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Description

Semiconductor component and production method

The invention relates to a semiconductor component having a semiconductor body, which has a front side, a rear side and at least one curved side surface.

Such semiconductor components belong to the prior art. Figure 3 shows, for example, a diagrammatic illustration of a cross-section through a semiconductor body 12 having a mesa structure. Semiconductor bodies 12 of this type are used in light-emitting diodes, for example. The characteristic feature of the mesa structure is the curved side surfaces 15, which at one end adjoin the front side 28 and at the other end adjoin the planar side surfaces 14.

In light-emitting diodes, semiconductor bodies 12 which are shaped in this way and allow the radiation produced by the light-emitting diode to pass bring about improved coupling out of the light produced in the light-emitting diode, in comparison with light-emitting diodes having a parallelepipedal semiconductor body, and thus an increased external quantum efficiency (= number of protons leaving the light-emitting diode per unit of time/number of charges transported through the light-emitting diode per unit of time). This is due to the fact that, in comparison with a parallelepipedal semiconductor body, in the case of the semiconductor body 12 described above, significantly more of the light which is emitted from the pn junction 17 of the semiconductor body 12 in the direction of the rear side 18 and is reflected there impinges on the surface of the semiconductor body 12 at an angle which is less than the critical angle of total reflection. The reflection and absorption losses in the semiconductor body are distinctly reduced as a result of this.

A method for producing a semiconductor body 12 having the geometry described above is diagrammatically illustrated in Figure 4. Applied first of all to the

front side of a semiconductor wafer 22 having a pn junction 17 are contact metallization layers 20, and then a plurality of etching masks 23. A plurality of mesa trenches 24 are then isotropically etched into the semiconductor wafer 22 using a suitable etchant. A suitable etchant for a semiconductor wafer 22 comprising GaAs and/or GaAlAs is, for example, a $\text{H}_2\text{SO}_4/\text{H}_2\text{O}_2/\text{H}_2$ solution (mixture ration 3:1:1). After this, the etching masks 23 are removed, the semiconductor wafer 22 is thinned to its final thickness and a contact metallization layer 21 is applied to the rear side of the semiconductor wafer 22. The surface of the semiconductor wafer 22 and the contact metallization layers 20 are subsequently covered with a protective layer 25, for example photoresist, silicon oxide or silicon nitride. The semiconductor wafer 22 is then secured on a carrier 26, for example a plastic adhesive film, and subsequently separated into chips, for example by sawing. The separation is followed by a further etching step, the so-called chip flank etching. In this etching process, the semiconductor material on the cut surfaces 27 which is damaged during the separation of the semiconductor wafer 22 is removed. The last step is to remove the chips from the carrier 26.

In the above-described method for producing semiconductor bodies 12 having a mesa structure, the risk of the semiconductor wafer 22 breaking during sawing is extremely high, since the wafer thickness in the mesa trenches 24 is very low.

In addition, in the case of semiconductor bodies for light-emitting diodes, although the coupling out of light from the above-described semiconductor body 12 is distinctly increased in comparison with the coupling out of light of a parallelepipedal semiconductor body, the external quantum efficiency of a light-emitting diode having a semiconductor body 12 shaped in this way is still very low. Specifically, a large part of the light emitted from the pn junction 17 in the direction of the rear side 18 and reflected there still impinges on the

surface of the semiconductor body 12 at an angle which is greater than the critical angle of total reflection. This light is therefore reflected anew into the interior of the semiconductor body 12.

5 The invention is based on the object of improving a semiconductor body of the type mentioned in the introduction in such a way that the method for producing it is simplified, with the result that, in particular, the risk of the semiconductor body breaking during sawing
10 is reduced.

At the same time, a further aim is to improve the coupling out of light in the case of semiconductor bodies for light-emitting diodes.

15 This object is achieved by virtue of the fact that, viewed from the outside, the curved side surface is convex adjacent to the rear side and is concave adjacent to the surface, and that the area of the rear side is greater than the area of the front side.

20 Subclaims 2 to 7 relate to developments of the invention. Claims 8 and 9 relate to a preferred method for producing the semiconductor component according to the invention.

25 In an advantageous development of the semiconductor component according to the invention, the curved side surface is convex up to a first thickness of the semiconductor body, and the first thickness is greater than half the total thickness of the semiconductor body. Particularly in the case of light-emitting semiconductor bodies, this advantageously results in a distinct
30 improvement in the coupling out of light, since the semiconductor body is very like a calotte.

In a preferred embodiment of the semiconductor component according to the invention, a plastic encapsulation is applied to the semiconductor body.

35 In a preferred method for producing at least two semiconductor components according to the invention, a prefabricated semiconductor wafer applied to a carrier means is severed into at least two parts after the application of at least two mutually separated etching

5 masks to that side of the semiconductor wafer which is opposite to the carrier means, those parts still secured on the carrier means are subsequently isotropically etched in such a way that an undercut of the etching masks is produced, and the parts are subsequently processed further to form semiconductor components.

A particularly preferred method has the following steps:

- production of a semiconductor wafer,
- 10 • application of at least two front side contacts to the semiconductor wafer in accordance with a predetermined grid pattern,
- application of at least one rear side contact to the semiconductor wafer,
- 15 • application of at least two mutually separated etching masks in such a way that the front side contacts and part of the front side of the semiconductor wafer are covered,
- securing of the semiconductor wafer on a carrier means,
- 20 • severing of the semiconductor wafer between the etching masks into chips, in such a way that the chips remain on the carrier means in their previous arrangement,
- 25 • isotropic etching of the chips in such a way that the etching masks are undercut,
- removal of the etching masks,
- detachment of the chips from the carrier,
- further processing of the chips to form semiconductor components.
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The invention is explained in more detail using an exemplary embodiment in connection with Figures 1 and 2, in which

35 Figure 1 shows a diagrammatic illustration of a section through the exemplary embodiment of the semiconductor body according to the invention, and
Figure 2 shows a diagrammatic illustration of the sequence of a method for producing a plurality of semiconductor bodies according to Figure 1.

The semiconductor body 1 of Figure 1, for example comprising GaAs or another III/V semiconductor material, has a pn junction 6, a front side contact 5, a rear side contact 4, a front side 2, a rear side 3 and a curved side surface 9. The pn junction 6 is formed, for example, by means of Si and/or Zn doping. The contacts 4 and 5 are made, for example, of aluminium, gold or another suitable metallic material. Seen from the outside, the curved side surface 9 is concave adjacent to the front side 2 and convex adjacent to the rear side 3. The semiconductor body 1 has a respective sharp edge 7, 8 only at the transition from the front side 2 to the side surface 9 and at the transition from the rear side 3 to the side surface 9. The rear side contact 4 can be designed to be reflective (for example polished) and cover the entire rear side 3 or only partial regions of the rear side 3. The front side contact 5 covers only a small part in the centre of the front side 2. In order to improve the reflection properties of the rear side with regard to the use as a light-emitting diode, the rear side of the semiconductor body may advantageously be polished or coated with a reflection-enhancing material, for example Si_3N_4 .

In the exemplary embodiment, the curved side surface 9 is convex up to a first thickness 29 of the semiconductor body 1, the first thickness 29 being greater than half the total thickness 30 of the semiconductor body 1. Equally, however, the first thickness 29 may also be less than or equal to half the total thickness 30.

A light-emitting diode having a semiconductor body 1 shaped in this way has a higher external quantum efficiency than a light-emitting diode having a semiconductor body 12 according to Figure 3. Specifically, significantly less of the light radiation which is emitted from the pn junction 6 in the direction of the rear side 3 of the semiconductor body and is reflected there is totally reflected into the semiconductor body 1 from the curved side surface 9, which is similar to a

calotte, than is the case with the semiconductor body 12 of Figure 3. The reason for this is that, in comparison with the semiconductor body 12 of Figure 3, in the case of the semiconductor body 1, a significantly larger part of the surface of the semiconductor body 1 is oriented in such a way that the light radiation reflected from the rear side 3 impinges on the surface of the semiconductor body 1 at an angle which is less than the critical angle of total reflection. The light losses are therefore distinctly less in the case of the semiconductor body 1 according to the invention.

As an option, it may also be provided that the semiconductor body 1 according to the invention is not curved over the entire side surface 9, but rather only a partial region or a plurality of partial regions of the side surface 9, for example partial areas of the side surface 9 situated opposite one another with regard to a mid-perpendicular 31, are curved. The production method described below must then be correspondingly adapted, for example by suitable masking.

A plurality of semiconductor bodies 1 with rear and front side contacts 4 and 5, respectively, according to Figure 1 can be produced simultaneously using the production method illustrated diagrammatically in Figure 2. This method has the following successive method steps:

- a) production of a semiconductor wafer 10 having a whole-area pn junction 6, for example GaAs:Si/GaAs;
- b) thinning of the semiconductor wafer 10 to the final thickness, for example by means of grinding;
- c) application of a plurality of front side contacts 5 in accordance with a predetermined grid pattern and application of the rear side contact 4, in each case by means of vapour deposition, for example;
- d) application of a plurality of etching masks 11, for example comprising photoresist, in accordance with the predetermined grid pattern;
- e) securing of the semiconductor wafer 10 on a carrier 26;
- f) separation of the semiconductor wafer 10 in accord-

ance with the predetermined grid pattern into a plurality of chips 13;

- g) isotropic etching of the chips 13 using, in the case of a semiconductor wafer 10 made of GaAs or AlGaAs, for example, an etching solution of phosphoric acid, H_2O_2 and H_2O with a mixture ratio of 1:2:3 or of sulphuric acid, H_2O_2 and H_2O with a mixture ratio of 3:1:1;
- h) removal of the etching masks 11;
- i) detachment of the chips 13 from the carrier 26.

Instead of a semiconductor wafer 10 having a whole-area pn junction 6, it is equally possible, in step a), to produce a semiconductor wafer 10 having pn junctions which are locally indiffused in accordance with a predetermined grid pattern. A suitable dopant is Zn, for example. Steps b) to i) remain identical.

The method according to the invention has two advantages over the mesa technique described above and diagrammatically illustrated in Figure 4:

Firstly, the semiconductor wafer has the same thickness at all points during the critical process steps "thinning of the semiconductor to the final thickness" and "separation of the semiconductor wafer". As a result, the breaking strength is distinctly higher than in the case of the conventional mesa technique according to Figure 4. In the conventional mesa technique, the breaking rate in the method steps following the mesa etching is very high due to the small thickness of the semiconductor wafer 22 prevailing in the mesa trenches.

Secondly, one etching step is dispensed with in the method according to the invention. The shaping of the side surfaces and the removal of the semiconductor material at the cut surfaces which has been damaged during separation take place in a single etching step. The production outlay is therefore distinctly lower in the case of the method according to the invention than in the case of the conventional method.

The above-described semiconductor body according to the invention and the associated production method are

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not exclusively restricted to the use in light-emitting diodes, but can be employed in all semiconductor bodies having mesa flanks, such as bipolar transistors, for example.



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Patent Claims

1. Semiconductor component having a semiconductor body (1), which has a front side (2), a rear side (3) and at least one curved side surface (9), characterized in that, viewed from outside, the curved side surface (9) is convex adjacent to the rear side (3) and is concave adjacent to the front side (2), and in that the area of the rear side (3) is greater than the area of the front side (2).
2. Semiconductor component according to Claim 1, characterized in that the curved side surface (9) is convex up to a first thickness (29) of the semiconductor body (1), and in that the first thickness is greater than half the total thickness (30) of the semiconductor body (1).
3. Semiconductor component according to Claim 1 or 2, characterized in that the semiconductor body (1) has a shape similar to a calotte.
4. Semiconductor component according to one of Claims 1 to 3, characterized in that a plastic encapsulation is applied directly to the semiconductor body (1).
5. Semiconductor component according to one of Claims 1 to 4, characterized in that the semiconductor component is a light-emitting diode, and in that the semiconductor body (I) comprises III/V semiconductor material.
6. Semiconductor component according to Claim 5, characterized in that the rear side (3) of the semiconductor body is designed to be reflective.
7. Semiconductor component according to Claim 4 and 5 or 6, characterized in that the plastic encapsulation is transparent to light.
8. Method for producing a plurality of semiconductor components according to one of Claims 1 to 7, characterized in that a prefabricated semiconductor wafer (10) applied to a carrier means (26) is severed into at least two parts after the application of at least two mutually separated etching masks (11) to that side of the semi-



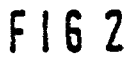
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conductor wafer (10) which is opposite to the carrier means (26), in that those parts still secured on the carrier means (26) are subsequently isotropically etched in such a way that an undercut of the etching masks (11) is produced.

9. Method according to Claim 8, characterized by the method steps:

- a) production of the semiconductor wafer (10),
- b) application of a plurality of front side contacts (5) in accordance with a predetermined grid pattern;
- c) application of the rear side contact (4) to the semiconductor wafer (10),
- d) application of the plurality of mutually separated etching masks (11), in such a way that the front side contacts (5) and part of the front side of the semiconductor wafer (19) are covered,
- e) securing of the semiconductor wafer (10) on a carrier means (26),
- f) separation of the semiconductor wafer (10) between the etching masks (11) into chips (13),
- g) isotropic etching of the chips (13) in such a way that the etching masks (11) are undercut,
- h) removal of the etching masks (11),
- i) detachment of the chips (13) from the carrier (26).



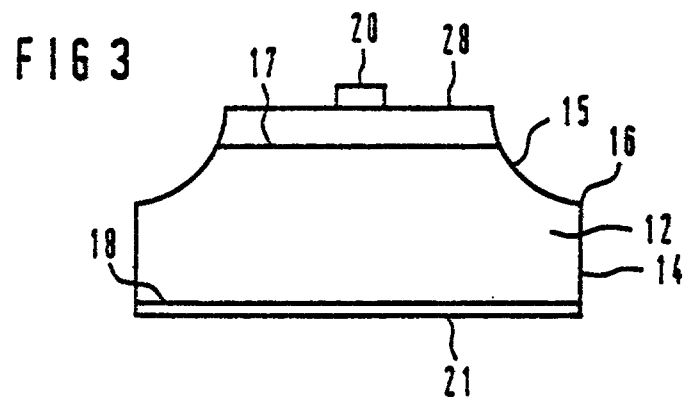
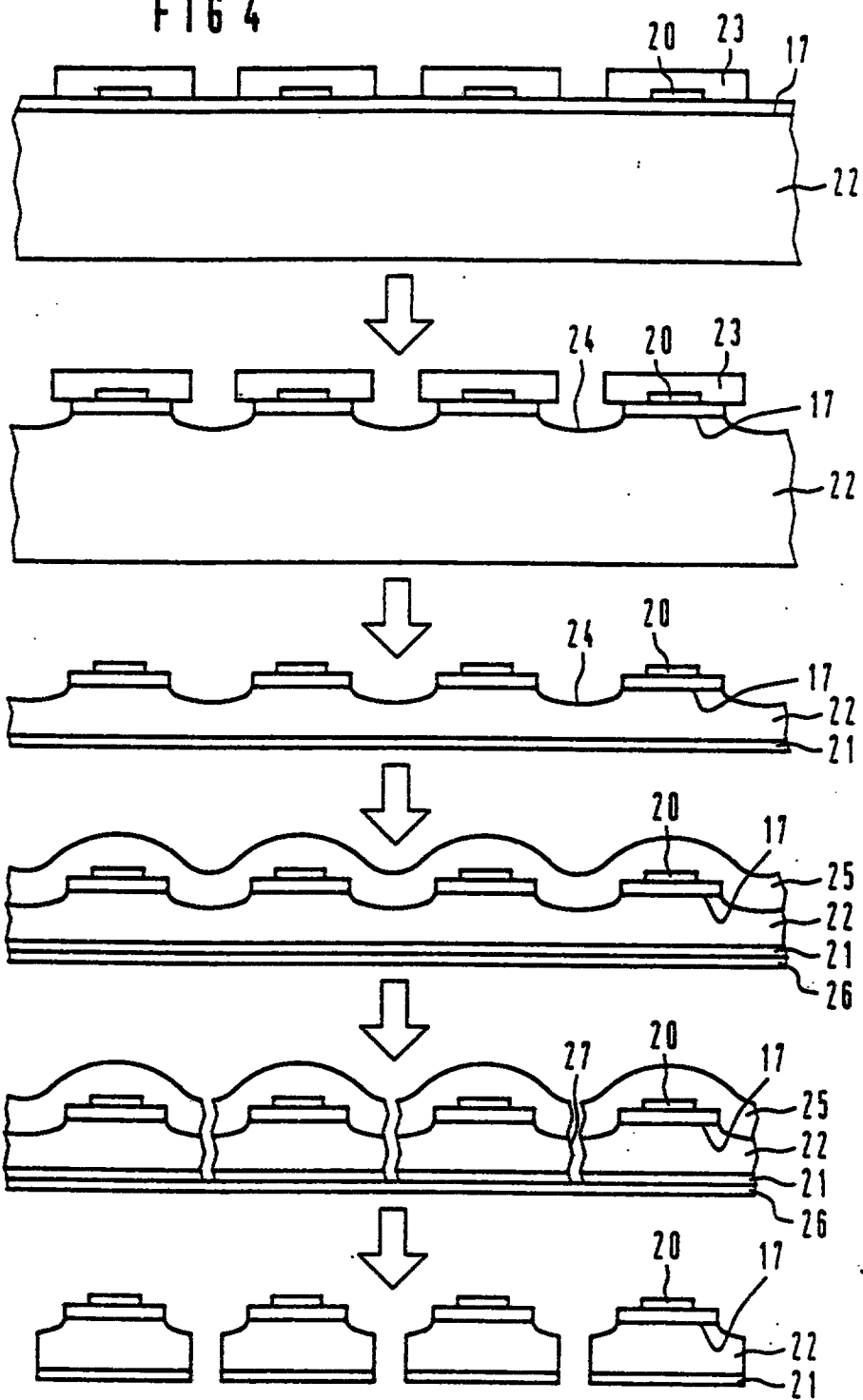


FIG 4



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Abstract

Semiconductor component and production method

Semiconductor component, in particular a light-emitting diode, whose semiconductor body (1) has a mesa structure. The curved side surface (9) is concave adjacent to the front side (2) of the semiconductor body (12) and convex adjacent to the rear side (3). This shaping distinctly increases the external quantum efficiency of the light-emitting diode according to the invention. In an advantageous method for producing a plurality of semiconductor components according to the invention, mesa etching is only carried out after the separation of a semiconductor wafer (10) into individual chips.

(Figure 1)