

Claims:

1. A method for processing a substrate, comprising:
forming a dielectric layer on patterned features of the substrate by exposing the substrate to a gas mixture of a first precursor and a second precursor simultaneously with plasma present in a process chamber, wherein the plasma is formed by a first pulsed RF power;
exposing the dielectric layer to a plasma treatment using a gas mixture of nitrogen and helium in the process chamber; and
performing a plasma etch process by exposing the dielectric layer to a plasma formed from a gas mixture of a fluorine-containing precursor and a carrier gas, wherein the plasma is formed in the process chamber by a second pulsed RF power.
2. The method of claim 1, further comprising:
exposing the dielectric layer to a silicon-containing precursor after exposing the dielectric layer to the first plasma treatment and prior to performing the plasma etch process.
3. The method of claim 2, wherein the silicon-containing precursor comprises silane.
4. The method of claim 2, wherein the dielectric layer is exposed to a nitrogen-containing gas while exposing to the silicon-containing gas.
5. The method of claim 1, further comprising purging the process chamber before and/or after the first plasma treatment.
6. The method of claim 1, wherein the patterned features are trenches having an aspect ratio of about 3:1 to about 10:1.
7. A method for processing a substrate, comprising:

forming a dielectric layer on patterned features of the substrate by a plasma deposition process, wherein a first plasma is formed by a first pulsed RF power in a process chamber;

densifying the dielectric layer by a plasma treatment; and

etching a portion of the dielectric layer by a plasma etch process, wherein a second plasma is formed from a gas mixture of a fluorine-containing gas and a carrier gas, wherein the second plasma is formed in the process chamber by a second pulsed RF power.

8. The method of claim 7, wherein the first and second pulsed RF power has a duty cycle in a range from about 5 % to about 30 % and a frequency in a range from about 10 kHz to about 20 kHz.

9. The method of claim 7, wherein the second pulsed RF power has a pulsing width of about 1 μ s to about 50 μ s.

10. The method of claim 7, wherein the fluorine-containing gas of the plasma etch process comprises NF_3 , F_2 , C_2F_6 , CF_4 , C_3F_8 , or SF_6 .

11. The method of claim 7, wherein the ratio of the fluorine-containing gas and the carrier gas is in a range of about 1 (fluorine-containing gas):6 (carrier gas) to about 1 (fluorine-containing gas):20 (carrier gas).

12. A method for processing a substrate, comprising:

forming a dielectric layer on patterned features of the substrate by a plasma deposition process, wherein a first plasma is formed by a first pulsed RF power in a process chamber;

densifying the dielectric layer by a plasma treatment using a gas mixture of nitrogen and helium in the process chamber;

forming a first passivation layer on the dielectric layer;

etching the first passivation layer and a portion of the dielectric layer by a plasma etch process to form an etched dielectric layer, wherein a second plasma is formed in the process chamber by a second pulsed RF power; and

forming a second passivation layer on the etched dielectric layer.

13. The method of claim 12, wherein the plasma treatment uses a gas mixture of nitrogen and helium in the process chamber.

14. The method of claim 13, wherein a ratio of the nitrogen and helium in the plasma treatment is in a range of about 1 (nitrogen):3 (helium) to about 1 (nitrogen):10 (helium).

15. The method of claim 112, wherein the first and second passivation layers comprise silicon layers.