CLAIMS

1. An apparatus for treating a surface with plasma, comprising:

a pedestal with a sample support area that is configured to retain a sample for plasma treatment;

an assistant plate surrounding the sample support area with a central opening configured to contain the sample;

an ignition plate adjacent to the assistant plate, the ignition plate has a solid upper surface that is configured to interact with the plasma during plasma ignition; and

a plasma reactor configured to produce the plasma and positioned above the pedestal, the plasma reactor has one or more plasma heads extending wider than the central opening of the assistant plate and is positionable over the ignition plate and the assistant plate.

2. The apparatus of claim 1, wherein the plasma is atmospheric pressure (AP) plasma.

3. The apparatus of claim 1, further comprising:

an optical emission spectrometer (OES) sensor configured to monitor characteristics of the plasma.

4. The apparatus of claim 1, further comprising:

a controller configured to (a) ignite the plasma over the ignition plate, wherein the plasma formed by the one or more plasma heads of the plasma reactor is positioned above the ignition plate and (b) move the plasma reactor over the central opening of the assistant plate while maintaining the plasma.

5. The apparatus of claim 4, wherein the controller is configured to monitor the plasma during treatment of the sample to determine an endpoint of the treatment based on an oxygen peak level.

6. The apparatus of claim 4, wherein the controller is configured to scan the plasma reactor back and forth over the central opening of the assistant plate.

7. The apparatus of claim 1, further comprising:

a plurality of gas nozzles configured to flow one or more gases around the one or more plasma heads.

8. The apparatus of claim 1, wherein the one or more plasma heads is positioned approximately 1 mm to approximately 2 mm above the ignition plate and above uppermost surfaces of the assistant plate.

9. The apparatus of claim 1, wherein at least one of a plurality of plasma heads is configured to extend over at least one end of the assistant plate during plasma treatment.

10. The apparatus of claim 1, wherein the one or more plasma heads has a central RF electrode surrounded by dielectric material with one ground electrode on each side of the central RF electrode.

11. The apparatus of claim 1, wherein the sample is a photomask, and the apparatus is configured to modify a surface of the photomask, to remove a photoresist layer on top of the photomask, or to remove organic defects.

12. A method of treating a surface with plasma, comprising:

igniting the plasma over an ignition plate, the plasma formed by one or more plasma heads of a plasma reactor positioned above the ignition plate; and

moving the plasma reactor over a central opening of an assistant plate while maintaining the plasma, wherein one or more plasma heads of the plasma reactor is wider than the central opening in the assistant plate.

13. The method of claim 12, further comprising:

monitoring the plasma to determine an endpoint of a treatment based on an oxygen peak level.

14. The method of claim 12, further comprising:

scanning back and forth over the central opening of the assistant plate with at least one of a plurality of plasma heads extending over the assistant plate at each end of a single scan to obtain identical plasma residence time on the surface disposed in the central opening.

15. The method of claim 12, wherein a sample disposed in the central opening is a photomask.

16. The method of claim 15, further comprising:

modifying a surface of the photomask;

removing a photoresist layer on top of the photomask; or

removing organic defects.

17. The method of claim 12, further comprising:

flowing a gas mixture of argon gas and oxygen-based gas around an RF electrode of one or more plasma heads.

18. The method of claim 17, further comprising:

flowing water vapor with the gas mixture to produce hydroxyl.

19. The method of claim 12, further comprising:

flowing a gas mixture of argon gas and hydrogen-based forming gas around an RF electrode of one or more plasma heads.

20. A non-transitory, computer readable medium having instructions stored thereon that, when executed, cause a method of treating a surface with plasma to be performed, the method comprising:

igniting the plasma over an ignition plate, the plasma formed by one or more plasma heads of a plasma reactor positioned above the ignition plate; and

moving the plasma reactor over a central opening of an assistant plate while maintaining the plasma, wherein the one or more plasma heads of the plasma reactor is wider than the central opening in the assistant plate.