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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 June 2019 (27.06.2019)

(10) International Publication Number
WO 2019/121289 A1

(51) International Patent Classification:
C23C 14/50 (2006.01) *C23C 16/458* (2006.01)
C23C 14/56 (2006.01) *C23C 16/54* (2006.01)
C23C 16/44 (2006.01)

(21) International Application Number: PCT/EP2018/084688

(22) International Filing Date: 13 December 2018 (13.12.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
17209514.3 21 December 2017 (21.12.2017) EP

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(54) **Title:** SURFACE TREATMENT CHAMBER TRANSPORT SYSTEM

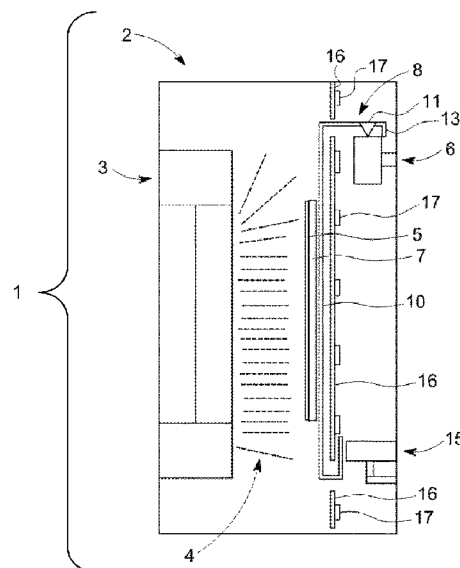

FIG. 2A

(57) **Abstract:** The present invention concerns a surface treatment assembly (1) extending along a longitudinal axis, X, a vertical axis Z and a transverse axis, Y; comprising: (a) a surface treatment chamber (2); (b) a surface treatment apparatus (3) located in the coating chamber; (c) a transport system (6) suitable for carrying at least one substrate (7) in the form of a sheet, through the surface treatment chamber from an entrance to an exit of the surface treatment chamber, said transport system comprising: i) a substrate carrier (8) suitable for holding the at least one substrate in a vertical plane, (Z, X), and for carrying the substrate to be treated into at least one position with respect to the surface treatment apparatus so that a surface of the substrate may be treated; ii) a drive system (9) suitable for driving the substrate carrier from the entrance to the exit of the surface treatment chamber in the longitudinal axis, X; characterised in that the substrate carrier comprises a vertical surface portion (20), extending along a vertical plane (Z, X), on which the at least one substrate

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[Continued on next page]

(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, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, 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, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

is held in a vertical plane; a top transverse surface portion (21), extending along a horizontal plane (X, Y);a bottom transverse surface portion (22), extending along a vertical plane (Z,X); and in that the substrate carrier has C-shaped cross section across a plane normal to the longitudinal axis, X; the C-shaped cross section comprising: a vertical portion (10) extending along the vertical axis, Z, from a top end to a bottom end and facing the coating apparatus; and a top transverse portion (11) and a bottom transverse portion (12), extending transverse to the top end and bottom end of the first portion, respectively; the vertical portion, the top transverse portion and the transverse bottom portion, defining an inner carrier volume (V), and in that the drive system is partially located in the inner carrier volume (V) and is suitable for coupling to the top transverse portion of the substrate carrier.

Surface Treatment Chamber Transport System

The invention refers to a surface treatment chamber as well as a method of transporting a substrate within a surface treatment chamber, and especially within a vacuum surface treatment chamber in which thin film deposition techniques like low pressure chemical vapor deposition (LPCVD) processes, plasma enhanced chemical vapor 5 deposition (PECVD) processes, physical vapor deposition (PVD) processes or sputter processes may be carried out.

Low pressure surface treatment techniques encompass coating techniques as well as surface treatment techniques, such as surface activation and surface cleaning, as well as ion implantation techniques. Low pressure surface treatment techniques are widely 10 used in industry for the surface treatment of a wide variety of materials that are compatible with low pressures. An exemplary material is glass, surface treated glass substrates for architectural and automotive use or for use in connection with displays, like thin film transistor TFT displays, organic light emitting diode (OLED) displays etc. must be coated with thin films. Other materials are metals and metal alloys, or polymers, or may be 15 crystalline such as sapphire or silicon carbide.

For all these materials it is desirable that homogeneous and uniform surface treatments are achieved. In addition, achieving high efficiencies in the surface treatment processes is necessary to keep costs low and to obtain competitive results. Accordingly, various methods and apparatuses have been suggested in prior art to obtain high quality 20 surface treatments at reasonable prices.

Among the various methods for carrying out surface treatments, such as for example the deposition of coatings, continuous processes are preferred for large scale substrates, such as those used for displays or architectural applications, but also for large numbers of smaller substrates being treated simultaneously. The substrate to be surface 25 treated is continuously moved through the coating zone, defined by the coating source, by means of movable substrate carriers. By doing this, large area substrates like architectural glass may be homogeneously coated, since due to the continuous movement of the substrate every point of the surface to be coated runs through the different areas of the

coating zone so that at least along the transport direction similar coating conditions are achieved at the whole substrate surface. The same holds true for large scale substrate carriers used for holding a large number of smaller substrates and for other surface treatment methods.

5 Stricter defect specifications have led to the development of vertical coaters wherein the substrate sheets as well as the coating device are held in an essentially vertical position. Debris generated from condensate build-up is the largest contributor of defects, such as pinholes for example, in a low pressure or vacuum coater. The condensate build-up originates from coating material deposited on parts of the coater, other than the 10 substrate. In these vertical coaters, most of the debris formed on shields and other internal elements falls down or away from the substrate surface.

As illustrated in Figure 1A, many transport systems (6) comprise a bottom conveyor. The bottom conveyor typically comprises a driving entity which is a row of conveyor rolls on which the substrate (7) or the substrate carrier (8) is positioned. Motor-15 driven chains or belts daisy chain the conveyor rolls to transport the substrate through the surface treatment chambers (2). The conveyor also comprises retaining rolls positioned in line with the upper edge of the substrates or substrate carriers for maintaining the substrates in their vertical position (not illustrated). However, the debris formed on shields and other internal elements tends to fall and accumulate on the conveyor's driving entity, 20 necessitating regular, time-consuming maintenance.

Substrate carriers (8) used in vertical surface treatment chambers vary greatly depending on substrate shape or size. Generally, they depend on their sturdy outer rectangular frame for carrying the weight of the substrates as pictured in Figures 1B and 1C. The frame also holds the fixation mechanism for holding one or more substrates. Large 25 substrate carriers, i.e. larger than 1 by 1 m^2, as well as large numbers of smaller substrates occupying an area of more than 1 by 1 m^2 on the carrier, call for a particularly rigid design, the frame having a thickness of several centimetres to be able to hold up the carriers' weight without distortion. These thick heavy substrate carriers have several drawbacks. The surface treatment chambers are provided with openings for moving substrate carriers 30 in and out. Due to the thickness of the frames these openings in the surface treatment

chambers must be relatively large. This means that it is difficult to avoid pollution of the process atmosphere in this chamber from process atmospheres neighbouring chambers. With the more recent complex multi-layer coatings and their significantly higher quality requirements this inter chamber pollution has become a limiting factor. Indeed, multi-layer coatings may for example comprise one or more metal layers, as well as several dielectric layers, such as metal oxide or metal nitride layers. Typically, contamination of the argon atmosphere of a metal sputtering chamber with nitrogen or oxygen from a neighbouring dielectric sputtering chamber will degrade the metal layer’s properties. Similar problems arise in the deposition in neighbouring chambers of oxides and nitrides, or even of different oxides requiring different process atmospheres, e.g. oxygen partial pressures. Gas isolation systems may be inserted in between depositing zones to separate different processes to reduce the contamination from neighbouring chambers, but their efficiency is highly dependent on the openings necessary for the transfer of the substrates.

These increasingly complex multilayer coatings also require the substrates to be held at precise distances from the coating sources. The typical transport system / substrate carrier combination described above leads to additional difficulties. In fact, the weight and high centre of gravity of these substrate carriers tends to pull the carriers out of their vertical alignment. This amplifies vibrational tilting movements and leads to variations in the substrate - coating source distances which are detrimental to coating thickness uniformity.

US5660114 discloses a transport system with an overhead drive system that can support weight with greater stability than a bottom drive system. However, overhead drive systems are generally disfavoured in low pressure surface treatment environments since such systems can generate more particulate contamination than bottom drive systems since the drive's mechanical components are above the surface of the substrate, and mechanical interaction between the mechanical components of the drive system on which condensate build-up has occurred, can cause contamination to fall on the substrate as the substrate is moved through the system.

DE102015116738 discloses a transport system with an overhead drive system. A substrate carrier is attached to a supporting structure is suspended from a drive system

and additional weights and spring mechanisms are attached to the substrate carrier in order to reduce vibrations.

There is therefore a need to provide surface treatment chamber that allows the deposition of very high quality coatings, that avoids debris related problems, that maintains precise substrate coating device distances, and that limits the diffusion of atmospheres in between neighbouring chambers.

The present invention relates to a low pressure surface treatment assembly extending along a longitudinal axis, X, a vertical axis Z and a transverse axis, Y; comprising:

(a) a surface treatment chamber;

(b) a surface treatment apparatus located in the coating chamber;

(c) a transport system suitable for carrying at least one substrate in the form of a sheet, through the surface treatment chamber from an entrance to an exit of the surface treatment chamber, said transport system comprising:

i. a substrate carrier suitable for holding the at least one substrate in a vertical plane, (Z, X), and for carrying the substrate to be treated into at least one position with respect to the surface treatment apparatus so that a surface of the substrate may be treated;

ii. a drive system suitable for driving the substrate carrier from the entrance to the exit of the surface treatment chamber in the longitudinal axis, X;

characterised in that the substrate carrier comprises

- a vertical surface portion (20), extending along a vertical plane (Z, X), on which the at least one substrate is held in a vertical plane;

- a top transverse surface portion (21), extending along a horizontal plane (X, Y);

- a bottom transverse surface portion (22), extending along a vertical plane (Z,X); and

in that the substrate carrier has C-shaped cross section across a plane normal to the longitudinal axis, X; the C-shaped cross section comprising:

5 - a vertical portion extending along the vertical axis, Z, from a top end to a bottom end and facing the surface treatment apparatus; and

- a top transverse portion and a bottom transverse portion, extending transverse to the top end and bottom end of the first portion, respectively;

the vertical portion, the top transverse portion and the transverse bottom 10 portion, defining an inner carrier volume (V), and

in that the drive system is partially located in the inner carrier volume (V) and is suitable for coupling to the top transverse portion of the substrate carrier.

The present invention further relates to method for treating a surface of a substrate in the form of a sheet comprising the following steps:

15 (a) providing a surface treatment assembly according to the present invention;

(b) loading the at least one substrate on a substrate carrier;

(c) driving the substrate carrier into the surface treatment chamber;

(d) treating the surface of the substrate as the substrate carrier is being driven 20 towards the exit.

Other aspects and advantages of the embodiments will become apparent from the following detailed description taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the described embodiments.

Figure 1A shows a cross sectional view of a surface treatment chamber with a transport system having a bottom drive system and a substrate carrier according to prior art Figure1B shows a perspective view of the substrate carrier according to prior art, and Figure 1C shows a cross sectional view of the substrate carrier according to prior art.

5 Figures 2A to 2E show a surface treatment chamber with a transport system having an overhead drive system and a substrate carrier according to the present invention, including (2A) a cross sectional view of the chamber, (2B) a perspective view of the substrate carrier, and (2C) (2D) (2E) cross sectional views of the substrate carrier.

Figure 3 shows a perspective view of a surface treatment chamber with a 10 transport system having an overhead drive system and a substrate carrier according to the present invention.

Figures 4A and 4B illustrate the self-stabilizing ability of a substrate carrier according to an embodiment of the present invention.

The present invention relates to a vertical surface treatment chamber, 15 preferably a low pressure treatment chamber, more preferably a vacuum surface treatment chamber, preferably to be used in a continuous process. It is an object of the present invention to provide a surface treatment chamber as well as a substrate transport system within the chamber which allows high quality surface treatment especially with respect to thickness homogeneity and while at the same time reducing maintenance down-20 time and debris-related defects.

As illustrated in Figure 2A, the present invention relates to a surface treatment assembly (1) extending along a longitudinal axis, X, a vertical axis Z and a transverse axis, Y; comprising: (a) a surface treatment chamber (2); (b) a surface treatment apparatus (3) located in the surface treatment chamber; (c) a transport system (6) suitable for carrying 25 at least one substrate (7) in the form of a sheet, through the surface treatment chamber from an entrance to an exit of the surface treatment chamber. The transport system comprises (i) a substrate carrier suitable for holding the at least one substrate in a vertical plane, (Z, X), and for carrying the substrate or substrates to be coated into at least one position with respect to the surface treatment apparatus so that a surface of the substrate

may be coated and (ii) a drive system (9) suitable for driving the substrate carrier from the entrance to the exit of the surface treatment chamber in the longitudinal axis, X.

The substrate carrier (8) of the transport system of the present invention, has C-shaped cross section across a plane normal to the longitudinal axis, X. As shown in Figure 2B and 2C, comprises a vertical surface portion (20), extending along a vertical plane (Z, X), on which the at least one substrate is held in a vertical plane; a top transverse surface portion (21), extending along a horizontal plane (X, Y); a bottom transverse surface portion (22), extending along a vertical plane (Z,X). The substrate carrier's C-shaped cross section thus comprises a vertical portion (10) extending along the vertical axis, Z, from a top end to a bottom end and facing the coating apparatus; and a top transverse portion (11) and a bottom transverse portion (12), extending transverse to the top end and bottom end of the first portion, respectively. The vertical portion, the top transverse portion and the transverse bottom portion, define an inner carrier volume (V). In certain embodiments, the substrate carrier further comprises a top vertical surface portion (23) extending along a vertical plane (X, Z) and/or a bottom vertical surface portion (24) extending along a vertical plane (X, Z). The C-shaped cross section of the substrate carrier may thus comprise a top vertical portion (13) extending along the vertical axis, Z, from the top transverse portion towards the bottom transverse portion, and/or a bottom vertical portion (14) extending along the vertical axis, Z, from the bottom transverse portion towards the top transverse portion - See Figure 2D and 2E.

The drive system (6) of the transport system of the present invention is partially located in the inner carrier volume (V) of the substrate carrier and is suitable for coupling to the top transverse portion (11) of the substrate carrier (8). The substrate carrier of the present invention is directly coupled to the drive system, i.e. there is no additional supporting structure in between the substrate carrier and the drive system.

Figure 3 is a perspective view of a surface treatment assembly according to the present invention, picturing a surface treatment chamber (2); the transport system suitable for carrying at least one substrate (7) wherein the transport system comprises the substrate carrier (8) suitable for holding the at least one substrate in a vertical plane, (Z, X) on a vertical surface portion , and for carrying the substrate or substrates. Figure 3 shows the

drive system (6) suitable for driving the substrate carrier from the entrance to the exit of the surface treatment chamber in the longitudinal axis, X; partially located in the inner carrier volume (V) and coupled to the top transverse portion of the substrate carrier. Figure 3 further illustrate the substrate carrier with a C-shaped cross section across a plane normal
5 to the longitudinal axis, X. The C-shaped cross section comprises the vertical portion (10), the top transverse portion (11), the bottom transverse portion (12), and a top vertical portion (13) and a bottom vertical portion (14); all surface portions defining the outer boundaries of the inner carrier volume (V). The transport system further comprises a guiding system (15) at the bottom transverse portion of the substrate and shields (16) being
10 arranged to prevent the treatment of surfaces of the chamber, opposite from the surface treatment apparatus.

It has been surprisingly found that by designing a surface treatment chamber wherein the drive system is at least partially positioned within the inner volume of the carrier substrate, gives additional protection against debris formation. Furthermore,
15 hanging the substrate carrier from the drive system reduces the tilting motions versus bottom driven substrate carriers.

Additionally, the specific cross-sectional design of the substrate carrier of the present invention allows forming the entrance and exit of the surface treatment chamber by openings homothetically similar to the C-shaped cross section of the substrate carrier.
20 These C-shaped openings to be used in the surface treatment chambers that have a smaller surface area than the openings for substrate carriers of equivalent sized substrates having a rectangular cross section. Thereby the gas diffusion in between chambers is reduced, allowing for more homogeneous surface treatments.

25 The present invention relates to a surface treatment assembly extending along a longitudinal axis, X, a vertical axis Z and a transverse axis, Y; wherein X is normal to Y, which is normal to Z. The surface treatment chamber according to the present invention is a vertical surface treatment chamber, preferably to be used in a continuous treatment process.

The surface treatment chamber comprises a surface treatment apparatus. For the purpose of the present invention, surface treatment techniques encompass coating techniques as well as surface modification techniques, such as surface activation and surface cleaning, as well as ion implantation techniques. Low pressure surface treatment 5 techniques of the present invention can be used for the surface treatment of a wide variety of materials that are compatible with low pressures.

The surface treatment apparatus may thus be a surface modification source that that modifies the surface of the substrate without adding layers of materials on the substrate surface. Such surface modification apparatus may be plasma sources for cleaning 10 or for activating the surface. It may also ion sources for bombarding and/or implanting the surface with ions. It may also be a laser source for modifying the surface or the coatings present thereupon.

The surface treatment chamber according to the present invention may also be used for different deposition technologies and may be especially designed as a vacuum 15 chamber for carrying out vacuum deposition techniques like low pressure chemical vapour deposition LPCVD, plasma enhanced chemical vapour deposition PECVD, physical vapour deposition PVD and especially sputter processes. Other deposition techniques like vapour deposition by thermal evaporation may also be used. Accordingly, the surface treatment chamber comprises a surface treatment apparatus designed for such depositing 20 technologies. Especially, the surface treatment apparatus may comprise treatment tools including electrodes, magnetron sputtering cathodes, for example rotatable magnetron sputtering cathodes, showerhead electrodes, rotatable electrodes, twin cathodes , plasma sources, heaters, gas inlets, and evaporation sources etc. as well as combinations thereof. In general, all the treatment tools necessary for depositing a layer or performing a coating 25 process may be included in or attached to the surface treatment chamber. The surface treatment apparatus may comprise only a single treatment tool like a sputter magnetron electrode, or may comprise several treatment tools in order to form a surface treatment apparatus extending over a specific area of the surface treatment chamber. Such a two-dimensional surface treatment apparatus may for example comprise an array of magnetron 30 sputtering cathodes arranged adjacent to each other side by side so that bigger coating

areas can be achieved. Especially, the cathodes may be arranged with their longitudinal axes parallel to each other transverse to the transport direction of the substrate.

Accordingly, a substrate with a surface to be coated which is bigger in the transport direction than the extension of the two-dimensional coating source may be coated in a uniform way in a continuous coating process.

Although the surface treatment chamber of the present invention may be operated at atmospheric pressure, its advantages are particularly important in low pressure, high vacuum, processes at pressures comprised between 0.5 and 15 mTorr. In the high vacuum flow regime, gas density (pressure) is very low, few molecule-molecule collisions occur, and molecule-chamber wall collisions dominate the flow process (molecules are held back by walls). This makes it particularly difficult to control the diffusion of gas molecules in between neighbouring surface treatment chambers.

As used herein, the term “substrate” generally refers to a substrate in the form of a sheet, preferably in the form of a planar sheet. An exemplary substrate is glass, surface treated glass substrates that are used for architectural and automotive use or for use in connection with displays, or metals and metal alloys, or polymers, or may be crystalline such as sapphire or silicon carbide.

The transport system (6) provided in the surface treatment chamber comprises a substrate carrier (8) having a C-shaped cross-section. The substrate carrier comprises a vertical portion, generally a rectangular vertical portion onto which one or more substrates are affixed and which is held in an essentially upright, vertical position along the vertical axis Z. The vertical position of the substrate carrier of the present invention encompasses configurations adapted for supporting the substrate in a vertical offset configuration wherein the substrate may be offset from vertical by an acute angle comprised between 0° and 15°, preferably comprised between 5° and 10°. Furthermore, the vertical portion of the substrate carrier is not necessarily a straight line as long as it extends along the vertical axis Z.

The substrate carrier of the transport system of the chamber of the present invention, has C-shaped cross section across a plane normal to the longitudinal axis, X

wherein its vertical portion, its top transverse portion and its transverse bottom portion, define an inner carrier volume (V) as pictured in Figure 2E. In a preferred embodiment and as illustrated in Figure 2A to 2D, the C-shaped cross section further comprises a top vertical portion (13) extending along the vertical axis, Z, from the top transverse portion (11)
5 towards the bottom transverse portion (12), wherein a length, Lt, of the top vertical portion is not more than 30%, more preferably not more than 20%, most preferably not more than 5% of a length, Lv, of the vertical portion, wherein both Lt and Lv are measured along the vertical axis, Z. In another preferred embodiment, the C-shaped cross section further comprises a bottom vertical portion (14) extending along the vertical axis, Z, from the
10 bottom transverse portion (12) towards the top transverse portion (11), wherein a length, Lb, of the bottom vertical portion is not more than 30%, more preferably not more than 20%, most preferably not more than 5% of a length, Lv, of the vertical portion, wherein both Lb and Lv are measured along the vertical axis, Z. Preferably, the top vertical portion and the bottom vertical portion define an outer boundary of the inner carrier volume as
15 shown in Figure 2D.

In the present invention, the drive system of the transport system of the surface treatment assembly of the present invention, is partially located in the inner carrier volume (V) and is suitable for coupling to the top transverse portion of the substrate carrier, as shown in figure 2A. This location of the drive system defines an overhead apparatus that
20 secures and supports at least a majority of the weight of the substrate or substrate carrier at the top of the substrate carrier, such that the substrate carrier hangs from the transport system as the substrate is transported through the surface treatment chamber. In a preferred embodiment, the drive system is partially located between the vertical portion and the top vertical portion of the substrate carrier.

25 The drive system can comprise an electrical motor that is linked to conveyor rolls via chains, belts and/or cog wheels. The conveyor rolls transport the substrate carrier through the surface treatment chamber. The upper rail of the substrate carrier, which comprises or consists of the top transverse surface portion, is configured so as be supported and driven by the drive systems conveyor rolls. The substrate carrier is
30 essentially suspended or hanging on the conveyor rolls from the upper rail. The substrate carrier is able to rotate along a horizontal axis (18) formed by the contact points of the

upper rail with the conveyor rolls, the contact between the substrate carrier and the conveyor rolls is made on the top of the conveyor rolls.

In a preferred embodiment of the present invention and as illustrated in Figure 2A, the transport system preferably further comprises a guiding system (15) suitable for engaging the bottom transverse portion of the substrate carrier and for guiding the substrate carrier from the entrance to the exit of the surface treatment chamber along the longitudinal axis, X. Suitable guiding means are maintaining rolls, contactless s or magnetic guides. The main purpose of the guiding system is to maintain the substrate carrier in an essentially vertical position. As illustrated in Figure 4A, the guiding system (15), by contacting the bottom transverse portion or the bottom vertical portion, stops the substrate carrier from rotating around the rotational, horizontal axis (18) beyond the vertical position desired for the substrate. When vibration induces a rotation of the substrate carrier out of its essentially vertical position, as illustrated in Figure 4B, the center of gravity (25) induces a rotational moment (19a) around the horizontal axis (18) that moves the bottom portion of the substrate carrier back (19b) towards the guiding system. The substrate carrier, due to its chosen shape is essentially self-stabilizing. The chosen shape of the substrate carrier positions the center of gravity of the substrate carrier not in a vertical plane (X, Z) passing through the rotational axis (18), but in a vertical plane that is positioned in a Y direction further away from the drive system (6) and the guiding system (15).

As mentioned hereinabove, the essentially vertical position of the substrate carrier of the present invention encompasses configurations adapted for supporting the substrate in a vertical offset configuration wherein the substrate is may be offset from vertical by an acute angle greater comprised between 0° and 15°, preferably comprised between 5° and 10°. The bottom vertical portion is preferably configured so as to slide against the drive system's maintaining rolls.

The substrate carriers' dimensions are configured so that its weight, together with the one or more substrates, holds its lower edge against the maintaining rolls. In this way, the inventors found, the gravitational force helps to stabilize the position of the substrate carrier throughout its transport through the surface treatment chambers.

Dimensions of the substrate carriers should accommodate large substrates: such as for example for displays of 300 mm x 400 mm size to the current 2940 mm x 3370 mm size; to very large substrates such as building windows with up to 3500 mm height and up to 6500 mm long. Alternatively a single substrate carrier may accommodate at least two smaller substrates less than 300 mm x 400mm in size, arranged to cover a total surface from 300mm x 400mm to 3500mm x 6500mm. Therefore, the size of the substrate carrier could range from >300mm to >3500 mm in height and >400 mm to >6500 mm in length, , for example from 300mm to 3600mm in height and 400mm to 6600mm in length, for example from 300mm to 3500mm in height and 400mm to 6500mm in length. The substrate carrier height, equivalent to the vertical portion, may for instance be ≤ 3600mm and > 300 mm, >400mm, >500 mm, >600 mm, >700 mm, >800 mm, >1000 mm, >1500 mm, >1900 mm, or >2000 mm. The substrate carrier length may for instance be ≤ 6500mm and > 400 mm, >500 mm, >700 mm, >800 mm, >900 mm, >1000 mm, >1200 mm, >1800 mm, >2200 mm, >2300 mm, or >2500 mm. Means for attaching one or more substrates, such as clamps or rails, may be provided on the substrate carrier. It is possible to attach the substrate at its top edge and/or at its bottom edge and at both lateral edges.

In particular for single large substrates it is possible for the substrate carrier's height and length dimensions to be smaller than the substrate's height and length dimensions to further reduce the weight of the substrate carrier. In this case the substrate is attached preferably by one, two or at most three of its edges.

Preferred dimensions for the substrate carrier could be for the different portions as follows: a vertical portion, equivalent to the substrate carrier height, ranging from 300 mm to 3600 mm, for instance from 500 mm to 3600 mm; a top transverse portion ranging from 25mm to 100mm, preferably 45 mm to 55 mm; a bottom transverse portion ranging from 25 mm to 100 mm, preferably 27 mm to 33 mm; a top vertical portion ranging from 15 mm to 100 mm preferably 20 mm to 24 mm; and a bottom vertical portion ranging from 25 mm to 100 mm, preferably 55 mm to 65 mm.

In a preferred embodiment, the surface treatment chamber of the present invention also comprises at least one shield (16) preventing the treatment of certain surfaces of the surface treatment chamber. A vertical shield system comprising one or

more shields can be positioned to protect certain surfaces of the surface treatment chamber opposite to the surface treatment apparatus. The vertical shield system can comprise a central shield which is positioned within the inner volume of the substrate carrier. The vertical shield system can further comprise an upper shield and/or a lower
5 shield that are positioned above and below the substrate carrier respectively. The distance in between the central shield and the upper and lower shields respectively can be kept very small so as to allow free movement of the substrate carrier while minimizing the impact of the surface treatment on the surfaces of the drive system, the guiding system and/or the surfaces of the surface treatment chamber. The surface treatment chamber can also
10 comprise shields specifically protecting the upper and/or lower surfaces of the surface treatment chamber.

In a preferred embodiment the central shield further comprises means for cooling (17). Circulating coolant fluid, such as water, is provided to heat exchangers, or sputtering shields to maintain temperatures within acceptable operating levels during
15 production and to prevent rapid deterioration of these system components. A coolant control sub-system can be added to monitor the temperature level of the coolant in the coolant system and controls the open/close states of coolant flow control valves.

In a preferred embodiment, the entrance and exit of the surface treatment chamber are formed by openings homothetically similar to the C-shaped cross section of
20 the substrate carrier. Indeed, it has been found that the C-shaped opening has a smaller surface area than an equivalent rectangular opening and was found to significantly limit the exchange of gases in between neighbouring chambers.

The present invention further relates to a method for treating a surface of a substrate in the form of a sheet comprising the following steps:

25
- providing a surface treatment assembly as described above;
- loading the substrate on a substrate carrier;
- driving the substrate carrier into the surface treatment chamber;

- treating the surface of the substrate as the surface carrier is being driven towards the exit.

In a preferred embodiment, vacuum is provided in the surface treatment chamber by one or more vacuum pumps.

Ref.#	Feature
1	Low pressure surface treatment assembly
2	Surface treatment chamber
3	Surface treatment apparatus
4	Surface treatment
5	Surface treatment layer
6	Transport system
7	Substrate
8	Substrate carrier having a C-shaped cross section
9	Drive system
10	Vertical Portion of the C-shaped cross-section
11	Top Transverse Portion of the C-Shaped cross-section
12	Bottom Transverse Portion of the C-shaped cross-section
13	Top Vertical Portion of the C-Shaped cross-section
14	Bottom Vertical Portion of the C-Shaped cross-section
15	Guiding system
16	Shield
17	Cooling element
20	Vertical Surface Portion of the substrate carrier
21	Top Transverse Surface Portion of the substrate carrier

22	Bottom Transverse Surface Portion of the substrate carrier
23	Top Vertical Surface Portion of the substrate carrier
24	Bottom Vertical Surface Portion of the substrate carrier
V	Inner volume of the Substrate Carrier

CLAIMS

1. A surface treatment assembly (1) extending along a longitudinal axis, X, a vertical axis Z and a transverse axis, Y; comprising:

(a) a surface treatment chamber (2);

5 (b) a surface treatment apparatus (3) located in the surface treatment chamber;

(c) a transport system (6) suitable for carrying at least one substrate (7) in the form of a sheet, through the surface treatment chamber from an entrance to an exit of the surface treatment chamber, said transport system comprising:

10 i. a substrate carrier (8) suitable for holding the at least one substrate in a vertical plane, (Z, X), and for carrying the substrate to be treated into at least one position with respect to the surface treatment apparatus so that a surface of the substrate may be treated;

ii. a drive system (9) suitable for driving the substrate carrier from the

15 entrance to the exit of the surface treatment chamber in the longitudinal axis, X;

characterised in that the substrate carrier comprises

- a vertical surface portion (20), extending along a vertical plane (Z, X), on which the at least one substrate is held in a vertical plane;

- a top transverse surface portion (21), extending along a horizontal
20 plane (X, Y);

- a bottom transverse surface portion (22), extending along a vertical plane (Z,X); and

in that the substrate carrier has C-shaped cross section across a plane normal to the longitudinal axis, X; the C-shaped cross section comprising:

- a vertical portion (10) extending along the vertical axis, Z, from a top end to a bottom end and facing the surface treatment apparatus; and

- a top transverse portion (11) and a bottom transverse portion (12), extending transverse to the top end and bottom end of the first
5 portion, respectively;

the vertical portion, the top transverse portion and the transverse bottom portion, defining an inner carrier volume (V), and

in that the drive system is partially located in the inner carrier volume (V) and is suitable for coupling to the top transverse portion of the substrate carrier.

10 2. A surface treatment assembly according to claim 1 wherein the substrate carrier further comprises a top vertical surface portion (23) extending along a vertical plane (X, Z) and wherein the substrate carrier's C-shaped cross section further comprises a top vertical portion (13) extending along the vertical axis, Z, from the top transverse portion towards the bottom transverse portion, wherein a length, Lt, of the top vertical portion is
15 not more than 30%, more preferably not more than 20%, most preferably not more than 5% of a length, Lv, of the vertical portion, wherein both Lt and Lv are measured along the vertical axis, Z.

3. A surface treatment assembly according to any one of the preceding claims wherein the substrate carrier further comprises a bottom vertical portion (24) extending
20 along a vertical plane (X, Z) and wherein the substrate carrier's C-shaped cross section further comprises a bottom vertical portion (14) extending along the vertical axis, Z, from the bottom transverse portion towards the top transverse portion, wherein a length, Lb, of the bottom vertical portion is not more than 30%, more preferably not more than 20%, most preferably not more than 5% of a length, Lv, of the vertical portion, wherein both Lb
25 and Lv are measured along the vertical axis, Z.

4. A surface treatment assembly according to any one of claims 2 to 3 wherein the top vertical surface portion and the bottom vertical surface portion define an outer boundary of the inner carrier volume (V).

5. A surface treatment assembly according to any one of the preceding claims 2 to 4 wherein the drive system is partially located between the vertical surface portion and the top vertical surface portion.

6. A surface treatment assembly according to any one of the preceding claims
5 wherein the coating chamber is a low pressure surface treatment chamber, preferably a vacuum surface treatment chamber.

7. A surface treatment assembly according to any one of the preceding claims wherein the entrance and exit of the surface treatment chamber are formed by openings homothetically similar to the C-shaped cross section of the substrate carrier.

10 8. A surface treatment assembly according to any one of the preceding claims wherein the transport system further comprises a guiding system (15) suitable for engaging the bottom transverse surface portion and/or the bottom vertical surface portion of the substrate carrier and for guiding the substrate carrier from the entrance to the exit of the surface treatment chamber along the longitudinal axis, X.

15 9. A surface treatment assembly according to any one of the preceding claims wherein the low pressure surface treatment chamber further comprises at least one shield (16) being arranged to prevent the treatment of surfaces of the surface treatment chamber.

10. A surface treatment assembly according to any one of the preceding claims
20 wherein the at least one shields comprise cooling elements (17).

11. A method for treating a surface of a substrate in the form of a sheet comprising the following steps:

(a) providing a surface treatment assembly according to any one of the preceding claims;

25 (b) loading the substrate on a substrate carrier;

(c) driving the substrate carrier into the surface treatment chamber;

(d) treating the surface of the substrate as the surface carrier is being driven towards the exit.

12. A method for treating a surface of a substrate according to claim 11 further comprising creating a vacuum in the surface treatment chamber.

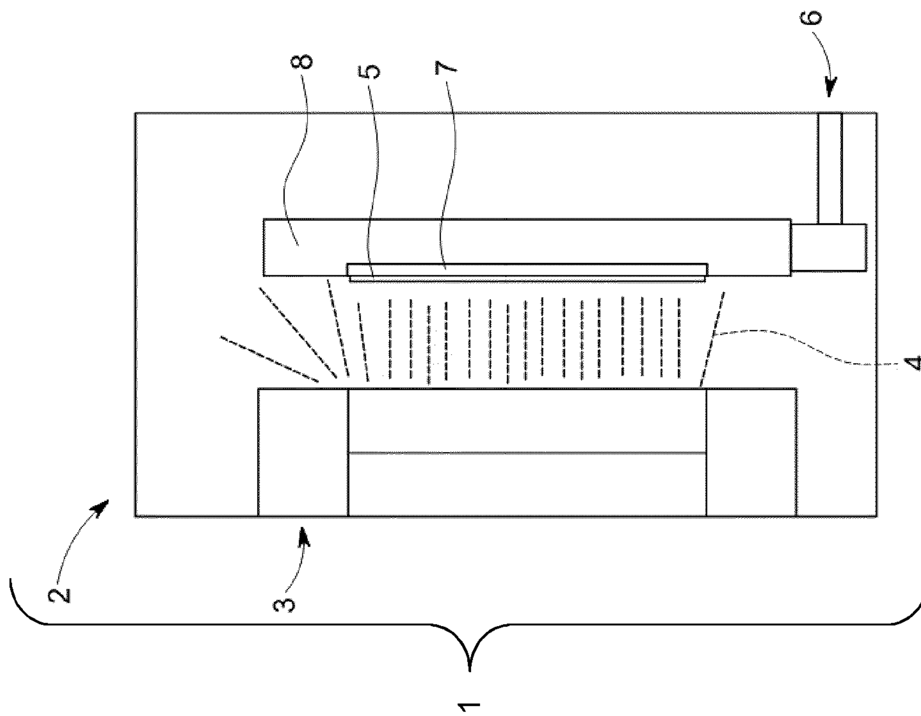

FIG. 1A
PRIOR ART

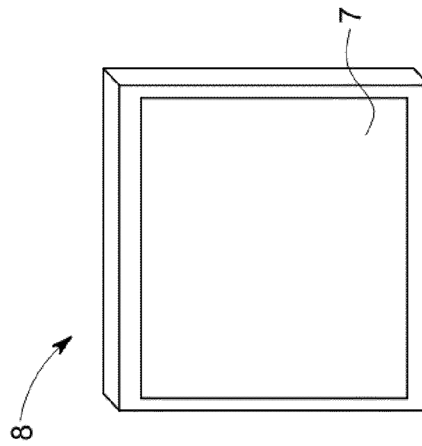

FIG. 1B
PRIOR ART

FIG. 1C
PRIOR ART

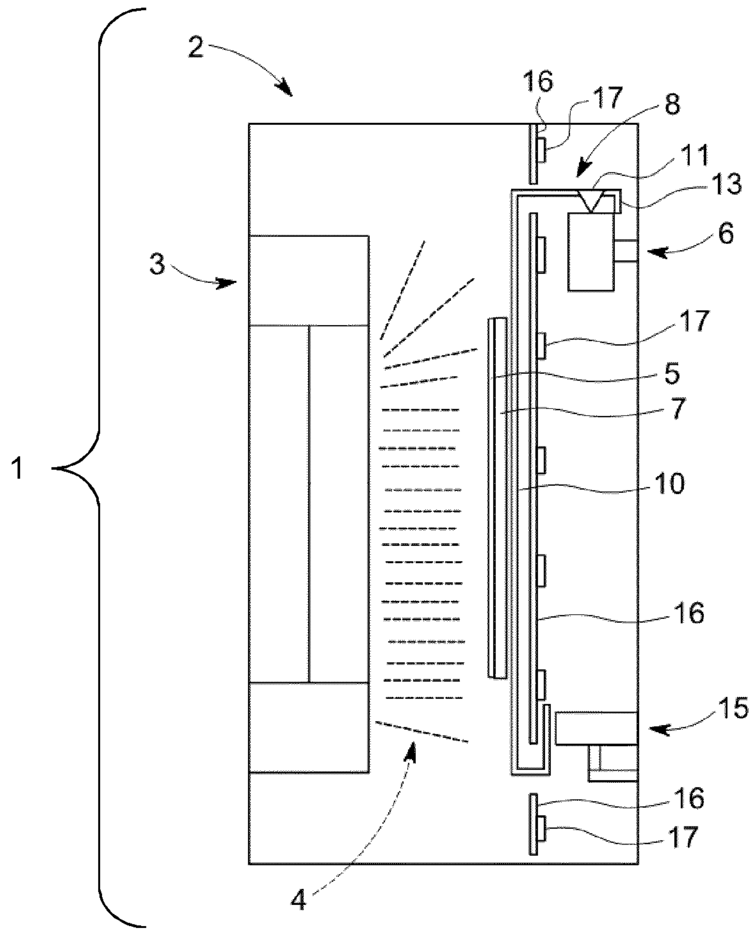

FIG. 2A

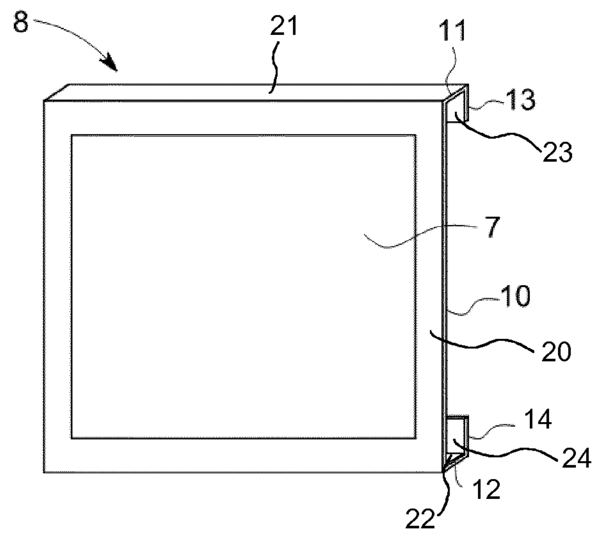

FIG. 2B

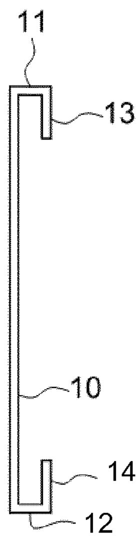

FIG. 2C

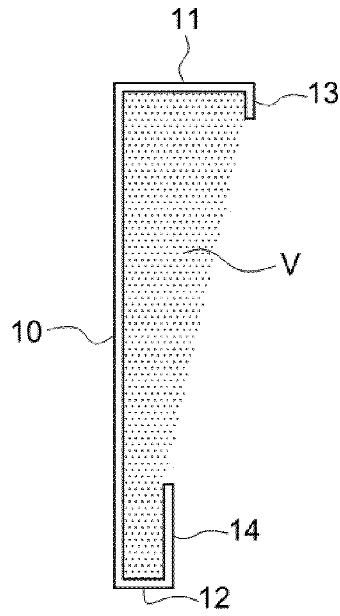

FIG. 2D

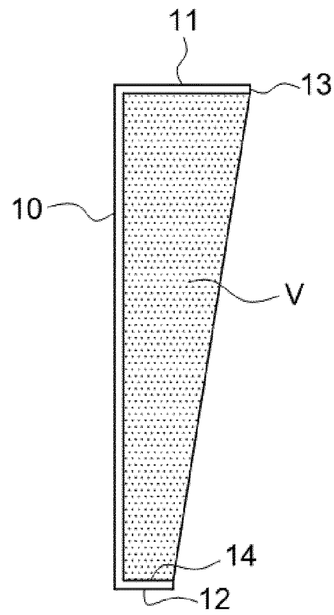

FIG. 2E

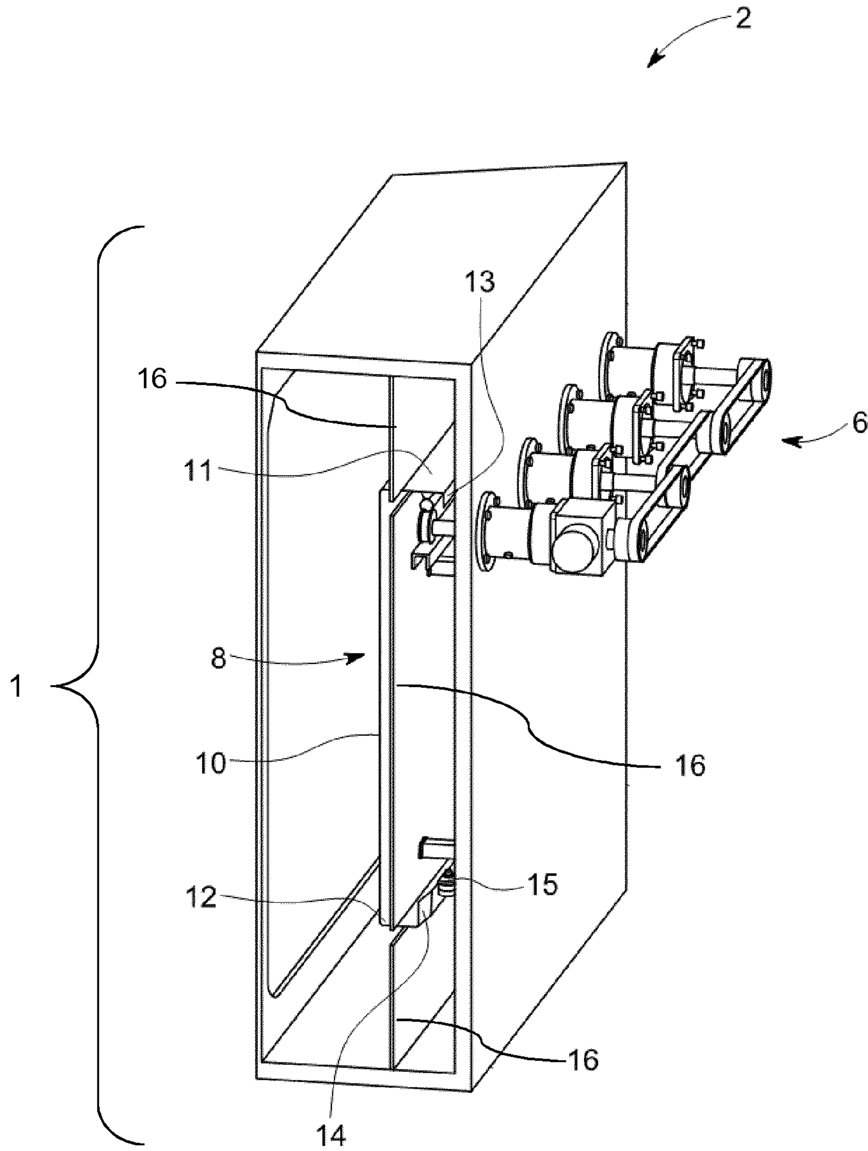

FIG. 3

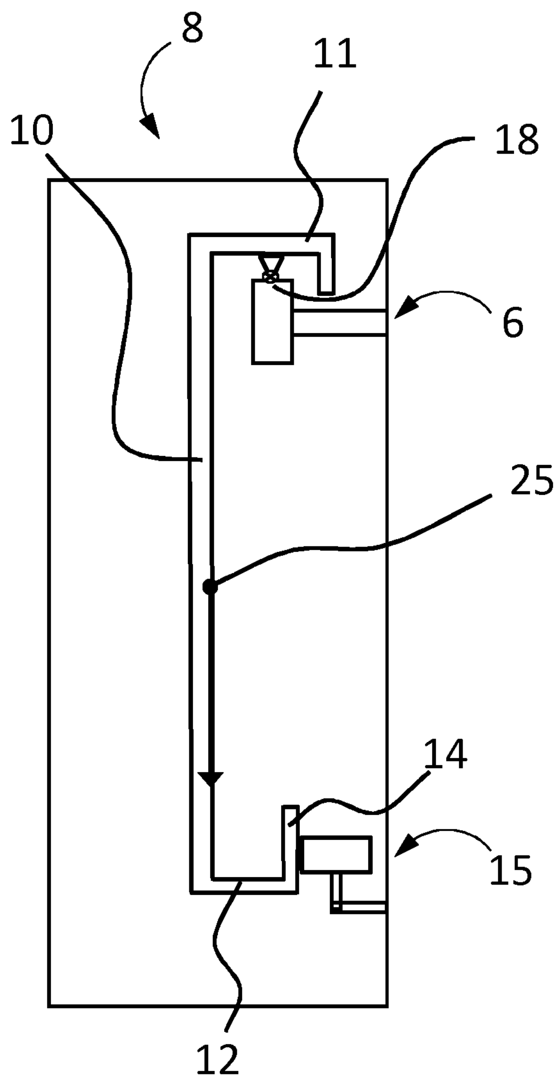

FIG. 4A

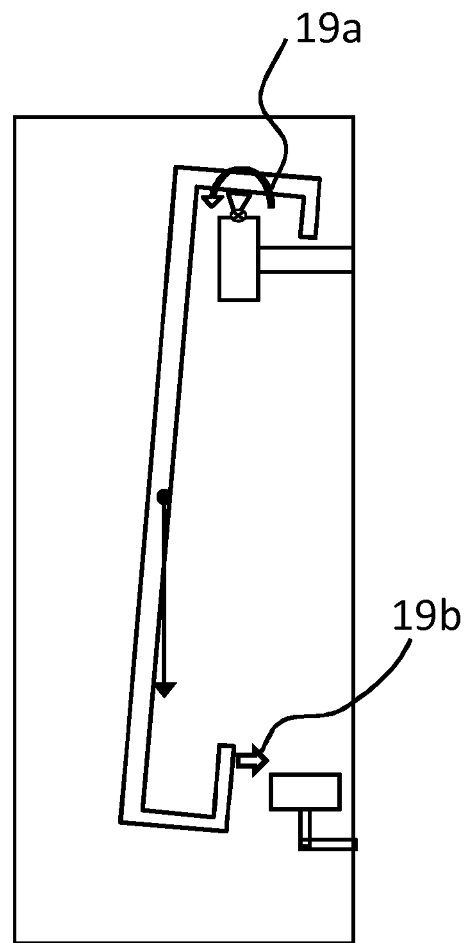

FIG. 4B

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/084688

A. CLASSIFICATION OF SUBJECT MATTER
INV. C23C14/50 C23C14/56 C23C16/44 C23C16/458 C23C16/54
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)
C23C 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	DE 10 2015 116738 A1 (ARDENNE GMBH VON [DE]) 6 April 2017 (2017-04-06) page 2, paragraphs 2,5,6 - page 5, paragraphs 38,39; figures 3A,3B,5A,5B -----	1-12
X	JP 3 462015 B2 (SHARP KK) 5 November 2003 (2003-11-05) paragraphs [0001], [0036], [0037], [0041], [0042], [0062], [0095]; claims 1,6,7 -----	1-12
A	DE 20 2008 004228 U1 (GRENZEBACH MASCHB GMBH [DE]) 29 May 2008 (2008-05-29) the whole document -----	1-12
A	DE 10 2011 083139 A1 (ARDENNE ANLAGENTECH GMBH [DE]) 21 March 2013 (2013-03-21) the whole document -----	1-12

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

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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
9 April 2019	16/04/2019

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	Boussard, Nadège

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/084688

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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DE 202008004228 U1	29-05-2008	NONE	
DE 102011083139 A1	21-03-2013	NONE	