~~What is claimed is:~~Claims

1. An apparatus for substrate metallization from electrolyte comprising:

an immersion cell containing metal salt electrolyte;

at least one 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 the at least one electrode, the substrate holder being electricity conducting;

an oscillating actuator oscillating the substrate holder along the axis with an amplitude and a frequency so that the substrate moves along the axis;

at least one ultrasonic device with an operating frequency and an intensity;

at least one ultrasonic power generator connecting to the ultrasonic device;

at least one inlet for metal salt electrolyte feed;

at least one outlet for metal salt electrolyte drain;

wherein each portion on substrate receives full cycle of intensity when the substrate moves a full distance of integer times of half wavelength, wherein each location of substrate receives the same amount of acoustic intensity including the same average intensity, the same maximum intensity, and the same minimum intensity. ~~.~~

2. The apparatus of claim 1, wherein

the amplitude is 0.25mm to 25mm and the frequency is 0.01 to 0.5Hz; and

the operating frequency is 5KHz to 5MHz and the intensity is 0.1 to 3W/cm^2.

3. The apparatus of claim 1 comprising,

an rotating actuator rotating the substrate holder around an axis perpendicular to a surface of the substrate and passing a center of said substrate, wherein the rotating actuator rotates the substrate holder at a speed of 10 to 300 rpm;

4. The apparatus of claim 1, wherein

the at least one ultrasonic device is disposed in a position at the side wall of the metallization apparatus;

5. The apparatus of claim 1, wherein

the at least one ultrasonic device is disposed in a position behind the electrode of the metallization apparatus;

6. A method for substrate metallization from electrolyte comprising:

flowing a metal salt electrolyte into an immersion cell;

transferring a substrate to a substrate holder that is electrically in contact with a conductive layer on a surface of the substrate;

applying a first bias voltage to the substrate;

applying an electrical current to electrode;

applying ultrasonic to the substrate and oscillating the substrate holder so that the substrate moves along the axis, wherein each portion on substrate receives full cycle of intensity when the substrate moves a full distance of integer times of half wavelength, wherein each location of substrate receives the same amount of acoustic intensity including the same average intensity, the same maximum intensity, and the same minimum intensity;

stop applying the ultrasonic and stopping oscillation of the substrate holder;

applying a second bias voltage on the semiconductor substrate;

bringing the substrate out of the metal salt electrolyte.

7. The method of claim 6, wherein

the first bias voltage is 0.1V to 10V;

the electrical current is 0.1A to 100A;

the ultrasonic has an operating frequency of 5KHz to 5MHz and an intensity of 0.1 to 3W/cm^2;

the substrate oscillates with an amplitude of 0.25mm to 25mm and a frequency is 0.01 to 0.5Hz;

the second bias voltage is 0.1V to 5V.

8. The method of claim 6 comprising

rotating the substrate and bringing the substrate into contact with the electrolyte, wherein the substrate is rotated at a speed of 10 to 300rpm;

9. The method of claim 6, wherein the metal salt electrolyte contains at least one cationic form of the following metals: Cu, Au, Ag, Pt, Ni, Sn, Co, Pd, Zn.

10. The method of claim 6, wherein the deep cavities on the substrate have dimensions of 0.5 to 50μm in width and 5 to 500μm in depth.

11. The method of claim 6, wherein the substrate holder oscillates at constant speed equal to $n \cdot \frac{N\lambda}{t}$, where λ is the wavelength of the ultrasonic wave and t is the full process time, and n and N are integers.

12. The method of claim 6, wherein the electrical current is applied in DC mode.

13. The method of claim 6, wherein the electrical current is applied in pulse reverse mode with a pulse period of 5ms to 2s.

14. The method of claim 6, wherein electrolyte agitation is provided proximate the deep cavities.

15. The method of claim 6, wherein electrolyte agitation is provided inside the deep cavities.

16. The method of claim 6, wherein material exchange rate of reactants and byproducts between the inside and outside of the deep cavities are increased.

17. The method of claim 6, wherein impurity levels in deposit in the deep cavities are is reduced.

18. The method of claim 6, wherein a diffusion boundary layer with a thickness of 0.1 to 10 micrometers is reformed proximate the surface of the substrate.

19. The method of claim 6, wherein metal deposition rate is increased by increasing limiting current density.

20. The method of claim 6, wherein an acoustic intensity received by substrate is uniform over the course of process.

21. The method of claim 6, wherein a metalized film with uniform thickness is formed.