A transparent layer of a LED device and the method for growing the same are disclosed in this present invention. This present invention provides an improved liquid phase epitaxy (LPE) process for growing a transparent layer of a LED device. In the above-mentioned LPE process, an improved supersaturated solution is utilized to overcome the shortcomings in the prior art, wherein the supersaturated solution comprises antimony and/or indium as a solvent. Furthermore, a metallic zinc and/or magnesium dopant is added into the supersaturated solution to optimize the characters of the transparent layer. Therefore, this invention can provide a more efficient method for growing a transparent layer of a LED device, and the quality of the above-mentioned transparent layer can thereby be improved.

Providing a supersaturated solution comprising Sb and (or) In as solvent

Immersing a LED substrate into the supersaturated solution

Growing a transparent layer onto the LED substrate
Providing a supersaturated solution comprising Sb and (or) In as solvent

Immersing a LED substrate into the supersaturated solution

Growing a transparent layer onto the LED substrate

FIG. 1

FIG. 2
TRANSPARENT LAYER OF A LED DEVICE AND THE METHOD FOR GROWING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This present invention relates to a transparent layer and the method for growing the same, and more particularly to a transparent layer and an improved liquid phase epitaxy method for growing the transparent layer onto a LED substrate.

[0003] 2. Description of the Prior Art

[0004] In recent years, The Light-Emitting Diode (LED) has become more and more popular. The LED has a semi-conductor light generation region situated on a light absorbing substrate. The popularity with LED’s is beginning to replace incandescent lamps. In order to meet the demands for light output, it is important that the overall light output efficiency of the LED be maximized. In this manner, the transparent layer plays an important role in a LED device.

[0005] In the prior art, one well-known method for growing the transparent layer in a LED device is formed by metal-organic chemical vapor deposition (MOCVD). However, there are many disadvantages in MOCVD. First, MOCVD causes a problem with environmental pollution, because the MOCVD vapor is poisonous. Furthermore, if the desired transparent layer comprises GaP or the like, there is still another safety problem with a possible explosion and spontaneous combustion of the phosphorous compound. Second, MOCVD is not an efficient method for growing the transparent layer. For example, in the case of growing a transparent layer of GaP, the growing rate is about 10 μm per hour.

[0006] Another well-known method for growing the desired transparent layer is liquid phase epitaxy (LPE). In the conventional LPE process, there are still many shortcomings and limits. A serious problem of the conventional LPE process is a melt back effect occurring in the LED substrate during the growing of the transparent layer onto the LED substrate. The above-noted “melt back” will crack the construction of the LED device. Moreover, the uppermost layer of the LED substrate, where the transparent layer is grown, is limited. For example, while growing a GaP onto the LED substrate, the uppermost layer of the LED substrate must be a thick layer of GaP.

[0007] Hence, it is an important object of developing an improved method for growing the transparent layer of a LED device more efficiently and optimizing the above-mentioned transparent layer.

SUMMARY OF THE INVENTION

[0008] In accordance with the present invention, a transparent layer of a LED structure is provided, wherein the transparent layer comprises semiconductor material, and zinc (Zn) and/or magnesium (Mg) as a dopant.

[0009] It is another object of this invention to provide a method for growing a transparent layer of a LED structure. An improved LPE process is utilized in this present invention, thus the transparent layer can be formed more efficiently.

[0010] Still another object of this invention is to provide an improved LPE process for forming a transparent layer of a LED structure. A different solvent is employed in the above-mentioned LPE process, and the shortcomings in the prior art, such as the melt back effect in the LED substrate during the growing of the transparent layer, and so on, can be overcome.

[0011] Still another object of this invention is to provide an improved LPE process for forming a transparent layer of a LED structure. A dopant is employed in the improved LPE process, and thus the surface of the desired transparent layer is smoother than the surface of the transparent layer without the above-noted dopant.

[0012] Still another object of this invention is to provide an improved LPE process for forming a transparent layer of a LED structure. A dopant is employed in the improved LPE process, and thus the characteristics of the desired transparent layer, such as the forward voltage, and so on, can be improved.

[0013] In accordance with the above-mentioned objects, the invention provides structure of a transparent layer of a LED device and the method for growing the same. The transparent layer is formed by an improved LPE process. The above-mentioned LPE process comprises the following steps: providing a supersaturated solution comprising Sb as a solvent, immersing a LED substrate into the supersaturated solution, and growing a transparent layer onto the LED substrate. Additionally, in order to smooth the surface of the transparent layer and improve the characteristics of the transparent layer, a special dopant is added into the supersaturated solution. Therefore, the improved LPE process according to this invention can improve the quality of the transparent layer, and the transparent layer can be formed efficiently.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

[0015] FIG. 1 is a diagram showing a flow chart for growing a transparent layer according to this invention; and

[0016] FIG. 2 is a schematic diagram showing a LED structure according to this present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Some sample embodiments of the invention will now be described in greater detail. Nevertheless, it should be recognized that the present invention can be practiced in a wide range of other embodiments besides those explicitly described, and the scope of the present invention is expressly not limited except as specified in the accompanying claims.

[0018] One preferred embodiment of this invention is a method for growing a transparent layer onto a light-emitting diode (LED) device. A liquid phase epitaxy (LPE) process is utilized in the above-mentioned method. A supersaturated solution is prepared for the LPE process, wherein the supersaturated solution comprises antimony (Sb) as a sol-
vent. A LED substrate is then immersed into the supersaturated solution and a transparent layer is grown onto the surface of the LED device.

[0019] In this preferred embodiment, the LPE process comprises the steps as shown in FIG. 1. First, a LED substrate is immersed into the SuperSaturated Solution and a transparent layer is grown onto the substrate. Then the LED substrate is immersed into the SuperSaturated Solution. The LED substrate comprises the layers of light generate region, bottom metal contact, and so on. Because the above-mentioned layers in the LED are not the key aspects of this invention, the layers will not be described in this application. Finally, the supersaturated solution is cooled down and a transparent layer consisting of the compound in the supersaturated solution, such as GaP, is grown onto the surface of the LED substrate, as shown in the step 130. On the other hand, if the above-mentioned supersaturated solution comprises the indium compound, the growth rate of the transparent layer will be raised.

[0020] In this manner, the LPE process disclosed in this application overcomes the shortcomings in the prior art. In contrast to the LPE process in the prior art, the LPE process in the invention employed antimony (Sb), or indium (In), or Sb and In, as a solvent instead of gallium (Ga) in the prior art for growing the transparent layer. Therefore, the LPE process according to this present invention can prevent the melt back effect in the prior art. Moreover, the LPE process in the prior art, the uppermost layer of the LED substrate must be GaP, if the solute in the supersaturated solution is GaP. However, in this present invention, the material of the uppermost layer of the LED substrate is not limited. The comparison between the LPE process in the prior art and the improved LPE process according to this invention is set forth in Table 1.

<table>
<thead>
<tr>
<th>Uppermost layer of the LED substrate</th>
<th>Occurring &quot;melt back&quot;</th>
<th>Improve growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior art GaSb</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Invention Sb</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Invention Sb + In</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
semiconductor materials. The dopant is metallic Zinc, metallic magnesium, or both of zinc and magnesium. The transparent layer 150 is formed by the LPE process. A supersaturated solution utilized in the above-mentioned LPE process comprises metallic antimony (Sb), or indium (In), or Sb and In, as a solvent, and metallic zinc (Zn), or zinc and magnesium, as a dopant. In the example of growing a GaP transparent layer onto a LED substrate, the supersaturated solution in the LPE process comprises metallic Sb as a solvent, GaP as a solute, and Zn or Mg as a dopant. The amount of the dopant Zn is from 1/1000 to 1/10 by weight of Sb. The above-mentioned LPE process can prevent the melt back effect from occurring at the uppermost layer of the LED substrate 140 during the growing of the transparent layer.

Moreover, by utilizing the LPE process according to this invention, the transparent layer 150 can be formed efficiently. In the example of growing a GaP transparent layer by the LPE process, the growing rate of the transparent layer is >0.5 μm per minute. Additionally, because of Zn doped in the supersaturated solution, the surface of the transparent layer 150 will be smoother than the surface of the transparent layer without Zn dopant. The Zn dopant can improve the characters of the transparent layer 150, for example, from the result of the examination of the LED device, the Diode Forward Voltage (VF) is lowered from about >2.5 V to <2.4 V, and the intensity of the GaP transparent layer is raised from 18.62 to about 22–24 Mcd.

In addition, in order to prevent the construction of the LED substrate broken down during the growing of the transparent layer 150 under the temperature about 500°C–1000°C, the growing process of the transparent layer can be performed in turn. For example, in the case of growing 20 μm transparent layer, the LED substrate 140 is immersed into the supersaturated solution to perform the first growing process of the transparent layer to obtain a first 10 μm transparent layer, and then the LED substrate 140 with the first 10 μm transparent layer is suffered to the secondary growing process of the transparent layer to obtain a secondary 10 μm transparent layer. In this manner, the desired 20 μm transparent layer 150 is grown onto the LED substrate 140, and the LED substrate 140 will not be broken down under the high temperature. Moreover, because the growing rate of the LPE process according to this invention is fast, it is still efficient for growing the transparent layer stepwise.

According to the preferred embodiment, this invention discloses a structure of a transparent layer of a LED device and the method for growing the same. The transparent layer is formed by an improved LPE process. The supersaturated solution utilized in the LPE process comprises antimony, and/or indium, as a solvent, and zinc, or zinc and magnesium, as dopant. Therefore, the above-mentioned method can overcome the problems, such as the melt back effect during the growing of the transparent layer, and efficiently form the transparent layer. Moreover, In is added together with Antimony as solvent to avoid the melt back effect to improve the growth rate of the transparent layer grown by LPE process. On the other hand, because of the Zn dopant, the method according to this present invention can not only advance the characters of the transparent layer, but also smooth the surface of the transparent layer. Thus, this invention discloses a more efficient method for growing a transparent layer onto a LED substrate, and thus the quality of the transparent layer formed by this present invention can be improved.

Although specific embodiments have been illustrated and described, it will be obvious to those skilled in the art that various modifications may be made without departing from what is intended, but not to be limited solely by the appended claims.

What is claimed is:

1. A method for growing a transparent layer on a LED substrate, comprising:
   providing a supersaturated solution, wherein said supersaturated solution comprises Sb as a solvent;
   immersing the LED substrate into said supersaturated solution; and
   growing the transparent layer onto the LED substrate.
2. The method according to claim 1, wherein said supersaturated solution further comprises In as the solvent.
3. The method according to claim 1, wherein said supersaturated solution further comprises a metallic dopant.
4. The method according to claim 3, wherein said metallic dopant comprises Zn.
5. The method according to claim 4, wherein said Zn is in an amount of 1/1000 to 1/10 by weight of the Sb.
6. The method according to claim 1, wherein said step of immersing the LED substrate into said supersaturated solution is performed under a temperature of about 500°C to 1000°C.
7. A method for growing a transparent layer onto a LED substrate, comprising:
   providing a supersaturated solution, wherein said supersaturated solution comprises Sb as a solvent;
   immersing the LED substrate into said supersaturated solution;
   growing a first transparent layer onto the LED substrate, wherein the first transparent layer has a first thickness;
   immersing the LCD substrate with the first transparent layer into said supersaturated solution; and
   growing a secondary transparent layer onto the first transparent layer on the LED substrate, wherein the secondary transparent layer has a secondary thickness.
8. The method according to claim 7, wherein said supersaturated solution further comprises In as the solvent.
9. The method according to claim 7, wherein said supersaturated solution further comprises a metallic dopant.
10. The structure according to claim 8, wherein said metallic dopant comprises Zn.
11. The method according to claim 10, wherein said Zn is in an amount of 1/1000 to 1/10 by weight of the Sb.
12. The method according to claim 7, wherein said step of immersing the LED substrate into said supersaturated solution is performed under a temperature of about 500°C to 1000°C.
13. A method for growing a transparent layer onto a LED substrate, comprising:
   providing a supersaturating solution, wherein said supersaturating solution comprises Sb and In as a solvent, GaP as a solute, and Zn as a dopant;
immersing the LED substrate into said supersaturated solution; and

growing the transparent layer onto the LED substrate.

14. The method according to claim 13, wherein said Zn is in an amount of 1/1000 to 1/10 by weight of Sb of the supersaturated solution in the LPE process.

15. The method according to claim 13, wherein said step of immersing the LED substrate into said supersaturated solution is performed under a temperature of about 500° C. to 1000° C.

16. The method according to claim 13, wherein said growing the transparent layer comprises the following steps:

growing a first transparent layer onto the LED substrate;

immersing the LED substrate with said first transparent layer into said supersaturated solution; and

growing a secondary transparent layer onto said first transparent layer.

17. A structure of a LED device, the structure comprising:

a LED substrate; and

a transparent layer on said LED substrate, wherein said transparent layer comprises a metallic Zn dopant.

18. The structure according to claim 17, wherein said transparent layer is formed by LPE process.

19. The structure according to claim 17, wherein said transparent layer is formed by LPE process utilizing a supersaturated solution comprising metallic antimony (Sb) and indium (In) as a solvent.

20. The structure according to claim 18, wherein said Zn dopant is in an amount of 1/1000 to 1/10 by weight of said solvent of a supersaturated solution in the LPE process.

21. The structure according to claim 19, wherein said Zn dopant is in an amount of 1/1000 to 1/10 by weight of Sb of the supersaturated solution in the LPE process.