CLAIMS

1. A substrate processing system, comprising:

a process chamber;

a remote plasma source coupled to a processing volume of the process chamber by a plasma conduit;

a mixing plate disposed between the process chamber and the remote plasma source, the mixing plate including an opening therein through which the plasma conduit extends, the mixing plate including:

a first passage formed in the mixing plate and fluidly coupled to the plasma conduit, the first passage oriented tangentially with respect to the plasma conduit, the first passage including a primary axis extending along a fluid flow path of first passage, and a first outlet which opens into the plasma conduit; and

a second passage fluidly coupled to the plasma conduit, the second passage positioned inward of the first passage relative to a center of the plasma conduit, the second passage including a second outlet which opens into the plasma conduit, and a primary axis extending along a fluid flow path of the second passage, the primary axis of the second passage parallel to the primary axis of the first passage, the primary axis of the second passage and the primary axis of the first passage are disposed in a common plane.

2. The substrate processing system of claim 1, wherein the first passage of the mixing plate and the second passage of the mixing plate are fluidly coupled upstream of the plasma conduit by a third passage formed in the mixing plate.

3. The substrate processing system of claim 2, further comprising a fourth passage formed in the mixing plate, the fourth passage oriented tangentially with respect to the plasma conduit.

4. The substrate processing system of claim 3, further comprising a fifth passage formed in the mixing plate, the fifth passage fluidly coupled to the plasma conduit, the fifth passage positioned parallel to the fourth passage.

5. The substrate processing system of claim 4, wherein the fourth passage of the mixing plate and the fifth passage of the mixing plate are fluidly coupled upstream of the plasma conduit by a sixth passage formed in the mixing plate.

6. The substrate processing system of claim 5, wherein the second passage of the mixing plate is offset from a centerline of plasma conduit in the common plane of the mixing plate, the plane of the mixing plate orthogonal to the plasma conduit.

7. The substrate processing system of claim 6, wherein the fifth passage of the mixing plate is offset from the centerline of plasma conduit in the common plane of the mixing plate.

8. A substrate processing system, comprising:

a process chamber;

a remote plasma source coupled to a processing volume of the process chamber by a plasma conduit;

a mixing plate disposed between the process chamber and the remote plasma source, the mixing plate including an opening therein through which the plasma conduit extends, the mixing plate including:

a first passage formed therein and fluidly coupled to the plasma conduit, the first passage oriented tangentially with respect to the plasma conduit, the first passage including a first outlet which opens into the plasma conduit; and

a second passage fluidly coupled to the plasma conduit, the second passage positioned parallel to and adjacent the first passage, the second passage including a second outlet which opens into the plasma conduit, the second and the first passage are disposed in a common plane.

9. The substrate processing system of claim 8, wherein the first passage has a first length and second passage has a second length less than the first length.

10. The substrate processing system of claim 9, the second passage positioned inward of the first passage relative to a center of the plasma conduit.

11. The substrate processing system of claim 10, wherein the first passage of the mixing plate and the second passage of the mixing plate are fluidly coupled upstream of the plasma conduit by a third passage formed in the mixing plate.

12. The substrate processing system of claim 11, further comprising a fourth passage formed in the mixing plate, the fourth passage oriented tangentially with respect to the plasma conduit.

13. The substrate processing system of claim 12, further comprising a fifth passage formed in the mixing plate, the fifth passage fluidly coupled to the plasma conduit, the fifth passage positioned parallel to the fourth passage.

14. The substrate processing system of claim 13, wherein the fourth passage of the mixing plate and the fifth passage of the mixing plate are fluidly coupled upstream of the plasma conduit by a sixth passage formed in the mixing plate.

15. The substrate processing system of claim 14, wherein the second passage of the mixing plate is offset from a centerline of plasma conduit in the common plane, the common plane of the mixing plate orthogonal to the centerline of the plasma conduit.

16. The substrate processing system of claim 15, wherein the fifth passage of the mixing plate is offset from the centerline of plasma conduit in the common plane.

17. A gas injection assembly, comprising:

a mixing plate, the mixing plate including an opening therein, the opening defining a plasma conduit, the opening including a central axis which is orthogonal to a major surface of the mixing plate, the mixing plate including:

a first passage formed in the mixing plate and fluidly coupled to the plasma conduit, the first passage oriented tangentially with respect to the plasma conduit, the first passage including a primary axis extending along a fluid flow path of first passage;

a second passage fluidly coupled to the plasma conduit, the second passage positioned inward of the first passage relative to a center of the plasma conduit, the second passage parallel to the first passage, the second passage including a primary axis extending along a fluid flow path of the second passage, the primary axis of the second passage parallel to the primary axis of the first passage, the primary axis of the second passage and the primary axis of the first passage are disposed in a common plane;

a third passage formed in the mixing plate, the third passage fluidly coupling the first passage to the second passage;

a fourth passage formed in the mixing plate and fluidly coupled to the plasma conduit, the fourth passage oriented tangentially with respect to the plasma conduit;

a fifth passage fluidly coupled to the plasma conduit, the fifth passage positioned inward of the first passage relative to the center of the plasma conduit, the second passage parallel to the fourth passage; and

a sixth passage formed in the mixing plate, the sixth passage fluidly coupling the fourth passage to the fifth passage.

18. The gas injection assembly of claim 17, wherein the mixing plate is divided into quadrants in the common plane, and wherein the first and second passages are located in a first quadrant, and the fourth and fifth passages are located in a second quadrant.

19. The gas injection assembly of claim 18, wherein the third and fourth quadrants are located between the first and second quadrants.

20. The gas injection assembly of claim 19, wherein the third passage is located in both first and third quadrants, and the sixth passage is located in both the second and forth quadrants.