

What is claimed is:

1. A micro-light emitting diode (LED) pixel unit, comprising,
a first color LED structure, formed on an IC substrate, wherein the first color LED structure includes a first light emitting layer, and a first reflective structure is formed on a bottom of the first light emitting layer;
a first bonding metal layer, formed at a bottom of the first color LED structure, and configured to bond the IC substrate and the first color LED structure;
a second bonding metal layer, formed on a top of the first color LED structure;
a second color LED structure, formed on the second bonding metal layer, wherein the second color LED structure includes a second light emitting layer, and a second reflective structure is formed on a bottom of the second light emitting layer;
a top electrode layer, covering the first color LED structure and the second color LED structure and electrically contacting with the first color LED structure and the second color LED structure, wherein the IC substrate is electrically connected with the first color LED structure and the second color LED structure; and
a reflective cup, surrounding the first color LED structure and the second color LED structure;
wherein light emitted from the first light emitting layer and the second light emitting layer is substantially in a horizontal direction that arrives at and is reflected upward by the reflective cup.
2. The micro-LED pixel unit according to claim 1, wherein the first reflective structure includes at least one first reflective layer and the second reflective structure includes at least one second reflective layer, reflectivity of the first reflective layer or the second reflective layer being above 60%.
3. The micro-LED pixel unit according to claim 2, wherein a material of the first reflective layer or the second reflective layer comprises one or more of Rh, Al, Ag, or Au.
4. The micro-LED pixel unit according to claim 2, wherein the first reflective structure includes two first reflective layers and refractive indices of the two first reflective

layers are different, and wherein the second reflective structure includes two second reflective layers and refractive indices of the two second reflective layers are different.

5. The micro-LED pixel unit according to claim 4, wherein the two first reflective layers comprise SiO_2 and Ti_3O_5 respectively, and the two second reflectivity layers comprise SiO_2 and Ti_3O_5 respectively.

6. The micro-LED pixel unit according to claim 2, wherein the first reflective structure further includes a first transparent layer on the first reflective layer, and the second reflective structure further includes a second transparent layer on the second reflective layer.

7. The micro-LED pixel unit according to claim 6, wherein the first transparent layer comprises one or more of indium tin oxide (ITO) or SiO_2 , and the second transparent layer comprises one or more of ITO or SiO_2 .

8. The micro-LED pixel unit according to claim 1, wherein the first color LED structure further includes a first bottom conductive contact layer and a first top conductive contact layer, and the second color LED structure further includes a second bottom conductive contact layer and a second top conductive contact layer;

wherein the first light emitting layer is between the first bottom conductive contact layer and the first top conductive contact layer, and the second light emitting layer is between the second bottom conductive contact layer and the second top conductive contact layer;

wherein the first bottom conductive contact layer is electrically connected with the IC substrate through the first reflective structure and the first bonding metal layer through a first contact via, and the second bottom conductive contact layer is electrically connected with the IC substrate through a second contact via; and

wherein an edge of the first top conductive contact layer is in contact with the top electrode layer, and a top surface of the second top conductive contact layer is in contact with the top electrode layer.

9. The micro-LED pixel unit according to claim 1, further comprising a third reflective structure formed on a top of the first light emitting layer, and a fourth reflective structure formed on a top of the second light emitting layer.

10. The micro-LED pixel unit according to claim 1, further comprising a micro-lens formed above the top electrode layer.

11. The micro-LED pixel unit according to claim 10, further comprising a spacer formed between the micro-lens and the top electrode layer.

12. The micro-LED pixel unit according to claim 11, wherein a material of the spacer comprises silicon oxide.

13. The micro-LED pixel unit according to claim 10, wherein a lateral dimension of the micro-lens is larger than that of an active emitting area of the first LED structure; and the lateral dimension of the micro-lens is larger than that of an active emitting area of the second LED structure.

14. The micro-LED pixel unit according to claim 1, wherein the first color LED structure and the second color LED structure have a same lateral dimension.

15. The micro-LED pixel unit according to claim 1, wherein the first color LED structure and the second color LED structure have a same center axis.

16. The micro-LED pixel unit according to claim 2, wherein a thickness of the at least one first reflective layer is in a range of 5 nm to 10 nm, and a thickness of the at least one second reflective layer is in a range of 5 nm to 10 nm, and wherein a thickness of the first color LED structure is not more than 300 nm, and a thickness of the second color LED structure is not more than 300 nm.

17. A micro-LED pixel unit, comprising,
an IC substrate;
a light emitting region, formed on the IC substrate, including a plurality of color LED structures, a bottom of each of the plurality of color LED structures being connected to a corresponding bonding metal layer in the light emitting region, wherein each of the plurality of color LED structures includes a light emitting layer and a reflective structure at a bottom of the light emitting layer;
a top electrode layer, covering each of the plurality of color LED structures and electrically contacting to each of the plurality of color LED structures, wherein the IC substrate

is electrically connected with each of the plurality of color LED structures; and,

a stair-shaped reflective cup forming a cavity, surrounding the light emitting region, light emitted from sidewalls of the light emitting layer of each of the plurality of color LED structures in a horizontal direction arriving at and being reflected upward by the reflective cup.

18. The micro-LED pixel unit according to claim 17, wherein an inner sidewall of the cavity includes a plurality of inclined surfaces.

19. The micro-LED pixel unit according to claim 18, wherein angles of the plurality of inclined surfaces relative to surface of the IC substrate from bottom to top of the cavity become smaller.

20. The micro-LED pixel unit according to claim 18, wherein sub-cavities formed by the plurality of inclined surfaces have different dimensions in the horizontal direction.

21. The micro-LED pixel unit according to claim 20, wherein inner sidewalls of the sub-cavities are not arranged in a same plane.

22. The micro-LED pixel unit according to claim 20, wherein heights of the sub-cavities are different.

23. The micro-LED pixel unit according to claim 20, wherein a height of a sub-cavity in middle of the cavity is less than heights of other sub-cavities.

24. The micro-LED pixel unit according to claim 20, wherein a height of a sub-cavity at top of the cavity is larger than a height of a sub-cavity at bottom of the cavity.

25. The micro-LED pixel unit according to claim 17, wherein the plurality of color LED structures further includes a top color LED structure.

26. The micro-LED pixel unit according to claim 25, wherein a top of the cavity is higher than a top of the top color LED structure.

27. The micro-LED pixel unit according to claim 17, wherein the cavity includes a plurality of sub-cavities, and each of the plurality of color LED structures is in a respectively different one of the sub-cavities.

28. The micro-LED pixel unit according to claim 17, further comprising a transparent dielectric bonding layer covering at least one of the plurality of color LED

structures, wherein the transparent dielectric bonding layer comprises solid inorganic materials or plastic materials.

29. The micro-LED pixel unit according to claim 28, wherein the solid inorganic materials comprise one or more materials selected from the group consisting of SiO₂, Al₂O₃, Si₃N₄, Phosphosilicate glass (PSG), and Borophosphosilicate glass (BPSG).

30. The micro-LED pixel unit according to claim 28, wherein the plastic materials comprise one or more polymers selected from the group consisting of SU-8, PermiNex, Benzocyclobutene (BCB), and spin-on glass (SOG)

31. The micro-LED pixel unit according to claim 25, wherein each of the plurality of color LED structures includes a bottom conductive contact layer and a top conductive contact layer, and the light emitting layer is formed between the bottom conductive contact layer and the top conductive contact layer; and wherein

the bottom conductive contact layer is electrically connected with the IC substrate through the reflective structure and the corresponding bonding metal layer through a contact via, and

a top surface of the top conductive contact layer of the top color LED structure is in contact with the top electrode layer, and an edge of the top conductive contact layer of a color LED structure under the top color LED structure is in contact with the top electrode layer.

32. The micro-LED pixel unit according to claim 25, wherein an extended portion is extended from one side of the light emitting layer of a color LED structure under the top color LED structure, a contact via connecting the extended portion to the top electrode layer.

33. The micro-LED pixel unit according to claim 17, wherein a material of the reflective cup comprises metal.

34. The micro-LED pixel unit according to claim 17, further comprising a micro-lens formed above the top electrode layer.

35. The micro-LED pixel unit according to claim 18, further comprising a spacer formed between the micro-lens and the top electrode layer.

36. The micro-LED pixel unit according to claim 19, wherein a material of the

spacer comprises silicon oxide.

37. The micro-LED pixel unit according to claim 18, wherein a lateral dimension of the micro-lens is larger than a light emitting dimension of each of the plurality of color LED structures.

38. The micro-LED pixel unit according to claim 17, wherein the plurality of color LED structures have a same center axis.

39. The micro-LED pixel unit according to claim 17, wherein the reflective structure includes a reflective layer and a thickness of the reflective layer is in a range of 5 nm to 10 nm, and a thickness of each of the plurality of color LED structures is not more than 300 nm.

40. The micro-LED pixel unit according to claim 17, wherein a material of the top electrode layer is selected from the group consisting of graphene, Indium tin oxide (ITO), Aluminum-Doped Zinc Oxide (AZO), and Fluorine doped Tin Oxide (FTO).

41. A micro-LED pixel unit, comprising,
a semiconductor substrate;

a light emitting region, formed on the semiconductor substrate, including a plurality of color LED structures, a bottom of each of the plurality of color LED structures being connected to a corresponding bonding metal layer in the light emitting region, wherein each of the plurality of color LED structure includes a light emitting layer and a reflective structure at a bottom of the light emitting layer;

a top electrode layer, covering each of the plurality of color LED structures and electrically contacting with each of the plurality of color LED structures, wherein the semiconductor substrate is electrically connected with each of the plurality of color LED structures;

a reflective cup, surrounding the light emitting region; and

a refractive structure, formed between the reflective cup and the light emitting region.

42. The micro-LED pixel unit according to claim 41, further comprising a micro-lens formed on a top surface of the refractive structure.

43. The micro-LED pixel unit according to claim 42, wherein a lateral dimension of the micro-lens is not less than a lateral dimension of the light emitting region.

44. The micro-LED pixel unit according to claim 42, wherein the reflective cup has a top opening area, and a lateral dimension of the micro-lens is less than a lateral dimension of the top opening area.

45. The micro-LED pixel unit according to claim 41, further comprising a bottom dielectric layer formed between a bottom of the reflective cup and the semiconductor substrate.

46. The micro-LED pixel unit according to claim 41, further comprising a top conductive layer formed on a top of the light emitting region, and the top conductive layer is electrically connected with the reflective cup.

47. The micro-LED pixel unit according to claim 46, wherein the top conductive layer directly contacts with a top of the reflective cup or a bottom of the reflective cup.

48. The micro-LED pixel unit according to claim 41, wherein a top of the refractive structure is higher than a top of the reflective cup.

49. The micro-LED pixel unit according to claim 41, wherein each of the plurality of color LED structures includes a bottom conductive contact layer and a top conductive contact layer, and the light emitting layer is formed between the bottom conductive contact layer and the top conductive contact layer; and wherein

the bottom conductive contact layer is electrically connected with the semiconductor substrate through the reflective structure and the corresponding bonding metal layer through a contact via, and

a top surface of the top conductive contact layer of a top color LED structure is in contact with the top electrode layer, and an edge of the top conductive contact layer of a color LED structure under the top color LED structure is in contact with the top electrode layer.

50. The micro-LED pixel unit according to claim 41, wherein the semiconductor substrate is an IC substrate.

51. The micro-LED pixel unit according to claim 41, wherein the reflective cup is a stair- shaped reflective cup forming a cavity encompassing the light emitting region.

52. The micro-LED pixel unit according to claim 51, wherein an inner sidewall of the cavity includes a plurality of inclined surfaces.

53. The micro-LED pixel unit according to claim 52, wherein angles of the plurality of inclined surfaces relative to surface of the semiconductor substrate from bottom to top of the cavity become smaller.

54. The micro-LED pixel unit according to claim 52, wherein sub-cavities formed by the plurality of inclined surfaces have different dimensions in a horizontal direction.

55. The micro-LED pixel unit according to claim 54, wherein inner sidewalls of the sub-cavities are not arranged in a same plane.

56. The micro-LED pixel unit according to claim 54, wherein heights of the sub-cavities are different.

57. The micro-LED pixel unit according to claim 54, wherein a height of a sub-cavity in middle of the cavity is less than heights of other sub-cavities.

58. The micro-LED pixel unit according to claim 54, wherein a height of a sub-cavity at a top of the cavity is larger than a height of a sub-cavity at a bottom of the cavity.

59. The micro-LED pixel unit according to claim 41, wherein the plurality of color LED structures further includes a top color LED structure.

60. The micro-LED pixel unit according to claim 59, wherein a top of the cavity is higher than a top of the top color LED structure.

61. The micro-LED pixel unit according to claim 51, wherein the cavity includes a plurality of sub-cavities, and each of the plurality of color LED structures is in a respectively different one of the sub-cavities.

62. The micro-LED pixel unit according to claim 41, wherein a material of the reflective cup comprises metal.

63. The micro-LED pixel unit according to claim 59, wherein an extended portion is extended from one side of the light emitting layer of a color LED structure under the top color LED structure, and a contact via connects the extended portion to the top electrode layer.

64. The micro-LED pixel unit according to claim 41, wherein the plurality of color

LED structures has a same center axis.

65. The micro-LED pixel unit according to claim 41, wherein the reflective structure includes a reflective layer and a thickness of the reflective layer is in a range of 5 nm to 10 nm, and a thickness of each of the plurality of color LED structures is not more than 300 nm.

66. The micro-LED pixel unit according to claim 41, wherein a material of the top electrode layer comprises one or more of graphene, indium tin oxide (ITO), aluminum-doped zinc oxide (AZO) or fluorine-doped tin dioxide (FTO).

67. The micro-LED pixel unit according to claim 41, wherein each of the plurality of color LED structures includes a respective extended portion extended from one side of the respective color LED structure, and the respective extended portion is electrically connected with the top electrode layer via a respective first contact via, and the bottom of each of the plurality of color LED structures is electrically connected with the semiconductor substrate via a respective second contact via.

68. A micro-LED pixel unit, comprising,

a semiconductor substrate;

a light emitting region, formed on the semiconductor substrate, including a plurality of color LED structures, a bottom of each of the plurality of color LED structures being connected to a corresponding bonding metal layer in the light emitting region, wherein each of the plurality of color LED structures includes a light emitting layer and a reflective structure at a bottom of the light emitting layer;

a top electrode layer, covering each of the plurality of color LED structures and electrically contacting with each of the plurality of color LED structures, wherein the semiconductor substrate is electrically connected with each of the plurality of color LED structures; and

a reflective cup, surrounding the light emitting region, light emitted from sidewalls of the light emitting layer of each of the plurality of color LED structures in a horizontal direction arriving at and being reflected upward by the reflective cup, a top of the reflective cup being

higher than a top of the light emitting region.

69. The micro-LED pixel unit according to claim 68, further comprising a micro-lens formed above the light emitting region.

70. The micro-LED pixel unit according to claim 69, wherein the top of the reflective cup is higher than a top of the micro-lens.

71. The micro-LED pixel unit according to claim 69, further comprising a refractive structure at a bottom of the micro-lens and formed between the reflective cup and the light emitting region.

72. The micro-LED pixel unit according to claim 69, wherein a lateral dimension of the micro-lens is not less than a lateral dimension of the light emitting region.

73. The micro-LED pixel unit according to claim 69, wherein the reflective cup has a top opening area and a lateral dimension of the micro-lens is less than a lateral dimension of the top opening area.

74. The micro-LED pixel unit according to claim 68, further comprising a bottom dielectric layer formed between a bottom of the reflective cup and the semiconductor substrate.

75. The micro-LED pixel unit according to claim 68, further comprising a top conductive layer formed on a top of the light emitting region, and the top conductive layer is electrically connected with the reflective cup.

76. The micro-LED pixel unit according to claim 68, wherein each of the plurality of color LED structures includes a bottom conductive contact layer and a top conductive contact layer, and the light emitting layer is formed between the bottom conductive contact layer and the top conductive contact layer; and wherein

the bottom conductive contact layer is electrically connected with the semiconductor substrate through the reflective structure and corresponding the bonding metal layer by a contact via, and

a top surface of the top conductive contact layer of a top color LED structure is in contact with the top electrode layer, and an edge of the top conductive contact layer of a color LED structure under the top color LED structure is in contact with the top electrode layer.

77. The micro-LED pixel unit according to claim 68, wherein a bottom of the light emitting region is electrically connected with the semiconductor substrate.

78. The micro-LED pixel unit according to claim 68, wherein the semiconductor substrate is an IC substrate.

79. The micro-LED pixel unit according to claim 68, wherein the reflective cup is a stair-shaped reflective cup forming a cavity encompassing the light emitting region.

80. The micro-LED pixel unit according to claim 79, wherein an inner sidewall of the cavity includes a plurality of inclined surfaces.

81. The micro-LED pixel unit according to claim 80, wherein angles of the plurality of inclined surfaces relative to surface of the semiconductor substrate from bottom to top of the cavity become smaller.

82. The micro-LED pixel unit according to claim 80, wherein sub-cavities formed by the plurality of inclined surfaces have different dimensions in a horizontal direction.

83. The micro-LED pixel unit according to claim 82, wherein inner sidewalls of the sub-cavities are not arranged in a same plane.

84. The micro-LED pixel unit according to claim 82, wherein heights of the sub-cavities are different.

85. The micro-LED pixel unit according to claim 82, wherein a height of a sub-cavity in the middle of the cavity is less than heights of other sub-cavities.

86. The micro-LED pixel unit according to claim 82, wherein a height of a sub-cavity at a top of the cavity is larger than a height of a sub-cavity at a bottom of the cavity.

87. The micro-LED pixel unit according to claim 79, wherein the plurality of color LED structures further includes a top color LED structure.

88. The micro-LED pixel unit according to claim 87, wherein a top of the cavity is higher than a top of the top color LED structure.

89. The micro-LED pixel unit according to claim 79, wherein the cavity includes a plurality of sub-cavities, and each of the plurality of color LED structures is in a respectively different one of the sub-cavities.

90. The micro-LED pixel unit according to claim 68, wherein a material of the reflective cup comprises metal.

91. The micro-LED pixel unit according to claim 87, wherein an extended portion is extended from one side of the light emitting layer of a color LED structure under the top color LED structure, and a contact via connects the extended portion to the top electrode layer.

92. The micro-LED pixel unit according to claim 68, wherein the plurality of color LED structures have a same center axis.

93. The micro-LED pixel unit according to claim 68, wherein the reflective structure includes a reflective layer and a thickness of the reflective layer is in a range of 5 nm to 10 nm, and a thickness of each of the plurality of color LED structures is not more than 300 nm.

94. The micro-LED pixel unit according to claim 68, wherein a material of the top electrode layer comprises one or more of graphene, indium tin oxide (ITO), aluminum-doped zinc oxide (AZO) or fluorine-doped tin dioxide (FTO).

95. A micro-LED pixel unit, comprising,

a semiconductor substrate;

a light emitting region, formed on the semiconductor substrate, including a plurality of color LED structures, a bottom of each of the plurality of color LED structures being connected to a corresponding bonding metal layer in the light emitting region, wherein each of the plurality of color LED structures includes a light emitting layer and a reflective structure at a bottom of the light emitting layer;

a top electrode layer, covering each of the plurality of color LED structures and electrically contacting with each of the plurality of color LED structures, wherein the semiconductor substrate is electrically connected with each of the plurality of color LED structures; and

a floating reflective cup, surrounding the light emitting region, wherein a bottom of the floating reflective cup is above the semiconductor substrate, light emitted from sidewalls of the light emitting layer of each of the plurality of color LED structures in a horizontal direction

arriving at and being reflected upward by the suspended floating reflective cup.

96. The micro-LED pixel unit according to claim 95, wherein the bottom of the floating reflective cup is higher than a top surface of the corresponding bonding metal layer at a bottom of one of the plurality of color LED structures.

97. The micro-LED pixel unit according to claim 95, wherein the floating reflective cup is stair-shaped.

98. The micro-LED pixel unit according to claim 97, further comprising a micro-lens formed above the light emitting region.

99. The micro-LED pixel unit according to claim 98, wherein a top of the floating reflective cup is higher than a top of the micro-lens.

100. The micro-LED pixel unit according to claim 98, further comprising a refractive structure at a bottom of the micro-lens and formed between the floating reflective cup and the light emitting region.

101. The micro-LED pixel unit according to claim 98, wherein a lateral dimension of the micro-lens is not less than a lateral dimension of the light emitting region.

102. The micro-LED pixel unit according to claim 98, wherein the floating reflective cup has a top opening area, and a lateral dimension of the micro-lens is less than a lateral dimension of the top opening area.

103. The micro-LED pixel unit according to claim 97, further comprising a bottom dielectric layer formed between the floating reflective cup and the semiconductor substrate.

104. The micro-LED pixel unit according to claim 95, wherein the top electrode layer directly contacts a top of the floating reflective cup or the bottom of the floating reflective cup.

105. The micro-LED pixel unit according to claim 104, wherein each of the plurality of color LED structures includes a bottom conductive contact layer and a top conductive contact layer, and the light emitting layer is formed between the bottom conductive contact layer and the top conductive contact layer; and wherein

the bottom conductive contact layer is electrically connected with the semiconductor substrate through the reflective structure and the corresponding bonding metal layer by a

contact via, and

a top surface of the top conductive contact layer of a top color LED structure is in contact with the top electrode layer, and an edge of the top conductive contact layer of a color LED structure under the top color LED structure is in contact with the top electrode layer.

106. The micro-LED pixel unit according to claim 95, wherein the semiconductor substrate is an IC substrate.

107. The micro-LED pixel unit according to claim 97, wherein the stair-shaped floating reflective cup forms a cavity encompassing the light emitting region.

108. The micro-LED pixel unit according to claim 107, wherein an inner sidewall of the cavity includes a plurality of inclined surfaces.

109. The micro-LED pixel unit according to claim 108, wherein angles of the plurality of inclined surfaces relative to surface of the semiconductor substrate from bottom to top of the cavity become smaller.

110. The micro-LED pixel unit according to claim 108, wherein sub-cavities formed by the plurality of inclined surfaces have different dimensions in a horizontal direction.

111. The micro-LED pixel unit according to claim 110, wherein inner sidewalls of the sub-cavities are not positioned in a same plane.

112. The micro-LED pixel unit according to claim 110, wherein heights of the sub-cavities are different.

113. The micro-LED pixel unit according to claim 110, wherein a height of a sub-cavity in the middle of the cavity is less than heights of other sub-cavities.

114. The micro-LED pixel unit according to claim 110, wherein a height of a sub-cavity at a top of the cavity is larger than a height of a sub-cavity at a bottom of the cavity.

115. The micro-LED pixel unit according to claim 107, wherein the plurality of color LED structures further includes a top color LED structure.

116. The micro-LED pixel unit according to claim 115, wherein a top of the cavity is higher than a top of the top color LED structure.

117. The micro-LED pixel unit according to claim 107, wherein the cavity includes

a plurality of sub-cavities, and each of the plurality of color LED structure is in a respectively different one of the sub-cavities.

118. The micro-LED pixel unit according to claim 95, wherein a material of the floating reflective cup comprises metal.

119. The micro-LED pixel unit according to claim 95, wherein each of the plurality of color LED structures includes a respective extended portion extended from one side of the respective color LED structure, and the respective extended portion is electrically connected with the top electrode layer via a respective first contact via, and the bottom of each of the plurality of color LED structures is electrically connected with the semiconductor substrate via a respective second contact via.

120. The micro-LED pixel unit according to claim 95, wherein the plurality of color LED structures have a same center axis.

121. The micro-LED pixel unit according to claim 95, wherein the reflective structure includes a reflective layer formed at the bottom of each of the plurality of color LED structures respectively.

122. The micro-LED pixel unit according to claim 121, wherein a thickness of the reflective layer is in a range of 5 nm to 10 nm, and a thickness of each of the plurality of color LED structures is not more than 300 nm.

123. The micro-LED pixel unit according to claim 95, wherein a material of the top electrode layer comprises one or more of graphene, indium tin oxide (ITO), aluminum-doped zinc oxide (AZO) or fluorine-doped tin dioxide (FTO).

124. A multi-color micro light - emitting diode (LED) pixel device for a display panel, comprising:

a first LED structure that emits a first color, formed on an IC substrate;

a first transparent dielectric bonding layer having a first flat top surface, covering the first LED structure;

a second LED structure that emits a second color, formed on the first flat top surface of

the first transparent dielectric bonding layer;

a second transparent dielectric bonding layer having a second flat top surface, covering the second LED structure; and

a top electrode layer, covering the multi-color micro LED pixel device and electrically contacting with the first LED structure and the second LED structure;

wherein the IC substrate is electrically connected with the first LED structure and the second LED structure.

125. The multi-color micro LED pixel device according to claim 124, wherein the first LED structure is embedded within a first planarized transparent dielectric layer.

126. The multi-color micro LED pixel device according to claim 124, wherein the second LED structure is embedded within a second planarized transparent dielectric layer.

127. The multi-color micro LED pixel device according to claim 124, wherein the first transparent dielectric bonding layer is composed of solid inorganic materials or plastic materials.

128. The multi-color micro LED pixel device according to claim 127, wherein the solid inorganic materials are composed of one or more materials selected from the group consisting of SiO₂, Al₂O₃, Si₃N₄, Phosphosilicate glass (PSG), and Borophosphosilicate glass (BPSG).

129. The multi-color micro LED pixel device according to claim 127, wherein the plastic materials are one or more polymers selected from the group consisting of SU-8, PermiNex, Benzocyclobutene (BCB), and spin-on glass (SOG).

130. The multi-color micro LED pixel device according to claim 124, wherein:
the first LED structure includes a first bottom electrode layer formed on a bottom of the first LED structure,

the second LED structure includes a second bottom electrode layer formed on a bottom of the second LED structure;

the first bottom electrode layer is electrically connected with the IC substrate by a first contact in a first via at a bottom of the first bottom electrode layer; and

the second bottom electrode layer is electrically connected with the IC substrate by a second contact in a second via through the first transparent dielectric bonding layer.

131. The multi-color micro LED pixel device according to claim 130, wherein the first bottom electrode layer is transparent, and the second bottom electrode layer is transparent.

132. The multi-color micro LED pixel device according to claim 124, wherein:

the first LED structure includes a first light emitting layer;

a first side portion is extended from a side of the first light emitting layer;

the second LED structure includes a second light emitting layer;

a second side portion is extended from a side of the second light emitting layer;

and

a third contact in a third via connects the first side portion and the second side portion to the top electrode layer through the second transparent dielectric bonding layer.

133. The multi-color micro LED pixel device according to claim 124, wherein an optical isolation structure is formed around the multi-color micro LED pixel device.

134. The multi-color micro LED pixel device according to claim 133, wherein the optical isolation structure is a reflective cup.

135. The multi-color micro LED pixel device according to claim 133, wherein the material of the reflective cup is metal.

136. The multi-color micro LED pixel device according to claim 124, wherein a micro-lens is formed above the top electrode layer.

137. The multi-color micro LED pixel device according to claim 136, wherein a spacer is formed between the micro-lens and the top electrode layer.

138. The multi-color micro LED pixel device according to claim 137, wherein the spacer is composed of silicon oxide.

139. The multi-color micro LED pixel device according to claim 136, wherein a lateral dimension of the micro-lens is larger than active emitting area of the first LED structure; and the lateral dimension of the micro-lens is larger than active emitting area of the second LED structure.

140. The multi-color micro LED pixel device according to claim 124, wherein lateral dimension of the first LED structure is the same as that of the second LED structure.

141. The multi-color micro LED pixel device according to claim 124, wherein the first LED structure and the second LED structure have a same central axis.

142. The multi-color micro LED pixel device according to claim 124, wherein a first reflective layer is formed at a bottom of the first LED structure; a second reflective layer is formed at a bottom of the second LED structure.

143. The multi-color micro LED pixel device according to claim 142, wherein:

a thickness of the first reflective layer is 5 to 10 nm;

a thickness of the second reflective layer is 5 to 10 nm;

a thickness of the first LED structure is not more than 300 nm; and,

a thickness of the second LED is not more than 300 nm.

144. The multi-color micro LED pixel device according to claim 124, wherein a bonding metal layer is formed at a bottom of the first LED structure.

145. The multi-color micro LED pixel device according to claim 124, wherein material of the top electrode layer is selected from the group consisting of graphene, Indium tin oxide (ITO), Aluminum-Doped Zinc Oxide (AZO), and Fluorine doped Tin Oxide (FTO).