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Inkjet printing system and method for processing substrates.

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Inkjet printing system for processing substrates including a chuck for placement of a substrate and an inkjet printing head with at least one nozzle. Each chuck has chuck reference marks, each of which is associated with an associated camera. An electronic controller assembly is configured to take a set of images each instance a substrate having substrate reference marks has been placed on a chuck, with each image containing a chuck reference mark and a substrate reference mark. For each image, the position of the chuck relative to the camera and the position of the substrate relative to the camera is determined. Subsequently, the substrate position relative to the chuck is calculated and based thereon the firing of the at least one nozzle is timed and the movement of the printing motion assembly is controlled so that the liquid drops are accurately positioned on the substrate.

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Title: Inkjet printing system and method for processing substrates

FIELD

5 The invention relates to an inkjet printing system and method for processing substrates.

BACKGROUND

U 6,436,843 B1 discloses a method for applying a coating material
10 on a substrate, wherein a print head is disposed over a substrate which is supported by a chuck. A digital signal processor provides control signals for controlling process parameters for dispensing drops of coating material and for controlling the relative position of the print head and the chuck. The manner in which the relative position between the print head and the chuck
15 is determined is not disclosed.

US2007/169806 A1 discloses a print assembly including a print head and a camera having high magnification capabilities mounted in a rigid mount. The rigid mount with the print head and the camera are mounted over a conveyor for supporting substrates. A computer/workstation
20 is coupled to receive and process imaging data from the camera. With this setup the rigid mount carrying the print head and the camera can be calibrated and registered with respect to a substrate which is on the conveyor. The camera having high magnification capabilities is relatively expensive.

25 WO2011/026880 A1 discloses a system and a method for centering a print track, on a substrate. Firstly, a printing station deposits a first print track and a marker element. Secondly, a second print track is deposited in a second step, which second print track includes a centering interruption which is positioned and centered with respect to the marker element. The
30 known method, which is primarily concerned with aligning subsequently applied screen printing patterns, may include use of an inspection system

including a CCD camera. The inspection system may locate the position of certain features of an incoming substrate and may communicate the inspection results to a system controller for analysis of the orientation and position of the substrate to assist in the precise position of the substrate
5 under a printing head prior to processing the substrate.

US 7,611,217 B2 discloses a method and a system for inkjet drop positioning. The known method includes determining an intended deposition location of an ink drop on a substrate. To that end an ink drop is deposited on the substrate using an inkjet printing system. Subsequently, a
10 deposited location of the deposited ink drop on the substrate is located and the deposited location is compared to the intended location. Then, the difference between the deposited location and the intended location is determined and the difference between the deposited location and the intended location is compensated by adjusting a control parameter of the
15 inkjet system.

This method is time consuming, because it has to be done for each substrate that has to be processed. In view thereof, the known system is not suited for a inkjet printer system in which large numbers of substrates have to be processed within a limited time.

20 EP 1 888 336 discloses an inkjet printing system including a calibration camera and a vision camera assembly and a fiducial mark on the calibration camera assembly. The vision camera assembly includes a high resolution camera and a low resolution camera with a greater field than the high resolution camera, typically in the order of 10 mm by 10 mm. With the
25 calibration camera the position errors between the print heads can be determined by looking at the printing heads with the calibration camera. When errors are found, these may be adjusted. Both the vision camera assembly and the calibration camera assembly are able to look at the fiducial mark in order to coordinate vision camera assembly and the
30 calibration camera assembly. Once relative positioning between calibration

camera assembly and machine vision camera assembly is known, relative positioning between print heads, calibration camera assembly, and machine vision camera assembly may be determined by a computer and may be used for print head and print head carriage adjustment. Further, relative
5 positioning between vision camera assembly and print head carriage frame may be known through the use of common optical strip. This may generally allow a computer to determine relative positioning between substrate and print heads and determine any positioning error therebetween.

In order to accurately determine the position of a substrate
10 relative to a printing head, an expensive dual camera vision assembly including a high resolution and a low resolution camera is necessary as well as a calibration camera assembly. The accuracy and the precision of the known measurement system are determined by the accuracy of the positions of the various cameras. In view thereof, the carriages of the various cameras
15 must be very robust in order to ensure that the relative positions of the cameras of the two systems remain intact. Such robust movable camera carriages are expensive.

SUMMARY

20 An object of the invention is to provide an inkjet printing system in which the disadvantages of the prior art are alleviated. More particular, it is an object of the invention to provide an inkjet printing system that uses relatively low cost cameras, but with which the deposition of the liquid on the substrate can be effected with a positioning variation around
25 theoretically desired positions that remains during the processing of a large number of substrates within the requirements of the printing job at hand even if a high volume of substrates is supplied in a limited amount of time.

To that end, the invention provides an inkjet printing system configured to inkjet patterns of liquid material on substrates that each have
30 a length and a width or, alternatively, a diameter, wherein each substrate

includes at least two substrate reference marks that are spaced from each other at a distance which is larger than at least half of the length, the width or the diameter of the substrate, the inkjet printing system including:

- 5 – at least one chuck on which a substrate can be placed, each chuck having a length and a width or, alternatively, a diameter and including at least two visual chuck reference marks that are spaced apart from each other at a distance which is larger than at least half of the length, the width or the diameter of the chuck;
- 10 – at least one inkjet printing head that includes at least one nozzle that is configured to discharge liquid when the nozzle is fired by a control signal;
- 15 – a printing motion assembly that supports at least one of the at least one chuck and the at least one inkjet printing head so that a two dimensional printing area on the at least one chuck can be covered with liquid discharged by the at least one printing head;
- 20 – an electronic controller assembly configured to produce control signals to fire the at least one nozzle and configured to control the printing motion assembly for positioning the at least one printing head relative to the at least one chuck so that the positioning variation with which the liquid is deposited relative to the chuck is less than a first threshold value;

wherein:

- 25 – each reference mark of the at least one chuck is associated with an associated camera that is directed to the associated chuck reference mark, each camera having a two dimensional matrix of camera pixels, each pixel having a pixel coordinate;
- 30 – each chuck includes a placement area extending within a boundary;
- 30 – when a substrate has been placed in or on the placement area of a said chuck, each camera that is associated with a chuck reference

mark is also associated with an associated substrate reference mark in that an image taken with a said camera includes an associated chuck reference mark and an associated substrate reference mark;

– the controller assembly is configured:

- 5 ~ to control the at least two cameras to take a set of images each instance a substrate has been placed on that chuck, wherein each camera takes a single image of the set of images, wherein each single image of the set of images includes an associated chuck reference mark and an associated substrate reference
- 10 mark;
- ~ to determine, for each set of images, the position of the chuck relative to the at least two cameras by detecting, for each image of the set of images, the position of a said chuck reference mark with respect to the camera pixel coordinates of
- 15 a said associated camera; and
- ~ to determine, for each set of images, the position of the substrate relative to the at least two cameras by detecting, for each image of the set of images, the position of a said substrate reference mark with respect to the camera pixel coordinates of
- 20 a said associated camera;
- ~ to use these two position determinations to calculate, for each set of images, the substrate position relative to the chuck reference marks and thus relative to the chuck with an accuracy of less than a second threshold value and, based on
- 25 that relative position, subsequently time the firing of the at least one nozzle of the at least one printing head and control the movement of the printing motion assembly so that the liquid discharged by the inkjet printing head is positioned on the substrate with a positioning variation which is less than
- 30 the sum of the first and the second threshold values.

In this respect, a substrate reference mark may be a fiducial mark that is applied to the substrate. Alternatively, a substrate reference mark may also be a structural feature of the substrate such as a corner of the substrate or a structural feature on the surface of the substrate.

5 A substrate may be a wafer for the production of solar cells or for the production of integrated circuits. However, a substrate may also be another object such as printed circuit board or an optical object such as a lens or a mirror.

 By virtue of the presence of the visual chuck reference marks on
10 the chuck, the relative position between the chuck and the substrate can be determined very accurately by taking a set of images of the chuck with the substrate placed thereon with at least two relatively low cost cameras, more particularly simple CCD-cameras. Preferably, the set of images is taken in a single shot by controlling the at least two cameras simultaneously to each
15 take an image of the set of images. The accurate determination of the relative position between the chuck and the substrate can be effected by comparing the relative positions of the visual reference marks on the chuck and the substrate reference marks as registered in the set of images taken by the at least two cameras. The comparison is made for each single image
20 that is taken by a single camera, after which the comparison information of each of the cameras is combined to accurately determine the relative position between the chuck and the substrate. The support structure of the at least two cameras does not have to be robust because the position of the at least two cameras relative to the print heads does not play a role in
25 determining the position of the substrate relative to the print head. The positioning variation of the liquid relative to the chuck is, of course, determined by the printing motion assembly that takes care of the relative movement between the chuck and the printing head and must be below a first threshold value. The positioning variation is a quantity of length
30 expressed, for example, in the unit micrometers. This printing motion

assembly has to be robust anyway in order to be able to deposit liquid droplets or liquid tracks relative to each other on a substrate with a repeatable precision. With the configuration according to the invention, the determination of the position of the substrate on the chuck can be effected
5 very quickly and with an accuracy that is less than the second threshold, namely by taking a set of images with the at least two cameras after a substrate has been placed on the chuck and some subsequent calculations based on those images. Preferably, the set of images is taken in one shot by simultaneously operating the individual cameras of the at least two
10 cameras. The accuracy is also a quantity of length, for example, expressed in the unit micrometers. Additionally, the determination of the position of the substrate relative to the chuck can be obtained with a camera assembly that is low cost in comparison with the prior art systems. As a consequence, the positioning variation of liquid that has been discharged on the substrate is
15 less than the sum of the first and the second threshold value.

An additional advantage of the inkjet printing system of the invention is that the system is capable of processing relatively large substrates, such as for example solar cells or even solar panels or OLED devices. The size of these solar cells may for example be as much as 120 cm
20 by 60 cm. This is possible by virtue of the fact that the system is provided with a plurality of relatively low cost cameras to take a set of images, in which each image comprises a visual chuck reference mark as well as an associated substrate reference mark to accurately determine the position of the (large) substrate relative to the chuck. As a result, accurate
25 positioning liquid or liquid drops on relatively large substrates can be achieved with a relatively low cost system as compared to the prior art systems.

The invention also provides a method for inkjetting patterns of liquid material on substrates, the method including:

30 – providing an inkjet system according to the invention;

and repeating for the processing of each substrate the following steps:

- picking up a substrate and placing a substrate on a said chuck;
- controlling the at least two cameras associated with said chuck to take a set of images, with each camera of said at least two cameras taking a single image of the set of images, wherein each single image of the set of images includes an associated chuck reference mark and an associated substrate reference mark;
- determining the position of the chuck relative to the at least two cameras by detecting for each image of the set of images the position of a said chuck reference mark with respect to the camera pixel coordinates of a said associated camera; and
- determining the position of the substrate relative to the at least two cameras by detecting for each image of the set of images the position of a said substrate reference mark of the substrate with respect to the camera pixel coordinates of a said associated camera;
- using these two position determinations to calculate the substrate position relative to the chuck reference marks and thus relative to the chuck with an accuracy of less than the second threshold value and, based on that relative position, subsequently timing the firing of the at least one nozzle of the at least one printing head and controlling the movement of the printing motion assembly with a positioning variation of less than the first threshold value so that the liquid discharged by the inkjet printing head is positioned on the substrate with a positioning variation which is less than the sum of the first and the second threshold values.

With this method, the placement of liquid on substrates can be effected very accurately and precisely with a relatively low cost inkjet printing system. The inkjet printing system can be low cost, because low cost cameras, for example simple CCD cameras, are needed to take a set of images of the visual chuck reference marks on an associated chuck and the

associated substrate reference marks of the substrate that is placed on the chuck. After having taken the set of images, which is performed every instance after a new substrate has been placed on the chuck, preferably in a single shot in which the at least two cameras are operated simultaneously, calculations suffice to determine the position of the substrate relative to the printing head. This can be done very quickly. Because the distance between the at least two substrate reference marks as well as the distance between the at least two chuck reference marks may be substantial, typically in the order of centimeters, for example even up to 120 cm, multiple cameras, that together cover substantially the entire substrate, are used to determine the position of the substrate relative to the chuck. Because of the relatively large distance between individual cameras of the at least two cameras, the accuracy of the determination of the relative positions of the substrate and the chuck can be very good, even with a low cost camera. With a low cost camera the threshold value of the accuracy can be smaller than 50 micrometer. With a slightly improved CCD camera with a better CCD-sensor the accuracy can be improved dramatically and be typically smaller than 5 micrometer.

Next, various embodiments of the invention will be discussed with reference to an example that is shown in the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a perspective view of an example of an inkjet printing system in which various embodiments of the invention are implemented;

Figure 2 shows a schematic elevation view of a chuck with two associated cameras;

Figure 3 shows top view of the inkjet printing system of figure 2.

DETAILED DESCRIPTION

The figures show an example of an inkjet printing system in which various embodiments of the invention are incorporated. It should be noted that the embodiments can also be applied independently and that the invention is not limited to the example which is shown in the figures. Below, various embodiments will be described, whereby reference numbers will be used to refer to the figures. The reference numbers are used herein for clarification but do not have a limiting effect. An embodiment may also be implemented in a different manner than the example shown in the drawing.

10 In the most general terms, the disclosure relates to an inkjet printing system 10 configured to inkjet patterns of liquid material on substrates W that each have a length and a width or, alternatively, a diameter. The advantages of the inkjet printing system 10 have been discussed in the summary, to which reference is made here. An example of such an inkjet printing system 10 is shown in figure 1.

Each substrate W includes at least two substrate reference marks W_1 , W_2 that are spaced from each other at a distance which is larger than at least half of one of the length, the width and the diameter of the substrate. As explained in the summary, a substrate reference mark may be a fiducial mark that is applied to the substrate. Alternatively, a substrate reference mark may also be a structural feature of the substrate such as a corner of the substrate or a structural feature on the surface of the substrate.

The system includes at least one chuck 14 on which a substrate W can be placed. Each chuck 14 has a length and a width or, alternatively, a diameter and includes at least two visual chuck reference marks F_1 , F_2 . The at least two visual chuck reference marks F_1 , F_2 are spaced apart from each other at a distance which is larger than at least half of one of the length, the width or the diameter of the chuck.

The placement of the substrate W on the chuck 14 will be performed automatically by a substrate handling system, such as a

substrate pick and place assembly that is configured to pick up substrates W that are supplied and to place the picked up substrates W on the at least one chuck 14 of the inkjet printing system 10. To that end, the substrate handling system may include at least one suction head that is configured to pick up a single substrate W. The substrate handling system may be a part of the inkjet printing system 10 but that does not have to be the case. The substrate handling system may be supplied separately and be positioned adjacent the inkjet printing system 10 for example next to or partly above the inkjet printing system 10.

The inkjet printing system 10 further comprises at least one inkjet printing head 16 that includes at least one nozzle wherein the at least one nozzle is configured to discharge liquid when the nozzle is fired by a control signal. The liquid that is discharged by the nozzle may take the form of a droplet or a continuous flow. The inkjet printing system also comprises a printing motion assembly 18, 20 that supports at least one of the at least one chuck 14 and the at least one inkjet printing head 16 so that a two dimensional printing area on the at least one chuck 14 can be covered with liquid discharged by the at least one printing head 16. The printing motion assembly may be configured to move the at least one printing head 16 relative to the chuck 14 both in X- and Y-direction. This may be effected by moving only the printing head 16 or by moving only the chuck 14. Alternatively, the relative X- Y-movement may also be effected by moving the printing head 16 in X-direction and by moving the chuck 14 in Y-direction or vice versa. The printing motion assembly may also be configured to rotate the chuck along a Z-axis which extends perpendicularly to the support surface of the chuck 14.

In an embodiment, each inkjet printing head 16 includes a plurality of nozzles. In the example shown in figure 1, the printing motion assembly includes two guides 18 extending in a Y-direction on which the tables 19 that are both connected with the chuck 14 are movable along the

Y-direction. The inkjet printing system 10 shown in the example includes a portal 21 that extends over the first guides 18 transversally in an X-direction. The portal 21 includes a second guide 20 on which a carriage 23 is movable along the X-direction. The carriage 23 carries the at least one printing head 16. The combined movement in X- and Y-direction provides the possibility of covering a two dimensional area with liquid that is discharged by the at least one printing head 16. In an alternative embodiment, the chucks may be fixed and the portal 21 may be movable in the Y-direction. In yet another alternative embodiment the at least one printing head 16 may be fixed and the chuck 14 may be movable in both X- and Y-direction. The chucks 14 may also be rotatable around a Z-axis to align a main direction of the printing head with a main direction of a substrate or with a pattern or structure on the substrate. Alternatively or additionally, the at least one printing head 16 may be rotatably mounted around a Z-axis to align a main direction of the printing head 16 with a main direction of a substrate edge or with a pattern or structure on the substrate. The number of chucks 14 may be varied as well in various embodiments. The embodiment of figure 1 shows a single chuck 14. However, embodiments with more than one chuck 14 are feasible as well.

20 The printing assembly 10 includes an electronic controller assembly 22, 24 that is configured to produce control signals to fire the at least one nozzle and that is configured to control the printing motion assembly 18, 20 for positioning the at least one printing head 16 relative to the at least one chuck 14 so that the positioning variation with which the liquid is deposited relative to the chuck is less than a first threshold value. The positioning variation is a quantity of length expressed, for example, in the unit micrometers. It will be clear that the electronic controller assembly 22, 24 may include various electronic controller units that are in communication with one another. For example, the printing head 16 may have its own controller unit 22 producing the control signals for firing the

nozzles. The printing motion assembly may have one or more electronic controller units, for example, one controller unit for each drive. A master controller 24 may communicate with the various drive controllers and the printing head controller 22 to coordinate the various drive controllers and
 5 the printing head controller 22.

Each reference mark F_1 , F_2 of the at least one chuck 14 is associated with an associated camera 26 that is directed to the associated chuck reference mark F_1 or F_2 . Each camera 26 has a two dimensional matrix of camera pixels. Each pixel of a said camera 26 has a pixel
 10 coordinate. The cameras 26 may be relatively simple and low cost CCD-cameras.

Figure 2 shows a schematic elevation view of a chuck 14 with two associated cameras 26. The figure clearly shows that the cameras 26 are positioned above the chuck 14 to each take an image I_1 , I_2 of the set of
 15 images. The image field of the camera may relatively be small and just be large enough to include a single substrate reference mark W_1 or W_2 and an associated chuck reference mark F_1 or F_2 . A top view of a chuck 14 with a substrate W placed on it is shown in figure 3. Figure 3 shows the boundaries of two images I_1 , I_2 that are taken by two associated cameras 26. Figure 3
 20 also shows that the chuck 14 includes a placement area extending within a boundary B . The boundary B may be a virtual boundary on a flat upper face of the chuck 14. In other words, each chuck 14 has a substantially flat upper surface on which a substrate W may be placed. Within the flat surface a specific area is designated to be the placement area. The placement area
 25 may be bounded by a boundary B which may not be visible and may not be defined by any structural feature of the chuck 14. It may be just the virtual boundary B within which the substrates W must be placed by the substrate handling system.

Each camera 26 that is associated with a chuck reference mark F_1
 30 or F_2 is, when a substrate W has been placed in or on the placement area of

a said chuck 14, also associated with an associated substrate reference mark W_1 or W_2 , in that an image I_1, I_2 taken with a said camera 26 includes an associated chuck reference mark F_1 or F_2 and an associated substrate reference mark W_1 or W_2 .

5 The visual chuck reference marks F_1, F_2 may for example be provided as fiducials on the chuck surface, as can be seen in figure 3. The orientation and positioning of the reference marks may differ for different chucks. The reference marks may for example be positioned on the boundary B of the placement area. For circular substrates, the reference marks may
10 however also be provided on the single circular boundary line B. The diameter of boundary line B will be slightly larger than the diameter of a circular substrate that is to be processed. This results in the chuck reference marks F_1, F_2 being positioned directly adjacent to the substrate edge of a substrate W, when the substrate is placed on the chuck 14.

15 Similarly, the substrate reference marks W_1, W_2 that are provided on the substrate W can be positioned in various configurations. Most preferably, the substrate reference marks W_1, W_2 are positioned in conjunction with the configuration of the chuck reference marks F_1, F_2 on the chuck 14. The substrate reference marks W_1, W_2 may for example be
20 positioned along a substrate edge W_{e1}, W_{e2} .

It will be clear that many variations of the visual chuck reference marks F_1, F_2 and the substrate reference marks W_1, W_2 are feasible. Both the number of chuck reference marks F_1, F_2 and associated substrate reference marks W_1, W_2 may be varied, as long as this number is two or
25 more, as well as the position of such reference marks F_1, F_2, W_1, W_2 may be varied.

The controller assembly 22, 24 mentioned above is configured to control the at least two cameras 26 to take a set of images each instance a substrate W has been placed on that chuck 14. Each camera 26 takes a
30 single image I_1, I_2 of the set of images. Each single image I_1, I_2 of the set of

images includes an associated chuck reference mark F_1 or F_2 and an associated substrate reference mark W_1 or W_2 .

Additionally, the controller assembly 22, 24 is configured to determine, for each set of images, the position of the chuck 14 relative to the at least two cameras 26 by detecting, for each image I_1, I_2 of the set of images, the position of a said chuck reference mark F_1, F_2 with respect to the camera pixel coordinates of a said associated camera 26.

Furthermore, the controller assembly 22, 24 is configured to determine, for each set of images, the position of the substrate W relative to the cameras 26 by detecting, for each image I_1, I_2 of the set of images, the position of a said substrate reference mark W_1, W_2 with respect to the camera pixel coordinates of a said associated camera;

Based on these two position determinations, the controller assembly 22, 24 is configured to calculate, for each set of images, the substrate position relative to the chuck reference marks F_1, F_2 and thus relative to the chuck 14 with an accuracy of less than a second threshold value. This accuracy is a quantity of length expressed in, for example, in the unit micrometers. Based on that relative position, the controller assembly 22, 24 is configured to subsequently time the firing of the at least one nozzle of the at least one printing head 16 and control the movement of the printing motion assembly 18, 20 so that the liquid discharged by the inkjet printing head 16 is positioned on the substrate W with a positioning variation which is less than the sum of the first and the second threshold values.

In an embodiment, of which an example is shown in figure 3, at least one of the chuck reference marks F_1, F_2 has a shape that defines a length and a direction. The size of the shape is such that a plurality of pixels of an associated camera 26 is involved for forming a representation of said chuck reference mark F_1, F_2 in the image I_1, I_2 . By virtue of the fact that a plurality of pixels of an associated camera 26 detects the shape of a chuck

reference mark, and because the size and the position of the chuck reference mark F_1 , F_2 on the chuck is fixed and known to the electronic controller, the relative distance between a chuck reference mark F_1 , F_2 and a wafer reference mark W_1 , W_2 can be determined even from a single image I_1 , I_2 of the set of images that is taken. By virtue of the knowledge about the direction of the chuck reference mark F_1 , F_2 in the image I_1 , I_2 the position of the substrate W relative to the chuck reference marks can be determined both in X- and Y-direction as well as in the rotative Z-direction by only using two chuck reference marks F_1 , F_2 .

In an embodiment, the first threshold value is 5 micrometer or less. With a printing motion assembly 18, 20 meeting this requirement, the inkjet printing system is able to print patterns on substrates with a repeatable precision. For example for the production of photovoltaic cells this first threshold value suffices to obtain good quality PV-cells.

In an embodiment, the second threshold value is 50 micrometer or less, more preferably 5 micrometer or less. Such accuracy suffices for the production of photovoltaic cells on which the patterns of the guiding tracks are printed with an inkjet printing system as disclosed herein.

In an embodiment, of which an example is shown in the figure 3, the inkjet printing system 10 may be configured for processing rectangular substrates W having four substrate edge parts W_{e1} , W_{e2} , W_{e3} , W_{e4} . Two substrate edge parts W_{e1} , W_{e3} are parallel and extend in a first direction and two other substrate edge parts W_{e2} , W_{e4} are also parallel and extend in a second direction. The first and the second direction are substantially orthogonal. In this embodiment, the placement area is substantially rectangular and bounded by four virtual boundary lines B which extend parallel to the substrate edge parts. The at least two chuck reference marks F_1 , F_2 are positioned on the boundary lines. Rectangular substrates may, for example, be used for the production of photovoltaic cells manufactured from Si. In an alternative embodiment, which is not shown in the figures, the

substrates to be processed may be circular and have a single substrate edge W_e . In this embodiment, the placement area is bounded by a single circular boundary line. The at least two chuck reference marks F_1, F_2 are positioned on the single boundary line. Circular substrates are, for example, used in the production of chips and LEDs or MEMS. It should be noted that term circular also includes substrates that are substantially circular but that have, for example, a notch in the circumferential edge or a circular edge of which one section is straight. Such features may be used to be able to rotationally orientate the circular substrate during various process steps.

By virtue of the fact that in these last two embodiments the chuck reference marks F_1, F_2 are positioned on the boundary lines B , the chuck reference marks F_1, F_2 will be relatively close to the substrate edges $W_{e1}, W_{e2}, W_{e3}, W_{e4}$. The associated substrate reference marks W_1, W_2 may, in an embodiment, also be positioned relatively close to the substrate edges $W_{e1}, W_{e2}, W_{e3}, W_{e4}$. Consequently, each chuck reference mark and substrate reference mark F_1, W_1, F_2, W_2 that are associated with each other to form a pair of which an image I_1, I_2 will be taken are relatively close together so that the field of view of the associated camera 26 that takes the image I_1, I_2 may be small. Cameras with a small field of view require a small number of pixels and are therefore relatively low in cost.

In an embodiment, each chuck may include at least three chuck reference marks F_1, F_2, F_3 and each substrate may include at least three substrate reference marks W_1, W_2, W_3 that are each associated with an associated one of the at least three chuck reference marks F_1, F_2, F_3 . With three reference marks F_1, F_2, F_3 on the chuck 14 and three associated reference marks W_1, W_2, W_3 on the substrate the relative position both in X- and in Y-direction as well as the relative rotational orientation in Z-direction can be determined even more accurately with a set of images including just three images. Preferably, the distances between the chuck reference marks F_1, F_2, F_3 , and consequently also the distances between the

associated substrate reference marks W_1 , W_2 , W_3 , are as large as possible and are in the order of the length, the width or the diameter of the substrate W . The greater the distances between the chuck reference marks F_1 , F_2 , F_3 are, the more accurate the position determination of the substrate W

5 relative to the chuck 14 can be performed.

In an embodiment, of which an example is shown in figure 1, each inkjet printing head 16 may be associated with a calibration camera 30 that is fixedly connected to the associated inkjet printing head 16. The calibration camera 30 may be configured to measure the position of an
10 amount of liquid that is discharged by the associated inkjet printing head 16 on one of the at least one chucks 14 or on a substrate W that is positioned on that chuck 14. The measurement of the position of the amount of liquid is effected relative to the chuck 14 so as to determine the position of the inkjet printing head 16 relative to the chuck 14 for the purpose of calibration of the
15 system. Such a calibration may be performed after maintenance of the system or after having processed a large number of substrates W , wherein the measurement of the position with the calibration camera has an accuracy which is less than a third threshold value. This accuracy is a quantity of length, for example, expressed in the unit of micrometers.

20 In an embodiment, the third threshold value may be 5 micrometer or less. It is explicitly not intended that the calibration takes place after each and every substrate W that has been processed by the inkjet printing system 10. The amount of liquid may, for example, be one or more liquid droplets or a continuous flow of liquid to form a track of liquid on the chuck
25 14 or substrate W .

Such a calibration camera 30 is advantageous for determining the position of a printing head 16 of the system relative to a chuck 14 of the system very precisely. Because this calibration only has to be performed once in a while, for example, after maintenance of the printing head 16 or

after having processed several thousands of substrates W, it has virtually no bearing on the production capacity of the inkjet printing system.

In an embodiment, of which an example is shown in the figures, each camera 26 may have an associated ring light source 32 that has a central axis C that is collinear with a camera axis C of the associated camera 26. The ring light source 32 directs light to an associated chuck mark reference F_1 , F_2 .

The ring light source 32 of a camera 26 sheds light on the chuck 14 with the substrate W in a uniform manner without unwanted shadows. This is beneficial for the quality of the image I that is taken by the camera 26 that is associated with the ring light source 32.

The invention also provides a method for inkjetting patterns of liquid material on substrates W. The method includes:

- providing an inkjet system 10 according to the invention;
- and repeating for the processing of each substrate W the following steps:
 - picking up a substrate W and placing a substrate on a said chuck 14;
 - controlling the at least two cameras 26 of said chuck 14 to take a set of images, with each camera 26 of said at least two cameras 26 taking a single image I_1 , I_2 of the set of images, wherein each single image I_1 , I_2 of the set of images includes an associated chuck reference mark F_1 or F_2 and an associated substrate reference mark W_1 or W_2 ;
 - determining the position of the chuck 14 relative to the at least two cameras 26 by detecting for each image I_1 , I_2 of the set of images the position of a said chuck reference mark F_1 , F_2 with respect to the camera pixel coordinates of a said associated camera 26; and
 - determining the position of the substrate W relative to the at least two cameras 26 by detecting for each image I_1 , I_2 of the set of images the position of a said substrate reference mark W_1 , W_2 of the

substrate W with respect to the camera pixel coordinates of a said associated camera 26;

- using these two position determinations to calculate the substrate position relative to the chuck reference marks F_1 , F_2 and thus relative to the chuck 14 with an accuracy of less than the second threshold value and, based on that relative position, subsequently timing the firing of the at least one nozzle of the at least one printing head 16 and controlling the movement of the printing motion assembly 18, 20 with a positioning variation of less than the first threshold value so that the liquid discharged by the inkjet printing head 16 is positioned on the substrate W with a positioning variation which is less than the sum of the first and the second threshold values.

As explained above, the method can be performed with a relatively low cost camera assembly. A high number of substrates may be processed with a very high accuracy without the necessity to frequently calibrate the system because the position of the cameras 26 relative to the chuck 14 are not relevant for determining the relative position of the substrate W relative to the chuck 14. Per chuck 14, the substrate production for photovoltaic cells may be typically at least four substrates per chuck per minute. This means that the production capacity of large substrates, for example substrates with a size of 120 x 60 cm, may be $4 \times 60 = 240$ substrates per hour per chuck 14. By virtue of the inkjet printing system and the method according to the invention, the time that needs to be spent to calibration of the system is minimized because the exact position of the cameras 26 relative to the printing motion assembly and the inkjet printing head 16 is not relevant for the accuracy of the determination of the position of the substrate W relative to the chuck 14. Calibration may have to be performed when the inkjet printing head 16 or the printing motion assembly has been serviced because the relative position between these parts is of the essence for being able to accurately deposit inkjet printing liquid on the

substrate during production. Such service does not occur very often and therefore a large number of substrates may be processed after each other without any time being lost for calibration activities. Another reason that may necessitate calibration may be a variation in the environmental

5 condition such as, for example, the room temperature.

In an embodiment, the first threshold value is 5 micrometer or less and the second threshold value is 50 micrometer or less, preferably 5 micrometer or less. With such thresholds, for example, the tracks on PV-cells can be printed with sufficient precision to obtain good quality PV-cells.

10 For other applications of the inkjet printing system 10 other threshold values may be feasible.

In an embodiment, wherein the inkjet printing system 10 includes a calibration camera 30 that is fixedly connected to the associated inkjet printing head 16, the method may include a calibration operation which is performed after maintenance of the system or after having processed a large number of substrates. Such calibration operation may include:

- determining a said inkjet printing head 16 and a said chuck 14 of which the relative position have to be calibrated;
- positioning the inkjet printing head 16 above the chuck 14 of which the relative position has to be calibrated;
- discharging an amount of liquid from the inkjet printing head 16 on the chuck 14 or on a substrate placed W on that chuck 14;
- activating the calibration camera 30 that is fixedly connected to the inkjet printing head 16;
- performing a measurement with the calibration camera 30 to determine with an accuracy of less than the third threshold value the position of the amount of liquid that is discharged by the associated inkjet printing head 16 relative to the chuck 14, more particular relative to the visual chuck reference marks F_1 , F_2 of the chuck 14; and

30

- on the basis of that measurement determining the position of the inkjet printing head 16 relative to the chuck 14 for the purpose of calibration.

In elaboration of the embodiment, the third threshold value may
5 be 5 micrometer or less. By virtue of the presence of a calibration camera, it is ensured that the inkjet printing system 10 remains accurate and precise even if the at least one printing head as been removed for maintenance or when several thousands of substrates W have been processed.

In an embodiment of the method that includes a calibration step,
10 the amount of liquid that is discharged to perform a measurement with the calibration camera on the position of the amount of liquid that is discharged from the associated inkjet printing head 16 may be at least one liquid drop or may be at least one liquid track.

In order to minimize the time for determining the position of the
15 substrate W relative to the chuck, it is beneficial that the electronic controller assembly 22, 24 is configured for simultaneously activating the respective cameras 26 of the system when a set of images has to be taken. As such the method includes in an embodiment that the images I_1 , I_2 of each set of images are taken simultaneously.

20 The various embodiments which are described above may be implemented independently from one another and may be combined with one another in various ways. The reference numbers used in the detailed description and the claims do not limit the description of the embodiments nor the claims and are solely used to clarify.

CONCLUSIES

1. Een inktjetprintsysteem (10) ingericht om patronen van vloeibaar materiaal te inktjetten op substraten (W) die elk een lengte en een breedte of, alternatief, een diameter hebben, waarbij elk substraat ten minste twee substraatreferentietekens (W_1 , W_2) omvat die op een afstand van elkaar zijn gelegen die groter is dan ten minste een helft van de lengte, de breedte of de diameter van het substraat, waarbij het inktjetprintsysteem omvat:
 - ten minste één klem (14) waarop een substraat (W) kan worden geplaatst, waarbij elke klem een lengte en een breedte, of alternatief, een diameter heeft en ten minste twee visuele klemreferentietekens (F_1 , F_2) omvat die op een afstand van elkaar zijn gelegen die groter is dan ten minste een helft van de lengte, de breedte of de diameter van de klem;
 - ten minste één inktjetprintkop (16) die ten minste één spuitmond omvat die is ingericht om vloeistof af te geven wanneer de spuitmond door een controlesignaal wordt bekrachtigd;
 - een printbewegingssamenstel (18, 20) dat ten minste één van de ten minste ene klem (14) en de ten minste ene inktjetprintkop (16) draagt zodat een tweedimensionaal printgebied op de ten minste ene klem (14) kan worden bedekt met door de ten minste ene printkop (16) afgegeven vloeistof;
 - een elektronisch bedieningssamenstel (22, 24) geconfigureerd voor het produceren van besturingssignalen (S_1 , S_2 , S_3) om de ten minste ene spuitmond te bekrachtigen en geconfigureerd voor het besturen van het printbewegingssamenstel (18, 20) om de ten minste ene printkop (16) te positioneren ten opzichte van de ten minste ene klem (14) zodat de positievariatie waarmee de vloeistof wordt gedeponerd ten opzichte van de klem kleiner is dan een eerste drempelwaarde;
- waarbij:
- elk referentieteken (F_1 , F_2) van de ten minste ene klem (14) is geassocieerd met een geassocieerde camera (26) die naar het geassocieerde klemreferentieteken (F_1 , F_2) is gericht, waarbij elke

- camera (26) een tweedimensionale matrix van camerapixels heeft,
 waarbij elke pixel een pixelcoördinaat heeft;
- elke klem (14) een plaatsingsgebied omvat dat zich binnen een
 begrenzing (B) uitstrekt;
 - 5 - wanneer een substraat (W) in of op het plaatsingsgebied van een
 genoemde klem (14) is geplaatst, elke camera (26) die is geassocieerd
 met een klemreferentieteken (F_1 of F_2) ook is geassocieerd met een
 geassocieerd substraatreferentieteken (W_1 of W_2) doordat een met een
 genoemde camera (26) genomen beeld (I_1 of I_2) een geassocieerd
 10 klemreferentieteken (F_1 of F_2) en een geassocieerd
 substraatreferentieteken (W_1 of W_2) omvat;
 - het bedieningssamenstel (22, 24) is geconfigureerd:
 - o om de ten minste twee camera's (26) te besturen om een set
 beelden (I) te maken elke keer wanneer een substraat (W) op
 15 die klem (14) is geplaatst, waarbij elke camera (26) één enkel
 beeld (I) van de set beelden maakt, waarbij elk enkel beeld van
 de set beelden een geassocieerd klemreferentieteken (F_1 of F_2)
 en een geassocieerd substraatreferentieteken (W_1 of W_2)
 omvat;
 - o om voor elke set beelden de positie van de klem (14) te bepalen
 20 ten opzichte van de ten minste twee camera's (26) door het
 voor elk beeld (I_1 , I_2) van de set beelden detecteren van de
 positie van een genoemd klemreferentieteken (F_1 , F_2) ten
 opzichte van de camerapixelcoördinaten van een genoemde
 25 geassocieerde camera (26); en
 - o om voor elke set beelden de positie het substraat (W) te
 bepalen ten opzichte van de ten minste twee camera's (26)
 door het voor elk beeld (I_1 , I_2) van de set beelden detecteren
 van de positie van een genoemd substraatreferentieteken (W_1 ,
 30 W_2) ten opzichte van de camerapixelcoördinaten van een
 genoemde geassocieerde camera;
 - o om deze twee positiebepalingen te gebruiken om voor elke set
 beelden de substraatpositie ten opzichte van de

klemreferentietekens (F_1 , F_2) en dus ten opzichte van de klem
 (14) te berekenen met een nauwkeurigheid die kleiner is dan
 een tweede drempelwaarde en om, gebaseerd op die relatieve
 positie, vervolgens de bekrachtiging van de ten minste ene
 spuitmond van de ten minste ene printkop (16) te timen en de
 beweging van het printbewegingssamenstel (18, 20) te
 besturen zodat de vloeistof die wordt afgegeven door de
 inktjetprintkop (16) wordt gepositioneerd op het substraat (W)
 met een positievariatie die kleiner is dan de som van de eerste
 en de tweede drempelwaarden.

2. Het inktjetprintsysteem volgens conclusie 1, waarbij ten minste één van
 de klemreferentietekens (F_1 , F_2) een vorm heeft die een lengte en een richting
 definiëren, waarbij de grootte van de vorm zodanig is dat een meervoud van pixels
 van een geassocieerde camera (26) betrokken is om een weergave van genoemd
 klemreferentieteken (F_1 , F_2) in het beeld (I_1 , I_2) te vormen.

3. Het inktjetprintsysteem volgens conclusie 1 of 2, waarbij de eerste
 drempelwaarde 5 micrometer of minder is.

4. Het inktjetprintsysteem volgens één der conclusies 1-3, waarbij de
 tweede drempelwaarde 50 micrometer of minder is, meer bij voorkeur 5 micrometer
 of minder.

5. Het inktjetprintsysteem volgens één der voorgaande conclusies, waarbij
 het systeem is geconfigureerd om rechthoekige substraten (W) te verwerken met
 vier substraatranddelen (W_{e1} , W_{e2} , W_{e3} , W_{e4}), waarvan twee substraatranddelen
 (W_{e1} , W_{e3}) parallel zijn en zich in een eerste richting uitstrekken en waarvan twee
 andere substraatranddelen (W_{e2} , W_{e4}) parallel zijn en zich in een tweede richting
 uitstrekken, waarbij de eerste en de tweede richting in hoofdzaak orthogonaal zijn,
 waarbij het plaatsingsgebied in hoofdzaak rechthoekig is en door vier grenslijnen
 (B) wordt begrensd die zich parallel aan de substraatranddelen (W_{e1} , W_{e2} , W_{e3} , W_{e4})

uitstrekken, waarbij de ten minste twee klemreferentietekens (F_1 , F_2) op de grenslijnen (B) zijn gepositioneerd.

6. Het inktjetprintsysteem volgens één der conclusies 1-4, waarbij de te
5 verwerken substraten cirkelvormig zijn en een enkele substraatrand (W_e) hebben, waarbij het plaatsingsgebied wordt begrensd door een enkele cirkelvormige grenslijn waarbij de ten minste twee klemreferentietekens (F_1 , F_2) op de enkele grenslijn zijn gepositioneerd.
- 10 7. Het inktjetprintsysteem volgens één der conclusies 1-6, waarbij elke klem ten minste drie klemreferentietekens (F_1 , F_2 , F_3) omvat en waarbij elk substraat ten minste drie substraatreferentietekens (W_1 , W_2 , W_3) omvat die elk zijn geassocieerd met een geassocieerde van de drie klemreferentietekens (F_1 , F_2 , F_3).
- 15 8. Het inktjetprintsysteem volgens één der conclusies 1-7, waarbij elke inktjetprintkop (16) is geassocieerd met een calibratiecamera (30) die vast is verbonden met de geassocieerde inktjetprintkop (16) en die is ingericht om de positie van een hoeveelheid vloeistof te meten die is afgegeven door de geassocieerde inktjetprintkop (16) op één van de ten minste ene klem (14) of op een
20 substraat (W) dat op die klem (14) is geplaatst, waarbij de meting van de positie van de hoeveelheid vloeistof wordt uitgevoerd ten opzichte van de klem (14) om de positie van de inktjetprintkop (16) te bepalen ten opzichte van de klem (14) met het oog op calibratie van het systeem die moet worden uitgevoerd na onderhoud van het systeem of nadat een groot aantal substraten (W) is verwerkt, waarbij de
25 meting van de positie met de calibratiecamera een nauwkeurigheid heeft die kleiner is dan een derde drempelwaarde.
9. Het inktjetprintsysteem volgens conclusie 8, waarbij de derde drempelwaarde 5 micrometer of minder is.
- 30 10. Het inktjetprintsysteem volgens één der conclusies 1-9, waarbij elke camera (26) een geassocieerde ringlichtbron (32) heeft die een centrale as (C) heeft

die collineair is met een camera-as (C) van de geassocieerde camera (26), waarbij de ringlichtbron (32) licht op een geassocieerd klemreferentieteken (F_1 , F_2) richt.

11. Een werkwijze voor het inktjetten van patronen van vloeibaar materiaal op substraten (W), waarbij de werkwijze inhoudt:

- het verschaffen van een inktjetsysteem (10) volgens één der conclusies 1-10;

en het herhalen van de volgende stappen voor het bewerken van elk substraat (W):

- het oppakken van een substraat (W) en het plaatsen van een substraat op een genoemde klem (14);
- het besturen van de ten minste twee met genoemde klem (14) geassocieerde camera's (26) om een set beelden te maken, waarbij elke camera (26) van genoemde ten minste twee camera's (26) een enkel beeld (I_1 , I_2) van de set beelden maakt, waarbij elk enkel beeld (I_1 , I_2) van de set beelden een geassocieerd klemreferentieteken (F_1 of F_2) en een geassocieerd substraatreferentieteken (W_1 of W_2) omvat;
- het bepalen van de positie van de klem (14) ten opzichte van de ten minste twee camera's (26) door het voor elk beeld (I_1 , I_2) van de set beelden detecteren van de positie van een genoemd klemreferentieteken (F_1 , F_2) ten opzichte van de camerapixelcoördinaten van een genoemde geassocieerde camera (26); en
- het bepalen van de positie van het substraat (W) ten opzichte van de ten minste twee camera's (26) door het voor elk beeld (I_1 , I_2) van de set beelden detecteren van de positie van een genoemd substraatreferentieteken (W_1 , W_2) van het substraat ten opzichte van de camerapixelcoördinaten van een genoemde camera (26);
- het gebruiken van deze twee positiebepalingen om de substraatpositie te berekenen ten opzichte van de klemreferentietekens (F_1 , F_2) en dus ten opzichte van de klem (14) met een nauwkeurigheid die kleiner is dan de tweede drempelwaarde en om, gebaseerd op die relatieve positie, vervolgens de bekrachtiging van de ten minste ene spuitmond van de ten minste

5 ene printkop (16) te timen en om de beweging van het
 printbewegingssamenstel (18, 20) te besturen met een positievariatie
 die kleiner is dan de eerste drempelwaarde zodat de door de
 inktjetprintkop (16) afgegeven vloeistof wordt gepositioneerd op het
 substraat (W) met een positievariatie die kleiner is dan de som van
 de eerste en de tweede drempelwaarden.

12. De werkwijze volgens conclusie 11, waarbij de eerste drempelwaarde 5
 micrometer of minder is en waarbij de tweede drempelwaarde 50 micrometer of
 10 minder is, bij voorkeur 5 micrometer of minder.

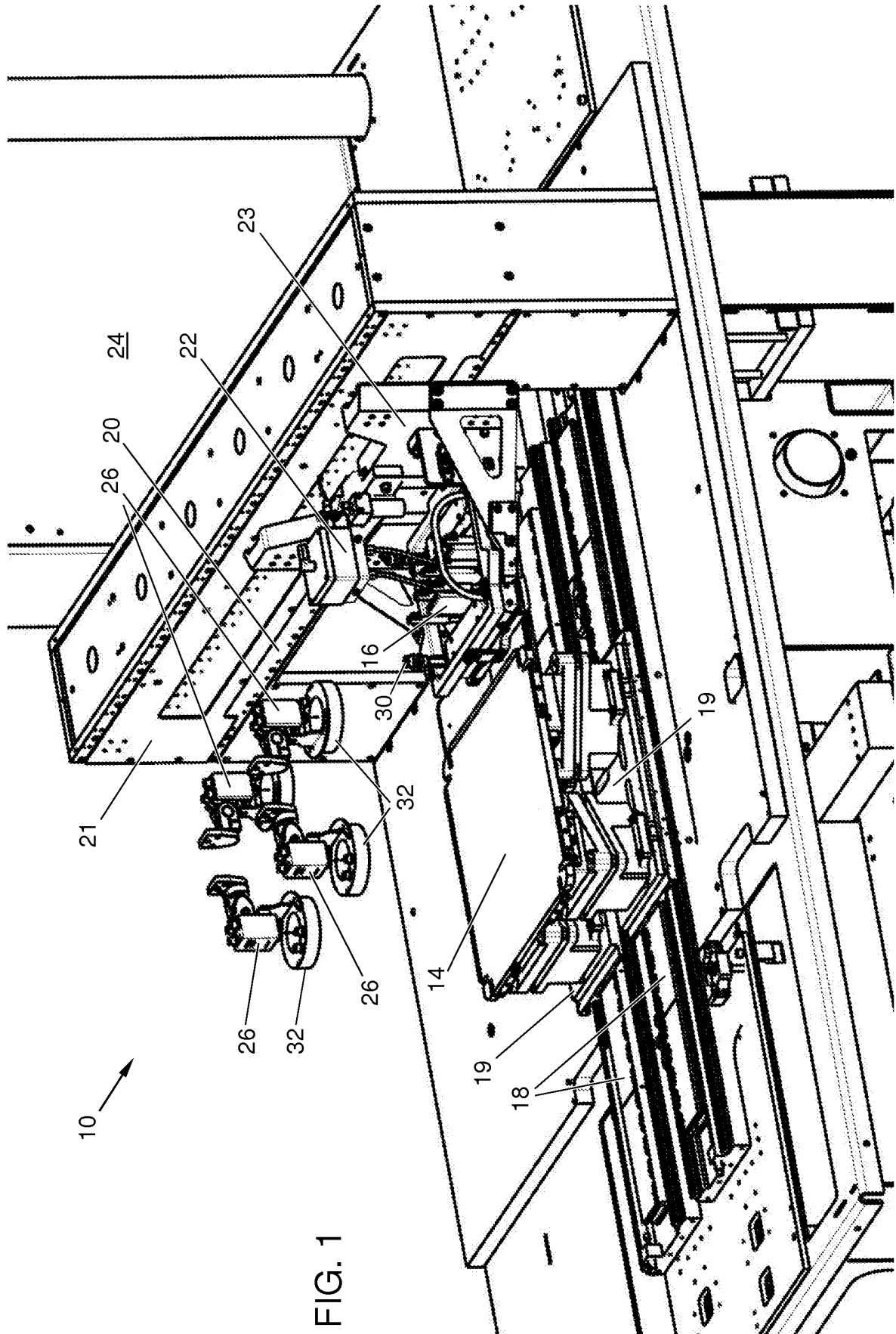
13. De werkwijze volgens conclusie 11 of 12, waarbij het inktjetprintsysteem
 (10) de kenmerken van conclusie 8 of 9 omvat en waarbij de werkwijze een
 calibratiebewerking omvat die wordt uitgevoerd na onderhoud van het systeem of
 15 nadat een groot aantal substraten is verwerkt, waarbij de calibratiebewerking
 omvat:

- het bepalen van een genoemde inktjetprintkop (16) en een genoemd
 klem (14) waarvan de onderlinge positie moet worden gecalibreerd;
- het positioneren van de inktjetprintkop (16) boven de klem (14)
 20 waarvan de onderlinge positie moet worden gecalibreerd;
- het afgeven van een hoeveelheid vloeistof door de inktjetprintkop (16)
 op de klem (14) of op een op die klem (14) geplaatst substraat (W);
- het activeren van de calibratiecamera (30) die vast is verbonden met de
 inktjetprintkop (16)
- 25 - het uitvoeren van een meting met de calibratiecamera (30) om met een
 nauwkeurigheid die kleiner is dan de derde drempelwaarde de positie
 van de hoeveelheid vloeistof die door de geassocieerde inktjetprintkop
 (16) is afgegeven te bepalen ten opzichte van de klem (14), meer in het
 bijzonder ten opzichte van de visuele klemreferentietekens (F_1 , F_2) van
 30 de klem (14); en
- het op basis van die meting bepalen van de positie van de
 inktjetprintkop (16) ten opzichte van de klem (14) met het oog op
 calibratie.

14. De werkwijze volgens conclusie 13, waarbij de derde drempelwaarde 5 micrometer of minder is.

15. De werkwijze van conclusies 13 of 14, waarbij de hoeveelheid vloeistof die
5 wordt afgegeven om een meting erop uit te voeren met de calibratiecamera, ten minste één vloeistofdruppel is of ten minste één vloeistofspoor.

16. De werkwijze volgens één der conclusies 11-15, waarbij de beelden (I_1 , I_2) van elke set beelden gelijktijdig worden gemaakt.



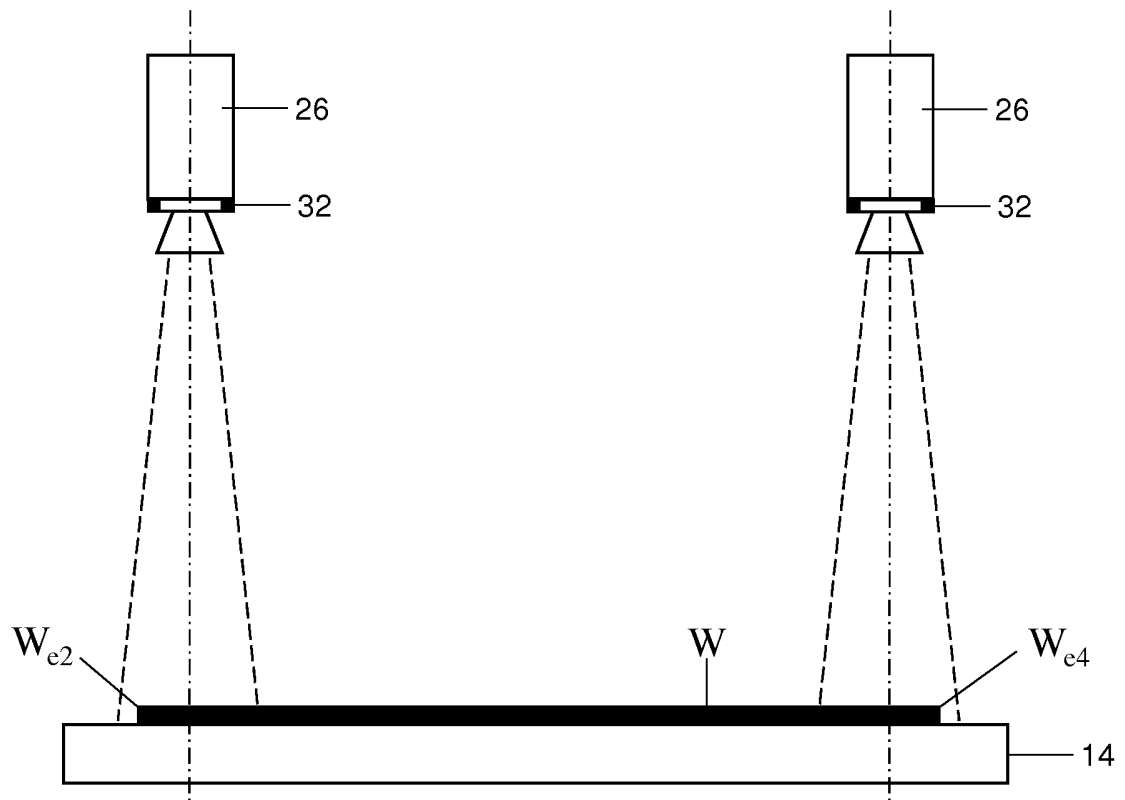


FIG. 2

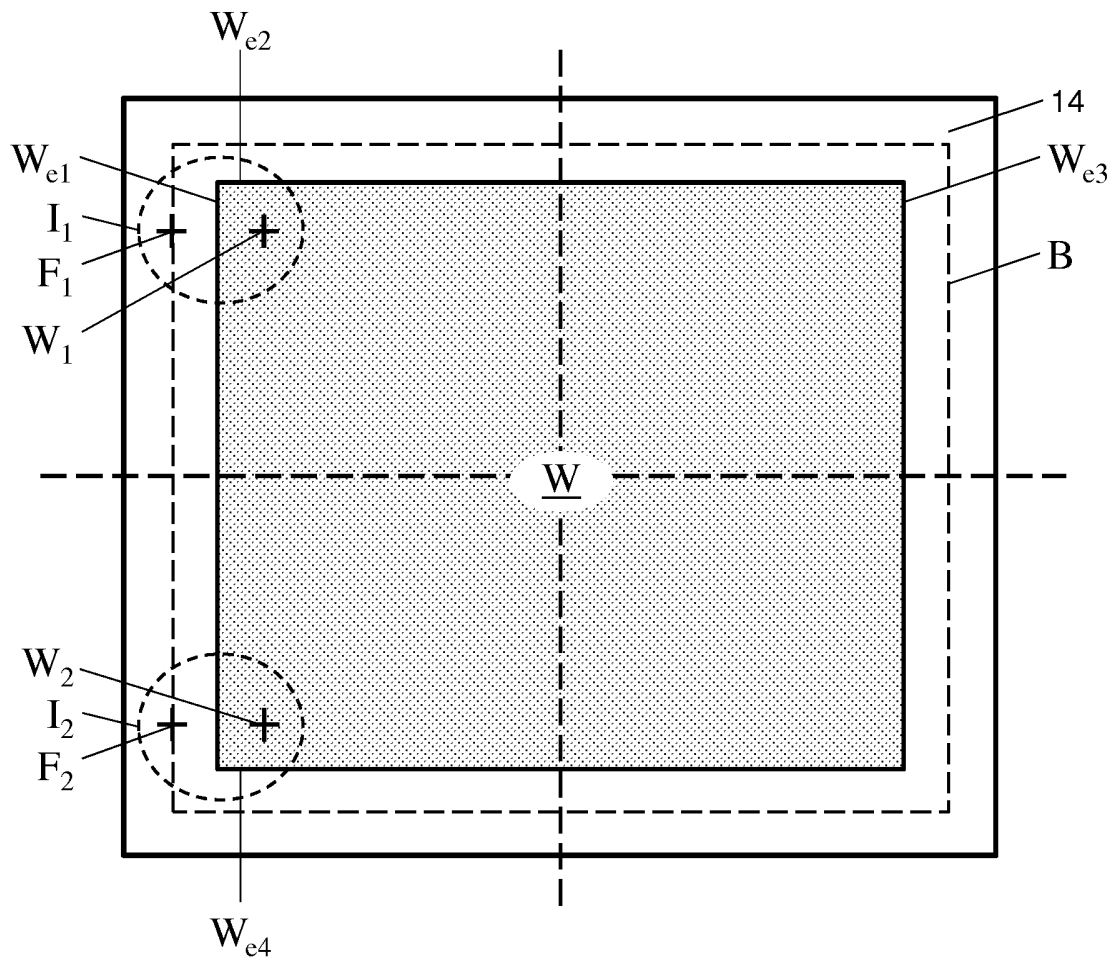


FIG. 3

Abstract

Inkjet printing system for processing substrates including a chuck for placement of a substrate and an inkjet printing head with at least one nozzle. Each chuck has chuck reference marks, each of which is associated with an associated camera. An electronic controller assembly is configured to take a set of images each instance a substrate having substrate reference marks has been placed on a chuck, with each image containing a chuck reference mark and a substrate reference mark. For each image, the position of the chuck relative to the camera and the position of the substrate relative to the camera is determined. Subsequently, the substrate position relative to the chuck is calculated and based thereon the firing of the at least one nozzle is timed and the movement of the printing motion assembly is controlled so that the liquid drops are accurately positioned on the substrate.

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE P108443NL00
Nederlands aanvraag nr. 2016137	Indieningsdatum 21-01-2016
	Ingeroepen voorrangsdatum
Aanvrager (Naam) Meyer Burger (Netherlands) B.V.	
Datum van het verzoek voor een onderzoek van internationaal type 04-06-2016	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. SN 66535
I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven) Volgens de internationale classificatie (IPC) H01L21/67H01L21/68H01L21/768	
II. ONDERZOCHE GEBIEDEN VAN DE TECHNIEK	
Onderzochte minimumdocumentatie	
Classificatiesysteem	Classificatiesymbolen
IPC	H01L
Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen 	
III.	☐ GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES (opmerkingen op aanvullingsblad)
IV.	☐ GEBREK AAN EENHEID VAN UITVINDING (opmerkingen op aanvullingsblad)

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2016137

A. CLASSIFICATIE VAN HET ONDERWERP
INV. H01L21/67 H01L21/68 H01L21/768
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimum documentatie (classificatie gevolgd door classificatiesymbolen)

H01L

Onderzochte andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie *	Geselecteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	EP 2 324 932 A1 (KONICA MINOLTA HOLDINGS INC [JP]) 25 mei 2011 (2011-05-25) * samenvatting * * conclusies 1-9 * * kolom 1, alinea 1 - kolom 3, alinea 18 * * figuren 1-15 *	1-16
A	WO 2006/116318 A2 (LITREX CORP [US]; ALBERTALLI DAVID [US]; BOEHM ROBERT G JR [US]; FOX R) 2 november 2006 (2006-11-02) * samenvatting * * conclusies 1-46 * * bladzijde 1, alinea 4 * * bladzijde 30, alinea 109 - bladzijde 33, alinea 116 * * figuren 1-38 * ----- -/-	1-16



Verdere documenten worden vermeld in het vervolg van vak C.



Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

*** Speciale categorieën van aangehaalde documenten**

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvraag vermeld

"E" eerdere octrooi(aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwaarlijk is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geselecteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"Z" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid

15 september 2016

Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type

Naam en adres van de instantie

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De bevoegde ambtenaar

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**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2016137

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie *	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	JP 2007 007522 A (SEIKO EPSON CORP) 18 januari 2007 (2007-01-18) * samenvatting * * alinea [0039] * * figuren 1-12 *	1-16
A	----- US 2007/070107 A1 (SHAMOUN BASSAM [US] ET AL) 29 maart 2007 (2007-03-29) * samenvatting * * conclusies 1-20 * * figuren 1-6 * -----	1-16

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2016137

In het rapport genoemd octrooigescrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie	
EP 2324932	A1	25-05-2011	EP 2324932 A1	25-05-2011
			JP 5556661 B2	23-07-2014
			US 2011169893 A1	14-07-2011
			WO 2010032615 A1	25-03-2010
WO 2006116318	A2	02-11-2006	CN 101258030 A	03-09-2008
			CN 101863163 A	20-10-2010
			EP 1888336 A2	20-02-2008
			JP 4793884 B2	12-10-2011
			JP 2008539073 A	13-11-2008
			KR 20080005275 A	10-01-2008
			US 2010295896 A1	25-11-2010
			WO 2006116318 A2	02-11-2006
JP 2007007522	A	18-01-2007	CN 1891461 A	10-01-2007
			JP 4353145 B2	28-10-2009
			JP 2007007522 A	18-01-2007
			KR 20070001805 A	04-01-2007
			TW 1301800 B	11-10-2008
			US 2007002114 A1	04-01-2007
US 2007070107	A1	29-03-2007	CN 1939731 A	04-04-2007
			JP 2007090886 A	12-04-2007
			KR 20070036727 A	03-04-2007
			TW 1324558 B	11-05-2010
			US 2007070107 A1	29-03-2007

WRITTEN OPINION

File No. SN66535	Filing date (day/month/year) 21.01.2016	Priority date (day/month/year)	Application No. NL2016137
International Patent Classification (IPC) INV. H01L21/67 H01L21/68 H01L21/768			
Applicant Meyer Burger (Netherlands) B.V.			

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

	Examiner Lachaud, Stéphane
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WRITTEN OPINION

Application number
NL2016137

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material:
 - ☐ on paper
 - ☐ in electronic form
 - c. time of filing/furnishing:
 - ☐ contained in the application as filed.
 - ☐ filed together with the application in electronic form.
 - ☐ furnished subsequently for the purposes of search.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes: Claims	1-16
	No: Claims	
Inventive step	Yes: Claims	1-16
	No: Claims	
Industrial applicability	Yes: Claims	1-16
	No: Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

D1: EP 2 324 932 A1 (KONICA MINOLTA HOLDINGS INC [JP]) 25 mei 2011 (2011-05-25)

D2: WO 2006/116318 A2 (LITREX CORP [US]; ALBERTALLI DAVID [US]; BOEHM ROBERT G JR [US]; FOX R) 2 november 2006 (2006-11-02)

D3: JP 2007 007522 A (SEIKO EPSON CORP) 18 januari 2007 (2007-01-18)

D4: US 2007/070107 A1 (SHAMOUN BASSAM [US] ET AL) 29 maart 2007 (2007-03-29)

V.1. The present application meets the criteria of patentability, because the subject-matter of claims 1-16 involve, *prima facie*, novelty and inventive step.

V.1.1. Claim 1:

Document D1, which is considered as being the most relevant state of the art, discloses:

"Een inktjetprintsysteem ingericht om patronen van vloeibaar materiaal te inktjetten op substraten die elk een lengte en een breedte of, alternatief, een diameter hebben, waarbij elk substraat ten minste twee substraatreferentietekens omvat die op een afstand van elkaar zijn gelegen die groter is dan ten minste een helft van de lengte, de breedte of de diameter van het substraat, (abstract; p. 1, par. [0001]; col. 18, par. [0093]; fig. 13, 14) waarbij het inktjetprintsysteem omvat:

- ten minste één klem waarop een substraat kan worden geplaatst, waarbij elke klem een lengte en een breedte, of alternatief, een diameter heeft en ten minste twee visuele klemreferentietekens omvat die op een afstand van elkaar zijn gelegen die groter is dan ten minste een helft van de lengte, de breedte of de diameter van de klem (col. 11, par. [0047], [0048]); fig. 4);*
- ten minste één inktjetprintkop die ten minste één spuitmond omvat die is ingericht om vloeistof af te geven wanneer de spuitmond door een controlesignaal wordt bekrachtigd (col. 2, par. [0011]; col. 9, par. [0036]; fig. 3, 4 (301, 302));*

- een printbewegingssamenstel dat ten minste één van de ten minste ene klem en de ten minste ene inktjetprintkop draagt zodat een tweedimensionaal printgebied op de ten minste ene klem kan worden bedekt met door de ten minste ene printkop afgegeven vloeistof (fig. 1-11c);

- een elektronisch bedieningssamenstel geconfigureerd voor het produceren van besturingssignalen om de ten minste ene spuitmond te bekrachtigen en geconfigureerd voor het besturen van het printbewegingssamenstel om de ten minste ene printkop te positioneren ten opzichte van de ten minste ene klem zodat de positievariatie waarmee de vloeistof wordt gedeponeerd ten opzichte van de klem kleiner is dan een eerste drempelwaarde (col. 17, par. [0091] to col. 20, par. [0106]; fig. 12, 14);

waarbij:

- elk referentieteken van de ten minste een klem is geassocieerd met een geassocieerde camera die naar het geassocieerde klemreferentieteken is gericht (col. 11, par. [0047], [0048]; fig. 1, 4: m1-m3), waarbij elke camera een tweedimensionale matrix van camerapixels heeft, waarbij elke pixel een pixelcoördinaat heeft (considered as obvious for the skilled person);

- elke klem een plaatsingsgebied omvat dat zich binnen een begrenzing uitstrekt (fig. 1, 2 (W1, W2));

- wanneer een substraat in of op het plaatsingsgebied van een genoemde klem is geplaatst, elke camera die is geassocieerd met een klemreferentieteken ook is geassocieerd met een geassocieerd substraatreferentieteken doordat een met een genoemde camera genomen beeld een geassocieerd klemreferentieteken en een geassocieerd substraatreferentieteken (col. 11, par. [0047], [0048]; col. 18, par. [0093], [0094]) omvat;

- het bedieningssamenstel is geconfigureerd:

* om de ten minste twee camera's te besturen om een set beelden te maken elke keer wanneer een substraat op die klem is geplaatst, waarbij elke camera één enkel beeld van de set beelden maakt, waarbij elk enkel beeld van de set beelden een geassocieerd klemreferentieteken en een geassocieerd substraatreferentieteken (fig. 8, 12, 15) omvat;

* om voor elke set beelden de positie van de klem te bepalen ten opzichte van de ten minste twee camera's door het voor elk beeld van de set beelden detecteren van de positie van een genoemd klemreferentieteken ten opzichte van de camerapixelcoördinaten van een genoemde geassocieerde camera (col. 14, par. [0066]; fig. 7); en

* om voor elke set beelden de positie het substraat te bepalen ten opzichte van de ten minste twee camera's door het voor elk beeld van de set beelden detecteren van de

positie van een genoemd substraatreferentieteken ten opzichte van de camerapixelcoördinaten van een genoemde geassocieerde camera (col. 17, par. [0091] to col. 19, par. [0100; fig. 12])".

The subject-matter of claim 1 differs from the inkjet printing system of D1 by disclosing, in the configuration of the electronic control assembly, this additional specific features:

- (i) "om deze twee positiebepalingen te gebruiken om voor elke set beelden de substraatpositie ten opzichte van de klemreferentietekens (F_1 , F_2) en dus ten opzichte van de klem te berekenen met een nauwkeurigheid die kleiner is dan een tweede drempelwaarde";*
- (ii) "om, gebaseerd op die relatieve positie, vervolgens de bekrachtiging van de ten minste ene spuitmond van de ten minste ene printkop te timen en de beweging van het printbewegingssamenstel te besturen zodat de vloeistof die wordt afgegeven door de inktjetprintkop wordt gepositioneerd op het substraat (W) met een positievariatie die kleiner is dan de som van de eerste en de tweede drempelwaarden".*

Therefore claim 1 is novel.

The problem to be solved by the present application may be considered as how to find an alternative to the configuration of the electronic control assembly of D1 in order to position with a maximum of precision, a substrate to be printed/inked on a chuck or support.

Technical effect: said precise positioning allows to precisely deposit ink on said substrate.

The solution proposed by the present application may be, *prima facie*, considered as involving an inventive step for the following reasons:

- Although D1 mentions a concern at least partly similar to the problem to be solved by the present application (see D1: col. 1, par. [0001] to col. 3, par. [0018]), nothing in said D1 indicates the presence of features (i) and (ii) as it is disclosed above.

- In the present application, it is clear that the result of calculation of position of chuck relative to at least two cameras and the result of calculation of position of substrate relative to the at least two cameras will be used in an interrelated way in order to finally precisely determine the relative position of a substrate to the chuck.
- In D1, the electronic control assembly is treating independently the positioning of the chuck, and the positioning the substrate, by:
 - * on one hand, calculating the position of a chuck according position of cameras, and correcting position of said chuck according reference markers position (fig. 7);
 - * and on the other hand calculating the position of the substrate according position of cameras, and correcting position of said substrate according substrate alignment marker (fig. 12).

Each of said position correction seeming to be independent from one to the other. The idea being to precisely position the chuck on one side, and on the other side to precisely position the substrate, by using to different referential systems: one dedicated to the chuck (reference markers/installment position of camera; fig. 7), the other to the substrate (substrate marker/expected position of marker; fig. 12).

Based on the teaching of D1, and because of the reasons given above, nothing would lead the skilled person to modify the apparatus of D1 by including features (i) and (ii) of the difference of subject-matter, in order to solve the problem posed.

Concerning D2 to D4, although the problems solved by said documents are at least partly similar to the problem to be solved by the application (D1: abstract; D3: abstract; D4: abstract; fig. 6), nothing discloses nor suggests any hint concerning features (i) and (ii) of the difference of subject-matter.

Therefore, nothing in the available prior art (D1 to D4) taken alone nor combined, would lead the skilled person to modify the configuration of the electronic control assembly of D1, by including feature (i) and (ii), in order to solve the problem posed. Furthermore, based only on the teaching of D1, the solution proposed can not be considered as being obvious for the same skilled person.

V.1.2. Claim 11:

The same reasoning and citations used for claim 1 can also be presented, *mutatis mutandis*, for present method claim 11 using the ink-jet system of claim 1. Method claim 11 is therefore considered as involving novelty and inventive step.

V.1.3. Dependent claims 2-10 and 12-16 being dependent on entity claim 1 and method claim 11, they are also considered as involving novelty and inventive step.