CLAIMS

1. An apparatus for substrate metallization from electrolyte comprising:

an immersion bath containing metal salt electrolyte;

at least one set of electrode connecting to at least one power supply;

an substrate holder holding at least one substrate to expose a conductive side of the substrate to face one set of electrode, the substrate holder being electricity conducting;

at least one ultra/mega sonic device coupled with a reflection plate for forming an ultra/mega sonic standing wave area in the immersion bath;

a first oscillating actuator oscillating the substrate holder along its axis for making the substrate holder pass through the entire ultra/mega sonic standing wave area with different ultra/mega sonic power intensity, so as to result in an uniformed sonic energy dose distribution across the substrate held by the substrate holder in an accumulated time; and

an adjusting mechanism for adjusting one of the reflection plate and the ultra/mega sonic device to be parallel to the other, wherein

the adjusting mechanism includes an actuator for oscillating the reflection plate or the ultra/mega sonic device along the propagating direction of the ultra/mega sonic standing wave, and the oscillation amplitude is equal to N time of half wave length of the ultra/mega sonic standing wave, where N is an integer number from 1 to 10.

2. The apparatus of claim 1, wherein the first oscillating actuator oscillates the substrate holder up and down along the axis perpendicular to propagation direction of the ultra/mega sonic standing wave.

3. The apparatus of claim 1, wherein the first oscillating actuator oscillates the substrate holder up and down along the axis tilted from an axis which is perpendicular to propagation direction of the ultra/mega sonic standing wave.

4. The apparatus of claim 1, further comprising a rotating actuator for rotating the substrate holder 180 degree around the axis of the substrate holder while the substrate is within non-acoustic areas.

5. The apparatus of claim 1, further comprising a third oscillating actuator for oscillating the substrate holder along propagation direction of the ultra/mega sonic standing wave, the frequency of the third oscillating actuator being larger than that of the first oscillating actuator while the substrate passing through the standing wave area.

6. The apparatus of claim 1, wherein the substrate holder holds two substrates with each one substrate on each side of the substrate holder.

7. The apparatus of claim 6, wherein two sets of electrodes are provided in the immersion bath with each set of electrode facing one substrate.

8. The apparatus of claim 1, wherein each set of electrode includes one or more pieces of electrodes with independent power control.

9. The apparatus of claim 1, wherein the frequency of the first oscillating actuator is from 0.001 to 0.5Hz.

10. The apparatus of claim 1, further comprising at least one layer of permeable membrane being set between the substrate and the electrode.

11. The apparatus of claim 1, wherein the ultra/mega sonic device includes at least one piece of piezo crystal.

12. The apparatus of claim 1, wherein the ultra/mega sonic device is operated at frequency from 20 KHz to 10 MHz with power intensity from 0.01 to 3W/cm^2.

13. The apparatus of claim 1, wherein the reflection plate is facing to and parallel to the ultra/mega sonic device.

14. The apparatus of claim 1, wherein the ultra/mega sonic device and the reflection plate are set on the opposite side walls of the immersion bath, with the both surfaces thereof immersed in the immersion bath.

15. The apparatus of claim 1, wherein the propagation direction of the ultra/mega sonic standing wave is parallel to surface of the substrate.

16. The apparatus of claim 1, wherein the ultra/mega sonic device and the reflection plate are parallel to the oscillating direction of the substrate holder.

17. The apparatus of claim 1, wherein the ultra/mega sonic device and the reflection plate are set at a tilted angle to the oscillating direction of the substrate holder.

18. The apparatus of claim 1, wherein the frequency of the actuator is 1 to 10 HZ.

19. The apparatus of claim 1, wherein the reflection plate is made of thin quartz material with thickness of n time of half wave length of the ultra/mega sonic standing wave, n is an integer number from 1 to 100.

20. The apparatus of claim 1, wherein the reflection plate includes at least two solid plates and an air gap between adjacent two solid plates thereof for minimizing the acoustic energy lost.

21. The apparatus of claim 1, further comprising a rotating actuator for rotating the substrate holder along an axis vertical to surface of the substrate, so as to uniform the ultra/mega sonic standing wave distribution across the substrate.

22. The apparatus of claim 21, wherein the rotating actuator rotates the substrate holder by magnetic coupling mechanism.

23. The apparatus of claim 21, wherein the rotating speed of the substrate holder is within the range from 10 to 100rpm.

24. An apparatus for substrate metallization from electrolyte comprising:

an immersion bath containing metal salt electrolyte;

at least one set of electrode connecting to at least one power supply;

a substrate holder holding at least one substrate to expose a conductive side of the substrate to face one set of electrode, the substrate holder being electricity conducting;

at least one ultra/mega sonic device mounted on a wall of the immersion bath for forming an ultra/mega sonic wave area in the immersion bath; and

a first oscillating actuator oscillating the substrate holder along its axis for making the substrate holder pass through the entire ultra/mega sonic acoustic area, so as to result in an uniformed power intensity distribution across the substrate held by the substrate holder in an accumulated time; wherein

forming standing wave across the surface of the substrate is avoided.

25. The apparatus of claim 24, further comprising an acoustic absorption material being placed to face the ultra/mega sonic device, avoiding forming standing wave across the surface of the substrate.

26. The apparatus of claim 24, further comprising a plate being set with its normal direction tilted with an angle with the propagation direction of the ultra/mega sonic wave, avoiding forming standing wave across the surface of the substrate, the angle being set between 0 degree and 45 degree.

27. The apparatus of claim 24, further comprising a rotating actuator for rotating the substrate holder 180 degree around the axis of the substrate holder while the substrate is within non-acoustic areas.

28. An apparatus for substrate metallization from electrolyte comprising:

an immersion bath containing metal salt electrolyte;

a substrate holder holding at least one substrate;

at least one ultra/mega sonic device mounted on a wall of the immersion bath for forming an ultra/mega sonic wave area in the immersion bath; and

a first oscillating actuator oscillating the substrate holder along its axis for making the substrate holder pass through the entire ultra/mega sonic acoustic area, so as to result in an uniformed power intensity distribution across the substrate held by the substrate holder in an accumulated time; wherein

forming standing wave across the surface of the substrate is avoided.

29. An apparatus for substrate metallization from electrolyte comprising:

an immersion bath containing metal salt electrolyte;

a substrate holder holding at least one substrate;

at least one ultra/mega sonic device coupled with a reflection plate for forming an ultra/mega sonic standing wave area in the immersion bath;

a first oscillating actuator oscillating the substrate holder along its axis for making the substrate holder pass through the entire ultra/mega sonic standing wave area, so as to result in an uniformed power intensity distribution across the substrate held by the substrate holder in an accumulated time; and

an adjusting mechanism for adjusting one of the reflection plate and the ultra/mega sonic device to be parallel to the other, wherein

the adjusting mechanism includes an actuator for oscillating the reflection plate or the ultra/mega sonic device along the propagating direction of the ultra/mega sonic standing wave, and the oscillation amplitude is equal to N time of half wave length of the ultra/mega sonic standing wave, where N is an integer number from 1 to 10.

30. A method for substrate metallization from electrolyte comprising:

flowing metal salt electrolyte into an immersion bath;

transferring at least one substrate to a substrate holder that is electrically in contact with a conductive side of the substrate;

applying a first bias voltage to the substrate;

applying an electrical current to electrode;

turning on ultra/mega sonic device;

oscillating the substrate holder along its axis for making the substrate holder pass through the entire acoustic area;

periodically changing the distance of space between the surface of ultra/mega sonic device and reflection plate opposite to the surface of the ultra/mega sonic device;

stopping applying the ultra/mega sonic and stopping oscillation of the substrate holder and periodically changing of said space distance;

applying a second bias voltage to the substrate; and

bringing the substrate out of the metal salt electrolyte, wherein

the distance of space between the surfaces of ultra/mega sonic device and reflection plate changes periodically, and an amplitude is equal to N time of half wave length of ultra/mega sonic wave, where N is an integer number from 1 to 10.

31. The method of claim 30, wherein

the first bias voltage is 0.1V to 10V;

the electrical current is 0.1A to 100A;

the ultra/mega sonic has an operating frequency of 20KHz to 10MHz and a power intensity of 0.01 to 3W/cm^2;

the substrate holder oscillates with an amplitude of 1mm to 300mm and a frequency of 0.001 to 0.5Hz;

the distance of space between the surfaces of ultra/mega sonic device and reflection plate changes periodically with a frequency of 1 to 10 HZ;

the second bias voltage is 0.1V to 5V.

32. The method of claim 30, wherein the metal salt electrolyte contains at least one cationic form of the following metals: Cu, Au, Ag, Pt, Ni, Sn, Co, Pd, Zn.

33. The method of claim 30, wherein the deep cavities on the substrate have dimensions of 0.5 to 50μm in width and 5 to 500μm in depth.

34. The method of claim 30, wherein the electrical current is applied in DC mode or pulse reverse mode with a pulse period of 5ms to 2s.

35. The method of claim 30, wherein the substrate flips at 180 degree while the substrate is within non-acoustic areas.

36. The method of claim 30, wherein each point of the substrate passes through the entire acoustic area and the power intensity on each point of the substrate is uniform over the course of process.

37. The method of claim 30, wherein two substrates are processed in the immersion bath at same time.

38. The method of claim 30, wherein the amplitude of the substrate oscillation equals to $\frac{N \bullet \frac{\lambda}{4}}{\sin\theta}$, N=1, 2, 3...where λ is the wavelength of the ultra/mega sonic wave and N is integers, θ is the angle of the ultra/mega sonic device to the side wall of the immersion bath.

39. The method of claim 30, wherein the frequency of the space distance changing periodically is larger than the frequency of substrate oscillation.

40. The method of claim 30, wherein the substrate is oscillated horizontally along the propagating direction of the standing wave while the substrate is oscillated vertically passing through the acoustic area.

41. The method of claim 30, wherein the amplitude of the horizontal oscillation is controlled as integral times of a quarter wave length of ultra/mega sonic wave.

42. The method of claim 30, wherein the substrate oscillates up and down with an angle θ in range of 0 to 45 degree, tilted to the ultra/mega sonic device and the reflection plate, and the amplitude of the oscillation equals to $\frac{N \bullet \frac{\lambda}{4}}{\sin\theta}$, N=1, 2, 3...where λ is the wavelength of the ultra/mega sonic wave and N is integers.

43. The method of claim 30, wherein the substrate rotates with the speed in range of 10rpm to 300rpm while the substrate oscillating up and down.

44. A method for substrate metallization from electrolyte comprising:

flowing metal salt electrolyte into an immersion bath;

transferring at least one substrate to a substrate holder that is electrically in contact with a conductive side of the substrate;

applying a first bias voltage to the substrate;

applying an electrical current to electrode;

turning on ultra/mega sonic device;

oscillating the substrate holder along its axis for making the substrate holder pass through the entire acoustic area, such that forming standing wave across the surface of the substrate is avoided;

stopping applying the ultra/mega sonic and stopping oscillation of the substrate holder;

applying a second bias voltage to the substrate; and

bringing the substrate out of the metal salt electrolyte.

45. The method of claim 44, wherein

the first bias voltage is 0.1V to 10V;

the electrical current is 0.1A to 100A;

the ultra/mega sonic has an operating frequency of 20KHz to 10MHz and a power intensity of 0.01 to 3W/cm^2;

the substrate oscillates with an amplitude of 1mm to 300mm and a frequency of 0.001 to 0.5Hz;

the second bias voltage is 0.1V to 5V.

46. The method of claim 44, wherein the substrate flips at 180 degree while the substrate is within non-acoustic areas.

47. A method for substrate metallization from electrolyte comprising:

flowing metal salt electrolyte into an immersion bath;

transferring at least one substrate to a substrate holder;

turning on ultra/mega sonic device;

oscillating the substrate holder along its axis for making the substrate holder pass through the entire acoustic area, such that forming standing wave across the surface of the substrate is avoided;

stopping applying the ultra/mega sonic and stopping oscillation of the substrate holder; and

bringing the substrate out of the metal salt electrolyte.

48. A method for substrate metallization from electrolyte comprising:

flowing metal salt electrolyte into an immersion bath;

transferring at least one substrate to a substrate holder;

turning on ultra/mega sonic device;

oscillating the substrate holder along its axis for making the substrate holder pass through the entire acoustic area;

periodically changing the distance of space between the surfaces of ultra/mega sonic device and reflection plate;

stopping applying the ultra/mega sonic and stopping oscillation of the substrate holder and periodically changing of said space distance; and

bringing the substrate out of the metal salt electrolyte; wherein

the distance of space between the surfaces of ultra/mega sonic device and reflection plate changes periodically, and an amplitude is equal to N time of half wave length of ultra/mega sonic wave, where N is an integer number from 1 to 10.