(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 885 474 A1**

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.09.2021 Bulletin 2021/39

(21) Application number: **20165608.9**

(22) Date of filing: **25.03.2020**

(51) Int Cl.:
C25D 5/02 (2006.01) *C25D 5/34* (2006.01)
C25D 7/00 (2006.01) *C25D 17/00* (2006.01)
C25D 17/06 (2006.01) *C25D 21/12* (2006.01)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **METHOD FOR A CHEMICAL AND/OR ELECTROLYTIC SURFACE TREATMENT OF A SUBSTRATE IN A PROCESS STATION**

(57) The invention relates to a method for a chemical and/or electrolytic surface treatment of a substrate in a process station and a process station for a chemical and/or electrolytic surface treatment of a substrate.

The method for a chemical and/or electrolytic surface treatment comprises the following steps, not necessarily in this order:
- mounting a substrate to be treated to a rotor unit,
- moving the rotor unit with the substrate into a pre-wetting chamber of the process station,
- applying a pre-wetting fluid to the substrate in the pre-wetting chamber,
- moving the rotor unit with the substrate at least partially out of the pre-wetting chamber,
- spinning the rotor unit with the substrate in a spinning plane to centrifugally reduce the pre-wetting fluid at a surface of the substrate,
- rotating the rotor unit with the substrate normal to the spinning plane so that the substrate faces away from the pre-wetting chamber,
- moving the rotor unit with the substrate into an electroplating chamber of the process station,
- applying an electrolyte liquid and an electric current to the substrate for an electroplating process on the substrate in the electroplating chamber, and
- moving the rotor unit with the substrate at least partially out of the electroplating chamber.

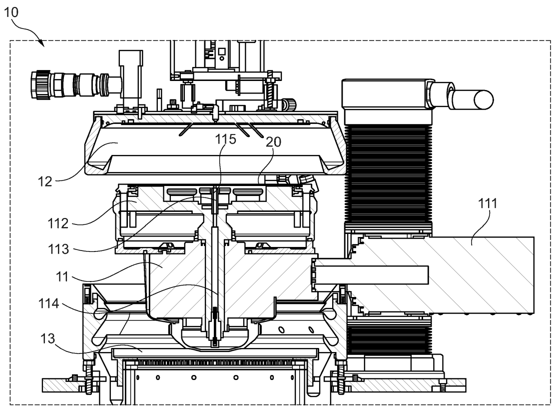

Fig. 1

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Description

Technical field

[0001] The invention relates to a method for a chemical and/or electrolytic surface treatment of a substrate in a process station and a process station for a chemical and/or electrolytic surface treatment of a substrate.

Background

[0002] In the microelectronics industry, there are several processes where small recesses on substrates have to be filled with a conductive metal (e.g. Cu), which is usually performed through so-called electroplating, electrochemical deposition, electrochemical plating or galvanic deposition. In specific cases, especially when very small and deep recesses have to be filled with a conductive material, such processes are sometimes also called high aspect ratio plating.

[0003] During the process of electrochemical deposition very often difficulties arise, because the recesses are filled with surrounding ambient air, in which the substrates are stored, handled or processed before the actual plating process. When the substrates containing the small recesses are immersed into the liquid electrolyte, the ambient air inside a small recess can form a gaseous barrier. The gaseous barrier then prevents the electrolyte to wet and penetrate into the recess and by doing so blocks or at least significantly deteriorates the deposition process for filling of the recess with an uninterrupted conductive material layer. A discontinuous or even interrupted coating or filling of the recess leads to e.g. voids within the material layer, loose contacts or even interrupted electrical circuits. In addition, the reliability, functionality and life span of a device with such non-adequate plated or filled recesses is commonly reduced.

[0004] Conventionally, ambient air is removed before and sometimes also during an electroplating process from such small recesses by means of sub-atmospheric pressure or vacuum in a pressure-controlled chamber. The subsequent plating or filling of the recesses has then to be done without interrupting the sub-atmospheric pressure or vacuum, which is very cumbersome, expensive and poses many issues and technology challenges to be implemented in a high volume and high throughput manufacturing process in order for the deposition process to deliver a qualified result.

[0005] When the plating is directly followed by the pre-wetting step under reduced pressure without release of the reduced pressure back to atmospheric pressure, the applicability to high volume manufacturing is limited. The limitation is based on the complexity of the tool construction, the costs involved to build and maintain the equipment, as well as the electrochemical processing challenges introduced when processing has to happen under reduced pressure. Further, the plating chamber needs to be capable to withstand certain levels of vacuum (pressure regulatable chambers and systems).

[0006] In another implementation, a prior rinsing of the recesses under various pressure conditions with an inert or degassed pre-wetting liquid can be performed on the substrates in a separate pre-wetting chamber before the substrate is transferred into a plating chamber where the recesses will be filled through electrochemical deposition. However, this is a very time consuming and complex procedure involving significant wet-substrate handling challenges from the pre-wet chamber to the plating chamber. This procedure is also cost intensive, as additional chambers have to be dedicated to just the pre-wet process, which in addition adds to the overall footprint of the tool, blocking very expensive manufacturing and cleanroom space.

[0007] A corresponding pre-wetting apparatus method and design is disclosed in US 2015/179458 A1: The method of electroplating a layer of copper on a wafer substrate comprises (a) providing the wafer substrate having an exposed metal layer on at least a portion of its surface to a pre-wetting process chamber; (b) contacting the wafer substrate with a pre-wetting fluid under sub-atmospheric pressure, the pre-wetting fluid comprising water and copper ions, to form a layer of pre-wetting fluid on the wafer substrate; (c) contacting the pre-wetted wafer substrate with a plating solution, the plating solution comprising copper ions, to electroplate a layer of copper on the wafer substrate, wherein the concentration of copper ions in the pre-wetting fluid is greater than the concentration of copper ions in the plating solution.

[0008] In case a separate pre-wetting chamber is applied, a disadvantage can be found in the large build size of the system (due to the additional chamber requirements), which means the tool requires a significantly larger manufacturing and/or cleanroom space. Another disadvantage is the need to transfer wet substrates from one chamber to the other without losing the liquid filling inside the recesses by full or only partial drying and without tripping liquid all over the tool space, which can cause lifetime and contamination issues with the tool.

Summary

[0009] Hence, there may be a need to provide an improved method for a chemical and/or electrolytic surface treatment of a substrate in a process station, which is in particular easier than conventional methods.

[0010] The problem is solved by the subject-matters of the independent claims of the present invention, wherein further embodiments are incorporated in the dependent claims. It should be noted that the aspects of the invention described in the following apply also to a method for a chemical and/or electrolytic surface treatment of a substrate in a process station and a process station for a chemical and/or electrolytic surface treatment of a substrate.

[0011] According to the present invention, a method for a chemical and/or electrolytic surface treatment of a substrate in a process station is presented. The method for a chemical and/or electrolytic surface treatment comprises the following steps, not necessarily in this order:

- mounting a substrate to be treated to a rotor unit,
- moving the rotor unit with the substrate into a pre-wetting chamber of the process station,
- applying a pre-wetting fluid to the substrate in the pre-wetting chamber,
- moving the rotor unit with the substrate at least partially out of the pre-wetting chamber,
- spinning the rotor unit with the substrate in a spinning plane to centrifugally reduce the pre-wetting fluid at a surface of the substrate,
- rotating the rotor unit with the substrate normal to the spinning plane so that the substrate faces away from the pre-wetting chamber,
- moving the rotor unit with the substrate in an electroplating chamber of the process station,
- applying an electrolyte liquid and an electric current to the substrate for an electroplating process on the substrate in the electroplating chamber, and
- moving the rotor unit with the substrate at least partially out of the electroplating chamber.

[0012] The present method for a chemical and/or electrolytic surface treatment of a substrate in a process station makes the surface treatment of the substrate in a process station significantly better manageable. It comprises a pre-wetting step in the process station, which can be done prior to a subsequent electroplating step in the process station without requiring an elaborate wet handling of the pre-wetted substrate from the pre-wetting chamber to the electroplating chamber. As a result, the present method allows reducing significantly process complexity and costs, because no involved wet substrate handling is necessary. There is no tripping liquid all over the tool space, which can cause lifetime and contamination issues. Further, the present method allows reducing an overall equipment size and manufacturing clean-room footprint requirements.

[0013] The substrate may comprise a conductor plate, a semi-conductor substrate, a film substrate, an essentially plate-shaped, metal or metallized workpiece and/or the like. The substrate may be held in a substrate holder.

[0014] The rotor unit can be understood as a device configured to rotate the substrate. It may comprise a drive unit and a holding unit for the substrate. The drive unit may be an engine with a transmission. The drive unit may be connected to the holding unit by means of an arm. The holding unit may be a frame to hold the substrate. The rotor unit can be used as a substrate holding and supporting device for a combined pre-wetting and electroplating process. The rotor unit may support a supply of a pre-wetting pressure (e.g. vacuum) and/or a pre-wetting atmosphere (e.g. a gas different to air) and/or an electrical current (e.g. up to 100 Ampere and more for the electroplating process) to the substrate. The rotor unit may enable a lateral movement of the substrate (e.g. up and down) and/or a spin movement (e.g. horizontally in or along a substrate surface and around an approximate center of the substrate) and/or a rotational movement around an axis normal to the spin movement of the substrate (e.g. tilt the substrate upwards to downwards). This allows process configurations for the substrate to be rotated e.g. from front-side-up on top of the rotor unit to front-side-down below the rotor unit.

[0015] The pre-wetting fluid can be understood as a liquid providing the function of pre-wetting the substrate. It can be water, high purity water and/or the like.

[0016] The pre-wetting chamber can be understood as a space or housing, in which the pre-wetting of the substrate may take place. After the pre-wetting, the substrate may be partially or completely moved out of the pre-wetting chamber. The movement direction out of the pre-wetting chamber may be a first movement direction. The substrate may then be arranged below the pre-wetting chamber.

[0017] The spinning plane can be understood as the plane in which the substrate is spun. The spinning plane may be normal to an imaginary connection line between the pre-wetting chamber and the electroplating chamber.

[0018] The wording "centrifugally reduce the pre-wetting fluid" can be understood in that the pre-wetting fluid is removed from a surface of the substrate, but still remains in recesses of the substrate.

[0019] When the rotor unit and the substrate is rotated normal to the spinning plane, this can be understood in that the substrate is tilted. Before rotating, the substrate faces the pre-wetting chamber, which can be understood to be directed upwards. After rotating, the substrate faces the electroplating chamber, which can be understood to be directed downwards.

[0020] The electrolyte liquid can be understood as a liquid providing the function of an electrolyte.

[0021] The electroplating process may be an electroplating, an electrochemical deposition, an electrochemical plating, a galvanic deposition and/or the like.

[0022] The electroplating chamber can be understood as a space or housing, in which the electroplating process may take place. After the electroplating, the substrate may be partially or completely moved out of the electroplating chamber. The movement direction out of the electroplating chamber may be a second movement direction, which is different and in particular opposite to the first movement direction. The substrate may then be arranged above the electroplating chamber.

[0023] The present method for a chemical and/or electrolytic surface treatment of a substrate can be understood to take place in the same process station. This means the pre-wetting chamber and the electroplating chamber are arranged in the same process station. In other words, the entire method for a chemical and/or electrolytic surface treatment of a substrate is done in the same process station. The substrate does not leave the process station during and between pre-wetting and electroplating. The process station comprises the pre-wetting chamber, the rotor unit and the electroplating chamber. The substrate may be fixed to the rotor unit and may then be moved by the rotor unit into the pre-wetting chamber, out of the pre-wetting chamber, to the electroplating chamber, into the electroplating chamber and out of the electroplating chamber. This can be done without releasing the substrate from the rotor unit and in particular without changing the fixture of the substrate to the rotor unit. As a result, a build size or footprint of a system for chemical and/or electrolytic surface treatment of a substrate can be rather small and a method for a chemical and/or electrolytic surface treatment can be done rather fast. In particular, a queue time and/or a transfer time can be rather limited, because subsequent steps of the method can be done immediately after one another and nearly without any transfer.

[0024] In an embodiment, the method for a chemical and/or electrolytic surface treatment comprises the step of

- modifying a gas system in the pre-wetting chamber before the pre-wetting step.

[0025] The modification of the gas system can be a reduction of pressure relative to atmospheric pressure before the pre-wetting step. The reduction of pressure can be followed by an increase of pressure to atmospheric pressure after the pre-wetting step. Alternatively or additionally, the modification of the gas system can be an exchange of gas relative to ambient air before and/or after the pre-wetting step. Generally, vacuum, reduced pressure relative to ambient pressure, ambient pressure and/or increased pressure relative to ambient pressure may be applied to the substrate in the pre-wetting chamber. Ambient air or another gas may be applied to the substrate in the pre-wetting chamber. In particular, a soluble gas like e.g. CO_2 may be applied to the substrate prior to the subsequent electroplating. There is no need to maintain the modification of the gas system (e.g. vacuum) after the pre-wetting and during the electroplating. Without such requirement, the plating chamber and plating process is easier, leading to further reduced process complexity as well as further reduced overall equipment size and manufacturing cleanroom footprint requirements.

[0026] The step of mounting a substrate to be treated to a rotor unit can be understood in that the substrate is loaded onto the rotor unit, which is enabled to support the substrate for the entire following process steps (from pre-wetting to electroplating to optionally rinsing and/or drying). For example, the substrate is mounted to the rotor unit through a clamping action of an electrical contact ring, which is closed after the substrate is loaded onto the rotor unit. The electrical clamping ring allows that a substrate front side and/or the complete substrate can be electrically connected and polarized, which means converted into a cathode during the electroplating process). Alternatively or in addition, the substrate is mounted to the rotor unit through vacuum suction forces or magnetic forces or the like.

[0027] The step of moving the rotor unit with the substrate in a pre-wetting chamber of the process station can be understood in that the rotor unit holding the substrate is moved in an e.g. upper part of the process station and into the pre-wetting chamber. A sealing between the pre-wetting chamber and the rotor unit can be established. A remaining open volume between the rotor unit and an interior of the pre-wetting chamber is thereby made very small so that only a small volume needs to be evacuated or flooded with an alternative gaseous medium. The evacuation or flooding can then be done extremely fast and/or with a very low consumption of flushing gas. Once the sealing between the pre-wetting chamber and the rotor unit is achieved, the pre-wetting as such or a combined pressure reduction and pre-wetting follows.

[0028] The step of applying a pre-wetting fluid to the substrate in the pre-wetting chamber allows removing gaseous barriers of ambient air which in particular fill recesses of the substrate. The term "recess" can be understood as an open cavity with a diameter in a range of millimeters, micrometers or nanometers. When the substrate is immersed into the liquid electrolyte, the ambient air inside the recesses can form a gaseous barrier, which prevents the electrolyte to wet and penetrate into the recess and by doing so blocks or deteriorates the deposition process for covering and filling the substrate and its recesses with an uninterrupted deposition material layer.

[0029] The step of applying a pre-wetting fluid to the substrate can be understood in that before the application of the pre-wetting liquid, optionally, a reduced pressure (e.g. 0.7 bar) may be applied to the substrate to remove ambient air out of recesses of the substrate to a level, which is not negatively impacting the process results anymore. This means gaseous barriers inside the recesses are reduced so that the following pre-wetting fluid can penetrate and wet bottom and sidewalls of the recesses. As soon as the gaseous barriers are sufficiently reduced (e.g. based on prior experimental determination of the duration), the pre-wetting fluid can be dispensed onto the substrate surface to penetrate all recesses and replace ambient air inclusions inside the recesses. The step of pre-wetting can also comprise only the application of the pre-wetting liquid without a prior subjection to reduced pressure.

[0030] After all recesses are sufficiently pre-wetted (e.g. based on prior experimental determination of the duration), the reduced pressure or vacuum can be released to achieve atmospheric ambient pressure (about 1 bar). This can be achieved by means of a gas stream into the open volume between the rotor unit and the interior of the pre-wetting chamber. The gas stream may be air, nitrogen, gases soluble in the pre-wetting liquid (e.g. CO_2 or SO_2) or the like. The step of moving the rotor unit with the substrate at least partially out of the pre-wetting chamber can be understood in that the rotor unit with the substrate is moved into a spin position (e.g. 25 mm below the pre-wetting position).

[0031] The step of spinning the rotor unit with the substrate in a spinning plane to centrifugally reduce the pre-wetting fluid at a surface of the substrate can be understood as a spinoff of an excess of the pre-wetting fluid through a spinning of the rotor unit at e.g. several hundred rpm.

[0032] The step of rotating the rotor unit with the substrate normal to the spinning plane so that the substrate faces away from the pre-wetting chamber can be understood in that the rotor unit with the substrate undergoes a rotational movement around an axis normal to the rotational spin movement of the substrate. The rotor unit with the substrate is then in a position to face e.g. down towards the electroplating chamber.

[0033] The step of moving the rotor unit with the substrate into an electroplating chamber of the process station can be understood in that the rotor unit holding the substrate is moved to the electroplating chamber of the processing station, establishes an alignment between the electroplating chamber and the rotor unit, and enters the electroplating chamber.

[0034] The step of applying an electrolyte liquid and an electric current to the substrate for an electroplating process on the substrate in the electroplating chamber can be understood in that the electroplating process is started. For the electrochemical process, the electroplating chamber of the process station contains an anode (in a state of opposite electrical polarization to the substrate), which is required to perform an electrochemical deposition of e.g. Cu or any other material that can be electrochemically deposited onto the substrate and into the recesses. An electroplating chamber also contains an electrolyte in which the substrate is submersed at the time the electrochemical process is started. The electrochemical process can be carried out in various ways from a slow, steady state plating to very high-speed plating. The rotor unit may supply up to 100 Ampere and more of current. In an embodiment, the electroplating is done in ambient air. In an embodiment, the electroplating is done in atmospheric pressure.

[0035] The step of moving the rotor unit with the substrate at least partially out of the electroplating chamber can be understood in that, when the electrochemical deposition process is determined as finished, the rotor unit is removed from the electroplating chamber.

[0036] In an embodiment, the method for a chemical and/or electrolytic surface treatment further comprises the following steps after moving the rotor unit with the substrate out of the electroplating chamber:

- rotating the rotor unit with the substrate so that the substrate faces towards the pre-wetting chamber,
- moving the rotor unit with the substrate in the pre-wetting chamber, and
- applying a rinsing liquid to the substrate in the pre-wetting chamber to remove the electrolyte liquid from the substrate.

[0037] This can be understood in that the rotor unit is removed from the electroplating chamber and rotated back into its initial position. The substrate may then be e.g. on top of the rotor unit and might be moved in the pre-wetting chamber again. The wording "in the chamber" can be understood as at least partially or completely into the chamber. In other words, "in the chamber" can be understood as next to or in the proximity of the chamber or as completely into an interior of the chamber. The wording "in the proximity of the pre-wetting chamber" can be understood as in a spin off position. In the pre-wetting chamber, a rinsing liquid may be dispensed onto the substrate surface to remove any electrolyte residues from the surface. As a summary, the rinsing can happen inside the pre-wetting chamber, but can also happen in the proximity of the pre-wetting chamber.

[0038] In an embodiment, the method for a chemical and/or electrolytic surface treatment further comprises the step:

- applying a drying flow to the substrate in the pre-wetting chamber to dry the substrate.

[0039] This can be understood in that the substrate undergoes a drying process in the pre-wetting chamber in order to enable a dry handling of the substrate from the rotor unit to e.g. a substrate transportation system or to a subsequent processing step for which the rotor unit moves into a substrate loading/unloading position. Again, the wording "in the pre-wetting chamber" can be understood as in the proximity of the chamber or as partially into the interior of the chamber or as completely into the interior of the chamber. Preferably, drying is done in the proximity to the pre-wetting chamber in the spin off position.

[0040] According to the present invention, also a process station for a chemical and/or electrolytic surface treatment of a substrate is presented. The process station comprises:

- a rotor unit,

- a pre-wetting chamber, and
- an electroplating chamber,

[0041] The rotor unit is configured to hold the substrate to be treated and to move the substrate at least partially into and out of the pre-wetting chamber and into and out of the electroplating chamber.
[0042] The pre-wetting chamber is configured to pre-wet the substrate by means of a pre-wetting fluid with or without the application of a reduced atmosphere.
[0043] The electroplating chamber is configured to apply an electrolyte liquid and an electric current to the substrate for an electroplating process on the substrate.
[0044] The rotor unit is further configured to spin the substrate in a spinning plane and to rotate with the substrate normal to the spinning plane so that the substrate faces towards the pre-wetting chamber or towards the electroplating chamber.
[0045] The present process station for a chemical and/or electrolytic surface treatment of a substrate in a process station makes the surface treatment of the substrate in a process station significantly manageable. The process station comprises the pre-wetting chamber and the electroplating chamber so that pre-wetting and electroplating can be done in the process station without requiring an elaborate wet handling of the pre-wetted substrate from the pre-wetting chamber to the electroplating chamber. There is no tripping liquid, which can cause lifetime and contamination issues. The process station reduces system complexity, size and cost.
[0046] The rotor unit may enable a lateral movement of the substrate (e.g. up and down) and/or a spin movement (e.g. horizontally in or along a substrate surface and approximately around a center of the substrate) and/or a rotational movement around an axis normal to the spin movement of the substrate (e.g. tilt the substrate upwards to downwards).
[0047] In an embodiment, the pre-wetting chamber and/or the electroplating chamber are arranged opposite to each other with the rotor unit in between. In an example, one of the chambers is arranged in a first position, e.g. on the floor, and the other chamber is arranged vertically above the first position in a second position. This means, the chambers can be stacked with the rotor unit in between moving the substrate vertically between the chambers. In another example, both chambers are arranged on the floor next to each other with the rotor unit in between moving the substrate horizontally between the chambers. In an embodiment, the process station comprises at least one more chamber.
[0048] In an embodiment, the rotor unit comprises a fixing means to fix the substrate to the rotor unit. The fixing means can be configured to enable a surface treatment of one or more substrate surfaces. In an embodiment, the fixing means is a clamping element, a magnetic element and/or a suction element. The suction element can be configured to fix the substrate by reduced pressure or vacuum.
[0049] In an embodiment, the rotor unit comprises a sealing means to close with the pre-wetting chamber liquid tight and/or gas tight. In an embodiment, the rotor unit comprises a sealing means to close with the electroplating chamber liquid tight and/or gas tight.
[0050] In an embodiment, the rotor unit comprises a gas supply system to supply gas to the pre-wetting chamber. The gas may be used for providing a specific atmosphere for the pre-wetting and/or for drying the substrate. The drying can be done in the electroplating chamber, in the pre-wetting chamber and/or between and outside these chambers.
[0051] In an embodiment, the rotor unit comprises a pressure reduction system to reduce a pressure in the pre-wetting chamber. In particular, the rotor unit may comprise two vacuum application elements, one for holding the substrate and one for reducing the pressure in the pre-wetting chamber.
[0052] In an embodiment, the rotor unit is configured to spin the substrate with 1500 rounds per minute and more, preferably 2000 rounds per minute.
[0053] In an embodiment, the rotor unit comprises an electric energy supply system to provide an electric current to the substrate for the electroplating process in the electroplating chamber. Preferably, the electric current amounts to 50 Ampere and more, more preferably 100 Ampere and more.
[0054] In an embodiment, the rotor unit comprises a rinsing liquid supply system to supply a rinsing liquid to the substrate.
[0055] It shall be understood that the method and the device 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 invention can also be any combination of the dependent claims with the respective independent claim.
[0056] These and other aspects of the present invention will become apparent from and be elucidated with reference to the embodiments described hereinafter.

Brief description of the drawings

[0057] Exemplary embodiments of the invention will be described in the following with reference to the accompanying drawing:

Figure 1 shows schematically and exemplarily an embodiment of a process station for a chemical and/or electrolytic surface treatment of a substrate according to the invention.

Figure 2 shows schematically and exemplarily the process station for a chemical and/or electrolytic surface treatment of a substrate according to Figure 1 in another position.

Figure 3 shows schematically and exemplarily the process station for a chemical and/or electrolytic surface treatment in another position.

Figure 4 shows schematically and exemplarily the process station for a chemical and/or electrolytic surface treatment in still another position.

Figure 5 shows schematically and exemplarily the process station for a chemical and/or electrolytic surface treatment in still another position.

Detailed description of embodiments

[0058] Figure 1 shows schematically and exemplarily a process station 10 for a chemical and/or electrolytic surface treatment of a substrate 20. The process station 10 comprises a pre-wetting chamber 12, an electroplating chamber 13, and a rotor unit 11. The pre-wetting chamber 12 and the electroplating chamber 13 are arranged opposite to each other with the rotor unit 11 in between.

[0059] The pre-wetting chamber 12 is a housing, in which a pre-wetting and optionally a rinsing and/or a drying of the substrate 20 takes place. The electroplating chamber 13 is a housing, in which an electroplating process takes place. The pre-wetting chamber 12 and the electroplating chamber 13 are arranged in the same process station 10. The substrate 20 does not leave the process station 10 during and between pre-wetting and electroplating.

[0060] As explained in more detail further below with reference to the other Figures, the rotor unit 11 moves the substrate 20 into the pre-wetting chamber 12, out of the pre-wetting chamber 12, to the electroplating chamber 13, into the electroplating chamber 13 and out of the electroplating chamber 13, back to the pre-wetting chamber 12, and out of the pre-wetting chamber 12. This is done without releasing the substrate 20 from the rotor unit 11 and in particular without changing the fixture of the substrate 20 to the rotor unit 11.

[0061] The rotor unit 11 therefore comprises a drive unit 111 and a holding unit 112 for the substrate 20. The drive unit 111 is an engine with a transmission. The holding unit 112 is a frame element to hold the substrate 20.

[0062] The rotor unit 11 holds the substrate 20 and provides a supply of a pre-wetting pressure (e.g. vacuum) and/or a pre-wetting atmosphere (e.g. a gas different to air) and/or an electrical current (e.g. up to 100 Ampere and more for the electroplating) to the substrate 20. The rotor unit 11 therefore comprises a pressure supply system 113, a gas supply system 114 and an electric energy supply system 115. The rotor unit 11 further comprises a rinsing liquid supply system to supply a rinsing liquid to the substrate 20.

[0063] The rotor unit 11 enables a lateral movement of the substrate 20 (up and down) and/or a spin movement (horizontally in a substrate 20 surface and approximately around a center of the substrate 20) and/or a rotational movement around an axis normal to the spin movement of the substrate 20 (tilt the substrate 20 upwards to downwards). This allows the substrate 20 to be moved up and down, be centrifuged and to be rotated from front-side-up on top of the rotor unit 11 to front-side-down below the rotor unit 11 as shown in the following:

A method for a chemical and/or electrolytic surface treatment of a substrate 20 in a process station 10 comprises the following steps, not necessarily in this order and not necessarily all of them:

- S1. mounting a substrate 20 to be treated to a rotor unit 11 (see Figure 1),
- S2. moving the rotor unit 11 with the substrate 20 into a pre-wetting chamber 12 of the process station 10 (see Figure 2),
- S3. optionally modifying a gas system in the pre-wetting chamber 12 (see Figure 2),
- S4. applying a pre-wetting fluid to the substrate 20 in the pre-wetting chamber 12 (see Figure 2),
- S5. optionally modifying the gas system in the pre-wetting chamber 12 (see Figure 2),
- S6. moving the rotor unit 11 with the substrate 20 at least partially out of the pre-wetting chamber 12 (see Figure 3),
- S7. spinning the rotor unit 11 with the substrate 20 in a spinning plane to centrifugally reduce the pre-wetting fluid at a surface of the substrate 20 (see Figure 3),
- S8. rotating the rotor unit 11 with the substrate 20 normal to the spinning plane so that the substrate 20 faces away from the pre-wetting chamber 12 (see Figure 4),

(continued)

S9. moving the rotor unit 11 with the substrate 20 into an electroplating chamber 13 of the process station 10 (see Figure 4),

S10. applying an electrolyte liquid and an electric current to the substrate 20 for an electroplating process on the substrate 20 in the electroplating chamber 13 (see Figure 4),

S11. moving the rotor unit 11 with the substrate 20 out of the electroplating chamber 13 (see Figure 5),

S12. optionally rotating the rotor unit 11 with the substrate 20 so that the substrate 20 faces towards the pre-wetting chamber 12 (see Figure 5),

S13. optionally moving the rotor unit 11 with the substrate 20 into or into proximity of the pre-wetting chamber 12 (see Figure 5),

S14. optionally applying a rinsing liquid to the substrate 20 inside or in proximity of the pre-wetting chamber 12 (see Figure 5), and

S15. optionally applying a drying flow to the substrate 20 in the pre-wetting chamber 12 (see Figure 5).

[0064] As shown in Figure 1, the step S1 of mounting the substrate 20 to the rotor unit 11 means that the substrate 20 is loaded onto the rotor unit 11, which supports, holds and moves the substrate 20 for the entire following process steps (from pre-wetting to electroplating to optionally rinsing and/or drying).

[0065] As shown in Figure 2, the step S2 of moving the rotor unit 11 with the substrate 20 into the pre-wetting chamber 12 of the process station 10 means that the rotor unit 11 with the substrate 20 is moved upwards into an upper part of the process station 10 and into the pre-wetting chamber 12. A sealing is established between the pre-wetting chamber 12 and the rotor unit 11.

[0066] Step S3 of modifying a gas system in the pre-wetting chamber 12 is a reduction of pressure (e.g. 0.7 bar or vacuum) relative to atmospheric pressure before the pre-wetting step to e.g. remove ambient air out of recesses of the substrate 20. The modification of the gas system can also or additionally be an exchange of gas in contrast to ambient air.

[0067] Step S4 of applying a pre-wetting fluid to the substrate 20 in the pre-wetting chamber 12 means that the pre-wetting fluid penetrates and wets the substrate 20 and in particular bottoms and sidewalls of recesses in the substrate 20.

[0068] Step S5 of modifying the gas system in the pre-wetting chamber 12 is an increase of the pressure after step S3 back to atmospheric pressure. The reduced pressure or vacuum of step S3 is released to achieve atmospheric ambient pressure (about 1 bar). This is achieved by means of a gas stream out of the rotor unit 11 or through a gas supply system installed on the chamber into an open volume between the rotor unit 11 and the interior of the pre-wetting chamber 12. The gas stream may be air, nitrogen, gases soluble in the pre-wetting liquid (e.g. CO_2 or SO_2) or the like. The modification of the gas system can also or additionally be an exchange of gas back to ambient air. There is no need to maintain any modification different to ambient air and pressure after the pre-wetting.

[0069] As shown in Figure 3, the step S6 of moving the rotor unit 11 with the substrate 20 out of the pre-wetting chamber 12 can be understood in that the rotor unit 11 with the substrate 20 is moved into a spin position (e.g. 25 mm) below the pre-wetting position and below the pre-wetting chamber 12.

[0070] Step S7 of spinning the rotor unit 11 with the substrate 20 in a spinning plane S to centrifugally reduce the pre-wetting fluid at a surface of the substrate 20 can be understood as ejecting an excess of the pre-wetting fluid through the spinning of the rotor unit 11 and the substrate 20 at e.g. several hundred rpm. The wording "centrifugally reduce the pre-wetting fluid" means that the pre-wetting fluid is removed from a surface of the substrate 20, but still remains in recesses of the substrate 20. The spinning plane S can be understood as the plane in which the substrate 20 is spun. The spinning plane is normal to an imaginary connection line between the pre-wetting chamber 12 and the electroplating chamber 13. The rotor unit 11 can spin the substrate 20 with e.g. 1500 rounds per minute or 2000 rounds per minute.

[0071] As shown in Figure 4, the step S8 of rotating the rotor unit 11 with the substrate 20 normal to the spinning plane means that the substrate 20 is tilted and now faces away from the pre-wetting chamber 12. The rotor unit 11 with the substrate 20 is subjected to a rotational movement around an axis normal to the rotational spin movement of the substrate 20 as shown in Figure 3. The rotor unit 11 with the substrate 20 is now in a position to face down towards the electroplating chamber 13.

[0072] Step S9 of moving the rotor unit 11 with the substrate 20 in the electroplating chamber 13 of the process station 10 can be understood in that the rotor unit 11 holding the substrate 20 is moved to the electroplating chamber 13 of the processing station, establishes an alignment between the electroplating chamber 13 and the rotor unit 11, and then enters the electroplating chamber 13.

[0073] Step S10 of applying an electrolyte liquid and an electric current to the substrate 20 for the electroplating process of the substrate 20 in the electroplating chamber 13 means that the electroplating process takes places. The rotor unit 11 may supply up to 100 Ampere and more of current. The electroplating can be done in ambient air and/or at atmospheric pressure.

[0074] As shown in Figure 5, the step S11 of moving the rotor unit 11 with the substrate 20 out of the electroplating chamber 13 can be understood in that the rotor unit 11 is removed from the electroplating chamber 13. The substrate 20 is then above the electroplating chamber 13.

[0075] Step S12 of rotating the rotor unit 11 with the substrate 20 means that the substrate 20 now faces again towards the pre-wetting chamber 12. The substrate 20 is on top of the rotor unit 11.

[0076] Step S13 is moving the rotor unit 11 with the substrate 20 back into or in proximity to the pre-wetting chamber 12.

[0077] Step S14 is applying a rinsing liquid to the substrate 20 in the pre-wetting chamber 12 to remove electrolyte residues from the substrate 20.

[0078] Step S15 is applying a drying flow to the substrate 20 inside the pre-wetting chamber 12 or in close proximity to dry the substrate 20. The substrate 20 is subjected to a dry process in the pre-wetting chamber 12 in order to enable a dry handling of the substrate 20 from the rotor unit 11 to e.g. a substrate 20 transportation system.

[0079] It has to be noted that embodiments of the invention 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.

[0080] While the invention 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 invention 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 invention, from a study of the drawings, the disclosure, and the dependent claims.

[0081] 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 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 method for a chemical and/or electrolytic surface treatment of a substrate (20) in a process station (10), comprising:

- mounting a substrate (20) to be treated to a rotor unit (11),
- moving the rotor unit (11) with the substrate (20) into a pre-wetting chamber (12) of the process station (10),
- applying a pre-wetting fluid to the substrate (20) inside the pre-wetting chamber (12),
- moving the rotor unit (11) with the substrate (20) at least partially out of the pre-wetting chamber (12),
- spinning the rotor unit (11) with the substrate (20) in a spinning plane to centrifugally reduce the pre-wetting fluid at a surface of the substrate (20),
- rotating the rotor unit (11) with the substrate (20) normal to the spinning plane so that the substrate (20) faces away from the pre-wetting chamber (12),
- moving the rotor unit (11) with the substrate (20) into an electroplating chamber (13) of the process station (10),
- applying an electrolyte liquid and an electric current to the substrate (20) for an electroplating process on the substrate (20) inside the electroplating chamber (13), and
- moving the rotor unit (11) with the substrate (20) at least partially out of the electroplating chamber (13).

2. Method according to claim 1, wherein the pre-wetting chamber (12) and the electroplating chamber (13) are arranged in the same process station (10).

3. Method according to one of the preceding claims, further comprising the step of modifying a gas system in the pre-wetting chamber (12), wherein the modification of the gas system is a reduction of pressure relative to atmospheric pressure before the pre-wetting step, an increase of pressure to atmospheric pressure after the pre-wetting step and/or an exchange of gas relative to ambient air before and/or after the pre-wetting step.

4. Method according to one of the preceding claims, wherein the electroplating is done in ambient air and/or atmospheric pressure.

5. Method according to one of the preceding claims, further comprising the following steps after moving the rotor unit

(11) with the substrate (20) out of the electroplating chamber (13):

- rotating the rotor unit (11) with the substrate (20) so that the substrate (20) faces towards the pre-wetting chamber (12),
- moving the rotor unit (11) with the substrate (20) into the pre-wetting chamber (12), and
- applying a rinsing liquid to the substrate (20) in the pre-wetting chamber (12) to remove the electrolyte liquid from the substrate (20).

6. Method according to one of the preceding claims, further comprising the step:

- applying a drying flow to the substrate (20) in the pre-wetting chamber (12) to dry the substrate (20).

7. A process station (10) for a chemical and/or electrolytic surface treatment of a substrate (20), comprising

- a rotor unit (11),
- a pre-wetting chamber (12), and
- an electroplating chamber (13),

wherein the rotor unit (11) is configured to hold a substrate (20) to be treated and to move the substrate (20) at least partially in and out of the pre-wetting chamber (12) and in and out of the electroplating chamber (13), wherein the pre-wetting chamber (12) is configured to pre-wet the substrate (20) by means of a pre-wetting fluid, wherein the electroplating chamber (13) is configured to apply an electrolyte liquid and an electric current to the substrate (20) for an electroplating process on the substrate (20), and
wherein the rotor unit (11) is further configured to spin the substrate (20) in a spinning plane and to rotate with the substrate (20) normal to the spinning plane so that the substrate (20) faces towards the pre-wetting chamber (12) or towards the electroplating chamber (13).

8. Process station (10) according to the preceding claim, wherein the pre-wetting chamber (12) and/or the electroplating chamber (13) are arranged opposite to each other with the rotor unit (11) in between.

9. Process station (10) according to one of the preceding claims, wherein the rotor unit (11) comprises a fixing means to fix the substrate (20) to the rotor unit (11), wherein the fixing means is configured to enable a surface treatment of one or more substrate (20) surfaces.

10. Process station (10) according to one of the preceding claims, wherein the rotor unit (11) comprises a sealing means to close the pre-wetting chamber (12) and/or the electroplating chamber (13) liquid tight and/or gas tight.

11. Process station (10) according to one of the preceding claims, wherein the rotor unit (11) comprises a gas supply system to supply gas to the pre-wetting chamber (12).

12. Process station (10) according to one of the preceding claims, wherein the rotor unit (11) comprises a pressure reduction system to reduce a pressure in the pre-wetting chamber (12).

13. Process station (10) according to one of the preceding claims, wherein the rotor unit (11) is configured to spin the substrate (20) with 1500 rounds per minute and more, preferably 2000 rounds per minute.

14. Process station (10) according to one of the preceding claims, wherein the rotor unit (11) comprises an electric energy supply system to provide an electric current to the substrate (20) for the electroplating process in the electroplating chamber (13), preferably wherein the electric current amounts to 50 Ampere and larger, more preferably 100 Ampere and larger.

15. Process station (10) according to one of the preceding claims, wherein the rotor unit (11) comprises a rinsing liquid supply system to supply a rinsing liquid to the substrate (20).

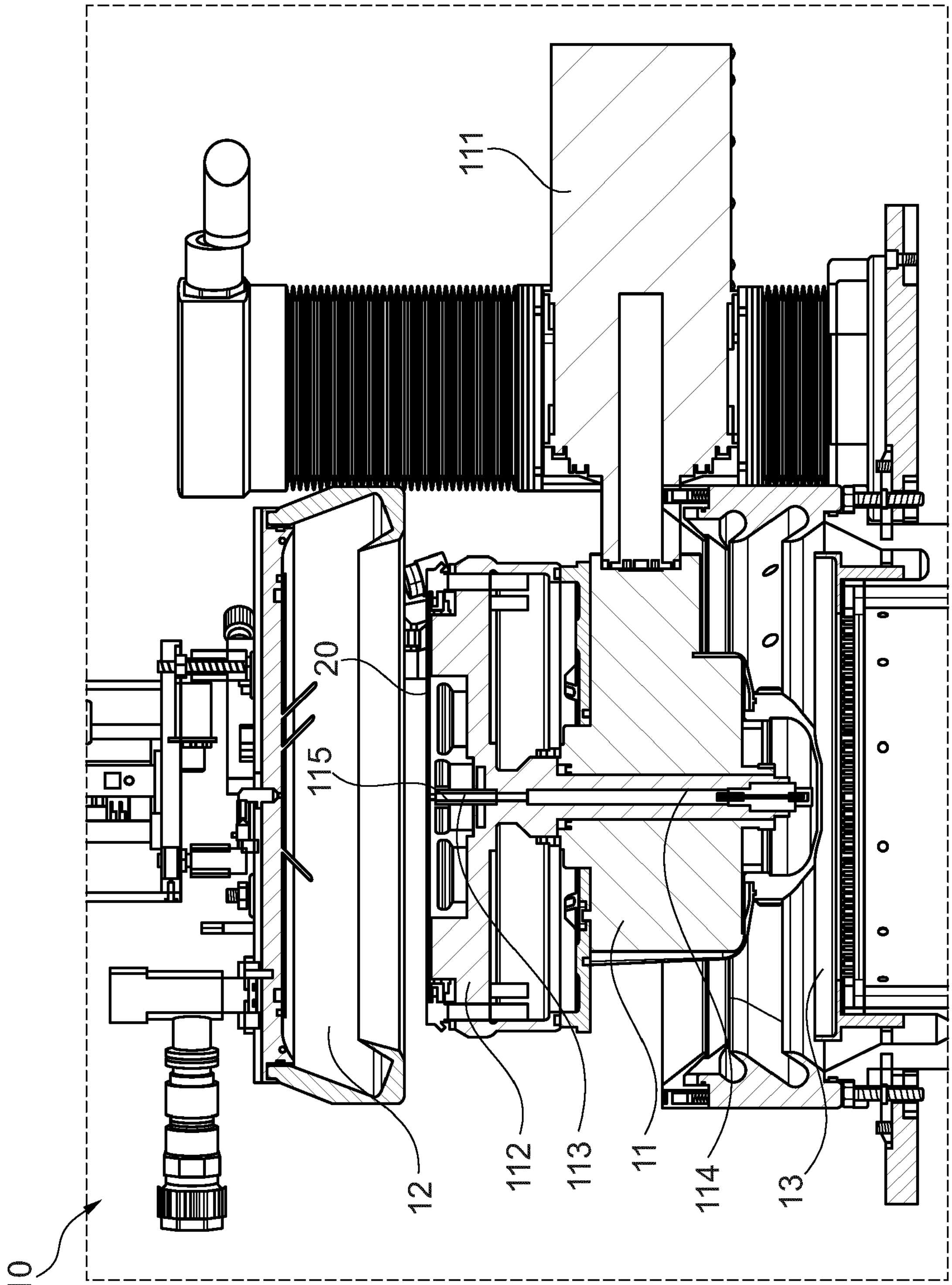

Fig. 1

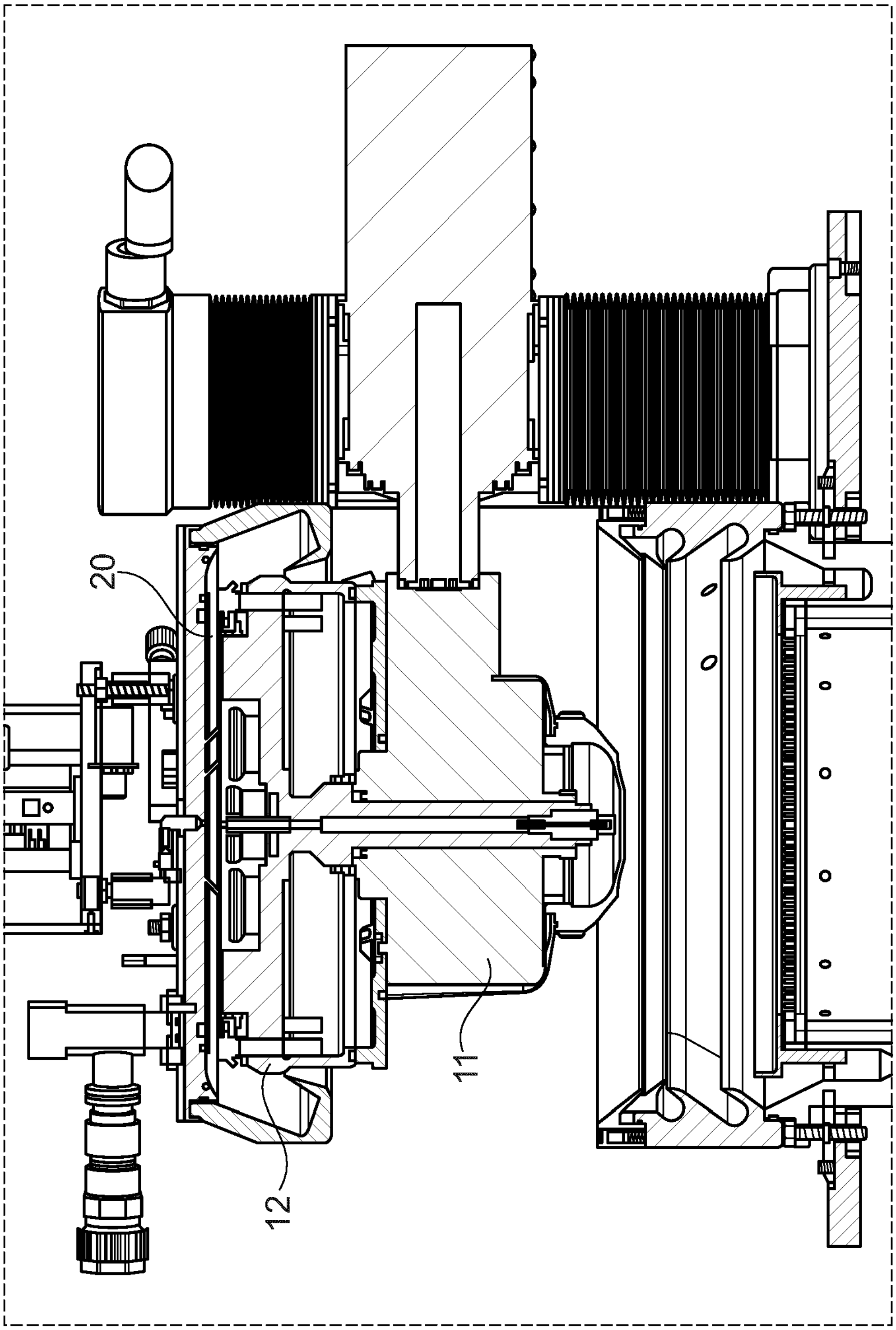

Fig. 2

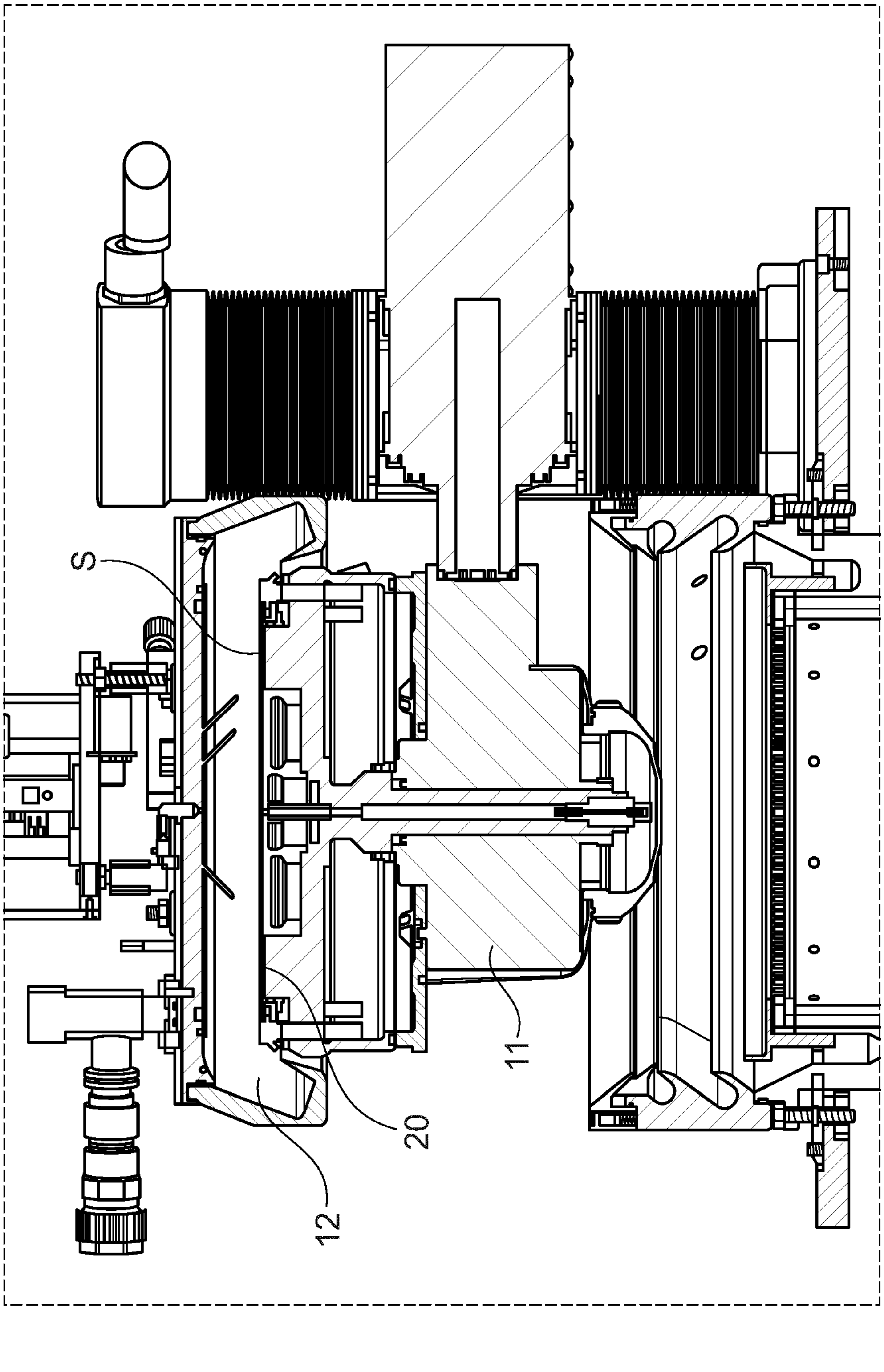

Fig. 3

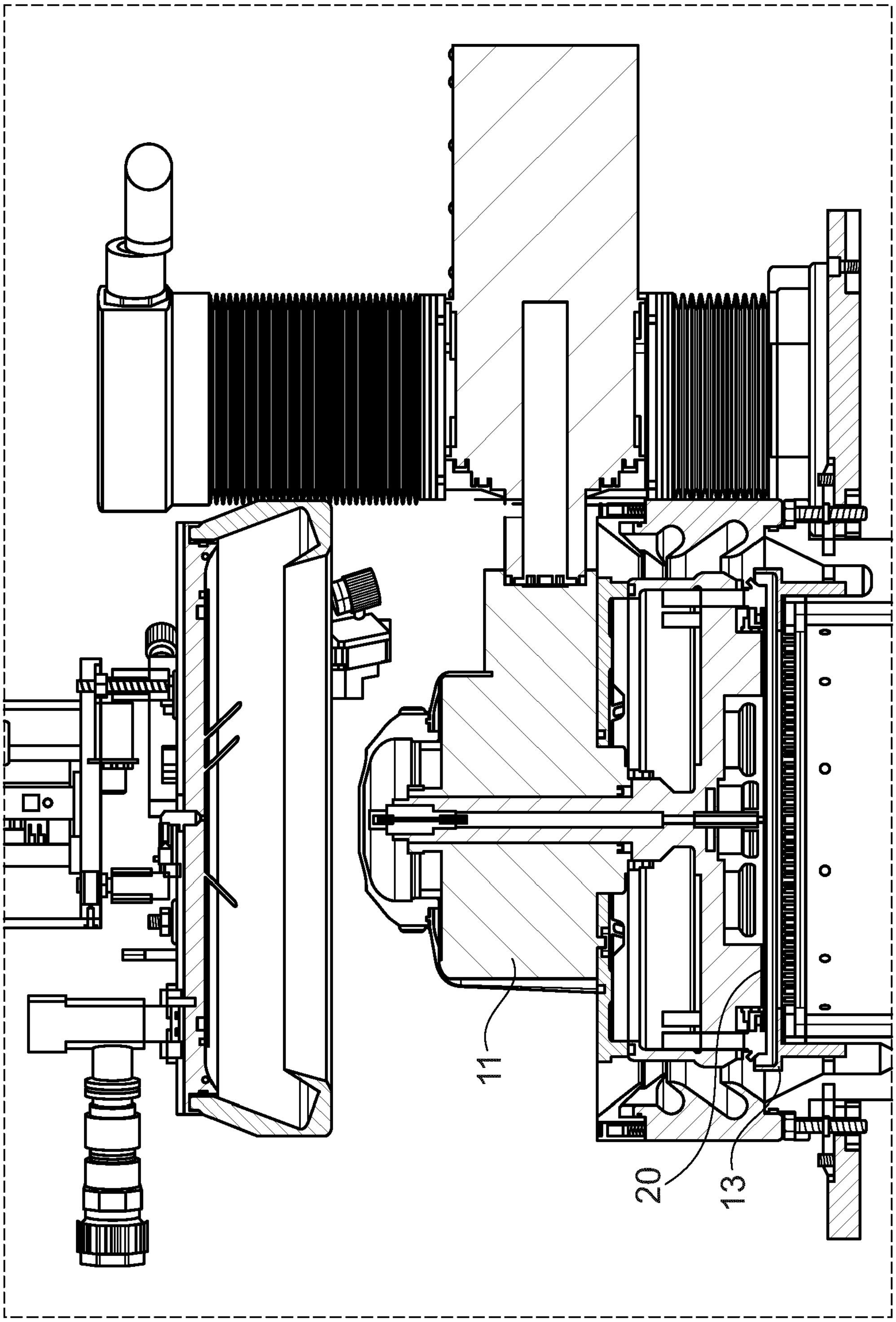

Fig. 4

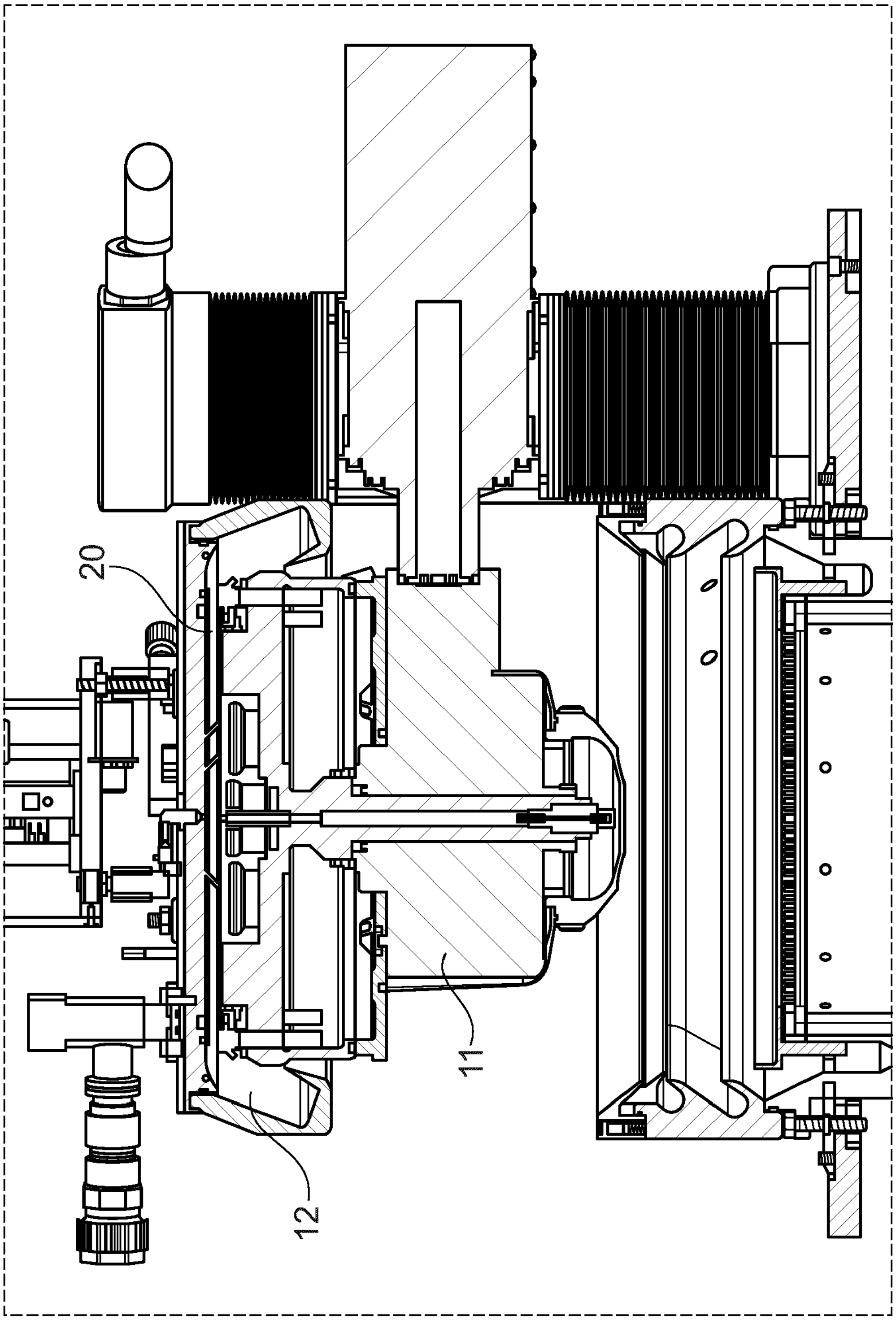

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 20 16 5608

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

C25D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	28 September 2020	Suárez Ramón, C

CATEGORY OF CITED DOCUMENTS

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28-09-2020

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