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 CF_2I_2, C_2F_3I, C_2H_2FI, $C_2H_3F_2I$, C_2H_4FI, $C_2F_4I_2$, C_3F_5I, C_3HF_4I, $C_3H_2F_3I$, C_3HF_6I, $C_3H_2F_5I$, $C_3H_3F_4I$, $C_3H_4F_3I$, C_3HF_4I, $C_3H_2F_3I$, $C_3H_2F_5I$, $C_3H_3F_4I$, and $C_3H_4F_3I$;

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.

2. The method of claim 1, further comprising 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.

3. The method of claim 2, further comprising introducing an oxidizer into the reaction chamber.

4. The method of claim 3, wherein the oxidizer is selected from the group consisting of O_2, O_3, CO, CO_2, NO, N_2O, NO_2, and combinations thereof.

5. The method of claim 2, further comprising introducing an etch gas into the reaction chamber.

6. The method of claim 5, 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≡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*-$C_4H_2F_6$).

7. The method of claim 1, wherein the inert gas is selected from the group consisting of He, Ar, Xe, Kr, Ne, N_2 or combinations thereof.

8. The method of any claims from 1 to 7, wherein the silicon-containing film comprises a layer of silicon oxide, silicon nitride, polysilicon, crystalline silicon, low-*k* SiCOH, SiOCN, SiON, $Si_aO_bH_cC_dN_e$, where a>0; b, c, d and e ≥ 0, or combinations thereof.

9. The method of any claims from 1 to 7, wherein the silicon-containing film is selectively etched from an amorphous carbon layer or a photoresist layer.

10. The method of any claims from 1 to 7, wherein the silicon oxide layer is selectively etched from a silicon nitride, polysilicon or amorphous carbon layer.

11. The method of any claims from 1 to 7, wherein the method produces an aperture in the silicon-containing film having an aspect ratio between approximately 10:1 and approximately 200:1.

12. 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_2H_2FI, $C_2H_3F_2I$, or C_2H_4FI;

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.

13. The method of claim 12, wherein the activated iodine-containing etching compound produces iodine ions that strengthen the patterned mask layer.

14. 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, $C_2H_3F_2I$, or C_2H_4FI;

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.