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# (12) United States Patent
**Yang et al.**

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(54) **METHOD FOR FORMING LIGHT EMITTING DEVICE**


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(22) Filed: **Mar. 15, 2011**

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(51) **Int. Cl.**
***H01L 21/00*** (2006.01)

(52) **U.S. Cl.** ......................................................... **438/27**

(58) **Field of Classification Search** ..................... 438/27
See application file for complete search history.


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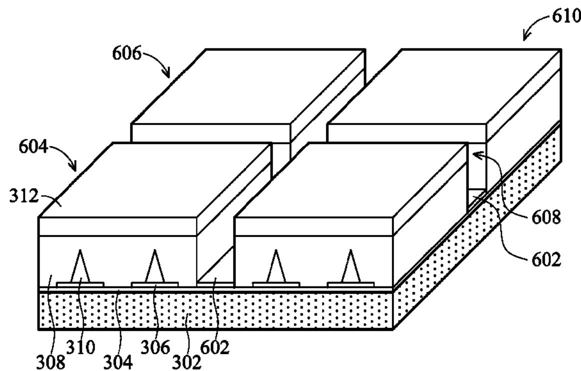
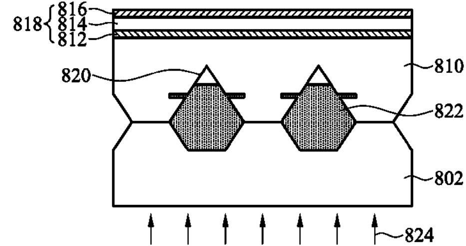
*Primary Examiner* — A. Sefer
*Assistant Examiner* — Monica D Harrison

(57) **ABSTRACT**


The invention provides a method for forming a light emitting device. A first substrate is provided. A plurality of patterned masks is formed on the first substrate, or on a semiconductor epitaxial layer grown on the first substrate, or the first substrate is etched to form a plurality of trenches, followed by performing an epitaxial lateral overgrowth process to grow an epitaxy layer over the first substrate. A light emitting structure is formed on the epitaxy layer. A first electrode layer is formed on the light emitting structure. The light emitting structure is wafer bonded to a second substrate. A photoelectrochemical etching process is performed to lift off the first substrate from the epitaxy layer.


**20 Claims, 12 Drawing Sheets**



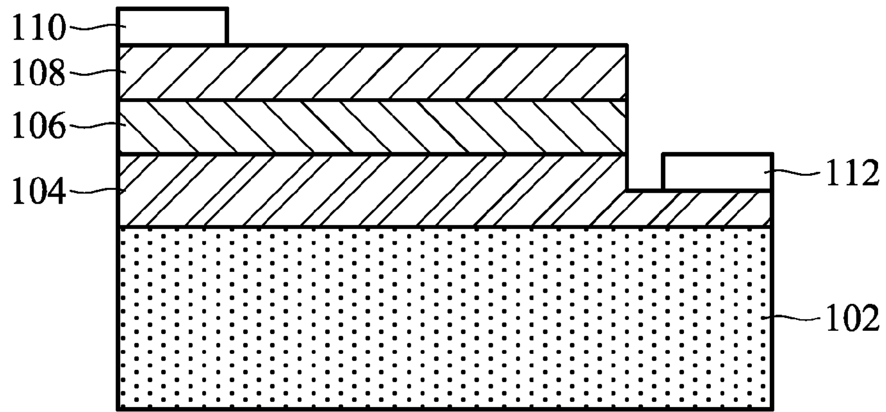



FIG. 1

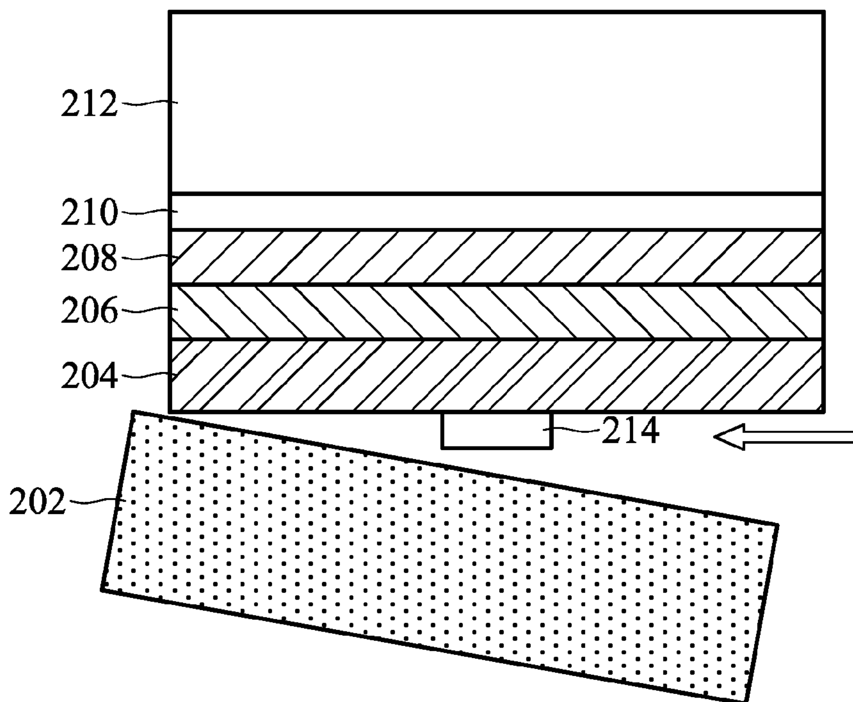



FIG. 2

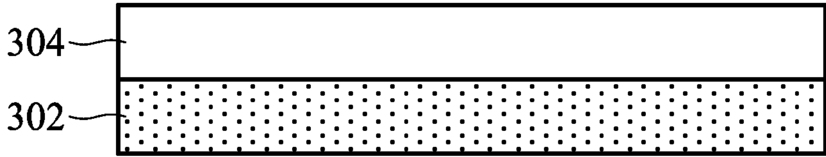



FIG. 3A

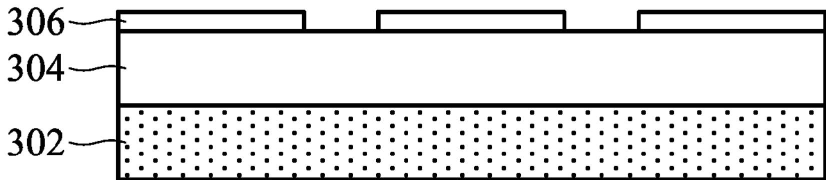



FIG. 3B

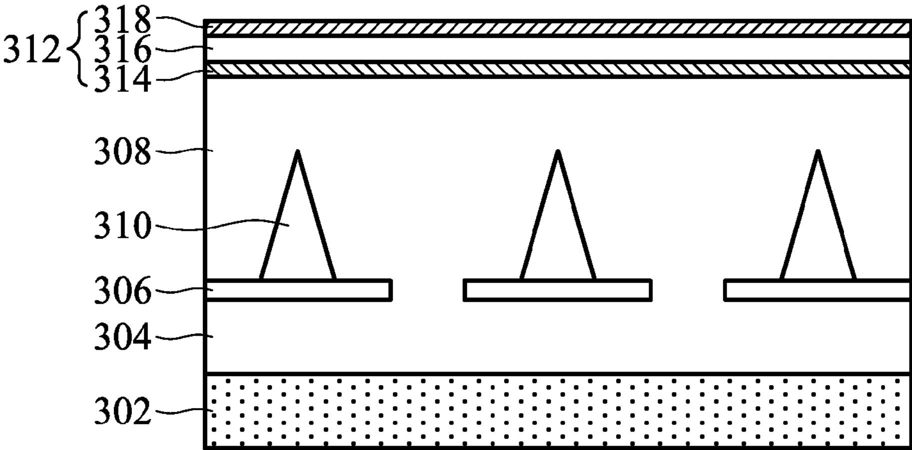



FIG. 3C

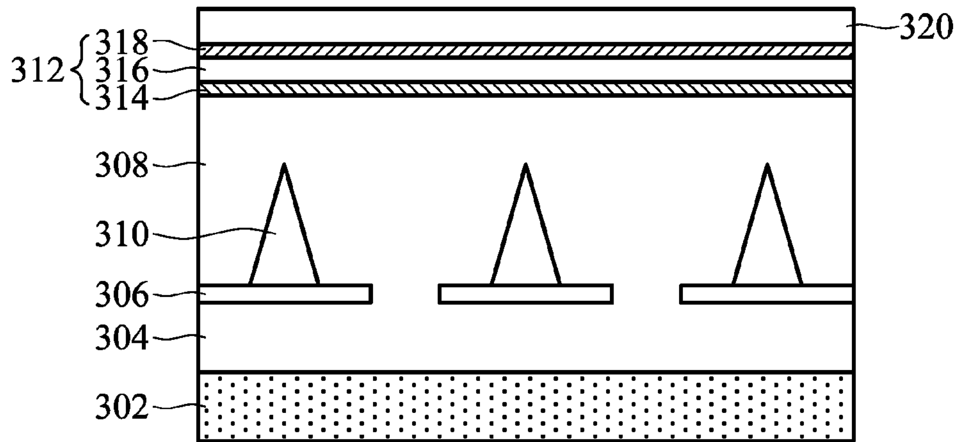



FIG. 3D

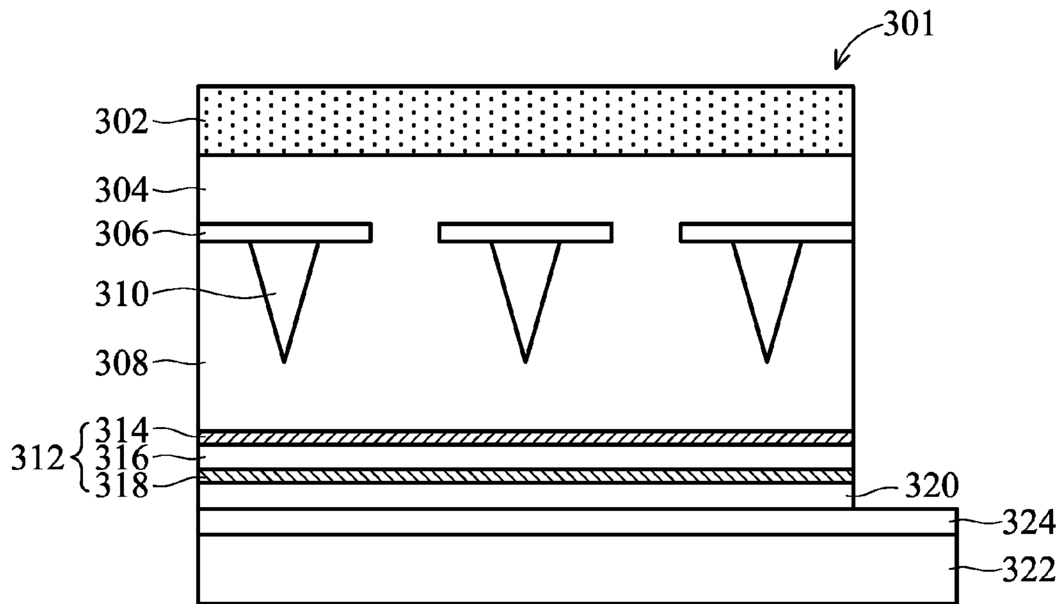



FIG. 3E

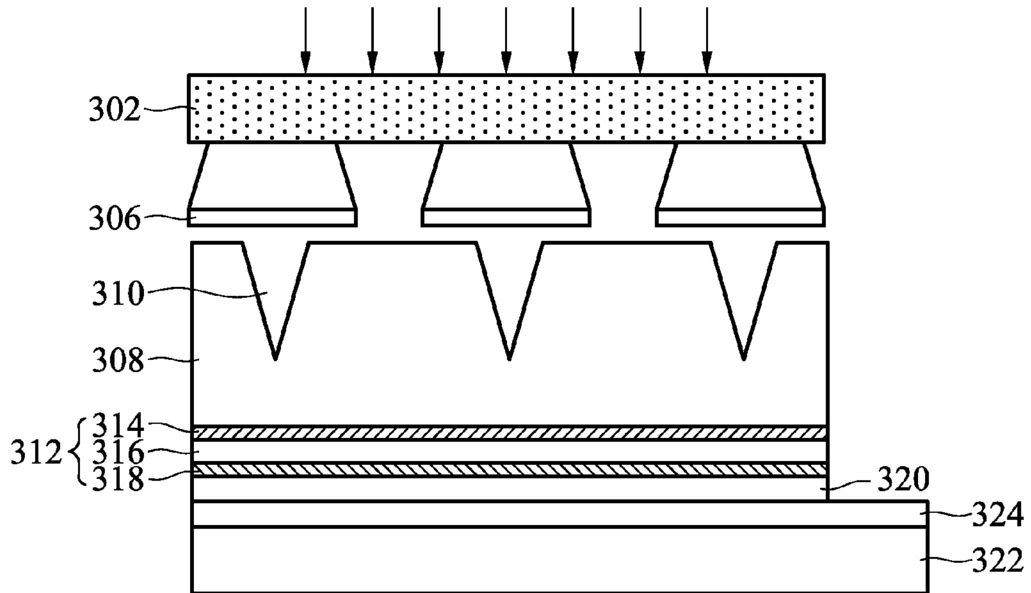



FIG. 3F

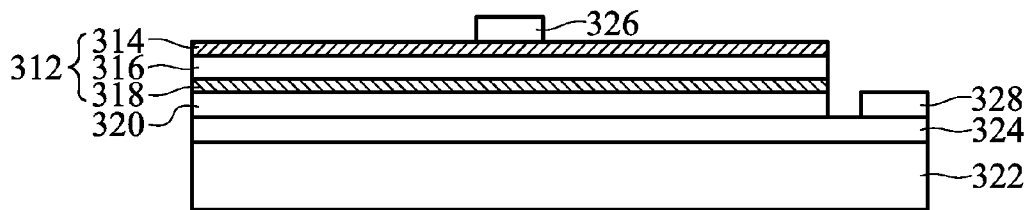



FIG. 3G

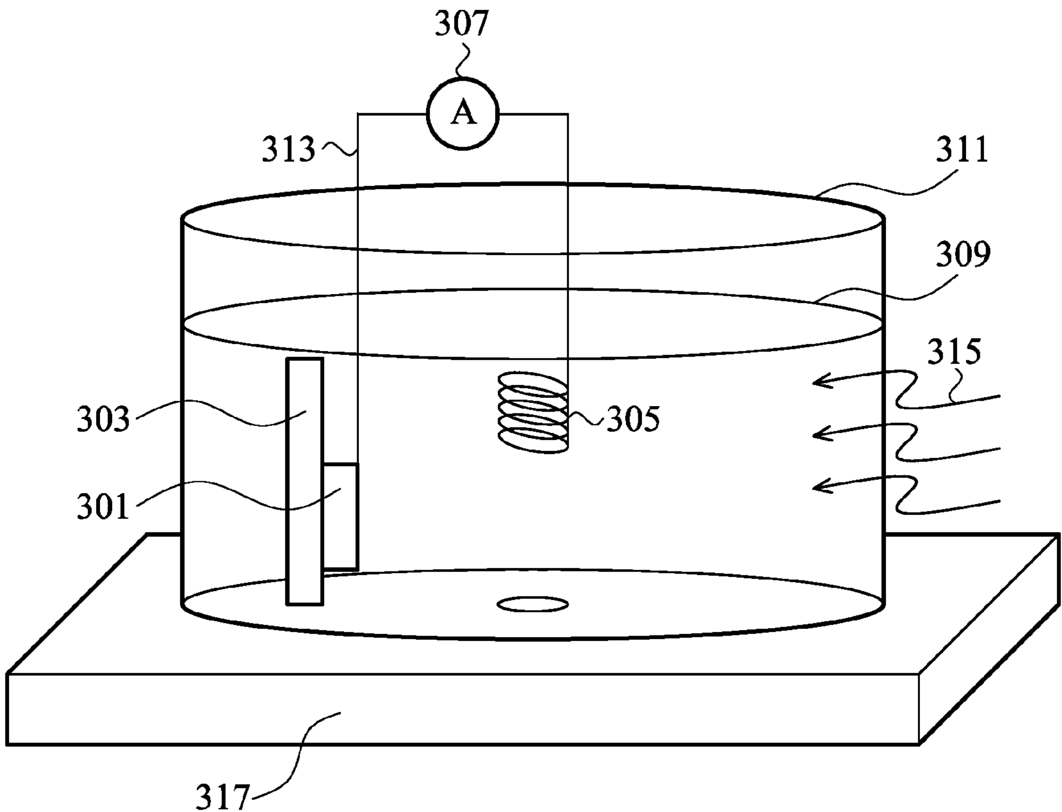



FIG. 4

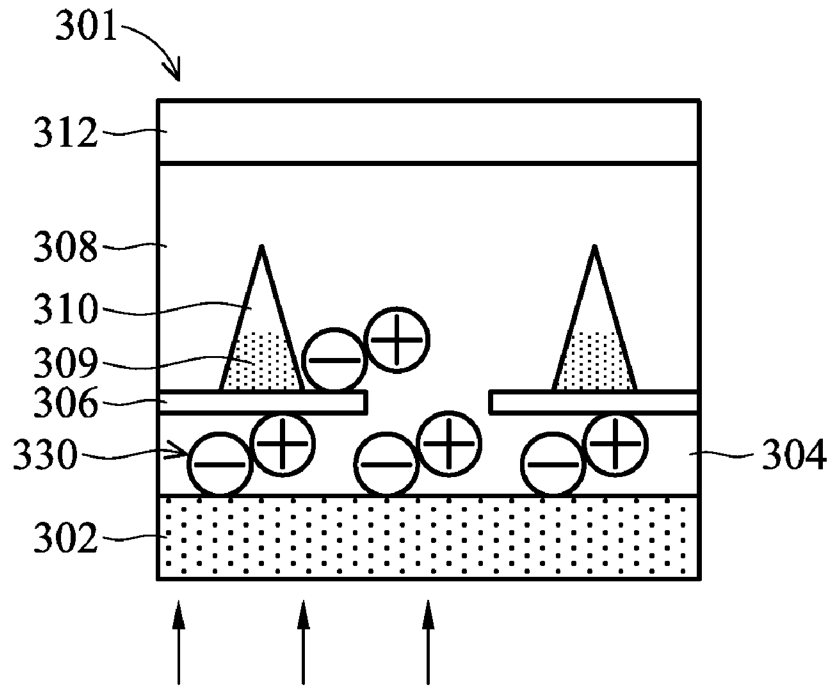



FIG. 5A

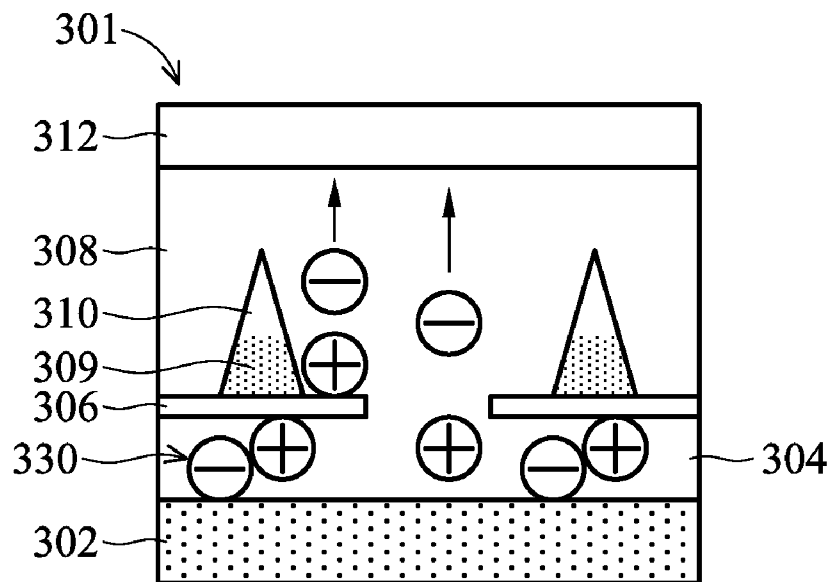



FIG. 5B

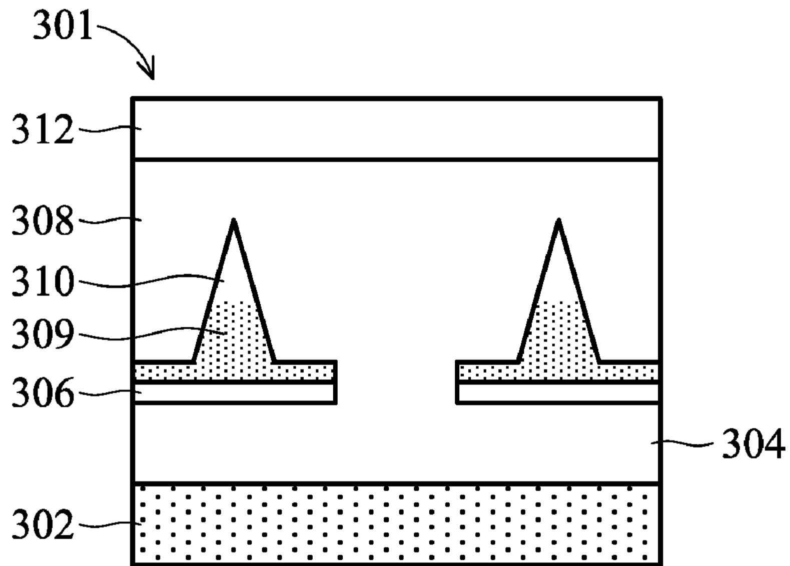


FIG. 5C

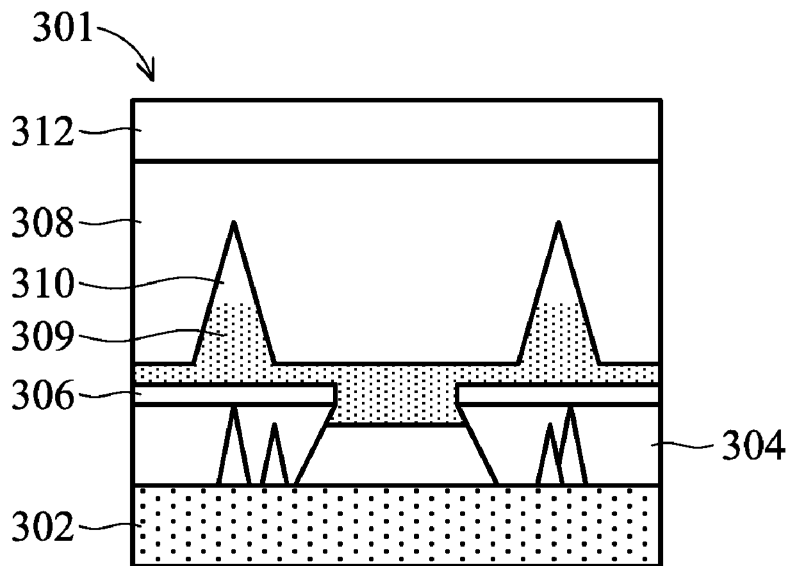


FIG. 5D

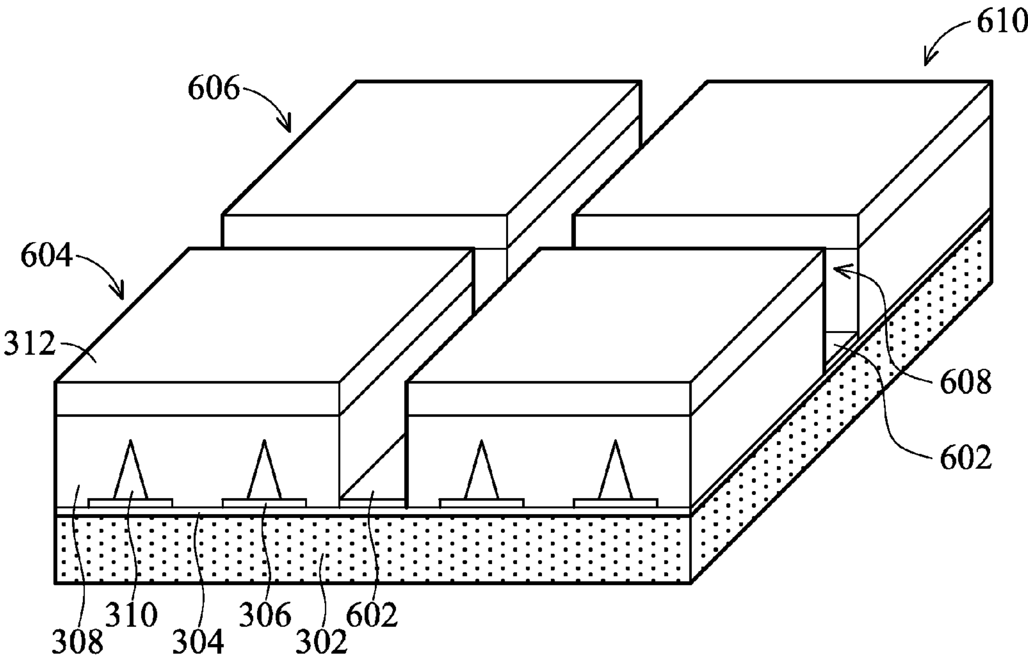



FIG. 6A

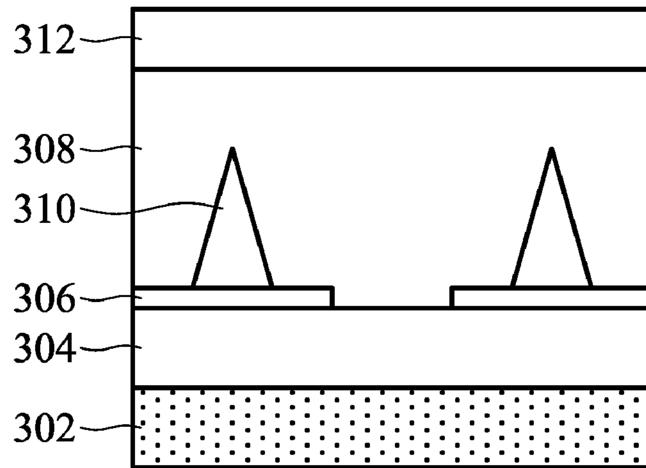



FIG. 6B

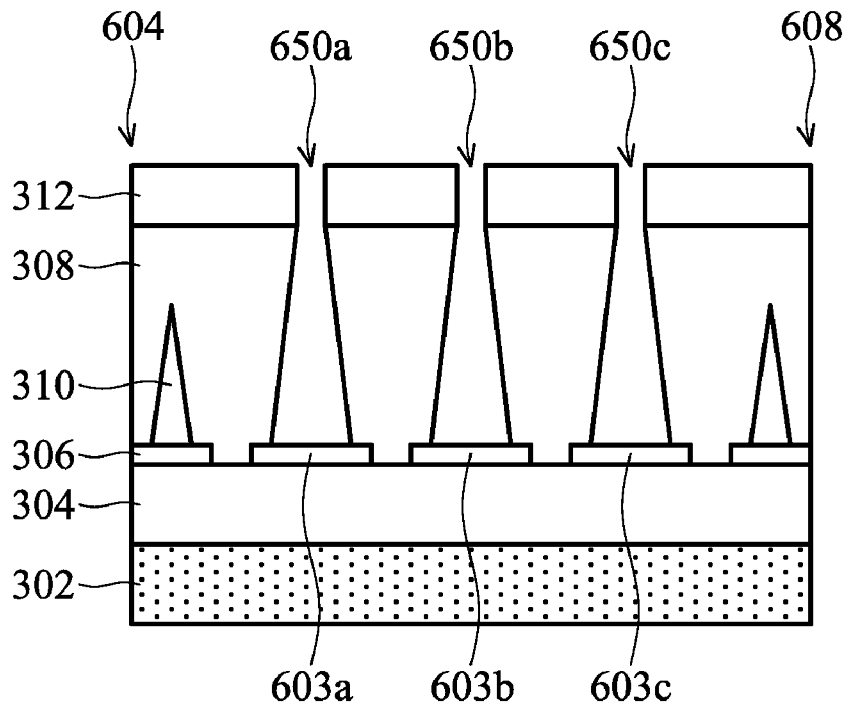



FIG. 6C

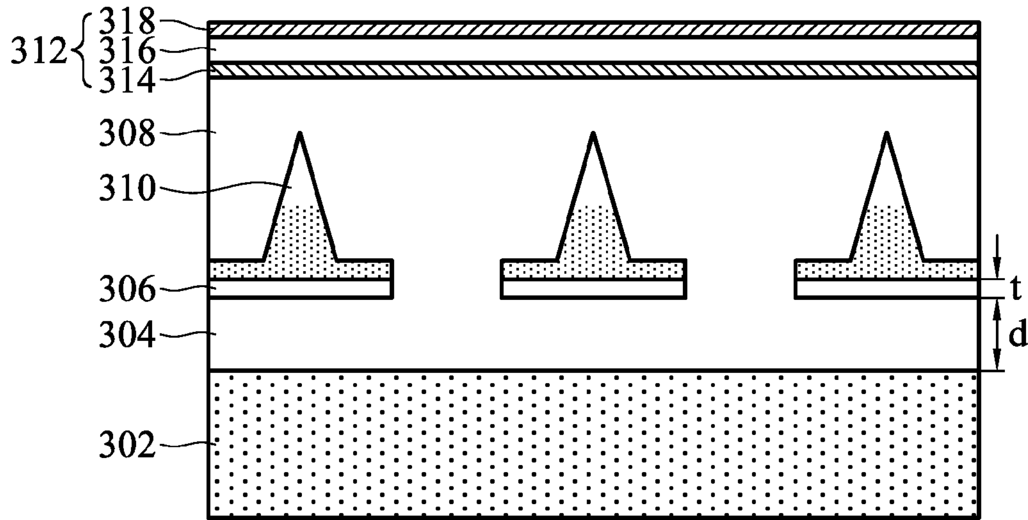



FIG. 7A

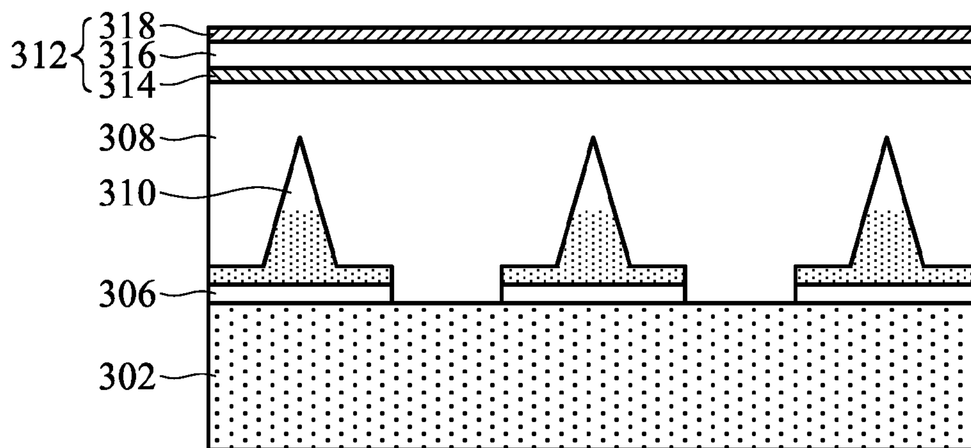



FIG. 7B

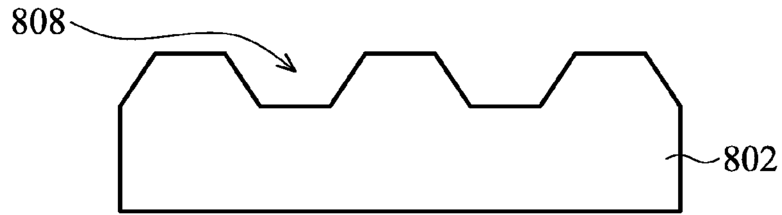



FIG. 8A

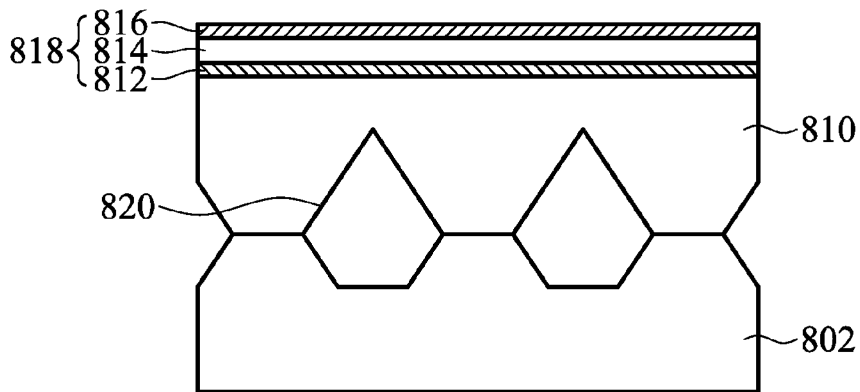



FIG. 8B

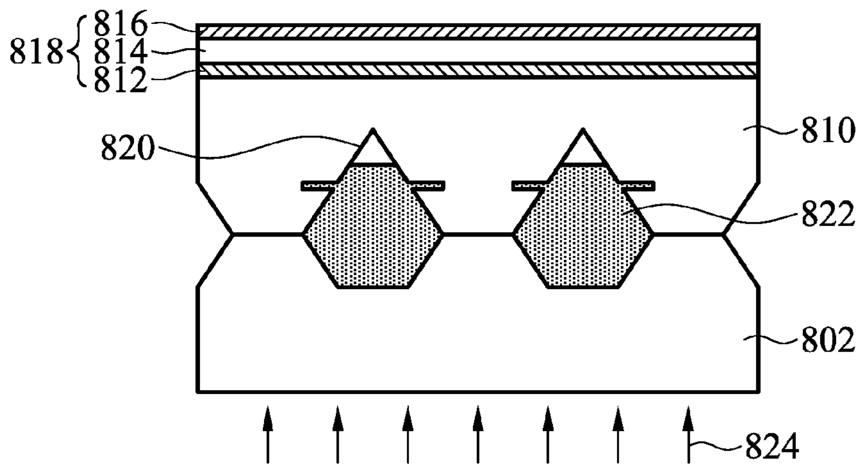



FIG. 8C

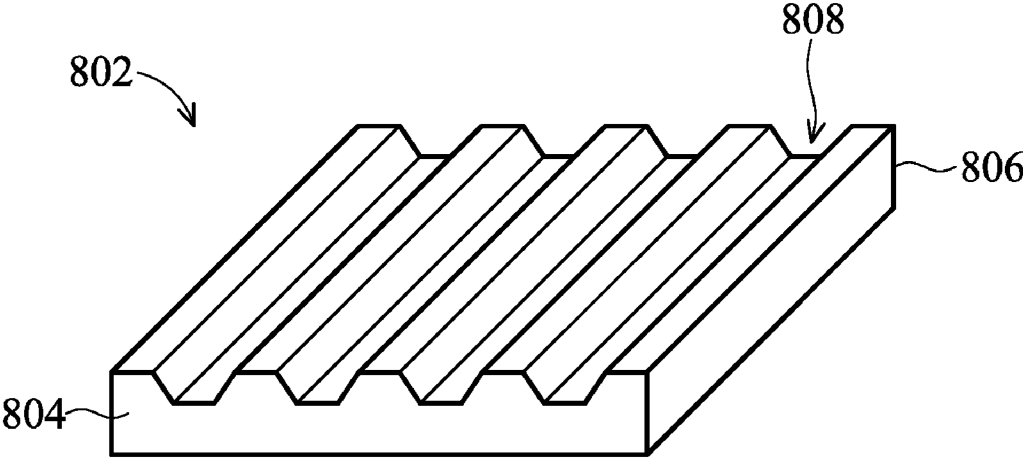



FIG. 9

# METHOD FOR FORMING LIGHT EMITTING DEVICE

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention generally relates to methods for forming a light emitting device, and more particularly to a technique for lifting-off a sapphire substrate from a light-emitting diode.

2. Description of the Related Art

Semiconductor light-emitting devices have developed rapidly in many applications, for example, general lighting and liquid crystal display backlighting. As such, semiconductor light-emitting devices may replace currently used illumination devices, such as fluorescent lamps or light bulbs. Specifically, GaN based light-emitting diodes represent a main focus in such application developments. FIG. **1** shows the structure of a typical conventional light emitting device, wherein an n-GaN layer **104**, quantum wells **106**, and a p-GaN layer **108** are sequentially formed on a sapphire substrate **102**, and a p-type electrode **110** connects to the p-GaN layer **108**, and an n-type electrode **112** connects to the n-GaN layer **104**. With the sapphire substrate, which is electrically and thermally insulating, such a light emitting device, however, has the disadvantage of long current path, such that the device resistance is high. Also, the thermally insulating nature of sapphire substrate makes it difficult in removing the generated heat.

Accordingly, a vertical light-emitting diode (VLED) has been developed. As shown in FIG. **2**, a vertical light-emitting diode is formed by placing a p-i-n structure (including an n-type GaN layer **204**, quantum wells **206** and an p-type GaN layer **208**) and a sapphire substrate **202** thereunder upside down, and bonding a p-type electrode **210** (connecting the p-type GaN layer **208**) with an electrically and thermally conducting substitution substrate **212**. Next, the sapphire substrate **202** is lifted off to expose the n-type GaN layer **204**, and the n-type GaN layer **204** is surface-polished for forming an n-type electrode **214** thereon for the fabrication of a light emitting diode with vertically flowing current. Compared to the conventional horizontal light emitting diode, the vertical light emitting diode has the advantages of being able to remove heat more easily and has better current spreading effect. Therefore, a vertical light emitting diode is more suitable to be used as a high power light emitting device. When fabricating a vertical light emitting diode, a substrate lifting-off process is the key technological component. Currently, an ultraviolet laser is used to illuminate the sapphire substrate and scan the light emitting diode structure to lift off the sapphire substrate. Since the material between the sapphire substrate and gallium nitride has a high defect density and strong light absorption, heat generated from laser irradiation can separate the sapphire substrate from the gallium nitride. Although this technique is widely used, it has some drawbacks. For example, laser irradiation may damage the material of the quantum wells in the light emitting diode. Also, semiconductor chips are likely to be broken. Therefore, it is important to develop a novel sapphire substrate lift-off technique for high power light emitting diodes.

## BRIEF SUMMARY OF INVENTION

A method for forming a light emitting device is disclosed, comprising providing a first substrate, forming a plurality of patterned masks over the first substrate or etching the first substrate to form a plurality of trenches, growing an epitaxy layer using an epitaxial lateral overgrowth (ELOG) method over the first substrate, forming a light emitting diode structure over the epitaxy layer, and performing a photoelectrochemical etching process to lift off the epitaxy layer from the first substrate.

A method for forming a light emitting device is disclosed, comprising providing a first substrate, forming a semiconductor layer on the first substrate, forming a plurality of patterned masks and at least one light emitting diode element separating mask on the semiconductor layer, using an epitaxial lateral overgrowth (ELOG) method to grow an epitaxy layer on the semiconductor layer, wherein the epitaxy layer laterally grows on the patterned mask layers and the light emitting diode element separating mask, and the epitaxy layer is not coalesced over the light emitting diode element separating mask to isolate the light emitting diode elements, forming a light emitting diode structure on the epitaxy layer, forming a first electrode layer on the light emitting diode structure, bonding the light emitting diode structure to a second substrate, and performing a photoelectrochemical etching process to lift off the epitaxy layer from the first substrate.

## BRIEF DESCRIPTION OF DRAWINGS

The invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein,

FIG. **1** shows a typical conventional light emitting diode.

FIG. **2** shows a vertical light-emitting diode.

FIGS. **3**A~**3**G show a method for forming a vertical light emitting diode of an embodiment of the invention.

FIG. **4** shows a photoelectrochemical (PEC) etching technique of a sample of the invention.

FIGS. **5**A~**5**D show a mechanism for lifting off sapphire substrate using PEC etching.

FIGS. **6**A and **6**B show a method for forming a vertical light emitting diode of another embodiment of the invention.

FIG. **6**C shows a light emitting diode device of a further embodiment of the invention.

FIG. **7**A shows a cross section of an intermediate stage of a method for forming a vertical light emitting diode of further another embodiment of the invention.

FIG. **7**B shows a cross section of an intermediate stage of a method for forming a vertical light emitting diode of yet another embodiment of the invention.

FIGS. **8**A~**8**C show cross sections of intermediate stages of a method for forming a vertical light emitting diode of further another embodiment of the invention.

FIG. **9** shows a three dimensional diagram of a substrate having trenches.

## DETAILED DESCRIPTION OF INVENTION

It is understood that specific embodiments are provided as examples to teach the broader inventive concept, and one of ordinary skill in the art can easily apply the teaching of the present disclosure to other methods or apparatus. The following discussion is only used to illustrate the invention, not limit the invention.

A method for forming a vertical light emitting diode of an embodiment of the invention is illustrated in accordance with FIGS. **3**A~**3**G. First, referring to FIG. **3**A, a first substrate **302** such as sapphire substrate is provided. A semiconductor layer **304** is formed on the first substrate **302**. In an embodiment of the invention, an undoped GaN layer with thickness of about 400 nm is deposited on the first substrate **302** by metal-organic chemical vapor deposition (MOCVD). Referring to FIG. **3**B, a plurality of patterned masks **306** are formed on the

undoped GaN layer **304**. In an embodiment of the invention, the patterned mask layer **306** is a stripe-shaped silicon oxide layer or silicon nitride layer arranged periodically. In a preferred embodiment of the invention, the patterned masks **306** has the stripe width in the range of 1~20 microns and the window between two adjacent mask stripes in the range of 1~20 microns. The patterned silicon oxide layer (or silicon nitride layer) can be formed by the method as follows. A silicon oxide layer with thickness of about 100 nm is grown on an undoped GaN layer by plasma-enhanced chemical vapor deposition (PECVD). Next, a lithography process is performed to form stripe-shaped resists having a period of 13 μm and width of 5 μm acting as a mask of reactive ion etching (RIE). Thereafter, the silicon oxide layer is etched using the resists as an etching mask to form a stripe-shaped silicon oxide layer having a period of 13 μm and width of 8 μm. In an embodiment of the invention, the patterned silicon oxide layers (or silicon nitride layers) can extend along two directions perpendicular to each other.

Referring to FIG. **3**C, an epitaxy layer **308** is grown on the undoped semiconductor layer **304** and the epitaxy layer **308** specifically laterally extends to be over the patterned mask layer **306**. In an embodiment of the invention, the epitaxy layer **308** is undoped GaN formed by the method as follows. A GaN material is grown by metal-organic chemical vapor deposition (MOCVD) with an epitaxial lateral overgrowth (ELOG) method. Since GaN cannot be grown on a silicon oxide layer, it can only be grown on openings in the silicon oxide layer. When the GaN film is grown to be thicker than the silicon oxide layer, it begins to grow laterally, and vertical and lateral growth rates of the GaN film affect the coalescence of the GaN film. Generally, when GaN films are coalesced, a triangle-like seam **310** is formed over each stripe-shaped silicon oxide mask. Next, a light emitting diode structure **312** comprising a first type semiconductor layer **314**, a quantum-well structure **316** and a second type semiconductor layer **318** is formed on the epitaxy layer **308**. In an embodiment of the invention, the first type semiconductor layer **314** is an n-GaN layer, and the second type semiconductor layer **318** is a p-GaN layer. The quantum-well structure **316** is a multi-layered InGaN/GaN structure.

Referring to FIG. **3**D, a first electrode layer **320** is formed on the light-emitting structure **312**. In an embodiment of the invention, the first electrode layer **320** can be a thick metal layer, such as a Ti/Au layer, formed on the surface of the GaN film by E-gun evaporation. Referring to FIG. **3**E, a second substrate **322** with a second metal layer **324** formed thereon is provided. In an embodiment of the invention, the second substrate **322** has good heat and electricity conduction characteristics. For example, the second substrate **322** can be a silicon or copper substrate. The second metal layer **324** is a thick metal layer. As shown in FIG. **3**E, the light emitting diode structure **312** and the epitaxy layer **308** are bonded to the second substrate **322** with the first electrode layer **320** bonded to the second metal layer **324** by wafer bonding technology. Therefore, a sample for photoelectrochemical etching (PEC) to lift off a sapphire substrate is prepared.

Referring to FIG. **4**, the sample **301** is fixed to a support substrate **303** and is immersed in an acid or alkaline electrolyte **309** in a container **311**. A platinum coil **305** is disposed in the electrolyte **309** and the sample **301** is connected to the platinum coil **305** through a conductive wire **313**, wherein the sample **301** acts as a cathode and the platinum coil **305** acts as an anode. A current meter **307** is interposed between the sample **301** and the platinum coil **305** to observe variations of photocurrent. The first substrate **302** of the sample **301** is irradiated by a light source **315**, such as a high power (800 W) Xe lamp. The light used in photoelectrochemical (PEC) etching in an embodiment of the invention can be ultraviolet light, and the diameter of the light can be controlled to be between 1 mm and 8 cm. An embodiment of the invention can irradiate an entire surface of the sample or two-dimensionally scan the sample to lift off the substrate. In an embodiment of the invention, the wavelength of the light spectrum is between 200 nm to 380 nm. Therefore, photoelectrochemical etching begins to etch a portion of GaN which contacts the KOH electrolyte solution **309** when illuminated by light. After conducting PEC etching for a period of time, as shown in FIG. **3**F, the portion of the epitaxy layer **308** grown by the ELOG method can be lifted off from the first substrate **302** such as a sapphire substrate. The mechanism for lifting off the sapphire substrate using PEC etching is illustrated in accordance with FIG. **5**A~FIG. **5**D. First, referring to FIG. **5**A, a sample **301** is placed into a KOH solution **309**. The KOH solution **309** permeates seams **310** over the pattern mask layer **306** in the GaN formed by the ELOG method. To enhance electrolyte permeation into the seams, the electrolyte container **311** is placed on an ultrasonic vibrator **317**, as shown in FIG. **4**. When the sample **301** is irradiated with light, the electron/hole pairs **330** are generated in the semiconductor layer **304** and a portion of the epitaxy layer **308**. The arrangement of the electron/hole pairs depends upon the depth of the ultraviolet light penetrating the GaN. For example, GaN substantially has an absorption coefficient of $\sim 1\times 10^5$ $cm^{-1}$ to light having a wavelength of 350 nm. Therefore, it can be estimated that the electron/hole pairs can be generated to the depth of 450 nm in the GaN layer over the sapphire substrate. Referring to FIG. **5**B, since a portion of the GaN is covered by the patterned mask **306**, the electron/hole pairs **330** are easily recombined in that portion of the GaN. On the contrary, the electron/hole pairs **330** over the patterned mask **306** and in the opening between the adjacent patterned masks **306** can be easily separated. Referring to FIG. **5**C, the holes in the epitaxy layer **308** enhances the GaN to react with the KOH solution **309** to form $Ga_2O_3$. $Ga_2O_3$ is then etched by the KOH solution **309**. Therefore, the KOH solution **309** can permeate into the region between the patterned mask **306** and the epitaxy layer **308**. Next, the portion of the GaN in the opening between the adjacent patterned masks **306** is etched and removed by the KOH solution **309**. Therefore, as shown in FIG. **5**D and FIG. **3**F, the epitaxy layer **308** and the first substrate **302** can be separated.

Refer to FIG. **3**G, wherein a polishing or etching process to remove the unnecessary epitaxy layer **308** and expose the light emitting diode structure **312** is performed. An n-type electrode pad **326** is formed on the light emitting diode structure **312**, and a p-type electrode pad **328** is formed on the second metal layer **324**. Therefore, a vertical type light emitting diode of an embodiment is completed. The epitaxy layer of the embodiment using the ELOG method and photoelectrochemical etching to lift off sapphire substrate has the advantages as follows. First, the KOH solution used in the photoelectrochemical etching can permeate into the seams of the epitaxy layer formed by the ELOG method. Therefore, the method of the embodiment can be used to lift off the sapphire substrate from the epitaxy layer with a large area. Second, the method of the embodiment can reduce the process time for lifting off the sapphire substrate using photoelectrochemical etching. Third, the method of the embodiment using the photoelectrochemical etching process to lift off the sapphire substrate should not cause damage to the semiconductor epitaxy layer. Therefore, yield of lifting off the substrate can be increased.

FIGS. **6**A and **6**B show the fabrication of a light emitting diode device of another embodiment of the invention. For simplicity, the like elements between FIGS. **6**A~**6**B and FIGS. **3**A~**3**G use the same reference numbers. Referring to FIG. **6**A, a first substrate **302**, such as sapphire substrate is provided. A semiconductor layer **304** is formed on the first substrate **302**. In an example, the semiconductor layer **304** is undoped GaN. Next, an important step of the embodiment is conducted. Pattern mask layers **306** and light emitting diode element separating masks **602** are formed on the semiconductor layer **304**. The pattern mask layers **306** and light emitting diode element separating masks **602** can be made of silicon oxide and can be formed in the same process step. It is noted that the width of the light emitting diode element separating mask **602** is greater than the width of the pattern mask layer **306**. Therefore, the light emitting diode element separating masks **602** can be used to define the light emitting diode elements **604**, **606**, **608** and **610**. In a preferred embodiment of the invention, the patterned masks **306** and the light emitting diode element separating masks **602** are stripe-shaped silicon oxide, silicon nitride or other dielectric layers, with the patterned mask stripe width in the range of 1~20 microns and the window between two adjacent patterned mask stripes in the range of 1~20 microns, and with the light emitting diode element separating mask stripe width in the range of 20~100 microns. Next, an epitaxy layer **308** is formed on the semiconductor layer **304**, wherein the epitaxy layer **308** laterally extends over the patterned mask layers **306**. In an embodiment of the invention, the epitaxy layer **308** is grown by metal-organic chemical vapor deposition (MOCVD) with the epitaxial lateral overgrowth (ELOG) method. Since GaN cannot be grown on a silicon oxide layer, it can only be grown on openings in the silicon oxide layer. When the GaN film is grown to become thicker than the silicon oxide layer, it begin to grow laterally, and vertical and lateral growth rate of the GaN film affects the coalescence of the GaN film. Generally, when the GaN films are coalesced, a triangle-like seam **310** is formed over each patterned mask **306**, as shown in FIG. **6**B. Since the light emitting diode element separating mask **602** has a greater width, the epitaxy layer **308** is not coalesced over the light emitting diode element separating masks **602**. Therefore, the light emitting diode elements **604**, **606**, **608** and **610** can be defined. Next, a light emitting diode structure **312** comprising a first type semiconductor layer, a quantum-well structure and a second type semiconductor layer is formed on the epitaxy layer **308**. The following step using a photoelectrochemical etching process to lift off the sapphire substrate **302** is similar to the embodiment illustrated in FIGS. **3**E~**3**G and is not described again herein. The embodiment using the light emitting diode element separating mask **602** to define the light emitting diode elements **604**, **606**, **608** and **610** has advantages as follows. First, the light emitting diode element separating masks for isolating the light emitting diode elements can be formed simultaneously as formation of the patterned masks for the ELOG process. Second, the embodiment can omit steps of patterning and etching a semiconductor layer for isolating the light emitting diode elements to reduce process time and cost. Third, since the semiconductor layer is not coalesced over the light emitting diode element separating masks, electrolytes, such as KOH, can flow into the seams more easily. Therefore, etching rate of photoelectrochemical etching is increased.

FIG. **6**C shows a light emitting diode device of a further embodiment of the invention. For simplicity, the like elements between FIG. **6**C and FIG. **6**A use the same reference numbers. In order to avoid generating bumps at edges of the epitaxy layers of the light emitting diode elements **604**, **606**, **608** and **610** in FIG. **6**A due to too great a space between the adjacent light emitting diode elements, as shown in FIG. **6**C, the embodiment places a plurality of separating masks **603***a*, **603***b* and **603***c* between the adjacent light emitting diode elements **604**, **608** and the epitaxy layer **308** is not coalesced over the separating masks **603***a*, **603***b* and **603***c*. Therefore, the light emitting diode elements **604**, **608** can be isolated by the seams **650***a*, **650***b* and **650***c* over the separating masks **603***a*, **603***b* and **603***c*, and the issue of generating bumps at edges due to too great a space between the adjacent light emitting diode elements **604**, **608** can be eliminated.

The conditions of fabricating a light emitting diode of an embodiment of the invention are discussed in accordance with FIG. **7**A. Referring to FIG. **7**A, a substrate, such as sapphire substrate is provided. A semiconductor layer **304** is formed on the first substrate **302**. In an example, the semiconductor layer **304** is undoped GaN. An epitaxy layer **308** is grown on the semiconductor layer and the epitaxy layer specifically laterally extends to be over the patterned masks **306**. In an embodiment of the invention, the epitaxy layer **308** is undoped GaN formed by the method as follows. A GaN material is grown by metal-organic chemical vapor deposition (MOCVD) with the epitaxial lateral overgrowth (ELOG) method. Since GaN cannot be grown on a silicon oxide layer, it can only be grown on openings in the silicon oxide layer. When the GaN film is grown to become thicker than the silicon oxide layer, it begins to grow laterally, and vertical and lateral growth rates of the GaN film affect coalescence of the GaN film. Generally, when the GaN film is coalesced, a triangle-like seam **310** is formed over each strip-shaped silicon oxide mask.

It is noted that the semiconductor layer **304** and the patterned mask layer **306** are specifically limited to a specific thickness range. In the embodiment, thickness d of the semiconductor layer **304** can be 0~800 nm, and thickness t of the patterned mask layer **306** can be 30~800 nm.

FIG. **7**B shows an example of FIG. **7**A when thickness d of the semiconductor layer **304** is zero. As shown in FIG. **7**B, since thickness d of the semiconductor layer **304** is zero, the patterned masks **306** are directly formed on the first substrate **302**. An epitaxy layer **308** is grown on the first substrate **302** and the epitaxy layer **308** specifically laterally extends to be over the patterned masks **306**. Since GaN cannot be grown on the pattern mask **306** such as silicon oxide, it can only be grown on openings of the patterned masks **306**. When the GaN film is grown to become thicker than the patterned mask **306**, it begins to grow laterally. Generally, when the GaN film is coalesced, a triangle-like seam **310** is formed over each stripe-shaped patterned mask **306**. Next, a light emitting diode structure **312** comprising a first type semiconductor layer **314**, a quantum-well structure **316** and a second type semiconductor layer **318** is formed on the epitaxy layer **308**. The following steps using a photoelectrochemical etching process to lift off the sapphire substrate **302** is similar to the embodiment illustrated in FIGS. **3**E~**3**G and is not described again herein.

A method for forming a light emitting diode device of an embodiment of the invention is illustrated in accordance with FIGS. **8**A~**8**D. First, referring to FIG. **8**A, a substrate **802** such as sapphire substrate is provided. Next, a plurality of one-dimensional or two-dimensional arranged trenches **808** is formed on the substrate **802**. It is noted that the trenches **808** are preferably connected to opposite ends of the substrate **802**, such that electrolytes can flow into the trenches **808** in the following steps. For example, the ends can be the first end **804** and the second end **806** shown in FIG. **9**. Specifically, the trenches **808** are required to have enough width and height for

the electrolyte to flow into a central portion of the substrate **802**. In an embodiment of the invention, the width of the trenches **808** is 0.5~10 microns, and the depth of the trenches **808** is 0.1~5 microns.

Referring to FIG. **8**B, an epitaxy layer **810** is grown on the substrate **802**. In an embodiment of the invention, the epitaxy layer **810** is undoped GaN formed by metal-organic chemical vapor deposition (MOCVD). It is noted that the epitaxy layer **810** cannot be grown over the trenches **808**. The epitaxy layer **810** can only be grown on a surface of the substrate **802** out of the trenches **808**, and the epitaxy layer **810** further extends laterally to be over the trenches **808**. Generally, when the GaN film is coalesced, a triangle-like seam **820** is formed over each trench **808**. Next, a light emitting diode structure **818** comprising a first type semiconductor layer **812**, a quantum-well structure **814** and a second type semiconductor layer **816** is formed on the epitaxy layer **810**. In an embodiment of the invention, the first type semiconductor layer **812** is an n-GaN layer, and the second type semiconductor layer **816** is a p-GaN layer. The quantum-well structure **814** is a multi-layered InGaN/GaN structure.

Referring to FIG. **8**C, the substrate **802** is immersed in an electrolyte **822**. The electrolyte **822** flows into the seams **820** between the substrate **802** and the epitaxy layer **810**, and the epitaxy layer **810** is irradiated by light **824** from the substrate **802** side using photoelectrochemical etching (PEC) to lift off the substrate **802**. It is noted that a portion of the epitaxy layer **810** neighboring an interface between the epitaxy layer **810** and the substrate **802** has poor quality and includes many defects. Therefore, the embodiment preferably adjusts parameters for the photoelectrochemical etching process to occur at the position at a distance separating from the interface between the epitaxy layer **810** and the substrate **802**. Consequently, the step of lifting off the substrate **802** can simultaneously remove the portion of the epitaxy layer **810** having poor quality. The following step using a photoelectrochemical etching process to lift off the sapphire substrate is similar to the embodiment illustrated in FIGS. **3**E~**3**G and is not described again herein.

According to the principles of the embodiment, the light emitting diode element separating masks can be replaced by the trenches having great enough height and width. Therefore, the trenches can act as isolations of light emitting diode elements.

While the invention has been described by way of example and in terms of the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. It is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

**1**. A method for forming a light emitting device, comprising:
- providing a first substrate;
- forming a plurality of patterned masks over the first substrate or etching the first substrate to form a plurality of trenches;
- growing an epitaxy layer using an epitaxial lateral overgrowth (ELOG) method over the first substrate with the patterned masks;
- forming a light emitting diode structure over the epitaxy layer;
- forming a first electrode layer on the light emitting diode structure;
- bonding the light emitting diode structure to a second substrate; and
- performing a photoelectrochemical etching process to lift off the epitaxy layer from the first substrate.

**2**. The method for forming a light emitting device as claimed in claim **1**, wherein the first substrate is a sapphire substrate.

**3**. The method for forming a light emitting device as claimed in claim **1**, further comprising forming a semiconductor layer on the first substrate before forming a plurality of patterned masks, wherein the semiconductor layer is GaN.

**4**. The method for forming a light emitting device as claimed in claim **3**, wherein the thickness of the semiconductor layer on the first substrate is 0~800 nanometer.

**5**. The method for forming a light emitting device as claimed in claim **3**, wherein the patterned masks are stripe-shaped silicon oxide, silicon nitride or other dielectric layers, with the stripe width in the range of 1~20 microns and the window between two adjacent mask stripes in the range of 1~20 microns, arranged along one direction or two perpendicular directions to spread over the entire surface of the first substrate or the semiconductor layer.

**6**. The method for forming a light emitting device as claimed in claim **1**, wherein the epitaxy layer extends laterally to be over the patterned masks or the trenches on the first substrate.

**7**. The method for forming a light emitting device as claimed in claim **6**, wherein the epitaxy forms a triangle-like seam over each patterned mask or trench.

**8**. The method for forming a light emitting device as claimed in claim **7**, wherein alkaline or acid electrolyte permeates the triangle-like seams to etch portions of the epitaxy layer over the patterned masks or between the adjacent patterned masks that is accelerated by placing the electrolyte container on an ultrasonic vibrator.

**9**. The method for forming a light emitting device as claimed in claim **1**, wherein the light emitting diode structure comprises a first type semiconductor layer, a quantum well structure and a second type semiconductor layer.

**10**. The method for forming a light emitting device as claimed in claim **1**, further comprising performing a polishing or etching process which removes the epitaxy layer to expose the light emitting diode structure.

**11**. The method for forming a light emitting device as claimed in claim **1**, wherein the epitaxy layer is undoped GaN.

**12**. The method for forming a light emitting device as claimed in claim **1**, wherein the trenches have a width of 0.5~10 microns, and a depth of 0.1~5 microns.

**13**. The method for forming a light emitting device as claimed in claim **1**, wherein the patterned masks have a thickness of 30 nm~800 nm.

**14**. A method for forming a light emitting device, comprising:
- providing a first substrate;
- forming a semiconductor layer on the first substrate;
- forming a plurality of patterned masks and at least one light emitting diode element separating mask on the semiconductor layer;
- using an epitaxial lateral overgrowth (ELOG) method to grow an epitaxy layer on the semiconductor layer, wherein the epitaxy layer laterally grows on the patterned masks and the light emitting diode element separating masks, and the epitaxy layer is not coalesced over the light emitting diode element separating masks to isolate the light emitting diode elements;

forming a light emitting diode structure on the epitaxy layer;

forming a first electrode layer on the light emitting diode structure;

bonding the light emitting diode structure to a second substrate; and

performing a photoelectrochemical etching process to lift off the epitaxy layer from the first substrate.

**15**. The method for forming a light emitting device as claimed in claim **14**, wherein the patterned masks and the light emitting diode element separating masks are stripe-shaped silicon oxide, silicon nitride or other dielectric layers, with the patterned mask stripe width in the range of 1~20 microns and the window between two adjacent patterned mask stripes in the range of 1~20 microns, and with the light emitting diode element separating mask stripe width in the range of 20~100 microns.

**16**. The method for forming a light emitting device as claimed in claim **14**, wherein the width of the light emitting diode element separating mask is greater than the width of each of the patterned masks.

**17**. The method for forming a light emitting device as claimed in claim **14**, wherein the first substrate is a sapphire substrate.

**18**. The method for forming a light emitting device as claimed in claim **14**, further comprising a polishing or etching process which removes the epitaxy layer to expose the light emitting diode structure.

**19**. The method for forming a light emitting device as claimed in claim **14**, wherein the patterned masks and at least one light emitting diode element separating mask are directly formed on the first substrate without the semiconductor layer therebetween.

**20**. The method for forming a light emitting device as claimed in claim **14**, further comprising forming the first trenches and at least a second trench to replace the patterned masks and the light emitting diode element separating mask.

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