CLAIMS

1. A method, comprising:

    a. providing a substrate having a surface, a surface neutralization layer, a block copolymer, and a top coat;

    b. treating said substrate surface with said surface neutralization layer under conditions such that a first layer is created;

    c. coating said surface neutralization layer with block copolymer under conditions such that a second layer on said surface is created comprising a block copolymer film, and

    d. coating said block copolymer with a top coat so as to create a third layer on said surface, wherein said third layer enables the orientation of the block copolymer domains perpendicular to the plane of the film by thermal annealing alone.

2. The method of claim 1, wherein thermal annealing in the absence of the top coat layer does not produce perpendicular features.

3. The method of claim 1, wherein a top coat of step d) is in a solvent or solvent mixture that will not damage, dissolve, or substantially swell the block copolymer.

4. The method of claim 1, wherein the top coat of step d) is in a solvent that reacts with the top coat.

5. The method of claim 1, wherein the top coat of step d) is in a solvent mixture, and the solvent mixture contains a component that reacts with the top coat.

6. The method of claim 1, wherein the top coat is dissolved in a liquid comprised of at least one of the group consisting of water, alcohol, and organic solvent.

7. The method of claim 1, wherein the top coat is dissolved in a liquid comprised of a mixture of any two or more of the group consisting of water, alcohol and organic solvent.

8. The method of claim 7, wherein the liquid further contains a base.

9. The method of claim 7, wherein the liquid is a base.

10. The method of claim 8, wherein the base is an amine.

11. The method of claim 10, wherein said amine is selected from the group consisting of an alkyl amine, aliphatic amine and an amine attached to any combination of functional groups.

12. The method of claim 10, wherein said amine is a salt.

13. The method of claim 12, wherein said salt has a cation selected from the group consisting of an ammonium cation, an alkyl ammonium cation and an aliphatic ammonium cation.

14. The method of claim 12, wherein the salt comprises a combination of cations.

15. The method of claim 12, wherein said salt comprises an anion.

16. The method of claim 15, wherein said anion is an hydroxide anion.

17. The method of claim 8, wherein said base comprises ammonium hydroxide.

18. The method of claim 8, wherein said base comprises an alkyl ammonium hydroxide.

19. The method of claim 8, wherein said base comprises trimethylamine.

20. The method of claim 8, wherein said base comprises a mixture of a salt and an amine.

21. The method of claim 4, wherein the reacted top coat is re-isolated.

22. The method of claim 6, wherein the dissolved top coat is re-isolated.

23. The method of claim 22, wherein the re-isolated top coat is used again in a method according to claim 1.

24. The method of claim 22, wherein the top coat is re-isolated by one or more techniques selected from the group consisting of precipitation, evaporation and distillation.

25. The method of claim 1, further comprising after step d) thermal annealing.

26. The method of claim 25, further comprising removing said top coat from said block copolymer with stripping solvent that does not damage, dissolve, or significantly swell the block copolymer.

27. The method of claim 3, wherein said top coat comprises an anhydride.

28. The method of claim 27, wherein the anhydride derives from maleic anhydride.

29. The method of claim 1, wherein the substrate is selected from the group consisting of silicon, silicon oxide, glass, surface-modified glass, plastic, ceramic, transparent substrates, flexible substrates, and substrates used in roll-to-roll processing.

30. The method of claim 1, wherein said block copolymer is comprised of plurality of different blocks.

31. The method of claim 30, wherein the block copolymer comprises at least one block that etches at a different rate than the other block(s).

32. The method of claim 30, wherein the block copolymer comprises silicon in at least one block.

33. The method of claim 30, wherein the block copolymer is poly(styrene-*block*-4-trimethylsilylstyrene-*block*-styrene).

34. The method of claim 30, wherein the block copolymer is poly(4-trimethylsilylstyrene-*block*-$_{D,L}$-lactide).

35. The method of claim 30, wherein the block copolymer comprises tin in at least one block.

36. The method of claim 30, wherein the block copolymer comprises an inorganic component.

37. The method of claim 30, wherein the block copolymer comprises an organometallic component.

38. The method of claim 25, wherein said thermal annealing creates block copolymer domains perpendicular to the plane of the film.

39. The method of claim 38, wherein the morphology of the domains is selected from the group consisting of lamellar, spherical, and cylindrical.

40. The method of claim 25, wherein said thermal annealing is performed under conditions selected from the group consisting of an air environment, an environment of inert gas, reduced pressure, and increased pressure.

41. The method of claim 2, wherein said surface neutralization layer comprises components selected from the group consisting of cross-linked polymer, brushes,

self-assembled monolayers, chemically modified surfaces, physically modified surfaces, and thermally cured surfaces.

42. A method, comprising:

a) providing a substrate having a surface, a surface neutralization layer, a block copolymer, and a top coat;

b) treating said substrate surface with said surface neutralization layer under conditions such that a first layer is created;

c) coating said surface neutralization layer with block copolymer under conditions such that a second layer on said surface is created comprising a block copolymer film; and

d) coating said block copolymer with a top coat so as to create a third layer on said surface;

e) treating said third layer under conditions which enable the orientation of block copolymer features perpendicular to the plane of the film.

43. The method of claim 42, wherein said treating of step e) comprises thermal annealing.

44. The method of claim 43, wherein thermal annealing in the absence of the top coat layer does not produce perpendicular features.

45. The method of claim 42, wherein said top coat is dissolved in trimethylamine.

46. The method of claim 42, wherein said coating comprises spin coating.

CLAIMS

1. A method, comprising:

a. providing a substrate having a surface, a surface neutralization layer, a block copolymer, in which the block copolymer forms nanometer scale patterns, and a top coat;

b. treating the substrate surface with the surface neutralization layer under conditions such that a first layer is created;

c. coating the surface neutralization layer with block copolymer under conditions such that a second layer on the surface is created comprising a block copolymer film, and

d. coating the block copolymer with a top coat, in which the top coat is dissolved in a liquid comprised of a mixture of any two or more of the group consisting of water, alcohol and organic solvent, in which the liquid further contains an amine base, so as to create a third layer on the surface, in which the third layer enables the orientation of the block copolymer domains perpendicular to the plane of the film by thermal annealing alone.

2. A method according to Claim1, in which thermal annealing in the absence of the top coat layer does not produce perpendicular features.

3. A method according to Claim1, in which a top coat of step d) is in a solvent or solvent mixture that will not damage, dissolve, or substantially swell the block copolymer.

4. A method according to Claim 1, in which the top coat of step d) is in a solvent that reacts with the top coat.

5. A method according to Claim 1, in which the top coat of step d) is in a solvent mixture, and the solvent mixture contains a component that reacts with the top coat.

6. A method according to Claim 1, in which the liquid is a base, in which the base reacts with the anhydride moiety.

7. A method according to Claim 1, in which the amine is selected from the group consisting of an alkyl amine, aliphatic amine and an amine attached to any combination of functional groups.

8. A method, comprising:

a. providing a substrate having a surface, a surface neutralization layer, a block copolymer, in which the block copolymer forms nanometer scale patterns, and a top coat;

b. treating the substrate surface with the surface neutralization layer under conditions such that a first layer is created;

c. coating the surface neutralization layer with block copolymer under conditions such that a second layer on the surface is created comprising a block copolymer film, and

d. coating the block copolymer with a top coat, in which the top coat is dissolved in a liquid comprised of a mixture of any two or more of the group consisting of water, alcohol and organic solvent, in which the liquid further contains an alkyl ammonium hydroxide base, so as to create a third layer on the surface, in which the third layer enables the orientation of the block copolymer domains perpendicular to the plane of the film by thermal annealing alone.

9. A method according to Claim 1, in which the base comprises trimethylamine.

10. A method according to Claim 1, in which the base comprises a mixture of a salt and an amine.

11. A method according to Claim 4, in which the reacted top coat is re-isolated.

12. A method according to Claim 1, in which the dissolved top coat is re-isolated.

13. A method according to Claim 12, in which the re-isolated top coat is used again in a method according to claim 1.

14. A method according to Claim 12, in which the top coat is re-isolated by one or more techniques selected from the group consisting of precipitation, evaporation and distillation.

15. A method according to Claim 1, further comprising after step d) thermal annealing.

16. A method according to Claim 15, further comprising removing the top coat from the block copolymer with stripping solvent that does not damage, dissolve, or significantly swell the block copolymer.

17. A method according to Claim 3, in which the top coat comprises an anhydride.

18. A method according to Claim 17, in which the anhydride derives from maleic anhydride.

19. A method according to Claim 1, in which the substrate is selected from the group consisting of silicon, silicon oxide, glass, surface-modified glass, plastic, ceramic, transparent substrates, flexible substrates, and substrates used in roll-to-roll processing.

20. A method according to Claim 1, in which the block copolymer is comprised of plurality of different blocks.

21. A method according to Claim 20, in which the block copolymer comprises at least one block that etches at a different rate than the other block(s).

22. A method according to Claim 20, in which the block copolymer comprises silicon in at least one block.

23. A method according to Claim 20, in which the block copolymer is poly(styrene-block-4-trimethylsilylstyrene-block-styrene).

24. A method, comprising:

a. providing a substrate having a surface, a surface neutralization layer, a block copolymer, in which the block copolymer comprises poly(4-trimethylsilylstyrene-block-D,L-lactide) and forms nanometer scale patterns, and a top coat;

b. treating the substrate surface with the surface neutralization layer under conditions such that a first layer is created;

c. coating the surface neutralization layer with block copolymer under conditions such that a second layer on the surface is created comprising a block copolymer film, and

d. coating the block copolymer with a top coat so as to create a third layer on the surface, in which the third layer enables the orientation of the block copolymer domains perpendicular to the plane of the film by thermal annealing alone.

25. A method, comprising:

a. providing a substrate having a surface, a surface neutralization layer, a block copolymer, in which the block copolymer is comprised of plurality of different blocks, in which the blocks form nanometer scale patterns,, in which the block copolymer comprises tin in at least one block, and a top coat;

b. treating the substrate surface with the surface neutralization layer under conditions such that a first layer is created;

c. coating the surface neutralization layer with block copolymer under conditions such that a second layer on the surface is created comprising a block copolymer film, and

d. coating the block copolymer with a top coat so as to create a third layer on the surface, in which the third layer enables the orientation of the block copolymer domains perpendicular to the plane of the film by thermal annealing alone.

26. A method, comprising:

a. providing a substrate having a surface, a surface neutralization layer, a block copolymer, in which the block copolymer is comprised of plurality of different blocks that form nanometer scale patterns,, in which the block copolymer comprises an inorganic component, and a top coat;

b. treating the substrate surface with the surface neutralization layer under conditions such that a first layer is created;

c. coating the surface neutralization layer with block copolymer under conditions such that a second layer on the surface is created comprising a block copolymer film, and

d. coating the block copolymer with a top coat so as to create a third layer on the surface, in which the third layer enables the orientation of the block copolymer domains perpendicular to the plane of the film by thermal annealing alone.

27. A method, comprising:

a. providing a substrate having a surface, a surface neutralization layer, a block copolymer, in which the block copolymer is comprised of plurality of different blocks that form nanometer scale patterns, in which the block copolymer comprises an organometallic component, and a top coat;

b. treating the substrate surface with the surface neutralization layer under conditions such that a first layer is created;

c. coating the surface neutralization layer with block copolymer under conditions such that a second layer on the surface is created comprising a block copolymer film, and

d. coating the block copolymer with a top coat so as to create a third layer on the surface, in which the third layer enables the orientation of the block copolymer domains perpendicular to the plane of the film by thermal annealing alone.

28. A method according to Claim 15, in which the thermal annealing creates block copolymer domains perpendicular to the plane of the film.

29. A method according to Claim 28, in which the morphology of the domains is selected from the group consisting of lamellar and cylindrical.

30. A method according to Claim 15, in which the thermal annealing is performed under conditions selected from the group consisting of an air environment, an environment of inert gas, reduced pressure, and increased pressure.

31. A method according to Claim 2, in which the surface neutralization layer comprises components selected from the group consisting of cross-linked polymer, brushes, self-assembled monolayers, chemically modified surfaces, physically modified surfaces, and thermally cured surfaces.

32. A method, comprising:

a. providing a substrate having a surface, a surface neutralization layer, a block copolymer that forms nanometer scale patterns, and a top coat;

b. treating the substrate surface with the surface neutralization layer under conditions such that a first layer is created;

c. coating the surface neutralization layer with block copolymer under conditions such that a second layer on the surface is created comprising a block copolymer film; and

d. coating the block copolymer with a top coat, in which the top coat is dissolved in trimethylamine, so as to create a third layer on the surface;

e. treating the third layer under conditions which enable the orientation of block copolymer features perpendicular to the plane of the film.

33. A method according to Claim 32, in which the treating of step e) comprises thermal annealing.

34. A method according to Claim 33, in which thermal annealing in the absence of the top coat layer does not produce perpendicular features.

35. A method according to Claim 32, in which the coating comprises spin coating.