~~What is claimed is:~~Claims

1. A flow cell, comprising:

a substrate including:

nano-depressions defined in a surface of the substrate; and

interstitial regions separating the nano-depressions; and

a barrier depression surrounding each of the respective sub-sets of the nano-depressions; and

a hydrophobic material layer i) having a surface that is at least substantially co-planar with the interstitial regions and ii) positioned to define a hydrophobic barrier around respective sub-sets of the nano-depressions; and

the hydrophobic material layer is positioned in the barrier depression.

~~2. The flow cell as defined in claim 1, wherein:~~

~~the substrate further includes a barrier interstitial surrounding each of the respective sub-sets of the nano-depressions; and~~

~~the hydrophobic material layer is defined on the barrier interstitial and has a thickness less than about 2 μm.~~

~~3. The flow cell as defined in claim 1, wherein:~~

~~the substrate further includes a barrier depression surrounding each of the respective sub-sets of the nano-depressions; and~~

~~the hydrophobic material layer is positioned in the barrier depression.~~

~~4~~2. The flow cell as defined in ~~any of claims 1, 2, or 3~~ claim 1, wherein the hydrophobic material layer has a thickness ranging from ~~about~~ 10 nm to ~~about~~ 1 μm.

~~5~~3. The flow cell as defined in ~~any of claims 1, 2, 3, or 4~~ claims 1 or 2, wherein the hydrophobic material is selected from the group consisting of a fluorinated polymer, a perfluorinated polymer, a silicon polymer, a silane, and a mixture thereof.

~~6~~4. The flow cell as defined in any of claims 1, 2~~,~~ or 3~~, 4, or 5~~, further comprising:

a polymer layer in the nano-depressions; and

a primer attached to the polymer layer.

~~7~~5. A method of forming the flow cell according to any one of claims 1-4, wherein the method comprises~~, comprising~~:

applying a hydrophobic material on a patterned substrate, including:

nano-depressions defined in a surface of the patterned substrate; and

interstitial regions separating the nano-depressions;

thereby forming a hydrophobic material layer i) in the nano-depressions and ii) on the interstitial regions, wherein the hydrophobic material layer on the interstitial regions has a thickness less than about 2 μm;

applying a mask material on a first portion of the hydrophobic material layer to define a pattern of a hydrophobic barrier around respective sub-sets of the nano-depressions and the interstitial regions, whereby a second portion of the hydrophobic material layer is exposed at the respective sub-sets;

removing the second portion of the hydrophobic material layer, thereby exposing the respective sub-sets of the nano-depressions and the interstitial regions;

attaching a gel material to the nano-depressions of the respective sub-sets; and

removing the mask material from the first portion of the hydrophobic material layer to reveal the hydrophobic barrier.

~~8~~6. The method as defined in claim ~~7~~5, wherein:

the patterned substrate further includes a barrier interstitial around the respective sub-sets of the nano-depressions and the interstitial regions; and

the hydrophobic barrier is formed on the barrier interstitial.

~~9~~7. The method as defined in claim ~~7~~5, wherein the hydrophobic barrier is formed in some of the nano-depressions and on some of the interstitial regions that

are positioned between the respective sub-sets of the nano-depressions and the interstitial regions.

~~10~~8. The method as defined in any of claims ~~7~~5, ~~8~~6, or ~~9~~7, wherein:

the attaching of the gel material involves:

silanizing the nano-depressions and interstitial regions of the respective sub-sets; and

depositing the gel material on the nano-depressions and interstitial regions of the respective sub-sets and on the mask material; and

the method further comprises removing the gel material from the mask material and from the interstitial regions of the respective sub-sets.

~~11~~9. The method as defined in any of claims ~~7~~5, ~~8~~6, ~~9~~7, or ~~10~~8, wherein the hydrophobic material is selected from the group consisting of a fluorinated polymer, a perfluorinated polymer, a silicon polymer, and a mixture thereof.

~~12~~10. The method as defined in any of claims ~~7~~5, ~~8~~6, ~~9~~7, ~~10~~8, or ~~11~~9, wherein prior to applying the hydrophobic material, the method further comprises forming the patterned substrate by patterning a non-patterned support to form the nano-depressions.

~~13~~11. The method as defined in claim ~~12~~10, wherein the patterning involves etching, nano-imprint lithography, or combinations thereof.

~~14~~12. The method as defined in any of claims ~~7~~5, ~~8~~6, ~~9~~7, ~~10~~8, ~~11~~9, ~~12~~10, or ~~13~~11, wherein:

the removing of the mask material from the first portion of the hydrophobic material layer to reveal the hydrophobic barrier occurs prior to attaching the gel material; and

attaching the gel material involves:

silanizing the nano-depressions and interstitial regions of the respective sub-sets; and

depositing the gel material on the nano-depressions and interstitial regions of the respective sub-sets and on the hydrophobic barrier; and

the method further comprises removing the gel material from the hydrophobic barrier and from the interstitial regions of the respective sub-sets.

~~15. A method, comprising:~~

~~applying a hydrophobic material on a patterned substrate, including:~~

~~sub-sets of nano-depressions defined in a surface of the patterned substrate and separated by interstitial regions; and~~

~~a barrier depression defined in the surface of the patterned substrate around each of the sub-sets;~~

~~thereby forming a hydrophobic material layer i) in the barrier depression and ii) in the nano-depressions;~~

~~applying a mask material on the hydrophobic material layer in the barrier depression;~~

~~removing the hydrophobic material layer from the nano-depressions;~~

~~attaching a gel material to the nano-depressions of the sub-sets; and~~

~~removing the mask material from the hydrophobic material layer in the barrier depression to reveal a hydrophobic barrier.~~

~~16. The method as defined in claim 15, wherein:~~

~~the attaching of the gel material involves:~~

~~silanizing the nano-depressions and the interstitial regions of the sub-sets; and~~

~~depositing the gel material on the nano-depressions and the interstitial regions of the sub-sets and on the mask material; and~~

~~the method further comprises removing the gel material from the mask material and from the interstitial regions.~~

17. The method as defined in any of claims 15 or 16, wherein the hydrophobic material is selected from the group consisting of a fluorinated polymer and a polysiloxane.

18. The method as defined in any of claims 15, 16, or 17, wherein prior to applying the hydrophobic material, the method further comprises forming the patterned substrate by patterning a non-patterned support to form the nano-depressions and the barrier depression.

19. The method as defined in claim 18, wherein the patterning involves etching, nano-imprint lithography, or combinations thereof.

20. A method, comprising:

applying a hydrophobic material on a patterned substrate, including:

sub-sets of nano-depressions defined in a surface of the patterned substrate and separated by interstitial regions, the nano-depressions having a first depth; and

a barrier depression defined in the surface of the patterned substrate around each of the sub-sets, the barrier depression having a second depth that is greater than the first depth;

thereby introducing the hydrophobic material i) into the barrier depression and ii) into the nano-depressions;

removing the hydrophobic material at least from the nano-depressions, whereby at least some of the hydrophobic material remains in the barrier depression; and

curing the at least some of the hydrophobic material that remains in the barrier depression.

21. The method as defined in claim 20, further comprising:

attaching a gel material to the nano-depressions by:

silanizing the nano-depressions and the interstitial regions of the sub-sets; and

depositing the gel material on the nano-depressions and the interstitial regions of the sub-sets; and

removing the gel material from the interstitial regions.

22. The method as defined in any of claims 20 or 21, wherein the hydrophobic material is selected from the group consisting of a fluorinated polymer, a perfluorinated polymer, a silicon polymer, and a mixture thereof.

23. The method as defined in any of claims 20, 21, or 22, wherein prior to applying the hydrophobic material, the method further comprises forming the patterned substrate by patterning a non-patterned support to form the nano-depressions and the barrier depression.

24. The method as defined in claim 23, wherein the patterning involves etching, nano-imprint lithography, or combinations thereof.

25. A method, comprising:

applying a mask material on a patterned substrate, including:

nano-depressions defined in a surface of the patterned substrate;

interstitial regions separating the nano-depressions; and

a gel material in the nano-depressions;

thereby defining a pattern for a hydrophobic barrier around respective sub-sets of the nano-depressions and the interstitial regions;

applying a hydrophobic material layer according to the pattern, thereby forming the hydrophobic barrier, wherein the hydrophobic material layer has a thickness less than about 2 μm; and

removing the mask material.

26. The method as defined in claim 25, wherein the hydrophobic material layer is also applied on the mask material, and wherein removing the mask material removes the hydrophobic material layer thereon.

27. The method as defined in any of claims 25 or 26, wherein the applying of the mask material includes:

applying a bi-layer resist on the patterned substrate, the bi-layer resist including a lift-off layer and an imaging layer;

defining the pattern in the imaging layer, thereby exposing portions of the lift-off layer; and

removing the exposed portions of the lift-off layer.

28. The method as defined in any of claims 25, 26, or 27, wherein the hydrophobic material is selected from the group consisting of a fluorinated polymer, a perfluorinated polymer, a silicon polymer, and a mixture thereof.

29. The method as defined in any of claims 25, 26, 27, or 28, wherein prior to applying the mask material, the method further comprises forming the patterned substrate by:

patterning a non-patterned support to form the nano-depressions; and

attaching the gel material to the nano-depressions by:

silanizing the nano-depressions and the interstitial regions;

depositing the gel material on the nano-depressions and the interstitial regions; and

removing the gel material from the interstitial regions.

30. A method, comprising:

laminating a hydrophobic material film having a thickness less than about 2 μm to a patterned substrate, including:

nano-depressions defined in a surface of the patterned substrate;

interstitial regions separating the nano-depressions; and

a gel material in the nano-depressions; and

exposing the dry hydrophobic material film to photolithography to form a hydrophobic barrier around respective sub-sets of the nano-depressions and the interstitial regions.

31. The method as defined in claim 30, wherein the hydrophobic material film is selected from the group consisting of a fluorinated polymer, a perfluorinated polymer, a silicon polymer, a silane, and a mixture thereof.

32. The method as defined in any of claims 30 or 31, wherein prior to laminating the hydrophobic material film, the method further comprises forming the patterned substrate by:

patterning a non-patterned support to form the nano-depressions; and

attaching the gel material to the nano-depressions by:

silanizing the nano-depressions and the interstitial regions;

depositing the gel material on the nano-depressions and the interstitial regions; and

removing the gel material from the interstitial regions.

33. A method, comprising:

printing a hydrophobic material to a patterned substrate, including:

nano-depressions defined in a surface of the patterned substrate;

interstitial regions separating the nano-depressions; and

a gel material in the nano-depressions;

wherein the hydrophobic material is printed to form a hydrophobic barrier around respective sub-sets of the nano-depressions and the interstitial regions and to have a thickness less than about 2 μm.

34. The method as defined in claim 33, wherein the hydrophobic material is selected from the group consisting of a fluorinated polymer, a perfluorinated polymer, a silicon polymer, a silane, and a mixture thereof.

35. The method as defined in any of claims 33 or 34, wherein prior to printing the hydrophobic material, the method further comprises forming the patterned substrate by:

patterning a non-patterned support to form the nano-depressions; and

attaching the gel material to the nano-depressions by:

silanizing the nano-depressions and the interstitial regions;

depositing the gel material on the nano-depressions and the interstitial regions; and

removing the gel material from the interstitial regions.

36. The method as defined in any of claims 33, 34, or 35, wherein the printing involves aerosol printing.

37. A method, comprising:

laser cutting and weeding a multi-layer precursor including:

two sacrificial layers; and

a hydrophobic material layer having a thickness less than about 2 µm positioned between the two sacrificial layers;

thereby removing a first of the two sacrificial layers and defining a pattern of a hydrophobic barrier in the hydrophobic material layer that is positioned on a second of the two sacrificial layers;

laminating the patterned hydrophobic material to a patterned substrate, including:

nano-depressions defined in a surface of the patterned substrate;

interstitial regions separating the nano-depressions; and

a gel material in the nano-depressions.

38. The method as defined in claim 37, further comprising removing the second of the two sacrificial layers.

39. The method as defined in any of claims 37 or 38, wherein the hydrophobic material is selected from the group consisting of a fluorinated polymer, a perfluorinated polymer, a silicon polymer, a silane, and a mixture thereof.

40. The method as defined in any of claims 37, 38, or 39, wherein prior to printing the hydrophobic material, the method further comprises forming the patterned substrate by:

patterning a non-patterned support to form the nano-depressions; and

attaching the gel material to the nano-depressions by:

silanizing the nano-depressions and the interstitial regions;

depositing the gel material on the nano-depressions and the interstitial regions; and

removing the gel material from the interstitial regions.

41. A method, comprising:

coating a stamp with a hydrophobic material, the stamp defining a pattern of a hydrophobic barrier; and

transferring the hydrophobic material in the pattern of the hydrophobic barrier to a patterned substrate, including:

nano-depressions defined in a surface of the patterned substrate;

interstitial regions separating the nano-depressions; and

a gel material in the nano-depressions;

thereby forming the hydrophobic barrier around respective sub-sets of the nano-depressions and the interstitial regions, the hydrophobic barrier having a thickness less than about 2 μm.

42. The method as defined in claim 41, wherein the hydrophobic material is selected from the group consisting of a fluorinated polymer, a perfluorinated polymer, a silicon polymer, a silane, and a mixture thereof.

43. The method as defined in any of claims 41 or 42, wherein prior to transferring the hydrophobic material, the method further comprises forming the patterned substrate by:

patterning a non-patterned support to form the nano-depressions; and

attaching the gel material to the nano-depressions by:

silanizing the nano-depressions and the interstitial regions;

depositing the gel material on the nano-depressions and the interstitial regions; and

removing the gel material from the interstitial regions.

44. The method as defined in any of claims 41, 42, or 43, further comprising forming the stamp from a master template.

45. A flow cell, comprising:

a substrate;

nano-pads of a gel material positioned on the substrate; and

a hydrophobic material layer i) having a surface that is at least substantially co-planar with a surface of the nano-pads and ii) positioned to define a hydrophobic barrier around respective sub-sets of the nano-pads.

46. The flow cell as defined in claim 45, wherein:

each of the nano-pads has a thickness less than about 2 μm; and

the hydrophobic material layer has a thickness less than about 2 μm.

47. The flow cell as defined in any of claims 45 or 46, further comprising a plurality of primers attached to each of the nano-pads.

48. A method, comprising:

forming discrete subsets of nano-pads on a substrate, each of the nano-pads having a thickness less than about 2 μm; and

selectively applying a hydrophobic material on the substrate around each of the discrete subsets, thereby forming a hydrophobic barrier i) around each of the discrete subsets, ii) having a surface that is at least substantially co-planar with a surface of the nano-pads, and iii) having a thickness less than about 2 µm.

49. The method as defined in claim 48, wherein the selectively applying of the hydrophobic material involves transferring the hydrophobic material in a pattern of the hydrophobic barrier to the substrate.

50. The method as defined in claim 48, wherein the selectively applying of the hydrophobic material involves printing the hydrophobic material in a pattern of the hydrophobic barrier to the substrate.

51. The method as defined in claim 48, wherein the selectively applying of the hydrophobic material involves:

applying a mask material on the discrete subsets of nano-pads, thereby defining a pattern for the hydrophobic barrier;

applying the hydrophobic material according to the pattern, thereby forming the hydrophobic barrier; and

removing the mask material

52. The method as defined in any of claims 48, 49, 50, or 51, wherein the forming of the discrete subsets of nano-pads involves:

applying a gel material on a surface of the substrate;

disposing a mask material on the gel material;

forming spaces in the mask material and the gel material; and

removing the mask material.