

What is claimed is:

1. A method for forming a patterned structure, the method comprising the steps of:
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 has the formula $C_nH_xF_yI_z$, wherein $4 \leq n \leq 10$, $0 \leq x \leq 21$, $0 \leq y \leq 21$, and $1 \leq z \leq 4$;
activating a plasma to produce an activated iodine-containing etching compound;
and
allowing an etching reaction to proceed between the activated iodine-containing etching compound and the silicon-containing film to selectively etch the silicon-containing film from the patterned mask layer, thereby forming the patterned structure.
2. The method of claim 1, further comprising the step of introducing an oxidizer into the reaction chamber, wherein the oxidizer is selected from O_2 , O_3 , CO, CO_2 , NO, N_2O , NO_2 , H_2O , H_2O_2 , COS, SO_2 and combinations thereof.
3. The method of claim 1, further comprising the step of introducing an inert gas into the reaction chamber, wherein the inert gas is selected from the group consisting of He, Ar, Xe, Kr, Ne and N_2 .
4. The method of claim 1, wherein the iodine-containing etching compound is C_4F_9I or its isomers.
5. The method of claim 1, wherein the silicon-containing film comprises a layer of silicon oxide (SiO), silicon nitride (SiN), crystalline Si, poly-silicon (p-Si), polycrystalline silicon, amorphous silicon, low- k SiCOH, SiOCN, SiC, SiON and $Si_aO_bH_cC_dN_e$, where $a > 0$; b , c , d and $e \geq 0$, alternating SiO and SiN (ONON) layers, alternating SiO and p-Si (OPOP) layers.
6. The method of any claims from 1 to 5, wherein the silicon-containing film optionally contains dopants such as B, C, P, As, Ga, In, Sn, Sb, Bi and/or Ge, and combinations thereof.
7. The method of any claims from 1 to 5, wherein an etch rate of etching the silicon oxide layer using the iodine-containing etching compound is higher than an etch rate of

etching the silicon oxide layer using as an alternative etching gases C_4F_8 , C_4F_6 , CF_4 , CH_3F , CF_3H , CH_2F_2 , and combinations thereof.

8. The method of any claims from 1 to 5, wherein the iodine-containing etching compound plasma etches the alternating SiO and SiN (ONON) layers having a selectivity between approximately 1:2 to approximately 2:1 with respect to the SiO layer versus SiN layer.

9. The method of any claims from 1 to 5, wherein the iodine-containing etching compound plasma etches the alternating SiO and SiN (ONON) layers having a selectivity of approximately 1:1 with respect to the SiO layer versus SiN layer.

10. The method of any claims from 1 to 5, wherein the iodine-containing etching compound plasma etches the alternating SiO and p-Si (OPOP) layers having a selectivity between approximately 1:2 to approximately 2:1 with respect to the SiO layer versus p-Si layer.

11. The method of any claims from 1 to 5, wherein the iodine-containing etching compound plasma etches the alternating SiO and p-Si (OPOP) layers having a selectivity of approximately 1:1 with respect to the SiO layer versus p-Si layer.

12. The method of any claims from 1 to 5, wherein the patterned mask layer is an amorphous carbon layer, a doped amorphous carbon layer, a photoresist layer, an anti-reflective layer, an organic planarization layer, and combinations thereof.

13. The method of claim 1, wherein the activated iodine-containing etching compound selectively etches the silicon-containing film from a landing layer located at the bottom of the silicon-containing film to be etched.

14. The method of either claim 1 or claim 13, wherein the landing layer is a metal layer selected from W, Cu, Al, Ru, Pt, Ti, Ta, Ni, Co, Mo, Mn, Nb, Cr, Rh, Pd, Ir, V, Au, Ag or combinations thereof.

15. The method of either claim 1 or claim 13, wherein the landing layer is a metal oxide layer or a metal nitride layer selected from AlO, WO, HfO, TiO, TaO, InO, WO, CrO, RuO, CoO, MoO, ZrO, SnO, TiN, TaN, HfN, AlN, WN, MoN, NiN, NbN, CrN, RuN, CoN, ZrN,

SrN or combinations thereof.

16. The method of any claims from 1 to 5, wherein the patterned structure formed in the silicon-containing film has an aspect ratio between approximately 1:1 and approximately 200:1.

17. A method of reinforcing and/or strengthening and/or minimizing damage of a patterned mask layer while forming a patterned structure 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 the patterned mask layer disposed on the silicon-containing layer, wherein the iodine-containing etching compound has the formula $C_nH_xF_yI_z$, wherein $4 \leq n \leq 10$, $0 \leq x \leq 21$, $0 \leq y \leq 21$, and $1 \leq z \leq 4$; and

etching the silicon-containing film from the patterned mask layer to form the patterned structure using an activated iodine-containing etching compound formed by activating a plasma,

wherein the activated iodine-containing etching compound produces iodine ions, which are implanted into the patterned hardmask layer, thereby strengthening the patterned mask layer.

18. The method of claim 17, wherein the iodine-containing etching compound is C_4F_8I or its isomers.

19. A method of increasing etch resistance of a patterned mask layer in a process of forming a patterned structure 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 the patterned mask layer disposed on the silicon-containing layer, wherein the iodine-containing etching compound has the formula $C_nH_xF_yI_z$, wherein $4 \leq n \leq 10$, $0 \leq x \leq 21$, $0 \leq y \leq 21$, and $1 \leq z \leq 4$;

activating a plasma to produce an activated iodine-containing etching compound capable of doping iodine into the patterned mask layer; and

implanting iodine ions from the activated iodine-containing etching compound into the patterned mask layer while etching the silicon-containing film from the patterned mask layer to form the patterned structure,

thereby modifying the patterned mask layer with iodine to increase the etch resistance of the patterned mask layer.

20. The method of claim 19, wherein the iodine-containing etching compound is C_4F_9I or its isomers.