Claims

What is claimed is

1. A method for depositing tin-containing films comprising:

(i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel;

(ii) purging the reactor vessel with inert gas;

(iii) contacting the substrate with a water-containing vapor to form an organotin oxo network layer;

(iv) purging the reactor vessel with inert gas;

(v) contacting the substrate with a carboxylic acid-containing vapor; and

(vi) purging the reactor vessel with inert gas.

2. The method of claim 1, wherein the organotin precursor of the step (i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel comprises an organotin precursor of formula: $RSn(NR^1R^2)_3$ wherein R, R^1 and R^2 are each independently selected from a linear C_1 to C_6 alkyl group, a branched C_3 to C_6 alkyl group, a C_3 to C_6 cyclic alkyl group, a C_2 to C_6 alkenyl group, a C_2 to C_6 alkynyl group and a C_4 to C_{10} aryl group.

3. The method of claim 1, wherein the organotin precursor of the step (i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel comprises one or more of $MeSn(NMe_2)_3$, $MeSn(NEt_2)_3$, $EtSn(NMe_2)_3$, $EtSn(NEt_2)_3$, n-$PrSn(NMe_2)_3$, i-$PrSn(NMe_2)_3$, n-$BuSn(NMe_2)_3$, i-$BuSn(NMe_2)_3$, s-$BuSn(NMe_2)_3$, t-$BuSn(NMe_2)_3$, cyclopentyl$Sn(NMe_2)_3$, $MeSn(NEtMe)_3$, $EtSn(NEtMe)_3$, n-$PrSn(NEtMe)_3$, i-$PrSn(NEtMe)_3$, n-$BuSn(NEtMe)_3$, i-$BuSn(NEtMe)_3$, s-$BuSn(NEtMe)_3$, t-$BuSn(NEtMe)_3$, cyclopentyl$Sn(NEtMe)_3$ and combinations thereof.

4. The method of claim 1, wherein the organotin precursor of step (i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel comprises $EtSn(NMe_2)_3$.

5. The method of claim 1, wherein the organotin precursor of step (i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel comprises i-$PrSn(NMe_2)_3$.

6. The method of claim 1, wherein the organotin precursor of step (i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel comprises n-$BuSn(NMe_2)_3$.

7. The method of claim 1, wherein the organotin precursor of step (i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel comprises t-$BuSn(NMe_2)_3$.

8. The method of claim 1, wherein the organotin precursor of step (i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel comprises cyclopentyl$Sn(NMe_2)_3$.

9. The method of claim 1, wherein the step of (i) contacting a substrate with organotin precursor vapor in a deposition reactor vessel comprises pulsing the organotin precursor vapor for about 0.1

seconds to about 3 seconds.

10. The method of claim 1, wherein the step of (iii) contacting the substrate with a water-containing vapor to form an organotin oxo network layer comprises pulsing the water-containing vapor from about 0.5 seconds to about 5 seconds.

11. The method of claim 1, wherein the carboxylic acid of the step (v) contacting the substrate with a carboxylic acid-containing vapor comprises a carboxylic acid of formula: R^3COOH wherein R^3 is selected from hydrogen, a linear C_1 to C_6 alkyl group, a branched C_3 to C_6 alkyl group, a C_3 to C_6 cyclic alkyl group, a C_2 to C_6 alkenyl group, a C_2 to C_6 alkynyl group, and a C_4 to C_{10} aryl group.

12. The method of claim 1, wherein the carboxylic acid of the step (v) contacting the substrate with a carboxylic acid-containing vapor comprises one or more of formic acid, acetic acid, dihydroxyacetic acid, propionic acid, lactic acid, butyric acid, iso-butyric acid, valeric acid, 2-methylbutyric acid, 3-methylbutyric acid, pivalic acid, caproic acid, enanthic acid, caprylic acid, pelargonic acid, capric acid, fluoroacetic acid, chloroacetic acid, iodoacetic acid, dichloroacetic acid, 4,4,4-trifluorobutanoic acid, 3,3,3-trifluoropropanoic acid, heptafluorobutyric acid (aka perfluoro-n-butanoic acid), perfluoropentanoic acid, 3,3,3-trifluoro-2,2-dimethylpropanoic acid, cyclobutanecarboxylic acid, cyclopentanecarboxylic acid, cyclohexanecarboxylic acid, 4,4-difluorocyclohexanecarboxylic acid, tetrahydro-3-furancarboxylic acid and combinations thereof.

13. The method of claim 1, wherein the carboxylic acid of the step (v) contacting the substrate with a carboxylic acid-containing vapor comprises acetic acid.

14. The method of claim 1, wherein the carboxylic acid of the step (v) contacting the substrate with a carboxylic acid-containing vapor comprises pivalic acid.

15. The method of claim 1, wherein the carboxylic acid of the step (v) contacting the substrate with a carboxylic acid-containing vapor comprises one or more carboxylic acid having a boiling point of 250 ^{O}C or lower.

16. The method of claim 1, wherein the carboxylic acid of the step (v) contacting the substrate with a carboxylic acid-containing vapor comprises one or more carboxylic acid having a boiling point of 200 ^{O}C or lower.

17. The method of claim 1, wherein the carboxylic acid of the step (v) contacting the substrate with a carboxylic acid-containing vapor is free or is substantially free of any carboxylic acids having boiling points of greater 250 ^{O}C.

18. The method of claim 1, wherein the carboxylic acid of the step (v) contacting the substrate with a carboxylic acid-containing vapor is free or is substantially free of any carboxylic acids having boiling points of greater 200 ^{O}C.

19. The method of any of claims 1-18, further comprising exposing tin-containing films to a radiation source selected from the group of KrF (248 nm), ArF (193 nm), VUV (157 nm), EUV (13 nm), E-beam, X-ray and ion beam.