What is claimed is:

1. A light emitting diode (LED) device comprising:

a mesa array comprising a first mesa and a second mesa separated by a trench, the first mesa and the second mesa comprising a photoluminescent quantum well, an n-type layer on the photoluminescent quantum well, an electroluminescent quantum well on the n-type layer, and a p-type layer on the electroluminescent quantum well, the first mesa comprising a multilayer contact on the p-type layer and the second mesa comprising a p-type contact on the p-type layer, the trench having at least one side wall and extending to an n-type current spreading layer on a substrate

CLAIMS

2. The LED device of claim 1, further comprising a nucleation layer on the substrate and a defect reduction layer on the nucleation layer.

3. The LED device of claim 1, wherein the multilayer contact is a bilayer contact comprising a reflecting metal layer on a transparent conductive oxide layer.

4. The LED device of claim 3, wherein the reflecting metal layer comprises one or more of silver (Ag), nickel (Ni), aluminium (Al), and titanium (Ti).

5. The LED device of claim 3 wherein the transparent conductive oxide layer comprises one or more of indium tin oxide (ITO), gallium oxide (Ga_2O_3), zinc oxide (ZnO), tin oxide (SnO_2), and indium zinc oxide (InZnO).

6. The LED device of claim 1, wherein the electroluminescent quantum well emits a first light having a first wavelength and the photoluminescent quantum well absorbs at least a portion of the first light and emits a second light having a longer wavelength than the first light.

7. The LED device of claim 1, further comprising an n-type contact in the trench on the n-type current spreading layer.

8. The LED device of claim 6, wherein the electroluminescent quantum well comprises multiple quantum wells emitting a same wavelength of light.

9. The LED device of claim 6, wherein the photoluminescent quantum well comprises multiple quantum wells emitting a same wavelength of light.

10. The LED device of claim 1, wherein the substrate is a transparent substrate.

11. The LED device of claim 10, further comprising a dichroic reflector on the substrate opposite the n-type current spreading layer.

12. A light emitting diode (LED) device comprising:

a mesa array comprising a first mesa and a second mesa separated by a trench, the first mesa and the second mesa comprising a photoluminescent quantum well, an n-type layer on the photoluminescent quantum well, an electroluminescent quantum well on the n-type layer, and a p-type layer on the electroluminescent quantum well, the first mesa comprising a first contact on the p-type layer, the first contact comprising a first reflecting metal layer on a first transparent conductive oxide layer, the first transparent conductive oxide layer having a first thickness, and the second mesa comprising a second contact on the p-type layer, the second contact comprising a second reflecting metal layer on a second transparent conductive oxide layer, the second transparent conductive oxide layer having a second thickness, and the trench having at least one side wall and extending to an n-type current spreading layer on a substrate.

13. The LED device of claim 12, further comprising a nucleation layer on the substrate and a defect reduction layer on the nucleation layer.

14. The LED device of claim 12, wherein the first reflecting metal layer and second reflecting metal layer independently comprises one or more of silver (Ag), nickel (Ni), aluminium (Al), and titanium (Ti).

15. The LED device of claim 12, wherein the first transparent conductive oxide layer and the second transparent conductive oxide layer independently comprise one or more of indium tin oxide (ITO), zinc oxide (ZnO), tin oxide (SnO), and indium zinc oxide (InZnO).

~~16. The LED device of claim 12, wherein the difference between the first thickness and the second thickness is in a range of from 40 nm to 60 nm.~~

~~17. The LED device of claim 12, wherein the electroluminescent quantum well emits a first light having a first wavelength and the photoluminescent quantum well absorbs at least a portion of the first light and emits a second light having a longer wavelength than the first light.~~

~~18. The LED device of claim 12, further comprising an n-type contact in the trench on the n-type current spreading layer.~~

~~19. The LED device of claim 18, further comprising a dichroic reflector on the substrate opposite the n-type current spreading layer.~~

~~20.~~1. A method of manufacturing an LED device, the method comprising:

forming a nucleation layer on a substrate;

forming a defect reduction layer on the nucleation layer;

forming an n-type current spreading layer on the defect reduction layer;

forming at least one photoluminescent quantum well on the n-type current spreading layer;

forming an n-type layer on the at least one photoluminescent quantum well;

forming at least one electroluminescent quantum well on the n-type layer;

forming a p-type layer on the electroluminescent quantum well;

etching to form a first mesa and a second mesa separated by a trench, the trench having at least one side wall and extending to the n-type current spreading layer;

conformally depositing a dielectric layer on the first mesa and the second mesa;

forming a contact hole in the first mesa and the second mesa; and

forming a first contact on the first mesa and a second contact on the second mesa.

2. The method of claim 1, wherein the first contact comprises a first reflecting metal layer on a first transparent conductive oxide layer.

3. The method of claim 2, wherein the reflecting metal layer comprises one or more of silver (Ag), nickel (Ni), aluminium (Al), and titanium (Ti).

4. The method of claim 2 wherein the first transparent conductive oxide layer comprises one or more of indium tin oxide (ITO), gallium oxide (Ga_2O_3), zinc oxide (ZnO), tin oxide (SnO_2), and indium zinc oxide (InZnO).

5. The method of claim 1, wherein the at least one electroluminescent quantum well emits a first light having a first wavelength and the at least one photoluminescent quantum well absorbs at least a portion of the first light and emits a second light having a longer wavelength than the first light.

6. The method of claim 1, further comprising forming an n-type contact in the trench on the n-type current spreading layer.

7. The method of claim 5, wherein the electroluminescent quantum well comprises multiple quantum wells emitting a same wavelength of light.

8. The method of claim 5, wherein the photoluminescent quantum well comprises multiple quantum wells emitting a same wavelength of light.

9. The method of claim 1, wherein the substrate is a transparent substrate.

10. The method of claim 9, further comprising forming a dichroic reflector on the substrate opposite the n-type current spreading layer.

11. A method of manufacturing an LED device, the method comprising:

forming an n-type current spreading layer on a substrate;

forming at least one photoluminescent quantum well on the n-type current spreading layer;

forming an n-type layer on the at least one photoluminescent quantum well;

forming at least one electroluminescent quantum well on the n-type layer;

forming a p-type layer on the electroluminescent quantum well;

etching to form a first mesa and a second mesa separated by a trench, the trench having at least one side wall and extending to the n-type current spreading layer;

conformally depositing a dielectric layer on the first mesa and the second mesa;

forming a contact hole in the first mesa and the second mesa; and

forming a first contact on the first mesa and a second contact on the second mesa.

12. The LED method of claim 11, wherein the first contact comprises a first reflecting metal layer on a first transparent conductive oxide layer.

13. The method of claim 12, wherein the reflecting metal layer comprises one or more of silver (Ag), nickel (Ni), aluminium (Al), and titanium (Ti).

14. The method of claim 12, wherein the first transparent conductive oxide layer comprises one or more of indium tin oxide (ITO), gallium oxide (Ga_2O_3), zinc oxide (ZnO), tin oxide (SnO_2), and indium zinc oxide (InZnO).

15. The method of claim 11, wherein the at least one electroluminescent quantum well emits a first light having a first wavelength and the at least one photoluminescent quantum well absorbs at least a portion of the first light and emits a second light having a longer wavelength than the first light.

16. The method of claim 11, further comprising forming an n-type contact in the trench on the n-type current spreading layer.

17. The method of claim 15, wherein the electroluminescent quantum well comprises multiple quantum wells emitting a same wavelength of light and the photoluminescent quantum well comprises multiple quantum wells emitting a same wavelength of light.

18. The method of claim 11, wherein the substrate is a transparent substrate.

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19. method of claim 18, further forming comprising a dichroic reflector on the substrate opposite the n-type current spreading layer.

20. The method of claim 11, further comprising forming a nucleation layer on the substrate and a defect reduction layer on the nucleation layer.