MULTIPLE MICROLENS SYSTEM FOR IMAGE SENSORS OR DISPLAY UNITS

FIELD OF THE INVENTION

[0001] The present invention relates generally to improved semiconductor imaging devices, and in particular to a multiple microlens system for an imager array or display unit.

BACKGROUND OF THE INVENTION

[0002] Solid state imagers, including charge coupled devices (CCD) and CMOS sensors, have been commonly used in photo imaging applications. A solid state imager circuit includes a focal plane array of pixel cells, each one of the cells including either a photogate, photoconductor or a photodiode overlying a doped region of a substrate for accumulating photo-generated charge in the underlying portion of the substrate. Microlenses are commonly placed over imager pixel cells. A microlens is used to focus light onto the initial charge accumulation region. Conventional technology uses a single microlens with a polymer coating, which is patterned into squares or circles provided respectively over the pixels which are then heated during manufacturing to shape and cure the microlens.

[0003] Use of microlenses significantly improves the photosensitivity of the imaging device by collecting light from a large light collecting area and focusing it on a small photosensitive area of the sensor. The ratio of the overall light collecting area to the photosensitive area of the sensor is known as the pixel's fill factor.

[0004] Microlenses are formed on planarized regions, which are above the photosensitive area. After passing through the planarization regions, the light is filtered by color filters. Each conventional pixel can have a separate color filter. Alternatively, a pixel's filter regions will be varied by depth in order to filter out undesirable wavelengths.

[0005] As the size of imager arrays and photosensitive regions of pixels decreases, it becomes increasingly difficult to provide a microlens capable of focusing incident light rays onto the photosensitive regions. This problem is due in part to the increased difficulty in constructing a smaller micro lens that has the optimal focal length for the imager device process and that optimally adjusts for optical aberrations introduced as the light passes through the various device layers. Also, it is difficult to correct the distortion created by multiple regions above the photosensitive area, which results in increased crosstalk between adjacent pixels. "Crosstalk" results when off-axis light strikes a microlens at an obtuse angle. The off-axis light passes through planarization regions and a color filter, misses the intended photosensitive region and instead strikes an adjacent light sensitive region. Consequently, smaller imagers with untuned or nonoptimized microlenses do not achieve optimal color fidelity and signal/noise ratios.

[0006] Lens structures used with display systems also suffer from a lack of efficient lens systems. For example, active matrix liquid crystal display (LCD) systems have a cross polarizer than can open or block a light path with a voltage signal. The LCD assumes a parallel or perpendicular state to the polarizer angles in question. Light comes through a color filter to be viewed by a user when the light path is open. Current systems do not provide for good viewing angles in both X and Y directions without expensive or complex structures that are needed to disperse the light to provide a good viewing angle.

BRIEF SUMMARY OF THE INVENTION

[0007] The present invention provides a microlens structure for a pixel array in which the microlens associated with pixel(s) of the array includes a plurality of lens regions, each region having a different optical property. The optical properties of the plurality of lens regions are such that an increased amount of incident light reaches a light detector pixel or is dispersed from a display pixel.

[0008] Various exemplary embodiments and methods of their manufacture are discussed in detail below. These and other features of the invention are described in more detail below in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 shows a cross sectional view of a portion of a microlens structure constructed in accordance with an exemplary embodiment of the invention;

[0010] FIG. 1A shows a top view of a portion of the FIG. 1 embodiment;

[0011] FIG. 2 shows a top view of a portion of another exemplary embodiment of a pixel array constructed in accordance with another aspect of the invention;

[0012] FIG. 3 shows a cross sectional view of an exemplary embodiment of the FIG. 1 microlens;

[0013] FIG. 4 shows a cross sectional view of another exemplary embodiment of a microlens constructed in accordance with another embodiment of the invention;

[0014] FIG. 5 shows a top view of a microlens constructed in accordance with an exemplary embodiment of the invention;

[0015] FIG. 6 shows a cross sectional view of the FIG. 5 microlens;

[0016] FIG. 7 shows a block diagram of an imager system constructed in accordance with an exemplary embodiment of the invention;

[0017] FIG. 8 shows a manufacturing method performed in accordance with an exemplary embodiment of the invention;

[0018] FIG. 9 shows a manufacturing method performed in accordance with another exemplary embodiment of the invention;

[0019] FIG. 10 shows a manufacturing method performed in accordance with another exemplary embodiment of the invention; and

[0020] FIG. 11 shows a cross sectional view of a lens constructed in accordance with another exemplary embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] The invention provides a new microlens structure for use with optical detectors or display systems. The invention increases the amount of incident light reaching a photosensitive region of a pixel in an imager array. The invention can also be used to diffuse light from a display unit more efficiently. The microlens structure includes a plurality of lens regions having different optical properties to refract or divert light incident to a microlens either to a photosensitive region of a pixel or from a display structure in a more efficient manner.

[0022] Referring to FIGs. 1 and 1A, a first exemplary embodiment of an imager array 2 constructed in accordance with the invention is shown in cross sectional and top view, respectively. A plurality of microlens structures is provided, each having an upper lens portion 1 and a lower lens portion 3. The structures are provided over passivation region 6, intervening region 4 (e.g., color filter array, metallization region, etc) and an array of imaging pixels 5. Each pixel 5 has a photosensor for converting photons to electrical charges. The light collection efficiency of each pixel 5 is increased by creating two or more lens layers 1, 3 in each microlens to focus light more directly onto a light sensitive region of pixel 5. The lens layers 1, 3 can be formed into various symmetrical geometric shapes, such as circles, squares, etc., and asymmetrical shapes to provide a path for incident light rays to reach the photo sensitive regions of the pixel 5. FIG. 1A shows the lens regions 1, 3 as circular and noncontiguous with other lens structures with lens regions 1, 3; however, it should be understood that a variety of shapes may be used with the invention, as is further discussed below.

[0023] FIG. 2 shows a top view of a second embodiment of the invention in which a microlens array has a first group of microlenses each having two lens regions 1, 3 and a second group of microlenses each having a single lens 10. FIG. 2 illustrates that a microlens array can have different microlens structures respectively associated with different pixels of a pixel array.

[0024] The construction of each microlens structure is based upon the determination of desired combined refractive effects of the two or more lens regions 1, 3. A desired combined refractive effect is produced by the combined optical properties of regions 1, 3 which improves the fill factor for a pixel 5.

[0025] Refraction behavior of light that passes through boundary areas of two mediums is described in Snells equation:

$$N_1 * \sin\theta_1 = N_2 * \sin\theta_2 \quad \ldots \ldots \ldots \ldots \ldots \ldots \quad (1)$$

which governs simple geometric optics. Refraction is the bending of the path of a light wave as it passes across the boundary separating two media. The angle at which a light wave encounters a boundary is referred to as the angle of incidence (θ_1). The angle at which the light wave moves in relation to the media boundary after passage is referred to as the angle of refraction (θ_2). N_1 and N_2 refer to the index of refraction associated with two materials that form a boundary between them, which a light wave passes through. Refraction is caused by the change in speed experienced by a light wave when the medium it passes through changes.

[0026] Referring to FIG. 3, the relationship $N_1 > N_2 > N_0$ is an example of a set of refractive indexes for a microlens having two different regions 1, 3. Regions 1, 3 have dimensions and refractive indexes selected to steer more light into a detector region than would otherwise occur using a single microlens or other conventional microlens structures. N_1 is the refractive index of the first lens region 1. N_2 is the refractive index of the second lens region 3 and N_0 is the refractive index of a medium outside the first lens region 1, such as air or other gasses.

[0027] FIG. 3 illustrates an expanded view of the FIG. 1 embodiment. The light collection efficiency of each pixel 5 is increased by creating more than one lens region 1, 3 in each microlens to focus light more directly on a photosensitive region of pixel 5. Lens region materials 1, 3 are positioned to steer, or direct, incident light 7 to an underlying photosensitive region 5. Lens regions 1, 3 can be formed into various symmetrical geometric shapes, such as circles, squares, etc. as well as asymmetrical shapes to provide a path for incident light rays to reach the photosensitive region of pixel 5.

[0028] A third embodiment of the invention includes a microlens having more than two lens regions to better selectively adjust the refraction of light onto a photosensitive region. FIG. 4 shows microlens 9 having a first lens region 8 formed over a second lens region 1 which is in turn formed over a third lens region 3. The lens regions are formed with different refractive indexes of N_3, N_2 and N_1. The regions refractive indexes and lens sizes and shapes are selected to provide, in combination with other intervening layer refractive properties, a desired fill factor for photosensitive regions of the pixel 5 below the exemplary microlens 9. The refractive indexes and shape selections for each lens' regions 8, 1, 3 may also be chosen based on the optical properties of the underlying regions, e.g., planarization layer 6 or other layers 4, which may also affect the fill factor. In the embodiment depicted in FIG. 4, incident light is refracted by the multiple regions 8, 1, 3 so that a desired portion of the light is directed onto the photosensitive region 5. A topmost one of the lens regions, e.g., 8, may be formed as segmented lens regions or a single lens region 8 over the entire pixel array. The microlens 9 may be formed over each of the pixels in an imager array or a portion of the pixels in the array.

[0029] FIGs. 5 and 6 respectively illustrate a top view and cross sectional view of a fourth exemplary embodiment of the invention. In this embodiment, a lower lens ring 13 deflects light from an outer peripheral portion of a lens region 11 towards a photosensitive region of a pixel 5. The lens region 13 refracts only a portion of the light refracted by lens region 11 in order to selectively adjust the fill factor for a particular photosensitive region 5. One or more additional lens regions may be provided above lens region 11 to further direct light towards the photosensitive region of pixel 5. In this

exemplary embodiment, a curved microlens region 11 is formed above another microlens region 13. However, the two microlens regions 11, 13 can be reversed; in which case, lens region 13 will be formed on lens region 11 to selectively refract light towards the photosensitive region of pixel 5.

[0030] As shown in FIG. 6, light 17 entering lens region 11 is refracted into the lower lens region 13. Lens region 13 further refracts the light 17 near the peripheral edge at a sharp angle onto the photosensitive region of the pixel 5.

[0031] The refractive indexes of the plurality of lens regions can be chosen based upon consideration of the light refractive properties of the layers between the microlens region and photosensitive region to maximize light transmission to the photosensitive regions of a pixel 5. As mentioned above, a microlens array in accordance with the invention can include different microlens structures in different portions of the pixel array. Light which is incident on pixels at the center of a pixel array can be very different from light which is incident on pixels at the outer edges of the pixel array. Accordingly, one microlens structure can be provided over pixels in the middle of the array and another different microlens structure can be used for incident light transmission in other peripheral pixels of the array.

[0032] FIG. 7 shows an image processing system that incorporates a processor 31, memory 33, an input/output system 35, a storage unit 37 and an imager 39. A bus 30 couples the image processing system components. The imager 39 contains an array of pixels having an associated microlens structure in accordance with the invention.

[0033] Pixel arrays having a microlens constructed in accordance with the invention, and described with reference to examples in FIGs. 1-7, may be employed in a CMOS, CCD, or other imagers. The microlens structures of the invention may be used as a single microlens for a pixel or as an array of microlenses for respective pixels.

[0034] FIG. 8 shows one method of manufacturing the microlens structures illustrated in FIGs. 1, 1A and 3. The method utilizes a substrate, which contains a pixel array, peripheral circuits, contacts and wiring. One or more protective layers, e.g., BPSG,

BSG, PSG, silicon dioxide or silicon nitride or other transparent material, are formed over the pixel array and planarized. A spacing layer may be formed over the protective layers. Construction of the microlens structure then begins. At S51, a first lens region, e.g., region 3 (FIG. 3), is formed with a material and thickness that will, in combination with other lens regions, increase incident light passing onto a photosensitive region of pixel 5. The first lens region 3 may be applied using a process such as spin coating and be formed of a transparent or polymeric material. Other lens forming materials may also be used including optical thermoplastic such as polymethylmethacrylate, polycarbonate, polyolefin, cellulose acetate butyrate, or polystyrene, a polymide, a thermoset resin such as an epoxy resin, a photosensitive gelatin or a radiation curable resin such as acrylate, methacrylate, urethane acrylate, epoxy acrylate, or polyester acrylate.

[0035] At S53, the first lens region is patterned to form individual microlens region 3. Patterning can be accomplished using standard photolithography equipment and techniques. At S55, individualized microlens region 3 is shaped into a desired configuration, such as asymmetric circular, by lens processing such as baking. At S57, the first lens region 3 is overcoated with a second lens region 1 and formed with a material and to a thickness which, in combination with other lens regions through which incident light travels, increases fill factor, or intensity of incident light, for photosensitive region of pixel 5. At S59, the second region 1 is patterned. Next, second lens region 1 is shaped (e.g., flowed) by baking at S61.

[0036] FIG. 9 shows an exemplary manufacturing method for forming the microlens structures of FIG. 4. Initially, at S71, a lens region 3 is formed over pixels of the pixel array. At S73, lens region 3 is patterned to produce individually shaped microlens region 3. Region 3 may be patterned into circular, rectangular or other shapes at processing segment S73. At S75, patterned lens region 3 is shaped into a light focusing lens configuration by baking. If desired, another lens region, e.g., 1 (FIG. 4), is formed above the previous lens region 3 at processing segment S79. Processing segments S73, S75 are repeated for each new applied layer. At S77, a determination is made on whether or not to apply another lens region. If another lens region is not to be applied, processing

terminates. If another lens region is to be formed, processing segments S79, S73 and S75 are repeated.

[0037] FIG. 10 shows another exemplary manufacturing method for forming an exemplary microlens array containing multiple lens regions in accordance with the invention. All microlens layers are formed over pixels 5 at steps S91-S93. The layers are patterned at S95 and shaped at S97.

[0038] At S97 the lens regions (e.g., 1, 3) are collectively shaped by means such as flowing the lens regions by baking. Steps S91-S97 are performed such that the resulting multiple lens regions in an exemplary microlens provides for maximized light refraction to respective photosensitive regions (e.g., 5).

[0039] The shape of the patterned individualized microlenses may be circular, lenticular, ovoid, rectangular, hexagonal or any other suitable shape. Shaping of lens regions can be accomplished by heat treatment to form refractive lens regions from the applied and patterned lens forming regions. The shaping process used to form the refractive lens regions depends on the material used to form the lens regions. If the material of the lens forming regions may be heat treated, then heat treatment processes such as baking may be used. If the material is extremely photosensitive, then special light exposure techniques may be used.

[0040] The invention can also be used with light projection systems as well as light detection systems. The same principles apply if the light is coming out of the substrate as when the light is going in. While the structural parameters might change for optimal performance with display systems as compared with imager systems, the invention still provides an improved structure for light distribution.

[0041] Referring to FIG. 11, a lens structure is formed over a display region 131. The display region 131 can be a display pixel or a light emitting unit. Multiple lens structures can be formed over the same display region 131 in a lens ensemble in order to further increase light dispersion and improve viewing angle from display region 131. Light is emitted from display region 131 and enters a layer 129, which can be a top glass or other

display layer (e.g., top glass layer in a LCD system) and then the light enters polarizer 127 and is refracted according to polarizer operation. Light then enters the first lens region 125 with refractive index N_2 where light is refracted into second lens region 123 having a refractive index N_1. The light is then further refracted by the second lens region 123 into air where it is refracted again. The display lens structure of Fig. 11 incorporates regions 123 and 125 are formed in the same manner and of the same material as the corresponding lens regions in other embodiments of the invention.

[0042] It should again be noted that although the invention has been described with specific reference to imaging circuits having a pixel array, the invention has broader applicability and may be used in any imaging apparatus as well as in display devices. Similarly, the process described above is but one method of many that could be used to form lenses in accordance with the invention. The above description and drawings illustrate exemplary embodiments in accordance with the invention. It is not intended that the present invention be limited to the illustrated embodiments. Any modification of the present invention which comes within the spirit and scope of the following claims should be considered part of the present invention.

CLAIMS

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A light detecting system comprising:

a photosensitive region; and

a lens structure for focusing light onto said photosensitive region, said lens structure comprising a first lens region and a second lens region, said first and second lens regions having different optical properties.

2. A light detecting system of claim 1, comprising a plurality of said lens structures and a plurality of said photosensitive regions, wherein each said lens structure is respectively provided over each of said plurality of said photosensitive regions.

3. A light detecting system as in claim 2, wherein said second lens region of each of said lens structures is noncontiguous with said second lens regions of other lens structures.

4. A light detecting system as in claim 2, wherein said first and second lens region is noncontiguous with other first and second lens regions in other said lens structures.

5. A light detecting system as in claim 1, wherein said first lens region is formed over said second lens region.

6. A light detecting system as in claim 1, wherein said first lens region has a circular shape and is formed over said second lens region.

7. A light detecting system as in claim 6 further comprising a plurality of said photosensitive regions arranged in an array, each photosensitive region having an associated lens structure.

8. A light detecting system as in claim 1, wherein said first lens region is formed over said second lens region and is aspherically shaped.

9. A light detecting system as in claim 1, wherein said lens structure further comprises a third lens region.

10. A light detecting system of claim 9 further comprising a plurality of said photosensitive regions and a plurality of said lens structures, wherein each said lens structure is patterned and formed over a respective one of said plurality of photosensitive regions.

11. A light detecting system as in claim 9, wherein said third lens region is formed over said first lens region.

12. A light detecting system as in claim 9, wherein said third lens region has a circular shape and is formed over said first lens region.

13. A light detecting system as in claim 9, wherein said third lens region is formed over said first lens region and is aspherically shaped.

14. A light detecting system as in claim 9, wherein said first, second and third lens regions have different refraction indexes.

15. A light detecting system as in claim 1, wherein said first and second lens regions have different refraction indexes.

16. A light detecting system as in claim 1, wherein said photosensitive region is a photodiode.

17. A light detecting system as in claim 1, wherein said second lens region refracts a portion of the light refracted by said first lens region.

18. A light detecting system as in claim 1, wherein said first lens is formed in contact with said second lens region.

19. A light detecting system as in claim 1, wherein said first lens region has a greater diameter than said second lens region.

20. A light detecting system as in claim 1, wherein said first lens region is formed and patterned over a larger portion of said photosensitive region than said second lens region.

21. A light detecting system as in claim 1, wherein one of said first and second lens regions refracts a portion of incident light that is not incident to the other of said first and second lens region.

22. A light detecting system as in claim 1, wherein said first and second lens regions are formed of respective first and second materials.

23. A light detecting system as in claim 1, wherein said first and second lens regions are formed of the same material but have different geometric shapes.

24. A light detecting system as in claim 1, wherein said first and second lens regions have a respective first and second optical focus for incident light.

25. A light detecting system as in claim 1, wherein at least one of said first and second lens regions is substantially aspherically shaped.

26. A light detecting system as in claim 1, wherein at least one of said first and second lens regions is substantially circularly shaped.

27. A light detecting system as in claim 1, wherein at least one of said first and second lens regions is substantially lenticularly shaped.

28. A light detecting system as in claim 1, wherein at least one of said first and second lens regions is substantially ovoid shaped.

29. A light detecting system as in claim 1, wherein at least one of said first and second lens regions is substantially rectangularly shaped.

30. A light detecting system as in claim 1, wherein at least one of said first and second lens regions is substantially hexagonally shaped.

31. A light detecting system as in claim 1, wherein said first lens region is formed above and in direct contact with a portion of said second lens regions, and wherein said second lens region has a ring shaped light refracting area.

32. A light detecting system as in claim 1, wherein a refractive index of said first lens region is greater than a refractive index of said second lens region.

33. A light detecting system as in claim 1, wherein said photosensitive region is part of a CMOS imager.

34. A light detecting system as in claim 1, wherein said photosensitive region is part of a CCD imager.

35. An imaging device comprising:

an imaging array comprising a plurality of photosensitive regions; and

a plurality of lens structures provided on said imaging array over respective ones of said photosensitive region, more than one lens structure comprising a plurality of microlenses, at least one of said microlenses comprises a plurality of lens regions, at least two of said lens regions having a different refractive property.

36. An imaging device as in claim 35, wherein at least two lens regions have a circular shape.

37. An imaging device as in claim 36, wherein each topmost lens region is not in contact with other topmost lens regions.

38. An imaging device as in claim 35, wherein at least two of said plurality of lens regions are aspherically shaped.

39. An imaging device as in claim 35, wherein said photosensitive regions comprise a photodiode.

40. An imaging device as in claim 35, wherein at least one lens region refracts a portion of the light refracted by at least one other lens region.

41. An imaging device as in claim 35, wherein at least one lens region is formed in contact with another lens region.

42. An imaging device as in claim 35, wherein each of said lens structures is noncontiguous with other of said lens structures.

43. An imaging device as in claim 42, wherein one of said plurality of lens regions has a greater diameter than another associated lens region.

44. An imaging device as in claim 35, wherein an upper lens region of said plurality of lens regions in a lens structure is noncontiguous with another upper lens region in at least one other lens structure.

45. An imaging device as in claim 35, wherein one of said plurality of said lens regions is formed and patterned over a larger portion of said photosensitive region than another lens region in the same lens structure.

46. An imaging device as in claim 35, wherein one of said plurality of lens regions refracts a portion of incident light that is not incident to another of said plurality of lens regions within the same lens structure.

47. An imaging device as in claim 35, wherein said plurality of lens regions are formed of more than one material.

48. An imaging device as in claim 35, wherein said plurality of lens regions are formed of the same material, but have at least one different geometric shape.

49. An imaging device as in claim 35, wherein each of said plurality of lens regions has a first and second optical focus for incident light.

50. An imaging device as in claim 35, wherein one of said plurality of lens regions is formed above and in direct contact with a portion of another lens region.

51. An imaging device as in claim 35, wherein one of said plurality of lens regions has a ring shaped light refracting area.

52. An imaging device as in claim 35, wherein said photosensitive regions are part of a CMOS imager.

53. An imaging device as in claim 35, wherein said photosensitive regions are part of a CCD imager.

54. An imaging device as in claim 35, wherein one of said plurality of lens regions within a same lens structure is formed above and in direct contact with another one of said plurality of lens regions and with a different diameter.

55. An imaging device as in claim 54, wherein at least one of said lens plurality of lens regions within a same lens structure comprises a ring shaped light condensing region.

56. An image processing system comprising:

a processor coupled to a memory device via a bus; and

an imaging device coupled to said bus, said device comprising:

an imaging array containing a plurality of photosensitive regions; and

a plurality of lens structures provided on said imaging array over respective ones of said photosensitive region, at least one of said lens structures comprising a plurality of microlenses, at least some of said microlenses each comprising a plurality of lens regions, at least two of each lens regions having a different refractive property.

57. An image processing system as in claim 56, wherein said plurality of lens regions have a circular shape.

58. An image processing system as in claim 56, wherein more than one of said plurality of lens structures are aspherically shaped.

59. An image processing system as in claim 56, wherein a topmost lens region of at least one of said lens structures is noncontiguous with a topmost lens region of another said lens structure.

60. An image processing system as in claim 56, wherein one of said plurality of lens regions refracts a portion of incident light that is not incident to another of said plurality of lens regions.

61. An image processing system as in claim 56, wherein said plurality of lens regions are formed of more than one material.

62. An image processing system as in claim 56, wherein one of said plurality of lens region comprises a ring shaped light refracting area.

63. A CMOS imager comprising:

a photosensitive region; and

a lens structure located vertically above the photosensitive region, wherein the lens structure comprises a first and second materials having refractive indexes of N1 and N2, respectively, where N1>N2.

64. A CMOS imager as in claim 63, further comprising a plurality of said lens structures and a plurality of said photosensitive regions, wherein each said lens structure is respectively provided over said plurality of said photosensitive regions.

65. A CMOS imager as in claim 63, wherein said first material is formed over said second material.

66. A CMOS imager as in claim 64, wherein said first material has a circular shape and is formed over said second material.

67. A display system comprising

a plurality of display structures; and

a lens structure formed above at least one of said plurality of display structures, said lens structure being adapted to redirect light from said display structure outwardly of said lens structure, said lens structure including a first lens region and a second lens region, said first and second lens regions having different optical properties from one another.

68. A display system as in claim 67 wherein one said lens structure is disposed above each of said plurality of display structures.

69. A display system as in claim 67 wherein a plurality of said lens structures is disposed above at least some of said plurality of display structures.

70. A display system as in claim 67, comprising a first plurality of said lens structures and a second plurality of said display structures, wherein each lens structure of said first plurality is disposed over a display structure of said second plurality respectively.

71. A display system as in claim 70, wherein said second lens region of each of said lens structures is noncontiguous with said second lens regions of other lens structures.

72. A display system as in claim 70, wherein said first and second lens region is noncontiguous with other first and second lens regions in other said lens structures.

73. A display system as in claim 67, wherein said first lens region is formed over said second lens region.

74. A display system as in claim 67, wherein said first lens region has a circular shape and is formed over said second lens region.

75. A display system as in claim 74 wherein said plurality of display structures is arranged in an array, each display structure of said plurality having an associated lens structure.

76. A display system as in claim 67, wherein said first lens region is disposed above said second lens region and is aspherically shaped.

77. A display system as in claim 67, wherein said lens structure further comprises a third lens region.

78. A display system as in claim 77, wherein each said lens structure is patterned and formed over a respective one of said plurality of display structures.

79. A display system as in claim 77, wherein said third lens region is disposed above said first lens region, wherein said second lens region is disposed between said first and said third lens regions.

80. A display system as in claim 77, wherein said third lens region has a circular shape and is disposed above said first lens region.

81. A display system as in claim 77, wherein said third lens region is disposed above said first lens region and is aspherically shaped.

82. A display system as in claim 77, wherein said first, second and third lens regions have differing indices of refraction with respect to one another.

83. A display system as in claim 67, wherein said first and second lens regions have different refraction indexes.

84. A display system as in claim 67, wherein said display structure is a display pixel in an active matrix liquid crystal display.

85. A display system as in claim 67, wherein said second lens region refracts a portion of the light refracted by said first lens region.

86. A display system as in claim 67, wherein said first lens is formed in contact with said second lens region.

87. A display system as in claim 67, wherein said first lens region has a greater diameter than said second lens region.

88. A display system as in claim 67, wherein said first lens region is formed and patterned over a larger portion of said display structure than said second lens region.

89. A display system as in claim 67, wherein one of said first and second lens regions refracts a portion of incident light that is not incident to the other of said first and second lens region.

90. A display system as in claim 67, wherein said first and second lens regions are formed of respective first and second materials.

91. A display system as in claim 67, wherein said first and second lens regions are formed of the same material but have different geometric shapes.

92. A display system as in claim 67, wherein at least one of said first and second lens regions is substantially asphericallly shaped.

93. A display system as in claim 67, wherein at least one of said first and second lens regions is substantially circularly shaped.

94. A display system as in claim 67, wherein at least one of said first and second lens regions is substantially lenticularly shaped.

95. A display system as in claim 67, wherein at least one of said first and second lens regions is substantially ovoid shaped.

96. A display system as in claim 67, wherein at least one of said first and second lens regions is substantially rectangularly shaped.

97. A display system as in claim 67, wherein at least one of said first and second lens regions is substantially hexagonally shaped.

98. A display system as in claim 67, wherein said first lens region is formed above and in direct contact with a portion of said second lens regions, and wherein said second lens region has a ring shaped light refracting area.

99. A display system as in claim 67, wherein a first and second plurality of said lens structures are disposed above said plurality of display structures, said first plurality of said lens structures having said first lens regions with a first refractive index, said second plurality of said lens structures having said first lens regions with a second refractive index.

100. A method of forming a lens structure for an imager, said method comprising:

forming a first plurality of light condensing regions having a first refractive index over a plurality of photosensitive regions; and

forming a second plurality of light condensing regions having a second refractive index over said first plurality of light condensing regions.

101. A method as in claim 100, wherein a refraction index of said first plurality of light condensing regions is greater than a refraction index of said second plurality of light condensing regions.

102. A method as in claim 100 further comprising forming a plurality of third light condensing regions respectively above said second plurality of light condensing regions.

103. A method as in claim 100, wherein each of said first and second plurality of light condensing regions are formed in a substantially circular shape over said photosensitive regions.

104. A method as in claim 100, wherein said light condensing regions are formed in a semicircular shape over said photosensitive regions.

105. A method as in claim 100, wherein said light condensing regions are formed in a rectangular shape over said photosensitive regions.

106. A method as in claim 100, wherein said light condensing regions are formed in a hexagonal shape over said photosensitive regions.

107. A method as in claim 100, wherein said light condensing regions are formed in a lenticular shape over said photosensitive regions.

108. A method as in claim 100, wherein said light condensing regions are formed in an ovoid shape over said photosensitive regions.

109. A method as in claim 100, wherein said forming steps include heat treatment.

110. A method as in claim 100, wherein said forming steps include baking.

111. A method of forming an imager structure comprising:

forming first and second groups of photosensitive regions on an imager substrate;

forming a first lens region with a first refractive property over each of said photosensitive regions of said first group;

forming a second lens region with a second refractive property over each of said first lens regions; and

forming at least one other lens region having a refractive property over each of said second photosensitive regions of said second group.

112. A method as in claim 111, wherein said first lens regions refractive index is greater than said second lens regions refraction index.

113. A method as in claim 111, wherein at least one of said first and second lens regions is formed in a circular shape over said photosensitive regions of said first group.

114. A method as in claim 111, wherein said first and second lens regions are formed in a circular shape over said photosensitive regions of said first group.

115. A method as in claim 111, wherein said first and second lens regions are formed in a semicircular shape over said photosensitive regions of said first group.

116. A method as in claim 111, wherein said first and second lens regions are formed in a rectangular shape over said photosensitive regions of said first group.

117. A method as in claim 111, wherein said first and second lens regions are formed in a hexagonal shape over said photosensitive regions of said first group.

118. A method as in claim 111, wherein said first and second lens regions are formed in a lenticular shape over said photosensitive regions of said first group.

119. A method as in claim 111, wherein said first and second lens regions are formed in an ovoid shape over said photosensitive regions of said first group.

120. A method as in claim 111, wherein said forming includes heat treatment.