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(54) **Title**: CARRIER SYSTEM FOR SUBSTRATES TO BE PROCESSED

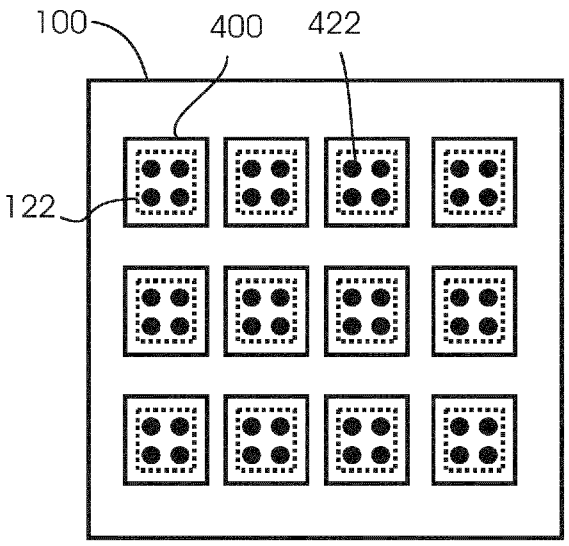


Fig. 9a

(57) **Abstract**: A carrier system for a substrate to be processed is described. The carrier system includes a main carrier (100) comprising a sub-carrier coupling means (201) for coupling one or more sub-carriers (400; 800) to the main carrier (100). The main carrier (100) includes a sub- carrier supporting portion (120) having the shape of a grid with crossing grid bars (121), wherein the sub-carrier coupling means (201) are provided at the grid bars (121). The carrier system further includes a sub-carrier (400; 800) for supporting one or more substrates (500) to be processed, wherein the sub-carrier (400; 800) includes one or more openings (422). The sub-carrier (400; 800) further includes substrate coupling means (430; 431) for coupling the substrates (500), wherein the substrate coupling means (430; 431) is configured to hold the substrate (500) in a position overlapping partially with the openings (422) of the sub-carrier (400; 800).

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CARRIER SYSTEM FOR SUBSTRATES TO BE PROCESSED

TECHNICAL FIELD

[0001] Embodiments of the present invention relate to a carrier system for carrying substrates during processing. Embodiments of the present invention particularly relate to a carrier system with a main carrier and a sub-carrier, specifically to a carrier system with a main carrier and a sub-carrier for carrying substrates to be processed in a vacuum process.

BACKGROUND

[0002] Several methods are known for depositing a material on a substrate. For instance, substrates may be coated by a physical vapor deposition (PVD) process, a chemical vapor deposition (CVD) process, a plasma enhanced chemical vapor deposition (PECVD) process, etc. Typically, the process is performed in a process apparatus or process chamber, where the substrate to be coated is located. A deposition material is provided in the apparatus. A plurality of materials, but also oxides, nitrides or carbides thereof may be used for deposition on a substrate.

[0003] Coated materials may be used in several applications and in several technical fields. For instance, in an application that lies in the field of microelectronics, such as generating semiconductor devices. Also, substrates for displays are often coated by a PVD process. Further applications include insulating panels, batteries, organic light emitting diode (OLED) panels, substrates with TFT, color filters or the like.

[0004] In coating processes or other deposition processes substrates are usefully supported in a carrier. For instance, substrates can be loaded in the carrier and the carrier is transported through the substrate processing apparatus or deposition apparatus for depositing a layer or a stack of layers on the substrate. Carriers can be used for one or a plurality of substrates during deposition.

[0005] There are also substrate processing applications where the substrate or the substrates are separated into smaller pieces (small substrates) corresponding to the size of the device to be manufactured and the small substrates corresponding to the device size need to be processed. For example, a layer or a stack of layers can be deposited on substrates with a size of 1 m^2 or below. The deposition on the substrates having the size of the device is beneficially still conducted on a large area scale, i.e., within a processing area corresponding to a large area substrate, e.g., 1.2 m^2 or above. In some systems, a plurality of substrates can be supported by a carrier, or a sub-carrier may be provided carrying the substrates to be processed and being coupled to a main carrier.

[0006] In view of the above, it is an object of embodiments to provide a sub-carrier, a main carrier, and a carrier system for carrying one or more substrates to be processed that overcome at least some of the problems in the art.

SUMMARY

[0007] In light of the above, a sub-carrier for substrates to be processed, a main carrier for a vacuum processing apparatus, a carrier system, and a method for transferring heat according to the independent claims are provided. Further aspects, advantages, and features are apparent from the dependent claims, the description, and the accompanying drawings.

[0008] According to one embodiment, sub-carrier for a substrate to be processed in a vacuum chamber is provided. The sub-carrier includes a substrate supporting portion having a substrate supporting portion surface, wherein the substrate supporting portion is configured for supporting one or more substrates to be processed. The substrate supporting portion includes one or more openings. The sub-carrier further includes a substrate coupling means configured to hold the at least one substrate onto the substrate supporting portion surface in a position where the substrate at least partially overlaps with the one or more openings. Further, the sub-carrier is configured for being coupled to a main carrier.

[0009] According to another embodiment, a main carrier for a vacuum processing apparatus is provided. The main carrier includes a main carrier frame and a sub-carrier supporting portion being surrounded by the main carrier frame. The sub-carrier supporting

portion has the shape of a grid with crossing grid bars configured to support one or more sub-carriers for substrates to be processed.

[0010] According to a further embodiment, a carrier system for a substrate to be processed is provided. The carrier system includes a main carrier including a sub-carrier coupling means for coupling one or more sub-carriers to the main carrier. The main carrier includes a sub-carrier supporting portion having the shape of a grid with crossing grid bars, wherein the sub-carrier coupling means are provided at the grid bars. The carrier system further includes a sub-carrier for supporting at least one substrate to be processed, wherein the sub-carrier includes one or more openings. The sub-carrier further includes a substrate coupling means for coupling the at least one substrate, wherein the substrate coupling means is configured to hold the substrate in a position overlapping partially with the openings of the sub-carrier.

[0011] According to a further embodiment, a method for transferring heat in a carrier system is provided. The method includes providing a main carrier including a main carrier frame and a sub-carrier supporting portion being surrounded by the main carrier frame and having the shape of a grid with crossing grid bars configured to support at least one sub-carrier for substrates to be processed. The main carrier further includes sub-carrier coupling means for coupling a sub-carrier to one of the grid bars. The method further includes using the sub-carrier coupling means for connecting a sub-carrier to the main carrier at positions where the sub-carrier faces grid openings between the grid bars of the main carrier.

[0012] Embodiments are also directed at apparatuses for carrying out the disclosed methods and include apparatus parts for performing each described method step. These method steps may be performed by way of hardware components, a computer programmed by appropriate software, by any combination of the two or in any other manner. Furthermore, embodiments may also be directed at methods by which the described apparatus operates. It includes method steps for carrying out every function of the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] So that the manner in which the above recited features of the embodiments can be understood in detail, a more particular description, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments and are described in the following:

Fig. 1	shows a schematic drawing of a main carrier according to embodiments described herein;
Figs. 2a – 2e	show schematic drawings of details of a main carrier according to embodiments described herein;
Fig. 3	shows a schematic drawing of a main carrier with sub-carrier supporting means according to embodiments described herein;
Figs. 4a and 4b	show a schematic drawing of a front side and a back side of a sub-carrier according to embodiments described herein;
Fig. 5	shows a schematic drawing of a sub-carrier according to embodiments described herein;
Figs. 6a to 6c	show schematic drawings of shapes of breakthroughs in a sub-carrier according to embodiments described herein;
Figs. 7a and 7b	shows schematic drawings of substrate supporting means of a sub-carrier according to embodiments described herein;
Fig. 8	shows a schematic drawing of a sub-carrier with a mask according to embodiments described herein;
Figs. 9a and 9b	show a schematic drawing of a carrier system according to embodiments described herein; and

Fig. 10 shows a flow chart of a method for transferring heat in a carrier system according to embodiments describes herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0014] Reference will now be made in detail to the various embodiments, one or more examples of which are illustrated in the figures. Within the following description of the drawings, the same reference numbers refer to same components. Generally, only the differences with respect to individual embodiments are described. Each example is provided by way of explanation and is not meant as a limitation. Further, features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet a further embodiment. It is intended that the description includes such modifications and variations.

[0015] Furthermore, in the following description, a main carrier may be understood as a carrier, which is able to support one or more sub-carriers. According to some embodiments, the main carrier may provide respective coupling means for coupling one or more sub-carriers to the main carrier. In one example, the main carrier is not configured for coupling one or more substrates to the main carrier. A sub-carrier as referred to herein may be understood as a carrier for substrates, which can be coupled to a main carrier, e.g. for being provided in a process chamber. Coupling a sub-carrier to a main carrier may mean that the sub-carrier can move with the main carrier through a process chamber or a process apparatus. According to some embodiments, the sub-carrier may provide respective coupling means for being coupled to the main carrier. In some embodiments, the main carrier is adapted for being moved through a process chamber or a process apparatus, such as by including movement devices allowing the main carrier to be transported through a process chamber, such as guiding rails, connection devices for connecting the main carrier to a transport system in the process chamber, a sliding surface, rolls, and the like. Typically, the sub-carrier includes coupling means for coupling substrates to the sub-carrier.

[0016] Coupling means as referred to herein may be understood as means to support, carry, attach, or fix. In particular, coupling means may be adapted for coupling, attaching or fixing one piece to another piece, such as a substrate to a sub-carrier, or a sub-carrier to a main carrier. In one example, the coupling means may be adapted to grip or hold a substrate or a sub-carrier in a defined position, e.g. during a deposition process. The coupling means may allow for carrying the weight of the coupled piece, such as a substrate or a sub-carrier.

[0017] Furthermore, a grid may be understood as a pattern having crossing bars and openings between the crossing bars. For instance, a grid may have more than one grid opening being surrounded by the grid bars. In some embodiments, the grid opening may have a substantially rectangular shape. Typically, the grid may provide an angle of about 90° between the crossing grid bars. According to some embodiments, the angle between the crossing grid bars may be below 90°, such as 80°, 70°, or less than 70°. Typically, the grid bars encompassing an angle of below 90° may include other grid bars crossing at an angle above 90°, such as 100°, 110°, or even above 110°. In other embodiments, the grid openings have a shape deviating from the rectangular shape, such as a round shape, a triangular shape, a polygonal shape, an asymmetric shape and the like.

[0018] As mentioned above, substrates may be transported through or in a processing system for performing a process, such as a deposition process. For several processes, the process chamber, or other components for the process to be performed, may experience heat input, e.g. by heating the process chamber, or by using materials with an elevated temperature compared to the temperature outside of the process chamber. The substrates to be processed may also be subjected to an elevated temperature, e.g. by the temperature in the process chamber, or by a deposition material being deposited on the substrate and having an elevated temperature. When a substrate is subjected to an elevated temperature, the characteristics of the substrate may change, such as the surface adhesiveness. Further, if a material having a low melting point is deposited on a substrate with a temperature near to the melting point, the material to be deposited may not stick to the substrate in a satisfactory way, e.g. the viscosity of the material to be deposited becomes too low on the substrate with elevated temperature. Embodiments described herein refer to a carrier

system which allows for keeping the substrate temperature within a certain range during processing.

[0019] According to embodiments described herein, a main carrier for a vacuum processing apparatus is provided. The main carrier includes a main carrier frame and a sub-carrier supporting portion being surrounded by the main carrier frame. Typically, the sub-carrier supporting portion substantially has the shape of a grid with crossing grid bars configured to support one or more sub-carriers for substrates to be processed.

[0020] Fig. 1 shows a main carrier 100 according to embodiments described herein. The main carrier 100 includes a main carrier frame 110 and a sub-carrier supporting portion 120 being surrounded by the main carrier frame 110. According to some embodiments described herein, the sub-carrier supporting portion 110 substantially has the shape of a grid. As can be seen in Fig. 1, the sub-carrier supporting portion 120 may include grid bars 121 and grid openings 122. In some embodiments, the grid bars 121 surround the grid openings. According to embodiments described herein, the grid includes crossing grid bars, as explained in detail above. The grid bars are shown as encompassing substantially rectangular grid openings. The skilled person will understand that embodiments described herein are not limited to a rectangular grid opening shape. The grid openings of the main carrier supporting portion of the main carrier may have any suitable shape, such as a round shape, a triangular shape, a polygonal shape, an asymmetric shape and the like. The crossing grid bars may be adapted to the shape of the grid opening. In one embodiment, the sub-carrier supporting portion of the main carrier may be formed from a plate having openings.

[0021] According to some embodiments, the grid of the sub-carrier supporting portion includes more than one opening. The embodiment of Fig. 1 shows 12 grid openings and the respective surrounding grid bars. The skilled person will understand that embodiments described herein are not limited to a main carrier having 12 openings. The main carrier according to embodiments described herein may have less than 12 openings, such as 10, 8, 6, or 2 openings. According to other embodiments, the main carrier supporting portion may include more than 12 grid openings, such as 16, 24, or even more than 24 grid openings, such as 50, 60, or 80 grid openings.

[0022] According to some embodiments, the grid bars of the sub-carrier supporting portion may be configured to support one or more sub-carriers for substrates to be processed in a vacuum processing apparatus. For instance, the grid bars may have a respective dimension for being able to hold one or more of the sub-carriers together with the substrates (e.g. by being stable enough for holding the weight of the sub-carrier together with the substrate). For instance, the grid bars may have a dimension of holding a sub-carrier having a weight of typically between 100 g and 1 kg, more typically between 200 g and 1 kg, and even more typically between 200 g and 600 g. In one embodiment, the weight of one sub-carrier may be 300 g. According to some embodiments, one grid bar may be adapted for carrying the weight of several sub-carriers, such as typically 2 to 20 sub-carriers, more typically 4 to 16 sub-carriers, and even more typically 6 to 14 sub-carriers. In one example, one grid bar is dimensioned to carry the weight of eight sub-carriers. The skilled person will understand that the grid bar is not only dimensioned to carry the weight of the sub-carrier(s), but also the weight of the substrates being coupled to the sub-carrier. In one example, the substrates may have a weight in a range of several grams, such as typically below 20 g, more typically below 10 g, and even more typically below 5 g.

[0023] In one example, the grid bars may be made form a material, which is suitable for carrying the sub-carriers and the substrates during a process in a vacuum processing chamber. For instance, the grid bars may be made from a material withstanding process conditions, such as changing temperature conditions, heat input, pressure variations, the presence of etching materials and the like. For instance, the material may be chosen taking into account parameters relevant for vacuum processes, such as outgassing rates, wear, temperature resistance, and the like. According to some embodiments, the main carrier (and/or the sub-carrier) may include aluminum, stainless steel, a ceramic, titan, and the like.

[0024] According to some embodiments described herein, the main carrier may have a length of typically between 0.5 m and 2.0 m, more typically between 1.0 m and 2.0 m, and even more typically between 1.2 m and 2.0 m. In one example, the length of the main carrier may be 1.6 m. According to some embodiments described herein, the main carrier may have a width of typically between 0.3 m and 2.0 m, more typically between 0.5 m and

1.8 m, and even more typically between 1.0 m and 1.5 m. In one example, the length of the main carrier may be 1.25 m.

[0025] In some embodiments, the main carrier provides a sub-carrier coupling means for coupling a sub-carrier to the main carrier. In particular, the grid bars of the grid of the sub-carrier supporting portion may be adapted for including, or for having attached to, sub-carrier coupling means. Typically, the sub-carrier coupling means may be attached to the main carrier, such as being welded to the main carrier, being attached to the main carrier by an adhesive, being clamped to the main carrier, being part of the main carrier, and the like. Figs. 2a to 2e show different embodiments of the section A of Fig. 1. In particular, Figs. 2a to 2e show different embodiments of sub-carrier coupling means, which may help the grid bars to hold the sub-carriers during processing.

[0026] Fig. 2a shows an example of a sub-carrier coupling means 201 being provided at a main carrier 100. The sub-carrier coupling means 201 means are provided as a kind of hook, at which a sub-carrier may be attached, e.g. by a respective coupling means (such as an opening or a recess). According to some embodiments, the hooks 201 may be adapted for holding a sub-carrier, e.g. by being adapted for holding the weight of the sub-carrier and for allowing the size of the sub-carrier being held by the hooks. The embodiment shown in Fig. 2a shows two hooks 201. The skilled person will understand that the number of hooks used as a sub-carrier coupling means is not limited to the shown embodiment of Fig. 2a. For instance, the number of sub-carrier coupling means for one sub-carrier may be one, or greater than two, such as 3, 4, 5, or more than 5 sub-carrier coupling means. In one embodiment, the number of the sub-carrier coupling means is dependent on the dimension and the weight of the sub-carrier to be coupled to the main carrier.

[0027] Fig. 2b shows an embodiment of sub-carrier coupling means 202 including a clamp for clamping the sub-carrier to the main carrier 100. In one embodiment, the clamp 202 may include a clamp force device, such as a spring or the like, for exerting a clamp force on the sub-carrier. The clamp force device may be configured for exerting a clamping force high enough for holding the sub-carrier, at least during processing. The clamp 202 may include a clamping surface, which is adapted for being in contact with the sub-carrier during processing. For instance, the clamping surface may include a material

having a suitable coefficient of friction, which allows holding the sub-carrier at the clamping surface.

[0028] Fig. 2c shows an embodiment of a main carrier 100 with sub-carrier coupling means 203. The sub-carrier coupling means 203 shown in the embodiment of Fig. 2c includes two bars or sticks, which allow for coupling a respectively shaped sub-carrier to be attached to the main carrier. For instance, the sub-carrier may include coupling openings, in which the bars 203 may engage for holding the sub-carrier. According to some embodiments, the bars may have a structured or patterned surface for improving the contact between the bars and the sub-carrier.

[0029] Fig. 2d shows an embodiment of a main carrier 100 with sub-carrier coupling means 204. The sub-carrier coupling means 204 shown in the embodiment of Fig. 2d includes two openings for coupling a sub-carrier to the main carrier 100. The openings 204 may be adapted for receiving a respective part of the sub-carrier, such as a bar or a stick fitting in the opening 204. According to some embodiments, the openings 204 may include a substantially straight hole, a bent hole, a structured or patterned hole and the like, e.g. for improving the coupling between the sub-carrier and the main carrier.

[0030] Fig. 2e shows an embodiment of a main carrier 100 with sub-carrier coupling means being provided within the grid opening 122 of the main carrier. The sub-carrier coupling means shown in the embodiment of Fig. 2d includes two flaps 205, which may be used to couple a sub-carrier to the main carrier 100. In some embodiments, the flaps 205 may be adapted for clamping, attaching, or fixing a sub-carrier between the flaps, e.g. for providing the sub-carrier in the grid opening 122. In one embodiment, the flaps 205 may include clamping surfaces for clamping the sub-carrier between the flaps 205.

[0031] According to some embodiments, features described with respect to Fig. 2a, such as referring to the size, the dimensioning, and the number of the sub-carrier coupling means, may also be applied to the embodiment shown in Figs. 2b to 2e. In some embodiments, the features exemplarily described with respect to Figs, 2a to 2d may be combined as long as the features do not contradict each other. For instance, the clamping device may additionally have openings for defining the position of the sub-carrier. In

another example, the number of two sub-carrier coupling means may be chosen for the embodiment of Fig. 2b shown with only one sub-carrier coupling means.

[0032] According to embodiments described herein, one coupling means may be adapted for supporting one sub-carrier. In other embodiments, more than one sub-carrier coupling means may be used for coupling one sub-carrier, such as the sub-carrier coupling means 201, 203, 204, and 205 shown in Figs. 2a, 2c, 2d, and 2e.

[0033] In some embodiments, one grid opening 122 is provided for one sub-carrier to be supported by the main carrier. In one example, one sub-carrier is placed to be in front of one opening of the main carrier. According to some embodiments, the one sub-carrier may also be described as facing or overlapping one opening of the main carrier. For instance, in Fig. 2a, the two sub-carrier coupling means 201 are adapted and/or placed for carrying one sub-carrier being placed in front of, or facing, the grid opening 122. In other embodiments, one sub-carrier may be placed in front of more than one grid opening, such as in front of, or facing, two or three openings of the main carrier. According to other embodiments, the main carrier having grid openings may be adaptable for different sub-carrier sizes and types so that one sub-carrier of a first type may be placed in front of one grid opening, and one sub-carrier of a second type may be placed in front of more than one grid opening. In one example, the sub-carrier coupling means may also be adaptable to different sizes and types of sub-carriers.

[0034] As can be seen in the embodiments of Figs. 2a to 2e, the sub-carrier coupling means are provided at the grid bars of the grid of the main carrier, which typically surround the grid openings 122. According to some embodiments, the grid bars may be provided between the grid openings and may surround the grid openings. According to embodiments described herein, the grid bars are adapted for providing the sub-carrier coupling means. In some embodiments, the outermost grid bar of the sub-carrier supporting portion is adjacent to the main carrier frame, as can exemplarily be seen in Fig. 3.

[0035] Fig. 3 shows a main carrier 100 including a main carrier frame 110 and a sub-carrier supporting portion 120 with the grid bars 121 and the grid openings 122. According to some embodiments, the grid bars of the outermost openings 122, such as the grid bars

surrounding the grid openings of the first row 123 of openings, are adjacent to the main carrier frame 110. Typically, the grid bars provide sub-carrier coupling means, and the main carrier frame does not provide sub-carrier coupling means. According to some embodiments, the frame 110 of the main carrier may be adapted for transporting the main carrier thorough a processing apparatus, such as adapted for ensuring a proper transport of the main carrier. In one example, the frame of the main carrier may include transport enabling devices. For instance, the frame 110 of the main carrier may include portions for engaging in guiding rails, guiding rails or tracks, connected rolls, areas, at which a transport mechanism may grab the main carrier, and the like.

[0036] In one example, the grid bar may be a part of the main carrier surrounding the grid opening and having a width of about 1 cm to about 20 cm, more typically about 2 cm to about 15 cm, and even more typically about 3 cm to about 10 cm. Fig. 3 further shows sub-carrier coupling means 205, as exemplarily described in Fig. 2e for coupling the sub-carrier to the main carrier. According to some embodiments, the sub-carrier supporting portion may be recessed compared to the carrier frame, or may include recesses for the sub-carriers, e.g. one recess for one sub-carrier, in which the sub-carrier fits.

[0037] According to embodiments described herein, a sub-carrier for substrates to be processed in a vacuum chamber is provided. The sub-carrier includes a substrate supporting portion having a substrate supporting portion surface. Further, the substrate supporting portion is configured for supporting one or more substrates to be processed. The substrate supporting portion according to embodiments described herein includes one or more openings. The sub-carrier further includes a substrate coupling means configured to hold a substrate onto the substrate supporting portion surface in a position where the substrate at least partially overlaps with the one or more openings. The sub-carrier is further configured for being coupled to a main carrier.

[0038] Fig. 4a and Fig. 4b show an embodiment of a sub-carrier according to embodiments described herein. Fig. 4a shows a front side of the sub-carrier 400. Fig. 4b shows a back side of the sub-carrier 400. According to some embodiments described herein, the sub-carrier includes a substrate supporting portion 420 and openings 422 in the substrate supporting portion 420. Typically, the substrate supporting portion 420 may at least partially be in contact with the substrate, when the substrate is mounted to the sub-

carrier. The substrate supporting portion 420 typically includes a substrate supporting portion surface 421. The substrate supporting portion surface may be understood as being a surface onto which the substrates may be provided for being carried by the sub-carrier. According to some embodiments, the substrate supporting portion surface is a surface facing the process which the substrate is to be subjected to. For instance, the substrate supporting portion surface may face a deposition process when the substrates to be carried by the sub-carrier are to be subjected to a deposition process. According to some embodiments, the substrate supporting portion may be recessed, or may include recesses for the substrates, e.g. one recess for one substrate, in which the substrate fits.

[0039] According to some embodiments, which will be discussed in detail below, the sub-carrier 400 includes substrate coupling means, which are positioned so that the substrates are in a position on the substrate supporting portion surface of the sub-carrier where the substrate at least partially overlaps with the one or more openings.

[0040] A substrate "overlapping with an opening" may be understood as the substrate facing the opening, or as the substrate being in front of the opening. According to some embodiments, a substrate overlapping with an opening may be described as covering the opening. In particular, a substrate only partially overlapping with an opening may mean that only a part of the substrate overlaps the opening. Nevertheless, in some embodiments, the opening may totally be covered with the substrate only partially overlapping with the opening. Another part of the substrate may overlap with the substrate supporting portion surface of the sub-carrier. The substrate coupling means of the sub-carrier are placed and adapted for ensuring a proper positioning of the substrates according to embodiments described herein. The above description of the term "overlapping" may also be applied to other components being described as overlapping with each other, such as a sub-carrier and an opening of the main carrier.

[0041] In some embodiments, the sub-carrier or the substrate supporting portion may be adapted for supporting a substrate, which partially overlaps with the sub-carrier or the substrate supporting portion of the sub-carrier. For instance, the sub-carrier or the substrate supporting portion may be configured such that a boundary portion of the substrate overlaps with the sub-carrier or the substrate supporting portion. In one example, the boundary portion of the substrate may have a width of typically between 0.5 mm and 10

mm, more typically between 1 mm and 8 mm, and even more typically between 1 mm and 5 mm. According to some embodiments, the substrate supporting portion surface may be treated for overlapping with the substrate, e.g. for being in contact with the substrate. In one example, the substrate supporting portion surface (or parts of the substrate supporting portion surface) may be treated with a surface treatment for having a defined roughness, a defined hardness, a defined evenness and the like.

[0042] According to some embodiments, the sub-carrier as described herein may be configured for being supported, attached or fixed to a main carrier, such as a main carrier as described above. Fig. 4b shows a backside view of the sub-carrier 400 shown in Fig. 4a. In one embodiment, the backside of the sub-carrier may also be denoted as the side facing the main carrier, when the sub-carrier is held by the main carrier. Fig. 4b shows a main carrier coupling means for allowing the sub-carrier to be carried by the main carrier. In the embodiment shown in Fig. 4b, the main carrier coupling means 401 includes a recess or an opening, which may be suitable for receiving sub-carrier coupling means of the main carrier. For instance, the sub-carrier coupling means 201 and 203 being designed as hooks or bars may engage into the openings 401.

[0043] Fig. 5 shows an embodiment of a back side of a sub-carrier 400. The sub-carrier 400 may be configured for being coupled to a main carrier and may include main carrier coupling means. The main carrier coupling means shown in Fig. 5 may be provided in the form of recesses 405, in which a sub-carrier coupling means (e.g. sub-carrier coupling means being provided as flaps 205) may engage for coupling the sub-carrier to the main carrier.

[0044] According to some embodiments, the sub-carrier may include main carrier coupling means for allowing coupling or attaching the sub-carrier to the main carriers as exemplarily described in Figs. 2a to 2e. However, the main carrier coupling means as well as the sub-carrier coupling means are not limited to the shown embodiments.

[0045] According to embodiments described herein, the openings of the sub-carrier may be designed depending on the substrates to be processed in the vacuum process. For instance, the number of the openings may depend on the substrates to be processed. In one embodiment, the sub-carrier is configured so that one opening is provided for one

substrate. As mentioned above, respective substrate coupling means may be provided for ensuring a proper alignment of the openings and the substrates. In some embodiments, more than one opening is provided for facing one substrate. For instance, two openings 423, 424 (see Fig. 5 as an example) may be provided for being covered by one substrate, when a substrate is coupled to the sub-carrier. The skilled person will understand that more than two openings may be provided for being covered with one substrate in some embodiments (e.g. four openings being provided for being covered with one substrate). According to some embodiments, the sub-carrier may be adaptable, e.g. by adapting the substrate coupling means, to substrates of different sizes. For instance, with one substrate of a first type, one opening of the sub-carrier may be covered. One substrate of a second type may overlap with two or more openings of the sub-carrier.

[0046] In some embodiments, the location of the opening of the sub-carrier may depend on the substrate type to be processed. For instance, the distance of the openings of the sub-carrier may be chosen depending on the number and the size of substrates to be processed. Further, the size of the openings may depend on the substrate type to be processed. According to some embodiments, the one opening has a size being between typically 30% and 95% of the size of the substrate, more typically between 40% and 90% of the size of the substrate, and even more typically between 50% and 80% of the size of the substrate to be supported by the sub-carrier. In some embodiments, the sub-carrier may further include a recess (e.g. on the substrate supporting portion surface) for defining a position for the substrate. In embodiments, where more than one opening is adapted to face one substrate, the more than one opening for the one substrate have together a size being between typically 30% and 95% of the size of the substrate, more typically between 40% and 90% of the size of the substrate, and even more typically between 50% and 90% of the size of the substrate to be supported by the sub-carrier. For instance, two openings of the sub-carrier may together have a size being about 85% of the size of the substrate.

[0047] The size of the substrate may be understood as the size of the area being intended to be subjected to a process. For instance, the area, which is subjected to a deposition process, may be regarded as the size of the substrate. According to some embodiments, the size of the opening may be described as being the area of the opening at the front side of the sub-carrier, which may be the side facing the process. For instance, the size of an

opening may be described as lying in a plane with the substrate, or in a plane substantially parallel to the substrate in a mounted condition. In one embodiment, the size of the substrate may be measured in the vertical direction, if a vertical process is performed, or in the horizontal direction, if a horizontal process is performed.

[0048] According to some embodiments, the shape of the openings may depend on the substrates to be processed. Figs. 6a to 6c show different shapes of the openings 122 of the sub-carrier. Fig. 6a shows a rectangular shape of the opening of the sub-carrier, Fig. 6b shows a round shape of the openings (e.g. a circle-like shape), and Fig. 6c shows a regular polygonal shape of the openings. The skilled person will understand that the openings of the sub-carrier may have any suitable shape for conducting the heat away from the substrate, such as by heat radiation. Further, the shape of the opening may depend on the shape of the substrate to be processed. According to some embodiments, which may be combined with other embodiments described herein, the one or more openings of the substrate supporting portion may have a larger diameter at the side adapted for facing the substrate than at the side adapted for facing the main carrier.

[0049] Generally, the openings may allow for a better heat radiation of the substrate, in particular in a vacuum environment. The substrate being subjected to increased temperature during processing may at least partially emit the absorbed heat due to the openings in the carrier. According to some embodiments, the substrate may be cooled by the openings in the sub-carrier and/or the main carrier. For instance, if the temperature of the substrate becomes too high, the process to be performed on the substrate may lose quality. In one example, a material deposition process is to be performed on the substrate. If the substrate has a temperature, which is close to, or even above the melting point of the material to be deposited, the material layer being deposited on the material may melt again and only an insufficient amount of the material sticks to the substrate.

[0050] In some embodiments, the openings of the sub-carrier may be configured and located so that the openings of the sub-carrier coincide with the openings of the main carrier. With coinciding openings of the main carrier and the sub-carrier, the heat radiation from the substrate may be improved. For example, the substrate may be coupled to the sub-carrier at a position, where the substrate overlaps with the opening of the sub-carrier. Further, according to the example, the sub-carrier may be coupled to the main carrier so

that the sub-carrier (and with the sub-carrier the substrates during operation) faces and/or overlaps with the openings of the main carrier. The substrate being coupled to the sub-carrier and the sub-carrier being coupled to the main carrier in the described manner allow for an improved heat radiation from the substrate.

[0051] Fig. 7a and 7b show embodiments of a substrate coupling means being provided on a sub-carrier according to embodiments described herein. In particular, Figs. 7a and 7b show an enlarged view of embodiments of the section B as indicated in Fig. 4a. Typically, the substrate coupling means may be provided on the sub-carrier on the substrate supporting portion surface. In some embodiments, the substrate coupling means may be provided on the sub-carrier by attaching, fixing, welding, gluing, or by being a structural part of the sub-carrier.

[0052] Fig. 7a shows a substrate coupling means 430 being provided by two clamps. The clamps may provide a clamping surface, which is in contact with the substrate, when the substrate is clamped by the clamps. According to some embodiments, one clamp may be provided for one substrate. According to other embodiments, more than one clamp may be provided for one substrate, e.g. in the case that the substrate overlaps with more than one opening in the sub-carrier.

[0053] Fig. 7b shows an embodiment of a substrate coupling means 431 being provided by two rails or guiding tracks. According to some embodiments, the substrate may be supported by a first rail at a first side (such as the bottom side) and may be held in position or clamped by a second rail at a second side of the substrate (such as the top side). When using rails or tracks for coupling the substrate to the sub-carrier, a large part of the substrate may be subjected to the process without a substantial loss of material at the edge part of the substrate.

[0054] Fig. 8 shows an embodiment of a sub-carrier 400 having an opening 422 and a mask 411 for masking a part of the substrate, when the substrate is coupled to the sub-carrier. According to some embodiments, the mask 411 may be an edge-exclusion mask.

[0055] According to some embodiments, which may be combined with other embodiments described herein, the substrate may be attached to the sub-carrier at a

substrate supporting portion surface, which does not face the process in the processing apparatus, e.g. the backside of the sub-carrier. In some embodiments, the opening of the sub-carrier may act as a mask for the substrate, such as an edge exclusion mask.

[0056] In some embodiments described herein, the substrate is described as being coupled onto the substrate supporting portion, in particular the substrate supporting portion surface. According to some embodiments, a substrate being coupled onto a surface may mean that the substrate is coupled to the substrate supporting portion surface by a substrate coupling means being provided on the substrate supporting portion surface. According to alternative or additional embodiments, the substrate being coupled onto a surface may mean that the substrate has, at least partially, contact with the substrate supporting portion surface. For instance, the part of the substrate, which does not overlap with the opening, may be in contact with the substrate supporting portion surface. In another example, the substrate is in contact with the substrate supporting portion surface at defined points or regions of the substrate, e.g. being in contact with the substrate supporting portion surface at 2 to 5 points of the substrate.

[0057] In some embodiments, the sub-carrier may have a thickness extending substantially perpendicular to a surface of the sub-carrier facing the substrate (such as the substrate supporting portion surface) in a mounted condition. Typically, the thickness of the sub-carrier may range from typically 0.1 mm to 2 cm, more typically from 0.2 mm to 1.5 cm, and even more typically from 0.3 mm to 1 cm. According to embodiments described herein, the thickness of the sub-carrier may be chosen dependent on the stability of the sub-carrier, which may, in one example, depend on the material of the sub-carrier. According to some embodiments described herein, the sub-carrier may have a length of typically between 10 cm and 1 m, more typically between 15 cm and 50 cm, and even more typically between 15 cm and 30 cm. In one example, the length of the sub-carrier may be 20 cm. According to some embodiments described herein, the width of the sub-carrier may typically be between 5 cm and 50 cm, more typically between 5 cm and 30 cm, and even more typically between 10 cm and 20 cm. In one example, the width of the sub-carrier is 12 cm.

[0058] According to some embodiments described herein, the sub-carrier may be adapted for supporting substrates having a length between 10 cm and 50 cm, more typically

between 15 cm and 40 cm, and even more typically between 15 cm and 30 cm. In some embodiments, the carrier may be adapted for substrates having a width of typically between 5 cm and 30 cm, more typically between 10 cm and 25 cm, and even more typically between 15 cm and 20 cm. In one embodiment, the sub-carrier may be adapted for substrates having a size between 10 cm x 30 cm and 15 cm x 20 cm.

[0059] In some embodiments, the sub-carrier may be adapted for supporting typically between 1 substrate to 30 substrates, more typically between 2 and 20 substrates, and even more typically between 2 and 18 substrates. According to some embodiments, the number of the openings may depend on the number of the substrates. In one example, the number of the openings corresponds to the number of the substrates to be supported, in another example the number of openings is twice as high as the number of the substrates to be supported. In some embodiments, the main carrier may be adapted for supporting between typically 5 and 50 sub-carriers, more typically between 10 and 50 sub-carriers, and even more typically between 15 and 40 sub-carriers.

[0060] According to embodiments described herein, the sub-carrier may be adapted for any kind of substrate, such as a substrate including a foil, glass, metal, an insulating material, Mica, polymers, and the like. In some examples, the sub-carrier and the main carrier may be used for PVD deposition processes, CVD deposition process, substrate structuring edging, heating (e.g. annealing) or any kind of substrate processing. Embodiments of the sub-carrier and the main carrier as described herein are particularly useful for non-stationary, i.e. continuous substrate processing of the vertically oriented substrates. The skilled person will understand that the sub-carrier and the main carrier may also be used in a non-stationary process.

[0061] In some embodiments, the sub-carrier and the main carrier may be used and may be suitable for processes having a process temperature of about 100°C to about 600 °C. According to some embodiments, the sub-carrier and the main carrier may in particular be used for processes, for which the process temperature may be above the melting temperature of included materials, such as deposition materials. In some embodiments, the sub-carrier and the main carrier may be used for processes, where the substrate runs the risk of being heated to a temperature above the melting temperature of a material to be deposited on the substrate, e.g. by the process temperature or the temperature in the

process apparatus. In one embodiment, the sub-carrier and the main carrier according to embodiments described herein may be used for the deposition of Lithium having a melting point of about 160°C. According to some embodiments, which may be combined with other embodiments described herein, the main carrier and the sub-carrier may beneficially be used in a deposition process for depositing layers having a layer thickness of typically about 1 µm to about 15 µm, more typically between about 1 µm and about 10 µm, and even more typically between about 5 µm and about 10 µm.

[0062] According to embodiments described herein, the substrate may be subjected to a deposition process, e.g. for depositing a material like a ceramic, a metal, an alkali metal (such as lithium), ITO, IZO, IGZO, AZO, SnO, AlSnO, InGaSnO, titanium, aluminum, copper, molybdenum, and combinations thereof.

[0063] Figs. 9a and 9b show a carrier system according to embodiments described herein.

[0064] A carrier system for a substrate to be processed in a vacuum process according to embodiments described herein may include a main carrier including a sub-carrier coupling means for coupling one or more sub-carriers to the main carrier. Typically, the main carrier has a sub-carrier supporting portion having the shape of a grid with crossing grid bars. According to some embodiments, the sub-carrier coupling means are provided at the grid bars. In some embodiments, which may be combined with other embodiments described herein, the main carrier may be a main carrier as described above.

[0065] The carrier system according to embodiments described herein further includes a sub-carrier for supporting one or more substrates to be processed. Typically the sub-carrier includes one or more openings. The sub-carrier further typically includes substrate coupling means for coupling the substrates. The substrate coupling means of the sub-carrier of the carrier system according to embodiments described herein is configured to hold the substrate in a position overlapping partially with the openings of the sub-carrier. According to some embodiments, the sub-carrier of the carrier system may be a sub-carrier as described in embodiments above.

[0066] Fig. 9a shows a carrier system for a substrate to be processed. The carrier system includes a main carrier 100 having openings 122 shown in dashed lines. In front of the openings, or above the openings, sub-carriers 400 are coupled to the main carrier 100. In the embodiment shown in Fig 9a, the sub-carriers 400 are larger than the openings 122 of the main carrier. The skilled person will understand that the openings 122 of the main carrier 100 may also be equally sized to the size of the sub-carrier, or may even be larger than the sub-carrier, e.g. depending on the sub-carrier coupling means used for the main carrier (examples are shown in Figs. 2a to 2e). The sub-carriers 400 have openings 422.

[0067] The number of the sub-carriers being coupled to the main carrier and the number of openings of the sub-carrier shown in Figs. 9a and 9b may be understood as a mere example and may be understood as not limiting the carrier system according to embodiments described herein.

[0068] In Fig. 9b, substrates 500 are coupled to the sub-carriers 400, which are coupled to the main carrier 100. The substrates 500 are located in a position, where the substrates 500 overlap the openings 422 of the sub-carrier. The openings 422 of the sub-carriers being overlapped by the substrates 500 are shown in dashed lines. As can be seen in the embodiment of Fig. 9b, the substrates are at a position, where the substrates overlap with the openings 422 of the sub-carriers 400 as well as with the openings 122 of the main carrier 100.

[0069] The term "substantially" as used herein may mean that there may be a certain deviation from the characteristic denoted with "substantially." For instance, the term "substantially a rectangular shape" refers to a shape which may have certain deviations from the exact rectangular shape, such as a deviation of about 1 to 10% of the general extension in one direction. According to a further example, the term "having substantially the shape of a grid" may refer to a shape having grid bars in regular distances to each other, but may allow a deviation from the regular distance of the grid bars. For instance, the "substantially grid shape" may include a deviation of about 1% to 15% of the regular distance between two grid bars.

[0070] The sub-carrier and the main carrier according to embodiments described herein allow for decreasing the temperature of the substrate during processing. In particular, the

sub-carrier and the main carrier according to embodiments described herein allow for decreasing the temperature of the substrate during processing by increasing the heat radiation from the substrate. Decreasing the temperature of the substrate may result in a better processing quality and to less rejects of the end product. Further, the main carrier and the sub-carrier according to embodiments described herein allow for keeping the substrate within a defined temperature range without increasing the costs of the processing, or without postponing the processing.

[0071] Fig. 10 shows a flow chart 600 of a method for transferring heat in a carrier system, in particular for transferring heat from a substrate, according to embodiments described herein. The method includes in block 610 providing a main carrier. The main carrier may include a main carrier frame and a sub-carrier supporting portion being surrounded by the main carrier frame. As described above with regard to the main carrier, the sub-carrier supporting portion may have the shape of a grid with crossing grid bars configured to support at least one sub-carrier for substrates to be processed. Further, the main carrier may include sub-carrier coupling means for coupling a sub-carrier to one of the grid bars. According to some embodiments, the sub-carrier coupling means may be sub-carrier coupling means as shown in Figs. 2a to 2e. The skilled person may understand that the sub-carrier coupling means are not limited to the examples shown in Figs. 2a to 2e.

[0072] The method further includes in block 620 using the sub-carrier coupling means for connecting a sub-carrier to the main carrier at positions where the sub-carrier faces grid openings between the grid bars. In some embodiments, the sub-carrier includes a substrate supporting portion providing at least one opening. According to some embodiments, the heat from the sub-carrier (or the substrates) may be transferred, when the sub-carrier is mounted to the main carrier in a way so that the sub-carrier faces the openings of the main carrier. The sub-carrier and the main carrier may together be denoted as a carrier system.

[0073] According to some embodiments, the method may further include coupling substrates to the sub-carrier, either before the sub-carrier is coupled to the main carrier of after the sub-carrier is coupled to the main carrier. In some embodiments, the sub-carrier may include substrate coupling means as for instance described with respect to Figs. 7a and 7b. The substrates may be coupled to the sub-carrier so that the substrates face one or more openings in the sub-carrier for ensuring heat transfer from the substrate. In some

embodiments, the substrates may be coupled to the carrier system at a location so that each substrate faces at least an opening in the sub-carrier as well as an opening in the main carrier. Coupling the substrate in a way so that the substrate faces the openings of the sub-carrier and the main carrier allows a heat transfer away from the substrate. For instance, the substrate may be vented through the openings in the main carrier and the sub-carrier, at least at the backside of the substrate (which may be the side of the substrate not intended to be subjected to a process in the process chamber).

[0074] In some embodiments, which may be combined with other embodiments described herein, the main carrier and sub-carrier may be carriers as described in embodiments above.

[0075] According to some embodiments, the use of a sub-carrier, a main carrier and/or a carrier system as described in embodiments herein is provided.

[0076] While the foregoing is directed to several embodiments, other and further embodiments may be devised without departing from the basic scope , and the scope is determined by the claims that follow.

CLAIMS

1. A sub-carrier (400; 800) for a substrate (500) to be processed in a vacuum chamber, the sub-carrier (400; 800) comprising:

a substrate supporting portion (420) including a substrate supporting portion surface (421), the substrate supporting portion (420) being configured for supporting at least one substrate (500) to be processed, wherein the substrate supporting portion (420) comprises at least one opening (422);

a substrate coupling means (430; 431) configured to hold the at least one substrate (500) onto the substrate supporting portion surface (421) in a position where the substrate (500) at least partially overlaps with the at least one opening (422);

wherein the sub-carrier (400; 800) is configured for being coupled to a main carrier (100).

2. The sub-carrier (400; 800) according to claim 1, wherein the one opening (422) has a size being between 40% and 90% of the size of the substrate (500), which overlaps the opening, when mounted to the sub-carrier (400; 800).

3. The sub-carrier (400; 800) according to claim 1, wherein more than one opening is adapted to face one substrate (500), when the substrate (500) is coupled to the sub-carrier (400; 800), and wherein the more than one opening for the one substrate (500) have altogether a size being between 50% and 90% of the size of the substrate (500) to be processed.

4. The sub-carrier (400; 800) according to any of claims 1 to 3, wherein the sub-carrier (400; 800) is configured for supporting between 5 and 15 substrates (500), and

wherein the number of the openings (422) is at least as high as the number of substrates (500) to be supported by the sub-carrier (400; 800).

5. The sub-carrier (400; 800) according to any of claims 1 to 4, wherein the sub-carrier (400; 800) is adapted for being coupled to the main carrier (100) according to any of claims 7 to 11.

6. A main carrier (100) for a vacuum processing apparatus, the main carrier (100) comprising:

a main carrier frame (110);

a sub-carrier supporting portion (120) being surrounded by the main carrier frame (110) and having the shape of a grid with crossing grid bars (121) configured to support at least one sub-carrier (400; 800) for substrates (500) to be processed.

7. The main carrier (100) according to claim 6, wherein the sub-carrier (400; 800) supporting portion is configured for supporting at least two rows and two columns of sub-carriers (400; 800) to the main carrier (100).

8. The main carrier (100) according to any claims 6 to 7, further comprising sub-carrier coupling means (201; 202; 203; 204; 205) for coupling the sub-carrier (400; 800) to one of the grid bars (121), wherein the sub-carrier coupling means (201; 202; 203; 204; 205) allow for coupling the sub-carrier (400; 800) to the main carrier (100) at positions where the sub-carrier (400; 800) faces grid openings between the grid bars (121), when the sub-carrier (400; 800) is mounted to the main carrier (100).

9. The main carrier (100) according to any of claims 6 to 8, wherein the main carrier (100) is adapted for a process having temperatures above 160°.

10. The main carrier (100) according to any of claims 6 to 9, wherein the sub-carrier supporting portion (120) is adapted for fixing one or more sub-carriers (400; 800) according to any of claims 1 to 5 to the main carrier (100).

11. A carrier system for a substrate (500) to be processed, comprising:

a main carrier (100) comprising a sub-carrier coupling means (201; 202; 203; 204; 205) for coupling one or more sub-carriers (400; 800) to the main carrier (100), the main carrier (100) comprising a sub-carrier supporting portion (120) having the shape of a grid with crossing grid bars (121), wherein the sub-carrier coupling means (201; 202; 203; 204; 205) are provided at the grid bars (121);

a sub-carrier (400; 800) for supporting at least one substrate (500) to be processed, wherein the sub-carrier (400; 800) comprising at least one opening (422) and wherein the sub-carrier (400; 800) comprises a substrate coupling means (430; 431) for coupling the substrates (500), wherein the substrate coupling means (430; 431) is configured to hold the substrate (500) in a position overlapping partially with the openings (422) of the sub-carrier (400; 800).

12. The carrier system according to claim 11, wherein the main carrier (100) is a main carrier (100) according to any of claims 6 to 10, and wherein the sub-carrier (400; 800) is a sub-carrier (400; 800) according to any of claims 1 to 5.

13. The carrier system according to any of claims 11 to 12, wherein the one or more openings (422) of the sub-carrier (400; 800) have a size being between 40% and 90% of the size of the substrate (500) to be supported by the sub-carrier (400; 800), and

wherein the sub-carrier (400; 800) coupling means of the main carrier (100) are adapted to couple the sub-carrier (400; 800) to the main carrier (100) at a position, where the substrate (500) to be coupled to the sub-carrier (400; 800) faces the openings of the main carrier (100), when the substrate (500) is mounted to the sub-carrier (400; 800) and the sub-carrier (400; 800) is mounted to the main carrier (100).

14. The carrier system according to any of claims 11 to 13, wherein the main-carrier is configured for supporting between 5 and 50 sub-carrier (400; 800), wherein each sub-carrier (400; 800) is configured for supporting 2 to 20 substrates (500), and wherein the sub-carrier (400; 800) is in particular configured for supporting substrates (500) having a dimension of between 10 cm x 30 cm and 15 cm x 20 cm.

15. Method for transferring heat in a carrier system, the method comprising:

providing a main carrier comprising a main carrier frame (110) and a sub-carrier supporting portion (120) being surrounded by the main carrier frame (110) and having the shape of a grid with crossing grid bars (121) configured to support at least one sub-carrier (400; 800) for substrates (500) to be processed, the main carrier further comprising sub-carrier coupling means (201; 202; 203; 204; 205) for coupling a sub-carrier (400; 800) to one of the grid bars (121); and

using the sub-carrier coupling means for connecting a sub-carrier to the main carrier at positions where the sub-carrier (400; 800) faces grid openings between the grid bars (121).

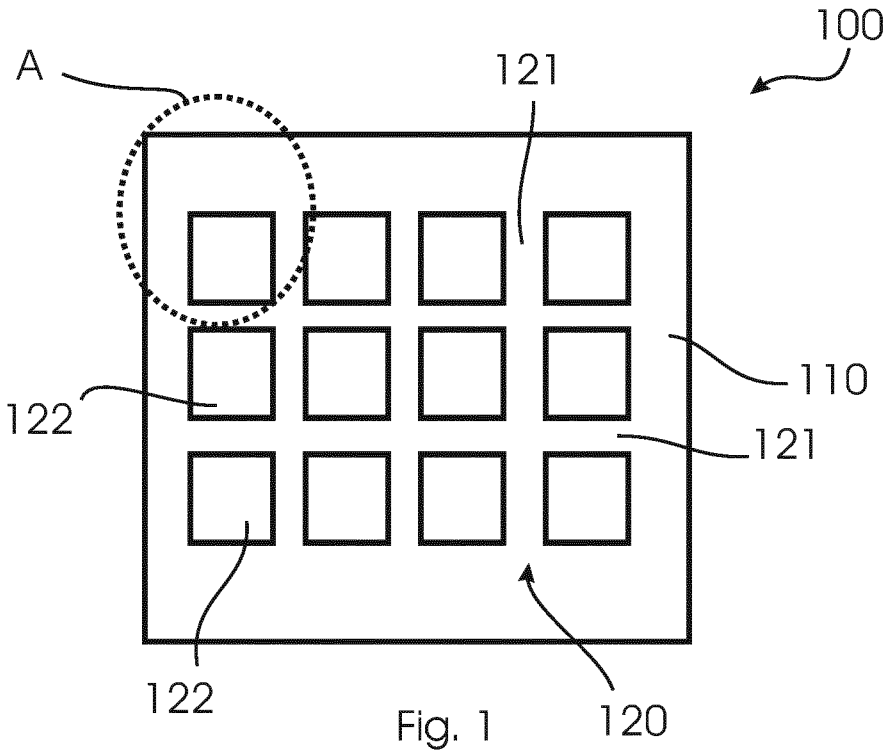


Fig. 1

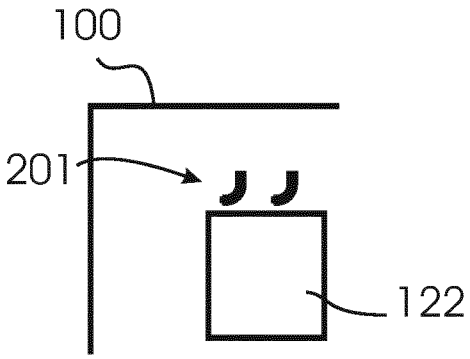


Fig. 2a

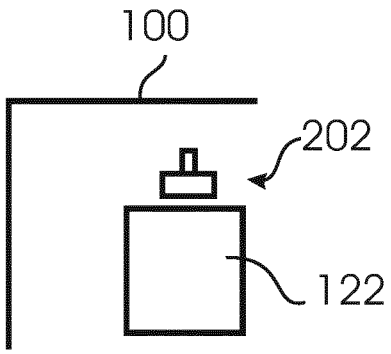


Fig. 2b

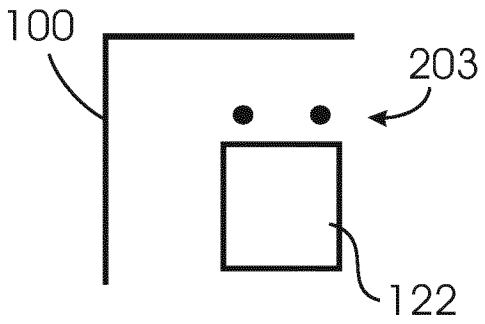


Fig. 2c

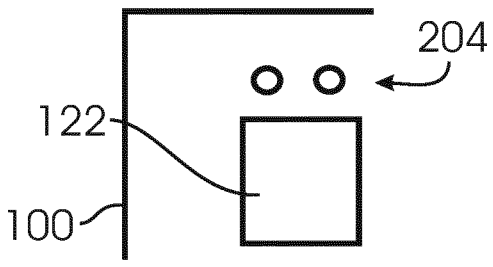


Fig. 2d

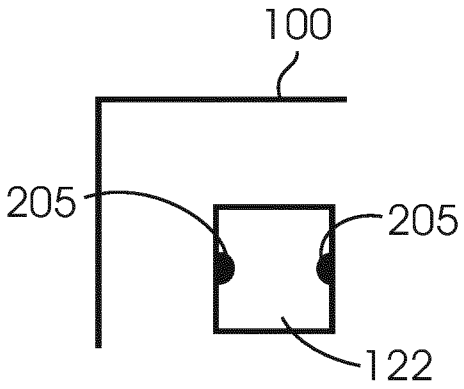


Fig. 2e

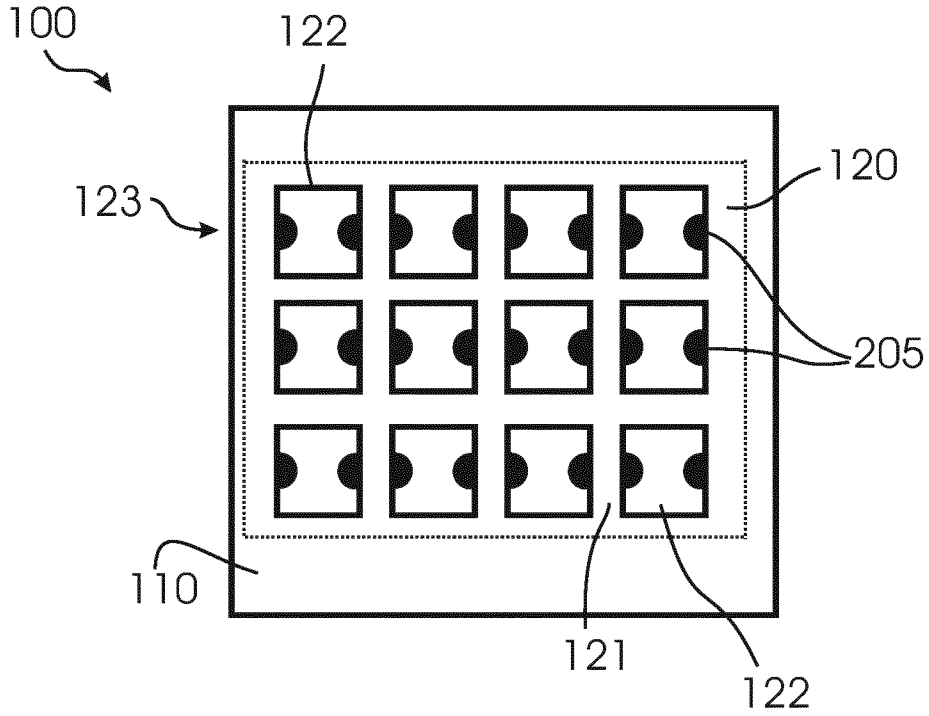


Fig. 3

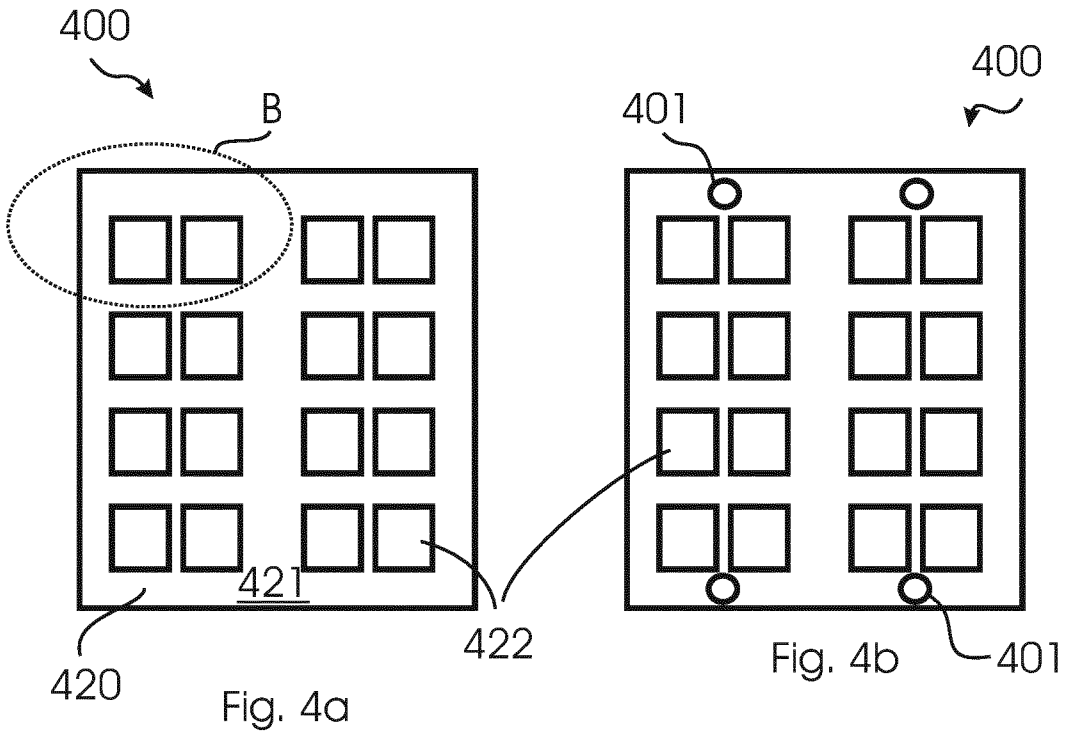


Fig. 4a

Fig. 4b

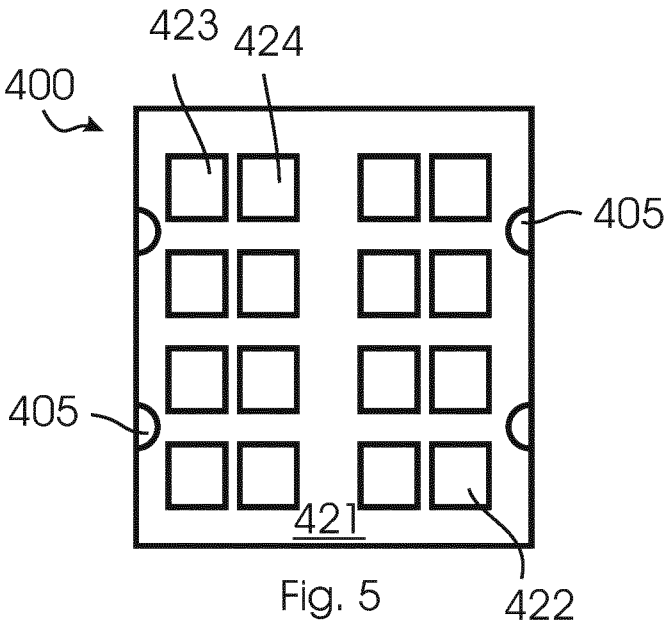


Fig. 5

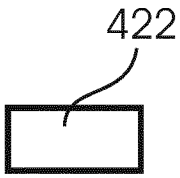


Fig. 6a

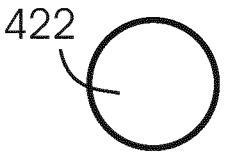


Fig. 6b

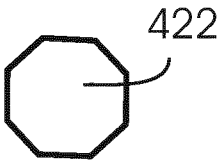


Fig. 6c

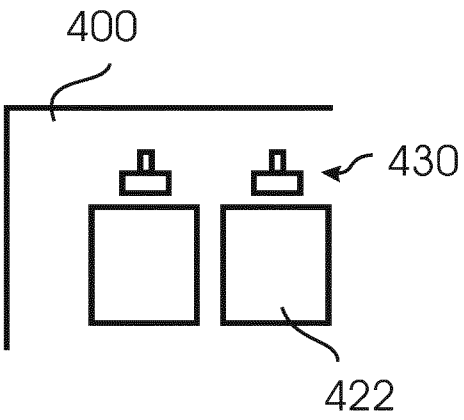


Fig. 7a

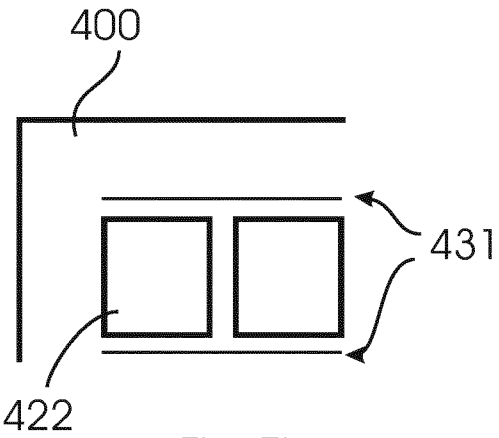


Fig. 7b

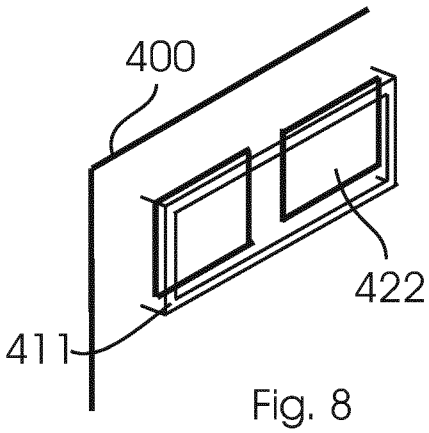


Fig. 8

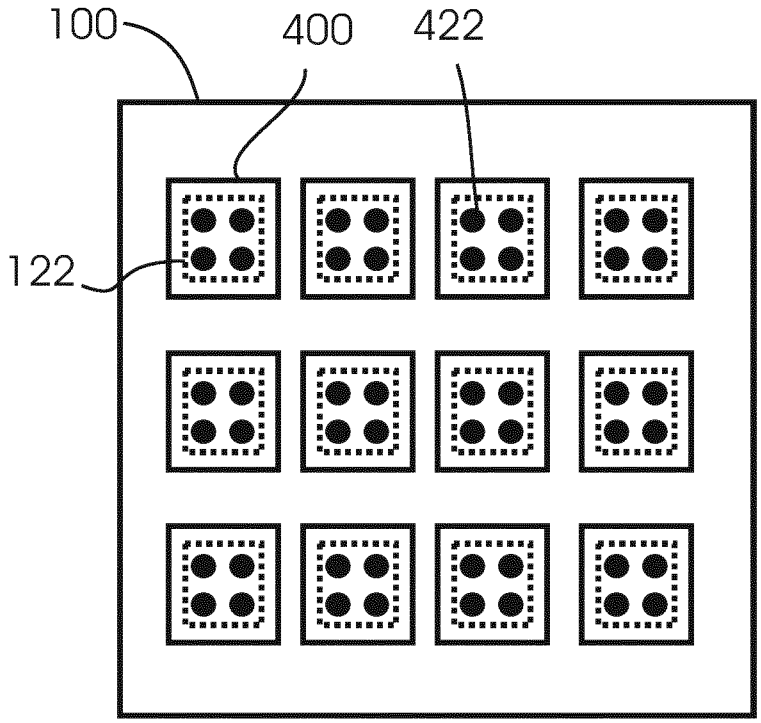


Fig. 9a

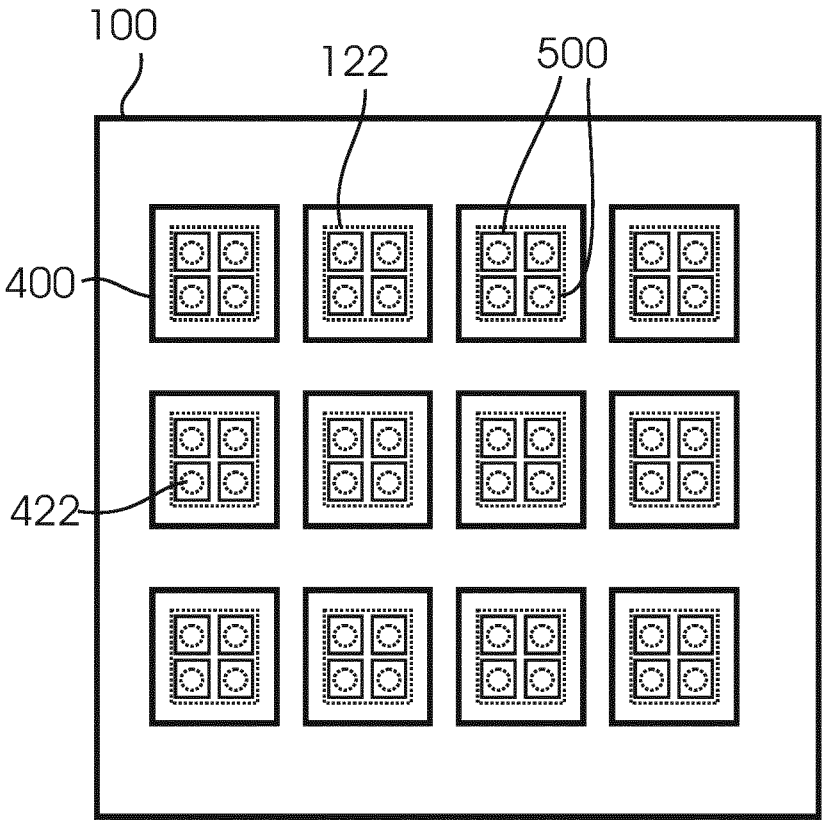


Fig. 9b

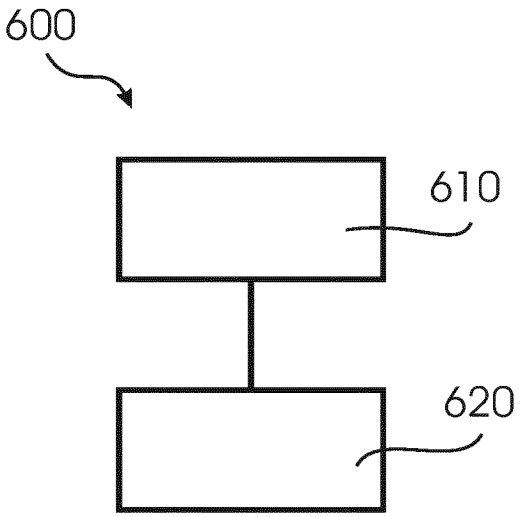


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/057768

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/687
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	DE 20 2009 001817 U1 (ROTH & RAU AG [DE]) 4 June 2009 (2009-06-04) paragraph [0013] - paragraph [0020] claim 1; figures 1-5	1,2, 5-13,15 3,4,14

Y A	US 2015/078864 A1 (SATO KAORU [JP] ET AL) 19 March 2015 (2015-03-19) paragraph [0059] - paragraph [0069] figures 6A-6D	3 1,6,11, 15

Y A	WO 03/034419 A1 (STEAG HAMATECH AG [DE]; KREUDER GERD [DE]; KAUSSEN HANS GUENTHER [DE];) 24 April 2003 (2003-04-24) page 7, line 29 - page 8, line 27 figures 1,2	4,14 1,6,11, 15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 October 2015	20/10/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Meixner, Matthias

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/057768

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		WO 03034419 A1	24-04-2003