

What is claimed is:

1. A method of forming a patterned structure, the method comprising:
  - introducing a vapor of an iodine-containing etching compound into a reaction chamber containing a silicon-containing film on a substrate, wherein the iodine-containing etching compound is selected from the group consisting of  $C_2H_2FI$  (1-fluoro-1-iodoethene, CAS No.: 420-28-0),  $C_3HF_6I$ ,  $C_3H_3F_2I$ ,  $C_3H_4FI$ ,  $C_3H_5F_2I$ ,  $C_3H_6FI$ ,  $C_2HFI_2$ ,  $C_2H_2F_2I_2$ ,  $C_2H_3FI_2$ ,  $C_2F_2I_2$ ,  $C_3HF_3I_2$ ,  $C_3HF_5I_2$ ,  $C_3H_2F_4I_2$ ,  $C_3H_3F_3I_2$ ,  $C_3H_4F_2I_2$  and  $C_3H_5FI_2$ ;
  - introducing an inert gas into the reaction chamber; and
  - activating a plasma to produce an activated iodine-containing etching compound capable of etching the silicon-containing film from the substrate to form the patterned structure; and
  - removing volatile by-products from the reaction chamber, wherein the activated iodine-containing etching compound reacts with the silicon-containing film to form the volatile by-products.
2. The method of claim 1, wherein the iodine-containing etching compound is  $C_3HF_6I$ .
3. The method of claim 1, further comprising introducing an oxidizer into the reaction chamber, wherein the oxidizer is selected from the group consisting of  $O_2$ ,  $O_3$ ,  $CO$ ,  $CO_2$ ,  $NO$ ,  $N_2O$  and  $NO_2$ .
4. The method of claim 1, further comprising introducing an etch gas into the reaction chamber, wherein the etch gas is selected from the group consisting of  $cC_4F_8$ ,  $cC_5F_8$ ,  $C_4F_6$ ,  $CF_4$ ,  $CH_3F$ ,  $CF_3H$ ,  $CH_2F_2$ ,  $COS$ ,  $F-C\equiv N$ ,  $CS_2$ ,  $SO_2$ , *trans*-1,1,1,4,4,4-hexafluoro-2-butene (*trans*- $C_4H_2F_6$ ), *cis*-1,1,1,4,4,4-hexafluoro-2-butene (*cis*- $C_4H_2F_6$ ), hexafluoroisobutene ( $C_4H_2F_6$ ), *trans*-1,1,2,2,3,4-hexafluorocyclobutane (*trans*- $C_4H_2F_6$ ), 1,1,2,2,3-pentafluorocyclobutane ( $C_4H_3F_5$ ), 1,1,2,2-tetrafluorocyclobutane ( $C_4H_4F_4$ ), and *cis*-1,1,2,2,3,4-hexafluorocyclobutane (*cis*- $C_4H_2F_6$ ).

5. The method of claim 1, wherein the silicon-containing film comprises a layer of silicon oxide, silicon nitride, polysilicon, crystalline silicon, low-*k* SiCOH, SiOCN, SiON, Si<sub>a</sub>O<sub>b</sub>H<sub>c</sub>C<sub>d</sub>N<sub>e</sub>, where  $a > 0$ ;  $b, c, d$  and  $e \geq 0$ , or combinations thereof.
6. The method of any one of claims 1 to 5, wherein the silicon-containing film is selectively etched from an amorphous carbon layer or a photoresist layer.
7. The method of any one of claims 1 to 5, wherein the silicon oxide layer is selectively etched from a silicon nitride, polysilicon or amorphous carbon layer.
8. The method of any one of claims 1 to 5, wherein the method produces an aperture in the silicon-containing film having an aspect ratio between approximately 10:1 and approximately 200:1.
9. The method of any one of claims 1 to 5, wherein the method produces an aperture in the silicon-containing film having a diameter ranging from approximately 5 nm to approximately 100 nm.
10. A method of minimizing damage to a patterned mask layer while forming a via or trench in a substrate, the method comprising:
  - introducing a vapor of an iodine-containing etching compound into a reaction chamber containing a substrate having a silicon-containing film disposed thereon and a patterned mask layer disposed on the silicon-containing layer, wherein the iodine-containing etching compound is selected from the group consisting of C<sub>2</sub>H<sub>2</sub>FI (1-fluoro-1-iodoethene, CAS No.: 420-28-0), C<sub>3</sub>HF<sub>6</sub>I, C<sub>3</sub>H<sub>3</sub>F<sub>2</sub>I, C<sub>3</sub>H<sub>4</sub>FI, C<sub>3</sub>H<sub>5</sub>F<sub>2</sub>I, C<sub>3</sub>H<sub>6</sub>FI, C<sub>2</sub>HFI<sub>2</sub>, C<sub>2</sub>H<sub>2</sub>F<sub>2</sub>l<sub>2</sub>, C<sub>2</sub>H<sub>3</sub>FI<sub>2</sub>, C<sub>2</sub>F<sub>2</sub>l<sub>2</sub>, C<sub>3</sub>HF<sub>3</sub>l<sub>2</sub>, C<sub>3</sub>HF<sub>5</sub>l<sub>2</sub>, C<sub>3</sub>H<sub>2</sub>F<sub>4</sub>l<sub>2</sub>, C<sub>3</sub>H<sub>3</sub>F<sub>3</sub>l<sub>2</sub>, C<sub>3</sub>H<sub>4</sub>F<sub>2</sub>l<sub>2</sub> and C<sub>3</sub>H<sub>5</sub>FI<sub>2</sub>;
  - introducing an inert gas into the reaction chamber; and
  - etching the silicon-containing film from the substrate to form the via or trench by activating a plasma to form an activated iodine-containing etching compound.
11. The method of claim 10, wherein the iodine-containing etching compound is C<sub>3</sub>HF<sub>6</sub>I.

12. The method of any one of claims 10 to 11, wherein the activated iodine-containing etching compound produces iodine ions that strengthen the patterned mask layer.

13. A method of reinforcing a patterned mask layer while forming a via or trench in a substrate, the method comprising:

introducing a vapor of an iodine-containing etching compound into a reaction chamber containing a substrate having a silicon-containing film disposed thereon and a patterned mask layer disposed on the silicon-containing layer, wherein the iodine-containing etching compound is selected from the group consisting of  $C_2H_2FI$  (1-fluoro-1-iodoethene, CAS No.: 420-28-0),  $C_3HF_6I$ ,  $C_3H_3F_2I$ ,  $C_3H_4FI$ ,  $C_3H_5F_2I$ ,  $C_3H_6FI$ ,  $C_2HFI_2$ ,  $C_2H_2F_2I_2$ ,  $C_2H_3FI_2$ ,  $C_2F_2I_2$ ,  $C_3HF_3I_2$ ,  $C_3HF_5I_2$ ,  $C_3H_2F_4I_2$ ,  $C_3H_3F_3I_2$ ,  $C_3H_4F_2I_2$  and  $C_3H_5FI_2$ ;

introducing an inert gas into the reaction chamber; and

implanting an I ion from the iodine-containing etching compound into the patterned mask while etching the silicon-containing film from the substrate to form the via or trench by activating a plasma to form an activated iodine-containing etching compound.

14. The method of claim 13, wherein the iodine-containing etching compound is  $C_3HF_6I$ .

15. The method of any one of claims 13 to 14, wherein the activated iodine-containing etching compound produces iodine ions that strengthen the patterned mask layer.