

What is claimed is:

1. A method for etching silicon-containing films, the method comprising the steps of:

introducing a vapor of a nitrogen containing etching compound into a reaction chamber containing a silicon-containing film on a substrate, wherein the nitrogen containing etching compound comprises an organofluorine compound having a formula selected from the group consisting of $\text{N}\equiv\text{C}-\text{R}^1$, wherein R^1 has the formula $\text{H}_a\text{F}_b\text{C}_c$ and $a=1-11$, $b=1-11$, and $c=1-5$; $(\text{N}\equiv\text{C})-(\text{R}^2)-(\text{C}\equiv\text{N})$, wherein R^2 has the formula $\text{H}_a\text{F}_b\text{C}_c$ with $a=0$, $b=1-11$, and $c=1-5$; and $\text{R}^1_x[-\text{C}=\text{N}(\text{R}^2_z)]_y$, wherein $x=1-2$, $y=1-2$, $z=0-1$, $x+z=1-3$, and each R^1 and R^2 independently has the formula $\text{H}_a\text{F}_b\text{C}_c$ with $a=0-11$, $b=0-11$, and $c=0-5$;

introducing an inert gas into the reaction chamber; and

activating a plasma to produce an activated nitrogen containing etching compound capable of etching the silicon-containing film from the substrate.

2. The method of claim 1, further comprising removing volatile by-products from the reaction chamber, wherein the activated nitrogen containing etching compound reacts with the silicon-containing film to form the volatile by-products.

3. The method of claim 2, wherein the organofluorine compound containing the $\text{C}\equiv\text{N}$ functional group has the formula: $\text{N}\equiv\text{C}-\text{R}^1$, wherein each R^1 is independently a functional group having the formula $\text{H}_a\text{F}_b\text{C}_c$ with $a=1-11$, $b=1-11$, and $c=0-5$.

4. The method of claim 2, wherein the organofluorine compound containing the $\text{C}\equiv\text{N}$ functional group has the formula: $(\text{N}\equiv\text{C})-(\text{R}^1)-(\text{C}\equiv\text{N})$, wherein each R^1 is independently a functional group having the formula $\text{H}_a\text{F}_b\text{C}_c$ with $a=0-11$, $b=1-11$, and $c=0-5$.

5. The method of claim 2, wherein the organofluorine compound containing the $\text{C}=\text{N}$ functional groups has the formula: $\text{R}^1_x[-\text{C}=\text{N}(\text{R}^2_z)]_y$, wherein $x=1-2$, $y=1-2$, $z=0-1$, $x+z=1-3$, and each R^1 and R^2 independently has the formula $\text{H}_a\text{F}_b\text{C}_c$ with $a=0-11$, $b=0-11$, and $c=0-5$.

6. The method of claim 1, wherein the organofluorine compound is selected from the group consisting of 2,2,3,3-tetrafluoropropionitrile, 2,3,3,3-tetrafluoropropionitrile (C_3HF_4N), difluoroacetonitrile (C_2HF_2N), Hexafluoroacetone imine (C_3HF_6N); 4,4,4-Trifluorocrotono-nitrile, 3,3,3-Trifluoropropionitrile, fluoroacetonitrile, octafluorohexane-1,6-dinitrile, 1,1-bis(trifluoromethyl)-2,2-dicyanoethylene, N,1,1,1,3,3,3-heptafluoro-propanamine, and 1,1,1,6,6,6-Hexafluoro-3-azahept-3-ene.

7. The method of claim 6, wherein the organofluorine compound is 2,3,3,3-tetrafluoropropionitrile (C_3HF_4N).

8. The method of claim 6, wherein the organofluorine compound is difluoroacetonitrile (C_2HF_2N).

9. The method of any one of claims 1 to 8, further comprising introducing an oxidizer into the reaction chamber.

10. The method of any one of claims 1 to 8, 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 $e \geq 0$, or combinations thereof.

11. The method of claim 10, wherein the silicon-containing film is selectively etched from an amorphous carbon layer or a photoresist layer.

12. The method of claim 10, wherein the silicon oxide layer is selectively etched from a silicon nitride, polysilicon or amorphous carbon layer.

13. The method of claim 9, wherein the method produces an aperture in the silicon-containing film having an aspect ratio between approximately 10:1 and approximately 200:1.

14. A nitrogen containing etching compound comprising an organofluorine compound having a formula selected from the group consisting of $N \equiv C-R^1$, wherein R^1 has the formula $H_aF_bC_c$ and $a=1-11$, $b=1-11$, and $c=1-5$; $(N \equiv C-)(R^1)-(-C \equiv N)$,

wherein each R^1 independently has the formula $H_aF_bC_c$ with $a=0$, $b=1-11$, and $c=1-5$; and $R^1_x[-C=N(R^2_z)]_y$, wherein $x=1-2$, $y=1-2$, $z=0-1$, $x+z=1-3$, and each R^1 and R^2 independently has the formula $H_aF_bC_c$ with $a=0-11$, $b=0-11$, and $c=0-5$.

15. The nitrogen containing etching compound of claim 14, wherein the organofluorine compound is selected from the group consisting of difluoroacetonitrile, 2,3,3,3-tetrafluoropropionitrile, 2,2,3,3-tetrafluoropropionitrile, hexafluoroacetone imine, 4,4,4-Trifluorocrotono-nitrile, 3,3,3-Trifluoropropionitrile, fluoroacetonitrile, octafluorohexane-1,6-dinitrile, 1,1-bis(trifluoromethyl)-2,2-dicyanoethylene, N,1,1,1,3,3,3-heptafluoro-propanamine, and 1,1,1,6,6,6-Hexafluoro-3-azahex-3-ene.