CLAIMS

What is claimed is:

1. An image sensor pixel, comprising:

a substrate;

a photoelectric conversion unit supported by the substrate;

an protection film extending over and across the substrate; and,

a cascaded light guide wherein a first portion of said cascaded light guide is between the protection film and the substrate and a second portion extends above the protection film.

2. The pixel of claim 1, wherein each cascaded light guide includes a transparent portion and a color filter that is contiguous with said transparent portion and extends above said insulator.

3. The pixel of claim 1, wherein the second portion includes a color filter.

4. The pixel of claim 3, wherein the color filters from cascaded light guides of adjacent pixels are

separated by a first air gap that has a width no more than 0.45um.

5. The pixel of claim 4, wherein said first air gap has a depth at least 1.0 times a wavelength of light.

6. The pixel of claim 5, where said wavelength of light is 450nm.

7. The pixel of claim 3, wherein the color filter self-aligns within the cascaded light guide.

8. The pixel of claim 3, wherein the top surface of the color filter is an air interface.

9. The pixel of claim 1, wherein all optical interfaces along the vertical axis of the cascaded light guide and above the protection film are flat and parallel.

10. The pixel of claim 1, wherein at least two cascaded light guides from two different pixels have different cross-sectional profiles.

11. The pixel of claim 1, wherein the vertical centerlines of the first and second portions are mutually offset.

12. The pixel of claim 11, wherein the cascaded light guide is configured so that light exits and re-enters said cascaded light guide.

13. A method for fabricating an image sensor pixel, comprising:

forming a support film with an opening and over a substrate that supports a photoelectric conversion unit; and,

forming a color filter in the opening of the support film.

14. The method of claim 11, further comprising forming a protection film between the color filter and the substrate.

15. The method of claim 13, further comprising removing at least a portion of the support film between two adjacent color filters.

16. The method of claim 13, further comprising forming a transparent light guide in the opening of the support film.

17. The method of claim 16, further comprising removing a portion of the support film adjacent the transparent light guide.

18. The method of claim 16, further comprising forming a lower transparent light guide between the transparent light guide and the substrate.

19. The method of claim 18, where the vertical centerline of the lower transparent light guide is offset from the vertical centerline of the opening of the support film.

20. The method of claim 16, wherein the forming of the color filter creates a flat air interface on a top surface of the color filter.

21. A method for fabricating an image sensor pixel array, comprising:

forming an insulator over a substrate that supports a photoelectric conversion unit;

forming a plurality of walls adjacent to the insulator;

forming a plurality of light guides between the walls;

forming a plurality of color filters adjacent to the light guides; and,

removing at least a portion of the walls so that there is an air gap between adjacent color filters.

22. The method of claim 21, wherein the walls are formed by forming a support film and creating openings within the support film.

23. The method of claim 21, further comprising forming a protection film over the insulator.

24. The method of claim 21, wherein a portion of the support film is removed so that a portion of each light guide has an air interface.

25. An image sensor pixel, comprising:

a substrate;

a photoelectric conversion unit supported by said substrate;

a light guide coupled to said photoelectric conversion unit;

anti-reflection means for reducing reflection between said light guide and said photoelectric conversion unit.

26. The pixel of claim 25, wherein said anti-reflection means includes a first anti-reflection film and a second anti-reflection film, said first anti-reflection film having an index of refraction lower than an index of refraction of said second anti-reflection film and an index of refraction of said light guide, and said first anti-reflection film located between the second anti-reflection film and the light guide.

27. The pixel of claim 26, wherein said anti-reflection means includes a third anti-reflection film which has an index of refraction lower than an index of refraction of said second anti-reflection film and wherein said second anti-reflection film is between said

first anti-reflection film and said third anti-reflection film.

28. The pixel of claim 26, wherein a first pixel has a thinner anti-reflection film than a corresponding anti-reflection film of a second pixel having a color filter of a different color.

29. The pixel of claim 26, wherein said second anti-reflection film is a contact etch stop.

30. The pixel of claim 26, wherein said second anti-reflection film includes silicon nitride.

31. The pixel of claim 25, further comprising a light-guide etch-stop layer between said light guide and said anti-reflection means.

32. A method for fabricating an image sensor pixel, comprising:

forming an anti-reflection stack on a photoelectric conversion unit supported by a substrate; and,

forming a light guide adjacent to the photoelectric conversion unit.

33. A method for forming a portion of an image sensor pixel, comprising:

forming a first anti-reflection film over a substrate that supports a photoelectric conversion unit;

forming an insulator over said first anti-reflection film;

etching an opening in the insulator with an etchant that etches the insulator faster than the first anti-reflection film;

forming a second anti-reflection film within the opening; and

forming light guide material within the opening.

34. The method of claim 33, further comprising etching a vertical sidewall portion of the second anti-reflection film.

35. A method for fabricating a color filter for an image sensor pixel, comprising:

forming at least one wall;

forming a color filter within the wall;

removing at least a portion of the wall.