

CLAIMS

What is claimed is:

- 5 1. A method of processing a semiconductor substrate, the method comprising:
- (a) providing a semiconductor substrate having a plurality of protruding features over a silicon-containing layer, wherein the semiconductor substrate comprises an exposed tin oxide at the protruding features and an exposed silicon-containing material of the silicon-containing layer;
- 10 (b) passivating the exposed silicon-containing material towards a tin oxide etch chemistry;
- (c) etching the exposed tin oxide using the tin oxide etch chemistry; and
- (d) repeating operations (b) and (c) such that operations (b) and (c) are performed in an alternating fashion.
- 15 2. The method of claim 1, wherein the exposed silicon-containing material is selected from the group consisting of amorphous silicon, silicon oxide, SiON, SiOC, SiONC, SiC, and SiN.
- 20 3. The method of claim 1, wherein (c) comprises etching tin oxide using a chlorine-based etch chemistry that comprises exposing the semiconductor substrate to a plasma-activated chlorine-containing reactant selected from the group consisting of Cl₂, BCl₃, and combinations thereof.
- 25 4. The method of claim 1, wherein (c) comprises etching the tin oxide using a hydrogen-based etch chemistry that results in a formation of a tin hydride.
5. The method of claim 1, wherein (c) comprises etching the tin oxide using a hydrogen-based etch chemistry, by contacting the semiconductor substrate with a
- 30 plasma-activated hydrogen-containing reactant selected from the group consisting of H₂, HBr, NH₃, H₂O, a hydrocarbon, and combinations thereof.
6. The method of claim 1, wherein (c) comprises etching tin oxide using a chlorine-based etch chemistry that comprises exposing the semiconductor substrate to

a plasma-activated process gas comprising a chlorine-containing reactant selected from the group consisting of Cl_2 , BCl_3 , and combinations thereof, and a diluent gas selected from the group consisting from helium, neon, argon, and xenon and combinations thereof.

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7. The method of claim 1, wherein (b) comprises treating the substrate with an oxygen-containing reactant.

8. The method of claim 1, wherein (b) comprises treating the substrate with a plasma-activated oxygen-containing reactant.

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9. The method of claim 1, wherein (b) comprises treating the substrate with a plasma formed in a process gas comprising a gas selected from the group consisting of O_2 , O_3 , SO_2 , and CO_2 .

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10. The method of claim 1, wherein (b) is performed before (c).

11. The method of claim 1, wherein (c) is performed before (b).

12. The method of claim 1, wherein operations (b) and (c) are performed between 2 - 50 times.

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13. The method of claim 1, wherein the protruding features comprise horizontal surfaces and sidewalls and wherein the method reduces a tin oxide footing at the sidewalls of the protruding features.

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14. The method of claim 1, wherein the silicon-containing material is selected from the group consisting of amorphous silicon, silicon oxide, SiON , SiOC , SiONC , SiC , and SiN , wherein the passivating in (b) comprises treating the substrate with a plasma-activated oxygen-containing reactant, and wherein (c) comprises etching the tin oxide using a chlorine-based etch chemistry that comprises exposing the semiconductor substrate to a plasma-activated chlorine-containing reactant selected from the group consisting of Cl_2 , BCl_3 , and combinations thereof.

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15. The method of claim 1, wherein (b) comprises treating the semiconductor substrate with a nitrogen-containing reactant.
16. An apparatus for processing a semiconductor substrate, the apparatus
5 comprising:
(a) a processing chamber having a support for the semiconductor substrate and an inlet for introduction of one or more reactants into the processing chamber; and
(c) a controller comprising program instructions for:
10 (i) causing passivation a silicon-containing layer on a semiconductor substrate towards a tin oxide etch chemistry;
(ii) causing etching of a tin oxide on a semiconductor substrate; and
(iii) causing a repeating, in an alternating fashion of (i) and (ii).
17. The apparatus of claim 16, wherein (i) comprises causing treatment of the
15 semiconductor substrate with a plasma-activated oxygen-containing reactant.
18. The apparatus of claim 16, wherein (i) comprises causing treatment of the semiconductor substrate with a plasma-activated O₂.
- 20 19. The apparatus of claim 16, wherein (ii) comprises causing etching of the tin oxide using a chlorine-based chemistry.
20. The apparatus of claim 16, wherein (ii) comprises causing etching of the tin oxide using a hydrogen-based chemistry.
- 25 21. The apparatus of claim 16, wherein the program instructions comprise instructions for performing (i) and (ii) in an alternating fashion between 2 – 50 times.