CLAIMS

1. A method of synthesizing a silicon and lactide-containing block copolymer, comprising:

(a) providing first and second monomers, the first monomer comprising a silicon atom and the second monomer being a lactide based monomer lacking silicon that can be polymerized;

(b) treating the first monomer under conditions such that reactive polymer of the first monomer is formed;

(c) reacting the second monomer with the reactive polymer of the first monomer under conditions such that the silicon-containing block copolymer is synthesized

(d) in which the glass transitions of both blocks are above room temperature; and

in which one of the blocks is polytrimethylsilylstyrene.

2. A method according to Claim 1, in which at least one of the blocks are cross-linkable

3. A method according to Claim 1, in which a third monomer is provided and the block copolymer is a triblock copolymer.

4. A method according to Claim 1, in which the block copolymers form nanostructured materials that can be used as etch masks in lithographic patterning processes.

5. A method according to Claim 4, in which the block co-polymer comprised of at least one block of a lactide and at least one block of a silicon containing polymer or oligomer with at least 10 wt% silicon.

6. A method according to Claim 1, in which the reactive polymer is endcapped.

7. A method according to Claim 6, in which the reactive polymer is endcapped with a functional group.

8. A method according to Claim 7, in which the reactive polymer is endcapped with a hydroxyl functionality by reacting with ethylene oxide.

9. A method according to Claim 1, further comprising a step (e) precipitating the silicon-containing block copolymer.

10. A method according to Claim 9, in which the silicon-containing block copolymer is precipitated in methanol.

11. A method according to Claim 1, in which the first monomer is trimethylsilylstyrene.

12. A method according to Claim 1, in which the first monomer is a silicon-containing methacrylate.

13. A method according to Claim 12, in which the first monomer is methacryloxymethyltrimethylsilane.

14. A method according to Claim 1, in which the second monomer is a lactide.

15. A method according to Claim 1, in which the second monomer is DL-lactide.

16. A method according to Claim 1, further comprising a step (e) coating a substrate with the block copolymer so as to create a block copolymer film.

17. A method according to Claim 16, in which the substrate comprises silicon.

18. A method according to Claim 16, in which the substrate is a silicon wafer.

19. A method according to Claim 16, in which the substrate is quartz.

20. A method according to Claim 16, in which the substrate is glass.

21. A method according to Claim 16, in which the substrate is plastic.

22. A method according to Claim 16, in which the substrate is a transparent substrate.

23. A method according to Claim 16, in which the substrate is a roll-to-roll substrate

24. A method according to Claim 16, in which prior to step (e) the substrate is pre-treated with a substrate surface energy neutralizing layer with surface energy in between that of two blocks.

25. A method according to Claim 24, in which the substrate surface energy neutralizing layer is selected from the group consisting of:

(a) high T_g polymer, (b) a cross-linked polymer, (c) vapor deposited polymer such as parylene, (d) small molecule derivatives of silylating agents, and (e) polymer brush by end-attaching polymer to substrate.

26. A method according to Claim 16, further comprising a step (f) treating the film under conditions such that nanostructures form on the surface of the substrate, the surface having a plane.

27. A method according to Claim 16, in which the treating comprises annealing.

28. A method according to Claim 26, in which the annealing is by exposure to solvent vapors.

29. A method according to Claim 26, in which the annealing is by heating.

30. A method according to Claim 26, in which the nanostructures are selected from the group consisting of: lamellae, cylinders, vertically aligned cylinders, horizontally aligned cylinders, spheres, gyroids, network structures, and hierarchical nanostructures.

31. A method according to Claim 26, in which the nanostructures comprise spherical structures.

32. A method according to Claim 26, in which the nanostructures comprise cylindrical structures, the cylindrical structures being substantially vertically aligned with respect to the plane of the surface.

33. A method according to Claim 26, in which the treating comprises exposing the surface to acetone, THF, cyclohexane, or other vaporizing agent or combinations thereof.

34. A method according to Claim 16, in which the surface is on a silicon wafer.

35. A method according to Claim 16, in which the surface is glass.

36. A method according to Claim 16, in which the surface is quartz.

37. A method according to Claim16, in which the substrate is not pre-treated with a surface energy neutralizing layer prior to step (e).

38. A film made by a process according to Claim 27.

39. A method of forming nanostructures on a surface, comprising:

(a) providing a silicon and lactide-containing block copolymer, in which the glass transitions of both blocks are above room temperature, and a surface;

(b) spin coating the block copolymer on the surface to create a coated surface; and

(c) treating the coated surface under conditions such that nanostructures are formed on the surface.

40. A method according to Claim 39, in which the nanostructures comprises cylindrical structures, the cylindrical structures being substantially vertically aligned with respect to the plane of the surface.

41. A method according to Claim 39, in which the treating comprises exposing the coated surface to acetone or THF.

42. A method according to Claim 39, in which the surface is the surface of a silicon wafer.

43. A method according to Claim 39, in which the surface is glass.

44. A method according to Claim 39, in which the surface is quartz.

45. A method according to Claim 40, in which the surface is not pre-treated with a substrate neutralization layer prior to step (b).

46. A method according to Claim 40, in which the surface is pre-treated with a cross-linked polymer prior to step (b).

47. A film made by a process according to Claim 39.

48. A method according to Claim 39, further comprising a step (d) etching the nanostructure-containing coated surface.

CLAIMS

1. A method of synthesizing a silicon and lactide-containing block copolymer, comprising:

(a) providing first and second monomers, the first monomer comprising trimethylsilylstyrene and the second monomer being a lactide based monomer lacking silicon that can be polymerized;

(b) treating the first monomer under conditions such that reactive polymer of the first monomer is formed;

(c) reacting the second monomer with the reactive polymer of the first monomer under conditions such that the silicon-containing block copolymer is synthesized;

(d) in which the glass transitions of both blocks are above room temperature; and

in which one of the blocks is polytrimethylsilylstyrene.

2. A method according to Claim 1, in which at least one of the blocks are cross-linkable

3. A method according to Claim 1, in which a third monomer is provided and the block copolymer is a triblock copolymer.

4. A method according to Claim 1, in which the block copolymers form nanostructured materials that can be used as etch masks in lithographic patterning processes.

5. A method according to Claim 4, in which the block co-polymer comprised of at least one block of a lactide and at least one block of a silicon containing polymer or oligomer with at least 10 wt% silicon.

6. A method according to Claim 1, in which the reactive polymer is endcapped.

7. A method according to Claim 6, in which the reactive polymer is endcapped with a functional group.

8. A method according to Claim 7, in which the reactive polymer is endcapped with a hydroxyl functionality by reacting with ethylene oxide.

9. A method according to Claim 1, in which the second monomer is a lactide.

10. A method according to Claim 1, in which the second monomer is DL-lactide.

11. A method according to Claim 1, further comprising a step (e) coating a substrate with the block copolymer so as to create a block copolymer film.

12. A method according to Claim 11, in which the substrate comprises silicon.

13. A method according to Claim 11, in which the substrate is a silicon wafer.

14. A method according to Claim 11, in which the substrate is quartz.

15. A method according to Claim 11, in which prior to step (e) the substrate is pre-treated with a substrate surface energy neutralizing layer with surface energy in between that of two blocks.

16. A method according to Claim 15, in which the substrate surface energy neutralizing layer is selected from the group consisting of:

(a) high T_g polymer, (b) a cross-linked polymer, (c) vapor deposited polymer such as parylene, (d) small molecule derivatives of silylating agents, and (e) polymer brush by end-attaching polymer to substrate.

17. A method according to Claim 11, further comprising a step (f) treating the film under conditions such that nanostructures form on the surface of the substrate, the surface having a plane.

18. A method according to Claim 11, in which the treating comprises annealing.

19. A method according to Claim 17, in which the annealing is by exposure to solvent vapors.

20. A method according to Claim 17, in which the annealing is by heating.

21. A method according to Claim 17, in which the nanostructures are selected from the group consisting of: lamellae, cylinders, vertically aligned cylinders, horizontally aligned cylinders, spheres, gyroids, network structures, and hierarchical nanostructures.

22. A method according to Claim 17, in which the nanostructures comprise cylindrical structures, the cylindrical structures being substantially vertically aligned with respect to the plane of the surface.

23. A method according to Claim 17, in which the treating comprises exposing the surface to a saturated atmosphere of acetone, THF, cyclohexane, or other vaporizing agent or combinations thereof.

24. A method according to Claim 11, in which the surface is on a silicon wafer.

25. A method according to Claim 11, in which the substrate is not pre-treated with a surface energy neutralizing layer prior to step (f).