WHAT IS CLAIMED IS:

1. A method of processing a substrate, the method comprising:

flowing an etch gas, O_2, and an adsorbate precursor into a plasma processing chamber that is configured to hold the substrate comprising a silicon-containing dielectric layer and a patterned mask layer, the etch gas comprising hydrogen and fluorine;

generating a plasma in the plasma processing chamber while flowing the etch gas, O_2, and the adsorbate precursor, the adsorbate precursor being oxidized to form an adsorbate; and

patterning, with the plasma, the silicon-containing dielectric layer on the substrate, wherein the adsorbate forms a sidewall passivation layer while keeping the substrate at a temperature above 0ºC.

2. The method of claim 1, wherein the adsorbate comprises H_3PO_4, and wherein the adsorbate precursor comprises PH_3.

3. The method of claim 1, wherein the adsorbate comprises boron.

4. The method of claim 1, wherein the adsorbate comprises silicon.

5. The method of claim 1, wherein the adsorbate comprises sulfur.

6. The method of claim 1, wherein the adsorbate comprises nitrogen.

7. The method of claim 1, wherein the etch gas is HF-free.

8. The method of claim 7, wherein the etch gas is a gas mixture comprising comprises dihydrogen (H_2) and a fluorocarbon.

9. The method of claim 7, wherein the etch gas is a gas mixture comprising comprises dihydrogen (H_2) and NF_3, H_2 and SF_6, H_2 and PF_3, or H_2 and PF_5.

10. The method of claim 1, wherein the silicon-containing dielectric layer comprises silicon oxide or silicon nitride.

11. The method of claim 1, wherein a ratio of a gas flow rate of O_2 to a gas flow rate of the adsorbate precursor is between 100:1 and 1:1.

12. A method of processing a substrate, the method comprising:

flowing, into a plasma processing chamber, an etchant comprising hydrogen and fluorine, O_2, and an adsorbate precursor, the adsorbate precursor comprising PH_3;

generating a plasma in the plasma processing chamber while flowing the etchant, O_2, and the adsorbate precursor, the adsorbate precursor being oxidized to form an adsorbate comprising H_3PO_4; and

forming a recess in a silicon-containing dielectric layer of the substrate by exposing the substrate to the plasma in the plasma processing chamber, the recess having an aspect ratio of at least 50:1, wherein the adsorbate forms a sidewall passivation layer in the recess.

13. The method of claim 12, wherein the substrate further comprises a patterned amorphous carbon layer (ACL) over the silicon-containing dielectric layer, the patterned ACL being an etch mask during forming the recess.

14. The method of claim 12, wherein the recess defines a feature having a critical dimension between 50 nm and 200 nm.

15. The method of claim 12, further comprising maintaining a temperature of the substrate at between 0°C and 50°C.

16. A method of processing a substrate, the method comprising:

depositing an organic layer over a silicon-containing dielectric layer of a substrate;

patterning the organic layer by a halogen-free plasma etch process; and

patterning the silicon-containing dielectric layer by a halogen-based plasma etch process using the patterned organic layer as an etch mask, the halogen-based plasma etch process comprising

generating a halogen-containing plasma from a gas mixture comprising a halogen-containing etch gas in a plasma processing chamber,

flowing O_2 and an adsorbate precursor into the plasma processing chamber, the adsorbate precursor comprising PH_3, wherein the adsorbate precursor is oxidized to form an adsorbate comprising H_3PO_4 under the halogen-containing plasma, and

forming a recess in the silicon-containing dielectric layer of the substrate by exposing the substrate to the halogen-containing plasma in the plasma processing chamber, the recess having an aspect ratio of at least 50:1, wherein the adsorbate forms a sidewall passivation layer in the recess.

17. The method of claim 16, wherein the halogen-containing plasma is a capacitively coupled plasma (CCP).

18. The method of claim 16, wherein flowing O_2 and the adsorbate precursor comprises flowing O_2 and the adsorbate precursor intermittently.

19. The method of claim 16, further comprising maintaining a temperature of the substrate at between 0°C and 50°C during the halogen-based plasma etch process.

20. The method of claim 16, further comprising maintaining a temperature of the substrate at greater than 0°C and less than 50°C.