CLAIMS

What is claimed is:

1. An apparatus for etching high aspect ratio features in a dielectric layer, comprising:

a plasma processing chamber, comprising:

a chamber wall forming a plasma processing chamber enclosure;

a lower electrode for providing power to the plasma processing chamber enclosure over which the substrate is supported;

an upper electrode for providing power to the plasma processing chamber enclosure spaced apart above the lower electrode;

a gas inlet for providing gas into the plasma processing chamber enclosure; and

a gas outlet for exhausting gas from the plasma processing chamber enclosure;

a high frequency radio frequency (RF) power source, electrically connected to at least one of the upper electrode or lower electrode;

a bias power system electrically connected to both the upper electrode and the lower electrode, wherein the bias power system is able to provide a bias to the upper and lower electrodes with a magnitude of at least 500 volts, and wherein the bias to the upper electrode creates secondary electrons and wherein the bias to the lower electrode is pulsed to intermittently collapse a generated plasma sheath with the secondary electrons;

a gas source in fluid connection with the gas inlet, comprising a dielectric etching gas source; and

a controller controllably connected to the gas source, the high frequency RF power source, and the bias power system.

2. The apparatus, as recited in claim 1, wherein the bias power system comprises:

a bias power source; and

a switch for alternatingly connecting the bias power source to the upper and lower electrodes.

3. The apparatus, as recited in claim 2, wherein the bias power source is a low frequency RF power source.

4. The apparatus, as recited in claim 3, wherein the controller comprises:

a processor; and

computer readable media, comprising:

computer readable code for providing dielectric etching gas from the dielectric etching gas source into the plasma processing chamber;

computer readable code for providing power from the high frequency RF power source to form the etching gas into an etching plasma;

computer readable code for switching the switch to alternatingly connect the bias power source to the upper and lower electrodes.

5. The apparatus, as recited in claim 4, wherein the computer readable code for switching the switch, performs the switching at a frequency of between 10 Hz to 100 kHz.

6. The apparatus, as recited in claim 1, wherein the controller comprises:

a processor; and

computer readable media, comprising:

computer readable code for providing dielectric etching gas from the dielectric etching gas source into the plasma processing chamber;

computer readable code for providing power from the high frequency RF power source to form the etching gas into a etching plasma;

computer readable code for pulsing the bias to the lower electrode.

7. The apparatus, as recited in claim 6, wherein the computer readable code for providing the pulsed bias power to the lower electrode, provides the pulsed bias power at a frequency of between 10 Hz to 100 kHz.

8. The apparatus, as recited in claim 1, wherein the bias to the upper electrode is pulsed at a frequency equal to a frequency of pulsed bias power to the lower electrode.

9. The apparatus, as recited in claim 1, wherein the bias power system, comprises:

a first bias source electrically connected to the upper electrode;

a first pulse source electrically connected to the first bias source;

a second bias source electrically connected to the lower electrode; and

a second pulse source electrically connected to the second bias source.

10. The apparatus, as recited in claim 1, wherein the upper electrode and lower electrode are parallel plate electrodes.

11. An apparatus for etching high aspect ratio features in a dielectric layer, comprising:

a plasma processing chamber, comprising:

a chamber wall forming a plasma processing chamber enclosure;

a lower electrode for providing power to the plasma processing chamber enclosure over which the substrate is supported;

an upper electrode for providing power to the plasma processing chamber enclosure spaced apart above the lower electrode;

a gas inlet for providing gas into the plasma processing chamber enclosure; and

a gas outlet for exhausting gas from the plasma processing chamber enclosure;

a high frequency radio frequency (RF) power source, electrically connected to at least one of the upper electrode or lower electrode;

a bias power system electrically connected to both the upper electrode and the lower electrode, comprising:

a low frequency RF source; and

a switch electrically connected between the low frequency RF source and the upper electrode and lower electrode for alternatingly switching between the upper electrode and lower electrode;

a gas source in fluid connection with the gas inlet, comprising a dielectric etching gas source; and

~~a controller controllably connected to the gas source, the high frequency RF power source, and the bias power system.~~

~~12. The apparatus, as recited in claim 11, wherein the controller comprises:~~

~~a processor; and~~

~~computer readable media, comprising:~~

~~computer readable code for providing dielectric etching gas from the dielectric etching gas source into the plasma processing chamber;~~

~~computer readable code for providing power from the high frequency RF power source to form the etching gas into a etching plasma;~~

~~computer readable code for switching the switch to alternatingly connect the bias power source to the upper and lower electrodes.~~

~~13. The apparatus, as recited in claim 11, wherein the computer readable code for switching the switch performs the switching at a frequency of between 10 Hz to 100 kHz.~~

~~14. The apparatus, as recited in claim 11, wherein the upper electrode and lower electrode are parallel plate electrodes.~~

~~15~~1. A method for etching high aspect ratio features in a dielectric layer over a substrate in a plasma processing chamber, comprising:

placing the substrate in the plasma processing chamber, with an upper electrode and a lower electrode, wherein the substrate is placed over the lower electrode, and wherein the upper electrode is spaced apart above the lower electrode and the substrate;

providing an etching gas into the plasma processing chamber;

forming a plasma in the plasma processing chamber, between the upper electrode and the lower electrode;

providing a bias to the upper electrode of at least 500 volts to ~~form~~ provide secondary electrons with enough energy to pass through the plasma sheath to vias, wherein a positive charge at the bottom of the vias accelerates the secondary electrons to the bottom of the vias; ~~and~~

providing a pulsed bias of at least 500 volts to the lower electrode for etching the dielectric layer; and

wherein the forming a plasma in the plasma processing chamber, between the upper electrode and the lower electrode, comprises providing a high frequency RF with a frequency of over 10 MHz to at least one of the upper electrode or lower electrode.

~~16~~2. The method, as recited in claim ~~15~~ 1, wherein the providing bias to the upper electrode comprises pulsing the bias to the upper electrode, so that bias is alternated between the upper electrode and the lower electrode.

~~17~~3. The method, as recited in claim ~~16~~ 2, wherein the providing bias to the upper electrode, further comprise providing a low frequency RF power to the upper electrode, and wherein the providing bias to the lower electrode comprises providing a low frequency RF power to the lower electrode.

~~18~~4. The method, as recited in claim ~~15~~ 1, wherein the providing bias to the upper electrode and providing bias to the lower electrode, comprises switching a bias between the upper electrode and lower electrode.

~~19. The method, as recited in claim 18, wherein the switch is performed at a frequency between 10 Hz to 100 kHz.~~

5. The method, as recited in claim 1, wherein the providing the bias to the upper electrode accelerates ions into the upper electrode to generate the secondary electrons and accelerates the secondary electrons to bottoms of vias and wherein the providing a pulsed bias of at least 500 volts to the lower electrode is pulsed to collapse a generated plasma sheath.

6. The method, as recited in claim 5, wherein the providing bias to the upper electrode and providing bias to the lower electrode are alternately switched a plurality of times, comprising switching a bias between the upper electrode and the lower electrode a plurality of times.

7. The method, as recited in claim 6, wherein the providing bias to the lower electrode accelerates positive ions to bottoms of vias to provide etching of the vias, which creates a positive charge at bottoms of the vias, and wherein the secondary electrons reduce the positive charge at bottoms of the vias.

8. The method, as recited in claim 7, wherein the high aspect ratio features have aspect ratios of at least 20-to-1.

9. The method, as recited in claim 1, wherein the providing bias to the upper electrode and providing bias to the lower electrode are alternately switched a plurality of times, comprising switching a bias between the upper electrode and the lower electrode a plurality of times.

10. The method, as recited in claim 1, wherein the providing bias to the lower electrode accelerates positive ions to bottoms of vias to provide etching of the vias, which creates a positive charge at bottoms of the vias, and wherein the secondary electrons reduce the positive charge at bottoms of the vias.

11. The method, as recited in claim 1, wherein the high aspect ratio features have aspect ratios of at least 20-to-1.

12. The method, as recited in claim 1, wherein providing the secondary electrons to the bottom of the vias reduces twisting that results from asymmetric etching.

13. A method for etching high aspect ratio features in a dielectric layer over a substrate in a plasma processing chamber, comprising:

placing the substrate in the plasma processing chamber, with an upper electrode and a lower electrode, wherein the substrate is placed over the lower electrode, and wherein the upper electrode is spaced apart above the lower electrode and the substrate;

providing an etching gas into the plasma processing chamber;

forming a plasma in the plasma processing chamber, between the upper electrode and the lower electrode;

providing a bias to the upper electrode of at least 500 volts to provide secondary electrons with enough energy to pass through a plasma sheath to vias, wherein a positive charge at the bottom of the vias accelerates the secondary electrons to the bottom of the vias;

providing a pulsed bias of at least 500 volts to the lower electrode for etching the dielectric layer, wherein the providing bias to the upper electrode and providing bias to the lower electrode, comprises switching a bias between the upper electrode and lower electrode, wherein the switch is performed at a frequency between 10 Hz to 100 kHz; and

wherein the forming a plasma in the plasma processing chamber, between the upper electrode and the lower electrode, comprises providing a high frequency RF with a frequency of over 10 MHz to at least one of the upper electrode or lower electrode.