

Claims

1. A method of forming an optical device, the method comprising the steps of:
forming a mesa, the mesa comprising an active layer configured to emit light from a first light emitting surface of the mesa when subjected to an electrical current, the mesa further comprising a second surface opposite the first light emitting surface and substantially vertical sidewalls;
forming spacers on the mesa sidewalls, the spacers being formed from a first electrically insulating optically transparent material, and having an internal face facing the mesa sidewalls, and an opposing external face;
depositing a first layer of transparent electrically conducting material on the light emitting surface of the mesa, the transparent electrically conducting material having an internal face facing the second surface of the mesa, and an opposing external face; and
depositing a layer of reflective electrically conducting material over the transparent electrically conducting material and external faces of the spacers.
2. The method of claim 1 wherein the external face of the first layer of transparent, electrically conducting material is substantially convex.
3. The method of claim 2 wherein the external face of the first layer of transparent, electrically conducting material has a radius of curvature of between 1 and 1.5 microns.
4. The method of any preceding claim wherein a second layer of transparent, electrically conducting material is formed on the first light emitting surface of the mesa.
5. The method of any preceding claim wherein the transparent, electrically conducting material is a transparent conducting oxide.
6. The method of claim 5 wherein the transparent conducting oxide is indium tin oxide.
7. The method of any preceding claim wherein the external faces of the spacers are angled relative to the internal faces.
8. The method of claim 7 wherein the external faces of the spacers have a pseudo-parabolic profile.
9. The method of claim 7 wherein the external faces of the spacers have a profile that approximates a Bézier curve having two control points with a Bézier coefficient of 0.5.

10. The method of any preceding claim wherein the spacers are formed of at least one of silicon nitride, silicon oxide or tin oxide.
11. The method of any preceding claim further comprising the step of depositing a second electrically insulating, optically transparent material on the external face of each of the spacers, the second electrically insulating, optically transparent material having a different refractive index to that of the first electrically insulating, optically transparent material.
12. The method of claim 11 wherein the refractive index of the first material is greater than that of the second material.
13. The method of any preceding claim wherein the sidewalls of the mesa are roughened prior to the formation of the spacers.
14. The method of any preceding claim wherein the active layer of the mesa is between an n-doped n-cladding layer and a p-doped p-cladding layer.
15. The method of any of claim 14 as dependent on claim 4 wherein a first electrical contact is made to the p-cladding layer via the first layer of transparent conducting oxide and the reflective, electrically conducting material and a second electrical contact is made to the n-cladding layer via the second layer of transparent conducting oxide.
16. An array of optical devices manufactured according to the method of any of claims 1-15.
17. An optical device comprising:
 - a light emitting structure having a first light emitting surface, a second opposing surface and substantially vertical sidewalls, the first light emitting structure further comprising an active layer, the active layer being configured to emit light when an electrical current is applied to the device;
 - an electrically insulating optically transparent spacer material having an internal face facing the sidewalls of the light emitting structure and an opposing external face;
 - a transparent electrically conducting material having an internal face facing the second surface of the light emitting structure and an opposing external face; and
 - a reflective electrically conducting material disposed on the external faces of the spacer layer and the transparent electrically conducting layer;

wherein the spacer material, transparent electrically conducting material and reflective electrically conducting material are configured to enhance light extraction from the active layer.

18. The optical device of claim 17 wherein the external face of the transparent electrically conducting material is convex.

19. The optical device of claim 17 wherein the external face of the transparent electrically conducting material has a radius of curvature of between 1 and 1.5 microns.

20. The optical device of any preceding claim wherein the external faces of the spacers are angled relative to the internal faces.

21. The optical device of claim 20 wherein the external faces of the spacers have a pseudo-parabolic profile.

22. The optical device of claim 21 wherein the external faces of the spacers have a profile that approximates a Bézier curve having two control points with a Bézier coefficient of 0.5.