CLAIMS

1. A surface treatment apparatus for subjecting a workpiece immersed at least partly in a solution to a surface treatment comprising:

a spray nozzle facing the workpiece for spraying a treatment solution towards a working surface of the workpiece,

wherein the surface treatment apparatus has a spray nozzle rotator to rotate the spray nozzle in a plane parallel to the working surface of the workpiece,

the surface treatment apparatus further comprising:

a treatment tank;

a base frame surrounding a part of the treatment tank; and

a vertical frame above the treatment tank,

wherein the spray nozzle communicates with a sparger pipe, the sparger pipe is attached to the vertical frame, and the vertical frame is fixed on the base frame with the spray nozzle rotator,

a first bearing and a second bearing are fixed to the vertical frame,

a pin is provided through the first bearing and the second bearing,

both ends of the pin are fixed respectively to places of a first plate and a second plate that are shifted from central axes of these plates,

a first shaft is connected to centers of the first plate, and a second shaft is connected to centers of the second plate,

a third bearing and a fourth bearing are fixed on the base frame,

the first shaft is connected with the third bearing, and the second shaft is connected with the fourth bearing,

the spray nozzle has a spraying hole having a hole diameter of 1 to 5 mm,

a distance between the spraying hole of the spray nozzle and the workpiece is 10 to 100 mm,

an average distance between spraying holes of the spray nozzle adjacent to one another is 5 to 150 mm, and

a direction of the spray nozzle is such that an angle of the spraying direction of the treatment solution sprayed from the spray nozzle is -70 degrees to +70 degrees when a horizontal direction is defined to be 0 degree,

the workpiece is placed in the treatment tank and the working surface of the workpiece is perpendicular to a surface of the solution.

2. The surface treatment apparatus according to claim 1, further comprising:

a workpiece rotator to rotate the workpiece in a plane perpendicular to a spraying direction

of the treatment solution sprayed from the spray nozzle.

3. The surface treatment apparatus according to claim 1 or 2,

wherein at least one of the workpiece or the spray nozzle is rotated at an average rotational speed of 100 to 3,000 mm/min.

4. The surface treatment apparatus according to any of claims 1 to 3,

wherein at least one of the workpiece or the spray nozzle is rotated with an equivalent circle diameter of 20 to 200 mm.

5. A surface treatment apparatus for subjecting a workpiece immersed at least partly in a solution to a surface treatment comprising:

a spray nozzle facing the workpiece for spraying a treatment solution towards a working surface of the workpiece;

a fixing unit that fixes the workpiece with inclination relative to a surface of the solution; and

a spray nozzle rotator to rotate the spray nozzle,

wherein an angle θ made between the working surface of the workpiece and ~~a~~ the surface of the solution is more than 0 degree and less than 90 degrees.

6. The surface treatment apparatus according to claim 5, further comprising:

a treatment tank;

a base frame surrounding a part of the treatment tank; and

a vertical frame above the treatment tank,

wherein the vertical frame is fixed on the base frame with the spray nozzle rotator,

the spray nozzle communicates with a sparger pipe, and

the sparger pipe is attached to the vertical frame.

7. The surface treatment apparatus according to claim 5 or 6, further having:

an inclining unit that incline the spray nozzle in a manner that the working surface of the workpiece and a spraying direction of the treatment solution sprayed from the spray become perpendicular to one another.

8. A surface treatment apparatus for subjecting a workpiece immersed at least partly in a solution to a surface treatment comprising:

a spray nozzle facing the workpiece for spraying a treatment solution towards a working surface of the workpiece, and

a spray nozzle rotator to rotate the spray nozzle around an axis parallel to the working surface, wherein the workpiece is disposed under the spray nozzle, and

the spray nozzle and the working surface of the workpiece are parallel to a surface of the solution.

9. The surface treatment apparatus according to claim 8,

wherein the workpiece is disposed under the spray nozzle, and

the spray nozzle and the working surface of the workpiece are parallel to a surface of the solution.

10. The surface treatment apparatus according to any of claims 5 to 9,

wherein the spray nozzle is rotated at an average rotational speed of 100 to 3,000 mm/min.

11. The surface treatment apparatus according to any of claims 5 to 10,

wherein the spray nozzle is rotated with an equivalent circle diameter of 20 to 200 mm.

12. The surface treatment apparatus according to any of claims 1 to 11,

wherein the spray nozzle sprays the treatment solution at an average flow speed of 1 to 30 m/sec.

13. The surface treatment apparatus according to any of claims ~~*1 to 12*~~ 1 to 4, and 6 , further comprising:

~~*a treatment tank,*~~

a circulation path for a circulation of the treatment solution from the treatment tank of the surface treatment apparatus to the spray nozzle; and

a pump on the circulation path for circulating the treatment solution from the treatment tank.

14. The surface treatment apparatus according to any of claims 5, 7 to 12, further comprising:

a treatment tank,

a circulation path for a circulation of the treatment solution from the treatment tank of the surface treatment apparatus to the spray nozzle; and

a pump on the circulation path for circulating the treatment solution from the treatment tank.

~~14~~15. The surface treatment apparatus according to any of claims 1 to ~~13~~14, wherein the surface treatment is a plating treatment, and a plating bath temperature is 20 to 50°C.

~~15~~16. The surface treatment apparatus according to any of claims 1 to ~~14~~15, wherein the surface treatment is an electrolytic plating treatment, and an average current density is 1 to 30 A/dm^2 .

~~16~~17. The surface treatment apparatus according to any of claims ~~1~~ 5 to ~~15~~16, wherein the spray nozzle has a spraying hole having a hole diameter of 1 to 5 mm.

~~17~~18. The surface treatment apparatus according to any of claims ~~1~~ 5 to ~~16~~17, wherein an average distance between spraying holes of the spray nozzle adjacent to one another is 5 to 150 mm.

~~18~~19. The surface treatment apparatus according to any of claims ~~1~~ 5 to ~~17~~18, wherein a distance between the spraying hole of the spray nozzle and the workpiece is 10 to 100 mm.

~~19~~20. The surface treatment apparatus according to any of claims ~~1~~ 5 to ~~18~~ 7, wherein a direction of the spray nozzle is such that an angle of the spraying direction of the treatment solution sprayed from the spray nozzle is -70 degrees to +70 degrees when a horizontal direction is defined to be 0 degree.

~~20~~21. A surface treatment method for subjecting a workpiece immersed at least partly in a solution to a surface treatment comprising:

spraying a treatment solution towards a working surface of the workpiece from a spray nozzle; and

providing the spray nozzle facing the workpiece,

wherein the surface treatment method includes rotating the spray nozzle in a plane parallel to the working surface of the workpiece,

the surface treatment method using a surface treatment apparatus,

wherein the surface treatment apparatus comprises the spray nozzle facing the workpiece for spraying the treatment solution towards the working surface of the workpiece, and

the surface treatment apparatus has a spray nozzle rotator to rotate the spray nozzle in the plane parallel to the working surface of the workpiece,

the surface treatment apparatus also comprising:

a treatment tank;

a base frame surrounding a part of the treatment tank; and

a vertical frame above the treatment tank,

wherein the spray nozzle communicates with a sparger pipe, the sparger pipe is attached to the vertical frame, and the vertical frame is fixed on the base frame with the spray nozzle rotator,

a first bearing and a second bearing are fixed to the vertical frame,

a pin is provided through the first bearing and the second bearing,

both ends of the pin are fixed respectively to places of a first plate and a second plate that are shifted from central axes of these plates,

a first shaft is connected to centers of the first plate, and a second shaft is connected to centers of the second plate,

a third bearing and a fourth bearing are fixed on the base frame,

the first shaft is connected with the third bearing, and the second shaft is connected with the fourth bearing,

the spray nozzle has a spraying hole having a hole diameter of 1 to 5 mm,

a distance between the spraying hole of the spray nozzle and the workpiece is 10 to 100 mm,

an average distance between spraying holes of the spray nozzle adjacent to one another is 5 to 150 mm, and

an angle of the spraying direction of the treatment solution sprayed from the spray nozzle is -70 degrees to +70 degrees when a horizontal direction is defined to be 0 degree,

the workpiece is placed in the treatment tank and the working surface of the workpiece is perpendicular to a surface of the solution.

~~21~~22. The surface treatment method according to claim ~~20~~21, the surface treatment apparatus further comprising:

a workpiece rotator to rotate the workpiece in a plane perpendicular to a spraying direction of the treatment solution sprayed from the spray nozzle.

~~22~~23. The surface treatment method according to claim ~~20~~ 21 or ~~21~~22,

wherein at least one of the workpiece or the spray nozzle is rotated at an average rotational speed of 100 to 3,000 mm/min.

~~23~~24. The surface treatment method according to any of claims ~~20~~ 21 to ~~22~~23,

wherein at least one of the workpiece or the spray nozzle is rotated with an equivalent circle diameter of 20 to 200 mm.

~~24~~25. A surface treatment method for subjecting a workpiece immersed at least partly in a solution to a surface treatment comprising:

spraying a treatment solution towards a working surface of the workpiece from a spray nozzle;

inclining the workpiece relative to a surface of the solution; and

rotating the spray nozzle,

wherein an angle θ made between the working surface of the workpiece and ~~a~~ the surface of the solution is more than 0 degree and less than 90 degrees.

~~25~~26. The surface treatment method according to claim ~~24~~25, using a surface treatment apparatus,

wherein the surface treatment apparatus comprises:

the spray nozzle facing the workpiece for spraying the treatment solution towards the working surface of the workpiece;

a fixing unit that fixes the workpiece with inclination relative to the surface of the solution;

a spray nozzle rotator to rotate the spray nozzle;

a treatment tank;

a base frame surrounding a part of the treatment tank; and

a vertical frame above the treatment tank,

wherein the vertical frame is fixed on the base frame with the spray nozzle rotator,

the spray nozzle communicates with a sparger pipe, and

the sparger pipe is attached to the vertical frame.

~~26~~27. The surface treatment method according to claim ~~24~~ 25 or ~~25~~26,

wherein the spray nozzle is inclined in a manner that the working surface of the workpiece and a spraying direction of the treatment solution sprayed from the spray nozzle become perpendicular to one another.

~~27~~28. A surface treatment method for subjecting a workpiece immersed at least partly in a solution to a surface treatment comprising:

spraying a treatment solution towards a working surface of the workpiece from a spray nozzle;

providing the spray nozzle facing the workpiece; and

rotating the spray nozzle around an axis parallel to the working surface,

wherein the workpiece is disposed under the spray nozzle, and

the spray nozzle and the working surface of the workpiece are parallel to a surface of the solution.

~~28~~29. The surface treatment method according to claim ~~27~~28, using a surface treatment apparatus,

wherein the surface treatment apparatus comprises:

the spray nozzle facing the workpiece for spraying the treatment solution towards the working surface of the workpiece; and

a spray nozzle rotator to rotate the spray nozzle around the axis parallel to the working surface,

wherein the workpiece is disposed under the spray nozzle, and

the spray nozzle and the working surface of the workpiece are parallel to a surface of the solution.

~~29~~30. The surface treatment method according to any of claims ~~24~~ 25 to ~~28~~29,

wherein the spray nozzle is rotated at an average rotational speed of 100 to 3,000 mm/min.

~~30~~31. The surface treatment method according to any of claims ~~24~~ 25 to ~~29~~30,

wherein the spray nozzle is rotated with an equivalent circle diameter of 20 to 200 mm.

~~31~~32. The surface treatment method according to any of claims ~~20~~ 21 to ~~30~~31,

wherein the spray nozzle sprays the treatment solution at an average flow speed of 1 to 30 m/sec.

~~32~~33. The surface treatment method according to any of claims ~~20~~ 21 to ~~31~~32,

wherein at least two of the workpieces are prepared and disposed in a treatment tank with the working surfaces of the workpieces facing outwards.

~~33~~34. The surface treatment method according to any of claims ~~20~~ 21 to ~~32~~33,

wherein the workpiece has a recess on its surface.

~~34~~35. The surface treatment method according to claim ~~33~~34,
wherein the workpiece having the recess is a printed board, a semiconductor or a wafer.

~~35~~36. The surface treatment method according to any of claims ~~20~~ 21 to ~~34~~35,
wherein the surface treatment is an electrolytic plating treatment or an electroless plating treatment.

~~36~~37. The surface treatment method according to any of claims ~~20~~ 21 to ~~34~~35,
wherein the surface treatment is a plating treatment, and
a plating bath temperature is 20 to 50°C.

~~37~~38. The surface treatment method according to any of claims ~~20~~ 21 to ~~34~~35,
wherein the surface treatment is an electrolytic plating treatment, and
an average current density is 1 to 30 A/dm^2.

~~38~~39. The surface treatment method according to any of claims ~~*20*~~ 25 to ~~*37*~~ 27,
wherein an angle of the spraying direction of the treatment solution sprayed from the spray nozzle is -70 degrees to +70 degrees when a horizontal direction is defined to be 0 degree.