

CLAIMS:

1. A method of forming a plurality of monolithic light emitting diode (LED) pixels for a LED display, the method comprising:
 - 5 forming a common semiconducting layer comprising a Group III-nitride on a sacrificial substrate;
forming an array of light emitting diode (LED) subpixels on a surface of the common semiconducting layer on an opposite side of the common semiconducting layer to the sacrificial substrate, each LED subpixel of the array of LED subpixels comprising a stack of
10 Group III-nitride layers;
forming a planarising dielectric layer on the array of LED subpixels to provide a planarised dielectric surface which is generally aligned with the surface of the common semiconducting layer;
dividing the array of the LED subpixels into a plurality of monolithic LED pixels by
15 etching a grid of pixel defining trenches from the planarised dielectric surface to the sacrificial substrate, wherein each monolithic LED pixel comprises at least two LED subpixels of the LED array formed monolithically on the common semiconducting layer;
forming a sacrificial dielectric layer on the pixel trenches and the planarised surface to form a bonding surface generally aligned with the surface of the common
20 semiconducting layer;
bonding a handling substrate to the bonding surface of the sacrificial dielectric layer;
selectively removing first portions of the sacrificial substrate through a thickness of the sacrificial substrate aligned with the grid of pixel defining trenches for separating each of the monolithic LED pixels; and
25 forming light extraction features for each of the monolithic LED pixels comprising:
selectively removing second portions of the sacrificial substrate aligned with each of the LED subpixels;
removing the sacrificial dielectric layer to separate each monolithic LED pixel from the handling substrate.
30
2. A method according to claim 1, wherein
forming light extraction features for each of the monolithic LED pixels comprises:
selectively removing second portions of the sacrificial substrate aligned with each of the LED subpixels to form a container volume for each LED subpixel; and

providing a first colour converting layer in at least one of the container volumes of each monolithic LED pixel, the first colour converting layer configured to absorb light of a first wavelength and emit converted light of a first converted light wavelength longer than the first wavelength.

5

3. A method according to claim 2, wherein the first converted light wavelength is at least 500 nm and/or no greater than 650 nm.

4. A method according to claim 2 or 3, wherein

10 a second colour converting layer is provided in in at least one other of the container volumes of each monolithic LED pixel, the second colour converting layer configured to absorb light of a first wavelength and emit converted light of a second converted light wavelength longer than the first converted light wavelength

15 5. A method according to any of claims 2 to 4 wherein, the first colour converting layer and/or the second colour converting layer comprises a phosphor, organic molecules, or quantum dots.

20 6. A method according to any preceding claim, wherein each LED subpixel is configured to generate light having a first wavelength of at least 380 nm and/or no greater than 490 nm.

7. A method according to any preceding claim, wherein forming light extraction features for each of the monolithic LED pixels comprises:

25 selectively removing second portions of the sacrificial substrate through the thickness of the sacrificial substrate such that first portions of the surface of the common semiconducting layer are exposed.

30 8. A method according to claim 7, wherein forming light extraction features for each of the monolithic LED pixels comprises:

patterning the first portions of the surface of the common semiconducting layer with scattering features configured to increase a light extraction efficiency of each LED subpixel.

9. A method according to any preceding claim, wherein

following the formation of the planarising dielectric layer, third portions of the planarising dielectric layer are selectively removed and an anode contact metallisation is formed between an anode of each LED subpixel and the planarised dielectric surface, and

fourth portions of the planarising dielectric layer are selectively removed and a
5 common cathode contact metallisation is formed for each monolithic LED pixel between the common semiconducting layer and the planarised dielectric surface.

10 A method according to claim 9, wherein
a surface of the common cathode contact metallisation forming part of the
10 planarised dielectric surface overlaps with at least one of the LED subpixels forming each monolithic LED pixel.

11. A method according to any preceding claim, wherein
one of the LED subpixels of each monolithic LED pixel has a greater surface area
15 on the common semiconducting layer than another LED subpixel of each monolithic LED pixel.

12. A method according to any preceding claim, wherein
the handling substrate is a testing substrate configured to form electrical
20 connections to each LED subpixel when bonded so that each LED subpixel may be tested in parallel,
the method further comprising:
following the bonding process, testing each of the LED subpixels by supplying
power from the testing substrate to the array of LED subpixels array.

25 13. A method according to any preceding claim, wherein
the surface area of each LED subpixel on the common semiconducting layer may define an area of no greater than 100 μm x 100 μm .

30 14. A monolithic light emitting diode (LED) pixel for a LED display comprising:
a common semiconducting layer comprising a Group III-nitride provided on a sacrificial substrate;
an array of light emitting diode (LED) subpixels provided on a surface of the
common semiconducting layer on an opposite side of the common semiconducting layer to

the sacrificial substrate, each LED subpixel of the array of LED subpixels comprising a stack of Group III-nitride layers;

a planarising dielectric layer provided on the array of LED subpixels to provide a planarised dielectric surface which is aligned with the surface of the common

5 semiconducting layer;

wherein the planarising dielectric layer, the common semiconducting layer, and the sacrificial substrate define etched sidewalls surrounding a light emitting surface of the monolithic LED pixel; and

the monolithic LED pixel further comprises light extracting features comprising:

10 first openings provided through a thickness of the sacrificial substrate aligned with each of the LED subpixels.

15. A monolithic LED pixel according to claim 14, wherein the light extraction features further comprise:

15 the first openings form a container volume for each LED subpixel; and

a first colour converting layer is provided in at least one of the container volumes, the first colour converting layer configured to absorb light of a first wavelength and emit converted light of a first converted light wavelength longer than the first wavelength.

20 16. A monolithic LED pixel according to claim 15, wherein the first converted light wavelength is at least 500 nm and/or no greater than 650 nm.

17. A monolithic LED pixel according to claim 15 or claim 16, wherein

25 a second colour converting layer is provided in in at least one other of the container volumes of the monolithic LED pixel, the second colour converting layer configured to absorb light of a first wavelength and emit converted light of a second converted light wavelength longer than the first converted light wavelength

18. A monolithic LED pixel according to any of claims 15 to 17, wherein,

30 the first colour converting layer and/or the second colour converting layer comprises a phosphor, organic molecules, or quantum dots.

19. A monolithic LED pixel according to any of claims 14 to 18, wherein

35 each LED subpixel is configured to generate light having a first wavelength of at least 380 nm and/or no greater than 490 nm.

20. A monolithic LED pixel according to any of claims 14 to 19, wherein the light extraction features for each of the monolithic LED pixels further comprises light scattering feature formed on first portions of the surface of the common semiconducting layer aligned with each of the first openings of the sacrificial substrate, the light scattering features configured to increase a light extraction efficiency of each LED subpixel.
21. A monolithic LED pixel according to any of claims 14 to 20, wherein the planarising dielectric layer comprises second openings in which an anode contact metallisation is provided between an anode of each LED subpixel and the planarised dielectric surface, and the planarising dielectric layer comprises a third opening in which a common cathode contact metallisation is provided between the common semiconducting layer and the planarised dielectric surface.
22. A monolithic LED pixel according to claim 21, wherein a surface of the common cathode contact metallisation forming part of the planarised dielectric surface overlaps with at least one of the LED subpixels forming each monolithic LED pixel.
23. A monolithic LED pixel according to any of claims 14 to 22, wherein one of the LED subpixels of the monolithic LED pixel has a greater surface area on the common semiconducting layer than another LED subpixel of the monolithic LED pixel.
24. A monolithic LED pixel according to any of claims 14 to 23, wherein the surface area of each LED subpixel on the common semiconducting layer may define an area of no greater than 100 μm x 100 μm .