

CLAIMS

What is claimed is:

1. A method for etching features in a dielectric layer over a substrate, comprising:
placing the substrate with the dielectric layer on a bottom electrode inside an etch reactor;
delivering an etch gas into the etch reactor;
delivering a first RF power with a first frequency into the etch reactor, ~~whereas~~ wherein the first frequency is between 100 kHz and 600 kHz;
delivering a second RF power with a second frequency into the etch reactor, ~~whereas~~ wherein the second frequency is at least 10 MHz; and
etching the dielectric layer to form at least one ultra-high aspect ratio (UHAR) feature, ~~whereas-wherein~~ the at least one ultra-high aspect ratio feature has a width no greater than ~~300~~150 nanometers (nm) and the ultra-high aspect ratio is at least ~~15-to-1~~ 20-to-1, wherein twisting is minimized.
2. The method of claim 1, ~~whereas-wherein~~ the first frequency is 400 kHz.
3. The method of claim 1, ~~whereas-wherein~~ the first frequency is between 350 kHz and 450 kHz.
4. ~~The method of claims 1, whereas the first RF power is between 100 W to 10000 W.~~
5. ~~The method of claim 1, wherein twisting is minimized.~~
64. The method of claim 1, further comprising:
delivering a third RF power with a third frequency into the etch reactor, ~~whereas~~ wherein the third frequency is at least 40 MHz.
75. The method of claim 1, ~~whereas-wherein~~ the dielectric layer is of a silicon oxide

based material.

86. The method of claim-~~6~~4, wherein the second frequency is between 27 MHz and 40 MHz.

97. The method of claim-~~8~~6, wherein the delivering of the first RF power delivers the first RF power to the bottom electrode and wherein the delivering of the second RF power delivers the second RF power to the bottom electrode.

~~10.~~ The method of claim ~~9~~, whereas the first frequency is between 350 kHz and 450 kHz.

~~118.~~ The method of claim-~~6~~4, wherein the second frequency is about 27 MHz.

~~129.~~ The method of claim-~~11~~8 wherein the delivering of the first RF power delivers the first RF power to the bottom electrode and wherein the delivering of the second RF power delivers the second RF power to the bottom electrode.

~~1310.~~ The method of claim-~~11~~8, whereas wherein the first frequency is between 350 kHz and 450 kHz.

~~1411.~~ The method of claim 1, wherein the delivering of the first RF power delivers the first RF power to the bottom electrode and wherein the delivering of the second RF power delivers the second RF power to the bottom electrode.

~~15.~~ The method of claim ~~14~~, whereas the first frequency is between 350 kHz and 450 kHz.

~~1612.~~ The method of claim-~~9~~7, wherein the delivering of the third RF power delivers the third RF power to the bottom electrode.

~~1713.~~ The method of claim-~~14~~11, wherein the third frequency is about 60 MHz.

14. The method of claim 1, further comprising delivering a third RF power with a third frequency into the etch reactor, wherein the third frequency is at least 40 MHz, and wherein the second frequency is between 10 MHz and 40 MHz, and wherein the delivering of the first RF power, the delivering of the second RF power and delivering of the third RF power deliver the first RF power, the second RF power, and the third RF power to the bottom electrode.

~~19. The method, as recited in claim 18, wherein the second frequency is between 27 and 40 MHz.~~

15. The method, as recited in claim 1, wherein twisting comprises deviations of location, orientation, shape, and size near bottom of a feature from a pattern defined by a mask on top of the feature.

16. A method for etching features in a dielectric layer over a substrate, comprising:
placing the substrate with the dielectric layer on a bottom electrode inside an etch reactor;

delivering an etch gas into the etch reactor;

delivering a first RF power with a first frequency into the etch reactor, wherein the first frequency is between 100 kHz and 600 kHz;

delivering a second RF power with a second frequency into the etch reactor, wherein the second frequency is at least 10 MHz; and

etching the dielectric layer to form at least one ultra-high aspect ratio (UHAR) feature, wherein the at least one ultra-high aspect ratio feature has a width no greater than 150 nanometers (nm) and the ultra-high aspect ratio is at least 20-to-1.

17. The method, as recited in claim 16, wherein the etch gas is free of nitrogen trifluoride.

18. The method, as recited in claim 16, wherein the etch gas is free of sulfur hexafluoride.

19. The method, as recited in claim 9, wherein the etch gas is free of hydrofluorocarbon.