CLAIMS

I/We claim:

1. A method for manufacturing a light emitting diode (LED), the method comprising:

applying a first light conversion material to a first region on the LED; and

applying a second light conversion material to a second, different region on the LED, wherein at least a portion of the LED is exposed after applying the first and second light conversion materials.

2. The method of claim 1 wherein the LED is one of a plurality of LEDs on a workpiece, and wherein the method further comprises:

applying the first light conversion material to the first region on multiple LEDs on the workpiece; and

applying the second light conversion material to the second region on multiple LEDs on the workpiece.

3. The method of claim 2 wherein:

the first light conversion material is applied to two or more LEDs on the workpiece simultaneously or approximately simultaneously; and

the second light conversion material is applied to two or more LEDs on the workpiece simultaneously or approximately simultaneously.

4. The method of claim 2 wherein each LED on the workpiece includes the same arrangement of first and second light conversion materials.

5. The method of claim 2 wherein each LED on the workpiece includes a different arrangement of first and second light conversion materials.

6. The method of claim 2 wherein the workpiece includes a first set of LEDs having a first emission characteristic and a second set of LEDs having a second emission characteristic different than the first emission characteristic, and wherein:

the first and second light conversion materials have a first arrangement relative to each other on each LED in the first set of LEDs; and

the first and second light conversion materials have a second arrangement relative to each other on each LED in the second set of LEDs, and wherein the second arrangement is different than the first arrangement.

7. The method of claim 1 applying a second light conversion material to a second, different region on the LED comprising applying the second light conversion material such that the first light conversion material is spaced apart from the second light conversion material.

8. The method of claim 1 wherein:

applying the first light conversion material to the first region comprises applying the first light conversion material in a plurality of individual first rectilinear blocks on the LED with first channels separating the individual first blocks from each other; and

applying the second light conversion material to the second region comprises applying the second light conversion material in a plurality of individual second rectilinear blocks on the LED with second channels separating the individual second blocks from each other and from the first blocks.

9. The method of claim 1, further comprising:

selecting the first light conversion material before applying the first light conversion material, wherein selecting the first light conversion material comprises selecting at least one of a composition, a concentration, and a quantity of a first phosphor such that the first phosphor has a desired first emission wavelength; and

selecting the second light conversion material before applying the second light conversion material, wherein selecting the second light conversion material comprises selecting at least one of a composition, a concentration, and a quantity of a second phosphor such that the second phosphor has a desired second emission wavelength.

10. The method of claim 1 wherein:

the first light conversion material comprises a yellow or yellowish phosphor, and

the second light conversion material comprises a red phosphor.

11. The method of claim 1 wherein applying the first light conversion material and applying the second light conversion material comprises screen printing the first and second light conversion materials onto the LED.

12. The method of claim 1 wherein:

applying the first light conversion material comprises applying the first light conversion material using a first photolithographic process; and

applying the second light conversion material comprises applying the second light conversion material using a second photolithographic process.

13. The method of claim 1 wherein the first light conversion material comprises a first phosphor and the second light conversion material comprises a second phosphor, and wherein:

applying the first light conversion material comprises–

applying and patterning a first photoresist material on the LED; and

depositing the first phosphor into openings in the first photoresist material using electrophoresis; and

applying the second light conversion material comprises–

removing the first photoresist material;

applying and patterning a second photoresist material on the LED;

depositing the second phosphor into openings in the second photoresist material using electrophoresis; and

removing the second photoresist material.

14. The method of claim 1 wherein the LED is one of a plurality of LEDs on a workpiece, and wherein the method further comprises measuring an emission characteristic of a plurality of LEDs on the workpiece before applying the first light conversion material.

15. The method of claim 1, further comprising selecting a first pattern for the first light conversion material on the LED and a second pattern for the second light conversion material on the LED based, at least in part, on a measured emission characteristic of the LED such that a combined emission from the LED and the first and second light conversion materials at least approximates a white light.

16. The method of claim 1, further comprising selecting a composition for the first light conversion material and a composition for the second light conversion material based, at least in part, on a measured emission characteristic of the LED such that a combined emission from the LED and the first and second light conversion materials at least approximates a white light.

17. A method for modifying an emission characteristic of individual light emitting diodes (LEDs) of a microelectronic workpiece, the method comprising:

selectively applying a first phosphor material onto each LED in a first pattern; and

selectively applying a second phosphor material onto each LED in a second pattern different than the first pattern; and

wherein for the individual LEDs, a combined emission from the corresponding LED, the first phosphor material, and the second phosphor material produces a light having desired spectral constituents.

18. The method of claim 17, further comprising forming a plurality of LEDs on the workpiece substrate before modifying an emission characteristic of the individual LEDs, and wherein forming individual LEDs comprises sequentially applying an N-type gallium nitride (GaN), an indium gallium nitride (InGaN), and P-type GaN onto a silicon substrate via epitaxial growth.

19. The method of claim 17 wherein each LED comprises an InGaN LED, and wherein:

applying a first phosphor material comprises applying a yellow phosphor containing Cerium(III)-doped Yttrium Aluminum Garnet (Ce:YAG), and wherein the first pattern comprises an array of first portions across the individual LEDs;

applying a second phosphor material comprises applying a red phosphor containing Ce:YAG, and wherein the second pattern comprises an array of second portions across the individual LEDs and out of contact with the first portions, and further wherein the first and second portions do not completely cover the LED.

20. The method of claim 17 wherein modifying an emission characteristic of individual LEDs comprises adjusting the emission characteristics of the LEDs such that the emission from each LED at least approximates a white light.

21. The method of claim 17, further comprising applying a third phosphor material onto each LED in a third pattern different than the first and second patterns, and wherein a combined emission from the corresponding LED, the first phosphor material, the second phosphor material, and the third phosphor material produces a desired color of light.

22. The method of claim 17 wherein the workpiece comprises a first workpiece including a plurality of first LEDs, and wherein the method further comprises processing a second workpiece including a plurality of second LEDs by—

selectively applying the first phosphor material onto each second LED in the first pattern; and

selectively applying the second phosphor material onto each second LED in the second pattern,

wherein for the individual second LEDs, a combined emission from the corresponding second LED, the first phosphor material, and the second phosphor material produces the desired color of light.

23. A method for color correction of light emitting diodes (LEDs), the method comprising:

forming a first color correction material over a first discrete area of an LED, wherein the first color correction material comprises a first phosphor having a first emission wavelength; and

forming a second color correction material over a second discrete area of the LED, wherein the second color correction material comprises a second phosphor having a second emission wavelength different than the first emission

wavelength, and wherein a combined emission from the LED and the first and second color correction materials at least approximates a white light.

24. A microelectronic workpiece, comprising:

a semiconductor substrate; and

a plurality of light emitting diodes (LEDs) on the substrate, wherein the individual LEDs include—

a first converter material in a first predetermined pattern on the LED; and

a second converter material in a second predetermined pattern on the LED, wherein the second pattern is different than the first pattern, and wherein at least a portion of the LED is accessible through the first and second patterns,

wherein a combined emission from the LED, the first converter material, and the second converter material produces a light having desired spectral constituents.

25. The microelectronic workpiece of claim 24 wherein:

the individual LEDs on the substrate comprise an indium gallium nitride (InGaN) material between an N-type gallium nitride (GaN) material and a P-type GaN material;

the first converter material comprises a yellow phosphor material; and

the second converter material comprises a red phosphor.

26. The microelectronic workpiece of claim 24 wherein:

the first pattern comprises an array of first blocks across the LED and separated by first gaps; and

the second pattern comprises an array of second blocks across the LED and separated by second gaps.

27. The microelectronic workpiece of claim 26 wherein:

the first blocks include generally circular, rectilinear, and/or polygonal-shaped blocks; and

the second blocks include generally circular, rectilinear, and/or polygonal-shaped blocks.

28. The microelectronic workpiece of claim 24 wherein the first converter material is spaced apart from the second converter material by a gap on the individual LEDs.

CLAIMS

I/We claim:

1. A method for manufacturing a light emitting diode (LED), the method comprising:

applying a first light conversion material to a first region on the LED; and

applying a second light conversion material to a second, different region on the LED, wherein the first light conversion material is spaced apart from the second light conversion material by a gap, and wherein at least a portion of the LED is accessible in the gap after applying the first and second light conversion materials,

wherein during operation of the LED, at least a portion of a light emitted by the LED passes through the gap.

2. The method of claim 1 wherein the LED is one of a plurality of LEDs on a workpiece, and wherein the method further comprises:

applying the first light conversion material to the first region on multiple LEDs on the workpiece; and

applying the second light conversion material to the second region on multiple LEDs on the workpiece.

3. The method of claim 2 wherein:

the first light conversion material is applied to two or more LEDs on the workpiece simultaneously or approximately simultaneously; and

the second light conversion material is applied to two or more LEDs on the workpiece simultaneously or approximately simultaneously.

4. The method of claim 2 wherein each LED on the workpiece includes the same arrangement of first and second light conversion materials.

5. The method of claim 2 wherein each LED on the workpiece includes a different arrangement of first and second light conversion materials.

6. The method of claim 2 wherein the workpiece includes a first set of LEDs having a first emission characteristic and a second set of LEDs having a second emission characteristic different than the first emission characteristic, and wherein:

the first and second light conversion materials have a first arrangement relative to each other on each LED in the first set of LEDs; and

the first and second light conversion materials have a second arrangement relative to each other on each LED in the second set of LEDs, and wherein the second arrangement is different than the first arrangement.

7. The method of claim 1 applying a second light conversion material to a second, different region on the LED comprising applying the second light conversion material such that the first light conversion material is spaced apart from the second light conversion material.

8. The method of claim 1 wherein:

applying the first light conversion material to the first region comprises applying the first light conversion material in a plurality of individual first rectilinear blocks on the LED with first gaps separating the individual first blocks from each other; and

applying the second light conversion material to the second region comprises applying the second light conversion material in a plurality of individual second rectilinear blocks on the LED with second gaps separating the individual second blocks from each other and from the first blocks.

9. The method of claim 1, further comprising:

selecting the first light conversion material before applying the first light conversion material, wherein selecting the first light conversion material comprises selecting at least one of a composition, a concentration, and a quantity of a first phosphor such that the first phosphor has a desired first emission wavelength; and

selecting the second light conversion material before applying the second light conversion material, wherein selecting the second light conversion material comprises selecting at least one of a composition, a concentration, and a quantity

of a second phosphor such that the second phosphor has a desired second emission wavelength.

10. The method of claim 1 wherein:

the first light conversion material comprises a yellow or yellowish phosphor, and

the second light conversion material comprises a red phosphor.

11. The method of claim 1 wherein applying the first light conversion material and applying the second light conversion material comprises screen printing the first and second light conversion materials onto the LED.

12. The method of claim 1 wherein:

applying the first light conversion material comprises applying the first light conversion material using a first photolithographic process; and

applying the second light conversion material comprises applying the second light conversion material using a second photolithographic process.

13. The method of claim 1 wherein the first light conversion material comprises a first phosphor and the second light conversion material comprises a second phosphor, and wherein:

applying the first light conversion material comprises–

applying and patterning a first photoresist material on the LED; and

depositing the first phosphor into openings in the first photoresist material using electrophoresis; and

applying the second light conversion material comprises–

removing the first photoresist material;

applying and patterning a second photoresist material on the LED;

depositing the second phosphor into openings in the second photoresist material using electrophoresis; and

removing the second photoresist material.

14. The method of claim 1 wherein the LED is one of a plurality of LEDs on a workpiece, and wherein the method further comprises measuring an emission characteristic of a plurality of LEDs on the workpiece before applying the first light conversion material.

15. The method of claim 1, further comprising selecting a first pattern for the first light conversion material on the LED and a second pattern for the second light conversion material on the LED based, at least in part, on a measured emission characteristic of the LED such that a combined emission from the LED and the first and second light conversion materials at least approximates a white light.

16. The method of claim 1, further comprising selecting a composition for the first light conversion material and a composition for the second light conversion material based, at least in part, on a measured emission characteristic of the LED such that a combined emission from the LED and the first and second light conversion materials at least approximates a white light.

17. The method of claim 1 wherein at least a portion of the light emitted by the LED does not pass through any intervening light conversion materials disposed on the LED.