CLAIMS

What is claimed is:

1. A device for cleaning a substrate, comprising:

a double-sided scrubber including a pair of brushes, wherein each brush of the pair of brushes is (a) substantially cylindrical and is configured to rotate about a longitudinal axis of the brush, and (b) extends around a conduit that is configured to direct a liquid through the brush, and wherein the pair of brushes are arranged such that the substrate is configured to move back-and-forth between the pair of brushes with the longitudinal axis of each brush of the pair of brushes extending parallel to each other on opposite sides of the substrate;

a gripper configured to grip the substrate and translate the substrate, wherein the gripper is configured to translate the substrate in a back-and-forth motion on a straight axis located between the brushes of the pair of brushes, and wherein the gripper is configured to translate the substrate in the back-and-forth motion while the brushes of the pair of brushes are in contact with the substrate;

a first set of nozzles fluidly coupled together and configured to spray a first liquid at an interface between the substrate and the pair of brushes, wherein the first set of nozzles includes a plurality of pairs of first nozzles spaced apart from each other along the longitudinal axis of each brush, and wherein each pair of first nozzles includes two first nozzles mirror-symmetrically positioned on opposite sides of the substrate; and

a second set of nozzles fluidly coupled together and configured to spray a second liquid at the interface, wherein the second set of nozzles includes a plurality of pairs of second nozzles spaced apart from each other along the longitudinal axis

of each brush, and wherein each pair of second nozzles includes two second nozzles mirror-symmetrically positioned on opposite sides of the substrate.

2. The device of claim 1, further including a third set of nozzles fluidly coupled together and configured to spray a third liquid at the interface, wherein the third set of nozzles includes a plurality of pairs of third nozzles spaced apart from each other along the longitudinal axis of each brush, and wherein each pair of third nozzles includes two third nozzles mirror-symmetrically positioned on opposite sides of the substrate.

3. The device of claim 1, further including a housing enclosing the pair of brushes, the first set of nozzles, and the second set of nozzles, and wherein a volume within the housing is maintained at a sub-atmospheric pressure.

4. The device of claim 1, wherein the gripper is configured to drive the substrate at a rate of about 5-50 mm/sec.

5. The device of claim 1, wherein the pair of brushes are arranged such that, when the substrate is positioned between the pair of brushes, each brush of the pair of brushes compresses by a distance between about 0-3 mm.

6. The device of claim 1, wherein the conduit is configured to direct about 0.5 – 5 liters/minute of the liquid through each brush of the pair of brushes.

7. The device of claim 1, wherein each brush of the pair of brushes is configured to rotate at a rotational speed between about 10-500 RPM.

8. The device of claim 9, wherein the brushes of the pair of brushes are configured to rotate in opposite directions.

9. The device of claim 1, wherein the plurality of pairs of first nozzles includes 2-10 pairs of first nozzles, and the plurality of pairs of second nozzles includes 2-10 pairs of second nozzles.

10. The device of claim 1, wherein the brush comprises bristles of a polymer or molded PVA.

11. The device of claim 1, wherein each first nozzle of the first set of nozzles and each second nozzle of the second set of nozzles includes a central axis inclined at an angle between about 20-70 degrees with a surface of the substrate.

12. The device of claim 1, further including a fourth set of nozzles fluidly coupled together and configured to spray of a fourth liquid at the interface, wherein the fourth set of nozzles includes a plurality of pairs of fourth nozzles spaced apart from each other along the longitudinal axis of the scrubber, and wherein each pair of fourth nozzles includes two fourth nozzles mirror-symmetrically positioned on opposite sides of the substrate.

13. A method of cleaning a substrate using a double-sided scrubber, comprising:

moving a substrate back-and-forth between a pair of rotating brushes of the double-sided scrubber;

directing de-ionized water to the moving substrate through the pair of rotating brushes;

spraying a first liquid through a first set of nozzles at an interface between the substrate and the pair of rotating brushes for a first time period as the substrate moves back-and-forth between the pair of rotating brushes; and

after the first time period, spraying de-ionized water through a second set of nozzles at the interface between the substrate and the pair of rotating brushes for a second time period as the substrate moves back-and-forth between the pair of rotating brushes.

14. The method of claim 13, further including, after the second time period, spraying a second liquid through a third set of nozzles at the interface between the substrate and the pair of rotating brushes for a third time period as the substrate moves back-and-forth between the pair of rotating brushes.

15. The method of claim 14, wherein spraying the first liquid includes spraying the first liquid when de-ionized water is directed to the moving substrate through the pair of rotating brushes, and

wherein spraying the second liquid includes spraying the second liquid when de-ionized water is directed to the moving substrate through the pair of rotating brushes.