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(54) **DEVICE, SYSTEM AND METHOD FOR USE IN MACHINES FOR ELECTROCHEMICAL PATTERN REPLICATION**

VORRICHTUNG, SYSTEM UND VERFAHREN FÜR MASCHINEN FÜR ELEKTROCHEMISCHE STRUKTURREPLIKATION

DISPOSITIF, SYSTÈME ET PROCÉDÉ DESTINÉS À ÊTRE UTILISÉS DANS DES MACHINES DE RÉPLICATION DE MOTIFS ÉLECTROCHIMIQUES

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Description

Technical Field

[0001] Disclosed is a system for monitoring and controlling relative or absolute displacement of machine parts moved between a first and a second position. For example, such a system is useful in machines for performing electrochemical pattern replication (ECPR) or other high precision manufacturing or measurement tools and enables improved movement accuracy, which in turn enables smaller electrical circuits to be produced with lower tolerances and higher quality.

Background

[0002] Electroplating/electroetching is used for microelectronics in a wide range of applications, such as interconnects, components, waveguides, inductors, contact pads etc.

[0003] In the field of microelectronics electroplating/electroetching is suitable for applications involving production of micro and nano structures in single or multiple layers, fabrication of PWB (printed wiring boards), PCB (printed circuit boards), MEMS (micro electro mechanical systems), IC (integrated circuit) interconnects, above IC interconnects, sensors, flat panel displays, magnetic and optical storage devices, solar cells and other electronic devices. It can also be used for different types of structures in conductive polymers, structures in semiconductors, structures in metals, and others. Even 3D-structures in silicon, such as by formation of porous silicon, are possible.

[0004] Chemical vapour deposition and physical vapour deposition are processes that may also be used for metallization, but electroplating/electroetching is often preferred since it is generally less expensive than other metallization processes and it can take place at ambient temperatures and at ambient pressures.

[0005] Electroplating/electroetching of a work piece takes place in a reactor containing an electrolyte. An anode, carrying the metal to be plated, is connected to a positive voltage. In some cases, the anode is inert and the metal to be plated comes from the ions in the electrolyte. The conductivity of the work piece, such as a semiconductor substrate, is generally too low to allow the structures to be plated to be connected through the substrate to backside contacts. Therefore, the structures to be plated first have to be provided with a conductive layer, such as a seed layer. Leads connect the pattern to finger contacts on the front side. The finger contacts are in turn connected to a negative voltage. The electroplating step is an electrolytic process where the metal is transferred from the anode, or from the ions in the electrolyte, to the conductive pattern (cathode) by the electrolyte and the applied electric field between the anode and the conductive layer on the work piece, which forms the cathode.

[0006] The ever-increasing demand for smaller, faster and less expensive microelectronic and micro-electromechanical systems requires corresponding development of efficient and suitable manufacturing techniques, which has resulted in the development of electrochemical pattern replication (ECPR).

[0007] In ECPR plating/etching cells or cavities are formed between a master electrode and the substrate, said cavities being defined by a conductive surface on the master electrode, an insulating material, defining the pattern to be plated/etched, and the conductive surface of the substrate. During plating, a predeposited anode material has been arranged, normally through electrochemical plating, in the cavities. The master electrode and the substrate are put in close contact with each other in the presence of an electrolyte, suitable for the intended purpose, such that the electrolyte is "trapped" in the ECPR plating/etching cavities. WO 02/103085, to the present inventors, describes a system of this kind.

[0008] Patent document published WO 02/103085 A1 discloses a method, and a corresponding device, for electrochemical pattern replication utilizing a master electrode and a substrate, said method comprising the steps of measuring x-, y- and theta values of the master electrode when the master electrode and the substrate are separated in a top position and when they are adjacent in a bottom position; calculating a delta value being the difference in measured x-, y-, and theta values; comparing the delta value to a reference value; and adjusting the position of the master electrode in relation to the substrate to minimize the delta value.

[0009] Due to the close interaction between the master electrode and the substrate during ECPR there is a need for aligning the master electrode and the substrate before performing the transport of material from one to the other, in order to ensure that the interaction surfaces of the master electrode and the substrate can be brought into substantially full contact.

Summary of the Invention

[0010] Accordingly, the present invention seeks to mitigate, alleviate or eliminate one or more of the above-identified deficiencies in the art and disadvantages singly or in any combination. At least one of these problems is solved by a device according to claim 1, for electrochemical pattern replication, ECPR, comprising; a base; a bottom chuck on a X-Y-Theta stage, said bottom chuck being configured to hold a master electrode or a substrate; and a Z-stage with an attached top chuck, said top chuck being configured to hold a master electrode when the bottom chuck is configured to hold a substrate or a substrate when the bottom chuck is configured to hold a master electrode; a displacement monitor system for measuring displacement of the master electrode relative the substrate, wherein said displacement monitor system comprises a position sensor and a reference frame, wherein the position sensor measures a distance to the reference frame; and a method according to claim 13, for electrochemical pattern replication method, ECPR, utilizing a master electrode and a substrate, said method comprising the steps of measuring x-, y-, and theta values of the master electrode, when the master electrode and the substrate are separated in a top position; measuring x-, y-, and theta values of the master electrode, when the master electrode and the substrate are adjacent in a bottom position; calculating a delta value, which is the difference in measured x-, y-, and theta values; comparing the delta value to a reference value; and adjusting the position of the master electrode in relation to the substrate to minimize the delta value.

[0011] Further advantageous embodiments will be apparent from the appended dependent claims.

Brief Description of the Drawings

[0012] These and other aspects, features and advantages of which the invention is capable of will be apparent and elucidated from the following description of embodiments of the present invention, reference being made to the accompanying drawings, in which Fig. 1 to 22 illustrates a systems, close ups and details of different embodiments of the present invention;

Description of Embodiments

[0013] Fig. 1 shows an embodiment of the system, which comprises a base 16, a bottom chuck on a X-Y-Theta stage 15, and a Z-stage 111. In an embodiment, the X-Y-Theta stage is a bottom stage.

[0014] A top chuck 110, 212, 312 is attached to the Z-stage 111, 21 1, 310. The bottom chuck 15 is configured to hold a master electrode 14, 25, 38 and the top chuck 110, 212, 312 is configured to hold a substrate wafer 19. The Z-stage 111, 21 1, 310 is guided by four guides 112, 113, 23, 27 to be movable relatively the X-Y-Theta stage 15, 26 back and forth along a Z-direction or axis 13, such that the master electrode 14, 25, 38 and the substrate 19 may be moved together and apart in a controlled manner. In order to adjust the relative positions of the master electrode 14, 25, 38 and the substrate 19, 24, 34 before they are brought together, the X-Y-Theta stage 15, 26 is movable in an x-y- plane, wherein the Z-direction is parallel to the normal direction of the x-y-plane.

[0015] Thereby, the relative position and rotation of the master electrode 14,25, 38 and the substrate 19, 24, 34 in the x-y-plane can be controlled by movement of the X-Y-Theta stage 15, 26.

[0016] In order to be able to determine the relative x-y-position and theta-rotation of the master electrode 14, 25, 38 and the substrate 19, 24, 34, the disclosed system is provided with inter-substrate measurement microscopes 12, 17 configured to be removably insertable into the space between the top and bottom chucks 110, 15 for scanning the master electrode 14, 25, 38 and substrate surfaces for alignment marks. When alignment marks on the substrate 19, 24, 34 and the master electrode 14, 25, 38, the position of the master electrode 14, 25, 38 is adjusted by movement and rotation of the X-Y-Theta stage 15, 26 until a desired relative position and rotation between master electrode 14, 25, 38 and the substrate 19, 24, 34 has been achieved. When the measurement microscopes have finished the measurement of alignment markers, the measurement microscopes are retracted to a respective parking position out of the space between the top and bottom chucks 110, 15 where after the Z-stage performs a Z-travel towards the bottom chuck 15. In this way, the substrate 19, 24, 34 and the master electrode 14, 25, 38 are moved together a remaining distance along the Z-direction for performing the ECPR process.

[0017] However, during the Z-travel, unpredictable relative movements between the substrate 19, 24, 34 and the master electrode 14, 25, 38 sometimes do occur, which in turn negatively affects tolerances and results of the ECPR process. Thus, when performing the Z-travel, there is a certain displacement error in x-y-direction during the travel plus a certain theta rotation error. In order to compensate for these displacement errors, a displacement monitoring system to measure and correct the errors has been developed. An embodiment of the monitoring system is shown in Figs. 2-5.

[0018] As shown in Fig. 1-5, the displacement monitoring system according to an embodiment comprises a base 16, 210, 311 , a reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55, and a plurality of position sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54. The reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 is attached to the base 16, 210, 311 and the position sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 are attached to a measurement frame 47, 53 which is attached either to the Z-stage 111, 21 1, 310 or to the top chuck 110, 212, 312. The system in Fig 2 is shown with the Z-stage 111, 211, 310 in a top position at the beginning of a Z-travel.

[0019] The position sensors are configured to determine the relative position and rotation of the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 and thereby the top chuck 110, 212, 312 and measurement frame 47, 53 by measuring the distance between each respective sensor 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 and the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55. Thereafter, conventional geometric calculations are used to calculate x-, y-, and a theta-values describing the relative position and rotation. The measurements between the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 and the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 are measured throughout the Z-travel of the Z-stage, from its top position, or open position, to its bottom position, or closed position, where the processing takes place. The measurement with the optical alignment system using microscopes, as described above with reference to Fig. 1, is done when the Z-stage is in its top position, whilst ECPR printing is done at the bottom position, or closed position, of the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55.

[0020] Fig. 3 shows the monitoring system when the

Z-stage has completed the Z-travel and is in its bottom position.

[0021] During the Z-travel, a delta coordinate is calculated describing difference in measured X-, y-, and theta values between the top position and bottom position of the Z-travel for each of the position sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54. This delta is then compared to a reference delta that was previously created by calibration of the system. At each production cycle, the calculated delta coordinate will vary slightly. The difference between the delta coordinate and the reference delta coordinate is then used to calculate correction factors in x-direction, in y direction and for theta rotation, which factors are then used for fine adjusting the position and rotation of the X-Y-Theta stage just before Z-travel completes and the substrate 19, 24, 34 and the master electrode 14, 25, 38 touch each other. In this way, a final correction of the position of the X-Y-Theta stage is done, where after the final Z-travel, for instance hundreds of micrometers or less, is completed such that final contact is established between the substrate and the master electrode 14, 25, 38. Hence, the disclosed monitoring system enables better control of the relative position between the master electrode 14, 25, 38 and any thereto applied substrate 34. Fig. 4-5 shows a top-down view of an embodiment of the monitoring system, in which the Z-stage 414, the guides 45, 46, 412, 414. , the measurement frame 53, the sensors 41, 43, 48, 410, 51, 54 and the top chuck 413 can be seen. Preferably, the material of choice for the base 16, 210, 311, reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 and measurement frame 47, 53 are materials which are rigid and stiff and have low thermal expansion, such that varying temperature, vibrations, bending, twisting or any other cause of deformation will only marginally affect measurements.

[0022] In order to further lower temperature impact on measurements due to thermal expansion of the various parts of the measurement frame 47, 53, the opposite ends 44, 411, 52 of the measurement frame may be positioned substantially symmetrically relatively the top chuck or Z-stage, so that any movements of said ends due to thermal expansion are substantially equally large.

[0023] By having the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 attached to a measurement frame going through the centre of the chuck in symmetry, one can capture rotation and displacement in x-direction and in y-direction, as well as thermal expansion or contraction of the mechanical parts.

[0024] One way of reducing the effect of thermal expansion is to first of all manufacture the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 in symmetrical highly stable construction, preferably also with a high eigenfrequency, and second of all attaching it to a base plate 16, 210, 311, for instance made of a thermally and mechanically stable material, such as granite or Zerodur, in a thermally insensitive manner using symmetrical attachment points that can allow the material to thermally expand or contract substantially without deforming the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55. The same applies to the measurement frame 47, 53 that is attached to either the top chuck 110, 212, 312 or the Z-stage that holds the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54. Also this frame and its connections to other parts can be designed and manufactured in materials that allow thermal expansions or other disturbances of any of the mechanical parts in the whole tolerance chain to be done in a way that does not deform or expand the measurement frame 47, 53. The measurement frame 47, 53 and the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 are typically manufactured typically in low thermal expansion materials such as invar, carbon fiber reinforced materials, Zerodur or other types low CTE materials commonly used.

[0025] For example, such symmetries should preferably be chosen so that expansion of each respective part hits both sides in an opposite way. In that way, if there is an expansion in x-direction of the whole top chuck/Z-stage construction, the expansion will affect each one of the two x-sensors in substantially opposite directions.

[0026] Since sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 are attached to both ends of the measurement frame 47, 53, the position of each end of the measurement frame 47, 53 can be determined, and since the positions of both ends of the measurement frame 47, 53 are known, information of any rotation of the measurement frame 47, 53 can easily be derived using basic trigonometry. Further, this information makes it possible to calculate any expansion of the measurement frame 47, 53 caused by expansion of the measurement frame 47, 53 itself, or by for example forces from a thermally expanding/contracting Z-stage/top chuck to which the measurement frame 47, 53 is attached. Thus, having this information on the change of the distance on the left and the right side x and y both the expansion of parts plus the displacement in x and y plus the rotational displacement through the travel can be calculated for each point. In one embodiment of the invention the displacement monitoring system is used for relative measurements where it is the delta between the top position to the bottom position which is the critical part to measure and monitor. However, also long term expansion or other types of drift can be measured using the monitoring system, by having sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 configured for relative and/or absolute distance measurements between the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 and the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55.

[0027] Fig. 5 is an enlarged partial view from above showing a portion of the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 and an end portion of the measurement frame 47, 53 where the measurement and reference frames 11, 18, 21, 29, 31, 37, 42, 49, 55 are in close proximity. A sensor attachment bracket 44, 411, 52 is provided at the end of the measurement frame 47, 53. The attachment bracket 44, 411, 52 attaches the position sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 in a thermally stable and vibration stable manner. Any spatial direction for stages, reference frames 11, 18, 21, 29, 31, 37, 42, 49, 55, sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 or base surfaces is given as examples and describing specific embodiments of the invention. The invention is in no way limited to these specific embodiment, but can be used in multiple configurations to measure absolute and/or relative displacement errors for stages or other moving bodies, while they are moving along any spatial direction.

Sensor positioning

[0028] For each pair of sensors, such as the pair 51, 54 shown in Fig. 5, the sensors 22, 28, 32, 36, 41, 43, 48, 410,51, 54 may be configured to measure distance in a substantially perpendicular manner, wherein one sensor measures a distance in the x-direction dX and the other measures a distance in y-direction dY. Said x- and y-directions being perpendicular or normal to a respective surface of the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 to which surface each respective sensor 51, 54 measures distance. The position of the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 are adjusted with respect to the two perpendicular faces of the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 so that the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 are within their working range of measurement. It should be understood that the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 could be otherwise arranged, as long as the trigonometric calculations used to determine the delta values take the orientations of the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 into account.

Sensor types

[0029] The sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 can be of several different types of distance measurement sensors , typically capacitive sensors measuring against a conductive reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55, which can be Invar or another low thermal expansion metallic material. The sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 can further be inductive sensors, wherein the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 should be a metallic material. Alternatively, the sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 may be optical sensors, such as triangulation sensors or optical absolute interferometric sensors measuring against the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55. The sensors 22, 28, 32, 36, 41, 43, 48, 410, 51, 54 can also be interferometers that send out a laser beam and measure the distance between the reference face and the sensor. Another option is acoustic sensors but the invention should not be considered as being limited to these types of sensors.

[0030] Different types of sensors have different pros and cons for performing both short term high accuracy measurement as well as showing long term stability. For instance, capacitive sensors exhibit very good accuracy in measurement that has a limited time where they can be considered stable.

[0031] For relative measurements between the top position of the Z-stage and the bottom position of the Z-stage during one stage movement cycle, the measurement requires fairly short time, typically only a few seconds. Hence, basically all of the mentioned types of sensors can be used to make the relative measurement with a very high accuracy despite showing linear drift over time which would prevent them from being used for long term monitoring of the position. Several different types of sensors can be combined on the sensor attachment brackets measuring against the same or a different reference frame face, or surface. For instance, one face of the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 may be provided with a metallic surface, wherein a capacitive or inductive sensor could be used for measuring the distance to said face, whilst another face of the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 can be provided with a non-metallic reflective surface suitable for optical measurement by an interferometric or other type of optical sensor. Combinations of different types of sensors could for example provide for good accuracy and low drift both for short term and for long term measurements.

Calibration of monitoring system

[0032] Calibration of the monitoring system is done in several ways. One way is to perform one single measurement sequence. A measurement sequence starts with measuring the distance between each sensor and the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 when the Z-stage is in its top position. There after, the distance between each sensor and the reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 is calculated when the Z-stage is at its bottom position, as previously mentioned. Then, one delta value for each sensor is calculated based on the difference between the two measured values of each respective sensor (between the top value and the bottom value). In this case, where two sensor pairs are used, four deltas are calculated, two x-distance deltas and two y-distance deltas. Standard trigonometry is then used with the delta values in order to calculate any expansion, x/y-movement or rotational movement that has occurred during the Z-travel. The result of the above measurements and calculations is one single reference delta for each measured dimension, which in this case means one x-reference delta, one y-reference delta and one theta-reference delta (rotational reference delta). The reference delta values are saved to a calibration data file where they are accessible for future calculations. As previously mentioned, the reference delta values are then used to calculate a correction factor used for fine adjusting the position and rotation of the X-Y-Theta stage just before Z-travel completes.

[0033] Another way of calibrating the measuring system is to perform a plurality of measurement sequences, where after an average delta value is calculated based on the plurality of delta values that are calculated for each sensor from the measurement sequences. The calculated average delta values are then used as reference deltas.

[0034] Further, it should be understood that although only two sensor pairs are shown, more than two sensor pairs could be used, thereby enabling further increased accuracy.

Design of the reference frame

[0035] The reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 is designed to provide a very high level of thermal stability and vibration stability over time. The actual geometry and shape of this frame can be done in many different embodiments. According to an embodiment, the measurement frame 47, 53 is a beam or profile, which is attached in a stable manner to a base 16, 210, 311, for instance a granite or Zerodur base. According to another embodiment, a reference frame 11, 18, 21, 29, 31, 37, 42, 49, 55 with two or more feet being connected to the base 16, 210, 311 is used to enhance the stability of the reference faces and by connecting top and bottom beams between vertical bodies of the frame, the eigenfrequency as well as the geometry and sensitivity to thermal expansion can be minimized.

Also disclosed is a device for making electrical contact to a substrate surface, said device being not part of the invention.

[0036] The present disclosure also relates to a device for providing electrical contact to a substrate 70, 80, 90, 1000 positioned on a substrate chuck 60, 73, 83, 93, 1003 within an ECPR-machine (machine for performing electrochemical pattern replication). It should be understood that the disclosed substrate chuck 60, 73, 83, 93, 1003 and contact module as well as disclosed contacting methods can also be applied to other application areas where an electrical contact to a substrate 70, 80, 90, 1000 is desired, such as conventional electroplating, electrochemical machining or electrical discharge machining tools. The substrate chuck 60, 73, 83, 93, 1003 is configured to removably receive and hold a substrate 70, 80, 90, 1000 for ECPR-processing. Here, it should be understood that the substrate chuck 60, 73, 83, 93, 1003 is configured to receive a certain size and shape of substrates 70, 80, 90, 1000 and if other sizes and shapes of substrates 70, 80, 90, 1000 are to be received, another similar but differently sized or shaped substrate chuck 60, 73, 83, 93, 1003 can be provided applying the teachings of this disclosure. Substrate typically have a seed layer to provide a conducting surface, wherein electrical contact with the seed layer is preferably made around the circumference, or perimeter, of the substrate 70, 80, 90, 1000.

Contact fingers and segments

[0037] In order to ensure low resistance and uniform electrical contact all around the perimeter of the substrate 70, 80, 90, 1000, multiple electrical contact points, hereinafter called contact fingers 1100, 1200, 99, are provided in the ECPR machine for contacting the perimeter of a seed layer of a substrate 70, 80, 90, 1000 positioned on a substrate chuck 60, 73, 83, 93, 1003.

[0038] According to an aspect, as shown in Figs. 11 and 12, several contact fingers 1100, 1200, 99 may be arranged together forming a unit, a so called contact segment 1101, 1201, wherein each contact segment 1101, 1201 is suitable for covering a portion of the perimeter of a seed layer 72, 82, 92, 1002 of a substrate 70, 80, 90, 1000. Since the seed layers 72, 82, 92, 1002 used on the substrate 70, 80, 90, 1000 are typically fairly thin, often in a range of a few tenths up to a few hundreds of nanometres, for instance for copper plating less than one hundred nanometres, the internal resistance of the seed layer 72, 82, 92, 1002 is significant, thereby creating a drop of potential within the seed layer 72, 82, 92, 1002 when electrical current/currents travels between different spatial locations of the seed layer 72, 82, 92, 1002.

[0039] Further, since high currents, up to as high as hundreds of amperes , travel through the seed layer 72, 82, 92, 1002 during an ECPR printing cycle, it is crucial to provide multiple distributed contact fingers 1100, 1200, 99 covering as big a portion of the perimeter of the substrate 70, 80, 90, 1000 as possible, such that no large concentrations of currents occur which could damage the seed layer 72, 82, 92, 1002 and disturb the distribution of current through the seed layer. It is also crucial that each of the contact fingers 1100, 1200, 99 is arranged and attached in a flexible manner so that each of the contact fingers 1100, 1200, 99 makes good electrical contact to the seed layer 72, 82, 92, 1002 by applying enough contact force on each individual contact finger 1100, 1200, 99.

Movement of contact fingers

[0040] As shown in Figs. 7-10, when making electrical contact to the seed layer 72, 82, 92, 1002 of a substrate 70, 80, 90, 1000, the contact segments 61, 71, 81, 91, 1001, 1101, 1201 are positioned in a contact position (as shown in Figs. 8 and 10) protruding inside the perimeter of the substrate 70, 80, 90, 1000, thereby contacting the surface of the seed layer 72, 82, 92, 1002. In order to allow for loading and unloading of substrates 70, 80, 90, 1000, the contact module comprises contact actuators configured to optionally move the substrate contact segments 61, 71, 81, 91, 1001, 1101, 1201 between said contact position and a substrate loading position (as shown in Figs. 7 and 9). When the contact segments 61, 71, 81, 91, 1001, 1101, 1201 are positioned in the substrate loading position, the whole contact module and the individual contact segments 61, 71, 81, 91, 1001, 1101, 1201 are so arranged that loading and unloading of substrates 70, 80, 90, 1000 can be done using standard substrate handling robots provided with standard end effectors for gripping, moving and releasing substrates 70, 80, 90, 1000 when moving them into and out of a chuck.

Contact module

[0041] Fig. 6 shows a top view of a substrate chuck 60 according to an aspect, said substrate chuck 60 being provided with a contact module comprising a plurality of contact segments 61. According to an alternative aspect, the contact module can instead of being provided by, or integrated with, a substrate chuck 60, 73, 83, 93, 1003, be provided by, or integrated with, another part of the ECPR-machine, such as the base chuck 74, 84, 94, 1004. Hence, what is important is that the contact module is configured and positioned for providing electrical contact to a substrate 70, 80, 90, 1000 positioned in a substrate chuck 60, 73, 83, 93, 1003.

[0042] The contact module comprises at least one contact segment 61, 71, 81, 91, 1001, 1101, 1201 arranged for contacting as large a portion as possible of the perimeter of a substrate 70, 80, 90, 1000 positioned within the substrate chuck 60, 73, 83, 93, 1003. Further, the contact fingers 1100, 1200, 99 of the contact module should be arranged to provide as uniformly distributed electrical contact as possible along the perimeter of a substrate 70, 80, 90, 1000 positioned in the substrate chuck 60, 73, 83, 93, 1003. Also, the distance between the contact fingers 1100, 1200, 99 should be kept low and the number of contact fingers 1100, 1200, 99 could be kept high. For instance, several hundreds of separate contact fingers 1100, 1200, 99 could be arranged with a distance between each contact finger 1100, 1200, 99 being smaller than 5 mm or smaller than 1 mm. The contact segments 61, 71, 81, 91, 1001, 1101, 1201 in themselves can be distributed along the perimeter of the substrate 70, 80, 90, 1000, preferably with a distance between each segment 61, 71, 81, 91, 1001, 1101, 1201 being in a similar distance to the distance between contact fingers 1100, 1200, 99 of an individual segment 61, 71, 81, 91, 1001, 1101, 1201 in a way that all contact fingers 1100, 1200, 99 arranged around the perimeter of the substrate 70, 80, 90, 1000 has a similar or nearly similar distance between each contact finger 1100, 1200, 99, no matter if they belong to the same contact segment 61, 71, 81, 91, 1001, 1101, 1201 or to adjacent contact segments 61, 71, 81, 91, 1001, 1101, 1201.

[0043] The contact segments 61, 71, 81, 91, 1001, 1101, 1201 can all be connected to the same electrical circuit or have separate electrical circuits. Further, groups of segments 61, 71, 81, 91, 1001, 1101, 1201 being connected together, may be connected to individual electrical circuits.

Movement of contact fingers

[0044] Figs. 7, 8, 9, and 10 all show a device according to different aspects of the present disclosure, in all aspects comprising a base chuck 74, 84, 94, 1004, a substrate chuck (top chuck) 60, 73, 83, 93, 1003, a substrate 70, 80, 90, 1000 positioned on the substrate chuck 60, 73, 83, 93, 1003, a master electrode 75, 85, 95, 1005 attached to the base chuck 74, 84, 94, 1004, a plurality of contact segments 61, 71, 81, 91, 1001, 1101, 1201 having contact fingers 1100, 1200, 99, actuators 77, 87, 97, 1007, 1008 for moving the contact segments 61, 71, 81, 91, 1001, 1101, 1201, and holding members 76, 86 ,96, 1006 for movably holding the contact segments 61, 71, 81, 91, 1001, 1101, 1201.

[0045] Figs. 7 and 9 show the chucks in an open position moved away from each other, wherein a substrate 70, 90 can be inserted and removed into and out of the substrate chuck 73, 93.

[0046] Fig. 10 shows the chucks in a closed position, wherein the substrate 1000 and the master electrode 1005 are brought together such that ECPR printing can be performed on said substrate 1000. As shown in Fig. 7-9, the contact segment 61, 71, 81, 91, 1001, 1101, 1201 is attached to the holding member 76, 86 ,96, 1006. Further, the actuator/actuators 77, 87, 97, 1007, 1008 are arranged to move the holding member 76, 86 ,96, 1006 to move the contact fingers 1100, 1200, 99 between a loading position and a contact position. Fig. 7 and 9 show the contact fingers 1100, 1200, 99 in the substrate loading position and Figs. 8 and 10 show the contact fingers 1100, 1200, 99 in the contact position.

[0047] According to an aspect, the actuator/actuators of the contact module are positioned within the substrate chuck 60, 73, 83, 93, 1003. However, as previously mentioned, the contact module can be either positioned by the substrate chuck 60, 73, 83, 93, 1003 or by the base chuck 74, 84, 94, 1004. As shown in Fig. 10, the master electrode 1005 positioned on the base chuck 74, 84, 94, 1004, comprises a recessed edge sized to fit an electrical contact segment 61, 71, 81, 91, 1001, 1101, 1201 within the recess when the chucks are in said closed position.

Actuators

[0048] The actuators 77, 87, 97, 1007, 1008 moving the holding members 76, 86 ,96, 1006 and thereby the attached contact segments 61, 71, 81, 91, 1001, 1101, 1201 can be electrical actuators such as linear or stepper motors , or other electrical actuators, hydraulic actuators or pneumatic actuators such as pneumatic cylinders. The actuators 77, 87, 97, 1007, 1008 may provide a rotational movement or a linear movement. The movements of the actuators 77, 87, 97, 1007, 1008 can be mechanically translated into vertical, horizontal and/or rotational movements for moving the contact fingers 1100, 1200, 99 or segments 61, 71, 81, 91, 1001, 1101, 1201 between a substrate loading position and a contact position.

Holding member

[0049] In an aspect, if the substrate is circular, the holding member 76, 86, 96, 1006 can be a unified ring. In another aspect, if the substrate 70, 80, 90, 1000 is rectangular, the holding member 76, 86, 96, 1006 can be rectangular. Hence, the position of the contact fingers 1100, 1200, 99 have to adapt to the shape of the substrate 70, 80, 90, 1000, wherein the holder member has to be adapted to hold the contact fingers 1100, 1200, 99 in such as shape.

[0050] If multiple contact segments 61, 71, 81, 91, 1001, 1101, 1201 are attached to one unified ring or frame, the frame being actuated in a vertical direction 910 from a substrate loading position and a contact position, in such a way that a standard substrate handling robot with a standard end effector can access the chuck surface to load and unload substrates 70, 80, 90, 1000 when the ring of frame shape contact member being in its loading position.

[0051] In the case of the holding member 76, 86, 96, 1006 being a ring or a rectangular frame a cut out is typically provided in one side of the holding member 76, 86, 96, 1006 in a portion so that the thickness is partially reduced such that a substrate handling robot can better reach and handle the substrate 70, 80, 90, 1000.

[0052] In a different example multiple separate holding members 76, 86, 96, 1006 are provided so that one or a group of several contact segments can be individually actuated in both vertical and lateral directing according to Figure 9 and 10. Using such contact module having multiple holding members 76, 86 ,96, 1006 with individual actuators 77, 87, 97, 1007, 1008 for independent movement of a single or a group of contact segments in vertical and lateral direction, in its contact position, each of the contact segments 61, 91, 1001, 1101, 1201 is arranged in a radial or lateral position where the tips of the contact fingers 1100, 1200, 99 of the contact segment 61, 71, 81, 91, 1001, 1101, 1201 are positioned at a distance from the substrate 70, 80, 90, 1000 in a normal direction of said substrate 70, 80, 90, 1000. According to Fig. 10, the contact segments, holding members 76, 86 ,96, 1006 and actuators 1001, 1002 can be arranged so that in the contact position, none of the contact fingers 1100, 1200, 99 touch any part of the master electrode 75, 85, 95, 1005, not even when the chucks are in the closed position.

Contact fingers

[0053] The contact fingers 1100, 1200, 99 typically have a slightly bent shape which allows the contact fingers 1100, 1200, 99 to easily and precisely be brought into and out of contact with the seed layer 72, 82, 92, 1002 of the substrate 70, 80, 90, 1000. The bent shape may also helps creating a small scratch movement when a contact finger 1100, 1200, 99 is pushed against the seed layer 72, 82, 92, 1002 surface, thereby enabling better electrical contact between the contact finger 1100, 1200, 99 and the substrate 70, 80, 90, 1000.

[0054] The force of the actuator 77, 87, 97, 1007 pressing the contact fingers 1100, 1200, 99 towards the seed layer 72, 82, 92, 1002 is sufficient to substantially flatten out the contact fingers 1100, 1200, 99 to a shape in which the size of the contact segment 61, 71, 81, 91, 1001, 1101, 1201, including any bent portion, is smaller than the recess of the master electrode 75, 85, 95, 1005, such that no physical contact occurs between the contact segment 61, 71, 81, 91, 1001, 1101, 1201 and the surface of the master electrode 75, 85, 95, 1005 when the chucks are in their closed position. Fig. 9 shows an example of the device of the present disclosure, in which each of the contact segments 91 are attached to a holding member 96. Here, the holding member 96 is not a single member but instead two separately movable members 96, such that the contact segments 91 attached to each holding member 96 can make movements in both vertical direction and radial direction, thereby allowing contact fingers 1100, 1200, 99 to be moved in opposite directions by movement of the respective holding members 96 in opposite directions.

[0055] Fig. 9 shows specifically how a contact module encloses and protects a first actuator 97, a second actuator 98, a holding member 96 and a contact segment 91 within the boundaries of the contact module. The contact segments 91 shown in Fig. 9 are shown in their parking position protected by a lid 910 of the contact module.

[0056] When moving the contact fingers 1100, 1200, 99 from their substrate loading position to their contact position, one or more actuators 77, 87, 97, 1007, 1008 first move the holder members in a first direction 911 substantially parallel to a normal direction of said seed layer 72, 82, 92, 1002 in order to unfold and show the contact fingers 1100, 1200, 99, where after the actuator/actuators 77, 87, 97, 1007, 1008 move the holder members in a different second, or radial, direction 912 substantially normal to the first direction, for bringing the contact fingers 1100, 1200, 99 towards their contact positions at a distance from the seed layer 72, 82, 92, 1002 in a normal direction to said layer. Finally, the actuator/actuators 97, 98 retracts, or adjusts the holder members 96 slightly in a direction opposite the first direction 911 to press the contact fingers 1100, 1200, 99 against the seed layer 72, 82, 92, 1002 for making electrical contact through a high and uniformly distributed contact force all around the perimeter of the substrate 70, 80, 90, 1000. When the substrate 70, 80, 90, 1000 is to be removed, the contact fingers 1100, 1200, 99/contact segments 91 are then retracted from their contact position to their substrate loading position in the reverse manner. Then, the lid 910 may once again be fully closed for protecting the interior of the contact module from fluids and foreign objects, effectively, allowing wet and dry operations to be performed inside the process chambers without leaking process liquids or gases into the contact module.

Materials

[0057] All members of the contact module are preferably manufactured in materials that can withstand the chemicals used within the processing environments of an ECPR process chamber, which can contain low-pH acids as well as corrosive chemicals, oxidizing chemicals and so on. The body of the contact module is preferably made in a non- electrically conducting material which has a good resistance and chemical inertness to these chemicals, such as Teflon-like materials such as PTFE or other polymers such as PP. The body of the contact module could also be manufactured of ceramic materials or other non-electrically conducting materials. One typically wants to avoid having the contact module in a conducting material in order to avoid any electrochemical thief currents created between electrolytes, contact segments 61, 71, 81, 91, 1001, 1101, 1201, the master electrode 75, 85, 95, 1005 or other ECPR chamber parts. Most types of actuators 77, 87, 97, 1007, 1008 can be made to withstand the above mentioned chemicals, and titanium, acid proof stainless steel or other high resistance metal alloys are good choices of materials.

Protection of sensitive parts

[0058] Further, the contact module can be divided into compartments where fluid and gas tight seals are used to seal off and protect any inner volumes enclosing contact segments 61,71,81,91, 1001, 1101, 1201, holding members 76, 86 ,96, 1006, actuators 77, 87, 97, 1007, 1008 and/or electrical routing, so that such inner volumes are kept dry and protected from any chemicals used within the process chamber.

[0059] The above described properties, materials and sealed and protected design applies to all applicable embodiments of the invention.

[0060] The surface of the master electrode 75, 85, 95, 1005 is coated with an insulating layer so all parts around the contact segments is insulating so touching would not detrimentally affect to the ERPC cell itself, but repeated mechanical contact over time may make mechanical wear of the master electrodes 75, 85, 95, 1005 and is therefore preferably avoided.

[0061] Another important aspect of the electrochemical setup is that in an outer recess area of the master electrode 75, 85, 95, 1005, where the contact segment is arranged during ECPR printing, there can be electrolyte present during the process sequences, hence in order to prevent electrical shorts or electrochemical thief current shorts it is preferred to avoid any contact to the insulating coating of the master electrode 75, 85, 95, 1005 in the recess area in order to prevent scratching or mechanical wear that might otherwise break the insulating coating of the master electrode. By providing a low resistance contact between the seed layer 72, 82, 92, 1002 of a substrate 70, 80, 90, 1000 and the contact fingers 1100, 1200, 99, the substrate contacts have the same potential as the seed layer 72, 82, 92, 1002. Since cathodic potential is applied to the contact segments and seed layer 72, 82, 92, 1002 during ECPR plating, any electrochemical contact to a corresponding anode surface immersed in the same electrolyte volume might give deposition of metal on the contact segments as well as the seed layer 72, 82, 92, 1002. This is a well known problem found with electrical contacts of conventional electroplating cells, where undesired electroplating of material can take place on electrical contacts. In the disclosed example shown in Fig. 7-10 and in any ECPR case the master electrode 75, 85, 95, 1005 has an insulating material coated all around the surface preventing any electrolyte contact to conducting parts of the master electrode 75, 85, 95, 1005. All other parts of the ECPR process chamber being in contact with electrolyte may also be in insulated materials, or have floating potential, so that the contact segments being immersed in electrolyte can have a negative potential cathodic a without having any electrochemical reaction or deposition of metal taking place on to the contact segment.

Dimension and shape of contact segment

[0062] Figs. 11 and 12, shows an example of a contact segment 1101, 1201, comprising a plurality of contact fingers 1100, 1200, 99. The contact fingers 1100, 1200, 99 should be dimensioned such that the stiffness of the contact fingers 1100, 1200, 99 is high enough to allow them to break through surface oxide of a seed layer upon being forced against the seed layer during movement of the contact fingers 1100, 1200, 99 from a substrate loading position to a contact position. The contact fingers 1100, 1200, 99 should also me dimensioned such that the contact fingers 1100, 1200, 99 are flexible enough to allow all fingers 1100, 1200, 99 of a segment 61, 71, 81, 91, 1001, 1101, 1201 to contact the seed layer even if the seed layer is uneven and/or if the contact segment approaches the seed layer in a slightly non-parallel manner. Thereby, good electrical contact is promoted.

[0063] For example the material, thickness, length, width and overall shape of the contact fingers 1100, 1200, 99 may be varied to affect the stiffness and function of the contact fingers 1100, 1200, 99. As shown in Figs. 11 and 12, the contact fingers 1100, 1200, 99 of a segment may be aligned in a slightly curved row in order to be able to follow the outer shape of a specific substrate shape. In the example shown in Fig. 11, the contact segment 1101 is about 20 mm wide and has individual contact fingers 1100 being approximately 1 mm wide and having less than 1 mm spacing in between the contact fingers 1100.

[0064] An advantage of providing contact segments 61, 71, 81, 91, 1001, 1101, 1201 rather than just providing separate contact fingers 1100, 1200, 99 is that it is far less problematic to connect the contact fingers 1100, 1200, 99 to the electric circuit/circuits of the ECPR-machine, since only one routing is needed for each contact segment 61, 71, 81, 91, 1001, 1101, 1201 rather than one routing per separate contact finger 1100, 1200, 99, thereby decreasing the total number of routings needed. In a specific example, a contact segment 61, 71, 81, 91, 1001, 1101, 1201 providing contact to a 200 mm diameter silicon substrate 70, 80, 90, 1000 can have as many as 700 separate contact fingers 1100, 1200, 99 but in other examples fewer or more separate contact fingers 1100, 1200, 99 may be needed. Also, the thickness of the contact segments 61, 71, 81, 91, 1001, 1101, 1201 can for instance be smaller than 500 micrometers, for instance less than 100 micrometers.

[0065] The contact segments 61, 71, 81, 91, 1001, 1101, 1201 including their contact fingers 1100, 1200, 99 can be rigid enough to be self supporting so that the contact segments 61, 71, 81, 91, 1001, 1101, 1201 can be directly attached to actuators 77, 87, 97, 1007, 1008 without the need of holding members 76, 86 ,96, 1006. In order to reduce internal stress in the contact fingers 1100, 1200, 99 when pressed against a seed layer and thereby be able to reduce the dimensions of the contact fingers 1100, 1200, 99, a lid 910 and/or holding member 76, 86 ,96, 1006 may be configured to apply a pressing force directly to each respective contact finger 1100, 1200, 99 somewhere between the inner and outer end of each respective contact finger 1100, 1200, 99.

[0066] The contact segments 61, 71, 81, 91, 1001, 1101, 1201 can comprise at least one layer of at least one material that does not erode or oxidize during electrochemical processing used in ECPR printing. For instance the material can be stainless steel, gold, silver, palladium, platinum, platinised titanium or combinations thereof.

Also disclosed is a method of testing a contact resistance between a contact segment and a seed layer of a substrate, method not being part of the invention.

[0067] Figure 13 shows schematically the electrical circuit diagram for a substrate contact module having 20 separate contact segments, each segment with a separate electrical routing to a relay 21 which is used to switch the connection to a contact segment between either ground, plating power circuit line or to a test signal circuit line. When performing a contact resistance test, one contact segment at a time may be connected to said test signal, driving a current from the contact segment into the seed layer of a substrate, while at least one of the other contact segments is connected to ground, letting the input test current propagate from the contact segment being tested through the seed layer of the substrate out through the one or more of the other contact segments that are connected to ground. By supplying a certain test voltage and measuring the resulting current the contact resistance for the segment being tested can be calculated and stored. In a short time each of the contact segments of a contact module may be tested in terms of contact resistance to a seed layer of a substrate by repeating the procedure for each segment. By connecting all contact modules that are currently not being tested to ground the variations or resistance effect from these contact resistances can be minimized, allowing an accurate measurement of the contact resistance of the specific contact segment being tested.

[0068] A de-multiplexer may also be connected to a line having an incoming test voltage, and used to select which of the 20 contact segments to be connected to the test signal line, which may be combined with a multiplexer to select which of the outgoing lines may be connected to ground and/or plating power.

[0069] The procedure for testing one or several of the contact segments may be performed after loading a new substrate to be printed in an ECPR process chamber, before the substrate is immersed in electrolyte or before the printing current is applied. By establishing thresholds for the lowest and highest allowed contact resistance for a contact segment, a test system that may abort the print sequence or give a warning signal if a contact resistance outside the allowed thresholds is detected, can be used together with the contact module. By used of such contact test system printing of non-uniform current distribution and thereby non-uniform metal layers onto substrates as a result of poor contacts can be avoided. The described contact test method can detect problems in the contact module itself as well as testing the electrical contact between contact segments and a seed layer of a substrate.

[0070] Fig. 13 shows the schematic circuit diagram describing how the contact segments of a substrate contact module can be connected in an electrical circuit for performing both testing of contact resistances according to disclosed test methods, as well as ECPR printing. The routing from the substrate chuck goes through a measurement resistance 80 through a multiplexer then back to a power supply that applies a current to the printing cell or plating cell of the ECPR-machine.

[0071] Each of the contact segments shown in Fig. 13 are during contact testing connected through a multiplexer, which makes it possible to apply a test signal to all contact segments. The multiplexer also provides means to disconnect one of the segments at a time from the other segments in order to be able to apply a test signal, that is applied between one contact segment, through the seed layer and then through the other contact segments and back through the multiplexer through a test resistance, which is used to measure the resistance of the contact finger/contact segment itself. By using a multiplexer the resistance of all contact segments can be individually tested. By stepping through the individual contact segments by switching the multiplexer to the individual positions, all of the contact segments can be tested prior to a print cycle.

[0072] In the same way, after performing a print cycle, one can verify that all contacts still have good electrical contact after the printing. For instance such a test can be used to ensure that no loss of seed layer has taken place during printing. When performing the test sequence after printing the resistance data of each contact segment is stored in a resistance test log file of the tool.

[0073] For all examples of contact modules, routing can be provided inside the contact module for a rinsing fluid, such as DI-water, to be able to periodically rinse either the entire module or a wet compartment of the module in which electrolyte typically enter. For instance a rinsing operation of the wet compartment of a contact module can be performed at the same time as the rest of process chamber is being rinsed after a printing cycle. Preferably inlets are provided to the contact module and/or the process chamber for a drying gas, such as room temperature or heated nitrogen, which drying gas can be introduced into and led out of the contact module to periodically dry out the contact module between printing cycles.

[0074] In a further example of the contact module, different sealing solutions involving standard lip seals, double lip seals, x-seals or o-rings, are provided for creating a fluid seal around the contact module in order to seal the contact module off from other parts of the process chamber to thereby avoid leaks of electrolytes or other process fluids into the contact module.

[0075] A complementary way to prevent leaks of fluids into the contact module is to apply a slight over pressure of gas inside the contact module when it is in its closed position, so that any damage to the seal or any other leak path shows.

[0076] According to an example, the entire contact module is enclosed in one body including electrical routing in order to create a field replaceable unit that may easily be attached and detached to a process chamber of an ECPR-machine. In some examples, the detachable attachment is achieved by quick connectors for electrical cables and media routing pipes, such as rinsing water and vacuum and pressurized air or nitrogen In examples involving pneumatic cylinders, or other types of pneumatic actuators, an over pressure can be used to actuate the cylinder in one direction, wherein vacuum can be routed to the cylinder to provide a force to move the actuator in the other direction. In examples involving rinsing and drying of the contact module, the contact module is arranged radially inside the fluidic seal that encloses the chamber so that any wet or dry processing operations can take place inside the confined chamber created between the surfaces of the substrate chuck, the base chuck and in radial position enclosed by a fluid seal. In order to avoid leaks between the contact module and a chuck, seal solutions can be applied between the contact module and the chuck surfaces in addition to having internal sealing solutions preventing leaks into the module itself.

Also disclosed is a means for providing electrical contact between a master electrode and a substrate, said means not being part of the invention.

[0077] Also disclosed is an electrical contact device for the backside of a master electrode for use in an ECPR-machine (machine for electrochemical pattern replication). Preferably, such a device can be integrated with a base chuck for holding the master electrode, or alternatively in the substrate chuck for making contact to the backside of substrates, in cases where electrical contact can be done to the backside of a substrate.

[0078] The electrical contact means according to the present disclosure for making contact to a master electrode is according to an aspect provided through a base chuck for holding a master electrode. The disclosed device provide a general, simple way to create electrical contacts to the master electrode, in a single center contact or multiple contact points, for instance distributed around the perimeter of the master.

[0079] Figs. 20-22 show three different cross-sections of a process chamber of an ECPR- machine.

[0080] More specifically, Fig. 1 shows a bottom rigid chamber base with resilient compression layer arranged between the rigid chuck surface and the master electrode, the compression layer being attached to the chuck and considered as part of the chuck, the chuck having a centre contact point and peripheral contact points around the circle and here shown with numerous of these contact pins going through the base chuck surface at the edge of the master electrode and one central contact in the middle.

[0081] Fig. 21 shows a portion of the same chuck with a peripheral contact pin making contact the backside of the master electrode at the perimeter of it, a resilient compression layer with an embedded lip seal, for preventing leaks of electrolyte going to the backside of the master electrode.

[0082] Figs. 20 and 21 show an example with an electrical pin in the centre area, which completely fill the cutout, the hole, in the chuck in order to minimize the any areas underneath the master that is mechanically unsupported. A center contact pin is arranged with a spring loaded mechanism either by a mechanical spring or by a gas over pressure from the back that creates an upforce of this contact point that both ensure a good electrical contact and also makes sure that it balances the mechanical counter pressure to the back of the master electrode that prevents any recession of the master electrode down into the chuck surface.

[0083] Fig 22. shows a similar solution at the edge of the master electrode where numerous contact pins that make electrical contacts to the master electrode are arranged. These contact pins have a smaller diameter and are housed inside a sleeve, ensuring that the area underneath the master that is mechanically unsupported is minimized.

[0084] The outer pins can be actuated by a inflatable tube that is inflated for moving the contact pins upwards. Other types of actuators may also be used, such as springs, pneumatic cylinders or electrical actuators, that gives the actuation of the pins. The purpose of the actuators is to apply a force which is high enough to create a good electrical contact, high enough to prevent bending of the master electrode, still preventing any significant deformation of the master electrode.

Also disclosed is a device for sealing and fixation of substrates and master electrodes, said device not being part of the invention.

[0085] One purpose with substrate and master seals is to prevent electrolyte from flowing between the chuck surface and any of the master electrode or the substrate. This may be accomplished by arranging a seal at the edge of the substrate, the seal may be embedded in the processing chamber of the ECPR-machine.

[0086] Figs. 14 to 21 for example show various examples of such seals for this application.

[0087] A specific challenge with ECPR is that if a standard industry seal, such as an solid O-ring, is used, there is a risk that any deflection of the surface of the master electrode would both endanger the function of the seal and give deflection of the master or substrate that may result in entrapment of electrolyte between the master and substrate during a docking sequence where the two surfaces are brought together for performing ECPR printing.

[0088] The disclosed seals and related sealing methods have been developed to achieve sufficient sealing between a chuck and a master electrode, or other substrate-like element, at the same time minimizing deformation of the master electrode, avoiding potential seal leaks and electrolyte entrapment problems.

[0089] One principle for fixating substrates or master electrodes on ECPR chuck surfaces disclosed is to provide an under pressure in an inner volume between the chuck 142, 152, 162 and a master electrode 144, 154, 164 to be mounted to said chuck 142, 152, 162, 172, 182, 192. Thereby, a fluid pressure, such as atmospheric pressure or pressure from electrolyte, from an outer volume on the other side of the master electrode 144, 154, 164 causes the master electrode 144, 154, 164 to be pressed against the chuck 142, 152, 162, 172, 182. By releasing said under pressure, the master electrode or substrate is once again free to move.

[0090] As shown in Figs. 16-19, by providing a sealing element 161, 171, 181, 191, 2102 between the master electrode 164 and the chuck 162, 172, 182, 192, the inner volume between the chuck 162, 172, 182, 192and the master electrode 164 is effectively sealed off from and the outer volume on the other side of the master electrode 164, such that it is possible to achieve a large pressure difference between the two volumes, to thereby firmly hold the master electrode to the chuck 162, 172, 182, 192.

[0091] In order to lower the pressure in the inner volume, a source of vacuum is provided, such as a vacuum pump (not shown). Further, vacuum grooves 140, 150, 160, 170, 180, 190 and channels 143, 153, 163, 173, 183, 193 are provided in the chuck 142, 152, 162, 172, 182, 192 for leading fluid from the inner volume to the source of vacuum in order to lower the pressure in the inner volume.

[0092] According some examples, as shown in Fig. 14 and 16, a compliant layer, or resilient compression layer 145, 165 is provided.

[0093] In other examples, as shown in Fig. 15, no such layer is provided in the chuck surface. Preferably, the sealing element 161 is positioned in a sealing element groove 165 which is provided close to the edge of the master electrode 164.

[0094] In the example shown in Fig. 16, the sealing element 161 has X-shaped cross section, but other examples are feasible within the scope of the present disclosure, such as the examples shown in Figs. 17, 18 and 19.

[0095] The material for the various examples of the sealing element 161 is preferably an elastomer or a flexible hollow body of another more rigid polymer material.

[0096] In order to achieve a good seal, the sealing element 161 should be resilient enough to follow the surfaces of both the chuck and the master electrode to form a well sealing contact surface. Further, the seal should be configured and positioned to press hard enough against the contact surfaces without substantially deforming or bending the master electrode.

[0097] In order to achieve this the sealing element 161 is positioned to protrude above the surface of the chuck when the sealing element 161 is not loaded so that when the master electrode is pressed against the sealing element 161, the sealing element 161 deforms and thus presses back on the contact surfaces. Disclosed sealing elements 161 are soft enough in the Z-direction(a direction normal to the one surface of the master electrode that faces the chuck) so that the sealing element 161 can be compressed enough to give sealing without substantially deflecting or bending the master electrode.

[0098] As shown in Fig. 16, the sealing element 161 has a X- shaped cross-section. According to other examples, such as the one shown in Fig 17, the sealing element 171 is inflatable. Further, an inflatable seal could be of a one layer membrane as shown in Fig 17, or the sealing element 180 could have the shape of a tube that is positioned in a rounded groove around the substrate, as shown in Fig. 18, wherein the tube 180 is connected to a source of pressurized fluid and wherein the tube can be inflated and deflated as wanted.

[0099] Another type of sealing element 191, 2102 disclosed is a high flexibility lip seal, as shown in Fig 19 and Fig. 21, such as a lip seal with a shape that is fairly thin and has a pre-defined direction in this case going outwards so that when there is an under pressure in the inner volume and pressure on the outer side the seal lips being pressed against the surface of the master electrode or substrate. For safety redundancy, one can have a double lip seal configuration. It can be a single or double lip impression of the seal.

[0100] According to an example shown in Figure 14 and 15, a sealing function to prevent leakage of electrolyte underneath the substrate or the master electrode is disclosed, based on a gas pressure zone created at the perimeter of the master electrode or substrate. A gas seal is provided be arranging a groove 140, 150 in the chuck surface close to the edge of the master electrode, pressurized gas is distributed through said groove with an over pressure of for example about 0-0,3 bar through a gas distribution lead 143, 153. The gas distribution pressure is regulated to provide an increased local pressure at an outer gas sealing area at the perimeter of the master electrode or substrate, preventing any fluid for entering this zone, but still avoiding creation of bubbles. Suitable gases for use in the gas seal are gases that do not oxidize the metals active in the ECPR-process. For example nitrogen, argon, helium or possibly regular air as a worst case scenario. Nitrogen is a typical solution because it is inert and is fairly inexpensive compared to other inert gases.

[0101] The above mentioned use of an under pressure to hold the master electrode to the chuck can be combined with the gas seal technique. However, in order to avoid substantial amounts of gas from the gas seal to escape into the inner volume and the vacuum system, the distance between the nearest vacuum groove 140, 150, 160, 170, 180, 190 and the groove of the gas seal may be larger than the distance between the groove of the gas seal and the periphery of the master electrode. Sufficient gas distribution through holes, 143, 153, are preferably provided into the groove of the gas seal, and the cross section of the gas groove should be large enough, in order to provide for a uniform distribution of the over pressure in all portions of the gas seal. The over pressure in the gas seal has a purpose to increase the local pressure under this surface of the master electrode to atmospheric or to the same pressure as the pressure inside the process chamber of the ECPR-machine. A PID regulator may be used to control the pressure inside the gas seal. A gas flow meter could also be used to measure the flow of gas into the gas seal and then control the supply rate and/or pressure of supplied gas using a PID controller. A gas seal function according to this disclosure may be combined with any of the additional sealing elements disclosed in this document, to further improve the reliability of the sealing function. Leaking electrolyte to the backside of master electrodes or substrates may impose difficulties rinsing and drying said master electrode or substrate without crystallization and creation of salts residues in small gaps between the master electrode or substrate surface and the chuck surfaces, creating problems for handling of the substrates and contamination and particle propagation.

[0102] According to an example, an insulating layer is inserted between the chuck and the master electrode to make sure that if there is electrolyte to some extent in an outer zone at the perimeter, the electrolyte it is still isolated from the chuck surface. The insulating layer is for example a Teflon tape or similar, an insulating layer that is laminated onto the chuck surface as a top coating of the chuck. In one example the chuck surface has a hydrophobic top coating which helps preventing leaks of electrolyte between the master electrode and the substrate. It is readily understood that all references to lower/upper are merely for illustrative purposes, without any limiting effect on the scope of protection. Moreover, it should be realized that equivalent setups to those described may include setups having a substrate arranged on a lower chuck while the master electrode is mounted on an upper chuck, as well as setups in which the positions of the lower and upper chuck are switched.

[0103] Furthermore, although individually listed, a plurality of means, elements or method steps may be implemented by e.g. a single unit or processor.

Claims

1. A device for electrochemical pattern replication, ECPR, **characterized in that** it comprises: a base (16, 210, 311); a bottom chuck on a X-Y-Theta stage (15, 26), said bottom chuck being configured to hold a master electrode (14, 25, 38) or a substrate (19, 24, 34); and a Z-stage (111, 211, 310) with an attached top chuck (110, 212, 312), said top chuck being configured to hold a master electrode (14, 25, 38) when the bottom chuck is configured to hold a substrate (19, 24, 34) or a substrate (19, 24, 34) when the bottom chuck is configured to hold a master electrode (14, 25, 38); a displacement monitor system for measuring displacement of the master electrode (14, 25, 38) relative the substrate (19, 24, 34), wherein said displacement monitor system comprises a position sensor (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) and a reference frame (11, 18, 21, 29, 31, 37, 42, 49, 55), wherein the position sensor (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) is attached to a measurement frame (47, 53), said measurement frame being attached either to the Z-stage (11, 211, 310) or to the top chuck (110, 212, 312) and measures a distance from the master electrode (14, 25, 38) or the substrate (19, 24, 34) to the reference frame (11, 18, 21, 29, 31, 37, 42, 49, 55) in the x-y plane..

2. The device according to claim 1, wherein movement of the Z-stage (111, 211, 310) is guided by guides (112, 113, 23, 27), traversing through the Z-stage (111, 211, 310) so that the Z-stage (111, 211, 310)may slide along the guides (112, 113, 23, 27) and thus allow the attached top chuck (110, 212, 312) and substrate (19, 24, 34), held by the top chuck (110, 212, 312), to be movable relatively the X-Y-Theta stage (15, 26), back and forth along a Z-direction or axis (13), which axis (13) is parallel to the length of the guides (112, 113, 23, 27), such that the master electrode (14, 25, 38) and the substrate (19, 24, 34) may be moved to and from each other in a

controlled manner.

3. The device according to any of claims 1 or 2, wherein the displacement monitor system comprises at least two position sensors (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) on opposite sides of the top chuck (110, 212, 312).

4. The device according to any of the preceding claims, wherein the position sensor (41, 43, 48, 410, 51, 54) is mounted on a measurement frame (47, 53), aligned with a reference frame (11, 18, 21, 29, 31, 37, 42, 49, 55), where the measurement frame (47, 53) is attached to the Z-stage (111, 211, 310) or to the top chuck (110, 212, 312).

5. The device according to claim 4, wherein the opposite ends (44, 411, 52) of the measurement frame (47, 53) are positioned substantially symmetrically relatively the top chuck (110, 212, 312) or Z-stage (111, 211, 310).

6. The device according to claim 4 or 5, wherein at least two sensors (41, 43, 48, 410, 51, 54) are mounted on a measurement frame (47, 53) in a perpendicular manner so that at least one sensor measures a distance in an x-direction dX, relative the reference frame (11, 18, 21, 29, 31, 37, 42, 49, 55), and at least one other sensor measures a distance in y-direction dY, relative the reference frame (11, 18, 21, 29, 31, 37, 42, 49, 55), wherein said x- and y-directions are perpendicular or normal to a respective surface of the reference frame (11, 18, 21, 29, 31, 37, 42, 49, 55) to which surface each respective sensor (51, 54) measures distance.

7. The device according to any of the preceding claims, further comprising an inter-substrate measurement microscope (12, 17) which is removably insertable between the top (110, 212, 312) and bottom (15, 26) chucks for simultaneous scanning of the surfaces of the master electrode (14, 25, 38) and the substrate (19, 24, 34) for alignment marks.

8. The device according to any of the preceding claims, wherein the base plate (16, 210, 311) is made of a thermally and mechanically stable material.

9. The device according to claim 8, wherein the thermally and mechanically stable material is granite or Zerodur.

10. The device according to any of the preceding claims, wherein the reference frame (11, 18, 21, 29, 31, 37, 42, 49, 55) is made by a low thermal expansion material.

11. The device according to claim 10, wherein the low thermal expansion material is invar, a carbon fiber reinforced material, or Zerodur.

12. The device according to any of the preceding claims, wherein the position sensor (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) is a capacitive sensors, an inductive sensor, an optical sensor, an acoustic sensor or an interferometer.

13. A method for electrochemical pattern replication method, ECPR, utilizing a device for electrochemical pattern replication comprising a master electrode (14, 25, 38) and a substrate (19, 24, 34), said device being in accordance with any one of claims 1 to 12, said method comprising the steps of
measuring by the sensors x-, y-, and theta values of the master electrode (14, 25, 38), when the master electrode (14, 25, 38) and the substrate (19, 24, 34) are separated in a top position;
measuring by the sensors x-, y-, and theta values of the master electrode (14, 25, 38), when the master electrode (14, 25, 38) and the substrate (19, 24, 34) are adjacent in a bottom position;
calculating a delta value, which is the difference in measured x-, y-, and theta values; comparing the delta value to a reference value; and
adjusting the position of the master electrode (14, 25, 38) in relation to the substrate (19, 24, 34) to minimize the delta value.

14. The method according to claim 13, wherein the sensors are positioned on opposite sides of the master electrode (14, 25, 38) and the substrate (19, 24, 34).

Patentansprüche

1. Vorrichtung zur elektrochemischen Strukturreplikation, ECPR, **dadurch gekennzeichnet, dass** sie umfasst: eine Basis (16, 210, 311), eine untere Einspannvorrichtung auf einer X-Y-Theta-Plattform (15,26), wobei die untere Einspannvorrichtung zum Festhalten einer Masterelektrode (14, 25, 38) oder eines Substrats (19, 24, 34) eingerichtet ist; und eine Z-Plattform (111, 211, 310) mit einer daran angebrachten oberen Einspannvorrichtung (110, 212, 312), wobei die obere Einspannvorrichtung zum Festhalten einer Masterelektrode (14, 25, 38) eingerichtet ist, wenn die untere Einspannvorrichtung zum Festhalten eines Substrats (19, 24, 34) eingerichtet ist, oder eines Substrats (19, 24, 34), wenn die untere Einspannvorrichtung zum Festhalten einer Masterelektrode (14, 25, 38) eingerichtet ist; ein Verlagerungsüberwachungssystem zum Messen der Verlagerung der Masterelektrode (14, 25, 38) in Bezug auf das Substrat (19, 24, 34), wobei das Verlagerungsüberwachungssystem einen Positionssensor (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) und einen

Referenzrahmen (11, 18, 21, 29, 31, 37, 42, 49, 55) umfasst, wobei der Positionssensor (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) an einem Messrahmen (47, 53) angebracht ist, wobei der Messrahmen entweder an der Z-Plattform (11,211,310) oder an der oberen Einspannvorrichtung (110, 212, 312) angebracht ist und einen Abstand von der Masterelektrode (14, 25, 38) oder dem Substrat (19, 24, 34) zu dem Referenzrahmen (11, 18, 21, 29, 31, 37, 42, 49, 55) in der x-y-Ebene misst.

2. Vorrichtung nach Anspruch 1, wobei die Bewegung der Z-Plattform (111, 211, 310) durch Führungen (112, 113, 23, 27) geführt wird, welche die Z-Plattform (111, 211, 310) durchqueren, sodass die Z-Plattform (111, 211, 310) entlang den Führungen (112, 113, 23, 27) gleiten und es somit der daran angebrachten oberen Einspannvorrichtung (110, 212, 312) und dem von der oberen Einspannvorrichtung (110, 212, 312) festgehaltenen Substrat (19, 24, 34) ermöglichen kann, bezüglich der X-Y-Theta-Plattform (15, 26) entlang einer Z-Richtung oder-Achse (13) hin- und herbewegbar zu sein, welche Achse (13) parallel zu der Länge der Führungen (112, 113, 23, 27) ist, sodass die Masterelektrode (14, 25, 38) und das Substrat (19, 24, 34) auf kontrollierte Weise zueinander hin und voneinander weg bewegt werden können.

3. Vorrichtung nach einem der Ansprüche 1 oder 2, wobei das Verlagerungsüberwachungssystem mindestens zwei Positionssensoren (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) an gegenüberliegenden Seiten der oberen Einspannvorrichtung (110, 212, 312) umfasst.

4. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei der Positionssensor (41, 43, 48, 410, 51, 54) an einem Messrahmen (47, 53) montiert ist, ausgerichtet zu einem Referenzrahmen (11, 18, 21, 29, 31, 37, 42, 49, 55), wo der Messrahmen (47, 53) an der Z-Plattform (111, 211, 310) oder an der oberen Einspannvorrichtung (110, 212, 312) angebracht ist.

5. Vorrichtung nach Anspruch 4, wobei die gegenüberliegenden Enden (44, 411, 52) des Messrahmens (47, 53) im Wesentlichen symmetrisch bezüglich der oberen Einspannvorrichtung (110, 212, 312) oder der Z-Plattform (111, 211, 310) angeordnet sind.

6. Vorrichtung nach Anspruch 4 oder 5, wobei mindestens zwei Sensoren (41, 43, 48, 410, 51, 54) auf senkrechte Weise an einem Messrahmen (47, 53) montiert sind, sodass mindestens ein Sensor einen Abstand in einer x-Richtung dX, in Bezug auf den Referenzrahmen (11, 18, 21, 29, 31, 37, 42, 49, 55), misst und mindestens ein anderer Sensor einen Abstand in y-Richtung dY, in Bezug auf den Referenzrahmen (11, 18, 21, 29, 31, 37, 42, 49, 55), misst, wobei besagte x- und y-Richtungen senkrecht oder normal zu einer betreffenden Oberfläche des Referenzrahmens (11, 18, 21, 29, 31, 37, 42, 49, 55) sind, zu welcher Oberfläche jeder betreffende Sensor (51, 54) den Abstand misst.

7. Vorrichtung nach einem der vorhergehenden Ansprüche, weiter ein Intersubstrat-Messmikroskop (12, 17) umfassend, das entfernbar zwischen die obere (110, 212, 312) und untere (15, 26) Einspannvorrichtung einbringbar ist, zum gleichzeitigen Scannen der Oberflächen der Masterelektrode (14, 25, 38) und des Substrats (19, 24, 34) auf Ausrichtungsmarkierungen.

8. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Basisplatte (16, 210, 311) aus einem thermisch und mechanisch stabilen Material besteht.

9. Vorrichtung nach Anspruch 8, wobei das thermisch und mechanisch stabile Material Granit oder Zerodur ist.

10. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei der Referenzrahmen (11, 18, 21, 29, 31, 37, 42, 49, 55) aus einem Material mit geringer Wärmeausdehnung besteht.

11. Vorrichtung nach Anspruch 10, wobei das Material mit geringer Wärmeausdehnung Invar, ein kohlenstofffaserverstärktes Material oder Zerodur ist.

12. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei der Positionssensor (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) ein kapazitiver Sensor, ein induktiver Sensor, ein optischer Sensor, ein akustischer Sensor oder ein Interferometer ist.

13. Verfahren zur elektrochemischen Strukturreplikation, ECPR Verfahren, welches eine Vorrichtung zur elektrochemischen Strukturreplikation anwendet, umfassend eine Masterelektrode (14, 25, 38) und ein Substrat (19, 24, 34), wobei die Vorrichtung einem der Ansprüche 1 bis 12 entspricht, wobei das Verfahren die Schritte umfasst des
mittels der Sensoren Messens von x-, y- und theta-Werten der Masterelektrode (14, 25, 38), wenn die Masterelektrode (14, 25, 38) und das Substrat (19, 24, 34) in einer oberen Position getrennt sind;
mittels der Sensoren Messens von x-, y- und theta-Werten der Masterelektrode (14, 25, 38), wenn die Masterelektrode (14, 25, 38) und das Substrat (19, 24, 34) in einer unteren Position aneinandergrenzen;
Berechnens eines delta-Werts, der die Differenz in den gemessenen x-, y- und theta-Werten ist;

Vergleichens des delta-Werts mit einem Referenzwert; und
Anpassens der Position der Masterelektrode (14, 25, 38) in Bezug auf das Substrat (19, 24, 34), um den delta-Wert zu minimieren.

14. Verfahren nach Anspruch 13, wobei die Sensoren an entgegengesetzten Seiten der Masterelektrode (14, 25, 38) und des Substrats (19, 24, 34) angeordnet sind.

Revendications

1. Dispositif pour la réplication électrochimique de motifs, ECPR, **caractérisé en ce qu'**il comprend : une base (16, 210, 311) ; une mâchoire inférieure sur une platine de positionnement X-Y-Thêta (15, 26), ladite mâchoire inférieure étant configurée pour maintenir une électrode maître (14, 25, 38) ou un substrat (19, 24, 34) ; et une platine de positionnement Z (111, 211, 310) comprenant une mâchoire supérieure fixée (110, 212, 312), ladite mâchoire supérieure étant configurée pour maintenir une électrode maître (14, 25, 38) lorsque la mâchoire inférieure est configurée pour maintenir un substrat (19, 24, 34) ou un substrat (19, 24, 34) lorsque la mâchoire inférieure est configurée pour maintenir une électrode maître (14, 25, 38) ; un système de surveillance de déplacement pour mesurer le déplacement de l'électrode maître (14, 25, 38) par rapport au substrat (19, 24, 34) ; dans lequel ledit système de surveillance de déplacement comprend un capteur de position (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) et un cadre de référence (11, 18, 21, 29, 31, 37, 42, 49, 55) ; dans lequel le capteur de position (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) est fixé à un cadre de mesure (47, 53), ledit cadre de mesure étant fixé, soit à la platine de positionnement Z (11, 211, 310), soit à la mâchoire supérieure (110, 212, 312), et mesurant une distance entre l'électrode maître (14, 25, 38) ou le substrat (19, 24, 34) et le cadre de référence (11, 18, 21, 29, 31, 37, 42, 49, 55) dans le plan x-y.

2. Dispositif selon la revendication 1, dans lequel le mouvement de la platine de positionnement Z (111, 211, 310) est guidé par des guides (112, 113, 23, 27), qui traversent la platine de positionnement Z (111, 211, 310) d'une manière telle que la platine de positionnement Z (111, 211, 310) peut coulisser le long des guides (112, 113, 23, 27) et ainsi permettre à la mâchoire supérieure fixée (110, 212, 312) et au substrat (19, 24, 34), maintenu par la mâchoire supérieure (110, 212, 312), de pouvoir se déplacer par rapport à la platine de positionnement X-Y-Thêta (15,26), en effectuant des mouvements de va-et-vient dans une direction Z ou en direction d'un axe (13), ledit axe (13) étant parallèle à la longueur des guides (112, 113, 23, 27), d'une manière telle que l'électrode maître (14, 25, 38) et le substrat (19, 24, 34) peuvent se rapprocher ou s'éloigner l'un de l'autre d'une manière contrôlée.

3. Dispositif selon l'une quelconque des revendications 1 ou 2, dans lequel le système de surveillance de déplacement comprend au moins deux capteurs de position (22, 28, 32, 36, 41, 43, 48, 410, 51, 54) sur les côtés opposés de la mâchoire supérieure (110, 212, 312).

4. Dispositif selon l'une quelconque des revendications précédentes, dans lequel le capteur de position (41, 43, 48, 410, 51, 54) est monté sur un cadre de mesure (47, 53), mis en alignement avec un cadre de référence (11, 18, 21, 29, 31, 37, 42, 49, 55), le cadre de mesure (47, 53) étant fixé à la platine de positionnement Z (111, 211, 310) ou à la mâchoire supérieure (110, 212, 312).

5. Dispositif selon la revendication 4, dans lequel les extrémités opposées (44, 411, 52) du cadre de mesure (47, 53) sont disposées essentiellement en position symétrique par rapport à la mâchoire supérieure (110, 212, 312) ou à la platine de positionnement Z (111, 211, 310).

6. Dispositif selon la revendication 4 ou 5, dans lequel au moins deux capteurs (41, 43, 48, 410. 51, 54) sont montés sur un cadre de mesure (47, 53) d'une manière perpendiculaire, si bien qu'au moins un capteur mesure une distance dans une direction x dX, par rapport au cadre de référence (11, 18, 21, 29, 31, 37, 42, 49, 55), et au moins un autre capteur mesure une distance dans une direction y dY, par rapport au cadre de référence (11, 18, 21, 20, 31, 37, 42, 49.55) ; dans lequel lesdites directions x et y sont perpendiculaires ou normales par rapport à une surface respective du cadre de référence (11, 18, 21, 29, 31, 37, 42, 49, 55), surface par rapport à laquelle chaque capteur respectif (51, 54) mesure la distance.

7. Dispositif selon l'une quelconque des revendications précédentes, comprenant en outre un microscope de mesure inter-substrat (12, 17) qui peut venir s'insérer de manière amovible entre la mâchoire supérieure (110, 212, 312) et la mâchoire inférieure (15, 26) pour le balayage simultané des surfaces de l'électrode maître (14, 25, 38) et du substrat (19, 24, 34) pour des repères de mise en alignement.

8. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la plaque de base (16, 210, 311) est réalisée à partir d'un matériau manifestant une stabilité thermique et mécanique.

9. Dispositif selon la revendication 8, dans lequel le matériau manifestant une stabilité thermique et mécanique est du granit ou du Zerodur.

10. Dispositif selon l'une quelconque des revendications précédentes, dans lequel le cadre de référence (11, 18, 21, 29, 31, 37, 42, 49, 55) est réalisé à partir d'un matériau possédant une faible dilatation thermique.

11. Dispositif selon la revendication 10, dans lequel le matériau manifestant une faible dilatation thermique est de l'invar, un matériau renforcé avec des fibres de carbone ou du Zerodur.

12. Dispositif selon l'une quelconque des revendications précédentes, dans lequel le capteur de position (22, 28, 32, 30, 41.43. 48, 410. 51, 54) est un capteur capacitif, un capteur inductif, un capteur optique, un capteur acoustique ou un interféromètre.

13. Procédé pour une réplication électrochimique de motifs, procédé ECPR, dans lequel on utilise un dispositif pour la réplication électrochimique de motifs comprenant une électrode maître (14, 25, 38) et un substrat (19, 24, 34), ledit dispositif étant conforme à l'une quelconque des revendications 1 à 12, ledit procédé comprenant les étapes dans lesquelles :

on mesure, via les capteurs, les valeurs x, y et thêta de l'électrode maître (14, 25, 38), lorsque l'électrode maître (14, 25, 38) et le substrat (19, 24, 34) sont séparés dans une position supérieure ;
on mesure, via les capteurs, les valeurs x, y et thêta de l'électrode maître (14, 25, 38), lorsque l'électrode maître (14, 25, 38) et le substrat (19, 24, 34) sont adjacents dans une position inférieure ;
on calcule une valeur delta, qui représente la différence entre les valeurs mesurées x, y et thêta ;
on compare la valeur delta à une valeur de référence ; et
on règle la position de l'électrode maître (14, 25, 38) par rapport au substrat (19, 24, 34) afin de minimiser la valeur delta.

14. Procédé selon la revendication 13, dans lequel les capteurs sont disposés sur des côtés opposés de l'électrode maître (14, 25, 38) et du substrat (19, 24, 34).

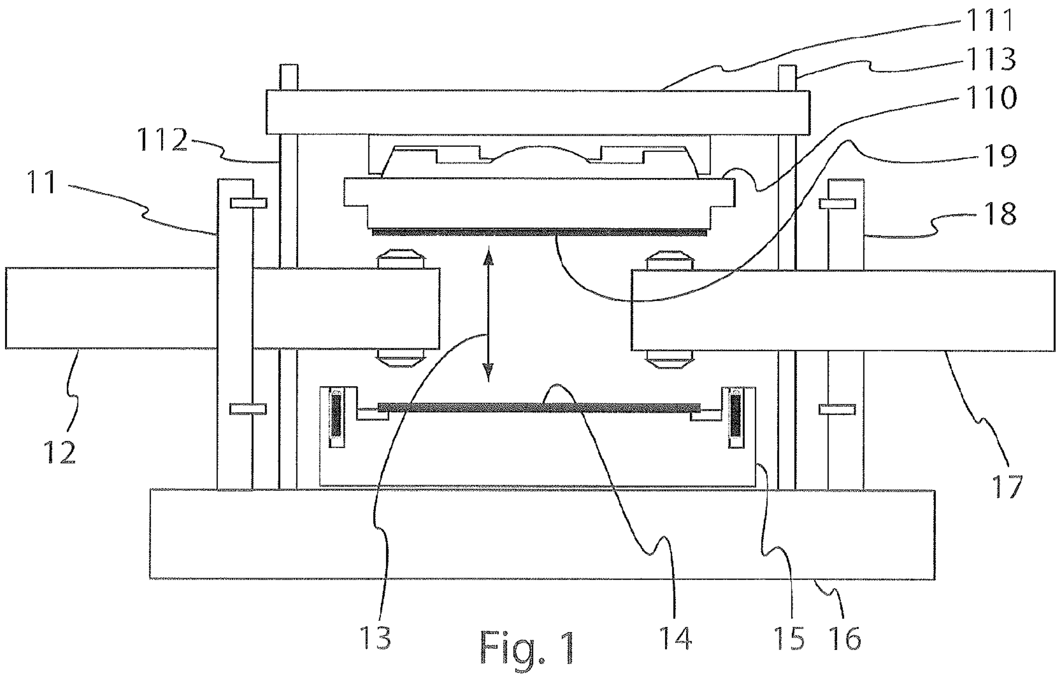


Fig. 1

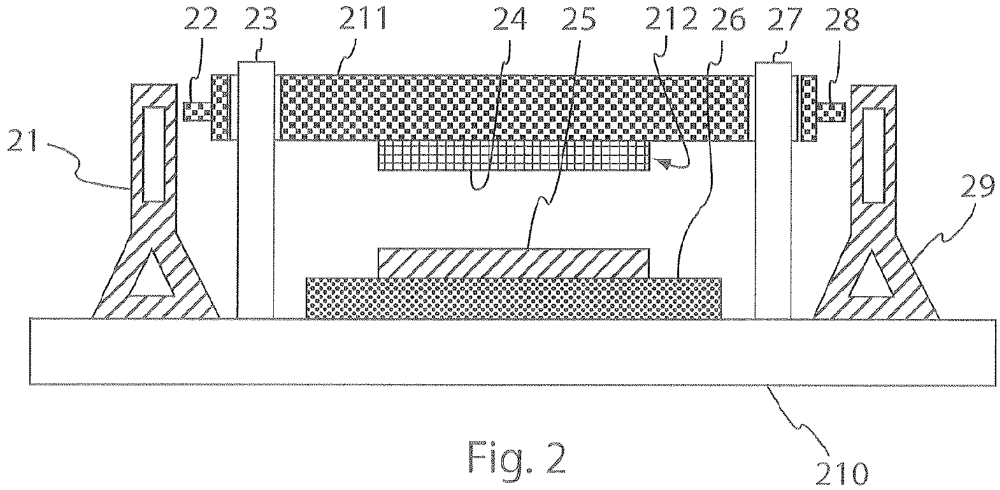


Fig. 2

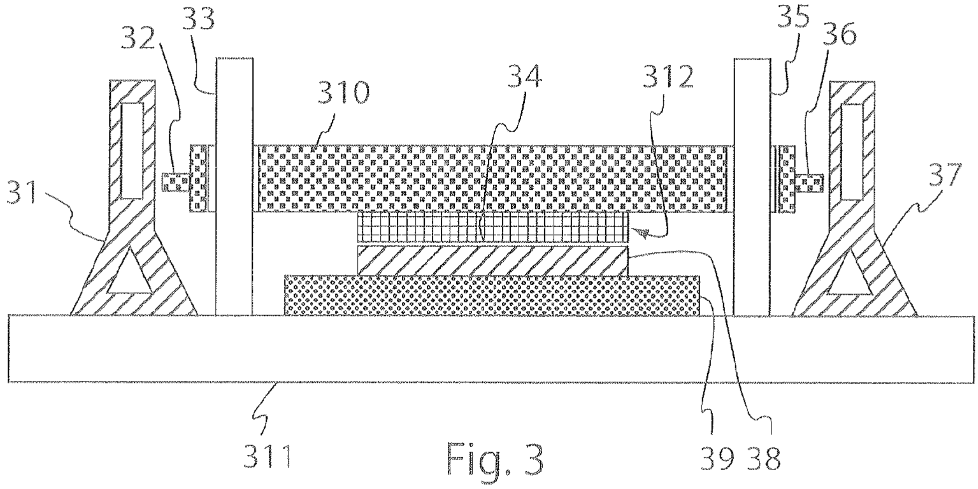
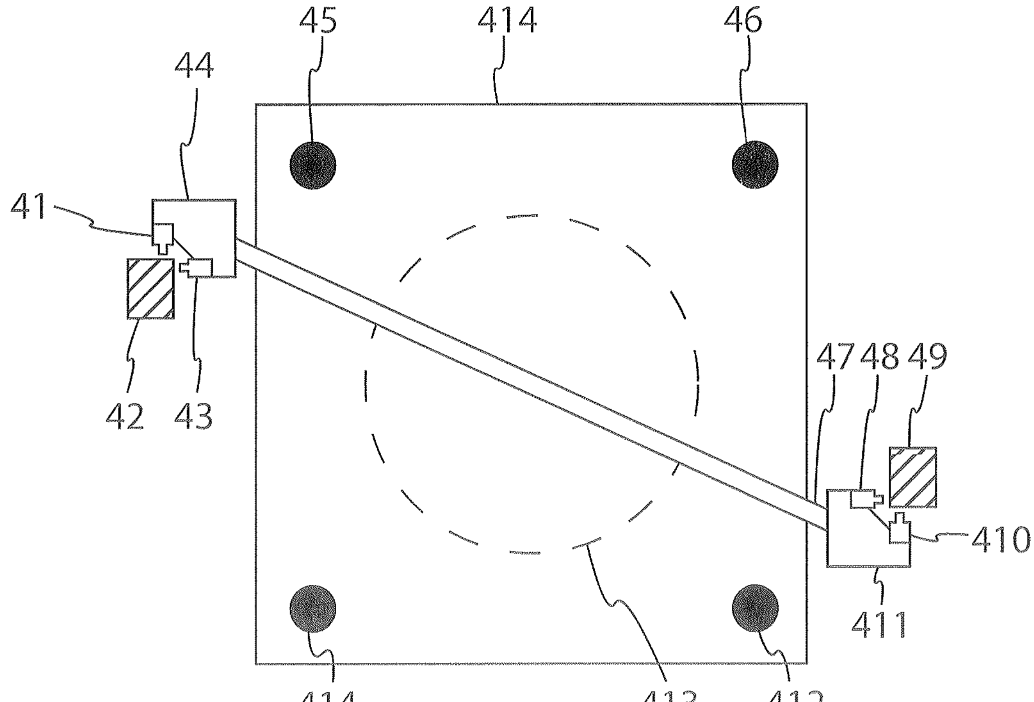


Fig. 3


45
414
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410
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413
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Fig. 4

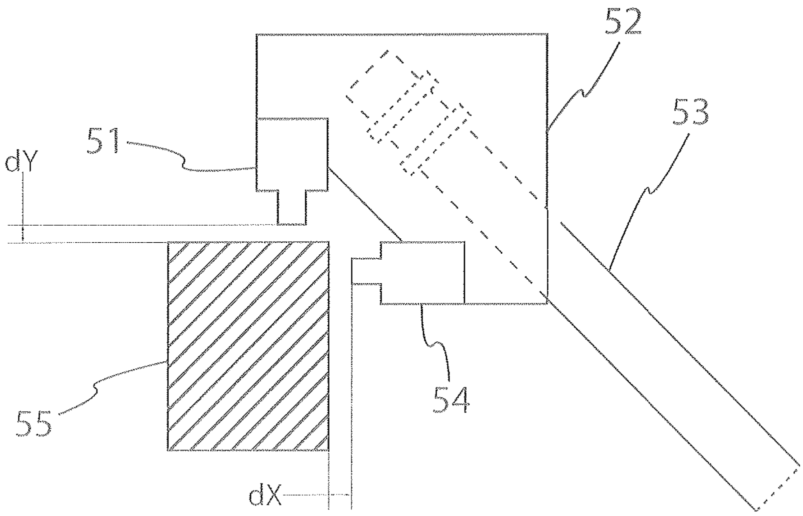
52
53
51
dY
54
55
dX

Fig. 5

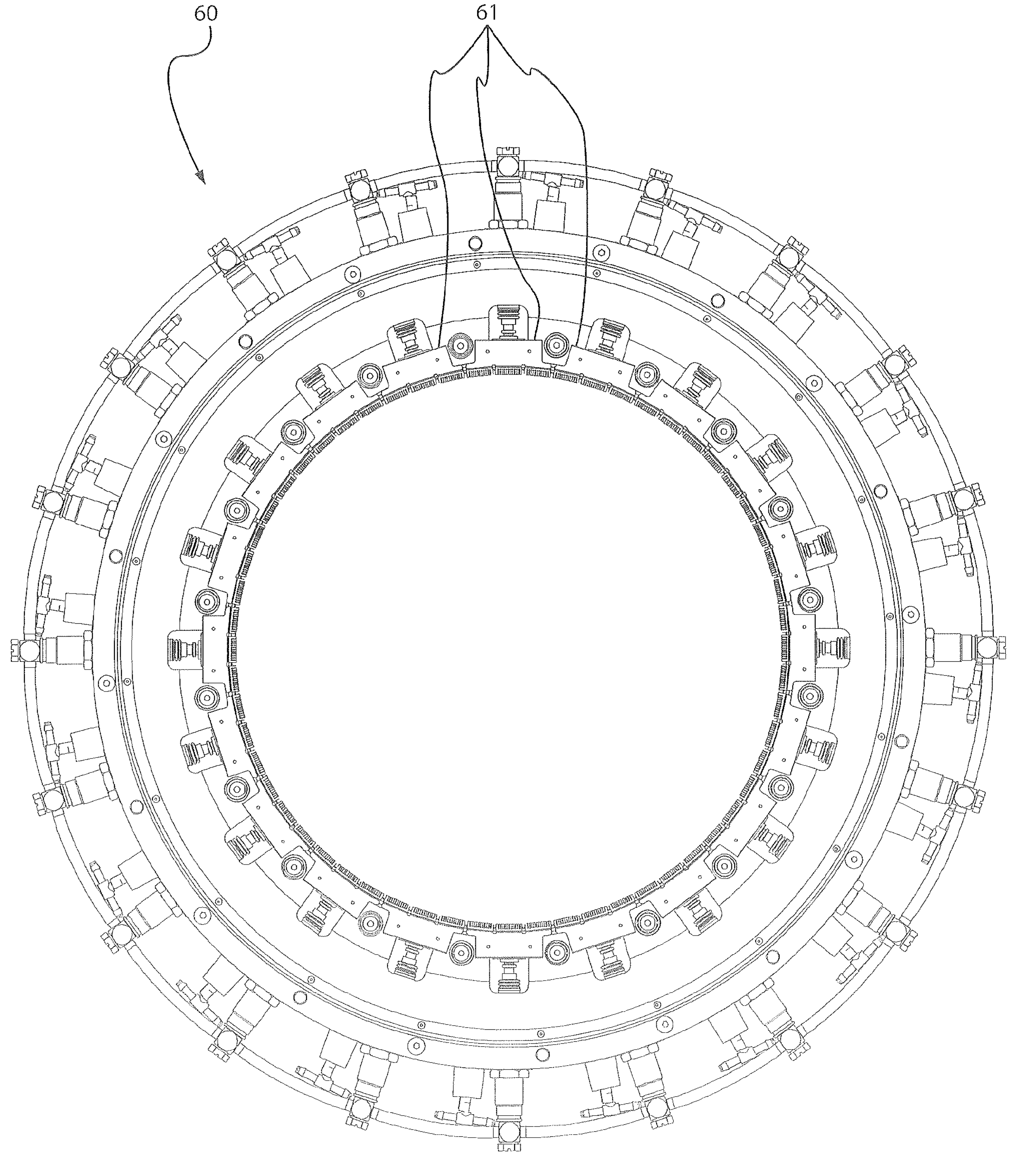

Fig. 6

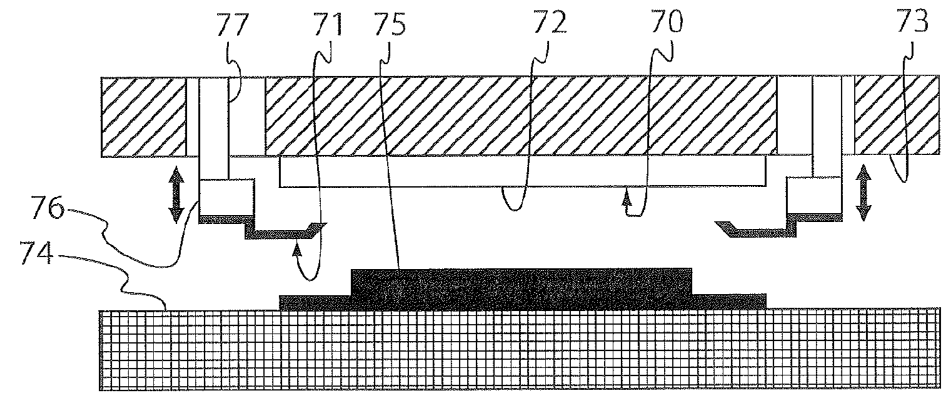

Fig. 7

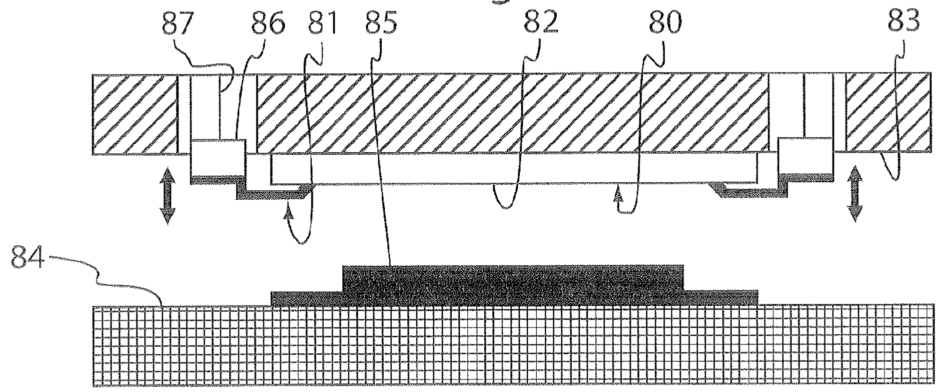

Fig. 8

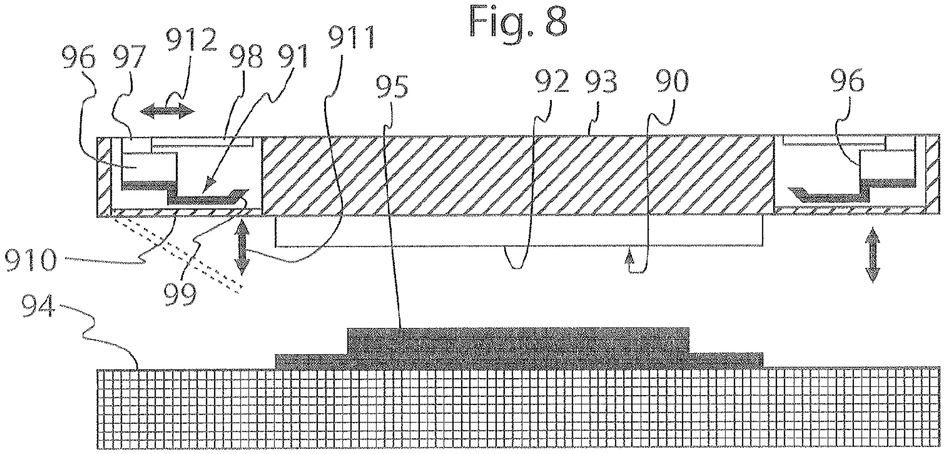

Fig. 9

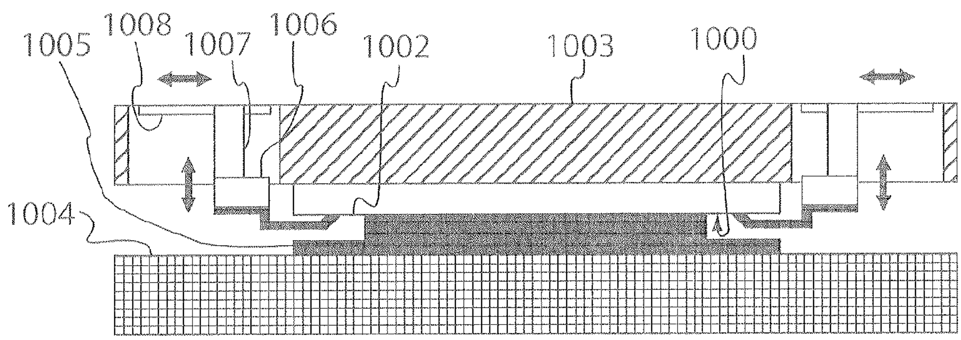

Fig. 10

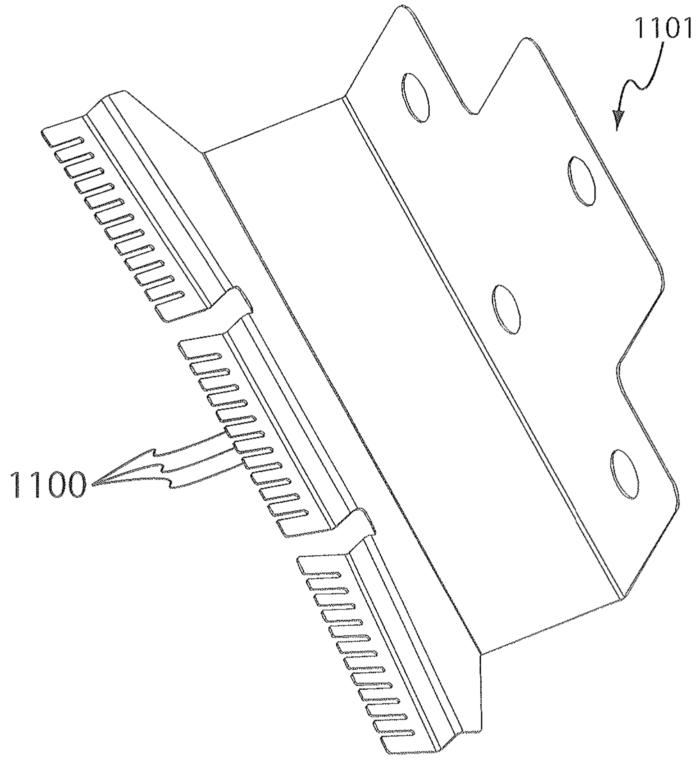

Fig. 11

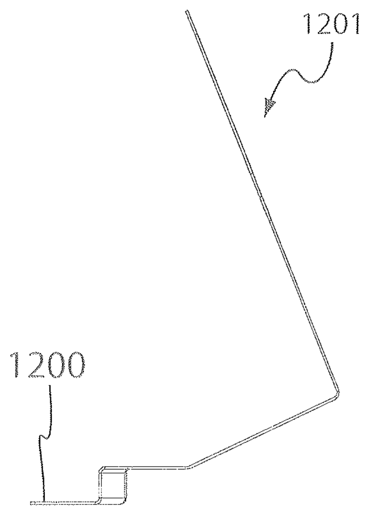

Fig. 12

Fig. 13

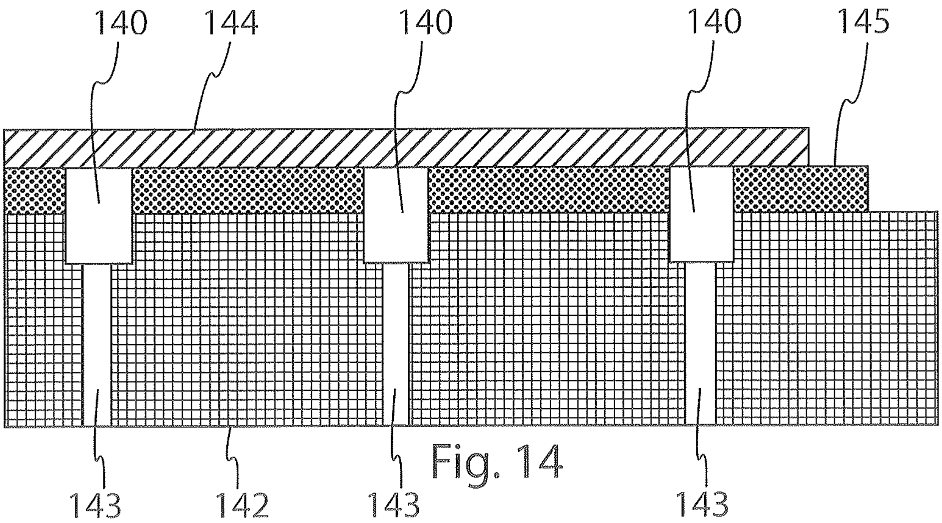

Fig. 14

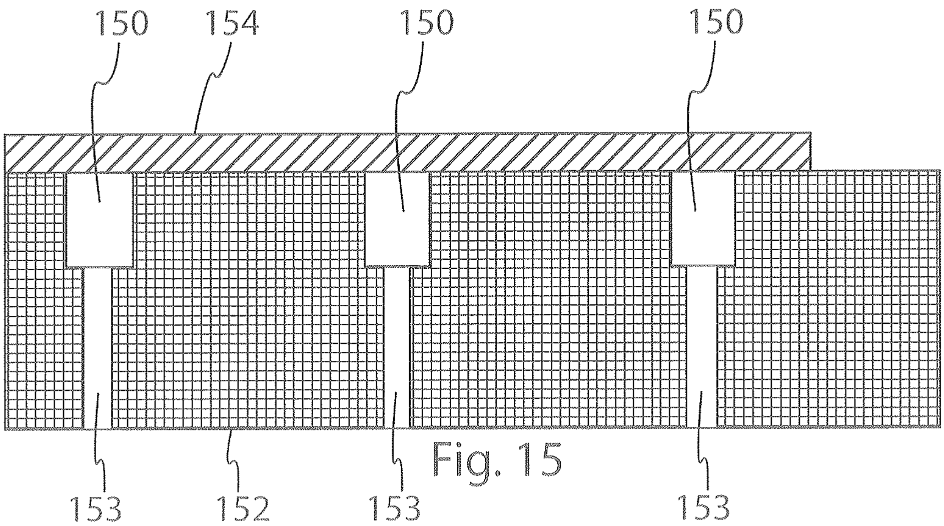

Fig. 15

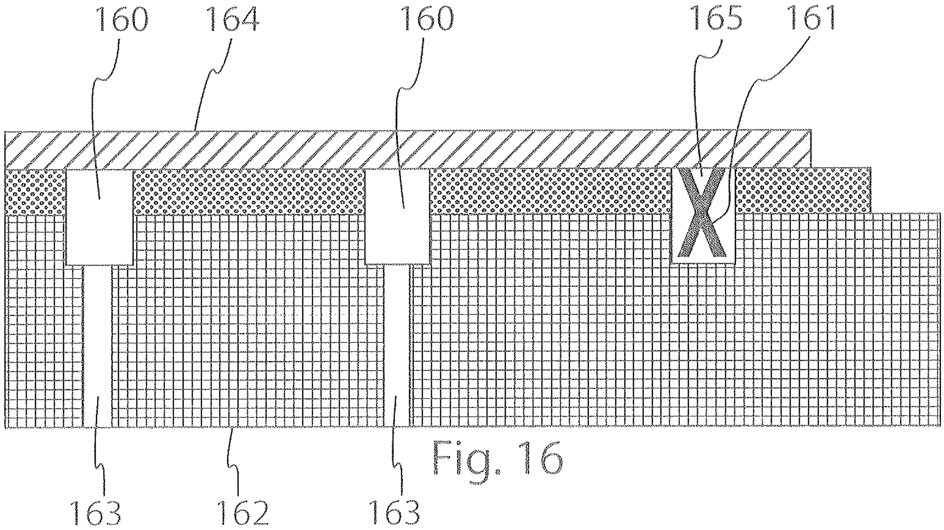

Fig. 16

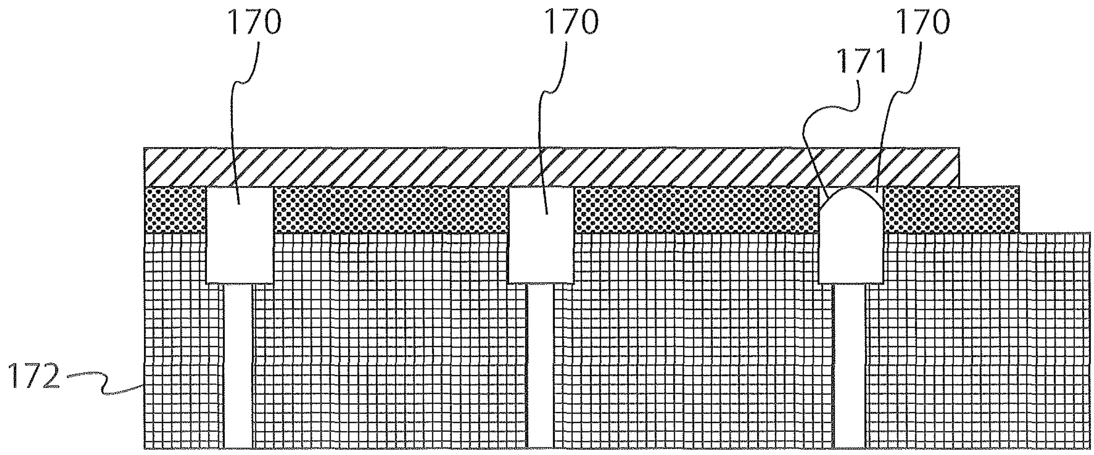

Fig. 17

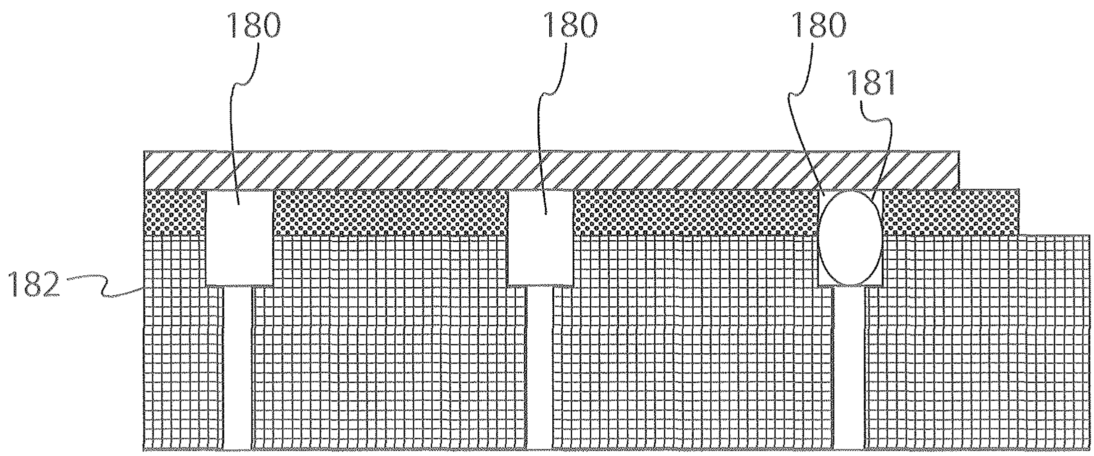

Fig. 18

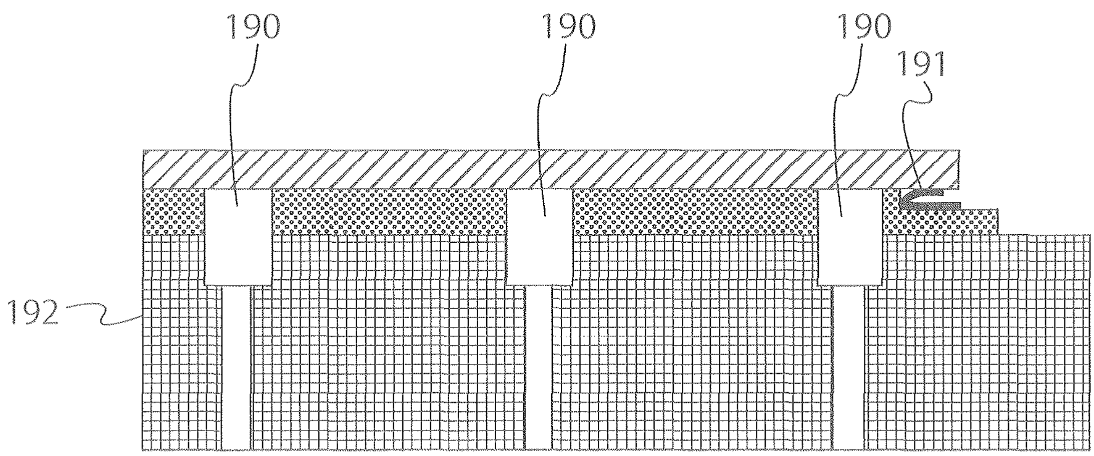

Fig. 19

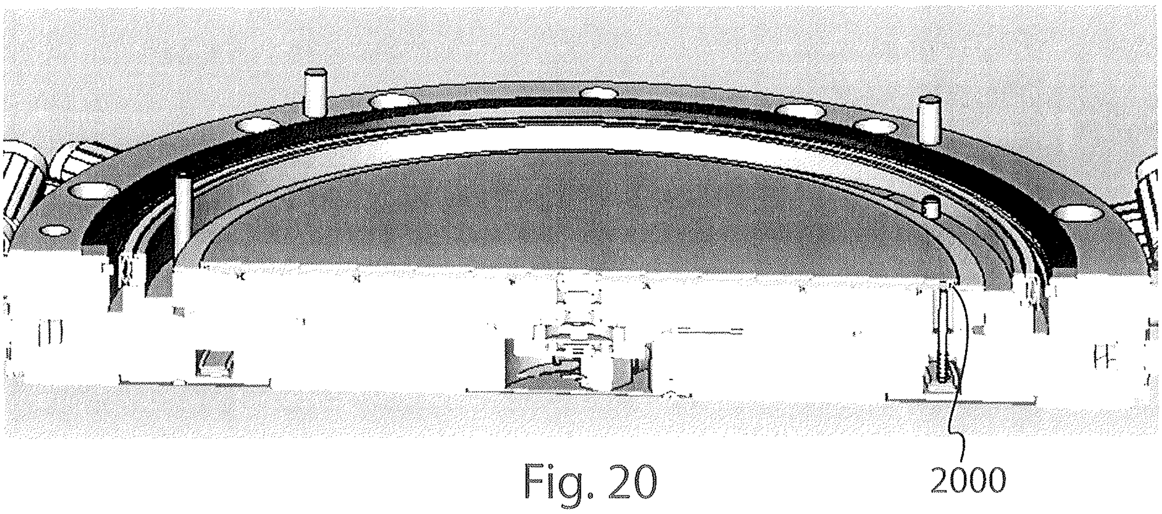

Fig. 20

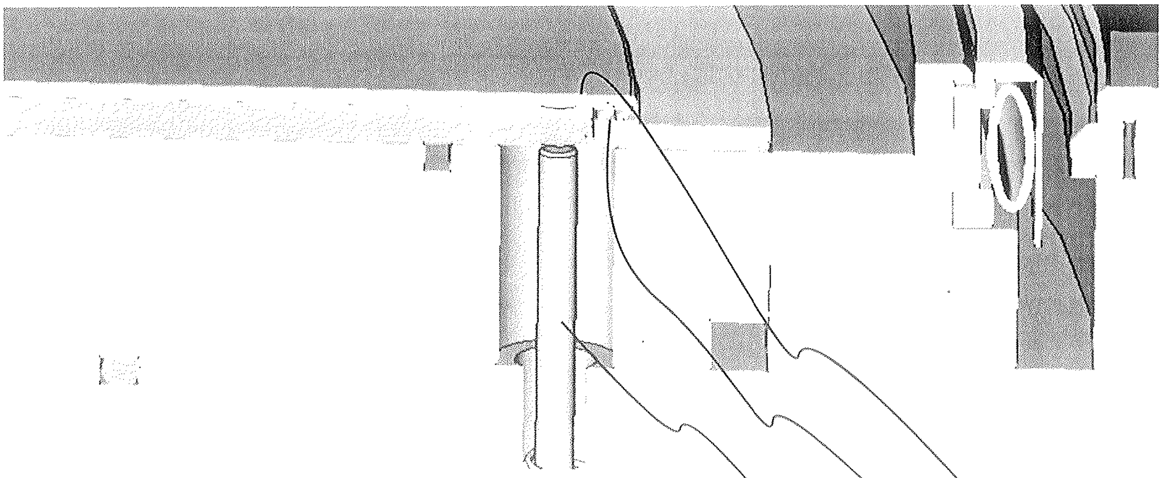

Fig. 21

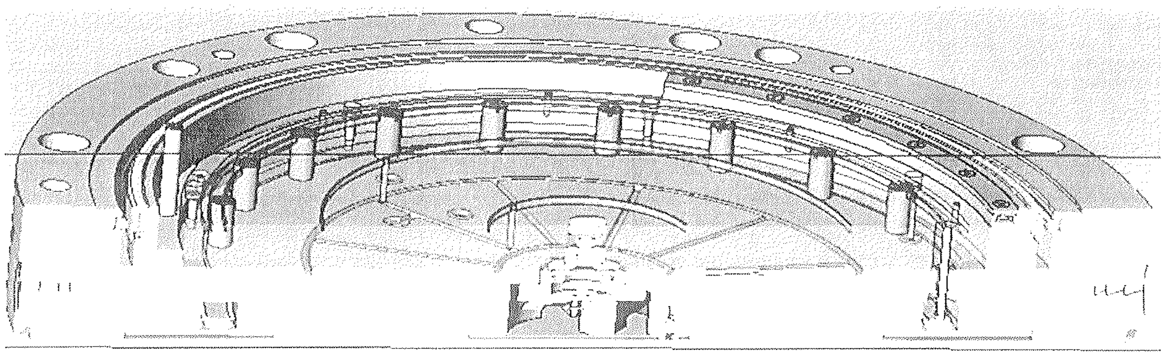

Fig. 22

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 02103085 A **[0007]**
- WO 02103085 A1 **[0008]**