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(54) **DISTRIBUTION SYSTEM FOR A PROCESS FLUID FOR CHEMICAL AND/OR ELECTROLYTIC
SURFACE TREATMENT OF A ROTATABLE SUBSTRATE**

(57) 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.

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.

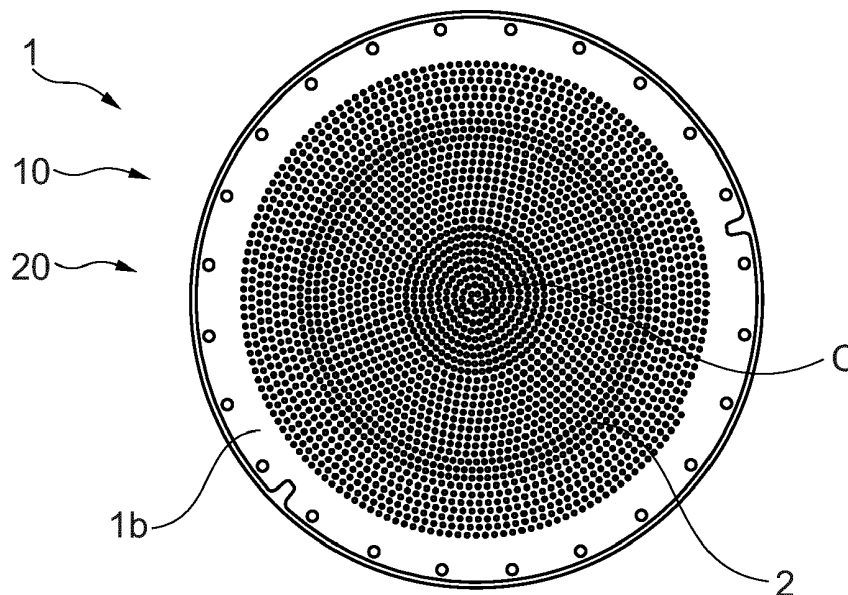


Fig. 1

Description

Technical Field

[0001] 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.

Background

[0002] 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.

[0003] 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.

[0004] 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.

[0005] 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.

[0006] 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.

[0007] 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.

[0008] 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.

[0009] 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

[0010] Hence, there may be a need to provide an improved distribution system for a process fluid for chemical and/or electrolytic surface treatment of a rotatable substrate, which allows a uniform electroplating of substrates with reduced artefacts or defect-patterns.

[0011] 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 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.

[0012] According to the present disclosure, a distribution system for a process fluid for chemical 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.

[0013] The distribution system according to the present disclosure is solving the issues of the prior 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 geometrical 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.

[0014] 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.

[0015] The locations for the electrolyte and current distribution openings can be arranged according 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.

[0016] 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.

[0017] In an example, the distribution body may be arranged between an electrode of the distribution system and the substrate.

[0018] In an example, the distribution body may be a high-speed plate (HSP).

[0019] In an example, the distribution body may be positioned parallel to the substrate.

[0020] 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.

[0021] 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.

[0022] 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.

[0023] In an example, the substrate may comprise or be made of metal (e.g. copper) or an alloy or a metallic compound.

[0024] 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.

[0025] In an example, the substrate may be placed in a substrate holder.

[0026] 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 plating process or may change during the process.

[0027] 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.

[0028] The openings can have an equal size throughout the distribution body or can vary throughout 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.

[0029] 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 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.

[0030] 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.

[0031] 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) surface of the substrate may be exposed to the same amount of substance for a homogenous electrodeposition.

[0032] 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, 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.

[0033] The spiral-shape may be based on a polar equation comprising polar coordinates. By 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.

[0034] 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 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.

[0035] 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 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 from the starting point.

[0036] 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 coordinates. For a distribution body with a circular cross-section, the geometric center would be at the center of the circumference.

[0037] 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 the geometric center.

[0038] 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 below, it is possible to target different surface areas of the substrate, which within themselves are required to be plated with very high uniformity.

[0039] 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 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.

[0040] 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 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 portion of the distribution body, while b controls the distance between consecutive loops. An Archimedean spiral always has the same distance between neighboring arcs.

[0041] 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 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.

[0042] 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.

[0043] 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.

[0044] 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 $\sqrt{n+1}$.

[0045] 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.

[0046] 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.

[0047] 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.

[0048] 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.

[0049] 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.

[0050] 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.

[0051] 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.

[0052] 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.

[0053] In an example, the substrate may be placed in a substrate holder.

[0054] In an example, the substrate may be releasably attached to the rotation system. This allows the substrate to be replaced by another substrate.

[0055] 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:

- providing a distribution system comprising a distribution body with a plurality of openings for the process fluid, wherein the openings are arranged in a spiral-shaped pattern on a surface of the distribution body,
- rotating the substrate relative to the distribution system, and
- chemically and/or electrolytically treating a surface of the substrate.

[0056] The method may further comprise a step of selecting a source of process fluid before the step of chem-

ically and/or electrolytically treating the surface.

[0057] 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.

[0058] 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

[0059] 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.

Detailed description of embodiments

[0060] 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.

[0061] 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.

[0062] 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.

[0063] 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 points along lines described by a spiral moving continuously outward from a fixed starting point C.

[0064] 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 rotating.

[0065] 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 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

[0066] Figure 2 shows schematically and exemplarily an Archimedean spiral S1. The distance 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.

[0067] 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 logarithmic spiral S2 can also be used to define the locations of the openings 2 on the surface 1b of the distribution body 1.

[0068] 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 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.

[0069] 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.

[0070] 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.

[0071] 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.

[0072] 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 recited in the claims. The mere fact that certain measures are re-cited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A distribution system (10) for a process fluid for chemical and/or electrolytic surface 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 the distribution body (1).
2. Distribution system (10) according to claim 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 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 claims, wherein 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.
4. Distribution system (10) according to claim 3, wherein the starting point (C) is a geometric centre (C) of the distribution body (1).
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. 5
13. An electrochemical deposition system (20) for a chemical and/or electrolytic surface treatment of a substrate, comprising: 10
- a distribution system (10) according to one of the preceding claims, and
 - a substrate rotation system, 15
- wherein the substrate rotation system is configured to rotate a substrate relative to a distribution body (1) of the distribution system (10). 20
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), 30
 - rotating the substrate relative to the distribution system (10), and
 - chemically and/or electrolytically treating a surface of the substrate. 35

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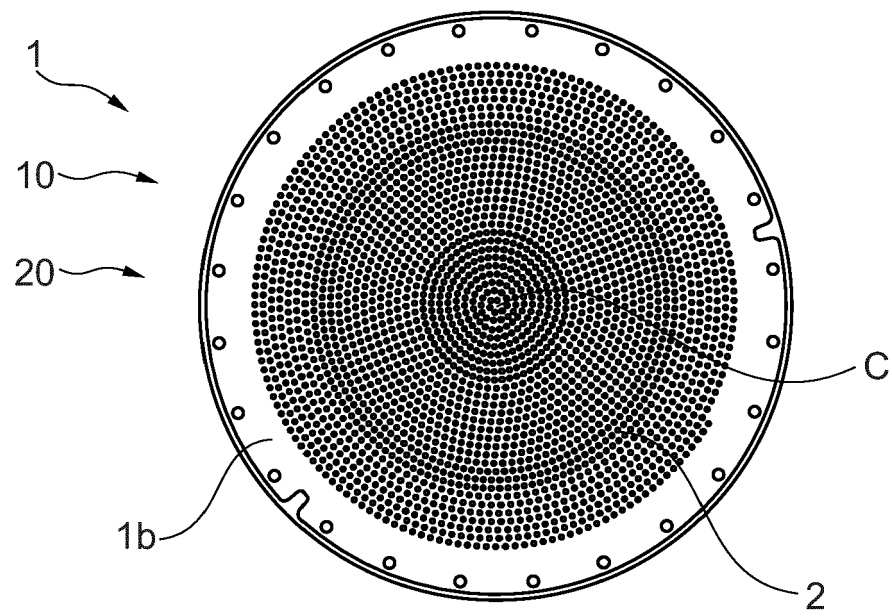


Fig. 1

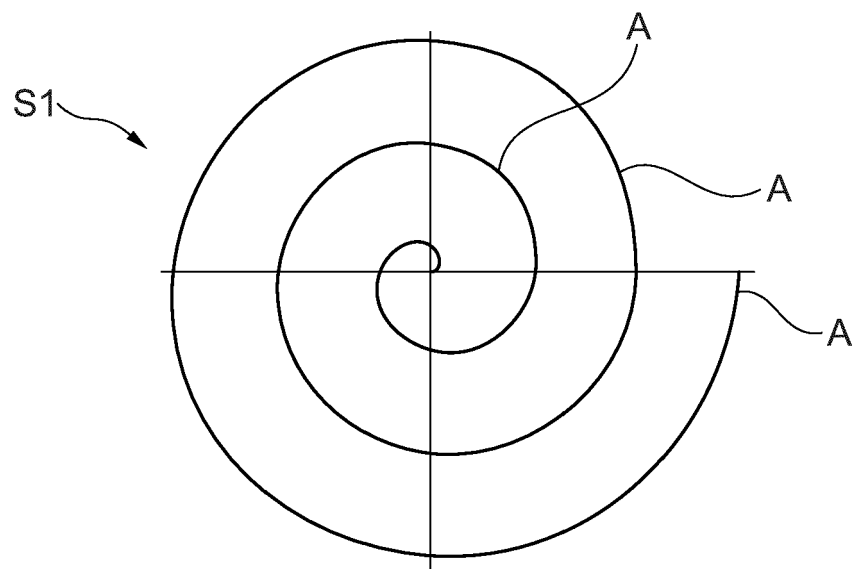


Fig. 2

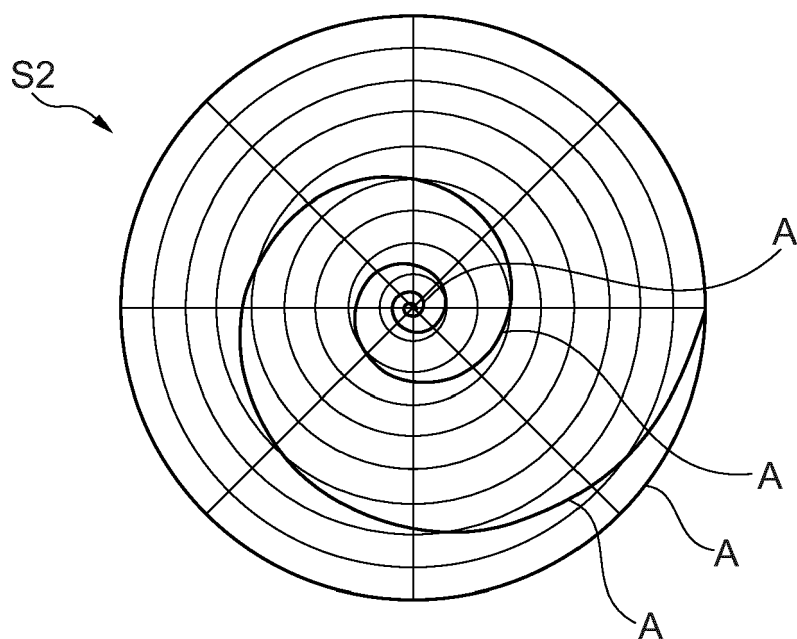


Fig. 3

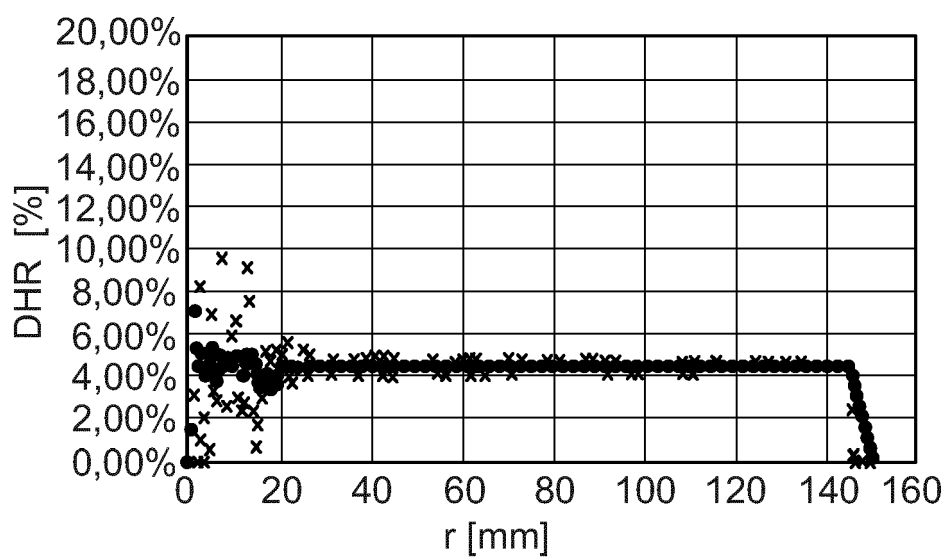


Fig. 4



EUROPEAN SEARCH REPORT

 Application Number
 EP 20 17 3988

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2002/046942 A1 (HANSON KYLE M [US] ET AL) 25 April 2002 (2002-04-25) * paragraphs [0020] - [0023] * * paragraph [0040] * * paragraphs [0046] - [0054] * * figures 2-4,8-10 *	1-4,6-14	INV. C25D17/00 H01L21/67 ADD. C25D21/10
X	US 2012/000786 A1 (MAYER STEVEN T [US] ET AL) 5 January 2012 (2012-01-05) * paragraph [0010] * * paragraph [0014] * * paragraph [0015] * * paragraphs [0046] - [0048] * * paragraphs [0132] - [0137] * * figures 1a,1b,4a-4c *	1-3,5-14	
X	US 6 103 085 A (WOO CHRISTY MEI-CHU [US] ET AL) 15 August 2000 (2000-08-15) * column 4, lines 1-34 * * column 5, lines 53-50 * * figure 4 *	1-4,6-14	
X	US 2017/342583 A1 (THORKESSON KARI [US] ET AL) 30 November 2017 (2017-11-30) * paragraph [0017] * * paragraphs [0096] - [0107] * * paragraph [0203] * * figure 2 *	1-14	TECHNICAL FIELDS SEARCHED (IPC) C25D H01L
X	US 2015/075976 A1 (HARRIS RANDY A [US] ET AL) 19 March 2015 (2015-03-19) * paragraphs [0015] - [0024] * * figures 5-6 *	1-4,6-14	
X	US 2006/191795 A1 (HANSON KYLE M [US] ET AL) 31 August 2006 (2006-08-31) * paragraphs [0028] - [0031] * * paragraphs [0057] - [0059] * * figure 5 *	1-4,6-14	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 16 October 2020	Examiner Crottaz, Olivier
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 17 3988

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

16-10-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002046942 A1	25-04-2002	US 6254742 B1 US 2002046942 A1	03-07-2001 25-04-2002
US 2012000786 A1	05-01-2012	CN 102330140 A CN 106637363 A KR 20120003405 A KR 20170057217 A KR 20170139477 A TW 201204877 A TW 201612367 A US 2012000786 A1 US 2014299477 A1 US 2014299478 A1 US 2016376722 A1	25-01-2012 10-05-2017 10-01-2012 24-05-2017 19-12-2017 01-02-2012 01-04-2016 05-01-2012 09-10-2014 09-10-2014 29-12-2016
US 6103085 A	15-08-2000	NONE	
US 2017342583 A1	30-11-2017	CN 107419312 A CN 111748835 A KR 20170132672 A SG 10201704179Y A TW 201809370 A US 2017342583 A1 US 2019301042 A1	01-12-2017 09-10-2020 04-12-2017 28-12-2017 16-03-2018 30-11-2017 03-10-2019
US 2015075976 A1	19-03-2015	CN 104272435 A CN 107419320 A DE 112013002400 T5 KR 20150013739 A SG 10201609390R A SG 11201406692W A TW 201402873 A TW 201712167 A US 2013299343 A1 US 2015075976 A1 WO 2013169477 A1	07-01-2015 01-12-2017 05-02-2015 05-02-2015 29-12-2016 27-11-2014 16-01-2014 01-04-2017 14-11-2013 19-03-2015 14-11-2013
US 2006191795 A1	31-08-2006	AU 8725501 A US 6368475 B1 US 2002084183 A1 US 2006191790 A1 US 2006191795 A1 WO 0171780 A2	03-10-2001 09-04-2002 04-07-2002 31-08-2006 31-08-2006 27-09-2001

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE 102010033256 A1 **[0004]**