional GaN-based, group III-V semiconductor laser diode. A reference numeral **90** indicates a submount as a heat discharge structure, a reference numeral **91** a substrate, and reference numerals **92*a*** and **92*b*** first and second metal layers, respectively. Reference numerals **93*a*** and **93*b*** indicate first and second solder layers, which are respectively fused to an n-type electrode layer **60** and a p-type electrode layer **50** of the semiconductor laser diode **80**.

[0013] By bonding the semiconductor laser diode to the submount, a separately prepared heat discharge structure, heat discharge efficiency can be increased.

[0014] However, as shown in FIG. **2**, the first solder layer **93*a*** is thicker than the second solder layer **93*b*** by the height of h**1** in order to compensate for the step height, h**1** between the p-type electrode **50** and the n-type electrode **60**. Due to such a thickness difference, the first and second solder layers **93*a*** and **93*b*** may not concurrently be molten.

[0015] The first and second solder layers **93*a*** and **93*b*** are generally made of a metal alloy, and thus, even if the chemical composition ratios of the first and second solder layers **93*a*** and **93*b*** slightly differ from each other, there is a large difference between their melting temperatures. In a case wherein the first and second solder layers **93*a*** and **93*b*** differ in thickness in a method of manufacturing the submount, the first and second solder layers **93*a*** and **93*b*** must be formed under separate two processes, not under a single process. As a result, there exists a likelihood for the first and second solder layers **93*a*** and **93*b*** to have different chemical composition ratios.

[0016] The ridge waveguide **70** is protruded from the p-type material layer **40**, and although exaggerated in FIG. **2**, has a width W**1** of no more than several micrometers. Therefore, when the semiconductor laser diode **80** is bonded to the submount **90**, a thermal stress may be concentrated on the ridge waveguide **70**. In addition, when the first and second solder layers **93*a*** and **93*b*** are not concurrently fused as mentioned above, the submount **90** may be inclined to one side. In this case, a mechanical stress may be concentrated on the narrow ridge waveguide **70**.

[0017] Stresses concentrated on the ridge waveguide **70** may affect light emission in the active layer **30** below the ridge waveguide **70**.

[0018] FIG. **3** shows an image plane photograph of laser light emission taken along the longitudinal direction A of the

stripe-like ridge waveguide **70**. As shown in FIG. **3**, light is emitted unevenly and discontinuously along the longitudinal direction A of the ridge waveguide **70**.

SUMMARY OF THE INVENTION

[0019] The present invention has been made in view of the above problems. The present invention provides a semiconductor laser diode with an improved structure capable of dispersing a stress concentrated on a ridge waveguide when flip-chip bonded to a submount.

[0020] According to an aspect of the present invention, there is provided a semiconductor laser diode comprising first and second material layers which are multi-material layers, and an active layer interposed between the first and second material layers to emit light, characterized in that the semiconductor laser diode comprises a ridge waveguide, which is formed in a ridge shape over the second material layer to define a channel so that a top material layer of the second material layer is limitedly exposed, and in which a second electrode layer which is in contact with the top material layer of the second material layer via the channel is formed; and a first protrusion, which is positioned at one side of the ridge waveguide and has not less height than that of the ridge waveguide.

[0021] According to specific embodiments of the present invention, the first protrusion may have a width wider than the width of the ridge waveguide.

[0022] The semiconductor laser diode may further comprise a second protrusion having not less height than that of the ridge waveguide at the other side of the ridge waveguide. The second protrusion may have a width wider than the width of the ridge waveguide and may have the same height as the first protrusion. When the first and second protrusions differ in height, the height difference may be 0.5 μm or less.

[0023] The second protrusion may be separated from the ridge waveguide by a valley portion, which is etched to expose a bottom material layer of the first material layer, and a top layer of the second protrusion may be a first electrode layer electrically connected to the bottom material layer of the first material layer.

[0024] The other side of the ridge waveguide may be formed with an exposed surface of the bottom material layer of the first material layer and a first electrode layer having not less height than that of the ridge waveguide may be formed on the exposed surface. The first electrode layer serves the same function as the second protrusion. The first protrusion and the first electrode layer may have the same height. The first electrode layer may have a width wider than the width of the ridge waveguide. When the first protrusion and the first electrode layer differ in height, the height difference may be 0.5 μm or less.

[0025] According to another aspect of the present invention, there is provided a semiconductor laser diode assembly comprising a semiconductor laser diode comprising first and second material layers which are multi-material layers, and an active layer interposed between the first and second material layers to emit light; and a submount flip-chip bonded to the semiconductor laser diode, wherein the semiconductor laser diode comprises a ridge waveguide, which is formed in a ridge shape over the second material layer to define a channel so that a top material layer of the second material layer is limitedly exposed, and in which a second electrode layer which is in contact with the top material layer of the second material layer via the channel is formed; a first protrusion, which is positioned at one side of the ridge waveguide and has not less height than that of the ridge waveguide; and a second protrusion, which is positioned at the other side of the ridge waveguide and has not less height than that of the ridge waveguide and of which a top material layer is a first electrode layer electrically connected to a bottom material layer of the first material layer, and wherein the submount comprises a substrate; a first solder layer bonded to the first protrusion and the ridge waveguide; and a second solder layer bonded to the second protrusion, the first and second solder layers being formed at a surface of the substrate and having substantially the same thickness.

[0026] According to yet another aspect of the present invention, there is provided a semiconductor laser diode assembly comprising a semiconductor laser diode comprising first and second material layers which are multi-material layers, and an active layer interposed between the first and second material layers to emit light; and a submount flip-chip bonded to the semiconductor laser diode, wherein the semiconductor laser diode comprises a ridge waveguide, which is formed in a ridge shape over the second material layer to define a channel so that a top material layer of the second material layer is limitedly exposed, and in which a second electrode layer which is in contact with the top material layer of the second material layer via the channel is formed; a first protrusion, which is positioned at one side of the ridge waveguide and has not less height than that of the ridge waveguide; and a first electrode layer, which is positioned at the other side of the ridge waveguide, has not less height than that of the ridge waveguide, and electrically connected to a bottom material layer of the first material layer, and wherein the submount comprises a substrate; a first solder layer bonded to the first protrusion and the ridge waveguide; and a second solder layer bonded to the first electrode layer, the first and second solder layers being formed at a surface of the substrate and having substantially the same thickness.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The above and other features and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

[0028] FIG. **1** is a perspective view of a conventional GaN-based, group III-V nitride semiconductor laser diode having n-type and p-type electrodes, which are formed on the same side;

[0029] FIG. **2** is a sectional view of an example of a conventional semiconductor laser diode assembly with a flip-chip bonded structure of a submount and the semiconductor laser diode shown in FIG. **1**;

[0030] FIG. **3** is an image plane photograph of laser light emission taken along the longitudinal direction of a ridge waveguide in the semiconductor laser diode assembly shown in FIG. **2**;

[0031] FIG. **4** is a perspective view of a semiconductor laser diode according to an embodiment of the present invention;

[0032] FIG. **5** is a sectional view of a flip-chip bonded structure of a submount and the semiconductor laser diode shown in FIG. **4** in a semiconductor laser diode assembly according to an embodiment of the present invention;

[0033] FIG. **6** is a perspective view of a semiconductor laser diode according to another embodiment of the present invention;

[0034] FIG. **7** is a sectional view of a flip-chip bonded structure of a submount and the semiconductor laser diode shown in FIG. **6** in a semiconductor laser diode assembly according to another embodiment of the present invention;

[0035] FIG. **8** is an image plane photograph of laser light emission in the semiconductor laser diode assembly shown in FIG. **7**; and

[0036] FIG. **9** is a perspective view of a semiconductor laser diode according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0037] Hereinafter, preferred embodiments of the present invention will be described in more detail with reference to the accompanying drawings.

[0038] FIG. **4** is a perspective view of a semiconductor laser diode according to an embodiment of the present invention. The illustration of the semiconductor laser diode of FIG. **4** has been exaggerated to show characteristics of the semiconductor laser diode according to the present invention more clearly. The semiconductor laser diode according to this embodiment of the present invention is a GaN-based, group III-V nitride semiconductor laser diode.

[0039] Referring to FIG. **4**, the semiconductor laser diode **100***a* comprises a substrate **110**, a first material layer **120**, an active layer **130**, and a second material layer **140** that are sequentially mounted on the substrate **110**.

[0040] The substrate **110** may be a GaN or SiC-based, group III-V semiconductor layer substrate or a high resistance substrate such as a sapphire substrate.

[0041] The active layer **130** is a material layer of emitting light by carrier recombination of an electron and a hole. Preferably, the active layer **130** is a GaN-based, group III-V nitride semiconductor layer having a multi quantum well (MQW) and more preferably, an $In_xAl_yGa_{1-x-y}$ layer where $0 \leqq x \leqq 1$, $0 \leqq y \leqq 1$, and $x+y \leqq 1$. The active layer **130** may also be a GaN-based, group III-V nitride semiconductor layer containing a predetermined ratio of Indium (In), for example, an InGaN layer.

[0042] The first material layer **120** comprises a buffer layer **121**, a first cladding layer **122**, and a first waveguide layer **123** that are sequentially mounted on the upper surface of the substrate **110**. The second material layer **140** comprises a second waveguide layer **141**, a second cladding layer **142**, and a cap layer **143** that are sequentially mounted on the upper surface of the active layer **130**. A bottom layer of the first material layer **120** is the buffer layer **121** and a top layer of the second material layer **140** is the cap layer **143**.

[0043] The buffer layer **121** is an n-type material layer made of a GaN-based, group III-V nitride semiconductor or an undoped material layer. Preferably, the buffer layer **121** is an n-GaN layer.

[0044] The cap layer **143** is a GaN-based, group III-V nitride semiconductor layer, preferably a p-type conductive impurity-doped direct transition layer, and more preferably a p-GaN layer. In addition, the cap layer **143** may be a GaN layer, an AlGaN layer or InGaN layer containing a predetermined ratio of Al or In, like the buffer layer **121**.

[0045] The first and second waveguide layers **123** and **141** are GaN-based, group III-V nitride semiconductor layers, and preferably, an n-GaN layer and a p-GaN layer, respectively. The first and second waveguide layers **123** and **141** have a reflective index lower than the active layer **130** and higher than the first cladding layer **122** and the second cladding layer **142** as will be described later.

[0046] The first cladding layer **122** is an n-AlGaN/GaN layer and the second cladding layer **142** is the same material layer as the first cladding layer **122** except that a p-type material is doped.

[0047] In order to induce laser emission in the active layer **130**, the semiconductor laser diode **100***a* comprises an n-type electrode layer **190***a* and a p-type electrode layer **170**, which are electrically connected to the buffer layer **121** and the cap layer **143**, respectively. A reference numeral **160** indicates a current restricting layer, which defines a channel **180** as a passage for limited contact between the p-type electrode layer **170** and the cap layer **143**.

[0048] As shown in the left part of FIG. **4**, the cap layer **143** is divided into first and second regions **143***a* and **143***b*. The cap layer **143** and the partially exposed second cladding layer **142** are covered with the current restricting layer **160**. The current restricting layer **160** covering the first region **143***a* of the cap layer **143** is removed to expose the cap layer **143**. As a result, the channel **180** is formed and the p-type electrode layer **170** and the cap layer **143** are limitedly in contact with each other through the channel **180**. The channel **180** is filled with a contact layer **171** and a bonding metal layer **172** is formed on the upper surfaces of the contact layer **171** and the current restricting layer **160**. Hereinafter, the p-type electrode layer **170** is designated a layer containing the contact layer **171** and the bonding metal layer **172**.

[0049] As mentioned above, when formation of the p-type electrode layer **170** is completed, a ridge waveguide **200** is formed at the first region **143***a* of the cap layer **143** and a first protrusion **210** is formed at the second region **143***b* of the cap layer **143**.

[0050] Preferably, the first protrusion **210** is formed with a width wider than the width W**2** of the ridge waveguide **200**. Although slightly exaggerated in FIG. **4**, the ridge waveguide **200** has a width W**2** of no more than several micrometers. Generally, the width W**4** of the semiconductor laser diode **100***a* is about 200 μm. The first protrusion **210** may be separated from one side of the ridge waveguide **200** by about 10 μm and be formed with a width W**3** of about 50 to 100 μm. Preferably, the width W**3** of the first protrusion

210 is formed to be wider than that W2 of the ridge waveguide **200**, but is not limited to the aforementioned range.

[0051] Preferably, the upper surface **211** of the first protrusion **210** is formed to be at the same height as the upper surface **201** of the ridge waveguide **200** and more preferably, to be at a slightly higher height than the upper surface **201** of the ridge waveguide **200**. For this, for example, the upper surface of the contact layer **171** is formed to be at a height equal to or slightly lower than the upper surface of the current restricting layer **160** on the second region **143***b* of the cap layer **143** and then the bonding metal layer **172** is formed to the same thickness. In addition, various approaches such as formation of the bonding metal layer **172** at the second region **143***b* of the cap layer **143** thicker than that at the first region **143***a* of the cap layer **143** may be considered.

[0052] The structural advantages of the semiconductor laser diode with the aforementioned structure will now be described.

[0053] FIG. **5** is a sectional view of a flip-chip bonded structure of a submount and the semiconductor laser diode shown in FIG. **4** in a semiconductor laser diode assembly according to an embodiment of the present invention.

[0054] The submount **410** is a heat discharge structure for preventing overheating of the semiconductor laser diode **100***a* by heat generated in an active layer during laser emission.

[0055] Referring to FIG. **5**, a reference numeral **411** indicates a substrate, reference numerals **412***a* and **412***b* indicate first and second metal layers, respectively, and reference numerals **413***a* and **413***b* indicate first and second solder layers, respectively.

[0056] Preferably, the substrate **411** is made of one of AIN, SiC, GaN, and an insulating material having a heat transfer coefficient corresponding to that of one of AIN, SiC, and GaN. The first and second metal layers **412***a* and **412***b* are made of an Au/Cr alloy or a metal material corresponding to the Au/Cr alloy. The first and second solder layers **413***a* and **413***b* are made of an Au/Sn alloy or a metal material corresponding to the Au/Sn alloy.

[0057] When the semiconductor laser diode **100***a* is bonded to the submount **410**, the first solder layer **413***a* is fused to the n-type electrode layer **190***a* and the second solder layer **413***b* is fused to the p-type electrode layer **170**. In the semiconductor laser diode **110***a* according to this embodiment of the present invention, the ridge waveguide **200** and the first protrusion **210** are positioned in the region of the p-type electrode layer **170**, and thus, the second solder layer **413***b* is fused to the ridge waveguide **200** and the first protrusion **210**.

[0058] As mentioned above, in the case of the conventional semiconductor laser diode **80** shown in FIG. **1**, only the ridge waveguide **70** with a width of no more than several micrometers is formed in the region of the p-type electrode layer **50**. As a result, when the semiconductor laser diode **80** is bonded to the submount **90**, thermal and mechanical stresses are concentrated on the protruded ridge waveguide **70**, thereby causing uneven light emission as shown in FIG. **3**.

[0059] In the case of the semiconductor laser diode **100***a* according to the embodiment of the present invention as shown in FIGS. **4** and **5**, the first protrusion **210** with not less height than the ridge waveguide **200** is formed at one side of the ridge waveguide **200**. Therefore, when the semiconductor laser diode **100***a* is bonded to the submount **410**, the second solder layer **413***b* comes in contact with the first protrusion **210** and the ridge waveguide **200** at the same time or with first protrusion **210** first. Then, the second solder layer **413***b* is molten and spontaneously bonded to the ridge waveguide **200** and the first protrusion **210**.

[0060] Because of this structural advantage in the semiconductor laser diode **100***a*, a thermal stress generated during flip-chip bonding is dispersed to the first protrusion **210** adjacent to the ridge waveguide **200**. Therefore, uneven light emission due to concentration of a thermal stress on the ridge waveguide can be prevented. In addition, although the first and second solder layers **413***a* and **413***b* are not concurrently molten due to their thickness differences, a mechanical stress is dispersed to the first protrusion **210** with a width wider than the width of the ridge waveguide **200**, and thus, the concentration of a mechanical stress on the ridge waveguide **200** can be prevented.

[0061] FIG. **6** is a perspective view of a semiconductor laser diode according to another embodiment of the present invention. The same reference numerals as used in FIG. **4** indicate the same constitutional elements.

[0062] The semiconductor laser diode **100***b* further comprises a second protrusion **220** at the other side of the ridge waveguide **200**, that is, at the opposite side of the first protrusion **210**.

[0063] Referring to FIG. **6**, the second protrusion **220** is separated from the ridge waveguide **200** by a valley portion **230**, which is etched to expose the buffer layer **121**. The second protrusion **200** has a structure comprising the first material layer **120**, the active layer **130**, the second material layer **140**, and the current restricting layer **160** that are sequentially mounted on the substrate **110**, and an n-type electrode layer **190***b* mounted on the current restricting layer **160** to be electrically connected to the buffer layer **121**. The n-type electrode layer **190***b* is a top layer of the second protrusion **220** and extends to the bottom surface **231** of the valley portion **230**, to thereby be in contact with the buffer layer **121**.

[0064] Preferably, the upper surface **221** of the second protrusion **220** is formed to be at the same height as the upper surface **201** of the ridge waveguide **200** and more preferably, at a slightly higher height than the upper surface **201** of the ridge waveguide **200**. As shown in FIG. **6**, preferably, the top layer of the second protrusion **220** is the n-type electrode layer **190***b* electrically connected to the buffer layer **121**. In addition, the second protrusion **220** may has the same height as the first protrusion **210**. If the first and second protrusions **210** and **220** differ in height, it is preferable to limit the height difference to 0.5 μm or less.

[0065] FIG. **7** is a sectional view of a flip-chip bonded structure of a submount and the semiconductor laser diode shown in FIG. **6** in a semiconductor laser diode assembly according to another embodiment of the present invention.

[0066] Referring to FIG. **7**, the submount **420** comprises a substrate **421**, first and second metal layers **422***a* and **422***b*,

and first and second solder layers **423***a* and **423***b*. The submount **420** differs from the submount **410** shown in FIG. **5** in that the n-type electrode **190***b* is the top layer of the second protrusion **220** and the first and second solder layers **423***a* and **423***b* have the same thickness due to the same height of the first and second protrusions **210** and **220**. Here, it is preferable to set the thickness of the first and second solder layers **423***a* and **423***b* to be the same. Unlike the submount **90** shown in FIG. **2**, the first and second solder layers **423***a* and **423***b* can be formed in a single process, and thus, can have almost the same chemical composition ratios.

[0067] Because of this structural advantage, when the semiconductor laser diode **100***b* is bonded to the submount **420**, a thermal stress can be dispersed to the first protrusion **210** with a width wider than the ridge waveguide **200**. In addition, because the first and second solder layers **413***a* and **423***b* have almost the same thickness, uneven melting of the first and second solder layers **423***a* and **423***b* is less likely to occur. Therefore, a mechanical stress to be applied to the ridge waveguide **200** can be significantly reduced. Furthermore, because the first and second protrusions **210** and **220** with a width wider than the ridge waveguide **200** support the submount **420**, more stable flip-chip bonding is possible.

[0068] FIG. **8** is an image plane photograph of laser light emission in the semiconductor laser diode assembly shown in FIG. **7**. It can be seen from FIG. **8** that uniform and continuous light emission occurs along the ridge waveguide, unlike in FIG. **3**.

[0069] FIG. **9** is a perspective view of a semiconductor laser diode according to another embodiment of the present invention. The same reference numerals as used in FIGS. **4** through **7** indicate the same constitutional elements.

[0070] The semiconductor laser diode **100***c* differs from the semiconductor laser diode **100***b* shown in FIG. **6** in that an n-type electrode layer **190***c* serves as the second protrusion **220**.

[0071] Referring to FIG. **9**, an exposed surface **240** of the buffer layer **121** is formed at the other side of the ridge waveguide **200**, that is, at the opposite side of the first protrusion **210** and the n-type electrode layer **190***c* is mounted on the exposed surface **240**. Preferably, the n-type electrode layer **190***c* has not less height than the ridge waveguide **200**. Preferably, the width **W6** of the n-type electrode layer **190***c* is wider than that **W2** of the ridge waveguide **200**. Preferably, the n-type electrode layer **190***c* has the same height as the first protrusion **210**.

[0072] Consequently, the n-type electrode layer **190***c* serves as the second protrusion **220** of FIG. **6**. Therefore, the structural advantages obtained by using the n-type electrode layer **190***c* are as described with reference to FIGS. **6** and **7**.

[0073] As apparent from the above description, a semiconductor laser diode and a semiconductor laser diode assembly of the present invention provide the following advantages.

[0074] A thermal stress generated upon flip-chip bonding can be dispersed to the first protrusion adjacent to the ridge waveguide. In addition, the semiconductor laser diode further comprises the second protrusion, and thus, a mechanical stress generated by time difference melting of the solder layers of the submount can be effectively dispersed. Therefore, a laser diode and its assembly with uniform light emission throughout the ridge waveguide can be provided.

[0075] While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

What is claimed is:

1. A semiconductor laser diode assembly comprising a semiconductor laser diode comprising first and second material layers which are multi-material layers, and an active layer interposed between the first and second material layers to emit light; and a submount flip-chip bonded to the semiconductor laser diode, characterized in that the semiconductor laser diode comprises:

a ridge waveguide, which is formed in a ridge shape over the second material layer to define a channel so that a top material layer of the second material layer is limitedly exposed, and in which a second electrode layer which is in contact with the top material layer of the second material layer via the channel is formed;

a first protrusion, which is positioned at one side of the ridge waveguide and has not less height than that of the ridge waveguide; and

a second protrusion, which is positioned at the other side of the ridge waveguide and has not less height than that of the ridge waveguide and of which a top material layer is a first electrode layer electrically connected to a bottom material layer of the first material layer, and

the submount comprises:

a substrate;

a first solder layer bonded to the first protrusion and the ridge waveguide; and

a second solder layer bonded to the second protrusion, the first and second solder layers being formed on the substrate and having substantially the same thickness.

2. The semiconductor laser diode assembly according to claim 1, wherein the second protrusion has a width wider than the width of the ridge waveguide.

3. The semiconductor laser diode assembly according to claim 1, wherein the first and second protrusions have the same height.

4. The semiconductor laser diode assembly according to a semiconductor laser diode assembly comprising a semiconductor laser diode comprising first and second material layers which are multi-material layers, and an active layer interposed between the first and second material layers to emit light; and a submount flip-chip bonded to the semiconductor laser diode, characterized in that the semiconductor laser diode comprises:

a ridge waveguide, which is formed in a ridge shape over the second material layer to define a channel so that a top material layer of the second material layer is limitedly exposed, and in which a second electrode layer which is in contact with the top material layer of the second material layer via the channel is formed;

a first protrusion, which is positioned at one side of the ridge waveguide and has not less height than that of the ridge waveguide; and

a first electrode layer, which is positioned at the other side of the ridge waveguide, has not less height than that of the ridge waveguide, and electrically connected to a bottom material layer of the first material layer, and

the submount comprises:

a substrate;

a first solder layer bonded to the first protrusion and the ridge waveguide; and

a second solder layer bonded to the first electrode layer, the first and second solder layers being formed on the substrate and having substantially the same thickness wherein the first protrusion and the first electrode layer have the same height.

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