

CLAIMS

What is claimed is:

1. ~~— An apparatus comprising: a first reaction site and a second reaction site over a single pixel, where the pixel comprises a light detector.~~
2. ~~— The apparatus of claim 1, wherein the first reaction site is a first nanowell, and the second reaction site is a second nanowell.~~
3. ~~— The apparatus of claim 2, wherein the first nanowell is half the size of the second nanowell.~~
4. ~~— The apparatus of any of claim 1 or 2, wherein a filter resides between the first reaction site and the single pixel.~~
5. ~~— The apparatus of claim 4, wherein the filter does not reside between the second reaction site and the single pixel.~~
6. ~~— The apparatus of any of claims 4 or 5, wherein the filter attenuates a cluster signal emitted from the first reaction site by about 50%.~~
7. ~~— The apparatus of any of claims 4 through 6, wherein the filter is a thin metallic layer.~~
8. ~~— The apparatus of any of claims 4 through 7, wherein the filter comprises tantalum.~~
9. ~~— A method comprising:~~
~~detecting a signal emitted from a first reaction site and a second reaction site;~~
~~determining the identity of a first analyte of interest in a first reaction site using an amplitude of the detected signal; and~~
~~determining the identity of a second analyte of interest in a second reaction site using the amplitude of the detected signal.~~

~~10.1.~~ An apparatus comprising:

a plurality of pixels;

a first reaction site associated to a pixel of the plurality of pixels;

a second reaction site associated to the pixel;

wherein the pixel includes a pixel sensor that detects a read signal, the read signal being dependent on a first cluster signal emitted from the first ~~reaction~~ site and on a second cluster signal emitted from the second ~~cluster~~ site; and

wherein the first ~~reaction~~ site and the second ~~reaction~~ site are configured so that the second cluster signal in an “on” state has a greater amplitude than the first cluster signal in an “on” state.

~~11.—The apparatus of claim 10, wherein the apparatus determines identities of respective analytes in the first reaction site and the second reaction site using a calling chart that maps signal amplitudes of the read signal under different illumination conditions to identities of respective analytes in the first reaction site and the second reaction site.~~

~~12.2.~~ The apparatus of claim 10, wherein the apparatus determines identities of respective analytes in the first reaction site and the second reaction site using a sixteen (16) cloud calling chart that maps signal amplitudes of the read signal under different illumination conditions to identities of respective analytes in the first reaction site and the second reaction site.

~~13.—The apparatus of any of claims 10 through 12, wherein a ratio of the second cluster signal in an “on” state to the first cluster signal in an “on” state is at least about 1.4.~~

~~14.3.~~ The apparatus of ~~any of claims 10 through 12~~ claim 1, wherein a ratio of the second cluster signal in an “on” state to the first cluster signal in an “on” state is between about 1.9 to about 2.0.

~~15.4.~~ The apparatus of ~~any of claims 10 through 14~~ claim 1, wherein the second reaction site has a larger size than the first reaction site so that the second cluster signal in the

“on” state has a greater amplitude than the first cluster signal in the “on” state.

~~16.5.~~ The apparatus of ~~any of claims 10 through 15~~ claim 1, wherein the second reaction site has a larger width than the first reaction site so that the second cluster in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

~~17.6.~~ The apparatus of ~~any of claims 10 through 16~~ claim 1, wherein the second reaction site is absent an attenuator, and wherein the first reaction site includes an attenuator so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

~~18.7.~~ The apparatus of ~~any of claims 10 through 17~~ claim 1, wherein, by an arrangement of attenuating material, attenuation of emission light rays radiating from the first reaction site is greater than attenuation of emission light rays radiating from the second reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

~~19.~~ The apparatus of claim 18, wherein the attenuating material comprises metal.

~~20.~~ The apparatus of claim 18, wherein the attenuating material comprises tantalum.

~~21.8.~~ The apparatus of ~~any of claims 10 through 20~~ claim 1, wherein the second reaction site is absent an attenuator aligned with and below a bottom surface of the second reaction site, and wherein the first reaction site includes an attenuator aligned with and below a bottom surface of the first reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

~~22.~~ The apparatus of any of claims 10 through 21, wherein the second reaction site is absent an attenuator intersected by a vertically extending center axis of the first reaction site, and wherein the first reaction site includes an attenuator intersected by a vertically extending center axis of the first reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

~~23.~~ The apparatus of any of claims 10 through 22, wherein the second reaction site is absent an attenuator for attenuating emission light rays radiating vertically downward from a

~~bottom surface of the second reaction site, and wherein the first reaction site includes an attenuator for attenuating emission light rays radiating vertically downward from a bottom surface of the first reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~24.9. The apparatus of any of claims 10 through 23 claim 1, wherein the apparatus includes an attenuating material layer that extends through an area aligned with and below a bottom surface of the first reaction site to define an attenuator of the first reaction site, the attenuating material layer being absent of a section that extends through an area aligned with and below the second reaction site.~~

~~25.10. The apparatus of any of claims 10 through 24 claim 1, wherein the first reaction site is defined by a first nanowell, and wherein the second reaction site is defined by a second nanowell.~~

~~26.11. The apparatus of claim 2510, wherein the second nanowell has a larger size than the first nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~27. The apparatus of any of claims 25 through 26, wherein the second nanowell has a larger width than the first nanowell so that the second cluster in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~28. The apparatus of any of claims 25 through 27, wherein claim 10 characterized by one or more of the following selected from the group consisting of: (a) the second nanowell is absent an attenuator, and wherein the first nanowell includes an attenuator so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~29. The apparatus of any of claims 25 through 28, wherein the attenuator of the first nanowell has an upwardly extending section.~~

~~30. The apparatus of any of claims 25 through 29, wherein the attenuator of the first nanowell has an upwardly extending section running in parallel with a circumferential~~

~~sidewall of the first nanowell.~~

~~31.—The apparatus of any of claims 25 through 30, wherein, by an arrangement of attenuating material, attenuation of emission light rays radiating from the first nanowell is greater than attenuation of emission light rays radiating from the second nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~32.—The apparatus of claim 31, wherein the attenuating material comprises metal.~~

~~33.—The apparatus of claim 31, wherein the attenuating material comprises tantalum.~~

~~34.—The apparatus any of claims 25 through 33, wherein; (b) the second nanowell is absent an attenuator aligned with and below a bottom surface of the second nanowell, and wherein the first nanowell includes an attenuator aligned with and below a bottom surface of the first nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~35.12. The apparatus any of claims 25 through 34, wherein; and (c) the second nanowell is absent an attenuator intersected by a vertically extending center axis of the first nanowell, and wherein the first nanowell includes an attenuator intersected by a vertically extending center axis of the first nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~36.—The apparatus of any of claims 25 through 35, wherein the second nanowell is absent an attenuator for attenuating emission light rays radiating vertically downward from a bottom surface of the second nanowell, and wherein the first nanowell includes an attenuator for attenuating emission light rays radiating vertically downward from a bottom surface of the first nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~37.13.~~ The apparatus of ~~any of claims 25 through 36~~ claim 10, wherein the apparatus includes an attenuating material layer that extends through an area aligned with and below a bottom surface of the first nanowell to define an attenuator of the first reaction site, the attenuating material layer being absent of a section that extends through an area aligned with and below the second nanowell.

~~38.14.~~ The apparatus ~~any of claims 10 through 37~~ of claim 1, wherein second to Nth pixels of the plurality of pixels have associated first and second reaction sites that are respectively configured according to the first reaction site and the second reaction site associated to the pixel, wherein the first and second reaction sites associated to adjacent pixels of the plurality of pixels have first and second different respective orientations relative to their respective pixels, the first and second different respective orientations increasing a spacing distance between reaction sites from adjacent pixel locations relative to a spacing distance between reaction sites from adjacent pixel locations in the absence of the different respective orientations.

~~39.~~—The apparatus ~~any of claims 10 through 39~~, wherein second to Nth pixels of the plurality of pixels have associated first and second reaction sites that are respectively configured according to the first reaction site and the second reaction site associated to the pixel, wherein the first and second reaction sites associated to adjacent pixels of the plurality of pixels have first and second different respective orientations relative to their respective pixels, the first respective different orientation characterized by back to front spacing between reaction sites, the second respective different orientation characterized by side to side spacing between reaction sites.

~~40.~~—The apparatus of claims ~~38 or 39~~, wherein the second to Nth pixels is second to one millionth pixels.

~~41.~~—The apparatus of any of claims 10 through ~~40~~, wherein the apparatus includes an attenuating material layer that includes a first section that extends through an area aligned with and below a bottom surface of the first nanowell to define an attenuator of the nanowell, and second sections extending adjacently laterally from the first section, the first section having first thickness, the second sections having a second thickness, the first thickness less than the second thickness.

42.15. A method for fabricating the apparatus of claim 25~~1~~, wherein the method includes depositing in an area aligned with and over a pixel a dielectric stack having integrally formed therein an attenuating material layer; etching in the dielectric stack a first trench for defining the first nanowell, wherein the first trench is etched to an elevation terminating at or above a top elevation of the attenuating material layer so that the attenuating material layer defines an attenuator for the first nanowell; and etching in the dielectric stack a second trench for defining the second nanowell, wherein the second trench is etched to an elevation terminating at or below a bottom elevation of the attenuating material layer.

~~43. A method for fabricating the apparatus of claim 25, wherein the method includes depositing in an area aligned with and over a pixel a dielectric stack; etching in the dielectric stack a first trench for defining the first nanowell; etching in the dielectric stack a second trench for defining the second nanowell, and depositing in the first trench an attenuating material layer that is not deposited in the second trench.~~

44.16. A method comprising:

detecting, using a pixel sensor of a plurality of pixels sensors, a read signal, the read signal being dependent on a first cluster signal emitted from a first reaction site associated to the pixel sensor and on a second cluster signal emitted from a second reaction site associated to the pixel sensor;

determining an identity of a first analyte of interest in the first reaction site using an amplitude of the read signal detected using the pixel sensor; and

determining an identity of a second analyte of interest in the second reaction site using the amplitude of the read signal detected using the pixel sensor.

~~45. The method of claim 44, wherein the determining the identity of a first analyte of interest in the first reaction site using an amplitude of the read signal detected using the pixel sensor and the determining the identity of a second analyte of interest in the second reaction site using the amplitude of the detected read signal includes using a calling chart that maps signal amplitudes of the read signal under different illumination conditions to identities of respective analytes in the first reaction site and the second reaction site.~~

~~46.17.~~ The method of claim ~~44~~16, wherein the determining the identity of a first analyte of interest in the first reaction site using an amplitude of the read signal detected using the pixel sensor and the determining the identity of a second analyte of interest in the second reaction site using the amplitude of the detected read signal includes using a calling chart having sixteen (16) signal clouds that map signal amplitudes of the read signal under different illumination conditions to identities of respective analytes in the first reaction site and the second reaction site.

~~47.~~ The method of any of claims ~~44 through 46~~, wherein the first reaction site and the second reaction site are configured so that the second cluster signal in an “on” state has a greater amplitude than the first cluster signal in an “on” state.

~~48.~~ The method of any of claims ~~44 through 47~~, wherein the second reaction site has a larger size than the first reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

~~49.~~ The method of any of claims ~~44 through 48~~, wherein a ratio of the second cluster signal in an “on” state to the first cluster signal in an “on” state is at least about 1.4.

~~50.~~ The method of any of claims ~~44 through 49~~, wherein a ratio of the second cluster signal in an “on” state to the first cluster signal in an “on” state is between about 1.9 to about 2.0.

~~51.~~ The method of any of claims ~~44 through 50~~, wherein the second reaction site has a larger width than the first reaction site so that the second cluster in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

~~52.~~ The method of any of claims ~~44 through 51~~, wherein the second reaction site is absent an attenuator, and wherein the first reaction site includes an attenuator so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

~~53.18.~~ The method of ~~any of claims 44 through 52~~ claim 16, wherein, by an arrangement of attenuating material, attenuation of emission light rays radiating from the first reaction site is greater than attenuation of emission light rays radiating from the second reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first

cluster signal in the “on” state.

~~54.—The method of claim 53, wherein the attenuating material comprises metal.~~

~~55.—The method of claim 53, wherein the attenuating material comprises tantalum.~~

~~56.—The method of any of claims 44 through 55, wherein the second reaction site is absent an attenuator aligned with and below a bottom surface of the second reaction site, and wherein the first reaction site includes an attenuator aligned with and below a bottom surface of the first reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~57.—The method of any of claims 44 through 56, wherein the second reaction site is absent an attenuator intersected by a vertically extending center axis of the first reaction site, and wherein the first reaction site includes an attenuator intersected by a vertically extending center axis of the first reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~58.—The method of any of claims 44 through 57, wherein the second reaction site is absent an attenuator for attenuating emission light rays radiating vertically downward from a bottom surface of the second reaction site, and wherein the first reaction site includes an attenuator for attenuating emission light rays radiating vertically downward from a bottom surface of the first reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~59.—The method of any of claims 44 through 58, wherein an attenuating material layer that extends through an area aligned with and below a bottom surface of the first reaction site defines an attenuator of the first reaction site, the attenuating material layer being absent of a section that extends through an area aligned with and below the second reaction site.~~

~~60.—The method of any of claims 44 through 59, wherein the first reaction site is defined by a nanowell, and wherein the second reaction site is defined by a nanowell.~~

~~61.—The method of claim 60, wherein the second nanowell has a larger size than the first nanowell so that the second cluster signal in the “on” state has a greater amplitude than the~~

first cluster signal in the “on” state.

62. — The method of any of claims 60 through 61, wherein the second nanowell has a larger width than the first nanowell so that the second cluster in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

63. — The method of any of claims 60 through 62, wherein the second nanowell is absent an attenuator, and wherein the first nanowell includes an attenuator so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

64. — The method of any of claims 60 through 63, wherein the attenuator of the first nanowell has an upwardly extending section.

65. — The method of any of claims 60 through 64, wherein the attenuator of the first nanowell has an upwardly extending section running in parallel with a circumferential sidewall of the first nanowell.

66. — The method of any of claims 60 through 65, wherein, by an arrangement of attenuating material, attenuation of emission light rays radiating from the first nanowell is greater than attenuation of emission light rays radiating from the second nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

67. — The method of claim 66, wherein the attenuating material comprises metal.

68. — The method of claim 66, wherein the attenuating material comprises tantalum.

69. — The method of any of claims 60 through 68, wherein the second nanowell is absent an attenuator aligned with and below a bottom surface of the second nanowell, and wherein the first nanowell includes an attenuator aligned with and below a bottom surface of the first nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

70. — The method of any of claims 60 through 69, wherein the second nanowell is

~~absent an attenuator intersected by a vertically extending center axis of the first nanowell, and wherein the first nanowell includes an attenuator intersected by a vertically extending center axis of the first nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

71.—~~The method of any of claims 60 through 70, wherein the second nanowell is absent an attenuator for attenuating emission light rays radiating vertically downward from a bottom surface of the second nanowell, and wherein the first nanowell includes attenuator for attenuating emission light rays radiating vertically downward from a bottom surface of the first nanowell so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

72.—~~The method of any of claims 60 through 71, wherein the apparatus includes an attenuating material layer that extends through an area aligned with and below a bottom surface of the first nanowell to define an attenuator of the first reaction site, the attenuating material layer being absent of a section that extends through an area aligned with and below the second nanowell.~~

73.—~~The method of any of claims 44 through 72, wherein the plurality of pixel sensors are associated, respectively, to a plurality of pixels, and wherein the pixel sensor defines a pixel of the plurality of pixels, and wherein the first reaction site and the second reaction site are associated to the pixel, wherein second to Nth pixels of the plurality of pixels have associated first and second reaction sites that are respectively configured according to the first reaction site and the second reaction site associated to the pixel, wherein the first and second reaction sites associated to adjacent pixels of the plurality of pixels have first and second different respective orientations relative to their respective pixels, the first and second different respective orientations increasing a spacing distance between reaction sites from adjacent pixel locations relative to a spacing distance between reaction sites from adjacent pixel locations in the absence of the different respective orientations.~~

74.—~~The method of any of claims 44 through 73, wherein the plurality of pixel sensors are associated, respectively, to a plurality of pixels, and wherein the pixel sensor defines a pixel of the plurality of pixels, and wherein the first reaction site and the second reaction site are associated to the pixel, wherein second to Nth pixels of the plurality of pixels have associated first and second reaction~~

sites that are respectively configured according to the first reaction site and the second reaction site associated to the pixel, wherein the first and second reaction sites associated to adjacent pixels of the plurality of pixels have first and second different respective orientations relative to their respective pixels, the first respective different orientation characterized by back to front spacing between reaction sites, the second respective different orientation characterized by side to side spacing between reaction sites.

75. — The method any of claims 60 through 74, wherein the apparatus includes an attenuating material layer that includes a first section that extends through an area aligned with and below a bottom surface of the first nanowell to define an attenuator of the nanowell, and second sections extending adjacently laterally from the first section, the first section having first thickness, the second sections having a second thickness, the first thickness less than the second thickness.

76. — An apparatus comprising:

a plurality of pixels;

a first reaction site associated to a pixel of the plurality of pixels;

a second reaction site associated to the pixel;

wherein the pixel includes a pixel sensor that detects a read signal, the read signal being dependent on a first cluster signal emitted from the first reaction site and on a second cluster signal emitted from the second cluster site; and

wherein the second reaction site has a larger size than the first reaction site so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.

77. — An apparatus comprising:

a plurality of pixels;

a first reaction site associated to a pixel of the plurality of pixels;

a second reaction site associated to the pixel;

~~wherein the pixel includes a pixel sensor that detects a read signal, the read signal being dependent on a first cluster signal emitted from the first reaction site and on a second cluster signal emitted from the second cluster site; and~~

~~wherein the second reaction site has a larger width than the first reaction site so that the second cluster in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~78. — An apparatus comprising:~~

~~a plurality of pixels;~~

~~a first reaction site associated to a pixel of the plurality of pixels;~~

~~a second reaction site associated to the pixel;~~

~~wherein the pixel includes a pixel sensor that detects a read signal, the read signal being dependent on a first cluster signal emitted from the first reaction site and on a second cluster signal emitted from the second cluster site; and~~

~~wherein the second reaction site is absent an attenuator, and wherein the first reaction site includes an attenuator so that the second cluster signal in the “on” state has a greater amplitude than the first cluster signal in the “on” state.~~

~~79.19. An apparatus comprising:~~

~~a plurality of pixels;~~

~~a first reaction site associated to a pixel of the plurality of pixels;~~

~~a second reaction site associated to the pixel;~~

~~wherein the pixel includes a pixel sensor that detects a read signal, the read signal being dependent on a first cluster signal emitted from the first ~~reaction~~ site and on a second cluster signal emitted from the second ~~cluster~~ site; and~~

~~wherein, by an arrangement of attenuating material, attenuation of emission light rays~~

radiating from the first ~~reaction~~-site is greater than attenuation of emission light rays radiating from the second ~~reaction~~-site so that the second cluster signal in the an “on” state has a greater amplitude than the first cluster signal in the an “on” state.

20. The apparatus of claim 1, wherein the first cluster signal and the second cluster signal are produced in response to simultaneous excitation of the first reaction site and the second reaction site with excitation light.