CLAIMS

1. A method for cleaning a semiconductor substrate, comprising:

applying a liquid medium to a surface of the semiconductor substrate so as to substantially cover a portion of the surface of the semiconductor substrate being cleaned; and

applying an acoustic energy to the semiconductor substrate so as to enable the semiconductor substrate to vibrate, the semiconductor substrate having a plurality of particle contaminants to be removed, the vibration of the semiconductor substrate transferring the acoustic energy to the liquid medium so as to introduce an acoustic wave velocity in the liquid medium, the acoustic wave velocity in the liquid medium together with the vibration of the semiconductor substrate providing a force to dislodge the plurality of particle contaminants from the surface of the semiconductor substrate.

2. The method of claim 1, wherein applying acoustic energy to the semiconductor substrate further comprising:

selecting a transducer for generating acoustic energy; and

generating the acoustic energy for applying to the semiconductor substrate so as to provide maximum acoustic wave displacement in the liquid medium.

3. The method of claim 2, further comprising tuning the acoustic energy so that the acoustic wave velocity in the liquid medium does not produce cavitation within the liquid medium.

4. The method of claim 2, further comprising controlling the acoustic energy applied by the transducer so as to maintain acoustic wave displacement uniformity within the liquid medium and the semiconductor substrate.

5. The method of claim 3, further includes providing a second transducer, the second transducer coupled to an underside of the semiconductor substrate, the second

transducer enabling application of acoustic energy to the semiconductor substrate from the underside through a couplant.

6. The method of claim 5, further includes,

selecting a couplant having intrinsic properties that enable transmission of acoustic energy; and

applying the couplant to the semiconductor substrate, the amount of acoustic energy delivered to the semiconductor substrate from the underside based on the intrinsic properties of the couplant.

7. The method of claim 6, wherein the acoustic energy applied to the semiconductor substrate and the liquid medium is based on intrinsic properties associated with the semiconductor substrate, the liquid medium and the couplant, the acoustic energy defining the acoustic behavior of the acoustic waves within the liquid medium.

8. The method of claim 5, wherein the couplant is one of a liquid or a liquid chemical used in rinsing the semiconductor substrate.

9. The method of claim 7, wherein the intrinsic properties associated with the couplant and the liquid medium include any one or more of chemical composition, density, and temperature, and wherein the intrinsic properties associated with the semiconductor substrate include any one or more o1 composition, thickness, width, temperature, type of contaminants, size of contaminants, contaminant composition.

10. The method of claim 1 , further includes selecting the liquid medium such that chemical structure of the liquid medium enables at least partial connection or interaction with the particle contaminant released from the surface of the semiconductor substrate during the cleaning process and wherein the liquid medium is partially hydrolyzed polyacrylamide.

11. An apparatus for cleaning a substrate, comprising:

a first outer tank having a cavity defined by a base and one or more sidewalls extending therefrom and an opening opposite the base, the first outer tank being configured to hold a volume of a first liquid medium within the cavity;

a second inner tank disposed within the first outer tank so as to define the cavity surrounding the second inner tank in the first outer tank, the space formed by the disposition of the second inner tank within the first outer tank filled with the first liquid medium, the second inner tank having a cavity defined by a base and one or more sidewalls extending therefrom and an opening opposite the base, the second inner tank being configured to hold a volume of second liquid medium within the cavity;

a carrier mechanism configured to support the substrate and to immerse the substrate completely into the second liquid medium within the cavity defined in the second inner tank; and

a transducer to apply acoustic energy to the substrate and the second liquid medium within the second inner tank, the acoustic energy enabling the substrate and the second liquid medium to work together in dislodging particle contaminants from the surface of the substrate;

wherein the opening of the first tank and the opening of the second tank being substantially parallel so as to allow the substrate to be introduced into the second tank through the openings of the first and second tanks, wherein the acoustic energy applied to the second liquid medium prevents cavitation within the second liquid medium and wherein the acoustic energy applied to the substrate enables maximum wave displacement of acoustic wave introduced into the second liquid medium; and

wherein the combined acoustic energy applied to the substrate and the liquid medium has frequencies between about 10 KHz to about 10 MHz.

12. The apparatus of claim 11, wherein the transducer is provided at the base of the first outer tank, the acoustic energy from the transducer is transmitted to the immersed substrate and the second liquid medium in the second inner tank through the first liquid medium in the first outer tank.

13. The apparatus of claim 12, wherein the transducer is made up of at least a first and a second transducer, the first and second transducers provided at the base of the first outer tank to generate acoustic energy to the second liquid medium and the substrate in the second inner tank through the first liquid medium in the first outer tank.

14. The apparatus of claim 11, further includes selecting the first and second liquid media so as to control the amount of acoustic energy delivered to the second liquid medium and the substrate, the amount of acoustic energy delivered to the second liquid medium and the substrate based on intrinsic properties associated with the substrate and the first and second liquid media.

15. The apparatus of claim 14, wherein the second liquid medium is selected such that chemical structure of the second liquid medium enables at least partial connection or interaction with the particle contaminants released from the surface of the substrate.

16. The apparatus of claim 11, wherein the second inner tank further includes an inlet to replenish clean and fresh second liquid medium into the second inner tank and an outlet to remove the second liquid medium along with the contaminated particles from the second inner tank and wherein the first outer tank receives the second liquid medium with the contaminated particles from the second inner tank during a cleaning process.

17. The apparatus of claim 11, wherein the carrier mechanism is configured to include locations to support and immerse a plurality of substrates in the second inner tank during the cleaning process and one of a single or a plurality of transducers are employed to apply acoustic energy to each of the plurality of substrates immersed in the second inner tank.

~~18. The apparatus as recited in claim 11, wherein the combined acoustic energy applied to the substrate and the liquid medium has frequencies between about 10 KHz to about 10 MHz.~~

819. The apparatus of claim 11, wherein a frequency of the combined acoustic energy applied to the substrate and the liquid medium is based on reciprocal time of relaxation of the liquid medium.

209. An apparatus for cleaning a substrate having particle contaminants on a surface of the substrate, comprising:

a processing chamber having a carrier mechanism configured to receive, support and transport the substrate within the processing chamber, the processing chamber further including;

a dispense head assembly configured to supply a liquid medium as a meniscus to a surface of the substrate; and

a rinse head assembly equipped with at least an inlet conduit to supply rinse chemical to a top surface of the substrate as a meniscus, at least an outlet conduit to remove the rinse chemical and liquid medium from the surface of the substrate and at least a transducer, the transducer configured to supply acoustic energy to the substrate supported by the carrier mechanism so as to enable the substrate to vibrate, the vibration of the semiconductor substrate transferring the acoustic energy to the meniscus of the liquid medium applied to the surface of the substrate so as to introduce an acoustic wave velocity in the liquid medium , the acoustic wave velocity in the meniscus of the liquid medium together with the vibration of the substrate assists to dislodge the particle contaminants from the surface of the substrate,

wherein the transducer is positioned close to a surface of the rinse head assembly that is proximal to the surface of the substrate to transmit acoustic energy to the substrate.

1021. The apparatus of claim 920, wherein the dispense head assembly and the rinse head assembly are linear proximity heads.

1122. The apparatus of claim 920, wherein the geometry of the transducer in the rinse head assembly is selected so as to fit the geometry of the rinse head assembly.

1223. The apparatus of claim 920, further including a second rinse head assembly, the second rinse head assembly equipped with at least an inlet conduit to supply a rinse chemical to the surface of the substrate, at least an outlet conduit to remove the rinse chemical and liquid medium from the surface of the substrate and at least a transducer, the geometry of the transducer within the second rinse head assembly fitting the geometry of the second rinse head assembly, the transducer within the second rinse head assembly is positioned close to the surface of the second rinse head assembly facing the surface of the substrate,

wherein the transducer in the second rinse head assembly is configured to supply acoustic energy through the rinse chemical to the substrate and to the meniscus of the liquid medium applied on the surface of the substrate, the amount of acoustic energy applied to the rinse chemical selected so as to provide maximum acoustic wave displacement difference to an acoustic wave introduced into the liquid medium and to prevent cavitation within the liquid medium.

1324. The apparatus of claim 1223, wherein the second rinse head assembly is positioned proximate to a back side of the substrate so as to provide the acoustic energy to the substrate and the liquid medium through the back side of the substrate, the transducer within the second rinse head assembly located close to a surface of the rinse head assembly proximal to the underside of the surface of the substrate.

1425. The apparatus as recited in claim 920, wherein the liquid medium is selected such that chemical structure of the liquid medium enables at least partial connection or interaction with the released particle contaminants, the liquid medium is partially hydrolyzed polyacrylamide.

1526. The apparatus as recited in claim 920, wherein the combined acoustic energy applied to the surface of the substrate and the liquid medium has a frequency between about 10 KHz to about 10 MHz.

1627. An apparatus for cleaning a substrate having particle contaminants on a surface of the substrate, comprising:

a receptacle equipped with a carrier mechanism, the receptacle configured to receive and hold liquid medium, the carrier mechanism within the receptacle configured to receive, support and move the substrate along an axis;

a transducer configured to supply acoustic energy to the substrate supported by the carrier mechanism so as to enable the substrate to vibrate, the vibration of the substrate transferring the acoustic energy to the meniscus of the liquid medium applied at the surface of the substrate so as to introduce an acoustic wave velocity in the liquid medium, the acoustic wave velocity in the meniscus of the liquid medium together with the vibration of the substrate assists to dislodge the particle contaminants from the surface of the substrate, and

a rinse mechanism equipped with at least an inlet conduit to supply rinse chemical to a top surface of the substrate as a meniscus,

wherein the acoustic wave velocity applied to the liquid medium prevents cavitation within the liquid medium.

1728. The apparatus of claim 1627, wherein the transducer is provided within the carrier mechanism, the transducer connected to a power supply and configured to generate acoustic energy from power supplied through the power supply.

1829. The apparatus of claim 1627, wherein the transducer is mounted on a moveable arm mechanism that is configured to move the transducer up, down and sideways so as to enable positioning the transducer proximate to the substrate surface.

1930. The apparatus of claim 1627, wherein the rinse mechanism is mounted on a moveable arm mechanism that is configured to move the rinse mechanism up, down and sideways so as to enable positioning the rinse mechanism proximate to the substrate surface, the movement of the rinse mechanism controlled using a rinse control mechanism.

2031. The apparatus of claim 1627, further including a motor mechanism, the motor mechanism connected to the carrier mechanism so as to enable the carrier mechanism to move up, down and along an axis of rotation.

2132. The apparatus of claim 1627, further including distinct receptacles to supply the rinse chemical and to collect the liquid medium and the rinse chemical removed from the surface of the substrate after cleaning and rinsing operations, wherein the receptacle includes distinct outlet conduits to remove the liquid medium from the receptacle during cleaning process.