

What is claimed is:

1. A flow cell, comprising:
a base support;
a multi-layer stack positioned over the base support, the multi-layer stack
5 including:
a resin layer positioned over the base support; and
a hydrophobic layer positioned over the resin layer; and
a depression defined in the multi-layer stack through the hydrophobic
material and through a portion of the resin.
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2. The flow cell as defined in claim 1, further comprising a polymeric
hydrogel positioned in the depression.
3. The flow cell as defined in claim 2, further comprising primers attached to
15 the polymeric hydrogel.
4. The flow cell as defined in claim 1, wherein:
a first region of the depression includes:
a first polymeric hydrogel; and
20 a first primer set attached to the first polymeric hydrogel; and
a second region of the depression includes:
a second polymeric hydrogel; and
a second primer set attached to the second polymeric hydrogel,
wherein the first primer set is different than the second primer set.
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5. A method, comprising:
defining a depression in a multi-layer stack including a hydrophobic layer
over a resin layer by:
30 i) etching through a depth of the hydrophobic layer; or
ii) imprinting and etching the hydrophobic layer through a depth of the
hydrophobic layer; or
iii) imprinting through a depth of the hydrophobic layer and through a
portion of a depth of the resin layer; and

applying a functionalized layer in at least one region of the depression.

6. The method as defined in claim 5, wherein defining the depression involves ii) imprinting and etching the hydrophobic layer through the depth of the hydrophobic layer, and wherein the imprinting and etching of the hydrophobic layer involves:

imprinting through a portion of the depth of the hydrophobic layer; and etching a remaining portion of the depth of the hydrophobic layer, whereby the resin layer acts as an etch stop.

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7. The method as defined in claim 5, wherein defining the depression involves i) etching through the depth of the hydrophobic layer, and wherein prior to etching through the depth of the hydrophobic layer, the method further comprises:

applying a lift-off resist and an additional resin layer over the hydrophobic layer;

imprinting the additional resin layer to form a concave region therein; and extending the concave region to a surface of the hydrophobic layer by selectively etching portions of the additional resin layer and the lift-off resist, whereby other portions of the additional resin layer and the lift-off resist that are adjacent to the concave region remain intact.

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8. The method as defined in claim 7, wherein after the functionalized layer is applied, the method further comprises lifting off the other portions of the lift-off resist.

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9. The method as defined in claim 5, wherein:

prior to applying the functionalized layer, the method further comprises applying a sacrificial layer over a first portion of the depression, whereby a second portion of the depression is exposed;

the functionalized layer is applied over the sacrificial layer and the second portion of the depression; and

subsequent to applying the functionalized layer, the method further comprises:

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removing the sacrificial layer to expose the first portion of the depression; and

applying a second functionalized layer over the first portion of the depression.

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10. A method, comprising:

applying a sacrificial layer over a first portion of a depression defined in a substrate, whereby a second portion of the depression remains exposed;

10 applying a first functionalized layer over the sacrificial layer and over the second portion of the depression;

removing the sacrificial layer and the first functionalized layer applied thereon, thereby exposing the first portion of the depression;

applying a second functionalized layer over the second portion of the depression; and

15 attaching respective primers sets to the first and second functionalized layers.

11. The method as defined in claim 10, wherein:

the substrate includes a resin layer over a base support; and

20 the depression is defined through a portion of the resin layer.

12. The method as defined in claim 10, wherein prior to applying the sacrificial layer over the first portion, the method further comprises forming the depression in the resin layer using nanoimprint lithography.

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13. The method as defined in claim 10, wherein prior to applying the sacrificial layer over the first portion, the method further comprises forming the depression in the resin layer by:

applying a photoresist to the resin layer;

30 developing the photoresist to define a depression pattern where soluble photoresist is removed and an interstitial pattern where insoluble photoresist remains over the resin layer;

etching the resin layer at the depression pattern; and

removing the insoluble photoresist.

14. A method, comprising

- 5 imprinting a resin layer to form a concave region including a deep portion,
and a shallow portion defined by a step portion, wherein the resin layer is
positioned over a multi-layer stack including at least two layers having differential
etching rates, which is positioned over a base support;
selectively etching the resin layer and the at least two layers to form a
depression adjacent to the deep portion;
10 applying a first functionalized layer to the depression;
selectively etching the resin layer, the at least two layers, or combinations
thereof to expose a region underlying the step portion; and
applying a second functionalized layer to the exposed region.

- 15 15. The method as defined in claim 14, wherein the at least two layers
include a sacrificial layer that is positioned over an additional resin layer.

16. The method as defined in claim 15, wherein the selectively etching to
form the depression involves:

- 20 etching a first portion of the resin layer underlying the deep portion;
etching a portion of the sacrificial layer underlying the deep portion, thereby
exposing a portion of the additional resin layer; and
etching i) a second portion of the resin layer to expose an other portion of
the sacrificial layer and ii) the exposed portion of the additional resin layer.

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17. The method as defined in claim 16, wherein the selectively etching to
expose a region underlying the step portion involves etching a second portion of
the sacrificial layer to expose a second portion of the additional resin layer.

- 30 18. The method as defined in claim 17, wherein the second functionalized
layer is applied to the second portion of the additional resin layer and the method
further comprising etching a remaining portion of the sacrificial layer.

19. The method as defined in claim 14, wherein the at least two layers include a poly(methyl methacrylate) lift-off layer that is positioned over a sacrificial layer.

- 5 20. The method as defined in claim 19, wherein the selectively etching to form the depression involves:
- etching a first portion of the resin layer underlying the deep portion;
 - etching a portion of the poly(methyl methacrylate) lift-off layer underlying the deep portion; and
 - 10 etching a portion of the sacrificial layer underlying the deep portion, thereby forming the depression in the sacrificial layer.

21. The method as defined in claim 20, wherein the region underlying the step portion is a portion of the base support, and wherein selectively etching to
- 15 expose the region underlying the step portion involves:
- etching the step portion of the resin layer;
 - etching a second portion of the poly(methyl methacrylate) lift-off layer underlying the step portion; and
 - etching a second portion of the sacrificial layer underlying the step portion.

- 20 22. The method as defined in claim 21, wherein the second functionalized layer is applied to the portion of the base support, and wherein the method further comprises:
- lifting off a remaining portion of the poly(methyl methacrylate) lift-off layer;
 - 25 and
 - etching a remaining portion of the sacrificial layer.

23. The method as defined in claim 14, wherein the at least two layers include a poly(methyl methacrylate) lift-off layer that is positioned over a sacrificial
- 30 layer that is positioned over an additional resin layer.

24. The method as defined in claim 23, wherein the selectively etching to form the depression involves:

etching a first portion of the resin layer underlying the deep portion;
etching a portion of the poly(methyl methacrylate) lift-off layer underlying the
deep portion; and
etching a portion of the sacrificial layer underlying the deep portion, thereby
5 forming the depression in the sacrificial layer.

25. The method as defined in claim 24, wherein prior to etching the portion
of the sacrificial layer underlying the deep portion, the method further comprises
etching the resin layer to remove the step portion and expose a second portion of
10 the poly(methyl methacrylate) lift-off layer.

26. The method as defined in claim 25, wherein the region underlying the
step portion is a portion of the additional resin layer, and wherein selectively
etching to expose the region underlying the step portion involves:
15 etching the second portion of the poly(methyl methacrylate) lift-off layer; and
etching a second portion of the sacrificial layer underlying the second portion
of the poly(methyl methacrylate) lift-off layer.

27. The method as defined in claim 26, wherein the second functionalized
20 layer is applied to the portion of the additional resin layer, and wherein the method
further comprises:
lifting off a remaining portion of the poly(methyl methacrylate) lift-off layer;
and
etching a remaining portion of the sacrificial layer.

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28. A method, comprising:
applying a first functionalized layer over a substrate including a concave
region having a deep portion, and a shallow portion defined by a step portion;
patterning the first functionalized layer, thereby forming a first functionalized
30 region covered by a photoresist in the deep portion adjacent to the step portion;
and
applying a second functionalized layer over the substrate and the
photoresist.

29. The method as defined in claim 28, wherein after the patterning of the first functionalized layer, the method further comprises dry etching the substrate to remove the step portion and form a depression adjacent to the first functionalized region;
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30. The method as defined in claim 29, wherein after the second functionalized layer is applied, the method further comprises:
lifting off the photoresist and the second functionalized layer thereon; and
10 removing a portion of the second functionalized layer, thereby forming a second functionalized region adjacent to the first functionalized region.

31. The method as defined in claim 29, wherein patterning the first functionalized layer involves:
15 applying the photoresist over the first functionalized layer; and
dry etching the photoresist and the first functionalized layer until the step portion is exposed.

32. The method as defined in claim 31, wherein the dry etching of the substrate or the dry etching of the photoresist involves reactive ion etching.
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33. The method as defined in claim 28, wherein:
the substrate is a multi-layer stack including a resin layer over a base support;
25 prior to applying the first functionalized layer, the method further comprises:
imprinting the resin layer to form the concave region; and
selectively etching the resin layer to expose the base support at the deep portion;
drying etching of the substrate involves dry etching the resin layer; and
30 the base support functions as an etch step during the dry etching.

34. The method as defined in claim 33, wherein after the second functionalized layer is applied, the method further comprises:

lifting off the photoresist and the second functionalized layer thereon; and
removing a portion of the second functionalized layer, thereby forming a
second functionalized region adjacent to the first functionalized region.

5 35. The method as defined in claim 33, wherein patterning the first
functionalized layer involves:
 applying the photoresist over the first functionalized layer; and
 dry etching the photoresist and the first functionalized layer until the step
portion is exposed.

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 36. The method as defined in claim 28, further comprising:
 lifting off the photoresist and the second functionalized layer thereon; and
 removing a portion of the second functionalized layer, thereby forming a
second functionalized region on the step portion.

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 37. A method, comprising:
 imprinting an additional resin layer to form a concave region therein, wherein
the additional resin layer is positioned over a poly(methyl methacrylate) lift-off layer
that is positioned over a first resin layer;

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 exposing a portion of the first resin layer underlying the concave region by
etching a first portion of the additional resin layer and a first portion of the
poly(methyl methacrylate) lift-off layer;

 etching i) the additional resin layer to expose a second portion of the
poly(methyl methacrylate) lift-off layer and ii) the exposed portion of the first resin
25 layer to form a depression in the first resin layer;

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 applying a functionalized layer over the depression and the second portion
of the poly(methyl methacrylate) lift-off layer; and
 removing the second portion of the poly(methyl methacrylate) lift-off layer
and the functionalized layer thereon.

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 38. A method, comprising:

imprinting a resin layer to form a convex region, wherein the resin layer is positioned over a multi-layer stack including a lift-off resist over a functionalized layer over a substrate;

5 selectively etching portions of the resin layer, the lift-off resist, and the functionalized layer to expose portions of the substrate, whereby other portions of the lift-off resist and the functionalized layer that are adjacent to the convex region remain intact; and

lifting off the other portion of the lift-off resist.

10 39. The method as defined in claim 38, wherein the substrate includes a base support and an additional resin layer over the base support.

40. A method, comprising:

15 imprinting a resin to form a convex region, wherein the resin is positioned over a multi-layer stack including a sacrificial layer over a substrate;

selectively etching portions of the resin and the sacrificial layer around the convex region to expose a portion of the substrate;

patterning a photoresist to cover the exposed portion of the substrate;

exposing a second portion of the substrate underlying the sacrificial layer;

20 applying a functionalized layer over the exposed second portion of the substrate; and

lifting off the photoresist.

25 41. The method as defined in claim 40, wherein the substrate includes an additional resin layer over a base support.

42. The method as defined in claim 41, wherein the selectively etching further involves selectively etching through a portion of a depth of the additional resin layer to form a protrusion in the additional resin layer having a shape of the
30 convex region.

43. The method as defined in claim 41, wherein the selectively etching exposes a surface of the additional resin layer.