

Distribution system for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate

5 Technical Field

The disclosure relates to a distribution system for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate, an electrochemical deposition system for a chemical and/or electrolytic surface treatment of a substrate and a method for a chemical and/or electrolytic surface treatment of a substrate in a process fluid.

10 Background

Chemical and/or electrolytic surface treatment like electroless and electrochemical or electrolytic deposition is frequently used for surface coating of planar, as well as non-planar, patterned, non-metallic as well as metallic and/or metallized surfaces. Through coating, it is possible to protect surfaces from corrosion, change the dimensions of the components and surface features, and obtain additive metal structures on the surface. Because of its various applications, chemical and/or electrolytic surface treatment is used in the production of many different electronic devices, e.g. on semiconductor substrates or printed circuit boards.

One common electrochemical deposition process is electroplating, more specifically high-speed-plating using a High-Speed-Plate (HSP) system. In an HSP based system, at least one HSP is immersed into a tank containing an electrolyte with at least one substrate and at least one anode. The electric current distribution from the electrolyte is directed from an anode through the HSP plate towards the substrate surface (acting as the cathode). The direction of the current distribution can also be reversed in specific applications e.g. reverse pulse plating.

For example, DE 102010033256 A1 discloses a device and method for producing targeted flow and current density patterns in a chemical and/or electrolytic surface treatment. The device comprises a flow distributor body, which is positioned with the front face plane-parallel to a substrate to be processed, and which has outlet openings on the front face, through which process solution flows onto the substrate surface. The process solution flowing back from the substrate is led off through connecting passages to the rear face of the flow distributor body. At the same time, a targeted distribution of an electrical field towards

a readily prepared substrate surface is effected by a specific arrangement of the connecting passages.

Highly uniform, defect-pattern free electroplating of metals like Cu using a high-speed-plate is especially difficult to achieve on a rotating substrate, meaning when a substrate is rotating in a horizontal position or also when placed in a vertical position facing directly an HSP system. Highly uniform, defect-pattern free can be understood in this context as rotational pattern free.

Achieving a rotational pattern free, highly uniform electroplating of metals using a high-speed-plate set-up requires that, averaged over the entire processing time, the same amount of electrolyte flow as well as current density reaches each and every individual unit area of the substrate.

In the prior art, the spatial non-uniform plating of substrates has been improved by creating a high density of electrolyte jets and current density distribution elements approximately corresponding to a distribution of surface elements reacting on the substrate, which define a structure to be displayed such that, for example, an outlet opening is in approximate alignment with a surface element.

The manufacturing of a high density of electrolyte jets and current density distribution elements, which are approximately aligned to a distribution of surface elements reacting on the substrate has become increasingly difficult to actually nowadays virtually impossible due to the continuous shrinking of these surface elements (i.e. electronic device geometries are continuing to scale down to ever smaller dimensions). So, the problem of spatial non-uniform plating on substrates cannot be addressed anymore by just shrinking the HSP features.

In addition, the arrangement of electrolyte jets and current density distribution elements geometrically aligned to the substrate surface elements (which are almost entirely arranged in patterns and shapes, which are arranged in 90° patterns to each other, for instance in rectangular shapes) creates significant rotational artefacts of the resulting plating uniformities. This is caused by the limitation to make the geometric arrangements of the electrolyte jets and the current distribution openings infinite small. Rotating a substrate over even the smallest openings possible to manufacture will create a non-uniform, rotational

pattern on the substrate due to non-uniformly, non-aligned area-averaged incoming electrolyte flow and current density patterns.

Summary

Hence, there may be a need to provide an improved distribution system for a process fluid
5 for chemical and/or electrolytic surface treatment of a rotatable substrate, which allows a uniform electroplating of substrates with reduced artefacts or defect-patterns.

Above described problem is solved by the subject-matters of the independent claims, wherein further embodiments are incorporated in the dependent claims. It should be noted that the aspects of the disclosure described in the following apply also to a distribution
10 system for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate, an electrochemical deposition system for a chemical and/or electrolytic surface treatment of a substrate and a method for a chemical and/or electrolytic surface treatment of a substrate in a process fluid.

According to the present disclosure, a distribution system for a process fluid for chemical
15 and/or electrolytic surface treatment of a rotatable substrate is presented. The distribution system comprises a distribution body. The distribution body comprises a plurality of openings for the process fluid. The openings are arranged in a spiral-shaped pattern on a surface of the distribution body.

The distribution system according to the present disclosure is solving the issues of the prior
20 art by implementing a novel way of arranging the openings (e.g. process fluid or electrolyte and current distribution openings) of a distribution body (e.g. a HSP plate) towards the substrate. The openings are arranged in a spiral-shaped geometrically order, where each unit area of the (e.g. rotating) substrate can be exposed to the same amount of incoming electrolyte flow and current density, averaged over the processing (i.e. plating) time.

25 The spiral arrangement of the process fluid/electrolyte and current distribution openings can be made following mathematical directives for a spiral where locations for the electrolyte and current distribution openings are determined corresponding to location points along lines described by a spiral moving continuously outward from a fixed start point.

The locations for the electrolyte and current distribution openings can be arranged according
30 to different types of spiral geometries as e.g. logarithmic spiral, parabolic spiral, square root spiral, hyperbolic spiral, or based on any other kind of geometric arrangement, which

enables that each unit area of a e.g. rotating substrate is exposed to approximately the same amount of incoming electrolyte flow and current density, averaged over the processing time.

As a result, an improved distribution system for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate is achieved, which allows a uniform electroplating of substrates with reduced or eliminated rotational artefacts and/or defect-patterns. The improved distribution system may be achieved without any complicated mechanical implementations or complicated managing implementations for e.g. the electrolyte flow to the substrate. This may allow the distribution system to be manufactured easily and without great expenses and/or to be used easily and without great maintenance and repair costs.

In an example, the distribution body may be arranged between an electrode of the distribution system and the substrate.

In an example, the distribution body may be a high-speed plate (HSP).

In an example, the distribution body may be positioned parallel to the substrate.

In an example, the substrate and the distribution body may be horizontally positioned. In another example, the substrate and the distribution body may be vertically positioned. Of course, the substrate and the distribution body may be positioned with any other angle relative to the ground.

In an example, the distribution body may comprise plastic, in particular polypropylene, polyvinyl chloride, polyethylene, acrylic glass, i.e. polymethacrylate, polytetrafluoroethylene, or another material that will not be decomposed by the process fluid.

In an example, the substrate may be rotating relative to the distribution body. The substrate can rotate for a thorough spread or distribution on the surface of the process fluid and/or to provide an additionally positive improvement of the diffusion of the chemical species in the critical areas, or stay fixed without movement, depending on the electrodeposition needs.

In an example, the substrate may comprise or be made of metal (e.g. copper) or an alloy or a metallic compound.

In an example, the substrate may be a plate-shaped workpiece. The substrate can be e.g. a masked or unmasked conductor plate, a semi-conductor substrate, a film substrate, or any metal or metallized workpiece.

In an example, the substrate may be placed in a substrate holder.

- 5 In an example, the process fluid is the electrolyte and may transport the current density. In an example, the process fluid may be dispensed from the openings in the distribution body onto the substrate surface. The electrolyte and current density may be distributed approximately aligned onto the substrate surface. The amount of electrolyte flow and/or current flow directed through the openings of the distribution body may be the same throughout the
- 10 plating process or may change during the process.

In an example, the openings may face the substrate. The openings in the distribution body may allow the process fluid to flow from the electrode to the substrate. In another example, the openings may face in an opposite direction of the substrate.

- The openings can have an equal size throughout the distribution body or can vary throughout
- 15 the distribution body, such that the radius of the openings increase or decrease. The openings may have a circular cross-section, but alternatively, the cross-sections can be formed in any other form, such as a square.

- The openings arranged in a spiral-shaped pattern may be electrolyte jets for discharging electrolyte or current density distribution elements for the current density distribution or a
- 20 combination of both. If the openings arranged in a spiral-shaped pattern are either jets for discharging electrolyte or distribution elements for the current density distribution, the other one (distribution elements or jets) can be arranged independent of the jets or distribution elements arranged in a spiral-shaped pattern. Independent can mean that they form another spiral-shaped pattern or a non-spiral shaped pattern or no pattern at all.

- 25 The electrolyte and the carried current density of the process fluid may be discharged from the same or from separate features and sections of the distribution body. In the latter alternative, the distribution body may comprise at least one jet for discharging electrolyte and at least one distribution element for the current density distribution. Discharge of electrolyte and current can take place simultaneously or one after another.

- 30 In an example, the openings may be divided into at least two portions, wherein a first portion of the openings is configured to provide the process fluid flow and a second portion of the

openings is configured to provide a current density distribution. The first portion of the openings may form jet holes for providing the process fluid flow and the second portion of the openings may form drain holes for providing the current density distribution. The second portion of the openings may be also configured to enable a backflow of the process fluid
5 from the substrate to the electrode through the distribution body.

Hence, the drain holes may be through holes extending between a front face and a rear face of the distribution body. The front face of the distribution body may be directed towards the substrate and the rear face of the distribution body may be arranged on an opposite side of the front face, not facing the substrate (but facing, for instance, at least one anode).

10 Directing the current density distribution separate from the process fluid through respective separate openings may provide further flexibility and conciseness in the treatment of the substrate surface. Accordingly, the flow rate of the process fluid and the current density distribution may be separately and independently controlled. For example, the flow rate of the current density distribution may be reduced during the flow rate of the process fluid is
15 maintained constantly, which would prevent hydrogen gas bubbles to adhere to the substrate during the chemical and/or electrolytic surface treatment of a substrate. Similarly, the flow rate of the process fluid may be changed (increased or decreased) while the flow rate of the current density distribution is maintained constantly.

In an example, the second portion of the openings may be arranged in a spiral-shaped pattern
20 on the surface of the distribution body and the first portion of the openings may be arranged on the surface of the distribution body independently of the second portion of the openings.

In an example, the first portion of the openings may comprise a smaller diameter than the second portion of the openings. In an example, the first portion of the openings may surround the second portion of the openings. In other words, one drain hole may be
25 surrounded by one, two or several jet holes.

In an embodiment, the spiral-shaped pattern of the openings may regulate an outflow of the process fluid onto the substrate. That is to say, the distribution body may produce a targeted electrolyte flow and current density pattern for the chemical and/or electrolytic surface treatment. As a result, when averaged over a certain amount of processing time, the (entire)
30 surface of the substrate may be exposed to the same amount of substance for a homogenous electrodeposition.

In an embodiment, the openings are configured to direct the process fluid flow and/or a current density distribution to the substrate, and in case the substrate is rotating relative to the distribution body, the spiral-shaped pattern enables that several areas of the substrate are exposed to similar process fluid flows and/or similar current density distributions,

5 respectively. With the rotation of the substrate, the process fluid flow may contact the substrate surface more uniformly and a formation of non-uniform current density patterns is reduced or prevented. The spiral-shaped pattern may enable that only parts or the entire surface of the substrate is coated at a similar amount.

The spiral-shape may be based on a polar equation comprising polar coordinates. By
10 changing the polar coordinates, the spiral-shaped pattern can be changed. The values for the polar coordinates may be defined to determine the shape of process liquid flow and/or the current density distribution on the substrate.

In an embodiment, the spiral-shaped pattern is formed in that the openings are arranged along an imaginary curve, which winds around a starting point on the distribution body at a
15 continuously increasing distance from the starting point. This means the distance from one arc or revolution of the spiral around the starting point to the next loop or revolution of the spiral around the starting point may increase.

The distance between adjacent openings along the imaginary curve may decrease or increase or be constant from the starting point of the spiral to the openings more remote from the
20 starting point. In other words, the openings arranged on the imaginary spiral-shaped curve can be placed equally distant to each other. Alternatively, the openings starting from the starting point on the imaginary spiral-shaped curve can be placed with increasing or decreasing distance to each other. In other words, the openings may be concentrated closer to the starting point or may be concentrated at an outer portion of the distribution body away
25 from the starting point.

In an embodiment, the starting point of the spiral-shaped pattern is a geometric center of the distribution body. The geometric center or the centroid of the distribution body is a shape dependent point, which is defined as the arithmetic mean position of all the points in all
30 coordinates. For a distribution body with a circular cross-section, the geometric center would be at the center of the circumference.

In an embodiment, the starting point of the spiral-shaped pattern is outside a geometric center of the distribution body. In other words, the starting point can be at the point of center of gravity of the distribution body. Alternatively, the starting point can be at a point closer to an outer portion of the distribution body, leaving e.g. an area without any openings around
5 the geometric center.

By choosing different spiral geometries, and even mixtures or geometrical sequences of different spiral types for different radial areas, it is possible to adjust the plating results to achieve high uniformities in the electrolytic deposition of the substrate. By placing the electrolyte and current distribution openings on a path of an imaginary spiral, on the
10 distribution body surface as exemplified by the types of spirals below, it is possible to target different surface areas of the substrate, which within themselves are required to be plated with very high uniformity.

By changing the type of spiral and/or the parameters in their formulas, or by varying the types of applied spirals along the radius of the distribution body it is possible to define a
15 varying intensity of the coating at specific radial areas. With this highly uniform, defect-pattern free or, for specifically patterned substrates a specifically defined uniform electroplating over the substrate can be obtained.

In an embodiment, the spiral-shaped pattern is based on an Archimedean spiral. Defined by the equation $r = a + b \theta$; where a and b are $\mathbb{R}$. In this formula, a and b are parameters, r
20 is the length of the radius from the center and θ is the angular position (amount of rotation) of the radius. The Archimedean spiral defines a locus of points corresponding to locations over time of a point moving away from a fixed point with a constant speed along a line that rotates with constant angular velocity. By changing the parameter a , a center-point of the spiral is moved away from the center of the distribution body in the direction of an outer
25 portion of the distribution body, while b controls the distance between consecutive loops. An Archimedean spiral always has the same distance between neighboring arcs.

Experimentation and testing of the inventors were very surprising and showed that e.g. the application of an Archimedean spiral closer to the center of a rotating substrate results in better uniformities for deposition on elongated device structures, while to achieve a similar
30 good uniformity on elongated structures at larger distances from the center of a rotating a logarithmic spiral arrangement showed better results. Other observations made are that on

non-elongated features, so more punctual type plating structures, a reverse observation to the elongated structures explained above was made.

In an embodiment, the spiral-shaped pattern is based on a logarithmic spiral. A logarithmic spiral can be distinguished from an Archimedean spiral by the fact that the distances between the arcs of a logarithmic spiral increase in geometric progression, whereas in the Archimedean spiral the distances between the spirals remain the same. In polar coordinates, the logarithmic spiral is defined by the equation $r = ae^{k\theta}$, where $a, k \neq 0$. In this formula, r is the length of the radius from the center, a is a constant, e is the natural logarithmic base, k is the slope of the spiral and θ is the angular position of the radius.

In an embodiment, the spiral-shaped pattern is based on a parabolic spiral. A parabolic spiral, also known as Fermat's spiral, is a plane curve represented in polar coordinates by the equation $r = \pm a \sqrt{\theta}$, where $\theta \geq 0$, describing a parabola with a horizontal axis. In this formula, r is the length of the radius from the center, a is a parameter and θ is the angular position of the radius. The pattern used in the shape of Fermat's spiral may have one branch or two branches, which are coiled around each other, symmetrical to a central plane.

In an embodiment, the spiral-shaped pattern is based on a square root spiral. The square root spiral is formed by right triangles placed edge to edge, i.e. a hypotenuse of one triangle is one leg of the triangle placed next to it and the other leg of the triangle always has a magnitude of 1. Thus, the n^{th} triangle in the sequence is a right triangle with side lengths $\sqrt{n}$ and 1, and with a hypotenuse of $\sqrt{n+1}$.

In an embodiment, the spiral-shaped pattern is based on a hyperbolic spiral. A hyperbolic spiral is an inverse spiral described with the equation $r = a/\theta$, where $\theta \neq 0$. In this formula, r is the length of the radius from the center, a is a parameter and θ is the angular position of the radius. The hyperbolic spiral can be generated by a circle inversion of an Archimedean spiral.

In an embodiment, the spiral-shaped pattern is based on Fibonacci numbers. A logarithmic spiral generated by Fibonacci numbers (Fibonacci spiral) has the growth factor of $\frac{1+\sqrt{5}}{2}$, in other words a constant ratio between successive terms in the Fibonacci sequence. The Fibonacci spiral is made by drawing squares, each sequent square having edges with a length amounting to the sum of the an edge of the previous two squares and connecting the corners of the squares to form the spiral.

In an embodiment, the spiral-shaped pattern is a combination of two or more spirals. It is possible to use a combination of more than one preferably different spiral types on the distribution body, e.g. a spiral of type Fibonacci from the centre to a radius A, and a spiral of type Fermat from radius A to an outer most radius B, or any other combination from the spirals stated above.

By choosing different spiral geometries, and even mixtures or geometrical sequences of different spiral types for different radial areas, it is possible to adjust the plating results to achieve high uniformities in the electrolytic deposition of the substrate. By placing the electrolyte and current distribution openings on a path of an imaginary spiral, on the distribution body surface as exemplified by the types of spirals, it is possible to target different surface areas of the substrate, which within themselves are required to be plated with very high uniformity.

According to the present disclosure, also an electrochemical deposition system for a chemical and/or electrolytic surface treatment of a substrate is presented. The electrochemical deposition system comprises a distribution system as described above and a substrate rotation system. The substrate rotation system is configured to rotate a substrate relative to a distribution body of the distribution system.

By rotating the substrate during application of the process fluid, even spread or distribution is ensured, therefore forming a homogenous, defect-pattern reduced or defect-pattern free coating on the substrate surface.

A rotation of the substrate can mean a full rotation corresponding to a rotation of 360 degrees or a partial rotation of less than 360 degrees, for example corresponding to about 180 degrees. The substrate may rotate in both opposite directions, for example back and forth or in other words, clockwise and counterclockwise.

A rotation speed of the rotation system can be set by a user depending on specific surface treatment needs such as for achieving a specific thickness of the accumulated coating in a defined time duration.

In an example, the substrate may be placed in a substrate holder.

In an example, the substrate may be releasably attached to the rotation system. This allows the substrate to be replaced by another substrate.

According to the present disclosure, also a method for a chemical and/or electrolytic surface treatment of a substrate in a process fluid is presented. The method for a chemical and/or electrolytic surface treatment comprises the following steps, not necessarily in this order:

- 5 - providing a distribution system comprising a distribution body with a plurality of openings,
- rotating the substrate relative to the distribution system, and
- providing the process fluid flow via a first portion of the openings and providing a current density distribution via a second portion of the openings.

10 The method may further comprise a step of selecting a source of process fluid before the step of chemically and/or electrolytically treating the surface.

15 It shall be understood that the system, the device, and the method according to the independent claims have similar and/or identical preferred embodiments, in particular, as defined in the dependent claims. It shall be understood further that a preferred embodiment of the disclosure can also be any combination of the dependent claims with the respective independent claim.

These and other aspects of the present disclosure will become apparent from and be elucidated with reference to the embodiments described hereinafter.

Brief description of the drawings

20 Exemplary embodiments of the disclosure will be described in the following with reference to the accompanying drawing:

Figure 1 shows schematically and exemplarily an embodiment of a distribution body for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate.

Figure 2 shows schematically and exemplarily an Archimedean spiral.

Figure 3 shows schematically and exemplarily a logarithmic spiral.

Figure 4 shows a graph depicting a distribution of a “drain hole ratio” as a function of a radius of a substrate.

Figure 5A show schematically and exemplarily an embodiment of a distribution body for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate. Figure 5B

Detailed description of embodiments

Figure 1 shows schematically and exemplarily an embodiment of a distribution body 1 for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate (not shown). The distribution body 1 is part of a distribution system 10 for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate. The distribution body 1 may be arranged between an electrode (not shown) of the distribution system 10 and the substrate. The distribution body 1 may be a high-speed plate (HSP). The substrate may rotate relative to the distribution body 1.

The distribution body 1 comprises a plurality of openings 2 for the process fluid. The process fluid is an electrolyte and may transport the current density. The openings 2 face the substrate and allow the process fluid to flow from the electrode to the substrate. The openings 2 are arranged in a spiral-shaped pattern on a surface of the distribution body 1. The openings 2 direct the process fluid flow and/or a current density distribution to the substrate, and in case the substrate is rotating relative to the distribution body 1, the spiral-shaped pattern enables that several areas of the substrate are exposed to similar process fluid flows and/or similar current density distributions, respectively. The electrolyte and the current density of the process fluid can be discharged from separate features and sections of the distribution body 1. For this, the distribution body 1 comprises at least one jet for discharging electrolyte and at least one distribution element for the current density distribution.

The distribution system 10 is part of an electrochemical deposition system 20 for a chemical and/or electrolytic surface treatment of a substrate. The electrochemical deposition system 20 comprises the distribution system 10 and a substrate rotation system (not shown). The substrate rotation system is configured to rotate a substrate relative to a distribution body 1 of the distribution system 10. By rotating the substrate during application of the process fluid, an even distribution of the process fluid is ensured, therefore forming a homogenous coating on the substrate surface.

The openings 2 are arranged in a spiral-shaped pattern on the distribution body 1, such as in an Archimedean spiral S1 pattern, as shown in Figure 2, or a logarithmic spiral S2 pattern, as shown in Figure 3. The spiral arrangement of the openings 2 follows mathematical directives for a spiral where locations for the openings 2 are determined corresponding to location
5 points along lines described by a spiral moving continuously outward from a fixed starting point C.

With the spiral-shaped pattern of the openings 2, each unit area of the substrate is exposed to the same amount of incoming electrolyte flow and current density averaged over the process time. A uniform electroplating without rotational artefacts is ensured when the substrate is
10 rotating.

The spiral-shaped pattern is formed in that the openings 2 are arranged along an imaginary curve, which winds around a starting point C on the distribution body 1 at a continuously increasing distance from the starting point C. The starting point C of the spiral-shaped pattern is the geometric center C of the distribution body 1 in Figure 1. A distance between
15 adjacent openings 2 along an imaginary spiral curve is constant from the starting point C of the spiral to more remote portions of the distribution body 1. As shown in Figure 1, the openings 2 have an equal size throughout the distribution body 1 and can have any cross-section, e.g. round, square or tri/multi-angular

Figure 2 shows schematically and exemplarily an Archimedean spiral S1. The distance
20 between neighboring arcs A is equal between each consecutive spiral loops or arcs A. The Archimedean spiral S1 is used to define the locations of the openings 2 on a surface 1b of the distribution body 1.

Figure 3 shows schematically and exemplarily a logarithmic spiral S2, in which the distances between consecutive arcs A are increasing starting from the center to the outer portions. The
25 logarithmic spiral S2 can also be used to define the locations of the openings 2 on the surface 1b of the distribution body 1.

Figure 4 shows a graph depicting a distribution of a “drain hole ratio” (DHR) as a function of a radius (r) of a rotating e.g. 300 mm wafer with an arrangement of electrolyte and current distribution openings 2. The drain hole ratio describes a percentage of an open area (area of
30 the openings 2) relative to a closed area (area without openings 2) along a specific radius of a distribution body 1 from a starting point C of a spiral to an outer edge of the distribution

body 1. The “X” symbols in Figure 4 depict the drain hole actual values of the distribution body 1 and the “O” symbols depict averaged values over 10 neighbouring drain holes.

In principle it was found, that the more uniform the drain hole ratio distribution over the radius from the starting point to the outer edge, the higher the uniformity of the material deposition on the substrate, especially, when the substrate is in rotational movement relative to the distribution body 1. As it can be seen from Figure 4, the distribution body 1 allows an excellent drain hole uniformity over the radius, resulting in a significant improvement of the deposition uniformity distribution over the substrate.

Figure 5A and figure 5B show an arrangement of the openings 2, which are divided into a first portion 21 (jet holes) and a second portion 22 (drain holes). Each drain hole 22 is surrounded by three jet holes 21, wherein the drain holes 22 are arranged in a spiral-shaped pattern on the surface 1b of the distribution body 1. The drain holes 22 may be formed as through-holes extending through the distribution body 1 and configured to provide a current density distribution to the substrate and to enable a backflow of the process fluid from the substrate. The jet holes 21 may be formed only in one direction on the distribution body 1, preferably in the direction of the substrate, to provide the process fluid to the substrate.

It has to be noted that embodiments of the disclosure are described with reference to different subject matters. In particular, some embodiments are described with reference to method type claims whereas other embodiments are described with reference to the device type claims. However, a person skilled in the art will gather from the above and the following description that, unless otherwise notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters is considered to be disclosed with this application. However, all features can be combined providing synergetic effects that are more than the simple summation of the features.

While the disclosure has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The disclosure is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing a claimed disclosure, from a study of the drawings, the disclosure, and the dependent claims.

In the claims, the word “comprising” does not exclude other elements or steps, and the indefinite article “a” or “an” does not exclude a plurality. A single processor or other unit may fulfil the functions of several items re-cited in the claims. The mere fact that certain measures are re-cited in mutually different dependent claims does not indicate that a
5 combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Embodiments

1. A distribution system (10) for a process fluid for chemical and/or electrolytic surface
5 treatment of a rotatable substrate,
wherein the distribution system (10) comprises a distribution body (1),
wherein the distribution body (1) comprises a plurality of openings (2) for the process
fluid, and
wherein the openings (2) are arranged in a spiral-shaped pattern on a surface (1b) of
10 the distribution body (1).
2. Distribution system (10) according to embodiment 1, wherein the openings (2) are
configured to direct the process fluid flow and/or a current density distribution to the
substrate, and wherein, in case the substrate is rotating relative to the distribution
15 body (1), the spiral-shaped pattern enables several areas of the substrate to be
exposed to similar process fluid flows and/or similar current density distributions,
respectively.
3. Distribution system (10) according to one of the preceding embodiments, wherein the
20 spiral-shaped pattern is formed in that the openings (2) are arranged along an
imaginary curve, which winds around a starting point (C) on the distribution body (1)
at a continuously increasing distance from the starting point.
4. Distribution system (10) according to embodiment 3, wherein the starting point (C) is
25 a geometric centre (C) of the distribution body (1).
5. Distribution system (10) according to embodiment 3, wherein the starting point (C) is
outside a geometric centre (C) of the distribution body (1).
- 30 6. Distribution system (10) according to one of the embodiments 1 to 5, wherein the
spiral-shaped pattern is based on an Archimedean spiral (S1).
7. Distribution system (10) according to one of the embodiments 1 to 5, wherein the
spiral-shaped pattern is based on a logarithmic spiral (S2).

8. Distribution system (10) according to one of the embodiments 1 to 5, wherein the spiral-shaped pattern is based on a parabolic spiral.
- 5 9. Distribution system (10) according to one of the embodiments 1 to 5, wherein the spiral-shaped pattern is based on a square root spiral.
10. Distribution system (10) according to one of the embodiments 1 to 5, wherein the spiral-shaped pattern is based on a hyperbolic spiral.
- 10 11. Distribution system (10) according to one of the embodiments 1 to 5, wherein the spiral-shaped pattern is based on a Fibonacci spiral.
12. Distribution system (10) according to one of the preceding embodiments, wherein the spiral-shaped pattern is a combination of two or more spirals.
- 15 13. An electrochemical deposition system (20) for a chemical and/or electrolytic surface treatment of a substrate, comprising:
- a distribution system (10) according to one of the preceding embodiments, and
- 20 - a substrate rotation system,
- wherein the substrate rotation system is configured to rotate a substrate relative to a distribution body (1) of the distribution system (10).
14. A method for a chemical and/or electrolytic surface treatment of a substrate in a process fluid, comprising:
- 25 - providing a distribution system (10) comprising a distribution body (1) with a plurality of openings (2) for the process fluid, wherein the openings (2) are arranged in a spiral-shaped pattern on a surface of the distribution body (1),
- rotating the substrate relative to the distribution system (10), and
- 30 - chemically and/or electrolytically treating a surface of the substrate.

Claims

1. A distribution system (10) for a process fluid for chemical and/or electrolytic surface
5 treatment of a rotatable substrate,
wherein the distribution system (10) comprises a distribution body (1),
wherein the distribution body (1) comprises a plurality of openings (2) divided into at
least a first portion (21) and a second portion (22),

10 wherein the first portion (21) of the openings (2) is configured to provide the process
fluid flow and the second portion (22) of the openings (2) is configured to provide a
current density distribution,
wherein the second portion (22) of the openings (2) is arranged in a spiral-shaped
pattern on a surface (1b) of the distribution body (1), and
15 wherein the first portion (21) of the openings (2) is arranged on the surface (1b) of
the distribution body (1) independently of second portion (22) of the openings (2).
2. Distribution system (10) according to claim 1, wherein, in case the substrate is
rotating relative to the distribution body (1), the spiral-shaped pattern enables several
20 areas of the substrate to be exposed to similar process fluid flows and/or similar
current density distributions, respectively.
3. Distribution system (10) according to one of the preceding claims, wherein the spiral-
shaped pattern is formed in that the openings (2) are arranged along an imaginary
25 curve, which winds around a starting point (C) on the distribution body (1) at a
continuously increasing distance from the starting point.
4. Distribution system (10) according to claim 3, wherein the starting point (C) is a
geometric centre (C) of the distribution body (1).
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5. Distribution system (10) according to claim 3, wherein the starting point (C) is
outside a geometric centre (C) of the distribution body (1).

6. Distribution system (10) according to one of the claims 1 to 5, wherein the spiral-shaped pattern is based on an Archimedean spiral (S1).
7. Distribution system (10) according to one of the claims 1 to 5, wherein the spiral-shaped pattern is based on a logarithmic spiral (S2).
8. Distribution system (10) according to one of the claims 1 to 5, wherein the spiral-shaped pattern is based on a parabolic spiral.
9. Distribution system (10) according to one of the claims 1 to 5, wherein the spiral-shaped pattern is based on a square root spiral.
10. Distribution system (10) according to one of the claims 1 to 5, wherein the spiral-shaped pattern is based on a hyperbolic spiral.
11. Distribution system (10) according to one of the claims 1 to 5, wherein the spiral-shaped pattern is based on a Fibonacci spiral.
12. Distribution system (10) according to one of the preceding claims, wherein the spiral-shaped pattern is a combination of two or more spirals.
13. An electrochemical deposition system (20) for a chemical and/or electrolytic surface treatment of a substrate, comprising:
- a distribution system (10) according to one of the preceding claims, and
 - a substrate rotation system,
- wherein the substrate rotation system is configured to rotate a substrate relative to a distribution body (1) of the distribution system (10).
14. A method for a chemical and/or electrolytic surface treatment of a substrate in a process fluid, comprising:

- providing a distribution system (10) comprising a distribution body (1) with a plurality of openings (2) divided into a first portion (21) and a second portion (22),,
- rotating the substrate relative to the distribution system (10), and
- 5 - providing the process fluid flow via a first portion of the openings (2) and providing a current density distribution via a second portion of the openings (2), wherein the first portion (21) of the openings (2) is configured to provide the process fluid flow and the second portion (22) of the openings (2) is configured to provide a current density distribution,
- 10 wherein the second portion (22) of the openings (2) is arranged in a spiral-shaped pattern on a surface (1b) of the distribution body (1), and wherein the first portion (21) of the openings (2) is arranged on the surface (1b) of the distribution body (1) independently of second portion (22) of the openings (2).