CLAIMS

What is claimed is:

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

a first-doped layer on a substrate;

an active layer on the first-doped layer;

a second-doped layer on the active layer; and

a metal layer on the second-doped layer,

wherein the second-doped layer is textured with a plurality of V-pits on a surface opposite to the active layer to define a first portion and a second portion, and

wherein the first portion of the second-doped layer has a first portion thickness constrained for electron-hole pairs in the active layer to couple efficiently to a surface plasmon mode at an interface of the metal layer and the second-doped layer thereby increasing the spontaneous emission rate of the LED, and

wherein the active layer is capable of emitting photons, and

wherein the second portion of the second-doped layer has a second portion thickness sufficient to ensure formation of a p-n junction in the LED.

~~2. The LED of claim 1, wherein the first portion of the second-doped layer has a thickness of less than 50 nm.~~

~~3. The LED of claim 1, wherein the second portion of the second-doped layer has a thickness of more than 70 nm.~~

24. The LED of claim 1, wherein the active layer comprises one or more quantum well layers comprising material selected from semiconductor emitting material and organic molecules.

35. The LED of claim 1, wherein the substrate comprises a material selected from quartz, fused silica, silicon, sapphire and polymer.

46. The LED of claim 1, wherein the first-doped layer is an n-doped layer and the second-doped layer is a p-doped layer.

57. The LED of claim 1, wherein the first-doped layer comprises a material selected from the group comprising Si, Ge, SiC, GaAs, InGaP, InGaAs, InGaN, GaN, AlGaN, ZnSe, ZnCdSe, AlGaAs, InP and a molecule doped polymer.

68. The LED of claim 1, wherein the second-doped layer comprises a material selected from the group comprising Si, Ge, SiC, GaAs, InGaP, InGaAs, InGaN, GaN, AlGaN, ZnSe, ZnCdSe, AlGaAs, InP and a molecule doped polymer.

79. The LED of claim 1, wherein the active layer comprises a material selected from the group comprising Si, Ge, SiC, GaAs, InGaP, InGaAs, InGaN, GaN, AlGaN, ZnSe, ZnCdSe, CdS, AlGaAs and InP.

810. The LED of claim 1, wherein the metal layer comprises a metal selected from the group consisting of Au, Ag, Al, Cu, Ti, Ni, Cr, Zn, and an alloy formed from one or more of Au, Ag, Al, Cu, Ti, Ni, Cr, and Zn.

9~~11~~. The LED of claim 1, wherein light is emitted from a rear side of the LED when the metal layer has a thickness of approximately 30nm or thicker, wherein the rear side comprises a surface of the substrate opposite the first-doped layer.

10~~12~~. The LED of claim 1~~1~~, wherein light is emitted from the rear side of the LED and a front side of the LED when the metal layer has a thickness of 5nm to 30 nm, wherein the front side comprises a surface of the metal layer opposite the electrode layer.

11~~13~~. The LED of claim 1, wherein the metal layer is formed on the first portion of the second-doped layer but not on the second portion of the second-doped layer.

12~~14~~. The LED of claim 1, wherein the metal layer is formed on the first and second portions of the second-doped layer.

13~~15~~. The LED of claim 1, wherein the metal layer comprises a random array of metal nanoparticles formed through annealing or spincoating of metallic nanoparticles; or wherein the metal layer comprises patterned metallic nanostructures fabricated using lithography and deposition processes.

~~16. The LED of claim 1, wherein the metal layer comprises patterned metallic nanostructures fabricated using lithography and deposition processes.~~

14~~17~~. The LED of claim 1, wherein the second-doped layer is patterned with any one of the following: plasmonic nanostructures,~~or~~ metamaterial nanostructures, a structure of sub-wavelength grating, a structure of nanoantennas, and a structure of nanoapertures.

~~18. The LED of claim 1, wherein the second-doped layer is patterned with a structure of sub-wavelength grating.~~

~~19. The LED of claim 1, wherein the second-doped layer is patterned with a structure of nanoantennas.~~

~~20. The LED of claim 1, wherein the second-doped layer is patterned with a structure of nanoapertures.~~

15~~21~~. The LED of claim 1, further comprising a first electrode in contact with the first-doped layer and the electrode layer forming a second electrode in contact with the second-doped layer.

16~~22~~. The LED of claim 1, further comprising a phosphors layer on a surface of the LED.

17~~23~~. A method for fabricating a light emitting diode (LED), the method comprising:

depositing a first-doped GaN layer with first impurities on a substrate;

forming one or more quantum well layers on the first-doped layer;

depositing a second-doped GaN layer with second impurities on the quantum well layer;

depositing a metal layer over the second-doped layer,

wherein depositing the second-doped GaN layer comprises texturing a plurality of sharp V-pits so that a first portion of the second-doped GaN layer has a first thickness and a second portion of the second-doped GaN layer has a second thickness, the first thickness being defined as a surface plasmon thickness that cause electron-hole pairs in the one or more quantum well layers to couple efficiently to a surface plasmon mode at an interface of the metal layer and the second-doped layer for an increased spontaneous emission rate of the LED and the second thickness being determined to ensure formation of a p-n junction in the LED.

1824. The method of claim 1723, further comprises forming an electrode pad being a first electrode in contact with the first-doped GaN layer and the electrode layer forming a second electrode in contact with the second-doped GaN layer.

1925. The method of claim 1723, wherein the thinnest portion of the second-doped layer and the metal layer over the thinnest portion both are within the surface plasmon coupling thickness.

2026. The method of claim 1723 wherein depositing the metal layer over the second-doped layer comprises depositing the metal layer over the electrode layer.

2127. The method of claim 1723, further comprising avoiding the second-doped layer where the electrode layer is formed when depositing the metal layer over the second-doped layer.

2228. The method of claim 1723, further comprising avoiding the second portion of the second-doped layer when depositing the metal layer over the second-doped layer.

2329. The method of claim 1723, wherein deposition of the metal layer is by annealing or spincoating of metallic nanoparticles.