erties are mainly determined by high In composition (minority) phase (i.e. a large band gap diode is used to produce lower energy photons).

For structures grown under different conditions, the phase separation extends into the InGaN graded regions, toward the lower indium fraction InGaN, as is the case in the embodiment illustrated in FIG. **4**. In FIG. **4**, section a shows the layer structure of a second embodiment of the device, and sections b and c show band diagrams with no external bias applied and with applied external bias applied, respectively. In this case, when the device structure is forward biased, at low bias values, e.g., less than 3V, the electron-hole recombination will take place predominantly across the low band gap InGaN clusters generating light with long wavelengths. As the forward bias is increased, the carriers will be injected into larger band gap regions, shifting the emission from long to shorter wavelength. This operation of the graded p-n junction LED is demonstrated by the electroluminescence measurements under increasing bias presented in FIG. **5**. This demonstrates the tunability of the improved LEDs described herein to multi-color and white light spectrums.

The above-described embodiments are not limited to the specific alloy compositions described. Judicious choice of the average composition and the growth conditions will allow fabrication of devices emitting light from red to blue providing basic components for light generation covering the full visible spectrum.

In accordance with one or more embodiments of the LED described herein, a long wavelength LED device is provided that utilizes low cost silicon wafer substrates. Low cost Green and longer wavelength LEDs have been sought after by both science and industry for an extensive period of time because they would fill a high-value gap in the rapidly growing global LED market for lighting and illumination where energy efficiency and miniaturization is paramount to the global renewable energy momentum. Green or longer wavelength nitride based LEDs are very challenging to fabricate compared to UV and Blue LEDs due to decreasing quantum efficiencies and have remained a tough milestone for the LED industry. In accordance with one or more embodiments of the LEDs described herein, efficient long wavelength LEDs are provided that allow for the achievement of essential milestones in the roadmap for Solid State Lighting (SSL), LED backlighting and next generation display technology.

One application of the present invention is in photovoltaic devices. For example, the present invention may be used in combination with photovoltaic devices having three-dimensional charge separation and collection, such as those taught in U.S. patent application Ser. No. 13/312,780 entitled "Photovoltaic Device With Three Dimensional Charge Separation And Collection" filed Dec. 6, 2011, the entire disclosure of which is incorporated herein by reference. In the referenced application, the inventors teach using a graded InGaN p/n junction for a charge separation in a photovoltaic device.

The above embodiments and preferences are illustrative of the present invention. It is neither necessary, nor intended for this patent to outline or define every possible combination or embodiment. The inventor has disclosed sufficient information to permit one skilled in the art to practice at least one embodiment of the invention. The above description and drawings are merely illustrative of the present invention and that changes in components, structure and procedure are possible without departing from the scope of the present invention as defined in the following claims. For example, elements and/or steps described above and/or in the following claims in a particular order may be practiced in a different order without departing from the invention. Thus, while the invention has been particularly shown and described with reference to embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

The invention claimed is:

1. A method of manufacturing a light emitting device or a component thereof, comprising:

providing a substrate;

depositing an N-type Gallium Nitride layer;

following said N-type Gallium Nitride layer with an n-type InGaN layer compositionally graded from GaN to a target InGaN composition having a desired percentage of In; and

following said graded n-type InGaN layer with at least an n-type InGaN layer and a p-type InGaN layer of the target InGaN composition.

2. The method of manufacturing a light emitting device according to claim **1**, wherein said desired percentage of In is selected in accordance with a desired color range of light to be output from the light emitting device.

3. The method of manufacturing a light emitting device according to claim **1**, wherein an alloy composition and/or thickness of an InGaN p/n junction is adjusted to optimize intensity or select wavelength of light emitted from the light emitting device.

4. The method of manufacturing a light emitting device according to claim **1**, further comprising a step of capping with a layer of p-type GaN.

5. The method of manufacturing a light emitting device according to claim **1**, further comprising a step of forming an ohmic contact for injecting current on a back of the substrate using metal deposition.

6. The method of manufacturing a light emitting device according to claim **1**, further comprising a step of forming a top ohmic contact on a top surface of a p-type GaN layer using a semi-transparent NiAl layer, a metallic grid or a transparent conducting oxide.

7. The method of manufacturing a light emitting device according to claim **1**, wherein said N-type Gallium Nitride layer is deposited on said substrate.

8. The method of manufacturing a light emitting device according to claim **1**, wherein said N-type Gallium Nitride layer is deposited on a buffer layer on said substrate.

9. The method of manufacturing a light emitting device according to claim **1**, wherein compositionally graded n-type and p-type layers of InGaN are grown with a composition range from 0% to 40% In.

10. The method of manufacturing a light emitting device according to claim **1**, wherein a p/n junction is formed in InGaN of a target composition.

11. The method of manufacturing a light emitting device according to claim **1**, wherein a p/n junction is formed in a graded n-type region.

12. The method of manufacturing a light emitting device according to claim **1**, wherein group III-nitride layers are deposited using molecular beam epitaxy.

13. The method of manufacturing a light emitting device according to claim **1**, wherein group III-nitride layers are deposited using metal-organic chemical vapor deposition.

14. The method of manufacturing a light emitting device according to claim **1**, wherein group III-nitride layers are deposited using hydride vapor phase epitaxy.