

1 WHAT IS CLAIMED IS:

1. A structure comprising a bistable molecular sensor for optical or electronic detection of an external stimulus on a surface, the bistable molecular sensor having a polynucleotide platform, comprising:

5 a first polynucleotide shape and a second polynucleotide shape with a flexible hinge or flexible linker therebetween, one of the first polynucleotide shape or the second polynucleotide shape being immobilized on the surface rendering an immobilized polynucleotide shape and a tethered polynucleotide shape; and

10 one or more functional molecules bound to at least one of the first polynucleotide shape and the second polynucleotide shape, the bistable molecular sensor having one of two states, the two states being a closed state and an open state, wherein:

15 in the open state, the tethered polynucleotide shape moves freely with respect to the second polynucleotide shape as constrained by the flexible hinge or flexible linker; and

in the closed state, the tethered polynucleotide shape is proximally positioned to the immobilized polynucleotide shape, and

20 the polynucleotide platform being selected from a scaffolded deoxyribonucleic acid (DNA) origami, scaffolded ribonucleic acid (RNA) origami, scaffolded hybrid DNA:RNA origami, single stranded DNA tiles, multi-stranded DNA tiles, single stranded RNA origami, multi-stranded RNA tiles, or hierarchically composed DNA or RNA origami with multiple scaffolds.

2. The structure of claim 1, wherein:

the external stimulus comprises a target molecule or the external stimulus interacts with the target molecule;

30 the one or more functional molecules comprise a first capture molecule and a second capture molecule, the first capture molecule capable of binding a different region of the target molecule than the second capture molecule, the first capture molecule and the second capture molecule being selected from a first antibody and a second antibody, a first nanobody and a second nanobody, or a first aptamer and a second aptamer;

35 one or more copies of the first molecule are attached to the first polynucleotide shape;

one or more copies of the second molecule are attached the second polynucleotide shape, and

1 ~~in the presence of the target molecule, the first molecule and the~~
~~second molecule bind the target molecule, thereby rendering the bistable~~
~~molecular sensor in the closed state.~~

5 ~~3. The structure of claim 1, wherein the first polynucleotide shape~~
~~comprises a first shape inside surface and a first shape outside surface and the~~
~~second polynucleotide shape comprises a second shape inside surface and a~~
~~second shape outside surface, the first shape inside surface capable of facing the~~
10 ~~second shape inside surface, and the one or more functional molecules are bound to~~
~~the first shape inside surface and/or the second shape inside surface.~~

~~4. The structure of claim 1, wherein:~~
 ~~the external stimulus comprises a target single stranded nucleic acid or~~
~~the external stimulus interacts with the target single stranded nucleic acid,~~
15 ~~the one or more functional molecules comprise a first single stranded~~
~~nucleic acid and a second single stranded nucleic acid, the first single~~
~~stranded nucleic acid and the second single stranded being different from~~
~~each other and complementary to the target single stranded nucleic acid,~~
 ~~one or more copies of the first single stranded nucleic acid are~~
20 ~~attached to the first polynucleotide shape,~~
 ~~one or more copies of the second single stranded nucleic acid is~~
~~attached to the second polynucleotide shape, and~~
 ~~in the presence of the target single stranded nucleic acid, the first~~
~~single stranded nucleic acid and the second single stranded nucleic acid bind~~
25 ~~to the target single stranded nucleic acid, thereby rendering the bistable~~
~~molecular sensor in the closed state.~~

~~5. The structure of claim 1, wherein:~~
 ~~the external stimulus comprises a target double stranded nucleic acid~~
30 ~~or the external stimulus interacts with the target double stranded nucleic acid,~~
 ~~the one or more functional molecules comprise a first CRISPR inactive~~
~~enzyme guide RNA complex and a second CRISPR inactive enzyme guide~~
~~RNA complex, the first CRISPR inactive enzyme guide RNA complex and the~~
~~second CRISPR inactive enzyme guide RNA complex being different from~~
35 ~~each other and complementary to the target double stranded nucleic acid,~~
 ~~one or more copies of the first CRISPR inactive enzyme guide RNA~~
~~complex are attached to the first polynucleotide shape,~~

1 ~~one or more copies of the second CRISPR inactive enzyme guide RNA-~~
~~complex are attached to the second polynucleotide shape, and~~
 ~~in the presence of the target double-stranded nucleic acid, the first~~
 ~~CRISPR inactive enzyme guide RNA complex and the second CRISPR-~~
5 ~~inactive enzyme guide RNA are bound to the target double-stranded nucleic~~
~~acid, thereby rendering the bistable molecular sensor in the closed state.~~

6. ~~The structure of claim 1, wherein:~~

~~the external stimulus comprises a target double-stranded nucleic acid~~
10 ~~or the external stimulus interacts with the target double-stranded nucleic acid,~~
 ~~the one or more functional molecules comprise an allosteric CRISPR-~~
~~inactive enzyme guide RNA complex and a complementary allosteric nucleic~~
~~acid sequence, the allosteric CRISPR inactive enzyme guide RNA complex~~
~~having a a conditionally hidden allosteric nucleic acid sequence,~~
15 ~~the allosteric CRISPR inactive enzyme guide RNA complex capable of~~
~~binding to the target double-stranded nucleic acid thereby exposing the~~
~~conditionally hidden allosteric nucleic acid sequence,~~

~~one or more copies of the allosteric CRISPR inactive enzyme guide~~
~~RNA complex attached to the first polynucleotide shape,~~

20 ~~one or more copies of the complementary allosteric nucleic acid-~~
~~sequence attached to the second polynucleotide shape, and~~

~~in the presence of the target double-stranded nucleic acid, the~~
~~allosteric CRISPR inactive enzyme guide RNA complex is bound to the target~~
~~double-stranded nucleic acid and the complementary allosteric nucleic acid-~~
25 ~~sequence is bound to the exposed conditionally hidden allosteric nucleic acid-~~
~~sequence, thereby rendering the bistable molecular sensor in the closed-~~
~~state.~~

7. ~~The structure of claim 1, wherein:~~

30 ~~the external stimulus comprises a target molecule or the external~~
~~stimulus interacts with the target molecule,~~

~~the one or more functional molecules comprise a capture molecule-~~
~~capable of binding the target molecule and a competitor molecule capable of binding~~
~~the capture molecule in the absence of the target molecule, the capture molecule-~~
35 ~~selected from an antibody, a nanobody, or an aptamer,~~

~~one or more copies of the competitor molecule are attached to the first~~
~~polynucleotide shape,~~

1 ~~one or more copies of the capture molecule are attached to the second~~
~~polynucleotide shape,~~

~~in the absence of the target molecule, the competitor is bound to the~~
~~capture molecule, thereby rendering the bistable sensor in the closed state, and~~

5 ~~in the presence of the target molecule, the competitor molecule is~~
~~displaced by the target molecule, thereby rendering the bistable molecular sensor in~~
~~the open state.~~

~~8. The structure of claim 1, wherein:~~

10 ~~the external stimulus comprises a chemical or enzymatic agent or the~~
~~external stimulus interacts with the chemical or enzymatic agent,~~

~~the one or more functional molecules comprise a first protein capable~~
~~of being chemically or enzymatically modified by the chemical or enzymatic agent~~
~~resulting in a modified first protein and a second protein capable of binding the~~

15 ~~modified first protein,~~
~~one or more copies of the first protein are attached to the first~~
~~polynucleotide shape,~~

~~one or more copies of the second protein are attached to the second~~
~~polynucleotide shape, and~~

20 ~~in the presence of the chemical or enzymatic agent, the first protein is~~
~~modified and the second protein binds the modified first protein, thereby rendering~~
~~the bistable molecular sensor in the closed state.~~

~~9. The structure of claim 8, wherein the first protein is capable of being~~
25 ~~modified by at least one of phosphorylation, acetylation, ubiquitination, prenylation,~~
~~adenylylation, or glycosylation.~~

~~10. The structure of claim 9, wherein the second protein is a naturally~~
~~occurring protein capable of binding the modified first protein.~~

30 ~~11. The structure of claim 9, wherein the second protein is an antibody~~
~~capable of binding to phosphorylation, acetylation, ubiquitination, prenylation,~~
~~adenylylation, or glycosylation.~~

35 ~~12. The structure of claim 1, wherein:~~
~~the external stimulus comprises a chemical or enzymatic agent or the external~~
~~stimulus interacts with the chemical or enzymatic agent,~~

1 ~~the one or more functional molecules comprise a capture nucleic acid~~
~~and a capture molecule, the capture nucleic acid capable of being chemically or~~
~~enzymatically modified by the chemical or enzymatic agent resulting in a modified~~
~~capture nucleic acid, the capture molecule capable of binding the modified capture~~
5 ~~nucleic acid,~~

~~one or more copies of the capture nucleic acid are attached to the first~~
~~polynucleotide shape,~~

~~one or more copies of the capture molecule are attached to the second~~
~~polynucleotide shape, and~~

10 ~~in the presence of the chemical or enzymatic agent, the capture nucleic~~
~~acid is modified resulting in the modified capture nucleic acid and the capture~~
~~molecule is bound to the modified capture nucleic, thereby rendering the bistable~~
~~molecular sensor in the closed state.~~

15 ~~13. The structure of claim 12, wherein the capture nucleic acid is capable~~
~~of being modified by at least one of cytosine methylation, cytosine~~
~~hydroxymethylation, cytosine formylation, cytosine carboxylation, adenosine~~
~~methylation, alkylation, or thymine dimerization.~~

20 ~~14. The structure of claim 13, wherein the capture molecule is a naturally~~
~~occurring molecule capable of binding the capture nucleic acid.~~

~~15. The structure of claim 12, wherein the capture molecule is an antibody~~
~~capable of binding the modified capture nucleic acid.~~

25 ~~16. The structure of claim 13, wherein the capture molecule is an antibody~~
~~capable of binding to cytosine methylation, cytosine hydroxymethylation, cytosine~~
~~formylation, cytosine carboxylation, adenosine methylation, alkylation, or thymine~~
~~dimerization.~~

30 ~~17. The structure of claim 1, wherein:~~
~~the external stimulus comprises a receptor ligand or the external~~
~~stimulus interacts with the receptor ligand,~~
~~the one or more functional molecules comprise a first protein and a~~
35 ~~second protein, the first protein being a transmembrane receptor protein~~
~~capable of binding at least one type of ligand and the second protein capable~~
~~of binding the first protein when the transmembrane receptor protein is bound~~
~~by the at least one type of ligand,~~

~~one or more copies of the first protein are attached to the first polynucleotide shape,~~

~~one or more copies of the second protein are attached to the second polynucleotide shape, and~~

~~in the presence of the at least one type of ligand, the second protein is bound to the first protein, thereby rendering the bistable molecular sensor in the closed state.~~

~~18. The structure of claim 17, wherein the one or more copies of the first protein attached to the first polynucleotide shape are attached by:~~

~~a direct linker molecule between the first protein and the first polynucleotide shape,~~

~~insertion of the first protein into a protein-lipid nanodisc capable of being attached to the first polynucleotide shape,~~

~~insertion of the first protein into a DNA-lipid nanodisc capable of being attached to the first polynucleotide shape, or~~

~~insertion of the first protein into a DNA-lipid nanodisc formed as part of the first polynucleotide shape.~~

~~19. The structure of claim 17, wherein:~~

~~the bistable molecular sensor further comprises a G-protein receptor-kinase (GRK), the GRK being in the solution or attached to the polynucleotide platform,~~

~~the first protein comprises a G-protein coupled receptor (GPCR) and the second protein comprises beta-arrestin or an antibody capable of binding phosphorylated GPCR, and~~

~~in the presence of the at least one type of receptor ligand to the GPCR, the GPCR is phosphorylated by the GRK and therefore beta-arrestin or the antibody binds the phosphorylated GPCR, thereby rendering the bistable molecular sensor in the closed state.~~

~~20. The structure of claim 17, wherein:~~

~~the first protein comprises a G-protein coupled receptor (GPCR); the second protein is an antibody, nanobody, or aptamer, and~~

~~in the presence of a GPCR ligand, the second protein binds the first protein, thereby rendering the bistable molecular sensor in the closed state.~~

~~21. A method of assaying for a receptor ligand that binds a transmembrane receptor, the method comprising:~~

~~providing a candidate receptor ligand to the structure of claim 17, wherein the surface is a chip.~~

~~22. The method of claim 21, wherein the transmembrane receptor is a G-protein coupled receptor (GPCR).~~

~~23. The structure of claim 1, wherein:~~

~~the external stimulus comprises a riboswitch ligand or the external stimulus interacts with the riboswitch ligand,~~

~~the one or more functional molecules comprise a first molecule and a second molecule, the first molecule comprising a DNA riboswitch or an RNA riboswitch capable of being bound by the riboswitch ligand, the binding of the riboswitch ligand inducing exposure of a nucleotide sequence or aptamer, the second molecule comprising a DNA sequence, an RNA sequence, or a protein capable of binding the exposed nucleotide sequence or aptamer on the DNA riboswitch or RNA riboswitch,~~

~~one or more copies of the first molecule are attached to the first polynucleotide shape,~~

~~one or more copies of the second molecule are attached to the second polynucleotide shape, and~~

~~in the presence of the riboswitch ligand, the second molecule binds to the first molecule, thereby rendering the bistable molecular sensor in the closed state.~~

~~24. The structure of claim 1, wherein:~~

~~the external stimulus comprises a chemical or enzymatic agent or the external stimulus interacts with the chemical or enzymatic agent,~~

~~the one or more functional molecules comprise a capture molecule capable of being modified by the chemical or enzymatic agent to form a modified capture molecule, the capture molecule capable of binding the first polynucleotide shape and the second polynucleotide shape, the modified capture molecule not capable of binding the first polynucleotide shape and the second polynucleotide shape, the capture molecule selected from a protein or a nucleic acid, and~~

~~one or more copies of the capture molecule are attached to the first polynucleotide shape and the second polynucleotide shape, and~~

1 ~~in the presence of the chemical or enzymatic agent, the capture molecule is modified, thereby rendering the bistable molecular sensor in the open state.~~

5 ~~25. The structure of claim 1, wherein:~~

~~the external stimulus comprises a chemical or enzymatic agent or the external stimulus interacts with the chemical or enzymatic agent,~~

~~the one or more functional molecules comprise a first molecule and a second molecule, at least one of the first molecule and the second molecule~~

10 ~~capable of being modified resulting in the first molecule binding to the second molecule, the first molecule and the second molecule being selected from nucleic acids or proteins,~~

~~one or more copies of the first molecule are attached to the first polynucleotide shape,~~

15 ~~one or more copies of the second molecule are attached to the second polynucleotide shape, and~~

~~in the presence of the chemical or enzymatic agent, the first molecule and the second molecule are bound together, thereby rendering the bistable molecular sensor in the closed state.~~

20 ~~26. The structure of claim 1, wherein:~~

~~the external stimulus is selected from temperature, light, pH, or ionic conditions,~~

25 ~~the one or more functional molecules comprise a capture molecule and a probe molecule, the capture molecule capable of being modified by one of temperature, light, pH, or ionic conditions resulting in a modified capture molecule, the probe molecule capable of binding the modified capture molecule, the capture molecule and the probe molecule each independently being a nucleic acid or a protein,~~

30 ~~one or more copies of the capture molecule are attached to the first polynucleotide shape,~~

~~one or more copies of the probe molecule are attached to the second polynucleotide shape, and~~

35 ~~in the presence of the external stimulus, the capture molecule is modified and the probe molecule binds the modified capture molecule, thereby rendering the bistable molecular sensor in the closed state.~~

~~27. The structure of claim 1 for optical detection, wherein:~~

~~the surface is gold or graphene,
the tethered shape comprises a light emitter selected from an organic
fluorophore, a quantum dot, a fluorescent bead, or a luminescent lanthanide
compound, and
the open state produces more light than the closed state.~~

~~28. A method for optical detection of an external stimulus, comprising:
assaying the external stimulus using the structure of claim 1, wherein:
the surface is gold or graphene,
the tethered shape comprises a light emitter selected from an organic
fluorophore, a quantum dot, a fluorescent bead, or a luminescent lanthanide
compound, and
the structure is in a microfabricated device capable of enhancing light
produced by a light emitter.~~

~~29. The method of claim 28, wherein the microfabricated device is selected
from a photonic crystal cavity, a ring resonator, or an optical bowtie.~~

~~30. The structure of claim 1 for optical detection using total internal
reflection (TIRF) microscopy, wherein:
the surface is transparent, and
the tethered shape is fluorescently labeled, luminescently labeled, or
labeled with a light scattering particle.~~

~~31. The structure of claim 1 for optical detection using surface plasmon
resonance (SPR), wherein:
the surface is gold, and
the tethered shape is unlabeled or labeled with an optically active
particle.~~

~~32. The structure of claim 1 for optical detection using surface reflectance
interferometry (RI), wherein:
the surface is transparent or nontransparent, and
the tethered shape is unlabeled or labeled with an optically active
particle.~~

1 ~~33. The structure of claim 1, further comprising a substrate comprising one or more of the bistable molecular sensors, wherein the substrate is the surface for each of the one or more bistable molecular sensors.~~

5 ~~34. The structure of claim 33, wherein the one or more bistable molecular sensors are positioned on the substrate by directed self-assembly or lithographically.~~

10 ~~35. The structure of claim 34, wherein when the one or more bistable molecular sensors are positioned on the substrate lithographically, the substrate comprises lithographically patterned binding sites that are adhesive for the immobilized shape and not adhesive for the tethered shape.~~

15 ~~36. The structure of claim 1 for electrical detection, wherein:~~

~~the surface is a working electrode comprising: gold, platinum, graphene, indium oxide, or indium tin oxide,~~

~~the tethered shape is labeled with one or more redox active molecules, and~~

~~a change in the states results in an electron transfer between the one or more redox active molecules and the working electrode.~~

20 ~~37. The structure of claim 36, wherein the one or more redox active molecules is selected from methylene blue, ferrocene, 1,3-diaza-2-oxophenothiazine, or a tricyclic cytosine analog.~~

25 ~~38. The structure of claim 36 for electrical detection by square wave voltammetry, the structure further comprising a silver/silver chloride reference electrode, and a platinum wire counter electrode positioned above the surface, wherein:~~

30 ~~the working electrode surface is a gold surface, the gold being e beam deposited or template-stripped gold,~~

~~the one or more redox active molecules is methylene blue, and~~

~~a position on the surface at which the immobilized polynucleotide shape is attached is coated with an alkanethiol self-assembled monolayer.~~

35 ~~39. The structure of claim 38, wherein the immobilized polynucleotide shape comprises thiol modifications for attachment to the gold surface.~~

1 ~~40. The structure of claim 38, wherein the immobilized polynucleotide shape comprises single stranded polyadenosine strands for attachment to the gold surface.~~

5 ~~41. The structure of claim 38, wherein the immobilized polynucleotide shape comprises phosphorothioate modifications for attachment to the gold surface.~~

~~42. The structure of claim 38, wherein the tethered polynucleotide shape comprises polyethylene glycol modifications to inhibit attachment to the gold surface.~~

10 ~~43. The structure of claim 38, wherein the tethered polynucleotide shape comprises dextran modifications to inhibit attachment to the gold surface.~~

~~44. The structure of claim 38, wherein the gold surface comprises thiolated polyethylene glycol molecules.~~

~~45. The structure of claim 36, wherein:
the tethered shape forms a rigid two dimensional (2D) plate,
the one or more redox active molecules are distributed on the tethered
20 shape, and
the immobilized shape is selectively positioned between the surface
and one of the one or more redox active molecules.~~

~~46. The structure of claim 36, wherein:
25 the tethered shape forms a rigid 2D plate,
the immobilized shape forms a plate with a window or a hole providing
direct access to the surface, and
in the closed state, the tethered shape with the one or more redox
active molecules thereon is positioned over the window or the hole.~~

30 ~~47. The structure of claim 36, wherein:
the tethered shape forms a rigid three dimensional (3D) shape with a
rigid arm, with the one or more redox active molecules being attached at the end of
the rigid arm.~~

35 ~~48. The structure of claim 36, wherein:~~

1 ~~the tethered shape forms a rigid hemisphere or rigid dome with the one~~
~~or more redox active molecules being attached along a perimeter edge of the rigid~~
~~hemisphere or rigid dome, and~~

5 ~~in the closed state, the redox active molecules on the perimeter edge~~
~~are positioned proximally to the immobilized shape.~~

~~49. The structure of claim 1 for field effect sensing, further comprising a~~
~~solution above the surface and a working solution electrode, wherein:~~

~~the surface functions as a transistor,~~

10 ~~the surface is a gate material selected from carbon nanotubes, silicon~~
~~nanowires, graphene, molybdenum disulfide, or indium oxide,~~

~~the immobilized shape is attached directly to the surface, and~~

~~the solution above the surface functions as a gate electrode for the~~
~~transistor.~~

15 ~~50. The structure of claim 49, wherein the surface is graphene and the~~
~~immobile shape is attached to the graphene by single stranded DNA extensions.~~

20 ~~51. The structure of claim 49, further comprising magnesium ions, wherein:~~

~~the surface is graphene coated with pyrene carboxylic acid, and~~

~~the immobile shape is attached to the coated graphene surface by~~
~~electrostatic interaction between the magnesium ions and the pyrene~~
~~carboxylic acid.~~

25 ~~52. The structure of claim 49, wherein:~~

~~the surface is graphene coated with polylysine, and~~

~~the immobile shape is attached to the surface by electrostatic~~
~~interaction.~~

30 ~~53. The structure of claim 49, wherein:~~

~~the surface is graphene, and~~

~~the tethered shape comprises polyethylene glycol.~~

35 ~~54. The structure of claim 49, wherein:~~

~~the surface is graphene, and~~

~~the tethered shape comprises polylysine-graft-polyethylene glycol~~
~~polymers.~~

1 ~~55. The structure of claim 49, further comprising magnesium ions, wherein:
the surface is indium oxide treated with oxygen plasma or coated with
carboxysilanes, and~~

5 ~~the magnesium ions bridge the immobilized shape to the surface.~~

~~56. The structure of claim 49, wherein:
the surface is indium oxide, and
the tethered shape comprises trimethyl silyl groups and/or~~
10 ~~polythethylene glycol (PEG) silane.~~

~~57. The structure of claim 49, wherein:
the tethered shape forms a rigid 2D plate capable of maintaining a
position in the closed state.~~

15 ~~58. The structure of claim 57, wherein:
the immobile shape is a plate with a window or a hole, and
in the closed state, the window or hole in the immobile shape renders a
space between the surface and the tethered shape without any of the~~
20 ~~immobile shape therebetween.~~

~~59. The structure of claim 49, wherein:
the tethered shape forms a rigid three dimensional (3D) shape with a
rigid arm, and~~
25 ~~in the closed state, the rigid arm is positioned above the surface
without any of the immobile shape therebetween.~~

~~60. The structure of claim 49, wherein:
the tethered shape forms a rigid hemisphere or rigid dome having a
perimeter edge, and~~
30 ~~in the closed state, the perimeter edge is positioned proximal to the
surface and peripheral to the immobilized shape without any of the immobilized
shape between the perimeter edge and the surface.~~

35 ~~61. The structure of claim 1 for field effect sensing, further comprising a
solution above the surface and a working solution electrode, wherein:~~

1 ~~the surface functions as a transistor, the surface comprises a~~
semiconductor gate underneath a capping layer selected from silicon dioxide,
aluminum oxide, or silicon nitride,
 ~~the immobilized shape is attached to the capping layer, and~~
5 ~~the solution above the surface functions as a gate electrode for the~~
~~transistor.~~

62. ~~The structure of claim 61, further comprising magnesium ions, wherein:~~
 ~~the capping layer is treated by oxygen plasma or coated with~~
10 ~~carboxylsilanes, and~~
 ~~the magnesium ions bridge the immobilized shape to the capping layer.~~

63. ~~The structure of claim 61, wherein the tethered shape comprises~~
~~trimethyl silyl groups and/or polythethylene glycol (PEG) silane.~~

15 ~~64. The structure of claim 61, wherein the tethered shape forms a rigid 2D~~
~~plate capable of maintaining a position in the closed state.~~

20 ~~64. The structure of claim 61, wherein:~~
 ~~the immobile shape is a plate with a window or a hole, and~~
 ~~in the closed state, the window or hole in the immobile shape renders a~~
 ~~space between the capping layer and the tethered shape without any of the~~
 ~~immobile shape therebetween.~~

25 ~~65. The structure of claim 61, wherein:~~
 ~~the tethered shape forms a rigid three dimensional (3D) shape with a~~
 ~~rigid arm, and~~
 ~~in the closed state, the rigid arm is positioned above the capping layer~~
 ~~without any of the immobile shape therebetween.~~

30 ~~66. The structure of claim 61, wherein:~~
 ~~the tethered shape forms a rigid hemisphere or rigid dome having a~~
 ~~perimeter edge, and~~
 ~~in the closed state, the perimeter edge is positioned proximal to the~~
35 ~~capping layer and peripheral to the immobilized shape without any of the~~
 ~~immobilized shape between the perimeter edge and the capping layer.~~

1 ~~67.~~ A detection system for optical detection, the detections system comprising:

5 ~~a plurality of the structure of claim 1, the plurality comprising up to 1,000 distinct bistable molecular sensors each of which is capable of detecting a different external stimulus or analyte interacting with an external stimulus,~~

10 ~~each of the plurality of the structures positioned on one of up to 1,000 corresponding distinct regions on the substrate surface using ink-jet printing or microarray printing, wherein multiple copies of each of the distinct bistable molecular sensors are positioned at each of the corresponding distinct regions on the substrate.~~

15 ~~68.~~ The detection system of claim 67, wherein the up to 1,000 corresponding distinct regions are lithographically patterned with each corresponding distinct region having a multiple of single molecule binding sites for nucleic acid-origami placement.

20 ~~69.~~ The detection system of claim 68, wherein each of the multiple of single molecule binding sites comprises no more than one bistable sensor.

25 ~~70.~~ The detection system of claim 67 capable of detecting the external stimulus by one selected from:

~~total internal reflectance spectroscopy on a transparent substrate, quenching of fluorescence on a gold surface, quenching of fluorescence on a graphene substrate, or enhancement of fluorescence using an optical bowtie.~~

30 ~~71.~~ A detection system for electrical detection, the detections system comprising:

35 ~~a plurality of the structure of claim 1, the plurality comprising up to 4,000 distinct bistable molecular sensors each of which is capable of detecting a different external stimulus or analyte interacting with an external stimulus,~~

~~each of the plurality of the structures positioned on one of up to 4,000 corresponding distinct regions on the substrate surface using ink jet printing or microarray printing, wherein multiple copies of each of the distinct bistable molecular sensors are positioned at each of the corresponding distinct regions on the substrate.~~

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~~72. The detection system of claim 71, wherein:~~

~~The surface is selected from gold, graphene, platinum, graphene,
indium oxide, molybdenum disulfide, carbon nanotubes, silicon nanowires, or silicon.~~

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~~73. The structure of claim 36, wherein:~~

~~DNA origami placement is used to position the bistable molecular
sensor at a position between electrodes spaced less than 100 nanometers
apart, and~~

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~~single-molecule measurements are obtained by redox cycling.~~

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Claims

1. An invention not claimed in any divisional application.