(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
01 June 2023 (01.06.2023)

WIPO | PCT

(10) **International Publication Number**
WO 2023/093992 A1

(51) **International Patent Classification:**
H01L 21/677 (2006.01)

(21) **International Application Number:** PCT/EP2021/083133

(22) **International Filing Date:** 26 November 2021 (26.11.2021)

(25) **Filing Language:** English

(26) **Publication Language:** English

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) **Title:** CARRIER TRANSPORT SYSTEM, VACUUM DEPOSITION SYSTEM, AND METHOD OF CARRIER TRANSPORT

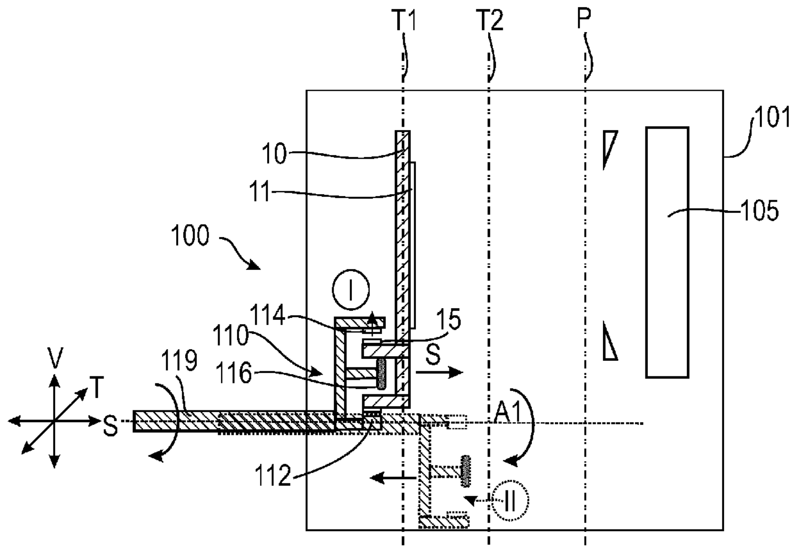

FIG. 1

(57) **Abstract:** A carrier transport system (100) for transporting a carrier in a transport direction (T) is described. The carrier transport system includes at least one first carrier holder (110) configured to hold a first carrier (10) in an essentially vertical orientation (V); at least one drive unit (112) for transporting the first carrier in the transport direction (T) on or off the at least one first carrier holder (110), wherein the at least one first carrier holder is movable in a path switch direction (S) transverse to the transport direction (T) and is turnable between a holding position (I) and a return position (II) around a first rotation axis (A1) that extends in the path switch direction (S).

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TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

CARRIER TRANSPORT SYSTEM, VACUUM DEPOSITION SYSTEM, AND METHOD OF CARRIER TRANSPORT

TECHNICAL FIELD

[0001] Embodiments of the present disclosure relate to systems and methods for transportation of carriers, particularly carriers for carrying large area substrates. More specifically, embodiments of the present disclosure relate to systems and methods for transportation of carriers employable, e.g., in vacuum processing systems for vertical substrate processing, e.g. material deposition on large area substrates for display manufacturing. In particular, embodiments of the present disclosure relate to carrier transport systems, vacuum deposition systems, and methods of carrier transport.

BACKGROUND

[0002] Techniques for layer deposition on a substrate include, for example, sputter deposition, physical vapor deposition (PVD), chemical vapor deposition (CVD) and thermal evaporation. Coated substrates may be used in several applications and in several technical fields. For instance, coated substrates may be used in the field of displays. Displays can be used for the manufacture of television screens, computer monitors, mobile phones, other hand-held devices, and the like for displaying information. Typically, displays are produced by coating a substrate with a stack of layers of different materials.

[0003] In order to deposit one or more material layers on a substrate, a vacuum deposition system with an arrangement of vacuum processing modules can be used, such as deposition modules and optionally further processing modules, e.g., cleaning modules and/or etching modules. A plurality of substrates can continuously or quasi-continuously be processed in the vacuum deposition system which may for example be an in-line processing system or a cluster system.

[0004] A substrate is typically carried by a substrate carrier, i.e. a carrying device for carrying the substrate. The carrier that carries the substrate is typically transported through the vacuum deposition system in a transport direction T along one or more transport paths, for example into a vacuum chamber that houses a deposition source. At least two transport paths can be provided next to each other in the vacuum deposition system, e.g. a first transport path T1 for transporting the carrier in a forward direction into the vacuum chamber and a second transport path T2 for transporting the carrier after substrate processing in a return direction opposite to the forward direction. A carrier transport system may be provided for moving the carrier between the first transport path T1 and the second transport path T2 in a path switch direction S transverse to the transport direction T.

[0005] However, such a path switch of a carrier between two transport paths may be time-consuming and may therefore reduce the throughput of the system. Further, the processing tact may be increased by the fact that a path switch of a first carrier in a vacuum chamber needs to be completed before a subsequent carrier can be loaded in the vacuum chamber. Further, particle generation due to wear of moving parts during a path switch can cause deterioration of the manufacturing process. Accordingly, there is a demand for the transportation of carriers in a vacuum chamber with reduced particle generation in a path switch direction that is transverse to the actual transport direction in a quick and time-saving manner.

[0006] Accordingly, it would be beneficial to provide improved systems and methods for carrier transport, particularly in a vacuum chamber, as well as improved vacuum deposition systems, which overcome at least some of the above problems.

SUMMARY

[0007] In light of the above, carrier transport systems, vacuum deposition systems, as well as methods of carrier transport 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 an aspect of the present disclosure, a carrier transport system is provided. The carrier transport system includes at least one first carrier holder configured to hold a first carrier in an essentially vertical orientation, and at least one drive unit for transporting the first carrier in a transport direction onto or off the at least one first carrier holder. The at least one first carrier holder is movable in a path switch direction transverse to the transport direction and is turnable between a holding position and a return position around a first rotation axis that extends in the path switch direction.

[0009] The path switch direction and the first rotation axis may be essentially perpendicular to the transport direction. The at least one first carrier holder may be rotated around the first rotation axis by an angle of essentially 180° between the holding position and the return position.

[0010] In particular, the at least one first carrier holder may be set in the holding position for holding the first carrier for moving the first carrier in the path switch direction, e.g. between a first transport path, a processing position, and/or a second transport path. The at least one first carrier holder may be set in the return position for moving at least one second carrier holder holding a second carrier in the path switch direction relative to and past the first carrier holder.

[0011] In some embodiments, the carrier transport system further includes at least one second carrier holder configured to support a second carrier in an essentially vertical orientation at a position offset from the at least one first carrier holder in the path switch direction. The at least one first carrier holder can be set in the return position for enabling a relative movement of the at least one first carrier holder and the at least one second carrier holder holding the second carrier past one another in the path switch direction, particularly for moving the at least one second carrier holder holding the second carrier in the path switch direction past the at least one first carrier holder.

[0012] In some embodiments, the at least one first carrier holder is at least partially arranged below the first carrier during the transport. For example, the first carrier is supported from below, e.g. at least partially on a mechanical support of the first carrier holder. In other embodiments, the at least one first carrier holder is at least partially arranged above the first carrier during the transport. For example, the at least one first carrier holder may magnetically hold the first carrier from above. In yet further embodiments, the at least one first carrier holder is at least partially arranged below the first carrier during the transport for holding a first part of the weight force, and an upper first carrier holder is additionally at least partially arranged above the first carrier for holding a second part of the weight force.

[0013] According to a further aspect of the present disclosure, a carrier transport system is provided. The carrier transport system includes at least one first carrier holder configured to hold a first carrier in an essentially vertical orientation, the at least one first carrier holder including a magnetic levitation unit for magnetically counteracting at least a part of a weight force of the first carrier, at least one drive unit for transporting the first carrier in a transport direction onto or off the at least one first carrier holder, the at least one first carrier holder being movable in a path switch direction transverse to the transport direction, and at least one second carrier holder configured to hold a second carrier in an essentially vertical orientation at a position offset from the at least one first carrier holder in the path switch direction, wherein the at least one first carrier holder can be set in a return position for enabling a relative movement of the at least one first carrier holder and the at least one second carrier holder holding the second carrier past one another in the path switch direction.

[0014] In some embodiments, the carrier transport systems described herein are configured to transport the carriers in a vacuum chamber, and the at least one first carrier holder and the at least one second carrier holder (if present) are located inside the vacuum chamber. Alternatively, the carrier transport system described herein may be configured to transport the carrier in an atmospheric environment, e.g. before or after loading of the carrier into a vacuum system.

[0015] According to a further aspect of the present disclosure, a vacuum deposition system is provided. The vacuum deposition system includes a vacuum chamber that houses a deposition source and the carrier transport system according to any of the embodiments described herein, wherein the at least one first carrier holder of the carrier transport system is movable in the vacuum chamber in the path switch direction between a first transport path, a second transport path, and a processing position facing the deposition source.

[0016] According to a further aspect of the present disclosure, a method of carrier transport is provided, particularly in a vacuum chamber. The method includes: (i) transporting a first carrier in an essentially vertical orientation along a first transport path in a transport direction on at least one first carrier holder; (ii) moving the at least one first carrier holder holding the first carrier in a path switch direction transverse to the transport direction; (iii) transporting the first carrier off the at least one first carrier holder, particularly after processing of a substrate carried by the first carrier; and (iv) turning the at least one first carrier holder from a holding position to a return position around a first rotation axis extending in the path switch direction.

[0017] In some embodiments, (i), (ii), (iii), and (iv) are conducted in this temporal order, followed by: (v) moving the at least one first carrier holder provided in the return position and at least one second carrier holder holding a subsequent second carrier relative to and past one another in the path switch direction, and/or (vi) turning the at least one first carrier holder back to the holding position for loading a subsequent first carrier on the at least one first carrier holder.

[0018] Embodiments are also directed at apparatuses for carrying out the disclosed methods and include apparatus parts for performing each described method aspect. These method aspects 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 according to the disclosure are also directed at methods for operating the described apparatus. The methods for operating the described apparatus include method aspects for carrying out every function of the apparatus. Embodiments are also directed at methods of manufacturing processed substrates, particularly coated substrates, in a vacuum deposition system described herein and/or using a carrier transport system described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments of the disclosure and are described in the following:

FIG. 1 shows a schematic sectional view of a carrier transport system according to embodiments described herein;

FIG. 2 shows a schematic sectional view of a carrier transport system according to embodiments described herein, wherein at least one first carrier holder holding a first carrier is arranged next to at least one second carrier holder holding a second carrier;

FIG. 3 shows a schematic top view of a carrier transport system according to embodiments described herein;

FIG. 4 shows a perspective view of a carrier transport system according to embodiments described herein; and

FIG. 5A-G are schematic top views illustrating subsequent stages of a method of carrier transport according to embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0020] Reference will now be made in detail to the various embodiments of the disclosure, one or more examples of which are illustrated in the figures. Within the following description of the drawings, same reference numbers refer to same components. Only the differences with respect to individual embodiments are described. Each example is provided by way of explanation of the disclosure and is not meant as a limitation of the disclosure. 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.

[0021] A carrier transport system may be configured for transporting a carrier in a vacuum environment, particularly in a vacuum chamber or in a vacuum system including a plurality of vacuum chambers arranged next to each other, e.g., in a linear arrangement. One, two or more transport paths may be arranged next to each other, for example in the vacuum chamber, wherein the carrier can be moved or conveyed along the one or more transport paths in a transport direction T. A first transport path T1 may extend adjacent to a second transport path T2, e.g., essentially parallel to the first transport path T1. The first transport path T1 and/or the second transport path T2 may extend next to each other in a transport direction T which may be an essentially horizontal direction.

[0022] The first transport path T1 and the second transport path T2 may be offset from each other in a path switch direction S. The distance between the first transport path T1 and the second transport path T2 in the path switch direction S may be 10 cm or more, particularly 20 cm or more, and/or 200 cm or less, particularly 100 cm or less.

[0023] The carrier transport system described herein can be a part of a vacuum processing system, particularly a vacuum deposition system configured for depositing a material on a substrate carried by a carrier. The vacuum deposition system may be an in-line processing system, such that substrates can be continuously or quasi-continuously processed. The carrier transport system may be configured to transfer the carrier from a first position on the first transport path T1 away from the first transport path T1 to at least one of a second transport path T2 and a processing position P in which the substrate faces toward a deposition source and can be processed. Specifically, the carrier transport system can laterally displace the carrier from a first position on the first transport path T1 to a second position away from the first transport path in the path switch direction S. The path switch direction S may be transverse to the transport direction T, particularly essentially perpendicular to the transport direction T. When the carrier is moved from one transport path to another transport path in the path switch direction S, said movement is also referred to herein as a “path switch” or “track switch”.

[0024] In some embodiments, a carrier is transported along the first transport path T1 in the transport direction T onto at least one first carrier holder, is moved away from the first transport path T1 in the path switch direction S to a processing position P where the substrate is processed, is moved in the path switch direction S to the second transport path T2, and is transported off the at least one first carrier holder along the second transport path T2, e.g. in a direction opposite to the initial direction.

[0025] The carrier transport system may include levitation magnets for partially or fully levitating the carrier during the transport along the first and second transport paths. In some embodiments, a first part of the weight force of the carrier may be counteracted by the magnetic levitation force of the magnetic levitation system, and a second part of the weight force of the carrier may be mechanically supported on a support during transport, e.g. on a plurality of support rollers. In other embodiments, the carrier is transported completely contactlessly in a floating state by the magnetic levitation system.

[0026] FIG. 1 is a schematic sectional view of a carrier transport system 100 according to embodiments herein. The carrier transport system 100 is configured for transporting a first carrier 10 which may carry a first substrate 11 in a transport direction T, for example in a vacuum chamber 101. The transport direction T is perpendicular to the paper plane of FIG. 1. The first carrier 10 (and the first substrate 11 that is carried by the first carrier 10) has an essentially vertical orientation V during the transport by the carrier transport system 100. “Essentially vertical” as used herein may be understood as an exactly vertical orientation or an orientation deviating from an exactly vertical orientation by +/-10° or less. A carrier transport in an essentially vertical orientation and/or a substrate processing in the essentially vertical orientation are particularly space-saving and reduce the footprint and the costs of the vacuum deposition system.

[0027] According to embodiments described herein, the carrier transport system 100 includes at least one first carrier holder 110 configured to hold the first carrier 10 in the essentially vertical orientation, and at least one drive unit 112 for transporting the first carrier 10 in the transport direction T on or off the at least one first carrier holder. The at least one drive unit 112 may include a linear motor configured to contactlessly drive the first carrier 10 in the transport direction T, in particular a plurality of linear motors arranged along the transport direction T, e.g. at regular spacings. Alternatively or additionally, the at least one drive unit may include a mechanical drive, such as one or more drive rollers driven in rotation by a motor for moving the first carrier in the transport direction T on the one or more drive rollers. After transporting the first carrier onto the at least one first carrier holder, the first carrier is held by the at least one first carrier holder, e.g. supported thereon and/or held therebelow.

[0028] The at least one first carrier holder 110 can be moved in the path switch direction S with the first carrier 10 held thereon for transferring the first carrier 10 in the path switch direction away from the first transport path T1, e.g., to the second transport path T2 or to the processing position P. Further, the at least one first carrier holder 110 can be turned between a holding position (I) and a return position (II) around a first rotation axis A1 that extends in the path switch direction S. In particular, the at least one first carrier holder 110 can be rotated by about 180° around the first rotation axis A1 for switching between the holding position (I) (shown in FIG. 1 in continuous lines) and the return position (II) (shown in FIG. 1 in dashed lines), and/or vice versa.

[0029] The at least one first carrier holder 110 in the holding position (I) is configured to hold the first carrier 10 for moving the first carrier 10 in the path switch direction S. The at least one first carrier holder 110 can be set in the return position (II) via a rotation around the first rotation axis A1, the return position (II) being meant for enabling a space-saving idle position of the at least one first carrier holder 110, in which the at least one first carrier holder 110 interferes to a lesser extent with other components arranged inside the vacuum chamber 101 above the level of the first rotation axis A1.

[0030] FIG. 1 shows the at least one first carrier holder 110 that is at least partially arranged below the first carrier during the transport, supporting the first carrier from below. However, embodiments are not limited to such an arrangement. Alternatively or additionally, even if not shown in the figures, the at least one first carrier holder (and similarly the at least one second carrier holder described in the following) may be at least partially arranged above the first carrier during the transport. For example, the at least one first carrier support may include at least one levitation magnet arranged at least partially above the first carrier, for example at least one active levitation magnet and/or at least one passive levitation magnet. Here, a rotation of the at least one first carrier holder around the first rotation axis A1 may bring the at least one first carrier holder to the return position in which the at least one first carrier holder is projects further upwardly.

[0031] As is schematically depicted in FIG. 1, the at least one first carrier holder 110 may be at least partially arranged below the first carrier. Here, the at least one first carrier holder 110 may extend in the carrier support position (I) higher above the first rotation axis A1 than in the return position (II). For example, the at least one first carrier holder 110 may have a carrier support, such as at least one support roller 116 and/or a magnetic levitation unit 114, that projects above the first rotation axis A1 in the holding position (I) for supporting the first carrier. By rotating the at least one first carrier holder 110 into the return position (II), the carrier support may project at least partially or entirely downward below the first rotation axis A1, providing space in the vacuum chamber 101 above the first rotation axis A1 for other components. In particular, by turning the at least one first carrier holder 110 into the return position (II), at least one second carrier holder 120 (shown in FIG. 2) that holds a second carrier can be moved relative to and past the at least one first carrier holder 110 in the path switch direction S.

[0032] In some embodiments, which can be combined with other embodiments described herein, the at least one first carrier holder 110 may include a magnetic levitation unit 114, particularly a levitation magnet, for magnetically counteracting at least a part of the weight force of the first carrier 10 when supported thereon. Specifically, 10% or more, particularly 30% or more, or even 50% or more of the weight of the first carrier may be magnetically held by one or more magnetic levitation units, when the carrier is supported on the at least one first carrier holder 110. In some embodiments, the first carrier 10 may be completely levitated, i.e. held in a floating state contactlessly relative to the at least one first carrier holder 110 by one or more magnetic levitation units.

[0033] In some embodiments, a first part of the weight of the first carrier 10 (e.g., between 20% and 60%, particularly between 30% and 50%) arranged on the at least one first carrier holder 110 is magnetically held by the magnetic levitation unit 114, and a second part of the weight of the first carrier 10 (e.g., between 20% and 60%, particularly between 30% and 50%) is supported on a mechanical support, such as on at least one support roller 116, as it is schematically depicted in FIG. 1. In some embodiments, a third part of the weight force of the first carrier (e.g. between 10% and 40%, particularly between 20% and 30%) is magnetically held by an upper first carrier holder that is at least partially arranged above the first carrier (not shown in the figures). In some embodiments, also the upper first carrier holder can move in the path switch direction S, e.g. synchronously with the first carrier holder 110, and can optionally be turned around a rotation axis that extends in the path switch direction S.

[0034] A (partial or complete) magnetic support of the first carrier 10 on the at least one first carrier holder 110 reduces the friction of the first carrier 10 during the transport and during the path switch, such that the generation of small particles that may negatively affect the substrate processing in the vacuum chamber can be reduced or avoided. The quality of the substrate processing, particularly the layer deposition quality, can be improved.

[0035] In some embodiments, which can be combined with other embodiments described herein, the magnetic levitation unit 114 is a passive magnet, particularly a permanent magnet. A passive magnet may attract the first carrier upwardly, e.g. by exerting an attractive magnetic force on a countermagnet 15 or on a ferromagnetic material (such as steel) of the first carrier 10 in an upward direction.

[0036] In some embodiments, an active levitation magnet may be provided in alternative or in addition to a passive magnet at the at least one first carrier holder 110, particularly if the at least one first carrier holder is arranged at least partially above the first carrier. An active levitation magnet is a levitation magnet, such as a coil, whose strength is actively controlled to maintain a predetermined gap distance between the at least one first carrier holder and the first carrier. A passive levitation magnet is a levitation magnet whose strength is not actively controlled, as it is schematically depicted in FIG. 1.

[0037] In some embodiments, which can be combined with other embodiments described herein, the at least one first carrier holder includes a mechanical support for supporting at least a part of the carrier weight thereon, for example at least one support roller 116 for mechanically supporting the first carrier 10 thereon. As mentioned above, a part of the weight force of the first carrier 10 may be magnetically held by the magnetic levitation unit 114 of the at least one first carrier holder 110, and a second part of the weight force of the first carrier 10 may be mechanically supported on the at least one support roller 116 of the at least one first carrier holder. The mechanical support may further stabilize the first carrier in the path switch direction S. The at least one support roller 116 may be rotatable around a rotation axis that extends in the path switch direction S. A completely contactless levitation of a carrier by magnetic forces is challenging and typically uses an active control of the magnetic levitation unit(s) for maintaining a stable position of the levitated carrier, which is more complex. On the other hand, by magnetically holding only a part of the carrier weight and mechanically supporting the remaining part of the carrier weight, the carrier can be held in a stable position via the mechanical support while at the same time reducing problems associated with frictional forces via the partial magnetic levitation. Accordingly, the carrier transport system shown in FIG. 1 allows for a reliable path switch of a carrier in the path switch direction S between two or more transport paths while reducing the generation of small particles that would have a negative effect on the substrate processing without an unnecessary complexity.

[0038] In some embodiments, which can be combined with other embodiments described herein, the at least one drive unit 112 includes a linear motor configured to contactlessly drive the first carrier 10 in the transport direction T, particularly on or off the at least one first carrier holder 110. In particular, a plurality of linear motors may be arranged along the transport direction T for transporting the carrier into the vacuum chamber 101 and on the at least one first carrier holder 110. In some implementations, at least one drive unit is part of the at least one first carrier holder 110 and moves together with the at least one first carrier holder 110 in the path switch direction S during a path switch (e.g., the at least one drive unit 112 shown in FIG. 1). Such a drive unit can be used both for moving the first carrier on the at least one first carrier holder along the first transport path T1 and for moving the first carrier off the at least one first carrier holder along the second transport path T2. In some implementations, at least one drive unit is stationarily arranged in the vacuum chamber 101 for driving the first carrier 10 along the first transport path T1 on the at least one first carrier holder 110. At least one further drive unit may be stationarily arranged in the vacuum chamber 101 for driving the first carrier 10 along the second transport path T2 off the at least one first carrier holder 110, e.g., after substrate processing.

[0039] As is schematically depicted in FIG. 1, the at least one first carrier holder 110 holding the first carrier 10 may be movable in the path switch direction S between the first transport path T1 for loading the first carrier 10 on the at least one first carrier holder 110, the second transport path T2 for unloading the first carrier from the at least one first carrier holder 110, and/or a processing position P for processing a first substrate 11 that is carried by the first carrier 10. In particular, when the at least one first carrier holder 110 is arranged at the processing position P, the first carrier 10 may face toward a deposition source 105 that is configured to deposit a material on the first substrate 11 carried by the first carrier 10.

[0040] In some embodiments, which can be combined with other embodiments described herein, the carrier transport system 100 includes a first movable arm 119 that extends through a side wall of the vacuum chamber 101. The at least one first carrier holder 110 may be connected to the first movable arm 119 inside the vacuum chamber, e.g., fixedly connected. The first movable arm 119 may be movable in the path switch direction S via a motor that is arranged outside the vacuum chamber for transferring the at least one first carrier holder 110 in the path switch direction S. Alternatively or additionally, the first movable arm 119 may be rotatable around the first rotation axis A1 via a rotation motor that is arranged outside the vacuum chamber, such that the at least one first carrier holder 110 is rotatable inside the vacuum chamber 101 between the holding position (I) and the return position (II). Optionally, the first movable arm 119 may be connected to the side wall of the vacuum chamber 101 via a flexible bellow (not depicted) that allows a movement of the first movable arm 119 relative to (extend into / retract from) the vacuum chamber 101 while maintaining a vacuum-tight connection between the first movable arm 119 and the vacuum chamber 101.

[0041] According to some embodiments described herein, the at least one first carrier holder 110 that is both movable in the path switch direction S and rotatable around the first rotation axis A1 allows for a quick and reliable path switch of the first carrier between two or more transport paths and/or a processing position P. After transferring the first carrier 10 in the path switch direction S, processing of the first substrate 11, and unloading the first carrier 10 from the at least one first carrier holder, the at least one first carrier holder can be switched from the holding position (I) to the return position (II). The return position (II) may create space for the path switch of a second carrier held by at least one second carrier holder and/or for returning the at least one first carrier holder to an initial position for loading of a subsequent first carrier (without interfering with the second carrier holder). The tact time of the system can be reduced and the processing quality can be improved.

[0042] FIG. 2 is a schematic sectional view of a carrier transport system 200 according to embodiments described herein. The carrier transport system 200 may include some or all the features of the carrier transport system 100 described above, such that reference can be made to the above explanations, which are not repeated here. In particular, the carrier transport system 200 includes the at least one first carrier holder 110 that is movable in the path switch direction S while holding a first carrier 10 and that is turnable around the first rotation axis A1 for setting the at least one first carrier holder 110 into the return position (II), as described above.

[0043] In addition to the at least one first carrier holder 110, the carrier transport system 200 includes at least one second carrier holder 120 configured to hold a second carrier 20 in the essentially vertical orientation V at a position offset from the at least one first carrier holder 110 in the path switch direction S. In particular, the at least one second carrier holder 120 can hold the second carrier 20 on the second transport path T2 while the at least one first carrier holder 110 holds the first carrier 10 on the first transport path T1.

[0044] The at least one second carrier holder 120 may be arranged at essentially the same vertical level adjacent to the at least one first carrier holder 110, such that the first carrier 10 can be supported parallel to and at the same height as the second carrier 20, e.g., with the first carrier 10 and the second carrier 20 arranged next to one another in the path switch direction S, particularly at a distance of 100 cm or less from each other, e.g. 50 cm or less.

[0045] In some embodiments, the at least one second carrier holder 120 may be arranged in the transport direction T offset from the at least one first carrier holder 110 (as is depicted in FIG. 3 and FIG. 4), e.g., offset by a distance of 10 cm or more and 100 cm or less. Despite said (slight) offset (which may allow the at least one first carrier holder 110 and the at least one second carrier holder 120 to move past each other in the path switch direction), the at least one first carrier holder 110 and the at least one second carrier holder 120 may be configured to hold the respective carrier at the same position in the transport direction T. Further, the at least one first carrier holder 110 and the at least one second carrier holder 120 may be configured to transfer the respective carrier in the path switch direction to the same processing position P facing a processing device, e.g. in front of the deposition source 105 in the vacuum chamber 101.

[0046] During the transport of the first carrier 10 on the at least one first carrier holder 110 along the first transport path T1, the second carrier 20 (carrying a second substrate 21 having undergone processing) can be transported off the at least one second carrier holder 120 along the second transport path T2. The tact time of the system can be reduced when the carrier transport system 200 can hold two carriers simultaneously next to each other in the path switch direction S in the vacuum chamber. Specifically, a subsequent carrier can already be prepared on the first transport path T1 to be moved toward the deposition source 105 for being processed, while a preceding carrier to be transported away along the second transport path T2 can still be arranged between the first carrier 10 and the deposition source 105. Further, a sluice opening 109 between the vacuum chamber 101 and a second vacuum chamber 102 may be opened only once for both loading of the first carrier 10 into the vacuum chamber 101 and for unloading of the second carrier 20 off the vacuum chamber 101 (see FIG. 5A), which may improve the vacuum quality and reduce the tact time of the system.

[0047] In some embodiments, which can be combined with other embodiments described herein, the at least one second carrier holder 120 may be constructed equally as the at least one first carrier holder 110. In particular, the at least one second carrier holder 120 may be movable in the path switch direction S while holding the second carrier 20, particularly between the first transport path T1, the second transport path T2, and/or the processing position P. The at least one second carrier holder 120 may also be turnable between a holding position and a return position around a second rotation axis A2 extending in the path switch direction S, particularly by a rotation by about 180°. In some embodiment, the at least one first carrier holder 110 is connected to a first movable arm 119 that extends out of the vacuum chamber 101, and the at least one second carrier holder 120 is connected to a second movable arm 160 that extends out of the vacuum chamber 101. Motors may be provided outside the vacuum chamber 101 for moving the respective carrier holder via the respective movable arm.

[0048] Accordingly, the at least one second carrier holder 120 – in analogy to the at least one first carrier holder 110 – can be set in a holding position for holding the second carrier for moving the second carrier in the path switch direction S. Further, the at least one second carrier holder 120 can be set in the return position for moving the at least one first carrier holder 110 holding the first carrier 10 in the path switch direction S relative to and past the at least one second carrier holder 120 provided in the return position. Specifically, the at least one second carrier holder 120 can be set in the return position for enabling a relative movement of the at least one second carrier holder 120 and the at least one first carrier holder 110, even if a carrier is held by one of the at least one first carrier holder 110 and the at least one second carrier holder 120.

[0049] In some embodiments, which can be combined with other embodiments described herein, the at least one first carrier holder 110 holding the first carrier 10 is movable in the path switch direction S relative to and past the at least one second carrier holder 120 provided in the return position, and/or the at least one second carrier holder 120 holding the second carrier 20 is movable in the path switch direction S relative to and past the at least one first carrier holder 110 provided in the return position. Accordingly, one of the first and second carrier holders can already be prepared and positioned for the loading of a subsequent carrier while the other one of the first and second carrier holder may still hold a preceding carrier. The tact time of the system can be improved.

[0050] According to an aspect described herein, the carrier transport system includes at least one first carrier holder 110 configured to hold a first carrier 10 in an essentially vertical orientation V, the at least one first carrier holder 110 including a magnetic levitation unit 114 for magnetically counteracting at least a first part of a weight force of the first carrier 10, and at least one drive unit 112 for transporting the first carrier in a transport direction T on or off the at least one first carrier holder 110, the at least one first carrier holder holding the first carrier 10 being movable in a path switch direction S transverse to the transport direction T. Further, the carrier transport system includes at least one second carrier holder 120 configured to hold a second carrier 20 in the essentially vertical orientation V at a position offset from the at least one first carrier holder in the path switch direction S, wherein the at least one first carrier holder 110 can be set in a return position for enabling a relative movement of the at least one first carrier holder 110 and the at least one second carrier holder 120 holding the second carrier past one another in the path switch direction S. Optionally, also the at least one second carrier holder 120 can be set in a return position for enabling a relative movement of the at least one second carrier holder 120 and the at least one first carrier holder 110 holding the first carrier past one another in the path switch direction S. Specifically, one of the at least one first carrier holder 110 and the at least one second carrier holder 120 holding the respective carrier and the other one of the at least one first carrier holder 110 and the at least one second carrier holder 120 being provided in the respective return position can be moved relative to and past each other in the path switch direction S.

[0051] The carrier transport system allows a quick and reliable path switch of carriers between two or more transport paths in the path switch direction S while reducing the generation of small particles due to the magnetic levitation unit that reduces or eliminates friction. Both the tact time of the system and the processing quality can be improved.

[0052] FIG. 3 is a schematic top view of a carrier transport system 300 according to embodiments described herein that is part of a vacuum deposition system 1000. FIG. 4 shows a perspective view of the carrier transport system 300. The carrier transport system 300 may include some features or all the features of the carrier transport systems described above, such that reference can be made to the above embodiments, which are not repeated here.

[0053] Specifically, the carrier transport system 300 may include at least one first carrier holder 110 and at least one second carrier holder 120, each of the first and second carrier holders being configured for holding a respective carrier. Each of the at least one first carrier holder 110 and the at least one second carrier holder 120 is movable in the path switch direction S while holding a respective carrier, particularly between the first transport path T1, the second transport path, and/or the processing position P. Further, the at least one first carrier holder 110 is turnable around the first rotation axis A1 that extends in the path switch direction S, and the at least one second carrier holder 120 is turnable around the second rotation axis A2 that extends in the path switch direction S. Each carrier holder is turnable between a respective holding position for holding a carrier and a respective return position for movement relative to an adjacent carrier holder in the path switch direction.

[0054] In some embodiments, which can be combined with other embodiments described herein, the at least one first carrier holder 110 includes a magnetic levitation unit 114 and/or the at least one second carrier holder 120 includes a magnetic levitation unit 114 (see FIG. 4), such that at least a part of the weight of the respective carrier can be magnetically held. In some embodiments, which can be combined with other embodiments described herein, the at least one first carrier holder 110 includes at least one drive unit 112, particularly a linear motor, and/or the at least one second carrier holder 120 includes at least one drive unit 112, particularly a linear motor, for driving a respective carrier in the transport direction T relative to the respective carrier holder, particularly on and off the respective carrier holder.

[0055] As it is schematically depicted in FIG. 3 and in FIG. 4, the carrier transport system 300 may include two, three or more first carrier holders 110, 118 arranged next to each other in the transport direction T for holding the first carrier in the essentially vertical orientation V, particularly for holding different sections of the first carrier 10 thereon, such as a front section, a middle section, and a rear section of the first carrier. Each of the two, three or more first carrier holders 110, 118 may be movable in the path switch direction S, particularly between the first transport path T1, the second transport path T2, and/or the processing position P, for transferring the first carrier in the path switch direction S. One single motor may be provided for simultaneously moving the two, three or more first carrier holder 110, 118 in the path switch direction. Alternatively, each of the two, three or more first carrier holders 110, 118 may be movable in the path switch direction S via a respective separate motor, the motors being optionally arranged outside of the vacuum chamber 101.

[0056] In some implementations, each of the two, three or more first carrier holders 110, 118 may be turnable around a respective rotation axis that extends in the path switch direction, particularly between a respective holding position and a respective return position, in particular by about 180°. For example, each of the two, three or more first carrier holders 110, 118 may be connected to a respective movable arm that extends outside the vacuum chamber 101, and one or more rotation motors for rotating the two, three or more first carrier holder 110, 118 via the respective movable arm may be provided outside the vacuum chamber.

[0057] In some embodiments, the carrier transport system 300 may also include two, three or more second carrier holders 120, 128 arranged next to each other in the transport direction T for holding the second carrier 20 (depicted in dashed lines in FIG. 3) in an essentially vertical orientation V, particularly for holding different sections of the second carrier thereon, e.g. a front section, a middle section, and a rear section of the second carrier 20. Each of the two, three or more second carrier holders 120, 128 may be movable in the path switch direction S, particularly between the first transport path T1, the second transport path T2, and/or the processing position P, for transferring the second carrier in the path switch direction S. Further, each of the two, three or more second carrier holders 120, 128 may be turnable around a respective rotation axis that extends in the path switch direction S, particularly between a respective holding position and a respective return position, in particular by about 180°.

[0058] Optionally, each of the two, three or more first carrier holders 110, 118 may include a magnetic levitation unit 114 configured to magnetically hold a respective part of the weight of the first carrier, and/or each of the two, three or more second carrier holders 120, 128 may include a magnetic levitation unit 114 configured to magnetically hold a respective part of the weight of the second carrier. Alternatively or additionally, each of the two, three or more first carrier holders 110, 118 may include at least one drive unit 112, particularly a linear motor, for contactlessly driving the first carrier in the transport direction T relative to the two, three or more first carrier holders 110, 118, and/or each of the two, three or more second carrier holders 120, 128 may include at least one drive unit 112, particularly a linear motor, for transporting the second carrier in the transport direction T relative to the two, three or more second carrier holders 120, 128.

[0059] The two, three or more first carrier holders 110, 118 and the two, three or more second carrier holders 120, 128 may be arranged offset from one another in the transport direction T, particularly in an alternate arrangement, as it is schematically depicted in FIG. 3 and FIG. 4. The two, three or more first carrier holders 110, 118 may partially overlap in the transport direction with respective neighboring ones of the two, three or more second carrier holders 120, 128. Despite said overlap, the two, three or more first carrier holders 110, 118 and the two, three or more second carrier holders 120, 128 can be moved relative to and past one another in the path switch direction S when the two, three or more first carrier holders 110, 118 are provided in the holding position and the two, three or more second carrier holders 120, 128 are provided in the return position, or vice versa.

[0060] Providing two, three or more first carrier holders 110, 118 arranged next to one another in the transport direction T in the vacuum chamber 101 for holding the first carrier 10 together may be beneficial, because one carrier holder can then have a shorter dimension in the transport direction T, which facilitates the rotation of each first carrier holder around the respective rotation axis. Further, the first carrier 10 is more stably held during the path switch and/or during processing, when being supported at different sections. Corresponding advantages are provided if there are two, three or more second carrier holders 120, 128 for simultaneously holding the second carrier 20.

[0061] The carrier transport system 300 according to any of the embodiments described herein may be used in a vacuum processing system, particularly in a vacuum deposition system 1000 that includes a vacuum chamber 101 that houses a deposition source 105 for depositing a material on a substrate carried by a carrier. The at least one first carrier holder 110 is movable in the vacuum chamber 101 between a first transport path T1, a second transport path T2, and a processing position P facing toward the deposition source 105. The first transport path T1 may extend in the transport direction T in the vacuum chamber 101 and through at least one second vacuum chamber that is arranged next to the vacuum chamber 101. The second transport path T2 may extend in the transport direction T parallel to and next to the first transport path T1 in the vacuum chamber 101 and through the at least one second vacuum chamber. Carriers carrying substrates to be processed can be transported along the first transport path T1 into the vacuum chamber 101 on the at least one first carrier holder 110. The at least one first carrier holder 110 can transfer a carrier in the path switch direction S to the processing position for processing and on the second transport path T2 for unloading. A carrier carrying a processed substrate can be transported along the second transport path T2 out of the vacuum chamber 101 from the at least one first carrier holder 110.

[0062] In some embodiments, at least one second carrier holder 120 as described herein may additionally be provided in the vacuum chamber 101 next to the at least one first carrier holder 110, the at least one second carrier holder 120 configured in accordance with the at least one first carrier holder 110. The processing tact can be improved and the substrate processing in the vacuum deposition system can be accelerated.

[0063] FIG. 5A-G are schematic top views illustrating subsequent stages (i) to (vi) of a method of carrier transport, e.g., in a vacuum chamber, according to embodiments described herein. The method may be conducted by any of the carrier transport systems described herein, in particular in the vacuum deposition system described herein. The vacuum deposition system may include a vacuum chamber 101 where substrate processing takes place and a second vacuum chamber 102 arranged adjacent to the vacuum chamber 101. The vacuum chamber 101 can also be referred to as the “vacuum processing chamber” or “process station”. The first transport path T1 and the second transport path T2 may extend next to each other from the second vacuum chamber 102 into the process station. One or more further vacuum chambers may be provided next to the second vacuum chamber 102, e.g. in a linear arrangement as depicted in

FIG. 5A-G. The vacuum deposition system may be an in-line system, in particular an in-line deposition system, e.g. for display manufacturing.

[0064] As is depicted in FIG. 5A and FIG. 5B, the method includes (i) transporting a first carrier 10 in an essentially vertical orientation along the first transport path T1 in the transport direction T onto at least one first carrier holder 110 arranged in the vacuum chamber 101, particularly onto two, three or more first carrier holders configured to hold the first carrier 10 together. The first carrier 10 may be transported into the vacuum chamber 101 from the second vacuum chamber 102 through a sluice opening 109, and the vacuum chamber 101 may house a processing device, particularly a deposition source 105.

[0065] As is depicted in FIG. 5B and FIG. 5C, the method includes (ii) moving the at least one first carrier holder 110 holding the first carrier 10 in the path switch direction S transverse to the transport direction T, particularly perpendicular to the transport direction T. For example, the at least one first carrier holder 110 may be moved to a processing position P facing toward the deposition source 105 for processing a first substrate that is carried by the first carrier 10, as it is depicted in FIG. 5C. In particular, the method may include coating of a first substrate that is carried by the first carrier 10 with a material in the vacuum chamber 101. After processing, the at least one first carrier holder 110 may optionally be moved from the processing position P onto the second transport path T2 for positioning the first carrier 10 for movement along the second transport path T2, as it is depicted in FIG. 5D.

[0066] As is depicted in FIG. 5D and FIG. 5E, the method includes (iii) transporting the first carrier 10 off the at least one first carrier holder 110, particularly along the second transport path T2. The first carrier 10 may be transported out of the vacuum chamber 101 back into the second vacuum chamber 102 through the sluice opening 109.

[0067] As is depicted in FIG. 5E, the method includes (iv) turning the at least one first carrier holder 110 from the holding position to the return position around the first rotation axis A1, particularly by about 180°. In particular, the two, three or more first carrier holders that have previously held the first carrier 10 may be turned into the respective return position around a respective rotation axis extending in the path switch direction S. This allows the at least one second carrier holder 120 holding a subsequent second carrier 30 to move relative to and past the at least one first carrier holder 110, as is depicted in FIG. 5E and FIG. 5F, because the first carrier holders extend less far above the vertical level of the rotation axes when provided in the respective return position as compared to the respective holding position.

[0068] Specifically, as is depicted in FIG. 5E and FIG. 5F, the method may include (v) moving the at least one first carrier holder 110 provided in the return position and the at least one second carrier holder 120 holding a subsequent second carrier 30 relative to and past one another in the path switch direction S. The at least one second carrier holder 120 may be moved to the processing position for processing, as is depicted in FIG. 5F. A “relative” movement as used herein may relate to any of a movement of the second carrier holder past the stationary first carrier holder, a movement of the first carrier holder past the stationary second carrier holder, or a movement of both the first carrier holder and the second carrier holder simultaneously past each other.

[0069] As is depicted in FIG. 5G, the method may further include (vi) turning the at least one first carrier holder 110 back to the holding position for loading of a subsequent first carrier 40 on the at least one first carrier holder 110. In particular, each of the two, three or more first carrier holders may be turned to the respective holding position essentially simultaneously.

[0070] Thereafter, the method may start again from the beginning with stage (i) depicted in FIG. 5A, with the subsequent first carrier 40 and the subsequent second carrier 30 replacing respectively the first carrier 10 and the second carrier 20, followed by respective stages (ii)-(vi). Accordingly, an “endlessly revolving path switch” is provided according to methods and systems described herein, enabling a fast carrier exchange between the vacuum chamber 101 and the second vacuum chamber 102 and an overall faster substrate processing. Specifically, two carriers can be held simultaneously by respective carrier holders in the vacuum chamber, and a first carrier holder can already be positioned for loading of a subsequent carrier while a second carrier holder still holds a preceding carrier at an offset position in the path switch direction. In particular, the at least one first carrier holder 110 and the at least one second carrier holder 120 can move relative to and past each other in the path switch direction S, even if a carrier is held on one of the at least one first carrier holder and the at least one second carrier holder. A carrier can be loaded on one of the at least one first carrier holder and the at least one second carrier holder while a subsequent carrier is simultaneously unloaded from the other one of the at least one first carrier holder and the at least one second carrier holder, allowing a faster carrier transport and a shorter tact rate of the system.

[0071] As is depicted in FIG. 5A and FIG. 5B, a second carrier 20 carrying a processed substrate may be moved off the at least one second carrier holder 120 that is provided on the second transport path T2 during the movement of the first carrier 10 into the at least one first carrier holder 110 in stage (i). The second carrier 20 may be moved off the at least one second carrier holder 120 out of the vacuum chamber 101 into the second vacuum chamber 102 through the sluice opening 109 while the first carrier 10 may be moved in stage (i) into the at least one first carrier holder 110 into the vacuum chamber 101 from the second vacuum chamber 102. Accordingly, the sluice opening 109 can be opened once for transporting the first carrier into the vacuum chamber 101 along the first transport path T1 and for transporting the second carrier out of the vacuum chamber 101 along the second transport path T2.

[0072] In some embodiments, which can be combined with other embodiments described herein, the at least one first carrier holder 110 holding the first carrier 10 is moved during stage (ii) in the path switch direction S past the at least one second carrier holder 120 that is provided in the return position, as it is schematically depicted in FIG. 5B and FIG. 5C.

[0073] The method may further include magnetically counteracting at least a part of the weight force of the first carrier 10, when the first carrier 10 is held by the at least one first carrier holder, particularly with a magnetic levitation unit of the at least one first carrier holder 110 and optionally with another magnetic levitation unit of an upper first carrier holder that is arranged at least partially above the first carrier. In particular, 30% or more, or 50% or more of the weight force of the first carrier 10 may be magnetically held during the transfer of the first carrier in the path switch direction S and/or during the coating of the first substrate that is carried by the first carrier by the deposition source 105. In some embodiments, the weight force may be “overcompensated” by levitation magnets, and a mechanical support may (slightly) push the first carrier downwardly. Hence, the deposition quality can be improved.

[0074] Alternatively or additionally, at least a part of the weight force of the second carrier 20 may be magnetically counteracted, when the second carrier is held by the at least one second carrier holder 120, particularly with a magnetic levitation unit of the at least one second carrier holder 120 and optionally with another magnetic levitation unit of an upper second carrier holder that is arranged at least partially above the second carrier. In particular, 30% or more, or 50% or more of the weight force of the second carrier 20 may be magnetically held during the transfer of the second carrier in the path switch direction S and/or during the coating of the second substrate that is carried by the second carrier by the deposition source 105. Hence, the deposition quality can be improved.

[0075] A remaining part of the weight force of the carrier may be supported on a mechanical support, e.g. on a respective support roller. For example, each of the two, three or more first carrier holders and/or each of the two, three or more second carrier holders may include at least one support roller for supporting at least a part of the respective carrier weight thereon.

[0076] Embodiments described herein can be used for transporting carriers carrying at least one of large-area substrates, glass substrates, wafers, semiconductor substrates, masks, shields, and other objects. Embodiments may also be used for semiconductor manufacture and processing, such as for wafer transport, wafer processing and/or wafer coating. The carriers can carry one single object, e.g., a large-area substrate with a size of 1 m^2 or more, particularly 5 m^2 or 10 m^2 or more, or a plurality of objects having a smaller size, e.g. a plurality of semiconductor wafers. The carrier may include a holding device configured to hold the one or more substrates at the carrier, e.g. a magnetic chuck, an electrostatic chuck, and/or a mechanical holder, such as a clamp or mechanical support.

[0077] The carriers that are transported may be carriers for carrying a large area substrate having a surface area of 1 m² or more, particularly 5 m² or more. Accordingly, each of the carriers may have a surface area for carrying a substrate thereon of 1 m² or more, particularly 5 m² or more. During transport along the transport direction T, a carrier may have a dimension in the transport direction of 1 m or more, e.g., 2 m or more. Therefore, it is beneficial to provide at least three first carrier holders and at least three second carrier holders, particularly in an alternate arrangement, for supporting a respective large-area carrier thereon. Each of the carrier holders may be both movable in the path switch direction and rotatable around a respective rotation axis extending in the path switch direction.

[0078] The vacuum deposition systems described herein may be configured for vertical substrate processing, and the carrier transport systems described herein may be configured for carrier transport in a vertical orientation.

[0079] While the foregoing is directed to 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 carrier transport system (100), comprising

at least one first carrier holder (110) configured to hold a first carrier (10) in an essentially vertical orientation (V); and

at least one drive unit (112) for transporting the first carrier (10) in a transport direction (T) onto or off the at least one first carrier holder (110),

wherein the at least one first carrier holder (110) is movable in a path switch direction (S) transverse to the transport direction (T) and is turnable between a holding position (I) and a return position (II) around a first rotation axis (A1) that extends in the path switch direction (S).

2. The carrier transport system of claim 1, wherein the at least one first carrier holder (110) comprises a magnetic levitation unit (114) for magnetically counteracting at least a part of a weight force of the first carrier (10).

3. The carrier transport system of claim 2, wherein the magnetic levitation unit is a passive magnet, particularly a permanent magnet.

4. The carrier transport system of any of claims 1 to 3, wherein the at least one first carrier holder comprises at least one support roller (116) for mechanically supporting the first carrier (10).

5. The carrier transport system of any of claims 1 to 4, further comprising at least one second carrier holder (120) configured to hold a second carrier (20) in the essentially vertical orientation (V) at a position offset from the at least one first carrier holder (110) in the path switch direction (S), the at least one second carrier holder (120) being movable in the path switch direction (S) and turnable to a return position around a second rotation axis (A2) that extends in the path switch direction (S).

6. The carrier transport system of claim 5, wherein the at least one first carrier holder (110) holding the first carrier (10) is movable in the path switch direction (S) relative to and past the at least one second carrier holder (120) provided in the return

position, and/or wherein the at least one second carrier holder (120) holding the second carrier (20) is movable in the path switch direction (S) relative to and past the at least one first carrier holder (110) provided in the return position.

7. The carrier transport system of any of claims 1 to 6, wherein the at least one first carrier holder (110) in the holding position (I) extends higher above the first rotation axis (A1) than in the return position (II).

8. The carrier transport system of any of claims 1 to 7, wherein the at least one drive unit (112) comprises a linear motor configured to contactlessly drive the first carrier (10) in the transport direction (T).

9. The carrier transport system of any of claims 1 to 8, wherein the at least one first carrier holder (110) is movable in the path switch direction (S) between a first transport path (T1) for loading the first carrier (10) on the at least one first carrier holder, a second transport path (T2) for unloading the first carrier from the at least one first carrier holder (110), and/or a processing position (P) for processing a first substrate (11) carried by the first carrier (10).

10. The carrier transport system of any of claims 1 to 9, further comprising a first movable arm (119) extending through a side wall of a vacuum chamber (101) and connected to the at least one first carrier holder (110), the first movable arm (119) being movable in the path switch direction (S) and turnable around the first rotation axis (A1) via a respective motor arranged outside the vacuum chamber (101).

11. The carrier transport system of any of claims 1 to 10, comprising two, three or more first carrier holders (110, 118) arranged next to each other in the transport direction (T) for holding different sections of the first carrier (10), each of the two, three or more first carrier holders (110, 118) being movable in the path switch direction (S) and being turnable around a respective rotation axis extending in the path switch direction (S).

12. A carrier transport system (100), comprising

at least one first carrier holder (110) configured to hold a first carrier (10) in an essentially vertical orientation, the at least one first carrier holder (110) comprising a magnetic levitation unit (114) for magnetically counteracting at least a first part of a weight force of the first carrier (10);

at least one drive unit (112) for transporting the first carrier in a transport direction (T) onto or off the at least one first carrier holder (110), the at least one first carrier holder being movable in a path switch direction (S) transverse to the transport direction (T); and

at least one second carrier holder (120) configured to hold a second carrier (20) in an essentially vertical orientation at a position offset from the at least one first carrier holder in the path switch direction (S), wherein the at least one first carrier holder (110) can be set in a return position (II) for enabling a relative movement of the at least one first carrier holder (110) and the at least one second carrier holder (120) holding the second carrier (20) past one another in the path switch direction (S).

13. A vacuum deposition system (1000), comprising:

a vacuum chamber (101) that houses a deposition source (105); and

the carrier transport system (100) according to any of claims 1 to 12,

wherein the at least one first carrier holder (110) is movable in the vacuum chamber (101) in the path switch direction (S) between a first transport path (T1), a second transport path (T2), and a processing position (P) facing toward the deposition source (105).

14. A method of carrier transport, comprising:

(i) transporting a first carrier (10) in an essentially vertical orientation along a first transport path (T1) in a transport direction (T) onto at least one first carrier holder (110);

(ii) moving the at least one first carrier holder (110) holding the first carrier (10) in a path switch direction (S) transverse to the transport direction (T);

(iii) transporting the first carrier (10) off the at least one first carrier holder (110); and

(iv) turning the at least one first carrier holder (110) from a holding position (I) to a return position (II) around a first rotation axis (A1) that extends in the path switch direction (S).

15. The method of claim 14, wherein, during (i), a second carrier (20) carrying a processed substrate is moved off a second carrier holder (120) that is provided on a second transport path (T2) extending parallel to and offset from the first transport path (T1).

16. The method of claim 14 or 15, further comprising:

(v) moving the at least one first carrier holder (110) provided in the return position and at least one second carrier holder (120) holding a subsequent second carrier (30) relative to and past one another in the path switch direction (S).

17. The method of claim 16, further comprising:

(vi) turning the at least one first carrier holder (110) back to the holding position for loading a subsequent first carrier (40) on the at least one first carrier holder (110).

18. The method of any of claims 14 to 17, wherein, during (ii), the at least one first carrier holder (110) is moved in the path switch direction past at least one second carrier holder (120) that is provided in a return position.

19. The method of any of claims 14 to 18, further comprising:

magnetically counteracting at least a part of a weight force of the first carrier (10) held by the at least one first carrier holder (110); and/or

magnetically counteracting at least a part of a weight force of the second carrier (20) held by the at least one second carrier holder (120).

20. The method of any of claims 14 to 19, wherein, after (ii) and before (iii), a first substrate (11) carried by the first carrier (10) is coated with a material.

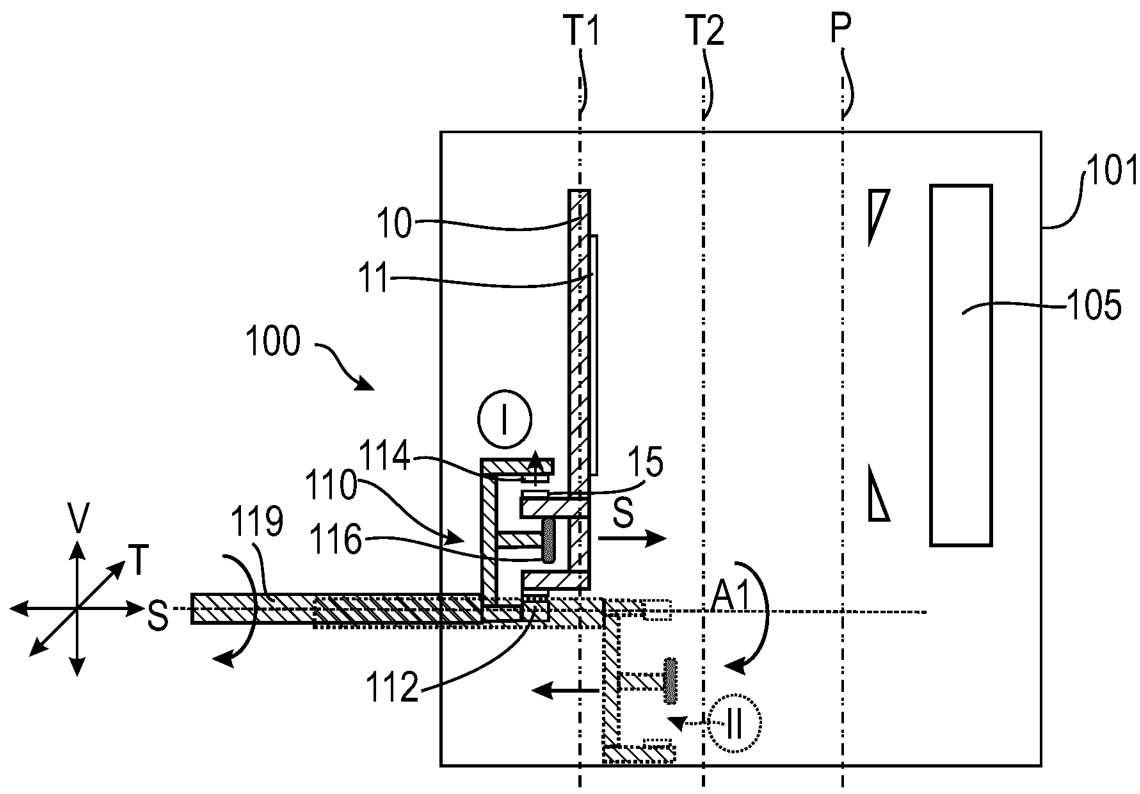

T1
T2
P
101
10
11
105
100
I
114
15
110
S
119
116
V
T
S
A1
112
II

FIG. 1

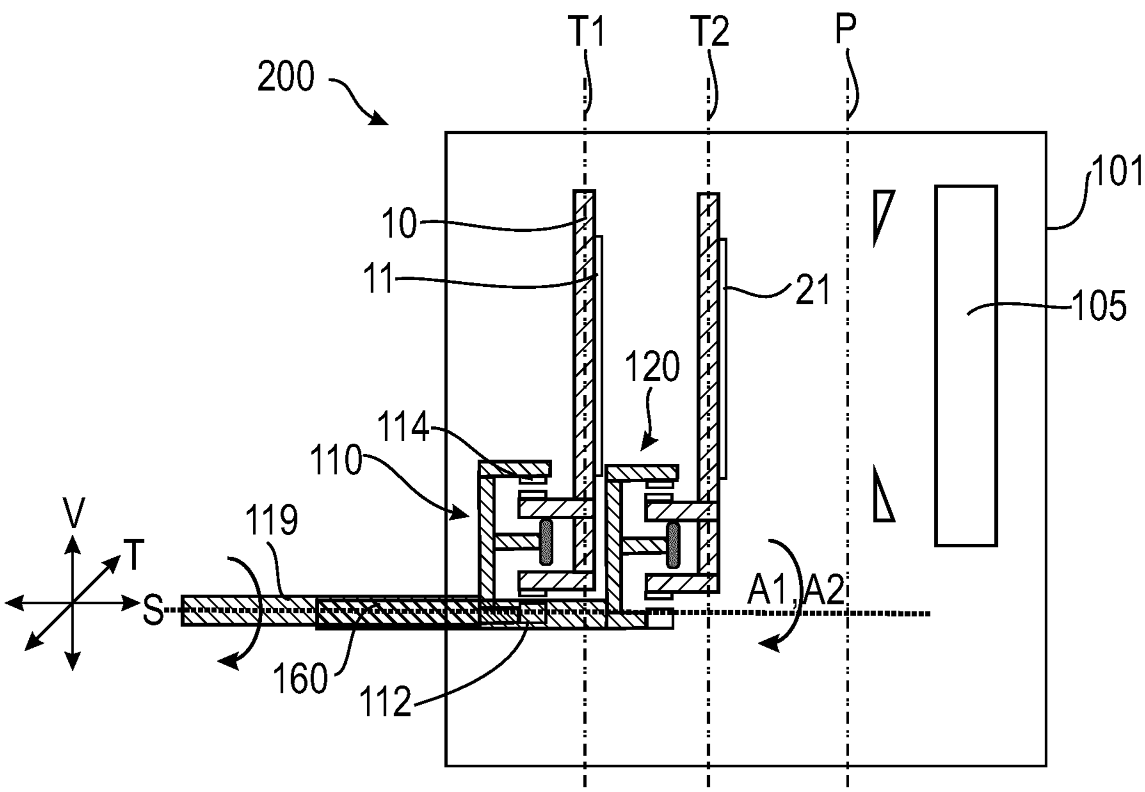

T1
T2
P
200
101
10
11
21
105
120
114
110
V
119
T
S
A1, A2
160
112

FIG. 2

FIG. 3

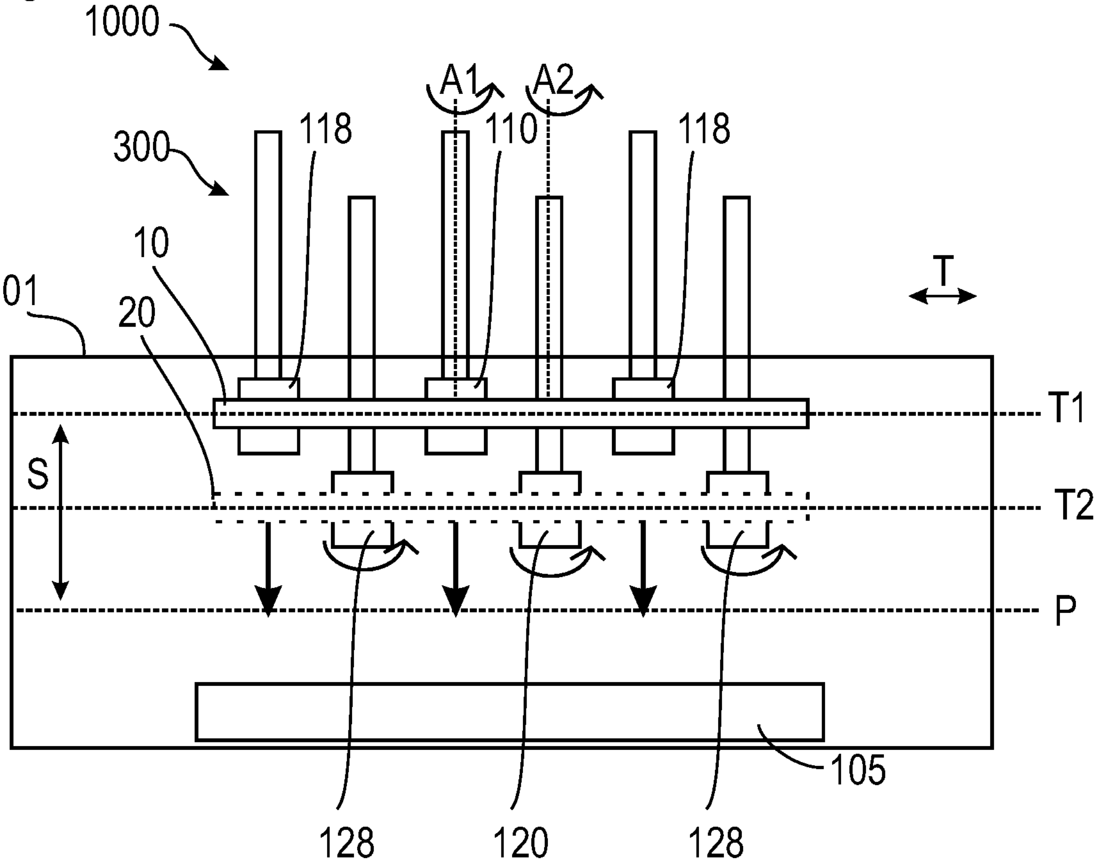
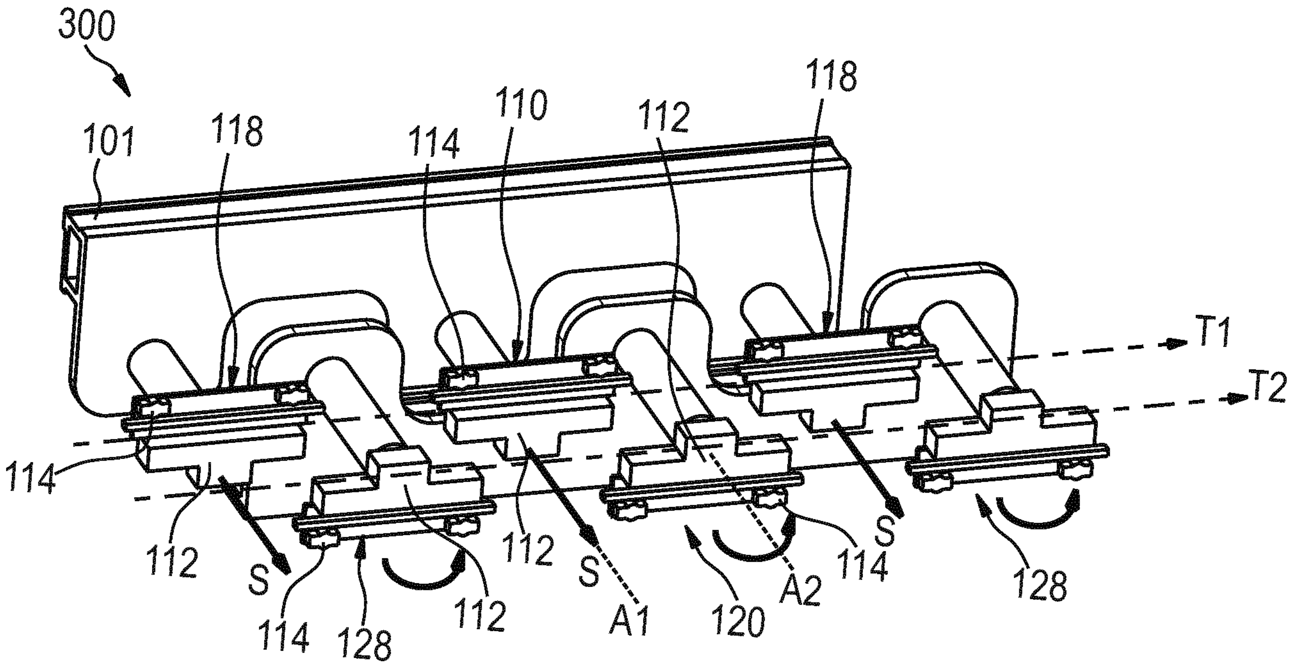

1000
A1
A2
300
118
110
118
10
T
101
20
T1
S
T2
P
105
128
120
128

FIG. 4


300
101
118
114
110
112
118
T1
T2
114
112
S
112
S
A1
120
A2
114
S
114
128
112
128

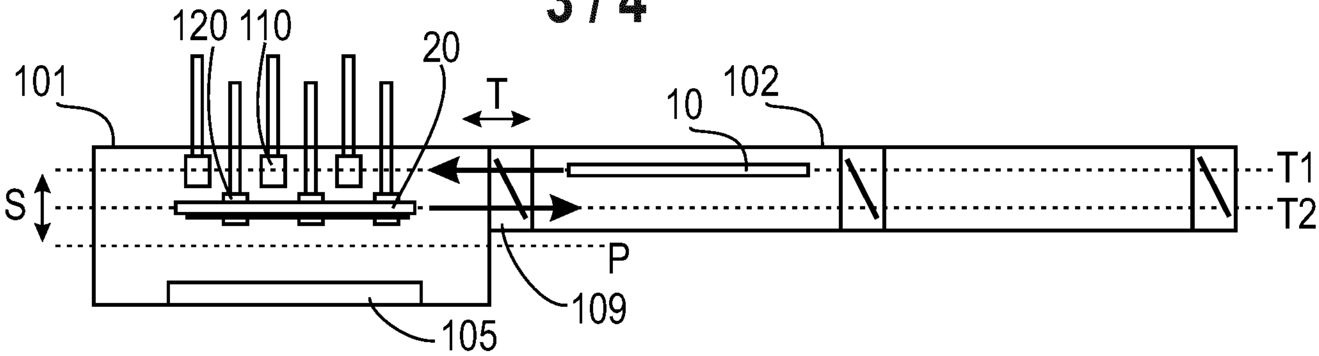


FIG. 5A

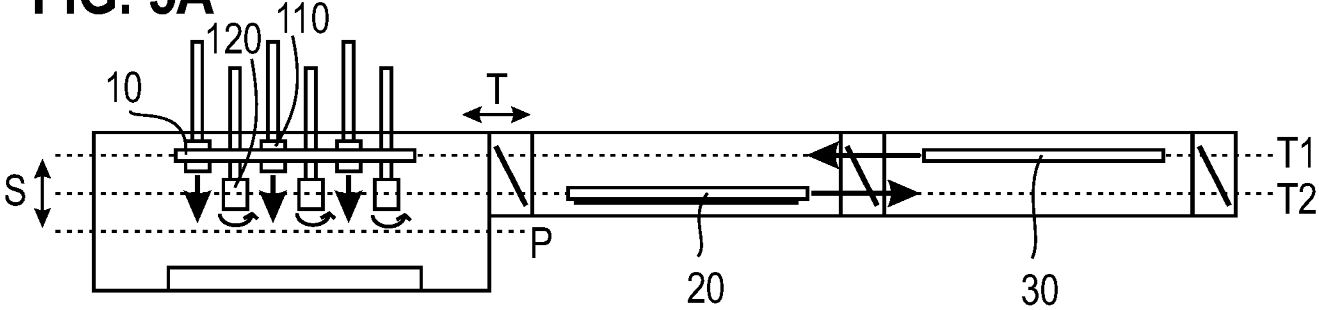


FIG. 5B

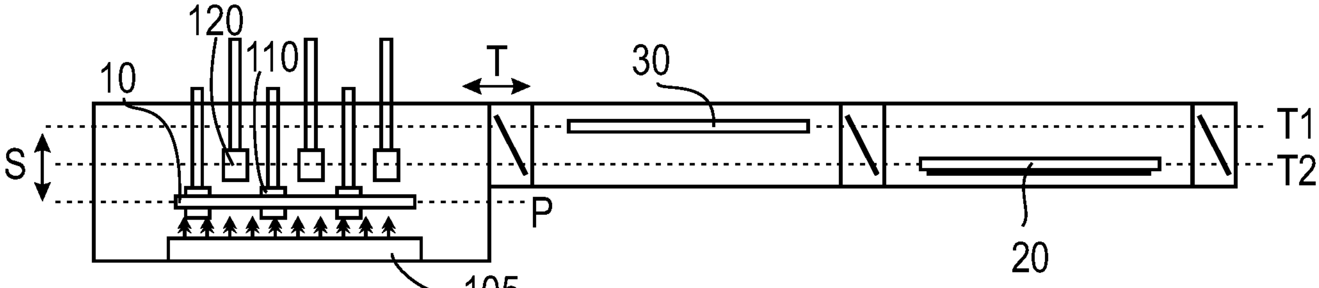


FIG. 5C

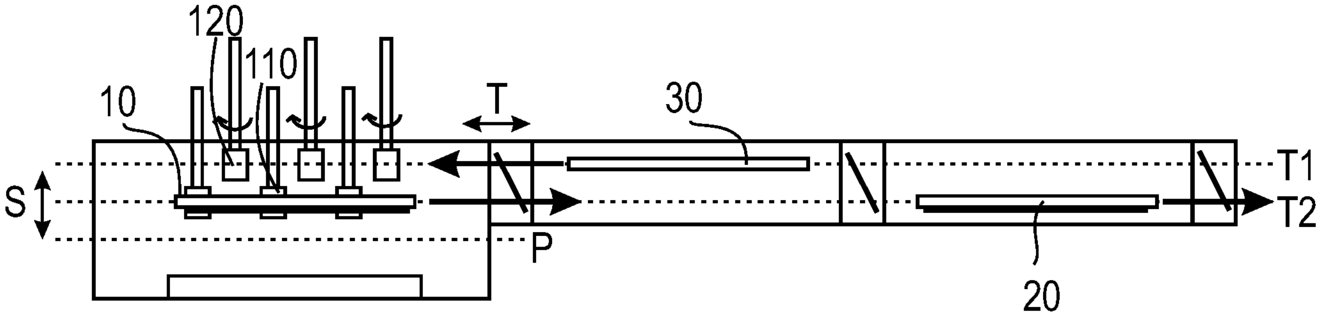


FIG. 5D

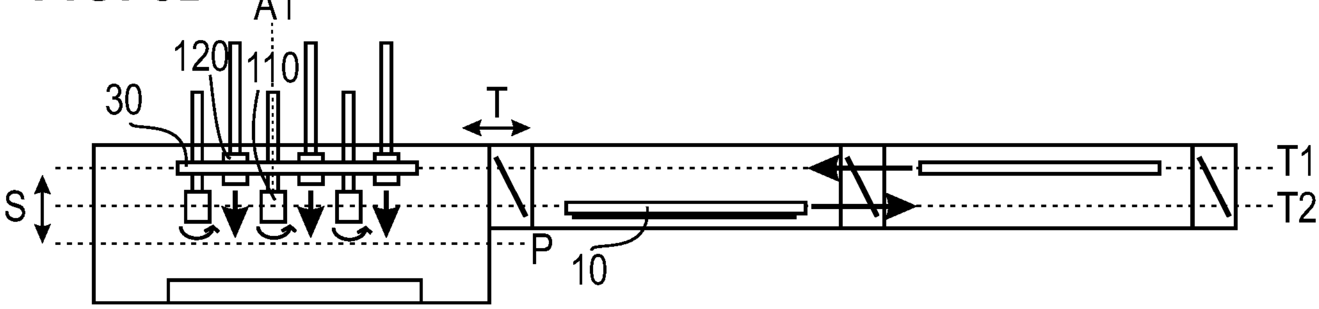


FIG. 5E

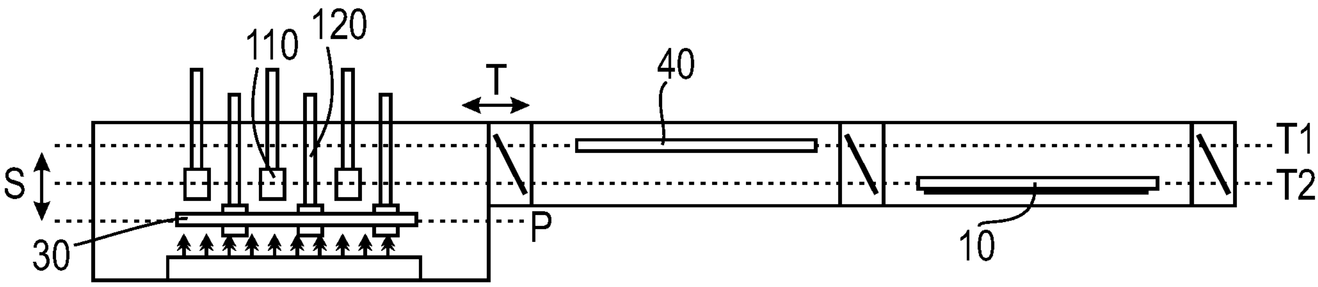


FIG. 5F

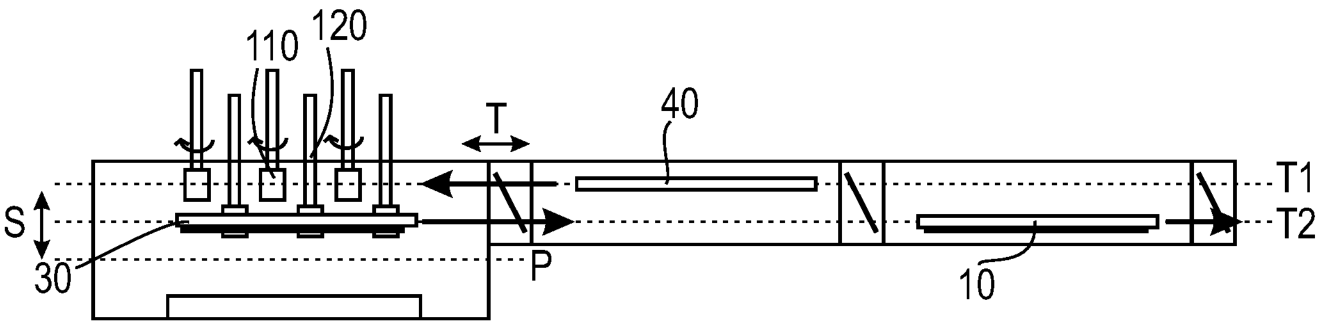


FIG. 5G

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2021/083133

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/677
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.
A	WO 2020/200443 A1 (APPLIED MATERIALS INC [US]; HEIMEL OLIVER [DE]; LINDENBERG RALPH [DE]) 8 October 2020 (2020-10-08) abstract; figures 1-4 -----	1-20

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

☒ See patent family annex.

* Special categories of cited documents :

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"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 July 2022	21/07/2022

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	Oberle, Thierry

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2021/083133

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2020200443 A1	08-10-2020	CN 216435860 U	03-05-2022
		WO 2020200443 A1	08-10-2020

Form PCT/ISA/210 (patent family annex) (April 2005)