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(54) [Title of the Invention] Light emitting element and light emitting device provided with the element**(57) [Abstract]**

[Problem] To provide a light emitting element which can realize a light emitting device capable of emitting a light emitting wavelength with desired color in high power and which has excellent weather resistance, and to provide a light emitting device provided with the element.

[Solution] The light emitting element has a semiconductor structure 11 which has a light emitting layer 8; a light extracting surface 18 which is provided in one main surface side of the semiconductor structure 11; and an electrode 3, which is provided in the other main surface side of the semiconductor structure 11 and electrically

[Selected Drawing] FIG. 1



A light emitting element comprising

- a semiconductor structure (11) having a light emitting layer (8),
- a light extracting surface (18) which is provided in one main surface side of the semiconductor structure (11),
- and
- an electrode (3), which is provided in the other main surface side of the semiconductor structure (11) and electrically connected to the semiconductor structure (11), wherein

- a reflecting structure (4) is formed between the semiconductor structure (11) and the electrode (3),
- the reflecting structure (4) is composed of a first reflecting layer (4a), which reflects the center wavelength, corresponding to the wavelength of the light from the light emitting layer (8), and a second reflecting layer (4b) which sets the wavelength different from the center wavelength as the center wavelength, and
- at least one of the center wavelength of the first reflecting layer (4a) or the second reflecting layer (4b) is in visible light region.

The light emitting element according to claim 1, wherein
the center wavelength of the first reflecting layer (4a) is shorter than the wavelength of light from the light emitting layer, and

the center wavelength of the second reflecting layer (4b) is longer than the wavelength of the light from the light emitting layer.

[Claim 3]

The light emitting element according to claim 1 or 2, wherein
the center wavelengths of the first reflecting layer (4a) and the second reflecting layer (4b) are different in hue from each other, and are in complementary color relation.

[Claim 4]

The light emitting element according to any one of claims 1 to 3, wherein
the center wavelength of the reflected light of the first reflecting layer (4a) is 0.8 times or more and less than 1.0 times the wavelength of the light from the light emitting layer (8), and
the center wavelength of the reflected light of the second reflecting layer (4b) is 1.15 times or more and 1.40 times or less the wavelength of the light from the light emitting layer (8).

[Claim 5]

The light emitting element according to any one of claims 1 to 4, wherein
the wavelength of light emitted from the light emitting layer (8) is in the range of 360 nm to 650 nm.

[Claim 6]

The light emitting element according to any one of claims 1 to 5, wherein
the reflecting structure (4) further comprises a third reflecting layer, and wherein
the center wavelength of the reflected light of the third reflecting layer is in the wavelength range between the center wavelengths of the first reflecting layer (4a) and the second reflecting layer (4b).

[Claim 7]

The light emitting element according to any one of claims 1 to 6, wherein
the reflecting structure (4) is a dielectric multilayer film formed by laminating two or more kinds of material films.

[Claim 8]

The light emitting element according to any one of claims 1 to 7, wherein
the reflecting structure groups (34) in which a plurality of the reflecting structures (4) are arranged in a horizontal direction at a predetermined interval are laminated to be separated substantially in parallel over a plurality of stages, and
in the reflecting structure group (34) in each stage, the reflecting structure (4) in the upper stage is formed so as to cover at least a part of the opening of the separating region in the horizontal direction of the reflecting structure (4) located in the lower stage.

[Claim 9]

The light emitting element according to any one of claims 1 to 8, wherein
the reflecting structure (4) is formed on at least a part of the semiconductor structure (11) through an insulating film (16).

[Claim 10]

The light emitting element according to any one of claims 1 to 9, wherein
a translucent conductive layer (13) is coated on the main surface of the semiconductor structure (11), and the reflecting structure (4) is formed on at least a part of the translucent conductive layer (13), and
the electrode (3) comprises a metal electrode layer (23) in contact with the reflecting structure (4) and the translucent conductive layer (13).

[Claim 11]

A light emitting device comprising
a light emitting element (10) and
a wavelength conversion member (12) capable of converting the wavelength of light emitted from the light emitting element (10), wherein
the light emitting element (10) is a light emitting element according to any one of claims 1 to 10.

[Claim 12]

The light emitting device according to claim 11, wherein
the wavelength conversion member (12) is disposed in contact with or close to the light extracting surface (18) of the light emitting element (10).

[Claim 13]

The light emitting device according to claim 11 or 12, wherein
the light emitting element is an LED having an emission peak wavelength of 360 nm to 800 nm, and
the wavelength conversion member (12) includes at least one phosphor selected from the group consisting of LAG, BAM, BAM: Mn, YAG, CCA, SCA, SCESN, SESN, CESN, CASBN, and CaAlSiN₃: Eu.

[Detailed Description of the Invention]

[Technical Field]

[0001]

The present invention relates to a light emitting element having a reflecting structure and a light emitting device provided with the element.

[Background]

[0002]

A light emitting device capable of emitting light of various colors has been developed based on the principle of color mixture of light by combining the source light emitted from the light emitting element with the wavelength conversion member that can be excited by the source light to emit light of a different hue from the

source light. Particularly, in recent years, the next-generation lighting with lower power consumption and long life has been gathering attention, and a high quality light emitting device with further improvement in light emission output and excellent weather resistance has been demanded.

[0003]

In the above light emitting device, an example of the method for improving output includes the following: When the primary light from a light source or the secondary light after wavelength conversion is directed to a member constituting a light emitting device, measures have been taken to prevent some of the light from being absorbed and causing light loss. As a proposal, a light emitting device has been developed wherein the surface of the electrode of the light emitting element is covered with a highly reflective Ag layer (Patent Document 1). For example, the light emitting element 100 shown in FIG. 13 is a face-down type element whose main light emitting surface is the substrate 101 side (upper side) opposite to the electrode forming surface side (lower side in FIG. 13) when mounted on a circuit board or the like and is illustrated upside down to show this. That is, the light emitting element 100 is formed by sequentially stacking the n-type semiconductor layer 102, the active layer 103, and the p-type semiconductor layer 104 on the substrate 101. The n-side electrode 106 is provided in the exposed region of the n-type semiconductor layer 102, and the p-side electrode 105 is provided on the p-type semiconductor layer 104, respectively. Furthermore, the p-type electrode 105 is composed of a first metal layer 105a made of an Ag layer having high reflectance and a second metal layer 105b covering the surface thereof.

[0004]

With this structure, when primary light and secondary light from the light source in the light emitting device is directed to the electrode 105 side, the light can be reflected by the Ag layer having high reflectance and can be guided to the substrate 100 side which is the main light emitting surface; therefore, light absorption to the metal electrode can be suppressed and light extraction efficiency can be improved.

[0005]

However, Ag may be susceptible to corrosion and ion migration under high temperature, high humidity, and an electric field. If migration occurs, the electrode layer is disturbed, thereby causing problems such as a decrease in emission intensity and a reduction in life span due to a short circuit. Therefore, in order to suppress these problems, for example, in the light emitting element 100 of FIG. 13, the first reflecting layer which is an Ag layer is covered with a second metal layer 105b made of a metal element other than Ag such as V and Ti. In addition, it is necessary to take some measures against migration, for example, forming the electrode with an alloy layer containing Ag, which causes a problem that the number of manufacturing steps and the number of parts increase, leading to an increase in cost.

[0006]

Furthermore, a reflecting structure using a nonmetallic reflecting film that can be substituted for a metallic reflecting film such as Ag has been proposed (Patent Document 2). That is, the semiconductor layer surface of the light emitting element is provided with a translucent insulating film having an opening/separating portion via a translucent electrode and a pad electrode that performs conduction to the translucent electrode through the opening/separating portion, and furthermore, a dielectric multilayer reflecting film is provided on the translucent

insulating film. This improves the external quantum efficiency and improves the light extraction efficiency of the light emitted from the light source.

[0007]

On the other hand, a reflecting structure has been proposed, in which by providing the reflecting layer with a dielectric multilayer film in which the region corresponding to reflection is broadened, the light emitted from the light emitting element can be reflected even when it is incident on the reflecting film at an angle, i.e. the reflecting structure has a function of suitably reflecting not only the light of the vertical direction but also the light of oblique incidence (Patent Document 3).

[Patent Document 1] JPH11-220171

[Patent Document 2] JP2005-197289

[Patent Document 3] JPH7-226535

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0008]

However, when the light emitting element having the above reflecting structure is adopted as the light source of the light emitting device, the output of the light emitted from the element alone is improved, but when the element with the enhanced output is applied as an excitation light source of the light emitting device having a wavelength conversion member, an output in a mixed color light could not be obtained as expected.

[0009]

The present invention has been made to solve the above conventional problems. An object of the present invention is to provide a light emitting element which can realize a light emitting device capable of emitting a light emitting wavelength with desired color in high power and which has excellent weather resistance, and to provide a light emitting device provided with the element.

[Means for Solving the Problems]

[0010]

In order to achieve the above object, the first light emitting element of the present invention has a semiconductor structure 11 which has a light emitting layer 8; a light extracting surface 18 which is provided in one main surface side of the semiconductor structure 11; and an electrode 3, which is provided in the other main surface side of the semiconductor structure 11 and electrically connected to the semiconductor structure 11. A reflecting structure 4 is formed between the semiconductor structure 11 and the electrode 3. The reflecting structure 4 is composed of a first reflecting layer 4a, which reflects the center wavelength, corresponding to the wavelength of the light from the light emitting layer 8, and a second reflecting layer 4b which sets the wavelength different from the center wavelength as the center wavelength. At least one of the center wavelengths of the first reflecting layer 4a or the second reflecting layer 4b is in visible light region.

[0011]

In the second light emitting element of the present invention, the center wavelength of the first reflecting layer 4a is shorter than the wavelength of light from the light emitting layer, and the center wavelength of the second reflecting layer 4b is longer than the wavelength of the light from the light emitting layer.

[0012]

In the third light emitting element of the present invention, the center wavelengths of the first reflecting layer 4a and the second reflecting layer 4b are different in hue from each other, and are in complementary color relation.

[0013]

In the fourth light emitting element of the present invention, the center wavelength of the reflected light of the first reflecting layer 4a is 0.8 times or more and less than 1.0 times the wavelength of the light from the light emitting layer 8, and the center wavelength of the reflected light of the second reflecting layer 4b is 1.15 times or more and 1.40 times or less the wavelength of the light from the light emitting layer 8.

[0014]

In the fifth light emitting element of the present invention, the wavelength of light emitted from the light emitting layer 8 is in the range of 360 nm to 650 nm.

[0015]

In the sixth light emitting element of the present invention, the reflecting structure 4 further comprises a third reflecting layer, and wherein the center wavelength of the reflected light of the third reflecting layer is in the wavelength range between the center wavelengths of the first reflecting layer 4a and the second reflecting layer 4b.

[0016]

In the seventh light emitting element of the present invention, the reflecting structure 4 is a dielectric multilayer film formed by stacking two or more kinds of material films.

[0017]

In the eighth light emitting element of the present invention, the reflecting structure groups 34 in which a plurality of the reflecting structures 4 are arranged in a horizontal direction at a predetermined interval are stacked to be separated substantially in parallel over a plurality of stages, and in the reflecting structure group 34 in each stage, the reflecting structure 4 in the upper stage is formed so as to cover at least a part of the opening of the separating region in the horizontal direction of the reflecting structure 4 located in the lower stage.

[0018]

In the ninth light emitting element of the present invention, the reflecting structure 4 is formed on at least a part of the semiconductor structure 11 through an insulating film 16.

[0019]

In the 10th light emitting element of the present invention, a translucent conductive layer 13 is coated on the main surface of the semiconductor structure 11, and the reflecting structure 4 is further formed on at least a part of the translucent conductive layer 13, and the electrode 3 comprises a metal electrode layer 23 in contact with the reflecting structure 4 and the translucent conductive layer 13.

[0020]

The 11th light emitting element of the present invention is the light emitting device comprising a light emitting element 10 and a wavelength conversion member 12 capable of converting the wavelength of light emitted from the light emitting element 10, wherein the light emitting element 10 is any one of the light emitting elements according to the first to tenth aspects of the present invention.

[0021]

In the 12th light emitting element of the present invention, the wavelength conversion member 12 is disposed in contact with or close to the light extracting surface 18 of the light emitting element 10.

[0022]

In the 13th light emitting element of the present invention, the light emitting element is an LED having an emission peak wavelength of 360 nm to 800 nm, and the wavelength conversion member 12 includes at least one phosphor selected from the group consisting of LAG, BAM, BAM: Mn, YAG, CCA, SCA, SCESN, SESN, CESN, CASBN, and CaAlSiN₃: Eu.

[Effects of the Invention]

[0023]

According to the light emitting element of the present invention, the light directed to the electrode formed on the surface side opposite to the light extracting surface can be reflected to the light extracting surface side by the reflecting structure. Thus, light loss due to absorption at the electrode can be reduced and external quantum efficiency can be enhanced.

[0024]

Moreover, with the light emitting element of the present invention, in particular, it is possible to improve the light output of the light emitting device having a wavelength conversion member capable of converting the wavelength of the light emitted from the light emitting element. This is because not only the light output from the active layer but also the secondary light, i.e., the wavelength-converted light by the wavelength conversion member, can be reflected with high efficiency; therefore, the output of the component light constituting the mixed color can be increased, and the output of the emitted light as the whole device can be improved. Since each component light is reflected by the same reflecting structure in the element, it can be a light emitting device with excellent light collectivity and directivity of primary light and secondary light. Furthermore, by using the reflecting structure having wavelength selectivity, it is possible to correct the hue difference between

the reflected primary light and the secondary light; thus, it is possible to reduce color unevenness of mixed colors between light emitting devices.

[Best Mode for Carrying Out the Invention]

[0025]

The embodiments of the present invention will now be described with reference to the drawings. However, the embodiments described below are to exemplify the light emitting element and the light emitting device provided with the element for embodying technical ideas of the present invention, and the present invention is not to be limited to the light emitting element and the light emitting device provided with the element described below. Furthermore, in the present specification, in order to facilitate the understanding of the claims, the numbers corresponding to the members shown in the embodiments are added to the members shown in the section of "What is Claimed is" and "Means for Solving the Problems." However, the members shown in the claims are not limited to the members of the embodiment. Particularly, the dimensions, materials, shapes, relative arrangements, and the like of the components described in embodiments are not intended to limit the scope of the present invention thereto unless specifically described otherwise, and are merely illustrative examples.

[0026]

Note that the size, positional relation and the like of the members shown in each drawing may be exaggerated for the sake of understanding the description clearly. Further, in the following description, the same names and reference numerals indicate the same member or the same quality as the member, and the detailed description will be appropriately omitted. Furthermore, each of the elements constituting the present invention may be configured such that a plurality of elements is constituted by the same member and one member may be used as the plurality of elements, or conversely, the function of one member can be shared and realized by a plurality of members. Further, in the present specification, the term "on," for example "on the layer," is not necessarily limited to the case of being formed in contact with the upper surface, but also includes the case in which something is separated and formed upward, and also includes the case where there is an intervening layer between layers.

[0027]

(Embodiment 1)

A light emitting device 1 according to the embodiment 1 of the present invention is shown in the cross-sectional view of FIG. 1. The light emitting element 10 mounted on the light emitting device 1 in this figure employs an LED chip which is an example of a nitride semiconductor element, and this LED chip is a flip chip mounted on a submount which is one of the wiring substrates 9. The flip chip mounting is a mounting method in which the side of the growth substrate 5 facing the electrode forming surface is a main light extraction surface, and is also called face-down mounting. The light emitting element 10 of FIG. 1 is displayed upside down to indicate that it is flip chip mounting.

[0028]

In the light emitting device 1 of FIG. 1, the wavelength conversion member 12 is disposed in the vicinity of the light emitting element 10 that is flip-chip mounted, and the wavelength conversion member 12 converts the wavelength of light emitted from the active layer 8. Thus, the light emitting device capable of emitting a desired light can be obtained by additive color mixing of the light emitted from the active layer 8 and the light wavelength converted by the wavelength conversion member.

[0029]

The light emitting element 10 has a semiconductor structure 11 having a light emitting layer 8. In the light emitting element 10 of FIG. 1, a nitride semiconductor layer as the semiconductor structure 11 is stacked on one main surface of the growth substrate 5 having a pair of main surfaces facing each other. Specifically, in the light emitting element 10 of FIG. 1, the nitride semiconductor layer 11 provided with a first nitride semiconductor layer 6, an active layer 8 and a second nitride semiconductor layer 7 in this order is stacked on the lower surface side of the growth substrate 5. In addition, the first nitride semiconductor layer 6 and the second nitride semiconductor layer 7 are respectively provided with a first electrode 3A and a second electrode 3B which are electrically connected. The light emitting element 10 emits light from the active layer 8 when power is supplied from the outside through the first electrode 3A and the second electrode 3B, and mainly extracts light from the upper surface side of the growth substrate 5 in FIG. 1. That is, in the light emitting element 10 of FIG. 1, the other main surface side (upper side of FIG. 1) opposite to the mounting surface side (lower side of FIG. 1) of the electrodes 3A and 3B is set as the main light extracting surface 18 in the growth substrate 5.

[0030]

Furthermore, a pair of electrodes 3 composed of the first electrode 3A and the second electrode 3B has reflecting structure 4, respectively. Example of the reflecting structure 4 includes a dielectric multilayer film 4 composed of a multilayer structure. The dielectric multilayer film 4 in the example of FIG. 1 is a multilayer structure in which two or more types of material films having different refractive indexes are alternately stacked, and is provided in at least a part between the semiconductor structure 11 and the electrode 3 and can selectively reflect desired wavelength light. FIG. 2 is an enlarged view around the second electrode 3B in the light emitting device of FIG. 1. The detailed structure of the dielectric multilayer film 4 will be described later, but in the example of FIG. 2, the dielectric multilayer film 4 composed of the first reflecting layer 4a and the second reflecting layer 4b is horizontally formed to be separated from each other. The first reflecting layer 4a has a reflection region which sets the light from the light emitting layer 8 as the center wavelength. On the other hand, the second reflecting layer 4b has a reflection region which sets the wavelength different from the center wavelength of the light from the light emitting layer 8 as the center wavelength. Furthermore, at least one of the center wavelengths of the first reflecting layer 4a and the second reflecting layer 4b is in the visible light region. In addition to the first reflecting layer 4a and the second reflecting layer 4b, the dielectric multilayer film 4 may have a third reflecting layer having reflection characteristics different from the center wavelength of these reflecting layers. The center wavelength of the third reflecting layer is preferably in the wavelength range between the center wavelengths of the first reflecting layer 4a and the second reflecting layer 4b. Thus, the occurrence of the valley of the transmittance due to the interference action of the dielectric multilayer film 4 can

be suppressed, and a highly efficient reflection effect can be continuously realized in a predetermined wavelength range. Also, the stacking order of the reflecting layers in the dielectric multilayer film 4 is not particularly limited. Each component of the light emitting device 1 will now be described in detail.

[0031]

(Light emitting element)

FIG. 3 is a schematic cross-sectional view showing a state of the light emitting element 10 of FIG. 1 before flip chip mounting, i.e. the state where the growth substrate 5 is set as the lowermost layer and the semiconductor structure 11 is stacked thereon. In actual manufacturing process of the light emitting device, the nitride semiconductor element in which each layer is stacked on the upper surface of the growth substrate 5 is mounted upside down as shown in FIG. 1. FIG. 4 is a plan view of the light emitting element 10, and is an explanatory view explaining the manufacturing process in which the reflecting structure is formed. FIGS. 5 and 6 show plan views of the light emitting element in one manufacturing process, respectively. Note that the same components are denoted by the same reference numerals and the detailed description thereof is omitted. Hereinafter, a method for manufacturing a semiconductor element will be described with reference to FIGS. 1 to 6.

[0032]

As light emitting element 10, for example, the nitride semiconductor element such as an LED shown in FIG. 3 has a nitride semiconductor layer 11, in which an n-type semiconductor layer as a first nitride semiconductor layer 6, a light emitting layer as an active layer 8, and a p-type semiconductor layer as a second nitride semiconductor layer 7 were epitaxially grown on a sapphire substrate as a growth substrate 5 in this order, and further has a translucent conductive layer 13 formed on the nitride semiconductor layer 11. Examples of the crystal growth method that can be used include methods such as metal-organic chemical vapor deposition (MOCVD), hydride vapor phase epitaxy (HVPE), hydride CVD, molecular beam epitaxy (MBE) and the like.

[0033]

Subsequently, the light emitting layer 8 and a part of the p-type semiconductor layer 7 are selectively etched and removed to expose a part of the n-type semiconductor layer 6, and further, an n-type pad electrode which is the first electrode 3A is formed. A p-type pad electrode, which is the second electrode 3B, is formed on the same side as the n-type electrode 3A and on the translucent conductive layer 13. Furthermore, only predetermined surfaces of the n-type pad electrode 3A and the p-type pad electrode 3B can be exposed, and the other part can be covered with an insulating protective film. Note that the n-type pad electrode may be formed on the exposed region of the n-type semiconductor layer 6 via the translucent conductive layer 13. The components of the semiconductor light emitting element 1 will be specifically described below.

[0034]

(Growth substrate)

The growth substrate 5 is a substrate on which the semiconductor layer 11 can be epitaxially grown, and the size, thickness and the like of the substrate are not particularly limited. Examples of the substrate in the nitride

semiconductor include an insulating substrate such as sapphire having a main surface of any of C plane, R plane and A plane, spinel (MgAl_2O_4) and the like, silicon carbide (6H, 4H, 3C), silicon, ZnS, ZnO, Si, GaAs, diamond, and an oxide substrate such as lithium niobate and neodymium gallate which are capable of forming a lattice matching with the nitride semiconductor, and a nitride semiconductor substrate such as GaN and AlN. The off-angle substrate (e.g. 0.01° to 3.0° for sapphire C-plane) can also be used. A semiconductor element structure without a substrate in which the growth substrate 5 is removed after forming the semiconductor layer 11; the structure in which the extracted semiconductor layer is bonded to a supporting substrate, such as a conductive substrate, and flip chip mounted; and the structure in which another translucent member/translucent substrate is bonded to the semiconductor layer, may be used. Specifically, the following structure may be used: In the case where the main surface of the light extraction side of the semiconductor layer has a growth substrate and bonded member/substrate, it is made translucent, in the case of non-translucent, light-shielding, or light-absorbing growth substrate, it is removed, and in the case where the semiconductor layer is bonded to such a substrate, it is provided on the light reflection side of the main surface of the semiconductor layer. In the case of supplying an electric charge to the semiconductor layer from the translucent substrate/member on the light extraction side, it is preferable to use a conductive one. In addition, an element having a structure in which the semiconductor layer is bonded and covered and supported with a translucent member such as glass or resin may be used. The growth substrate can be removed, for example, by polishing or LLO (Laser Lift Off) by holding it on the chip mounting portion of the device or submount. Even if it is a translucent different type substrate, the light extraction efficiency and the output can be preferably improved by removing substrate.

[0035]

(Semiconductor layer)

As the semiconductor layer 11, the nitride semiconductor described in the embodiment and below has a short wavelength region and a near ultraviolet region of the visible light region, or a shorter wavelength region; and hence, is preferably used in the light emitting device which has a combination of these above points and the light conversion member (phosphor). Further, without being limited thereto, a semiconductor such as InGaAs type or GaP type may be used.

[0036]

(Light emitting element structure)

For the light emitting element structure by the semiconductor layer, the structure having an active layer between the first conductivity type (n type) and the second conductivity type (p type) layers described later is preferable in terms of output and efficiency. Other light emitting structures such as a structure described later without being limited thereto may also be used. It may be a structure in which each conductivity type layer may be partially provided with an insulating, semi-insulating or reversed conductivity type structure, or they may be additionally provided to the first and second conductivity type layers. It may be a structure which additionally has another circuit structure, for example a protective element structure, or it may be a structure in which the substrate plays a part of the conductivity type of the light emitting element.

[0037]

The electrode provided in the semiconductor layer preferably has a structure in which the electrode of the first conductivity type (n-type) and the second conductivity type (p-type) layer is provided on one main surface side described in the embodiment and below. However, without being limited thereto, a structure may be employed in which electrodes are provided facing each main surface of the semiconductor layer, for example, a structure in which the electrode is provided on the removal side in the substrate removal structure.

[0038]

(Nitride semiconductor layer)

As a nitride semiconductor, a general formula is $\text{In}_x\text{Al}_y\text{Ga}_{1-x-y}\text{N}$ ($0 \leq x, 0 \leq y, x + y \leq 1$), and B, P or As may be mixed crystal. The n-type semiconductor layer 6 and the p-type semiconductor layer 7 do not particularly limit to single layer and multilayer. The nitride semiconductor layer 11 has a light emitting layer 8 which is an active layer, and this active layer has a single (SQW) or multi-quantum well structure (MQW). The details of the nitride semiconductor layer 11 are shown below.

[0039]

The following structure is used, in which the growth substrate has a base layer of the nitride semiconductor such as a buffer layer, for example, through a low temperature growth thin film GaN and a GaN layer; a n-type nitride semiconductor layer, for example, a Si-doped GaN n-type contact layer and GaN/InGaN n-type multilayer; and a p-type nitride semiconductor layer, for example, a Mg-doped InGaN / AlGaIn p-type multilayer and Mg-doped GaN p-type contact layer; and furthermore, there is an active layer between the p-type and n-type layers.

[0040]

The light emitting layer 8 (active layer) of the nitride semiconductor has, for example, a quantum well structure including a well layer made of $\text{Al}_a\text{In}_b\text{Ga}_{1-a-b}\text{N}$ ($0 \leq a \leq 1, 0 \leq b \leq 1, a + b \leq 1$) and a barrier layer made of $\text{Al}_c\text{In}_d\text{Ga}_{1-c-d}\text{N}$ ($0 \leq c \leq 1, 0 \leq d \leq 1, c + d \leq 1$). The nitride semiconductor used in the active layer may be any of non-doped, n-type impurity doped, and p-type impurity doped; however, the power of the light emitting element can be increased by preferably using a non-doped or n-type impurity doped nitride semiconductor. The barrier layer is formed of a nitride semiconductor having a band gap energy larger than the well layer. By including Al in the well layer, it is possible to obtain a wavelength shorter than the wavelength 365 nm, which is the band gap energy of GaN. The wavelength of light emitted from the active layer is set to a wavelength of about 360 nm to 650 nm, preferably 380 nm to 560 nm, depending on the application and the purpose of the light emitting element.

[0041]

The composition of the well layer is preferably InGaIn used in the visible light/near-ultraviolet region, and the composition of the barrier layer at that time is preferably GaN or InGaIn. A single quantum well structure of one well layer, where the thickness of the well layer is preferably 1 nm or more and 30 nm or less, more preferably 2 nm or more and 20 nm or less, or a multi-quantum well structure of a plurality of well layers via a barrier layer can be made.

[0042]

The stacked structure of the nitride semiconductor layer 11 include a homostructure having a MIS junction, PIN junction or a PN junction, a heterostructure or a double heterostructure. Further, each layer may have a superlattice structure, or may have a single quantum well structure or a multi-quantum well structure in which the light emitting layer 8, which is an active layer, is formed in a thin film in which a quantum effect occurs.

[0043]

Then, a mask having a predetermined shape is formed on the surface of the p-type semiconductor layer 7, and the p-type semiconductor layer 7 and the light emitting layer 8 which is an active layer are etched. Thus, as shown in FIG. 4(a), the n-type contact layer 6a constituting the n-type semiconductor layer 6 at a predetermined position is exposed.

[0044]

(Light reflecting structure)

Specifically, regarding the basic structure of the light emitting element of the present invention, one of the two main surfaces of the semiconductor layer facing each other is the light extraction side, and the other is the light reflection side. A light reflecting structure is provided on the light reflection side; particularly, it is provided in a region having a light emitting structure such as an active layer.

[0045]

The light reflecting structure is provided as a part of the electrode structure, an overlapping structure with the electrode structure, an in-plane separation structure with the electrode structure, or the like. Preferably, the overlapping structure is used to increase the light emitting area corresponding to the light emitting structure and to enhance the charge injection efficiency. Specifically, the reflecting structure is provided between a translucent conductive layer which is an electrode on the semiconductor layer contact side and an external connection (pad) electrode connected to the outside of the device. The reflecting structure between the electrodes is structured to perform conduction between the electrodes. Specifically, although it is preferable to have a structure in which the conduction path and the reflection area shown below are separately disposed in the plane, it may be a conductive reflecting structure without being limited thereto. Since the reflecting structure of this in-plane separation has a conduction structure in the separate region, it can be made as insulating. Note that when the electrode is provided on the light extraction side, it is possible to use a partial electrode, an optically transparent electrode, a translucent electrode, or a combination of these.

[0046]

The reflecting structure of the present invention has a reflecting portion whose reflectance depends on the light emitting wavelength, and specifically, the following dielectric multilayer film, DBR or the like is used. In addition to the wavelength dependent reflecting portion, the reflecting structure may additionally have a translucent film that causes reflection by the difference in the refractive index with the semiconductor layer, the translucent member (wavelength dependent reflector, electrode), and a metal reflecting film. In that case, these translucent members are disposed on the semiconductor layer side, and the light-shielding metal reflecting film is disposed on the outside thereof. The arrangement of the wavelength dependent film and the translucent film is not particularly limited. Preferably, when the translucent film and the wavelength dependent film are provided in this order from the semiconductor layer side, each function can be preferably enhanced by functionally separating the reflection function of the refractive index difference by the translucent film and the reflection of the wavelength and direction dependence by the wavelength dependent film.

[0047]

These reflecting structures include not only structures provided one by one, but also include a multiple structure as described later, for example, an overlapping structure in which the reflecting structure provided with each film/member is repeated, or a structure multiplexed or provided with a plurality of films/members of the reflecting structure. Specifically, the former overlapping of reflecting structure is a structure as shown in FIG. 10 described later, and the latter multiplexing of constituent films and members is a structure in which various wavelength dependent

films, for example, dielectric multilayer films having different center wavelengths are stacked. Note that, although each film/member constituting reflecting structure are integrally formed and the example thereof is shown below. However, without being limited thereto, each film and member can also be made into a mutually different shape and pattern.

[0048]

In the above, the reflecting structure provided corresponding to the light emitting structure has been described. However, without being limited thereto, the reflecting structure can be provided in a non-light emitting region such as an n-electrode region described later, the side surface of the semiconductor layer or the side surface of the light emitting structure, or the region of the element surface. For example, it can be provided in a superimposed manner corresponding to a protective film described later.

[0049]

Hereinafter, the translucent conductive layer (electrode), the dielectric multilayer film, the insulating film (translucent film), the electrode, and the protective film in the reflecting structure will be described in order.

[0050]

(Translucent conductive layer)

Furthermore, the translucent conductive layer 13 is formed on the p-type semiconductor layer 7. As shown in FIG. 4(b), a conductive layer is formed on almost the entire surface of the p-type semiconductor layer 7 and the exposed n-type semiconductor layer 6, so that the current is spread uniformly throughout the p-type semiconductor layer 7, thereby providing translucency; and thus, a reflecting structure can be provided thereon.

[0051]

Also, the covering region of the translucent conductive layer 13 can be limited to the semiconductor layers, both the n-type semiconductor layer 6 and the p-type semiconductor layer 7 as well as limited to only one of the semiconductor layers. In the example of FIG. 4 (b'), the translucent conductive layer 13 is not formed on the n-type semiconductor layer 6, but is coated only on the p-type semiconductor layer 7.

[0052]

The translucent conductive layer 13 is made of an oxide containing at least one element selected from the group consisting of Zn, In, and Sn, although there are many types such as transparent electrode. Specifically, it is preferable to form a translucent conductive layer 13 containing an oxide of Zn, In, Sn such as ITO ZnO, In_2O_3 , SnO_2 or the like; preferably ITO is used. As an alternative, a thin metal film such as Ni having a thickness of 30Å, oxides and nitrides of other metals, compounds thereof, a light transmitting structure such as a metal film having a window opening, or a composite of the above may be used. Thus, the conductive layer is formed on almost the entire surface of the exposed p-type semiconductor layer 7 so that the current can be uniformly spread throughout the p-type semiconductor layer 7.

[0053]

The thickness of the translucent conductive layer 13 is, for example, 1 μm or less, specifically 10 nm to 500 nm, in consideration of the light absorption and electric resistance/sheet resistance of the layer, i.e., the reflecting structure of light and current spreading. Further, it is preferable to set the wavelength λ of the light emitted from the active layer 8 approximately to an integral multiple of $\lambda/4$ because the light extraction efficiency is increased.

[0054]

(Dielectric multilayer film)

Specifically, the dielectric multilayer film 4 shown in FIG. 2, FIG. 3 and FIG. 4 (c) is formed on at least a part of the interface 19 between the nitride semiconductor layer 11 and the electrode 3, and preferably formed so as to cover substantially the entire semiconductor layer and translucent conductive layer in a predetermined pattern. The number

of in-plane arrangements of the dielectric multilayer film 4 is not particularly limited, but in the case of forming a plurality of multilayer films, it is preferable to be separated from each other. Particularly, as shown in FIG. 3, when the reflecting structures are formed through insulating film 16, they are preferably arranged horizontally while being separated at a predetermined interval so as to open at least a part of the interface 19 with the translucent conductive layer 13. Thus, power can be supplied from the external electrode side to the nitride semiconductor layer 11 side without blocking the conduction path 32 (see the arrow in FIG. 2) of the power supplied from the electrode.

[0055]

The dielectric multilayer film 4 according to the first embodiment has a multilayer structure in which two or more types of material films having different refractive indexes are alternately stacked. The dielectric multilayer film 4 can reflect a predetermined wavelength with high efficiency. This is a multilayer film in which the dielectric multilayer film 4 is formed by alternately stacking films having different refractive indexes in a thickness of $1/4$ wavelength. An example of the dielectric multilayer film 4 is preferably a dielectric multilayer film in which at least two selected from at least one oxide or nitride selected from the group consisting of Si, Ti, Zr, Nb, Ta, and Al are repeatedly stacked. More preferably, it is comprised of a material made of a nonmetallic element, or has a stacked structure of oxide, for example, a stacked structure of $(\text{SiO}_2/\text{TiO}_2)_n$ (where n is a natural number).

[0056]

The dielectric multilayer film 4 shown in FIG. 3 has a structure in which the first reflecting layer 4a which sets the light from the active layer 8 as the center wavelength and the second reflecting layer 4b which sets the wavelength different from this center wavelength as the center wavelength are stacked. Also, the second reflecting layer 4b can have a center wavelength longer than the first reflecting layer 4a and a reflection band wider than the first reflecting layer 4a. Specifically, the second reflecting layer 4b has a reflection characteristic corresponding to a wavelength range of 1.15 times to 1.40 times, preferably 1.20 times to 1.35 times the wavelength of light from the light emitting layer 8. It is preferable that the center wavelength of at least one reflecting layer of the first reflecting layer 4a and the second reflecting layer 4b is in the visible light region, and that both reflecting layers have different hues from each other.

[0057]

The second reflecting layer 4b preferably has a constant center wavelength and is composed of a pair of layers, more preferably a plurality of pairs of layers. Further, as another form, it may preferably have a plurality of sets of layers of the constant center wavelength; for example, it may have two sets, for example, the second and third reflecting layers in the below-mentioned embodiment, or more layers, preferably one set or two sets. Further, in order to correspond to the above wavelength range, the range can be broadened by having a plurality of layer pairs in which the thickness of each layer in multilayer film or the center wavelength is gradually shifted within the above wavelength range by continuously varying film thickness satisfying a predetermined arithmetical series or geometrical series.

[0058]

The reflecting structure 4 in the example of FIG. 3 has a first reflecting layer 4a corresponding to a narrow wavelength range and a second reflecting layer 4b corresponding to a wide wavelength range. As a result, the variation in the wavelength of the secondary light due to the variation in Stokes shift caused by the error in the energy conversion amount can be covered by the wide range second reflecting layer 4b. That is, by making each reflecting structure correspond to the light emission characteristic of the component light of the mixed light, the output of the component light can be enhanced, and as a result, a high output mixed color can be obtained. Also, by selecting the wavelength range of reflection, it is possible to obtain emitted light with improved color rendering property. On the

other hand, it can also play the role of a filter to reduce the enhancement of the output of the secondary light having an undesired hue.

[0059]

Particularly, in the case of light emitting device in which a yellow phosphor is combined with a blue excitation light source which is a visible light, since a white LED can be configured with only a single phosphor, optical characteristics can be easily adjusted and high conversion efficiency can be obtained. Also, when compared with color conversion from ultraviolet light, the Stokes shift is small and the essential energy conversion can be improved. Furthermore, since the transmitted light of the blue LED can be used, the light emitting efficiency is high. Therefore, by mounting the reflecting structure according to the hue on the light emitting device having the source light and the fluorescence based on the combination of the hues described above, the light loss can be reduced and higher output can be further achieved.

[0060]

By adopting the reflecting structure corresponding to the wavelength of the component light of the mixed light emitted from the light emitting device, the hue of the component light can be substantially unified, so the variation of the emission color among the light emitting element or the light emitting device can be reduced. Furthermore, in the dielectric multilayer film, by limiting the center wavelength of the reflection to the source light and the light emitting wavelength of the wavelength conversion member after excitation, it can be made thinner compared to gratings of a wide range of wavelengths, and manufacturing process can be simplified. In addition, when the primary light as a light source is incident on the dielectric multilayer film at an angle, the inclined light shifted to the long wavelength side can be reflected by the second reflecting layer 4b, and the light extraction efficiency of the element can be improved.

[0061]

(Formation pattern of dielectric multilayer film)

Any patterns may be used for forming dielectric multilayer film 4. These patterns are formed on the resist pattern by methods such as reactive ion etching (RIE), ion milling, and lift-off. Preferable opening shape includes a stripe shape shown in FIG. 5, a dot shape shown in FIG. 6, or a block shape. In the example of FIG. 4(c), the openings 35 of the dielectric multilayer film 4 are patterned in a dot shape. As shown in FIG. 3, the dielectric multilayer film 4 has an exposed region of the translucent conductive layer 13 by providing at least openings 35. Thus, by partially exposing the ITO and contacting with the pad electrode, this region, as shown in FIG. 2, becomes the conduction path 32, and the contact resistance can be substantially reduced to reduce the forward voltage. Note that the formation pattern of the dielectric multilayer film 4 is not limited to the above example. For example, the shape of the dot may be circular, oval, rectangular, or polygonal; the height, width and depth of the block pattern may be appropriately changed; the block may be triangular, circular, semicircular or polygonal; or the arrangement of these may be staggered; or the shape or arrangement of various formations/openings may be used. The present invention is not limited to the example of uniformly arranging the whole, and the size and density may be appropriately changed for each area, or the above patterns may be combined.

[0062]

Although the reflecting structure is formed only on the p-type semiconductor layer 7 in the plan view of FIG. 4(c), as shown in FIG. 3, it can also be provided in the n-type semiconductor layer 6. If the reflecting structure is formed on both the first and second electrodes 3A and 3B, the light directed to both regions can be selectively reflected to effectively reduce the loss of light having a predetermined wavelength. In the light emitting device of the embodiment 1, both electrodes are disposed on the same side, so forming the reflecting structure on both electrodes results in

providing a reflecting structure region on almost the whole of the main surface of the light emitting element, thereby enhancing the light extraction efficiency.

[0063]

In the light emitting element 10 of FIG. 3, the optical characteristics of the dielectric multilayer film 4 formed on both the electrodes 3, more preferably reflecting structure, are substantially the same. So, if the dielectric multilayer film 4 is substantially the same for both electrodes, color unevenness due to the light source of the light emitting device 1 can be reduced and in addition, the manufacturing process can be simplified by simultaneously forming on both electrodes. On the other hand, each dielectric multilayer film 4 mounted on each electrode 3A and 3B may have different optical characteristics. For example, the thickness of the reflecting layer can be determined by considering the incident angle of light by the portion of the electrode, the distance from the wavelength conversion member, and the like.

[0064]

(Insulating film)

In the nitride semiconductor element 10 of FIG. 2, a translucent insulating film 16 may be interposed between the translucent conductive layer 13 and the dielectric multilayer film 4 appropriately formed on the semiconductor structure 11, and preferably provided in the reflecting structure. The translucent insulating film 16 has high translucency so as to efficiently reflect the light from the light emitting element 10 and partially transmit the light to the multilayer film 4. Therefore, the insulating film 16 is preferably made of an oxide, and more preferably an oxide of at least one element selected from the group consisting of Si and Al. Specifically, SiO_2 , Al_2O_3 and the like are used, and preferably SiO_2 is used.

[0065]

The thickness of the insulating film 16 is not particularly limited, and the insulating film can be formed with a thickness of about 10 nm to 2 μm . Particularly, the thickness of insulating film 16 in the case of being provided together with a metal electrode layer formed on the upper surface of the insulating film 16 is preferably from 10 nm to 500 nm.

[0066]

(Electrode)

After the reflecting structure including dielectric multilayer film 4 is formed on the translucent conductive layer 13, as shown in FIGS. 3 and 4 (d), a metal electrode layer 23 is formed and electrically connected to the translucent conductive layer. The metal electrode layer 23 is formed on the side of the first electrode 3A and the second electrode 3B in contact with the translucent conductive layer 13 appropriately provided on the p-type semiconductor layer 7 and n-type semiconductor layer 6 sides and the dielectric multilayer film 4 which is a reflecting structure.

[0067]

The metal electrode layer electrically connects the light emitting element to the external electrode and functions as a pad electrode. For example, a conductive member 24 such as an Au bump is disposed on the surface of the metal electrode layer, and the electrode of the light emitting element is electrically connected to the external electrode opposed thereto via the conductive member. Also, a part of the metal electrode layer is directly electrically connected to the translucent conductive layer 13. The existing configuration may be appropriately adopted for the pad electrode. For example, it consists of any metal of Au, Pt, Pd, Rh, Ni, W, Mo, Cr, Ti, or an alloy thereof, or a combination thereof. As an example of the metal electrode layer, a stacked structure of W/Pt/Au, Rh/Pt/Au, W/Pt/Au/Ni, Pt/Au or Ti/Rh can be adopted from the lower surface.

[0068]

In the present embodiment, the metal electrode layer is formed in contact with at least a part of the translucent conductive layer 13. In addition, a part of the metal electrode layer in another embodiment according to the present invention may be extended into the through hole provided in the translucent conductive layer 13 or may be provided as a contact portion in direct contact with the nitride semiconductor layer outside the translucent conductive layer 13. Thus, adhesion can be enhanced by the contact portion of the metal electrode layer part.

[0069]

The metal electrode layers formed on the p-type nitride semiconductor layer 7 side and the n-type nitride semiconductor layer 6 side preferably have the same thickness and same kind of metal used. This is because the simultaneous formation can simplify the process of forming the metal electrode layer as compared to the case of forming separately. The electrodes used on the n-type nitride semiconductor layer side in the case of being separately provided include, for example, W/Pt/Au electrode (the thickness thereof is, for example, 20 nm/200 nm/500 nm, respectively), stacked in order from n-type nitride semiconductor layer 6 side, or further Ni--stacked electrode of W/Pt/Au/Ni or Ti/Rh/Pt/Au electrode.

[0070]

(Protective film)

After the metal electrode layer 23 is formed, the insulating protective film 14 can be formed on almost the entire surface of the semiconductor light emitting element 10 except for the region in connection with the external region. In the example of FIG. 4(e), the openings 21 and 22 are respectively formed in the protective film 14 covered with the n-type electrode 3A portion and the p-type electrode 3B portion. For the protective film 14, SiO₂, TiO₂, Al₂O₃, polyimide or the like may be used. As shown in the embodiment, the insulating film 16 and the protective film 14 may be used in combination in the same member, i.e., the protective film 14 and the insulating film 16 are preferably formed in the same process as the same film; hence, the process can be simplified.

[0071]

In the above example, an example of flip-chip mounting of the light emitting element in which the p electrode and the n electrode exist on the same side has been described. However, the present invention can also be applied to a so-called vertical light emitting element in which a pair of electrodes of the light emitting element vertically sandwich the light emitting layer. In the electrodes of the vertical light emitting element, the reflecting layer is provided on at least the electrode on the wiring substrate on which the light emitting element is mounted, so the light directed to the reflecting layer can be reflected to the opposing light extraction surface side. In addition to this, the reflecting structure is also formed on the electrode formed on the light extraction surface side to suppress light absorption to the electrode, whereby external quantum efficiency can be enhanced.

[0072]

(Light emitting device)

The light emitting element obtained by the above method is flip chip mounted on the wiring substrate to obtain a light emitting device. A method of manufacturing the light emitting device 1 shown in FIG. 1 as an example will be described with reference to FIG. 7. First, as shown in FIG. 7(a), the bumps 24 are formed on the wafer 25 that serves as the submount substrate 9, in accordance with the pattern in which the light emitting element 10 is flip-chip mounted. Next, as shown in FIG. 7 (b), the light emitting element 10 is flip chip mounted through the bumps 24. In this example, two LED chips are aligned and mounted in a region where one submount substrate 9 is to be formed. Further, screen printing is performed in FIG. 7 (c). In screen printing, a metal mask is placed on the wafer 25, and the resin that forms the coating layer 26 is then applied and spread with a squeegee. The resin 26 is then cured. After curing the resin, the

metal mask is removed, and dicing is performed as shown in FIG. 7 (d) to cut into submount substrate sizes. The cut submount substrates 9 are each fixed on the support 27 via eutectic layer 28 by eutectic die bonding as shown in FIG. 7 (e). Here, Au—Sn was used as eutectic solder and eutectic was performed at about 290°C. Thereafter, as shown in FIG. 7(e), the electrodes of the submount substrate 9 and the electrodes 29 of the support 27 are wired by wire bonding 31. Further, as shown in FIG. 7(g), a resin lens 36 is fixed by an adhesive or the like so as to cover the outer periphery of the LED chip, to obtain a light emitting device.

[0073]

However, the method of arranging the resin 26 covering the periphery of the light emitting element 10 is not particularly limited. For example, it is possible to form a package which constitutes the interface of the region where the resin 26 is disposed, and to fill the resin 26 inside. Also, the light emitting element may not have a form directly mounted on the predetermined mounting portion of the light emitting device, i.e., no submount. The submount substrate cut out individually or one in which a lens or the like is bonded and sealed thereto can be used as the light emitting device.

[0074]

(Wavelength conversion member)

As shown in FIG. 1, the wavelength conversion member 12 such as a fluorescent material, which emits fluorescence by being excited by the light of the light emitting element 10, is mixed with the resin 26 as the sealing member. That is, a part of the light from the light source excites the phosphor as the wavelength conversion member, to obtain a light having a wavelength different from the wavelength of the main light source; thus, it is possible to achieve emitted light having a desired hue by color mixing. The phosphor can be suitably used as this wavelength conversion member 12. This is because the phosphor also has a light scattering property and a light reflection function; and thus, it can play a role as a light scattering member in addition to the wavelength conversion function and can obtain the light diffusion effect. The phosphor may be mixed into the resin 26 at a substantially uniform ratio or may be blended so as to be partially unevenly distributed. For example, when it comes close to the light emitting element, the amount of the phosphor light reaching the reflecting structure increase, so the light emitting device having high light emission output and efficiency can be obtained. Also, by separating it from the light emitting element 10 by a predetermined distance, the heat generated by the light emitting element 10 is less likely to be transmitted to the phosphor, thereby suppressing the deterioration of the phosphor. Two or more kinds of phosphor may be present in the light emitting layer consisting of one layer on the surface of the light emitting device, or one or two or more kinds of phosphor may be present respectively in the light emitting layer consisting of two layers. Thus, the light emitting device having a desired wavelength can be achieved. Note that, in addition to the resin, it is also possible to use a translucent member such as glass, an aggregate of phosphor particles, and a crystalline member thereof.

[0075]

Representative phosphors 12 include copper-bodied zinc sulfide cadmium and cerium-bodied YAG-based phosphors and LAG-based phosphors. Particularly, $(\text{Re}_{1-x}\text{Sm}_x)_3(\text{Al}_{1-y}\text{Ga}_y)_5\text{O}_{12}:\text{Ce}$ ($0 \leq x < 1$, $0 \leq y \leq 1$, provided that Re is at least one element selected from the group consisting of Y, Gd, La and Lu) or the like is preferable when using for a long time with high brightness. In addition, phosphor containing at least one selected from the group consisting of YAG, LAG, BAM, BAM: Mn, CCA, SCA, SCESN, SESN, CESN, CASBN and $\text{CaAlSiN}_3:\text{Eu}$ can be used.

[0076]

As the wavelength conversion member 12 of the embodiment 1, YAG phosphor is used to obtain, for example, a white color by mixing the light emitted from the light source and the light having a wavelength different from that of

the emitted light when a part of the light is excited by the phosphor 12. As the phosphor, a phosphor glass in which phosphor is mixed with glass or resin, or a phosphor-containing resin may also be used. The phosphor resistant to the heat emitted from the light source and having weather resistance which is not influenced by the use environment is more preferred.

[0077]

In the light emitting device 1, the phosphor may be a mixture of two or more types of phosphors. When using a nitride phosphor or the like that emits yellow to red light, a reddish component can be increased, and in this case, lighting with a high general color rendering index Ra or an LED with electric bulb color can be provided. Specifically, by adjusting the amount of phosphor with different chromaticity points on the CIE chromaticity diagram based on the light emitting wavelength of the light emitting element, it is possible to emit light at any point on the chromaticity diagram that is connected between the phosphors and the light emitting element. In addition to this, examples of phosphor include nitride phosphor, which converts near ultraviolet to visible light into yellow to red region oxynitride phosphor, silicate phosphor, $L_2SiO_4:Eu$ (L is an alkaline earth metal), in particular $(Sr_xMae_{1-x})_2SiO_4:Eu$ (Mae is an alkaline earth metal such as Ca or Ba) and the like. Examples of the nitride group phosphor and the oxynitride phosphor include Sr-Ca-Si-N:Eu, Ca-Si-N:Eu, Sr-Si-N:Eu, Sr-Ca-Si-O-N:Eu, Ca-Si-O-N:Eu, Sr-Si-O-N:Eu, and the like. Examples of the alkaline-earth silicon nitride phosphor can be represented by general formula $LSi_2O_2N_2:Eu$, general formula $L_xSi_yN_{(2/3x+4/3y)}:Eu$, or $L_xSi_yO_zN_{(2/3x+4/3y-2/3z)}:Eu$ (L is Sr, Ca, or Sr and Ca).

[0078]

Specifically, the phosphor 12 according to the embodiment 1 is unevenly distributed around the semiconductor light emitting element 1 as shown in FIG. 1. Thus, the effect of reflecting or scattering the light emitted from the semiconductor light emitting element 1 is enhanced, and since the emission angle of the light emitted from the light emitting device can be made wide, the light diffused in four directions can be obtained. Furthermore, by uniformly covering the wavelength conversion member around the periphery of the light emitting element, the amount of wavelength conversion by the portion of the light emitting device can be made almost constant, thereby reducing the light unevenness for each light emitting device and reducing the light loss. Since the distance until the light emitted from the light emitting element travels to the wavelength conversion member can be made substantially constant, the amount of wavelength conversion and the amount of diffusion become stable. That is, the mixing ratio of the primary light and the secondary light can be made substantially constant, and the emitted light with reduced color unevenness and light unevenness can be obtained.

[0079]

The material of the resin 26 which is a sealing member is not particularly limited as long as it is translucent. Silicone resin compositions, denatured silicone resin compositions and the like are preferably used. However, translucent insulating resin compositions may be used such as epoxy resin compositions, denatured epoxy resin compositions and acrylic resin compositions. Also, excellent weather-resistant sealing members may be used such as hybrid resins containing at least one of these resins. Also, excellent light-resistant inorganic material may be used, such as glass and silica gel. Also, the sealing member can be formed in a desired shape on the light emission side to provide a lens effect. In this case, it is possible to focus light from the light emitting chips. In the embodiment 1, silicone resin is used as the sealing member.

[0080]

(Additive member)

In addition to the wavelength conversion member, appropriate members such as viscosity increasing agent, pigment, fluorescent substance and the like can be added to the sealing member in accordance with the applications. Thus, a light emitting device having desired directional characteristics can be provided. Similarly, various types of coloring agents can be added as a filter material that provides a filter effect cutting off external entering light and light with unnecessary wavelength from the light emitting element.

[0081]

Here, in the present specification, example of the diffusing agent includes the diffusing agent having a central particle size of 1 nm or more and less than 5 μm , which can diffusely reflect the light from the light emitting element 10 and the fluorescent material, and suppress the color unevenness that is easily caused by using a large particle size fluorescent material. In addition, diffusing agent can narrow half value width of an emission spectrum. Thus, a light emitting device with high color purity can be obtained. On the other hand, the diffusing agent of 1 nm or more and less than 1 μm has a low interference effect on the light wavelength from the light emitting element 10, but has high transparency and can increase the resin viscosity without reducing the light intensity.

[0082]

(Filler)

In addition to the fluorescent substance, the sealing member may contain filler. Specific material that can be used includes the same one as the diffusing agent. However, it is preferable that the central particle sizes of the diffusion agent and the filler should be different, and in the present specification, the central particle size of the filler is preferably from 5 μm to 100 μm . When the sealing member contains the filler having such a particle size, the light scattering action can improve the chromaticity variation of the light emitting device as well as the thermal shock resistance of the sealing member.

[0083]

Also, as for the light emitting element installed on the light emitting device, although the light emission peak wavelength of outgoing light emitted from the light emitting layer is not specifically limited, semiconductor light emitting elements can be used that have an emission spectrum of about 240 nm to 500 nm, which corresponds to the near ultraviolet range to the visible short wavelength range, preferably of 380 nm to 420 nm or of 450 nm to 470 nm. In the embodiment 1, the light emitting element 10 obtained by the above manufacturing method was used.

[0084]

(Embodiment 2)

FIG. 8 shows a schematic cross-sectional view of the light emitting element according to the embodiment 2. The light emitting device according to embodiment 2 is different from the light emitting device according to embodiment 1 only in the reflecting structure of the mounted light emitting element, and the other structures are substantially the same. Therefore, in the light emitting element 20 according to the embodiment 2, the same components as those of the light emitting element 10 according to the embodiment 1 are denoted by the same reference numerals, and the detailed description thereof will be omitted.

[0085]

The light emitting element 20 shown in FIG. 8 has a reflecting structure group 34 in which a plurality of reflecting structures 4 similar to the embodiment 1 are stacked. The dielectric multilayer films 4 are separated from each other and arranged, and the plurality of planarly arranged dielectric multilayer films 4 will be referred to as a first stage reflecting structure group 34A for the sake of convenience.

[0086]

In addition to the first stage reflecting structure group 34A, a second stage reflecting structure group 34B is formed on the stacking direction side (upper side). Also, the first stage reflecting structure group 34A and the second stage reflecting structure group 34B are arranged so as to cover at least a part of the opening region of the first stage reflecting structure group 34A in planar view from the stacking direction. Thus, in planar view from the surface side of the electrode 3, the area where the reflecting structure is formed can be increased, thereby improving the light extraction efficiency.

[0087]

Specifically, as shown in FIG. 8, the second stage reflecting structure group 34B is stacked on the top of the first stage reflecting structure group 34A via the translucent conductive layer 13 such as ITO. Furthermore, the first stage reflecting structure group 34A and the second stage reflecting structure group 34B are not in contact and are separated from each other. Therefore, a conduction path 32 (see FIG. 2) is provided from the metal electrode layer 23 side formed on the upper side of the reflecting structure group 34 to the active layer 8, to supply power to the semiconductor structure 11.

[0088]

In the example of FIG. 8, the dielectric multilayer film group is stacked in two stages. However, the number of layers in the stacked layer is not limited to two, and it can be 3 or more, and similarly to two stages, the upper layer dielectric multilayer film group is formed above the opening region of the lower dielectric multilayer film group via the translucent conductive layer. Thus, the conduction path can be provided to increase the forming area of the reflecting structure in planar view from the light extracting surface 18. Further, the metal electrode layer 23 is provided on the uppermost surface side of the reflecting structure group 34 in the same manner as the embodiment 1.

[0089]

(Embodiment 3)

FIG. 9 shows another embodiment of the reflecting structure. The light emitting element according to embodiment 3 is different from the light emitting element according to embodiment 2 only in the reflecting structure, and the other structures are substantially the same. Therefore, in the light emitting element 30 according to the embodiment 3, the same components as those of the light emitting element 20 according to the embodiment 2 are denoted by the same reference numerals, and the detailed description thereof will be omitted.

[0090]

In the example of FIG. 9, both the first reflecting layer 4a and the second reflecting layer 4b are not connected in the stacking direction (vertical direction in FIG. 9) and they are separated from each other and alternately arranged in the horizontal direction. However, the arrangement order of the two reflecting layers is not limited to alternate arrangement, and the forming regions of the respective reflecting layers can be determined so as to correspond to the distribution ratio of the component light constituting the mixed color. Preferably, the respective reflecting layers are separated from each other at a constant distance, and both reflecting layers are formed in a uniformly mixed arrangement, so that mixed colors can be obtained in which color unevenness caused due to the position is reduced. In addition, the reflecting structure can be made thinner because the two reflecting layers are separated and arranged in parallel horizontally without being stacked vertically. As a result, thinning of the light emitting element and the light emitting device can be realized.

[0091]

(Embodiment 4)

FIG. 10 shows another embodiment of the reflecting structure. The light emitting element according to embodiment 4 is different from the light emitting element according to embodiment 2 only in the reflecting structure, and the other

structures are substantially the same. Therefore, in the light emitting element 40 according to the embodiment 4, the same components as those of the light emitting element 20 according to the embodiment 2 are denoted by the same reference numerals, and the detailed description thereof will be omitted.

[0092]

In the example of FIG. 10, the first reflecting layer 4a and the second reflecting layer 4b separated from each other are displaced in the horizontal direction, and have reflecting structure groups 34 laminated one on top of the other. That is, the reflecting structure groups 34 have a first stage reflecting structure group 34A, in which the first reflecting layer 4a having the same center wavelength is horizontally formed, and a second stage reflecting structure group 34B on the first stage in which the second reflecting layer 4b is horizontally formed around the opening region of the first reflecting layer 4a. They are laminated through the translucent conductive layer 13 similarly to the embodiment 3. That is, in planar view from the surface side of the electrode 3, the second reflecting layer 4b is disposed so as to fill the spaced area between the first reflecting layer 4a and the second reflecting layer. With this structure, the reflecting structure can be arranged two-dimensionally and three-dimensionally to obtain an element having a desired characteristic.

[0093]

In the example of FIG. 10, the center wavelengths of the reflecting layers arranged horizontally in each stage are the same. However, as shown in FIG. 9, the center wavelength of adjacent reflecting layers may be different, i.e., the reflecting layer group consisting of several types of reflecting layers may be formed over multiple stages.

[Examples]

[0094]

(Comparative Example 1 and Examples 1 to 5)

According to the aforementioned procedure, the light emitting elements having different reflecting structures can be formed. The light emitting elements of Comparative Example 1 and Examples 1 to 5 include LEDs with \square of 1 mm, and include dielectric multilayer films in the reflecting structures. The electrode structure has a reflecting structure in which a translucent conductive layer (ITO) is provided on each conductive-type semiconductor layer, and the insulating film (SiO_2) / the dielectric multilayer film are stacked in this order. The light emitting elements of Comparative Example 1 and Examples 1 to 5 differ in the configuration of the dielectric multilayer film 4 and the other structures are substantially the same as the light emitting elements described above; therefore, the detailed description thereof is omitted.

[0095]

As shown in FIG. 6, the reflecting structure has a square dot-shaped opening with a side of 10 μm , and this opening is arranged at a lattice-shaped lattice point. The distance between adjacent dots is 30 μm . The dielectric multilayer film is formed on the translucent conductive layer (ITO) of about 60 nm formed on the nitride semiconductor layer, and further through the insulating film (SiO_2) of about 0.5 μm , and these constitute a reflecting structure. Furthermore, on the surface side of the dielectric multilayer film 4, a metal electrode layer made of Ti—Rh is stacked as a connection region of the external electrode to constitute an electrode, and the translucent conductive layer is conducted at an opening 35 of the reflecting structure provided in part. As shown in the cross-sectional view of FIG. 3, the insulating film 16 is formed on the surface of the exposed portion of semiconductor structure 11 and is used in combination with the protective film. That is, the protective film and the insulating film are formed in the same step and with the same material without providing the protective film and the insulating film in separate steps. Furthermore, in this example, the reflecting structure is provided on the substantially entire surface of the exposed portion of the

semiconductor layer by providing an opening serving as a conductive portion with the external electrode 23 on the translucent conductive layer.

[0096]

The reflecting structure of Comparative Example 1 comprises only the first reflecting layer 4a having reflection characteristics corresponding to the emission peak spectrum of the light source. Specifically, in the first reflecting layer 4a, four pairs of two-layer films made of Nb_2O_3 and SiO_2 are stacked, and the center wavelength of each reflection is set to 460 nm.

[0097]

In addition to the center wavelength (460 nm) of the first reflecting layer which is the emission peak wavelength of the LED, the dielectric multilayer film according to Example 1 comprises a second reflecting layer having a reflection characteristic on the long wavelength side than the peak wavelength. The center wavelength of the second reflecting layer is within the wavelength range that is excited by the light source to convert wavelength. However, the half width at the emission peak (wavelength about 560 nm) of the converted light on the long wavelength side is wider than the half width at the emission peak of LED light on the short wavelength side. Therefore, the center wavelength of the second reflecting layer is on the longer wavelength side. In Example 1, the center wavelength of the second reflecting layer is 575 nm, i.e., 1.25 times the center wavelength of the first reflecting layer. Further, similarly to the peak wavelengths of the LED light and the converted light according to the Example 1, the hues corresponding to the center wavelengths of the respective reflecting layers are different from each other, and both are in a complementary color relation.

[0098]

The dielectric multilayer film according to Example 2 has a first reflecting layer having reflection characteristic of 368 nm equivalent to 0.8 times the light source wavelength (460 nm) and a second reflecting layer having reflection characteristic of 552 nm equivalent to 1.2 times the light source wavelength (460 nm).

[0099]

Furthermore, the dielectric multilayer films of Examples 3 to 5 comprise a reflecting layer having three types of center wavelengths. The number of stacked pairs and the specific center wavelengths in each reflecting layer based on the light source wavelength (460 nm) are as follows.

Example 3: First reflecting layer (368 nm (0.8 times)) 2 pairs / third reflecting layer (460 nm (1.0 times)) 2 pairs / second reflecting layer (552 nm (1.2 times)) 2 pairs

Example 4: First reflecting layer (431 nm (0.9375 times)) 3 pairs/third reflecting layer (518 nm (1.125 times)) 3 pairs /second reflecting layer (621 nm (1.35 times)) 3 pairs

Example 5: First reflecting layer (437 nm (0.95 times)) 3 pairs/ third reflecting layer (529 nm (1.15 times)) 3 pairs /second reflecting layer (621 nm (1.35 times)) 3 pairs

Note that in each of the dielectric multilayer films of Examples 1 to 5, the thickness of a two-layered film made of the same material as that of Comparative Example 1 is changed to obtain center wavelength.

[0100]

Here, in addition to the second reflecting layer, Examples 3 to 5 have a third reflecting layer having a center wavelength shorter than the peak wavelength of the converted light, i.e. between the peak wavelengths of the LED light and the converted light. The second reflecting layer has a center wavelength on the long wavelength side than the peak wavelength of converted light compared to the third reflecting layer. In Examples 2 to 5, the short wavelength than the peak wavelength of the LED light is set as the center wavelength for first reflecting layers.

[0101]

The light emitting elements of Comparative Example 1 and Examples 1 to 5 are mounted on the light emitting device which differs in the presence or absence of phosphor which is a wavelength conversion member. As a result, the obtained light emission characteristics, drive voltage, light emission output ϕ_e , external quantum efficiency η_{ex} , center wavelength λ_d , light flux ϕ_v , power efficiency WPE (Watt Per Energy), and light emission efficiency (lm/W) are shown in Table 1. The power ratio and the light flux ratio in Table 1 are shown by the ratio to the value of Comparative Example 1, [each Example]/[Comparative Example 1]. Further, FIG. 11 shows a graph of the reflectance of the reflecting structure of the light emitting element according to Comparative Example 1 and Examples 1 to 5. FIG. 12 shows emission spectra of the light emitting devices of Examples 1 and 2 and Comparative Example 1. Note that, in the table, the light emitting device described as "device B" is a light emitting device as shown in FIG. 1, and two light emitting elements of each Example and Comparative Example are connected in series to the submount thereof by wiring, and the wavelength conversion member is covered with resin to emit white light. Also, in the table, "device A" is a blue light emitting device obtained by mounting one light emitting element in the cup of one set of mounting leads from among the two sets of leads for each polarity (total four), and sealing it integrally with a resin lens. The same applies to Table 2.

[0102]

[Table 1]

	Device A @350 mA						Device B @350 mA			
	Voltage [V]	ϕ_e [mW]	Output ratio	WPE [%]	η_{ex} [%]	λ_d [nm]	vol [V]	Φ_v [lm]	Light flux	Efficiency [lm/W]
Comparative Example 1	3.12	465.1	-	42.6	48.3	455.1	6.40	138.9	-	62.0
Example 1	3.09	467.1	1.004	43.2	48.2	455.7	6.44	145.8	1.050	64.7
Example 2	3.10	464.2	0.998	42.8	49.0	455.0	6.41	152.2	1.096	67.8
Example 3	3.11	466.3	1.003	42.9	48.2	453.2	6.47	145.9	1.050	64.4
Example 4	3.10	467.8	1.006	43.1	48.0	453.9	6.45	150.0	1.080	66.5
Example 5	3.09	470.5	1.012	43.4	48.6	455.4	6.46	153.1	1.103	67.8

[0103]

As shown in Table 1, in the light emitting device containing the wavelength conversion member in any of the light emitting elements of Examples, the light emission characteristics are improved as compared to Comparative Example 1 and the light flux ratio with the Comparative Example is also improved. In other words, in the light emitting device that emits only a single hue, the improvement of light emission characteristics does not depend on the number of center wavelengths in the reflecting layer. However, in the light emitting device capable of emitting wavelengths corresponding to a plurality of hues, the light emission characteristics are improved by about 5 to 10% by having a reflecting layer corresponding to each hue (see Table 1 Wavelength conversion member). Comparison of Examples 1 and 2 shows that improvement in the light emission characteristic is made even when the center wavelength of the first reflecting layer corresponding to the light source is shifted to the short wavelength side and the wavelength range with the center wavelength of the second reflecting layer is expanded. Specifically, the center wavelength of the first reflecting layer is 0.8 times or more and less than 1.0 times the wavelength of the light source, or/and the center wavelength of the second reflecting layer is 1.20 times or more and 1.35 times or less. Thus, by separating the wavelength difference of the center wavelength of each reflecting layer, the above-mentioned effect can be remarkably obtained. Therefore, it is preferable that the range between the center wavelengths of the first and second

reflecting layers is made larger than wavelength region between LED light and converted light peak; preferably, the center wavelength of the first reflecting layer on the short wavelength side is shorter than the peak wavelength of LED light and the center wavelength of the second reflecting layer on the long wavelength side is the same as or longer than the peak wavelength of the converted light. Thus, for example, it is preferable to be included on the peak side (wavelength range of more than half of the peak value) from the wavelength at which the converted light peak is half, specifically within ± 20 nm of the peak wavelength. More preferably, between the center wavelengths of the first and second reflecting layers, the LED light peak wavelength and the converted light peak wavelength or a part of the wavelength range of half or more of the peak value is included, and specifically, $1/4$ or more of the wavelength range is included. Thus, as compared to the structure in which the center wavelength of the multilayer reflecting layer in the prior art corresponds to the component having high angle of incidence, i.e. the wavelength longer than the wavelength of LED light is added, or a range is broadened on the long wavelength side, the following points in the present invention differ: a point of having center wavelength (first reflecting layer) on the short wavelength side and a point that the range between the center wavelength of the reflecting layer is wider than the peak between LED-converted light or between the LED peak wavelength-half wavelength of the short wavelength side of the converted light. Thus, characteristics of the light emitting element and the light emitting device are improved. Specifically, as compared between LED-converted light peak (about 100 nm), the range between the center wavelengths of the first and second reflecting layers in each example are as follows: 115 nm in Example 1, 184 nm in Examples 2, 3, and 5, and 190 nm in Example 4. The ratio [between the center wavelengths of first and second reflecting layers]/[between LED and converted light peaks] is 1.15, 1.84 and 1.90. From this, it is clear that the ratio of between the center wavelength of the first and second reflecting layers to between the LED-converted light peaks is about 1.1 to 3 times, preferably about 1.3 to 2.5 times.

[0104]

In the examples 3 to 5, in addition to the first and second reflecting layers, the third reflecting layer has a center wavelength between the center wavelengths of the first and second reflecting layers at both ends of the wavelength range. Example 3 has the third reflecting layer corresponding to the LED light peak wavelength in the Example 2. Example 4 has the third reflecting layer substantially corresponding to the converted light peak wavelength, in addition to the first and second reflecting layers corresponding to the short wavelength side of the LED light peak wavelength and the long wavelength side of the converted light peak wavelength similar to Example 2. In Example 5, between the center wavelengths of the first and second reflecting layers are the same as compared to Example 2 and both ends of the center wavelength are set on the long wavelength side. Compared to Example 2, Examples 3 and 4 tend to have lower light fluxes and ratios thereof, but Example 3 has a particularly lower values. Thus, the third reflecting layer is preferably provided in the region between the LED-converted light peaks, and the long wavelength side than the center (490 nm) between the LED-converted light peaks, and the long wavelength side than the center (529 nm in Example 5) between the center wavelengths of the first and second reflecting layers are preferable.

[0105]

(Comparative Examples 2 to 3 and Examples 6 to 7)

Furthermore, as compared to Example 1, the reflecting structures of Comparative Examples 2 to 3 and Examples 6 to 7 differ in the presence or absence of an intervening insulating film (SiO_2) between the translucent conductive layer (ITO) having a thickness of about 50 nm and the dielectric multilayer film layer. The opening pattern of the dielectric multilayer film, which is a reflecting structure, has the same dot shape as in Example 1.

[0106]

Specifically, the reflecting structures of Comparative Example 2 and Example 6 comprise only the first reflecting layer in the same manner as the Comparative Example 1, i.e., the center wavelength of reflection is 460 nm. However, Comparative Example 2 does not have insulating film, while the light emitting element of Example 6 has insulating film. In the reflecting structures in Comparative Example 3 and Example 7, a total of six pairs of layers each having a center wavelength of 0.7 to 1.2 times relative to the light source (460 nm) and corresponding to a tolerance of 0.1 are stacked. That is, it has a plurality of reflecting layers. However, Comparative Example 3 does not have insulating film, while the light emitting element of Example 7 has insulating film. Table 2 shows the light emission characteristics obtained by mounting each light emitting element on the light emitting device containing a wavelength conversion member. From Table 2, it is clear that in the electrode structure having the insulating film, the light emission characteristics are improved regardless of the reflecting structure.

[0107]

[Table 2]

	Device B @350 mA						
	Voltage [V]	Φ_v [lm]	White/Blue	Output ration I	Output ration II	Efficiency [lm/W]	λ_d [nm]
Comparative Example 2	6.42	91.2	0.231	0.809	-	40.60	577
Example 6	6.44	113	0.255	1.000	-	50.06	579
Comparative Example 3	6.49	100	0.246	1.101	0.924	44.22	580
Example 7	6.42	117	0.267	1.033	1.000	51.91	577

[Industrial Applicability]

[0108]

The semiconductor light emitting device and the method for producing the semiconductor light emitting device according to the present invention can be suitably applied to a light source for lighting, an LED display, a backlight source, a signal light, an illuminated switch, various sensors, various indicators and the like.

[Brief Description of the Drawings]

[0109]

[FIG. 1] is a schematic cross-sectional view of the light emitting device according to an embodiment 1.

[FIG. 2] is a partially expanded cross-sectional view of the light emitting device according to an embodiment 1.

[FIG. 3] is a cross-sectional view of the light emitting device according to an embodiment 1.

[FIG. 4] is explanatory drawing explaining the process for producing a reflecting structure of the light emitting element according to an embodiment 1.

[FIG. 5] is a schematic plan view showing an example in which the dielectric multilayer film is provided in the upper surface of the translucent conductive layer.

[FIG. 6] is a schematic plan view showing the other example in which the dielectric multilayer film is provided in the upper surface of the translucent conductive layer.

[FIG. 7] is a schematic view showing a method for producing a light emitting device according to an embodiment 1.

[FIG. 8] is cross-sectional view of the light emitting element according to an embodiment 2.

[FIG. 9] is cross-sectional view of the light emitting element according to an embodiment 3.

[FIG. 10] is cross-sectional view of the light emitting element according to an embodiment 4.

[FIG. 11] is a graph showing the reflectance in the reflecting structure of Comparative Example 1 of Examples 1 to 5.

[FIG. 12] is an emission spectrum view of the light emitting device according to Examples and Comparative Examples.

[FIG. 13] is a cross-sectional view showing the conventional light emitting element.

[Reference Numerals]

[0110]

1...Light emitting device

3...Electrode

3A... First electrode (n-type pad electrode)

3B... Second electrode (p-type pad electrode)

4...Reflecting structure (dielectric multilayer film)

4a...First reflecting layer

4b...Second reflecting layer

5... Growth substrate (sapphire substrate)

6...First nitride semiconductor layer (n-type semiconductor layer)

6a... n-type contact layer

7...Second nitride semiconductor layer (p-type semiconductor layer)

8...Light emitting layer (active layer)

9... Wiring board (submount board)

10, 20, 30, 40...Light emitting element (nitride semiconductor element)

11...Semiconductor structure (nitride semiconductor layer)

12...Wavelength conversion member (phosphor)

13...Translucent conductive layer (translucent electrode, ITO)

14...Protective film

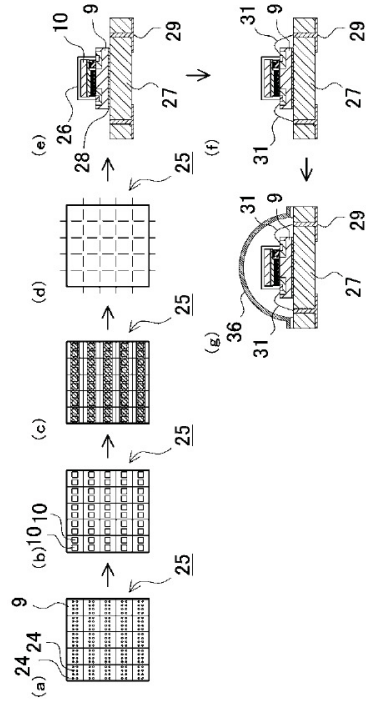
16...Insulating film (protective film)

18...Light extracting surface

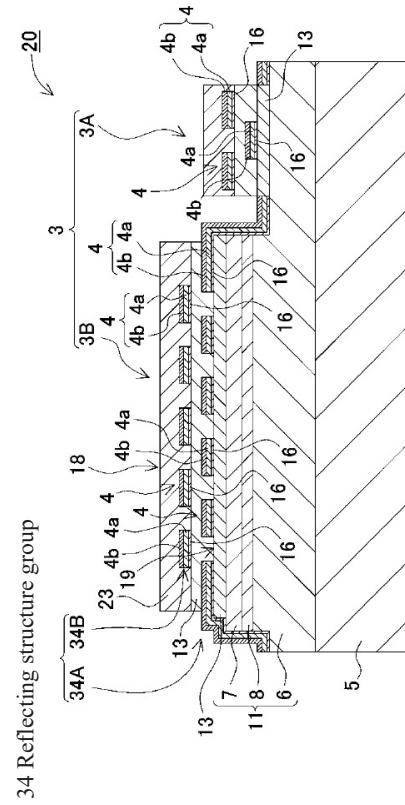
19...Interface
21, 22... Protective film opening
23...Metal electrode layer
24... Conductive member (bump)
25...Wafer
26...Coating layer (resin)
27...Support
28... Eutectic layer
29... Electrode of support
31...Wire bonding
32... Conduction path
34...Reflecting structure group
34 A ...First stage reflecting structure group
34 B ...Second stage reflecting structure group
35...Opening
36...Lens
100...Light emitting device
101...Substrate
102...n-type semiconductor layer
103...light emitting layer
104...p-type semiconductor layer
105... p-side electrode
105a...Ag layer
105b... Metal layer
106... n-side electrode

[illegible][illegible]

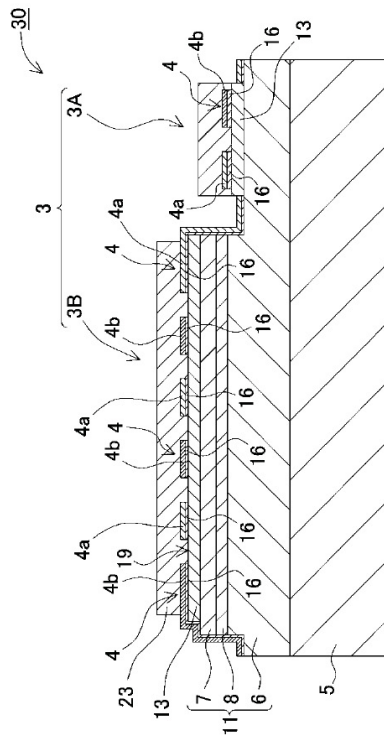
[FIG. 7]



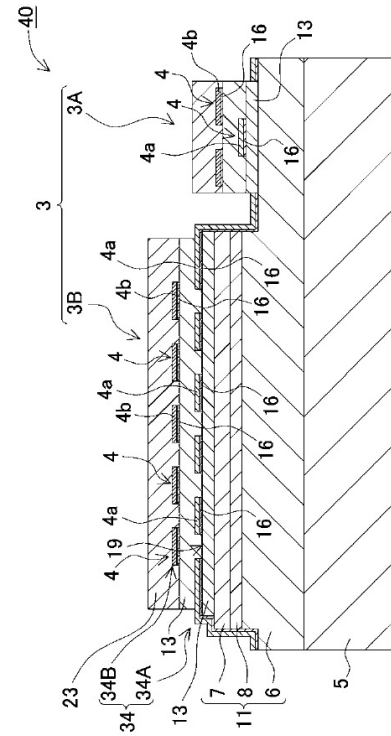
[FIG. 8]



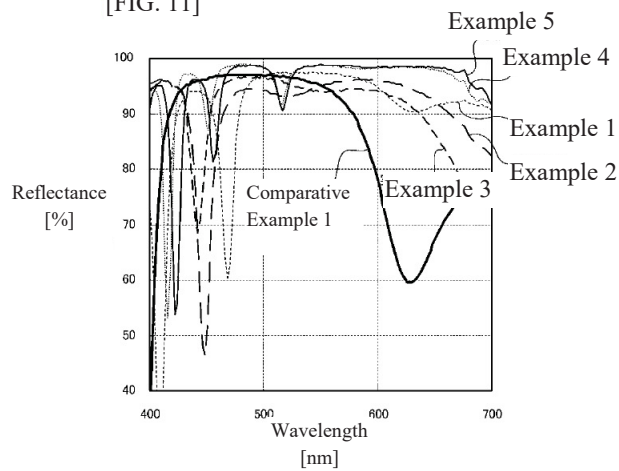
[FIG. 9]



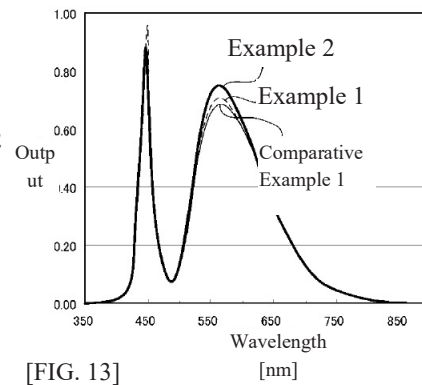
[FIG. 10]



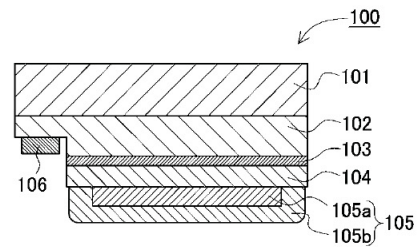
[FIG. 11]



[FIG. 12]



[FIG. 13]





TRANSLATOR CERTIFICATION

Date: May 29, 2019

To whom it may concern:

I, Varsha Vinaydutt, a translator fluent in the Japanese and English languages, on behalf of Morningside Translations, do solemnly and sincerely declare that the following is, to the best of my knowledge and belief, a true and correct translation of the documents listed below in a form that reflects the intention and meaning of the original text.

I declare under the penalty of perjury under the laws of the United States that the foregoing is true and correct; and further declare that I am aware that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 1001 of Title 18 of the United States Code.

The document is designated as:

Japanese Unexamined Patent Application Publication Number: JP2009-88299 (P2009-88299A)

Signature

Varsha Vinaydutt

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