CLAIMS

We claim:

1. A light emitting die, comprising:

a first semiconductor material having a first surface;

a second semiconductor material having a second surface facing away from the first surface of the first semiconductor material;

an active region between the first and second semiconductor materials, wherein the first semiconductor material, the active region, and the second semiconductor material together have a stack thickness equal to a distance between the first and second surfaces;

a first electrode in contact with the first surface of the first semiconductor material;

a second electrode in contact with the second surface of the second semiconductor material, the second electrode being spaced apart from the first electrode by at least the stack thickness; and

wherein a portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material.

2. The light emitting die of claim 1 wherein both the first electrode and the second electrode are accessible from the same side of the light emitting die.

3. The light emitting die of claim 1 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material; and

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material.

4. The light emitting die of claim 1 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material; and

the second portion of the second electrode laterally extends beyond the second semiconductor material, the active region, and the first semiconductor material.

5. The light emitting die of claim 1 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material;

the second portion of the second electrode includes a plurality of individual sections spaced apart from one another; and

the individual sections of the second portion laterally extend beyond the first semiconductor material, the active region, and the second semiconductor material.

6. A light emitting device, comprising:

a first semiconductor material;

a second semiconductor material spaced apart from the first semiconductor material;

an active region between the first and second semiconductor materials;

an opening extending completely through the second semiconductor material and the active region and only a portion of the first semiconductor material;

a passivation material having a first passivation portion lining a sidewall of the opening and a second passivation portion extending laterally relative to the first passivation portion external to the opening;

a first electrode in the opening and adjacent the first passivation portion; and

a second electrode external to the opening between the second semiconductor material and the second passivation portion of the passivation material, a portion of the second electrode being exposed through the first semiconductor material, the active region, and the second semiconductor material.

7. The light emitting device of claim 6 wherein:

the light emitting device further includes a conductive substrate proximate the second semiconductor material; and

the first electrode is in direct contact with the conductive substrate.

8. The light emitting device of claim 6 wherein:

the light emitting device further includes a conductive substrate proximate the second semiconductor material;

the first electrode is in direct contact with the conductive substrate; and

the second passivation portion electrically isolates the second electrode from the conductive substrate.

9. The light emitting device of claim 6 wherein:

the light emitting device further includes a conductive substrate proximate the second semiconductor material;

the first electrode has a first end proximate the first semiconductor material and a second end proximate the second semiconductor material;

the second passivation portion has a first surface and a second surface opposite the first surface, the first surface being in contact with the second electrode; and

the second surface of the second passivation portion is generally co-planar with the second end of the first electrode.

10. The light emitting device of claim 6 wherein:

the light emitting device further includes a conductive substrate proximate the second semiconductor material;

the first electrode has a first end proximate the first semiconductor material and a second end proximate the second semiconductor material;

the second passivation portion of the passivation material has a first surface and a second surface opposite the first surface, the first surface being in contact with the second electrode;

the second surface of the second passivation portion is generally co-planar with the second end of the first electrode; and

both the second surface of the second passivation portion and the second end of the first electrode are in contact with the conductive substrate.

11. The light emitting device of claim 6 wherein:

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening; and

the second conductive portion extends laterally beyond the second electrode.

12. The light emitting device of claim 6 wherein:

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the first passivation portion of the passivation material electrically isolates the first conductive portion from the active region and the second semiconductor material; and

the second conductive portion extends laterally beyond the second electrode.

13. The light emitting device of claim 6 wherein:

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the first passivation portion of the passivation material electrically isolates the first conductive portion from the active region and the second semiconductor material;

the second conductive portion is in contact with the second passivation portion; and

the second conductive portion extends laterally beyond the second passivation portion and the second electrode.

14. The light emitting device of claim 6 wherein:

the light emitting device further includes a substrate and an insulating material on the substrate;

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the first passivation portion of the passivation material electrically isolates the first conductive portion from the active region and the second semiconductor material;

the second conductive portion is between the insulating material and the second passivation portion; and

the second conductive portion extends laterally beyond the second passivation portion and the second electrode.

15. A light emitting diode ("LED") die, comprising:

a first semiconductor material;

a second semiconductor material spaced apart from the first semiconductor material;

an active region between the first and second semiconductor materials;

a first electrode extending through the second semiconductor material, the active region and a portion of the first semiconductor material, wherein the first electrode is electrically coupled to the first semiconductor material and electrically isolated from the second semiconductor material and the active region; and

a second electrode in contact with the second semiconductor material and surrounding at least a portion of the first electrode, wherein the second electrode is electrically isolated from the first electrode and a portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material.

16. The LED die of claim 15 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material; and

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material.

17. The LED die of claim 15 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material;

the LED die has an opening extending through the first portion of the second electrode;

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material;

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening; and

the second conductive portion extends laterally beyond the second portion of the second electrode.

18. The LED die of claim 15 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material;

the LED die has an opening extending through the first portion of the second electrode;

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material;

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the second conductive portion extends laterally beyond the second portion of the second electrode; and

the second conductive portion and the second portion of the second electrode are accessible from the same side of the LED die.

19. The LED die of claim 15 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material;

the LED die has an opening extending through the first portion of the second electrode;

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material;

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the second conductive portion extends laterally beyond the second portion of the second electrode; and

the LED die further includes a passivation material between the second conductive portion of the conductive material and the second electrode.

20. A solid state lighting ("SSL") die, comprising:

a first semiconductor material;

a second semiconductor material spaced apart from the first semiconductor material;

an active region between the first and second semiconductor materials;

an opening extending from the second semiconductor material into the first semiconductor material through the active region;

a first electrode having a first portion in the opening and a second portion external to the opening;

a second electrode having a first part covered by the second semiconductor material and a second part extending laterally from the first part; and

wherein the second portion of the first electrode and the second part of the second electrode are both at least partially exposed through the first semiconductor material, the active region, and the second semiconductor material.

21. The SSL die of claim 20 wherein the second portion of the first electrode extends laterally beyond the second part of the second electrode.

22. The SSL die of claim 20 wherein:

the second part of the second electrode extends laterally beyond the first semiconductor material, the active region, and the second semiconductor material; and

the second portion of the first electrode extends laterally beyond the second part of the second electrode.

23. The SSL die of claim 20 wherein:

the SSL die further includes a passivation material having a first passivation portion in the opening and a second passivation portion external to the opening;

the first passivation portion generally conforms to a sidewall of the opening; and

the second passivation portion is between the second portion of the first electrode and the second part of the second electrode.

24. The SSL die of claim 20 wherein:

the SSL die further includes a passivation material having a first passivation portion in the opening and a second passivation portion external to the opening;

the second passivation portion is between the second portion of the first electrode and the second part of the second electrode; and

the second portion of the first electrode extends laterally beyond both the second part of the second electrode and the second passivation portion.

25. The SSL die of claim 20, further comprising:

a substrate proximate the second portion of the first electrode; and

an insulation material between the substrate and the second portion of the first electrode.

26. A method of forming a light emitting device having a first semiconductor material, a second semiconductor material spaced apart from the first semiconductor material, and an active region between the first and second semiconductor materials, the method comprising:

forming an opening extending completely through the second semiconductor material and the active region and only a portion of the first semiconductor material;

depositing a passivation material onto the light emitting device, the passivation material having a first passivation portion lining a sidewall of the opening and a second passivation portion extending laterally relative to the first passivation portion external to the opening;

forming a first electrode in the opening and adjacent the first passivation portion;

forming a second electrode external to the opening on the second semiconductor material; and

exposing a portion of the second electrode through the first semiconductor material, the active region, and the second semiconductor material.

27. The method of claim 26, further comprising:

attaching a conductive substrate to the second passivation portion on the second semiconductor material; and

contacting the conductive substrate with the first electrode.

28. The method of claim 26 wherein exposing a portion of the second electrode includes removing a portion of the first semiconductor material, the active region, and the second semiconductor material.

CLAIMS

We claim:

1. A light emitting die, comprising:

a first semiconductor material having a first surface;

a second semiconductor material having a second surface facing away from the first surface of the first semiconductor material;

an active region between the first and second semiconductor materials, wherein the first semiconductor material, the active region, and the second semiconductor material together have a stack thickness equal to a distance between the first and second surfaces;

a first electrode in contact with the first surface of the first semiconductor material;

a second electrode in contact with the second surface of the second semiconductor material, the second electrode being spaced apart from the first electrode by at least the stack thickness, wherein the second electrode includes

a first portion covered by the first semiconductor material, the active region, and the second semiconductor material;

a second portion extending from the first portion, the second portion of the second electrode including a plurality of individual sections spaced apart from one another; and

the individual sections of the second portion laterally extend beyond the first semiconductor material, the active region, and the second semiconductor material; and

wherein a portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material.

2. A light emitting device, comprising:

a first semiconductor material;

a second semiconductor material spaced apart from the first semiconductor material;

an active region between the first and second semiconductor materials;

an opening extending completely through the second semiconductor material and the active region and only a portion of the first semiconductor material;

a passivation material having a first passivation portion lining a sidewall of the opening and a second passivation portion extending laterally relative to the first passivation portion external to the opening;

a first electrode in the opening and adjacent the first passivation portion; and

a second electrode external to the opening between the second semiconductor material and the second passivation portion of the passivation material, a portion of the second electrode being exposed through the first semiconductor material, the active region, and the second semiconductor material.

3. The light emitting device of claim 2 wherein:

the light emitting device further includes a conductive substrate proximate the second semiconductor material; and

the first electrode is in direct contact with the conductive substrate.

4. The light emitting device of claim 2 wherein:

the light emitting device further includes a conductive substrate proximate the second semiconductor material;

the first electrode is in direct contact with the conductive substrate; and

the second passivation portion electrically isolates the second electrode from the conductive substrate.

5. The light emitting device of claim 2 wherein:

the light emitting device further includes a conductive substrate proximate the second semiconductor material;

the first electrode has a first end proximate the first semiconductor material and a second end proximate the second semiconductor material;

the second passivation portion has a first surface and a second surface opposite the first surface, the first surface being in contact with the second electrode; and

the second surface of the second passivation portion is generally co-planar with the second end of the first electrode.

6. The light emitting device of claim 2 wherein:

the light emitting device further includes a conductive substrate proximate the second semiconductor material;

the first electrode has a first end proximate the first semiconductor material and a second end proximate the second semiconductor material;

the second passivation portion of the passivation material has a first surface and a second surface opposite the first surface, the first surface being in contact with the second electrode;

the second surface of the second passivation portion is generally co-planar with the second end of the first electrode; and

both the second surface of the second passivation portion and the second end of the first electrode are in contact with the conductive substrate.

7. The light emitting device of claim 2 wherein:

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening; and

the second conductive portion extends laterally beyond the second electrode.

8. The light emitting device of claim 2 wherein:

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the first passivation portion of the passivation material electrically isolates the first conductive portion from the active region and the second semiconductor material; and

the second conductive portion extends laterally beyond the second electrode.

9. The light emitting device of claim 2 wherein:

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the first passivation portion of the passivation material electrically isolates the first conductive portion from the active region and the second semiconductor material;

the second conductive portion is in contact with the second passivation portion; and

the second conductive portion extends laterally beyond the second passivation portion and the second electrode.

10. The light emitting device of claim 2 wherein:

the light emitting device further includes a substrate and an insulating material on the substrate;

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the first passivation portion of the passivation material electrically isolates the first conductive portion from the active region and the second semiconductor material;

the second conductive portion is between the insulating material and the second passivation portion; and

the second conductive portion extends laterally beyond the second passivation portion and the second electrode.

11. A light emitting diode ("LED") die, comprising:

a first semiconductor material;

a second semiconductor material spaced apart from the first semiconductor material;

an active region between the first and second semiconductor materials;

a first electrode extending through the second semiconductor material, the active region and a portion of the first semiconductor material, wherein the first electrode is electrically coupled to the first semiconductor material and electrically isolated from the second semiconductor material and the active region; and

a second electrode in contact with the second semiconductor material and surrounding at least a portion of the first electrode, wherein the second electrode is electrically isolated from the first electrode and a portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material.

12. The LED die of claim 11 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material; and

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material.

13. The LED die of claim 11 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material;

the LED die has an opening extending through the first portion of the second electrode;

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material;

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening; and

the second conductive portion extends laterally beyond the second portion of the second electrode.

14. The LED die of claim 11 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material;

the LED die has an opening extending through the first portion of the second electrode;

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material;

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the second conductive portion extends laterally beyond the second portion of the second electrode; and

the second conductive portion and the second portion of the second electrode are accessible from the same side of the LED die.

15. The LED die of claim 11 wherein:

the second electrode includes a first portion and a second portion extending from the first portion;

the first portion of the second electrode is covered by the first semiconductor material, the active region, and the second semiconductor material;

the LED die has an opening extending through the first portion of the second electrode;

the second portion of the second electrode is exposed through the first semiconductor material, the active region, and the second semiconductor material;

the first electrode has a first conductive portion in the opening and a second conductive portion external to the opening;

the second conductive portion extends laterally beyond the second portion of the second electrode; and

the LED die further includes a passivation material between the second conductive portion of the conductive material and the second electrode.

16. A solid state lighting ("SSL") die, comprising:

a first semiconductor material;

a second semiconductor material spaced apart from the first semiconductor material;

an active region between the first and second semiconductor materials;

an opening extending from the second semiconductor material into the first semiconductor material through the active region;

a first electrode having a first portion in the opening and a second portion external to the opening;

a second electrode having a first part covered by the second semiconductor material and a second part extending laterally from the first part; and

wherein the second portion of the first electrode and the second part of the second electrode are both at least partially exposed through the first semiconductor material, the active region, and the second semiconductor material.

17. The SSL die of claim 16 wherein the second portion of the first electrode extends laterally beyond the second part of the second electrode.

18. The SSL die of claim 16 wherein:

the second part of the second electrode extends laterally beyond the first semiconductor material, the active region, and the second semiconductor material; and

the second portion of the first electrode extends laterally beyond the second part of the second electrode.

19. The SSL die of claim 16 wherein:

the SSL die further includes a passivation material having a first passivation portion in the opening and a second passivation portion external to the opening;

the first passivation portion generally conforms to a sidewall of the opening; and

the second passivation portion is between the second portion of the first electrode and the second part of the second electrode.

20. The SSL die of claim 16 wherein:

the SSL die further includes a passivation material having a first passivation portion in the opening and a second passivation portion external to the opening;

the second passivation portion is between the second portion of the first electrode and the second part of the second electrode; and

the second portion of the first electrode extends laterally beyond both the second part of the second electrode and the second passivation portion.

21. The SSL die of claim 16, further comprising:

a substrate proximate the second portion of the first electrode; and

an insulation material between the substrate and the second portion of the first electrode.

22. A method of forming a light emitting device having a first semiconductor material, a second semiconductor material spaced apart from the first semiconductor material, and an active region between the first and second semiconductor materials, the method comprising:

forming an opening extending completely through the second semiconductor material and the active region and only a portion of the first semiconductor material;

depositing a passivation material onto the light emitting device, the passivation material having a first passivation portion lining a sidewall of the opening and a second passivation portion extending laterally relative to the first passivation portion external to the opening;

forming a first electrode in the opening and adjacent the first passivation portion;

forming a second electrode external to the opening on the second semiconductor material; and

exposing a portion of the second electrode through the first semiconductor material, the active region, and the second semiconductor material.

23. The method of claim 22, further comprising:

attaching a conductive substrate to the second passivation portion on the second semiconductor material; and

contacting the conductive substrate with the first electrode.

24. The method of claim 22 wherein exposing a portion of the second electrode includes removing a portion of the first semiconductor material, the active region, and the second semiconductor material.