

CLAIMS

1. An apparatus for removing material from sidewalls of features on a semiconductor substrate surface, comprising:
 - (a) a reaction chamber;
 - (b) an ion extractor plate positioned in the reaction chamber, thereby dividing the reaction chamber into a plasma generation sub-chamber and a processing sub-chamber, wherein at least part of the ion extractor plate is corrugated, and wherein the ion extractor plate has apertures designed or configured to permit the passage of ions therethrough;
 - (c) one or more gas inlets to the plasma generation sub-chamber;
 - (d) one or more gas outlets to the reaction chamber;
 - (e) a plasma generation source designed or configured to produce a plasma in the plasma generation sub-chamber; and
 - (f) a substrate support.
2. The apparatus of claim 1, further comprising a controller designed or configured to generate a plasma in the plasma generation sub-chamber, apply a bias to the ion extractor plate, and rotate the ion extractor plate by less than or equal to about 360° as measured in a single direction.
3. The apparatus of claim 2, wherein the controller is further designed or configured to rotate the ion extractor plate clockwise and counterclockwise while removing material from said sidewalls of said substrate.
4. The apparatus of claim 1, further comprising RF straps connecting the ion extractor plate with the substrate support, wherein the RF straps are designed or configured to provide a bias on the substrate support that corresponds to the bias applied to the ion extractor plate.
5. The apparatus of claim 1, wherein axes extending through the centers of the apertures are oriented normal to the local surfaces of the ion extractor plate where the apertures are positioned, to thereby direct passage of ions in a direction that is generally normal to the local surface of the ion extractor plate.
6. The apparatus of claim 1, wherein at least some of the apertures are cone-shaped, such that when considering a single aperture, an aperture open area on the side of the ion

extractor plate facing the processing sub-chamber is larger than an aperture open area on the side of the ion extractor plate facing the plasma generation sub-chamber.

7. The apparatus of claim 1, wherein the corrugated part of the ion extractor plate comprises a plurality of cone-shaped features, wherein the apertures are positioned such that they extend through surfaces of the cone-shaped features that are slanted with respect to the substrate support.

8. The apparatus of claim 1, wherein the ion extractor plate comprises a plurality of corrugated segments, wherein the orientation of corrugation is different between adjacent segments.

9. The apparatus of claim 8, wherein at least two distinct types of corrugated segments are used.

10. The apparatus of claim 9, wherein a first distinct segment type is designed or configured to direct ions in a direction radially offset from a direction normal to the processing face of the substrate and a second segment type is designed or configured to direct ions in a direction azimuthally offset from a direction normal to the processing face of the substrate.

11. The apparatus of claim 1, wherein an angle of corrugation is between about $1-75^{\circ}$.

12. The apparatus of claim 11, wherein at least two angles of corrugation are used.

13. The apparatus of claim 1, wherein a distance between the average position of the ion extractor plate and a plating face of a substrate, when present on the substrate support, is less than about 10 cm.

14. The apparatus of claim 1, wherein the ion extractor plate is rotatable about an axis extending through the center of the ion extractor plate.

15. The apparatus of claim 1, further comprising a translation actuator for moving the ion extractor plate toward and away from the substrate support during processing of the substrate.

16. The apparatus of claim 1, wherein a distance between adjacent corrugation peaks of the ion extractor plate is at least about 2 mm.
17. The apparatus of claim 1, wherein a distance between adjacent corrugation peaks of the ion extractor plate is between about 5-20 mm.
18. The apparatus of claim 1, wherein patterns of aperture position vary between adjacent corrugation features.
19. The apparatus of claim 1, wherein the reaction chamber is configured to etch a substrate in a vertical direction when the corrugated ion extractor plate is not present, and to etch a substrate in a plurality of angled directions when the corrugated ion extractor plate is present.