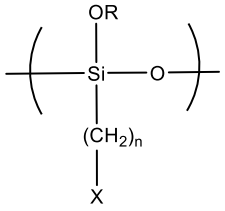
We claim:

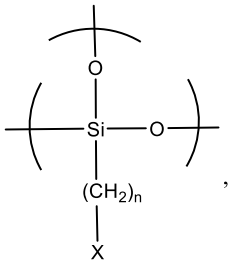
1. A method of forming a structure, said method comprising:

providing a substrate, said substrate optionally including one or more intermediate layers thereon;

applying a composition to said substrate, or on said one or more intermediate layers, if present, so as to form a silicon hardmask layer, said composition comprising a polysiloxane comprising:

an adhesion promoting monomer having a structure chosen from one or both of:



and


,

where:

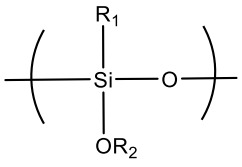
each R is individually chosen from C_1 to ~~about~~ C_6 alkyls and hydrogen;

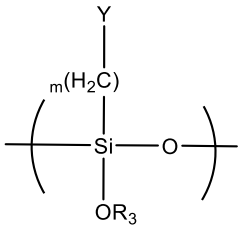
n is 1 to ~~about~~ 6; and

each X is individually chosen from glycidoxy, epoxy, epoxycycloalkyls, succinic anhydride, <u>and</u> acetamido~~, and isocyanurate~~ moieties; and

one or both of the following:

a surface modification monomer having a structure chosen from one or both of:



and


,

where:

each R_1 is individually chosen from C_1 to ~~about~~ C_6 alkyls and from C_6 to ~~about~~ C_{20} aryls;

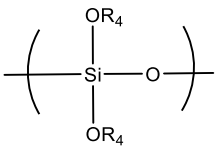
each R_2 is individually chosen from C_1 to ~~about~~ C_6 alkyls and hydrogen;

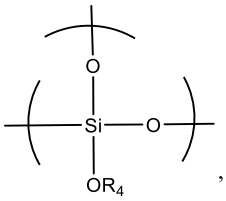
each R_3 is individually chosen from C_1 to ~~about~~ C_6 alkyls and hydrogen;

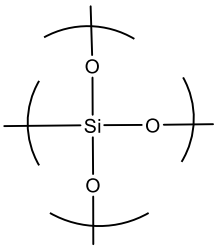
m is 1 to ~~about~~ 6; and

each Y is individually chosen from acetoxy, ester, and aryl moieties; and

a densification monomer having a structure chosen from one, two, or three of:



,


,
and


,

where each R_4 is individually chosen from C_1 to ~~about~~ C_6 alkyls and hydrogen;

optionally forming a hexamethyldisilizane priming layer on said silicon hardmask layer;

forming a photoresist layer on said hexamethyldisilizane priming layer, if present, or on said silicon hardmask layer if no hexamethyldisilizane priming layer is present; and

subjecting at least a portion of said photoresist layer to EUV radiation.

2. The method of claim 1, wherein said polysiloxane comprises both of said surface modification monomer and said densification monomer.

3. The method of claim 1, wherein said polysiloxane comprises:

from ~~about~~ 2 mol % to ~~about~~ 50 mol % adhesion promoting monomer;

from ~~about~~ 5 mol % to ~~about~~ 90 mol % surface modification monomer; and

from ~~about~~ 0 mol % to ~~about~~ 80 mol % densification monomer.

4. The method of claim 1, wherein said polysiloxane comprises:

from ~~about~~ 2 mol % to ~~about~~ 50 mol % adhesion promoting monomer;

from ~~about~~ 0 mol % to ~~about~~ 70 mol % surface modification monomer; and
from ~~about~~ 2 mol % to ~~about~~ 90 mol % densification monomer.

5. The method of claim 1, wherein said polysiloxane comprises:
from ~~about~~ 0.01 mol % to ~~about~~ 30 mol % adhesion promoting monomer;
from ~~about~~ 0 mol % to ~~about~~ 70 mol % surface modification monomer; and
from ~~about~~ 30 mol % to ~~about~~ 95 mol % densification monomer.

6. The method of any of claims 1 to 5, wherein said substrate is selected from the group consisting of silicon, SiGe, SiO_2, Si_3N_4, SiON, SiCO:H, aluminum, tungsten, tungsten silicide, gallium arsenide, germanium, tantalum, tantalum nitride, Ti_3N_4, hafnium, HfO_2, ruthenium, indium phosphide, glass, and mixtures of the foregoing.

7. The method of any of claims 1 to 6, further comprising forming a pattern in said photoresist layer after said subjecting said photoresist layer to EUV radiation.

8. The method of any of claims 1 to 7, further comprising transferring said pattern to said silicon hardmask layer; to said intermediate layers, if present; and to said substrate.

9. The method of any of claims 1 to 8, wherein an intermediate layer is present, and said intermediate layer is a carbon-rich layer.

10. A method of forming a structure, said method comprising:
providing a substrate, said substrate optionally including one or more intermediate layers thereon;
applying a composition to said substrate, or on said one or more intermediate layers, if present, so as to form a silicon hardmask layer, said composition comprising a polysiloxane that comprises:
an adhesion promoting monomer comprising an epoxy functional trialkoxysilane, an anhydride functional trialkoxysilane, an acetamido functional trialkoxysilane, ~~a trialkoxysilylalkyl isocyanurate,~~ and mixtures thereof; and
one or both of:
a tetra<u>a</u>lkoxysilane; and

a surface modification monomer chosen from dialkoxysilanes, trialkoxysilanes, and combinations thereof;

optionally forming a hexamethyldisilizane priming layer on said silicon hardmask layer;

forming a photoresist layer on said hexamethyldisilizane priming layer, if present, or on said silicon hardmask layer if no hexamethyldisilizane priming layer is present; and

subjecting at least a portion of said photoresist layer to EUV radiation.

11. The method of claim 10, wherein said tetraalkoxysilane is chosen from one or both of tetraethoxysilane or tetramethyl orthosilicate.

12. The method of claims 10 or 11, wherein said adhesion promoting monomer is chosen from (3-glycidoxypropyl)trimethoxysilane, 5,6-epoxyhexyl-triethoxysilane, 2-(3,4-epoxycyclohexyl)-ethyltrimethyoxysilane, [3-(triethoxysilyl)propyl]-succinic anhydride, (3-acetamidopropyl)-trimethoxysilane, (1,3-Di-2-propen-1-yl)-5-(~~{~~[3-triethoxysilylpropyl])-(1,3,5-triazine-2,4,6 (1H, 3H, 5H)-trione), and mixtures thereof.

13. The method of any of claims 10 to 12, said polysiloxane comprising both said tetraalkoxysilane and said surface modification monomer.

14. The method of any of claims 10 to 13, wherein said surface modification monomer is chosen from methyltrimethoxysilane, methyltriethoxysilane, dimethyldimethoxysilane, dimethyldiethoxy-silane, phenyltrimethoxysilane, phenethyl-trimethoxysilane, 2-(carbomethoxy)ethyltrimethoxy-silane, acetoxyethyltrimethoxysilane, ethyl-trimethoxysilane, n-butyltrimethoxysilane, and mixtures thereof.

15. The method of any of claims 10-12 or 14, wherein said polysiloxane comprises:

from ~~about~~ 2 mol % to ~~about~~ 50 mol % adhesion promoting monomer;

from ~~about~~ 5 mol % to ~~about~~ 90 mol % surface modification monomer; and

from ~~about~~ 0 mol % to ~~about~~ 80 mol % densification monomer.

16. The method of any of claims 10-12 or 14, wherein said polysiloxane comprises:

from ~~about~~ 2 mol % to ~~about~~ 50 mol % adhesion promoting monomer;

from ~~about~~ 0 mol % to ~~about~~ 70 mol % surface modification monomer; and
from ~~about~~ 2 mol % to ~~about~~ 90 mol % densification monomer.

17. The method of any of claims 10-12 or 14, wherein said polysiloxane comprises:
from ~~about~~ 0.01 mol % to ~~about~~ 30 mol % adhesion promoting monomer;
from ~~about~~ 0 mol % to ~~about~~ 70 mol % surface modification monomer; and
from ~~about~~ 30 mol % to ~~about~~ 95 mol % densification monomer.

18. The method of any of claims 10 to 17, wherein said substrate is selected from the group consisting of silicon, SiGe, SiO_2, Si_3N_4, SiON, SiCO:H, aluminum, tungsten, tungsten silicide, gallium arsenide, germanium, tantalum, tantalum nitride, Ti_3N_4, hafnium, HfO_2, ruthenium, indium phosphide, glass, and mixtures of the foregoing.

19. The method of any of claims 10 to 18, further comprising forming a pattern in said photoresist layer after said subjecting said photoresist layer to EUV radiation.

20. The method of any of claims 10 to 19, wherein an intermediate layer is present, and said intermediate layer is a carbon-rich layer.