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(54) **SPUTTERING APPARATUS INCLUDING  
NOVEL TARGET MOUNTING AND/OR  
CONTROL**

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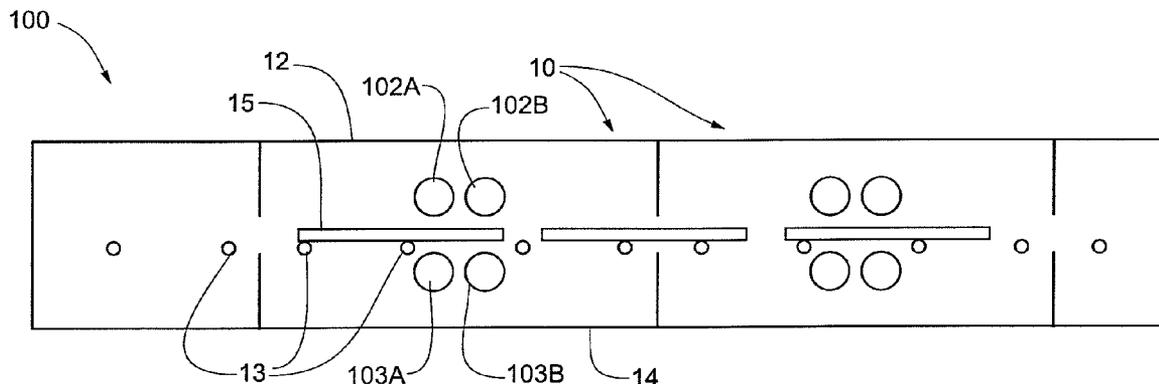
(57) **ABSTRACT**

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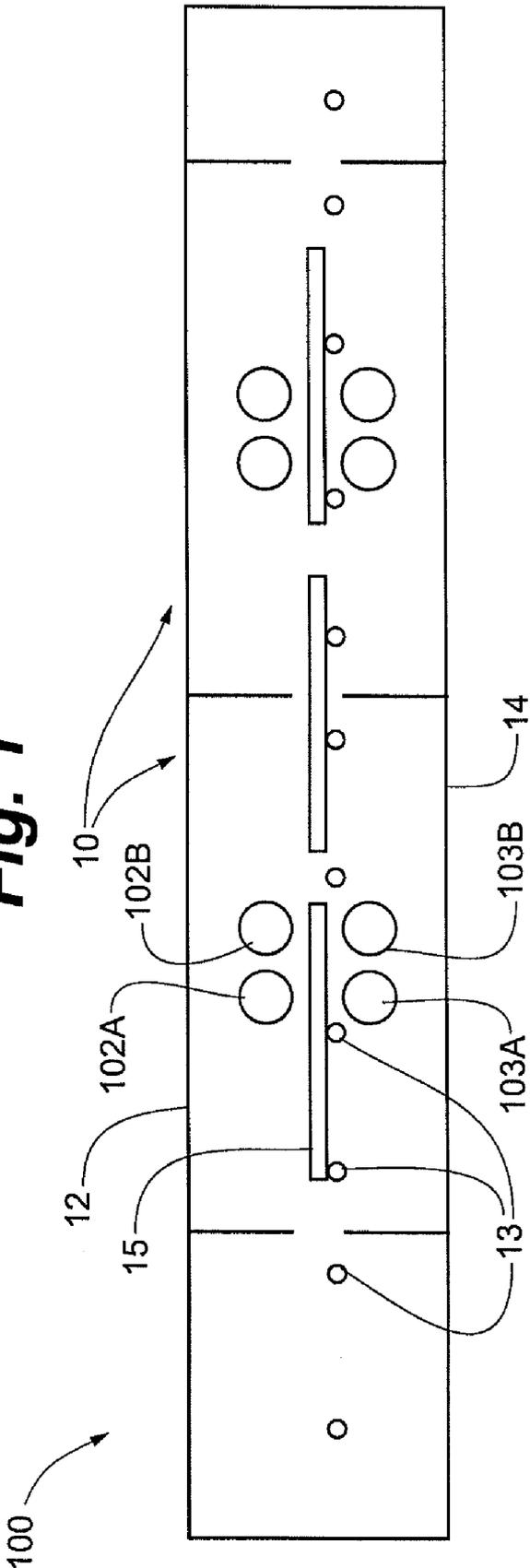
A sputtering chamber includes at least two sputtering targets, one of the at least two targets disposed on a first side a substrate conveyor extending within the chamber, and another of the at least two targets disposed on a second side of the conveyor. The at least two targets may be independently operable, and at least one of the targets, if inactivated, may be protected by a shielding apparatus. Both of the at least two targets may be mounted to a first wall of a plurality of walls enclosing the sputtering chamber.

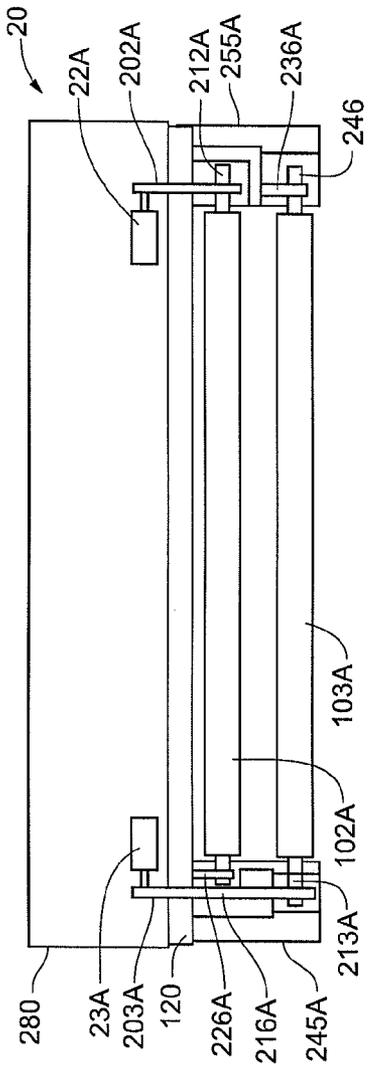
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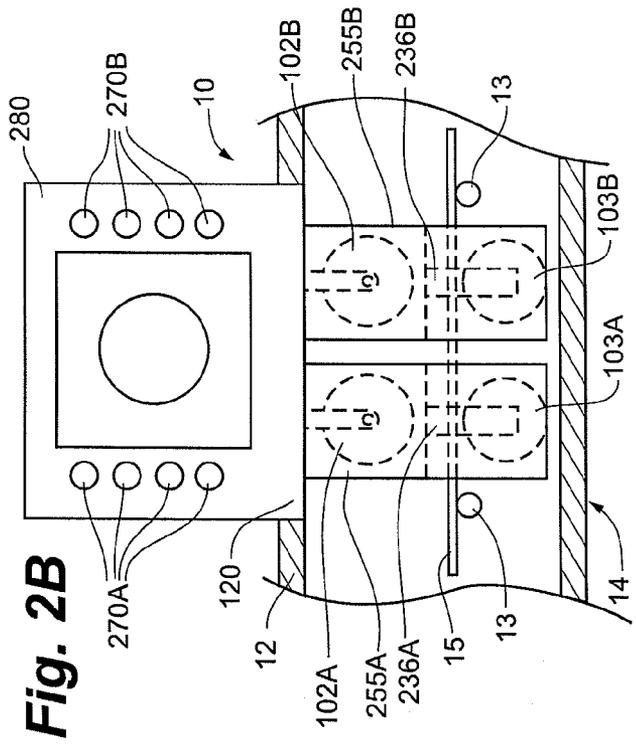


**Fig. 1**



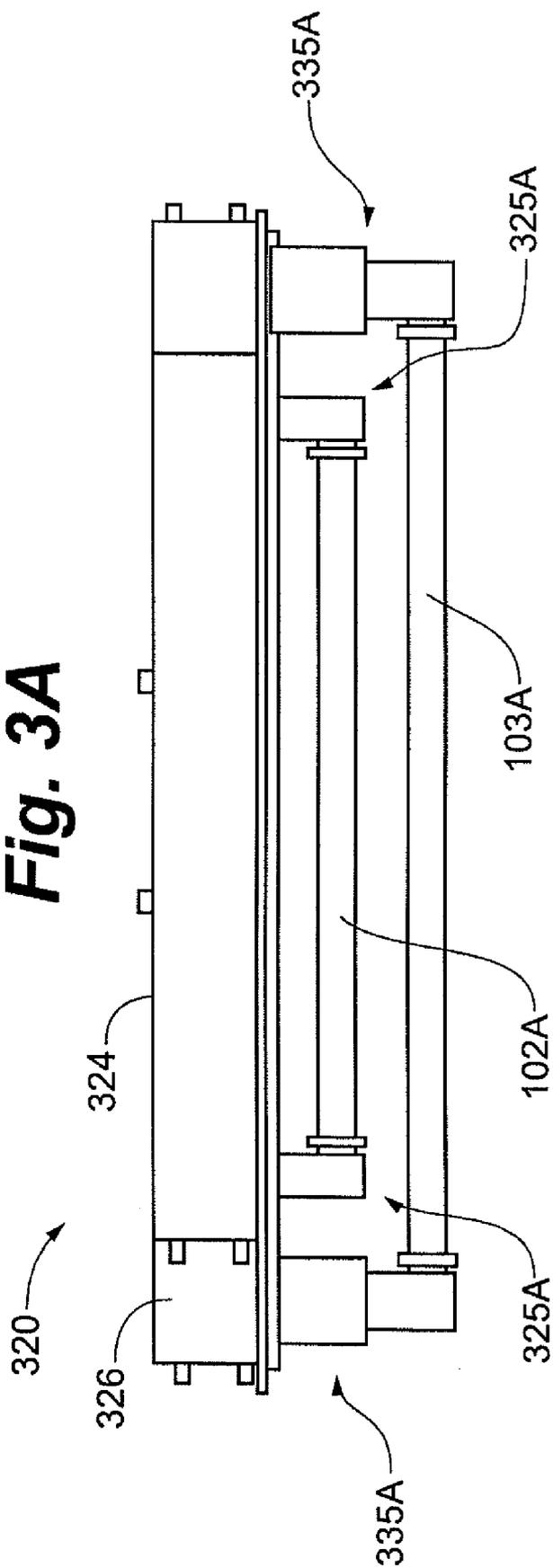


**Fig. 2A**

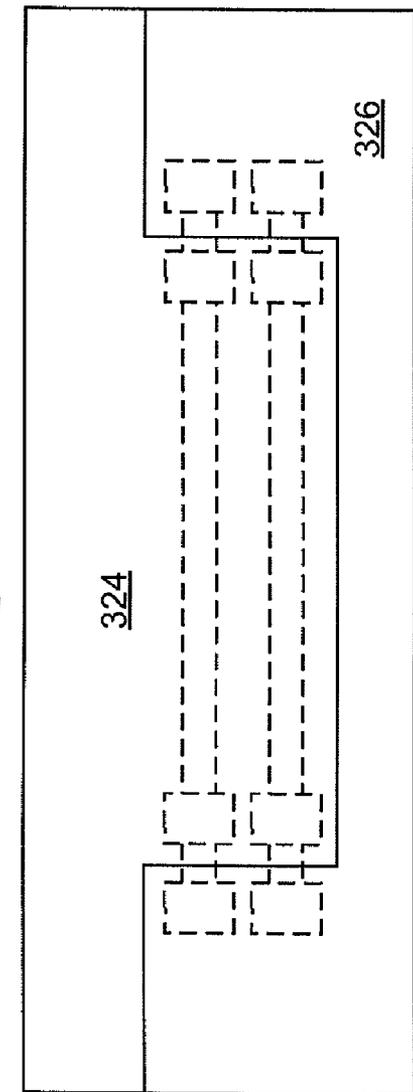


**Fig. 2B**

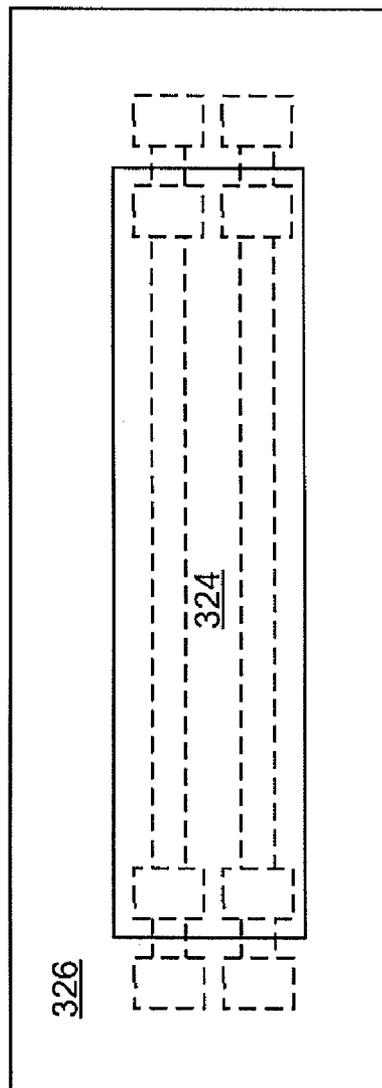
**Fig. 3A**



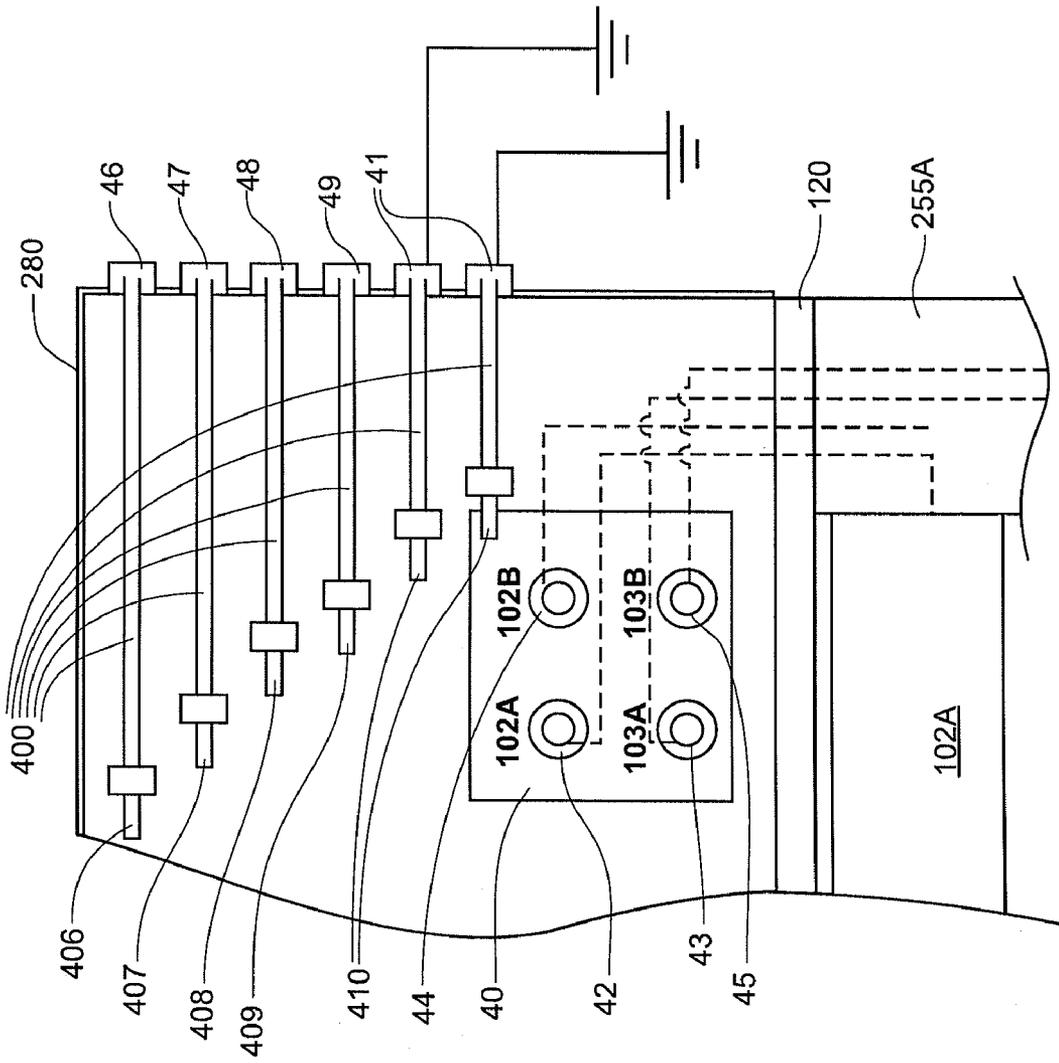
**Fig. 3B**

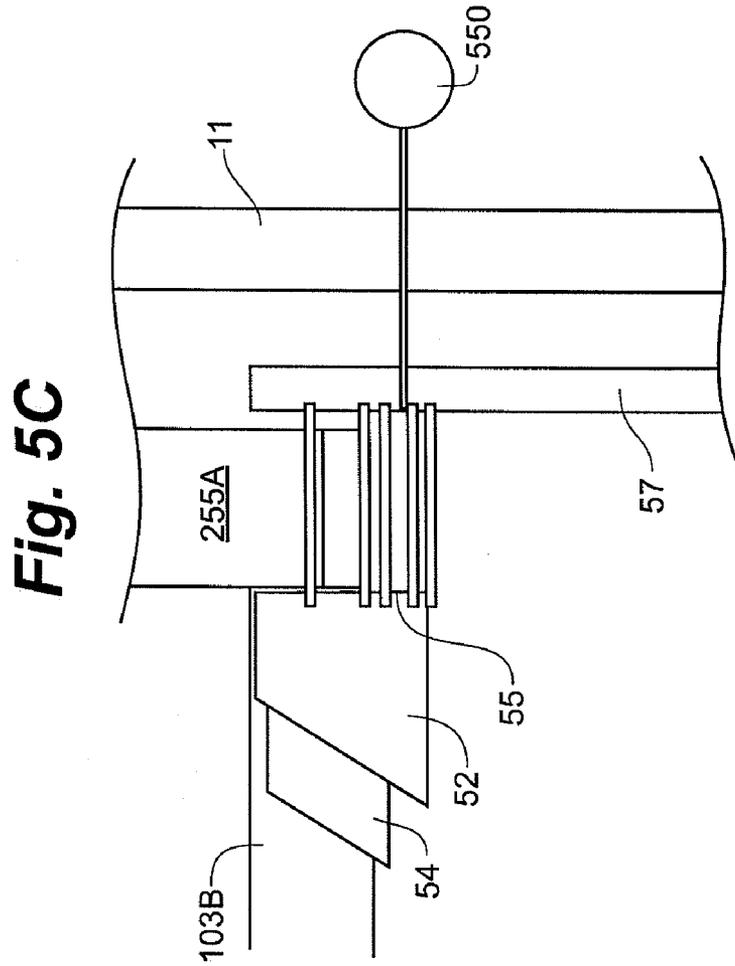
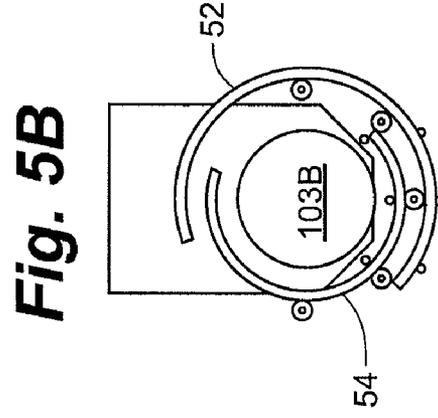
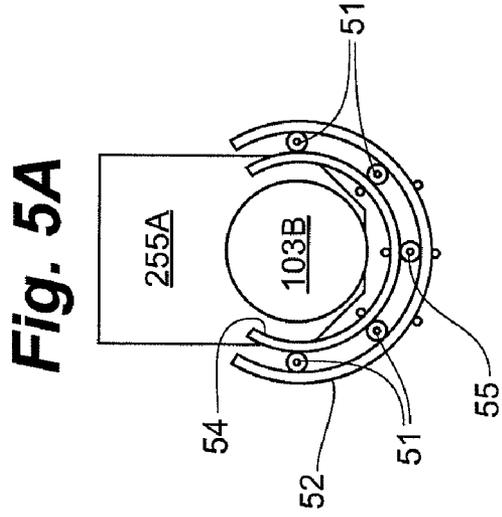


**Fig. 3C**



**Fig. 4**





**SPUTTERING APPARATUS INCLUDING  
NOVEL TARGET MOUNTING AND/OR  
CONTROL**

**TECHNICAL FIELD**

**[0001]** The present invention pertains to the deposition of thin films via a sputtering process and more particularly to the mounting arrangement and control of sputtering targets within a sputtering chamber.

**BACKGROUND**

**[0002]** Sputtering apparatus typically employ one or more sputtering chambers through which substrates, for example, computer memory disks, integrated circuits, flat panel displays and glass sheets or panels, are conveyed for the application of thin films thereto. The substrates are coated via physical vapor deposition, which utilizes a plasma energy source, the position and density of which is controlled by a magnetic field; this process is known to those skilled in the art as "magnetron" sputtering. Magnetrons, which may be planar or cylindrical, include an electrode coupled to an array of magnets; the electrode is overlaid with a target, which includes the material that is to be deposited on the substrates. The deposition is brought about by bombardment of the target surface by ions, which are formed in a gaseous plasma and energized via a voltage applied by the electrode to the target. The terms 'magnetron' and 'sputtering target', or just 'target', are sometimes used interchangeably by those skilled in the art, and may likewise be used herein.

**[0003]** Often times substrates, such as those given above, by way of example, require a coating on opposing sides. Commonly assigned U.S. Pat. No. 6,964,731 discloses sputtering chambers that have been developed to include magnetrons, or sputtering targets, disposed on either side of the substrates being conveyed therethrough. However, there remains a need in the industry for improved mounting arrangements and control of sputtering targets, within sputtering chambers, that will provide an improved combination of features favorably impacting speed, expense, and ease of operator use.

**SUMMARY**

**[0004]** Embodiments of the invention pertain to a sputtering apparatus that includes a sputtering chamber (optionally, a large area sputtering chamber), a substrate conveyor, and at least two sputtering targets (e.g. a first and second target). The substrate conveyor, for example, including a series of transport rollers, extends through the chamber defining a path of substrate travel, which may extend either horizontally or vertically through the chamber, between the first and second targets. If the conveyor defines a horizontal path through the chamber, the first and second targets may be above and below, respectively, the path.

**[0005]** Certain embodiments of the present invention include apparatus, assemblies and methods for deploying the at least two sputtering targets within a sputtering chamber enclosed by a plurality of walls, wherein the targets are mounted to a first wall of the plurality of walls such that the first target is disposed on a first side of the substrate conveyor, and a second target is disposed on a second side of the conveyor. A substrate, for example, a glass sheet, to be sputtered coated, being conveyed through the sputtering

chamber, passes between the first and second targets. According to preferred embodiments, the at least two targets includes a first pair of targets disposed on the first side of the conveyor, and a second pair of targets disposed on the second side of the conveyor; such a configuration of four targets may be called a quad configuration. The targets may be cylindrical, i.e. rotatable cylindrical magnetrons, and extend from a first end to a second end over a length which at least spans a width of the substrate being conveyed therebetween.

**[0006]** A sputtering target assembly, according to some embodiments of the present invention, includes the first wall, which may form a lid of the chamber, together with the targets mounted thereto. The targets mounted to the first wall as a lid, which may be a top lid, are mounted to the lid for placement within the chamber when the lid seals off an opening of the chamber. The lid and targets mounted thereto are removable from the chamber as an integral unit, thereby providing access to all the targets outside the chamber, for example, for maintenance purposes. As previously described, the first target or pair of targets is spaced apart from the second target or pair of targets to allow passage of a substrate (e.g. a glass sheet) therebetween, when the lid seals off the chamber's opening. According to some embodiments, the first wall, or lid, to which the targets are mounted, includes two separable parts, wherein the first target or pair of targets is mounted to a first of the two parts and the second target or pair of targets is mounted to a second of the two parts.

**[0007]** If the lid is a top lid, the first target or pair of targets can be mounted to the lid so as to be disposed side-by-side and adapted for downward sputtering, and the second target or pair of targets can be mounted to the lid so as to be disposed side-by-side and adapted for upward sputtering. In some embodiments a gas distribution system, for example including a sparge pipe, is also mounted to the lid. According to preferred embodiments, the targets are cylindrical, tube-shaped targets, optionally all being held parallel to one another in such a way as to be rotatable respectively about their horizontal axes.

**[0008]** According to certain methods of the present invention, each target deployed within a sputtering chamber is independently operable such that any one or a combination of more than one of the targets may be selected to be active, while remaining targets may be selected to be inactive. The selection of active and inactive targets may be made from outside the sputtering chamber by electrically connecting an electrode of an active target to a power supply, and electrically connecting an electrode of an inactive target to ground. For these embodiments a mobile shielding apparatus may be incorporated within the chamber to protect the inactive targets from being coated by material sputtered from the active targets during operation. Additional embodiments of the present invention pertain to such a mobile shielding apparatus. According to some embodiments, the mobile shielding apparatus is actuated from outside the sputter chamber. For those embodiments, which provide shielding for cylindrical targets, each moveable shield of the shielding apparatus may include first and second arcuate panels that extend between first and second ends of the cylindrical targets, and which are adapted to move with respect to one another about a circumference of the target from a first position, in which the panels protect the target from being coated by sputtered material from another target, to a second

position, in which the panels allow a portion of the target to be exposed for sputtering. One or more rotatable sprockets may be disposed between the arcuate shield panels to facilitate movement of one panel with respect to the other and an external motor may be coupled to at least one of the sprockets to drive the rotation thereof.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The following drawings are illustrative of particular embodiments of the present invention and therefore do not limit the scope of the invention. The drawings are not to scale (unless so stated) and are intended for use in conjunction with the explanations in the following detailed description. Embodiments of the present invention will hereinafter be described in conjunction with the appended drawings, wherein like numerals denote like elements.

[0010] FIG. 1 is a schematic side plan view of a portion of an exemplary sputter coating apparatus, according to some embodiments of the present invention.

[0011] FIG. 2A is a schematic front plan view of a sputtering target assembly, according to some embodiments of the present invention.

[0012] FIG. 2B is a side plan view with a partial cut-away section of a sputtering chamber including the assembly of FIG. 2A.

[0013] FIG. 3A is a front plan view of a sputtering target assembly, according to alternate embodiments of the present invention.

[0014] FIG. 3B-C are a top plan views of alternate configurations for the assembly shown in FIG. 3A.

[0015] FIG. 4 is a schematic plan view of a portion of a target assembly, according to some embodiments of the present invention.

[0016] FIGS. 5A-B are schematic end views of a shielding apparatus.

[0017] FIG. 5C is a schematic side view of the apparatus as depicted in FIG. 4A.

#### DETAILED DESCRIPTION

[0018] The following detailed description is exemplary in nature and is not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the following description provides practical illustrations for implementing exemplary embodiments of the present invention. Examples of constructions, materials, dimensions, and manufacturing processes are provided for selected elements, and all other elements employ that which is known to those of skill in the field of the invention. Those skilled in the art will recognize that many of the examples provided have suitable alternatives that can be utilized.

[0019] FIG. 1 is a schematic side plan view of a portion of an exemplary sputter coating apparatus 100, according to some embodiments of the present invention. FIG. 1 illustrates coating apparatus 100 including sputter chambers 10, which are enclosed by a top wall 12, a bottom wall 14, and, it should be understood, two side walls (not shown); a series of transport rollers 13 serve as a conveyor of substrates 15, for example, glass panels, through chambers 10. Alternately, substrates 15 may be transported through chambers 10 by an interrupted conveyor system, according to any of the embodiments described in commonly-assigned U.S. patent application publication no. U.S. 2006/0048708, which is hereby incorporated by reference. With further reference to

FIG. 1, it should be understood that partial walls segregate chambers 10 and provide tunnels through which substrates 15 pass from one chamber to the next.

[0020] FIG. 1 further illustrates a first pair of cylindrical magnetrons or sputtering targets 102A, 102B disposed on a first side, or above, the conveyor to deposit material on, or to coat an upper surface of substrates 15, and a second pair of cylindrical sputtering targets 103A, 103B disposed on a second side, or below, the conveyor to deposit material on, or to coat a lower surface of substrates 15. With reference to FIG. 1, it should be understood that each of the targets, for example, 102A, 102B, 103A and 103B, is, preferably, generally tubular, and has a length that extends into the page, and, according to preferred embodiments of the present invention, the length of each target at least spans a width of substrate 15. According to preferred embodiments of the present invention, substrates 15 are glass sheets or panels having a length from approximately 24 inches to approximately 144 inches, and having a width from approximately 18 inches (about 0.46 meters) to approximately 100 inches (about 2.5 meters). Some exemplary embodiments of the present invention include commercially available cylindrical magnetrons, one example of which has a target length of approximately 96 inches, for example, to accommodate a glass panel-type substrate having a width of approximately 84 inches, and another example of which has a target length of approximately 126 inches, for example, to accommodate a glass panel-type substrate having a width of approximately 100 inches. Other commercially available lengths include 84 inches, 105 inches and 114 inches.

[0021] According to the illustrated embodiment, as substrates 15 are conveyed through a vacuum environment of chambers 10, for example, from left to right, both sides of substrates 15 may be simultaneously coated in each chamber 10 via the bombardment of each sputtering target pair by ions of a process gas, for example, argon, nitrogen, and/or oxygen, which are pumped into each chamber 10 as targets 102A, 102B, 103A and 103B are rotated about their longitudinal axes according to methods known to those skilled in the art. Some examples of dual direction sputtering chambers are described in commonly assigned U.S. Pat. No. 6,964,731, salient portions of which are hereby incorporated by reference.

[0022] The system depicted in FIG. 1 exemplifies embodiments wherein a sputtering chamber is equipped with at least one sputter-down target mounted to a top wall of the chamber and at least one sputter-up target also mounted to the top wall. According to these embodiments, the at least one sputter-down target is a pair of sputter-down targets held side-by-side, preferably parallel to one another, and the at least one sputter-up target is a pair of targets held side-by-side, preferably parallel to one another, and spaced apart from the sputter-down targets. The pair of sputter-down targets are held at a first distance from the top wall and the pair of sputter-up targets held at a second distance from the top wall; the first distance may be between approximately 10.75 inches and approximately 11 inches and the second distance may be between approximately 22.5 inches and approximately 22.75 inches.

[0023] According to certain embodiments of the present invention, each sputtering target in each chamber 10, for example each of targets 102A, 102B, 103A and 103B, is mounted to a single wall of each chamber 10, the wall being separable from the chamber to provide access outside the

chamber to all of the targets for maintenance purposes, for example, to swap out expired or consumed targets; such mounting may thereby further increase operational efficiency. Although exemplary embodiments of the present invention, as described herein, show the targets mounted to a wall disposed above the conveyor, for example, to top wall 12 (FIG. 2B), the scope of the present invention is not so limited, and the targets may all be mounted to any of the walls of chambers 10.

[0024] FIG. 2A is a schematic front plan view of a sputtering target assembly 20, according to some embodiments of the present invention; and FIG. 2B is a side plan view with a partial cut-away section of sputtering chamber 10 including assembly 20. FIG. 2A illustrates target assembly 20 including a wall portion 120 and end blocks 245A and 255A coupled thereto, for example, via bolted joints; portions of assemblies coupling targets 102A and 103A to wall portion 120 are shown housed within end blocks 245A, 255A. With reference to FIGS. 1 and 2B, it should be understood that another pair of end blocks 245B and 255B are coupled to wall portion 120 to house assemblies for targets 102B and 103B, which are behind targets 102A and 103A in FIG. 2A.

[0025] According to the illustrated embodiment, targets 103A,B are spaced apart from targets 102A,B at a distance that allows passage of a substrate, for example, substrate 15, horizontally conveyed between targets 102A,B and 103A,B. Substrate 15 may be a glass sheet or panel, for which horizontal conveyance, as illustrated, is preferred, but the scope of the present invention is not limited to horizontal conveyance. FIG. 2B illustrates wall portion 120 fitting into upper wall 12 of chamber 10 such that targets 103A-B are disposed below transport rollers 13 and substrate 15, while targets 102A-B are disposed above rollers 13 and substrate 15. Although assembly 20 includes target pairs 102A-B and 103A-B, the scope of the present invention is not limited as such, and embodiments of target assemblies may include a single first target mounted for positioning on one side of a substrate conveyor and a single second target mounted for positioning on the other side of the substrate conveyor, or may include more than two targets mounted for positioning on each side of the conveyor. With reference to FIG. 2B, it may be appreciated that wall portion 120 can form a separable lid for chamber 10; as such, wall portion 120 is sized and equipped to seal off an opening in wall 12, when chamber 10 is operating, and to be removed, for example, by raising portion 120 away from chamber 10, when maintenance of target assembly 20 is required, for example, to swap out expired targets.

[0026] FIGS. 2A-B further illustrate a cover or housing 280 disposed over a top of wall portion 120 to enclose portions of the assemblies that provide utility hookups for targets 102A,B and 103A,B. The assemblies include motors 23A,B and 22A,B (23B and 22B being disposed behind 23A and 22A, respectively, in FIG. 2A), one motor to rotate each of targets 102A,B and 103A,B, water lines (not shown) connecting into either end of each target 102A,B, 103A,B and electrical lines (not shown) to power an electrode of each target 102A,B, 103A,B and to power each motor 23A,B, 22A,B. Feedthrough openings for utility hookups are provided through wall portion 120 into end blocks 245A,B and 255A,B; for example, as illustrated in FIG. 2A, a drive chain or belt 203A extends from motor 23A to a first spindle end 213A of target 103A, and a drive chain or belt

202A extends from motor 22A to a first spindle end 212A of target 102A. Any suitable arrangement of utility hookups may be implemented according to methods known to those skilled in the art for powering and cooling sputtering targets. FIG. 2B further illustrates feedthrough openings 270A and 270B extending through an end wall of housing 280 to facilitate connection of water and electrical lines with external sources. It should be noted that assembly 20 may further include a gas delivery system, which may include a sparge pipe for dispersing process gas, for example, argon, nitrogen, and/or oxygen, within chamber 10, and one of feedthroughs 270A,B may facilitate coupling of the pipe to an external gas source. FIG. 2A further illustrates second spindle ends, or journals 216A and 246A of targets 102A and 103A, respectively, inserted in bearing supports 226A and 236A, respectively. It should be understood that targets 102B and 103B, disposed behind targets 102A and 103A in FIG. 2A, likewise include second spindle ends 216B and 246B inserted in bearing supports 226B and 236B, respectively, which are disposed behind supports 226A and 236A within end blocks 245B and 255B, respectively, in FIG. 2A.

[0027] FIG. 3A is a front plan view of a sputtering target assembly 320, according to alternate embodiments of the present invention. FIG. 3A illustrates target assembly 320 including a first part 324, to which end blocks 325A are coupled, and a second part 326, to which end blocks 335A are coupled; end blocks 325A and 335A enclose assemblies that couple targets 102A and 103A, respectively, to first part 324 and second part 326, respectively, and portions of assemblies that provide utility hookups for targets 102A and 103A; these assemblies may be similar to those described in conjunction with FIGS. 2A-B. It should be understood that end blocks 325B and 335B and associated targets 102B and 103B are disposed behind end blocks 325A and 335B and targets 102A and 103A, respectively, for example, as shown by dashed lines in FIGS. 3B-C; however, alternate embodiments of the present invention may only include one target mounted to each part 324, 326. As with assembly 20, first and second parts 326, 324, together, may form a lid to fit within and seal off an opening in a wall of a sputtering chamber, for example chamber 10, such that targets 102A-B and 103A-B are disposed on either side of a substrate conveyor, such as is illustrated in FIG. 1. According to an exemplary embodiment of the present invention, targets 103A-B are sufficiently long to accommodate a length of targets 102A-B, which is, preferably, approximately 96 inches to coat glass sheets being approximately 84 inches wide.

[0028] According to the illustrated embodiment, first lid portion 324 is separable from second lid portion 326 to provide full access to target pair 102A-B, without having to remove target pair 103A-B. Additionally, the entire assembly 320 need not be separated from a wall of a sputtering chamber, for example chamber 10, in order to access individual target pairs 102A-B and 103A-B. FIG. 3B is a top plan view of assembly 320 according to one configuration of first and second parts 324 and 326, and FIG. 3C is a top plan view of assembly 320 according to an alternate configuration of first and second parts 324 and 326. According to the embodiment illustrated in FIG. 3B, either of first and second parts 324 and 326 can be removed from wall 12 while the other remains in place.

[0029] With reference back to FIG. 1, according to some embodiments of the present invention, each of targets, or

magnetrons 102A-B and 103A-B are independently operable so that an operator of sputtering apparatus 100 may select to be operable, or active, one, some, or all of the magnetrons, for example, via a switchboard-type network as illustrated in FIG. 4, according to an exemplary embodiment. The terms 'operable' and 'active' are used herein to denote a magnetron that is functional and whose electrode is coupled to a power supply. FIG. 4 is a schematic plan view of a portion of target assembly 20 showing a switchboard 40 that is mounted within cover 280 and includes connector ports 42, 44, 43 and 45 to receive connector plugs 406, 407, 408, 409 and 410, also disposed within cover 280; each port 42, 44, 43 and 45 is shown, by the dashed lines, to be electrically coupled to an electrode of a corresponding target 102A, 102B, 103A, 103B, for example, via electrical wire hookups extending through end block 255A to targets 102A, 103A, and through end block 255B to targets 102B, 103B. (Reference FIG. 2B.) FIG. 4 further shows each of plugs 406-410 electrically coupled by a flexible conductor cord or cable 400 to one of connections 46, 47, 48, 49 and 41 mounted on an external surface of cover 280. With reference to FIG. 4, along with the following description, it should be appreciated that such a switchboard-type network facilitates powering of electrodes for any one or a combination of magnetrons 102A,B, 103A,B by allowing an operator to reconfigure plugs 406-410 beneath cover 280 without having to break a vacuum of a sputter chamber to gain direct access to magnetrons 102A,B, 103A,B.

[0030] According to the illustrated embodiment, a power supply (not shown) may be coupled to any two connectors of connectors 46-49, and an operator may select a pair of targets 102A, 102B, 103A, 103B for coupling to the power supply by plugging the corresponding pair of connector plugs from connector plugs 406-409 into the selected ports of ports 42, 44, 43, 45 corresponding to the selected targets. For example, if all of targets 102A, 102B, 103A, 103B are selected to be operable, a first power supply is coupled to connectors 46 and 47, which are, in turn coupled to connector ports 42 and 44 for targets 102A and 102B, respectively, via plugs 406 and 407, and a second power supply is coupled to connectors 48 and 49, which are, in turn, coupled to connector ports 43 and 45 for targets 103A and 103B, respectively, via plugs 408 and 409. Alternately, if any one of targets 102A,B, 103A,B has become non-operational, for example due to target depletion, the operator may decide to continue operation with only two of the remaining operational targets by detaching one of the power supplies, re-configuring the electrical connection of the other power supply, if necessary, and grounding the non-operational, or inactive target(s) by plugging ground connector plugs 410 into the corresponding ports of switchboard 40. For example, if target 102A fails, the first power supply is disconnected from connectors 46 and 47, plug 406 is removed from port 42, and one of plugs 410 is plugged into port 42 to ground the electrode of target 102A; then, the operator selects two of remaining targets 102B, 103A,B for continued sputtering operation. If the operator selects 102B and 103B for continued operation, plug 408 is removed from port 43 so that the electrode of target 103A may be grounded, for example, via a second of plugs 410, and then plug 408 is switched out with plug 407, in port 44, so that the second power supply, which is coupled to connectors 48 and 49 is now connected to power the electrodes of targets 102B and 103B.

[0031] It may be necessary to shield inactive targets, which are in the same chamber as active targets, so that the inactive targets are not coated by material sputtered from the operational targets. FIGS. 5A-B are schematic end views of a portion of an externally activated mobile shielding apparatus; and FIG. 5C is a schematic side view of the apparatus as depicted in FIG. 5A. FIGS. 5A-C illustrate a pair of moveable arcuate shield panels 52, 54 disposed about target 103B and supported by sprockets 51, 55 that project from a supporting structure 57 residing within a sputter chamber and extending alongside a wall 11 of the chamber in proximity to end block 255A. According to the illustrated embodiment, sprockets 51, 55 mate with an outer surface of shield panel 54 and an inner surface of shield panel 52 such that a rotation of at least sprocket 55, as the drive sprocket, moves shield panels 52, 54 relative to one another from an open position, illustrated in FIG. 5A, wherein target 103B is exposed for sputtering, to a closed position, illustrated in FIG. 5B, wherein target 103B is shielded or protected from being coated by material sputtered by other active targets in the chamber. Shield panels 52, 54 may be formed from stainless steel or aluminum, or any other suitable heat-resistant, relatively light weight and formable material known to those skilled in the art. Likewise, sprockets 51, 55 may be formed from any suitable material known to those skilled in the art, examples of which include, without limitation, carbon or stainless steel metals and relatively hard polymers.

[0032] FIG. 5C further illustrates a feedthrough line through chamber wall 11 joining drive sprocket 55 to an external motor 550 so that shield panels 52, 54 may be actuated to move between the opened and closed positions from outside the chamber. Such a shielding apparatus may be implemented for each target within a sputtering chamber, for example, for each of targets 102A,B and 103A,B as described above. With reference to FIG. 5C, it should be understood that shield panels 52 and 54 are cut away for illustrative purposes, and, in actuality, each would extend along a length of target 103B to opposing end block 245A (FIG. 2A); according to some embodiments, the opposite end of shield panels 52, 54 are supported by at least supporting sprockets, i.e. sprockets 51, extending from another supporting structure 57 located in proximity to end block 245A within the chamber.

[0033] In the foregoing detailed description, the invention has been described with reference to specific embodiments. However, it may be appreciated that various modifications and changes can be made without departing from the scope of the invention as set forth in the appended claims.

1. A sputtering apparatus, comprising:
  - a sputtering chamber enclosed by a plurality of walls;
  - a substrate conveyor extending through the sputtering chamber;
  - a first sputtering target mounted to a first wall of the plurality of walls such that the first target is disposed on a first side of the conveyor; and
  - a second sputtering target mounted to the first wall such that the second target is disposed on a second side of the conveyor.
2. The apparatus of claim 1, wherein a portion of the first wall, to which the targets are mounted, and the first and second targets are removable from the chamber as an integral unit.

3. The apparatus of claim 1, wherein:  
the first target is part of a pair of first targets, both of the first targets being disposed on the first side of the conveyor; and  
the second target is part of a pair of second targets, both of the second targets being disposed on the second side of the conveyor.
4. The apparatus of claim 3, wherein each target of the first and second target pairs is independently operable, such that one target from each of the first and second target pairs can be selected to be active, and another target from each of the first and second target pairs can be selected to be inactive.
5. The apparatus of claim 4, further comprising:  
a first moveable shield to protect the inactive target of the first target pair from being coated by material sputtered from the active targets of the first and second target pairs; and  
a second moveable shield to protect the inactive target of the second target pair from being coated by material sputtered from the active targets of the first and second target pairs.
6. The apparatus of claim 5, wherein the first and second moveable shields are adapted to be actuated from outside the chamber to move into a position protecting the inactive targets.
7. The apparatus of claim 1, wherein:  
each of the first target and the second target is cylindrical and extends from a first end to a second end; and  
the first target and the second target are independently operable, such that a one of the first and second targets may be selected to be active and another of the first and second targets may be selected to be inactive; and further comprising:  
a first moveable shield including first and second arcuate panels extending between the first and second ends of the first target, the first and second panels of the first shield being adapted to move with respect to one another about a circumference of the first target from a first position, in which the panels of the first shield protect the first target from being coated by sputtered material, to a second position in which the panels of the first shield allow at least a portion of the first target to be exposed for sputtering;  
a second moveable shield including first and second arcuate panels extending between the first and second ends of the second target, the first and second panels of the second shield being adapted to move with respect to one another about a circumference of the second target from a first position, in which the panels of the second shield protect the second target from being coated by sputtered material, to a second position, in which the panels of the second shield allow at least a portion of the second target to be exposed for sputtering.
8. The apparatus of claim 7, wherein:  
the first moveable shield further includes a drive sprocket mating with an outer surface of the first arcuate panel of the first shield and an inner surface of the second arcuate panel of the second shield such that rotation of the drive sprocket moves the first arcuate panel of the first shield with respect to the second arcuate panel of the first shield; and  
the second moveable shield further includes a drive sprocket mating with an outer surface of the first arcuate panel of the second shield and an inner surface of the second arcuate panel of the second shield such that rotation of the drive sprocket of the second shield moves the first arcuate panel of the second shield with respect to the second arcuate panel of the second shield.
9. The apparatus of claim 1, wherein the first target and the second target are independently operable, such that a one of the first and second targets may be selected to be active and another of the first and second targets may be selected to be inactive.
10. The apparatus of claim 9, further comprising a moveable shield to protect the inactive target from being coated by a material sputtered from the active target.
11. The apparatus of claim 10, wherein the moveable shield is adapted to be actuated from outside the chamber to move into a position protecting the inactive target.
12. The apparatus of claim 1, wherein the first wall extends over a top of the chamber, the first target being disposed above the conveyor, and the second target being disposed below the conveyor.
13. The apparatus of claim 12, wherein:  
the first target is part of a pair of first targets, both of the first targets being disposed above the conveyor; and  
the second target is part of a pair of second targets, both of the second targets being disposed below the conveyor.
14. The apparatus of claim 12, wherein the substrate conveyor includes a series of spaced-apart transport rollers, each roller having a support surface adapted to directly contact a sheet-like substrate being conveyed through the chamber between the first target and the second target.
15. The apparatus of claim 14, wherein the second target is adapted to sputter material upwardly between adjacent rollers of the conveyor to coat a lower surface of the sheet-like substrate as the substrate is conveyed through the chamber between the first target and the second target.
16. The apparatus of claim 1, wherein the first wall defines a top lid adapted to be raised away from the chamber in order to remove the first and second targets from the chamber as an integral unit.
17. The apparatus of claim 1, wherein:  
the first wall includes a first part and a second part, the first part being separable from the second part; and  
the first target is mounted to the first part and the second target is mounted to the second part.
18. The apparatus of claim 17, wherein:  
the first part of the first wall and the first target, mounted thereto, are removable from the chamber as a first integral unit; and  
the second part of the first wall and the second target, mounted thereto, are removable from the chamber as a second integral unit.
19. The apparatus of claim 18, wherein one of the first and second parts can be removed from the chamber while the other of the first and second parts remains with the chamber.
20. The apparatus of claim 17, wherein the first part surrounds at least a portion of the second part.
21. The apparatus of claim 1, wherein each of the first target and the second target is cylindrical and extends from a first end to a second end, and further comprising:  
a first end block housing an assembly coupling one of the first and second ends of the first target to the first wall; and

- a second end block housing an assembly coupling one of the first and second ends of the second target to the first wall.
- 22.** The apparatus of claim 1, wherein the first and second targets bound a passage through which a sheet-like substrate can be conveyed by the substrate conveyor, the sheet-like substrate having a length of at least approximately 24 inches and a width of at least approximately 18 inches.
- 23.** The apparatus of claim 22, wherein the first and second targets each have a length spanning a width of the passage, the width of the passage accommodating the width of the substrate and the length of each target spanning at least the width of the substrate.
- 24.** The apparatus of claim 23, wherein the length of each target is greater than the width of the substrate.
- 25.** The apparatus of claim 1, further comprising:  
a first connector port electrically coupled to an electrode of the first target; and  
a second connector port electrically coupled to an electrode of the second target;  
wherein the first and second ports are disposed outside the sputtering chamber; and  
the first and second ports are adapted to receive a connector plug electrically coupled to either a power supply or a grounded connection so that one of the first and second targets can be selected to be active by coupling to the power supply, and another of the first and second targets may be selected to be inactive by coupling to ground.
- 26.** The apparatus of claim 3, further comprising:  
a pair of first connector ports, each of the pair of first ports electrically coupled to a corresponding electrode of each of the pair of first targets; and  
a pair of second connector ports, each of the pair of second ports electrically coupled to a corresponding electrode of each of the pair of second targets;  
wherein the pairs of first and second ports are disposed outside the sputtering chamber; and  
each port of the first and second pairs of ports are adapted to receive a connector plug electrically coupled to either a power supply or a grounded connection so that any one or a combination of the first targets and the second targets can be selected to be active by coupling to the power supply, and the remaining targets can be selected to be inactive by coupling to ground.
- 27.** A sputtering target assembly for a sputtering chamber, comprising:  
a lid to seal off an opening to the chamber;  
at least one first sputtering target mounted to the lid for placement within the chamber when the lid seals off the opening; and  
at least one second sputtering target mounted to the lid for placement within the chamber when the lid seals off the opening;  
wherein the at least one second sputtering target is spaced apart from the at least one first sputtering target at a distance allowing conveyance of a substrate therebetween, when the lid seals off the opening.
- 28.** The assembly of claim 27, wherein the opening extends over a top of the chamber.
- 29.** The assembly of claim 27, wherein the at least one first sputtering target comprises of a pair of first targets and the at least one second sputtering target comprises a pair of second targets.
- 30.** The assembly of claim 29, wherein each of the pair of first targets is independently operable and each of the pair of second targets is independently operable, such that one target of each of the pairs can be activated, while another target of each pair can be inactivated.
- 31.** The assembly of claim 27, wherein the at least one first target and the at least one second target are independently operable, such that one target of the first and second targets can be activated while another target of the first and second targets can be inactivated.
- 32.** The assembly of claim 27, wherein:  
the lid includes a first part and a second part, the first part being separable from the second part;  
the at least one first target is mounted to the first part; and  
the at least one second target is mounted to the second part.
- 33.** The assembly of claim 32, wherein the first part surrounds at least a portion of the second part, when the lid seals off the opening to the chamber.
- 34.** The assembly of claim 27, wherein each of the at least one first target and the at least one second target is cylindrical and extends from a first end to a second end, and further comprising:  
a first end block housing an assembly coupling one of the first and second ends of the at least one first target to the lid; and  
a second end block housing an assembly coupling one of the first and second ends of the at least one second target to the lid.
- 35.** The assembly of claim 27, wherein the substrate is conveyed between the at least one first target and the at least one second target by a series of spaced-apart transport rollers defining a path of substrate travel, and the at least one first target is disposed above the path and the at least one second target is disposed below the path, when the lid seals off the opening.
- 36.** The assembly of claim 27, wherein the substrate is a sheet-like substrate being horizontally conveyed between the at least one first target and the at least one second target when the lid seals off the opening to the chamber.
- 37.** The assembly of claim 36, wherein the substrate has a length of at least approximately 24 inches and a width of at least approximately 18 inches.
- 38.** The assembly of claim 37, wherein the at least one first target and the at least one second target each have a length at least spanning the width of the substrate.
- 39.** The assembly of claim 38, wherein the length of each target is greater than the width of the substrate.
- 40.** The assembly of claim 27, wherein each of the at least one first sputtering target and the at least one second sputtering target is cylindrical and adapted for rotation about a longitudinal axis thereof.
- 41.** The assembly of claim 40, further comprising:  
at least one first rotary drive coupled to the at least one first target to rotate the first target; and  
at least one second rotary drive coupled to the at least one second target to rotate the second target.
- 42.** The assembly of claim 27, further comprising:  
a first connector port electrically coupled to an electrode of the at least one first target; and  
a second connector port electrically coupled to an electrode of the at least one second target;

- wherein the first and second ports are mounted to the lid such that the ports are disposed outside the sputtering chamber, when the lid seals off the opening; and the first and second ports are adapted to receive a connector plug electrically coupled to either a power supply or a grounded connection so that one of the at least one first target and the at least one second target can be selected to be active by coupling to the power supply, and another of the at least one first target and the at least one second target may be selected to be inactive by coupling to ground.
- 43.** The assembly of claim **29**, further comprising:  
 a pair of first connector ports, each of the pair of first ports electrically coupled to a corresponding electrode of each of the pair of first targets; and  
 a pair of second connector ports, each of the pair of second ports electrically coupled to a corresponding electrode of each of the pair of second targets;  
 wherein the pairs of first and second ports are mounted to the lid such that the ports are disposed outside the sputtering chamber, when the lid seals off the opening; and  
 each port of the first and second pairs of ports are adapted to receive a connector plug electrically coupled to either a power supply or a grounded connection so that any one or a combination of the first targets and the second targets can be selected to be active by coupling to the power supply, and the remaining targets can be selected to be inactive by coupling to ground.
- 44.** A method for deploying sputtering targets in a sputtering chamber, the method comprising:  
 mounting at least one first sputtering target to a first portion of a lid of the chamber;  
 mounting at least one second sputtering target to a second portion of the lid of the chamber; and  
 placing the lid over an opening of the chamber to seal the opening, thereby disposing the at least one mounted first target and the at least one mounted second target within the chamber;  
 wherein the at least one mounted first target is spaced apart from the at least one mounted second target, such that, when the lid is placed over the opening, a substrate being conveyed through the chamber can pass between the mounted targets.
- 45.** The method of claim **44**, wherein placing the lid comprises lowering the lid over the opening, and wherein the at least one mounted first target is disposed above the at least one mounted second target within the chamber when the lid is placed.
- 46.** The method of claim **44**, further comprising:  
 activating the at least one mounted first target to deposit material on a surface of the substrate as the substrate passes between the mounted targets; and  
 shielding the at least one mounted second target against sputtering from the at least one first target.
- 47.** The method of claim **46**, wherein shielding the at least one mounted second target comprises actuating a moveable shield from outside the chamber.
- 48.** The method of claim **44**, wherein the at least one first target comprises a pair of first targets and the at least one second target comprises a pair of second targets.
- 49.** The method of claim **48**, further comprising:  
 activating one of the pair of first targets to deposit material on a first surface of the substrate as the substrate passes between the mounted targets;  
 shielding the other of the pair of first targets;  
 activating one of the pair of second targets to deposit material on a second surface of the substrate as the substrate passes between the mounted targets; and  
 shielding the other of the pair of second targets.
- 50.** The method of claim **49**, wherein:  
 shielding the other of the pair of first targets comprises actuating a first moveable shield from outside the chamber; and  
 shielding the other of the pair of second targets comprises actuating a second moveable shield from outside the chamber.
- 51.** The method of claim **44**, wherein the substrate comprises a glass sheet having a length of at least approximately 24 inches and a width of at least approximately 18 inches; the substrate being conveyed through the chamber by a series of spaced-apart transport rollers that contact the substrate; the method further comprising activating the at least one mounted first sputtering target to deposit material on a first surface of the substrate as the substrate passes between the mounted targets.
- 52.** The method of claim **51**, further comprising activating the at least one mounted second sputtering target to deposit material on a second surface of the substrate as the substrate passes between the mounted targets.
- 53.** The method of claim **52**, wherein the first surface of the substrate is disposed above the second surface of the substrate as the substrate passes between the mounted targets.
- 54.** The method of claim **44**, wherein, when the lid is placed over the opening, the at least one mounted first target is disposed above the substrate being conveyed through the chamber and the at least one mounted second target is disposed below the substrate being conveyed through the chamber.
- 55.** The method of claim **44**, further comprising:  
 activating the at least one mounted first target to deposit material on a first surface of the substrate being conveyed through the chamber; and  
 activating the at least one mounted second target to deposit material on a second surface of the substrate being conveyed through the chamber;  
 wherein the first and second surfaces of the substrate are opposing major surfaces of the substrate.
- 56.** The method of claim **55**, wherein the first surface of the substrate is disposed above the second surface of the substrate as the substrate is conveyed through the chamber.
- 57.** The method of claim **44**, wherein the first portion of the lid is separable from the second portion of the lid, and further comprising:  
 removing the first portion of the lid from the opening by separating the first portion from the second portion; and  
 dismantling at least one spent target from the first portion of the lid prior to mounting the at least one first target to the first portion of the lid.
- 58.** The method of claim **57**, wherein removing the first portion of the lid comprises raising the first portion and the spent target together, as an integral unit, away from the chamber

**59.** The method of claim **57**, wherein the second portion of the lid remains over the opening of the chamber while removing the first portion and dismantling the spent target.

**60.** The method of claim **48**, further comprising:  
electrically disconnecting electrodes of two targets of the pairs of first and second targets from at least one power supply, one of the two targets having been detected as being non-operational; and  
electrically grounding the disconnected electrodes;  
wherein disconnecting and grounding are accomplished after placing the lid and without removing the lid from over the opening.

**61.** The method of claim **60**, further comprising:  
electrically disconnecting an electrode of one of another two targets of the pairs of the first and second targets from a first power supply of the at least one power supply; and  
electrically connecting the electrode of the one of the other two targets to a second power supply of the at least one power supply;  
wherein an electrode of another of the other two targets is already connected to the second power supply; and  
disconnecting and connecting the electrode of the one of the other two targets is accomplished after placing the lid and without removing the lid from the opening.

**62.** A shielding apparatus for a sputtering target assembly within a sputtering chamber, the sputtering target assembly comprising a cylindrical target extending from a first end to a second end within the chamber, the shielding apparatus comprising:

a first moveable arcuate shield panel extending between the first and second ends of the target and circumferentially about the target; and

a second moveable arcuate shield panel extending between the first and second ends of the target and circumferentially about the first panel and the target;  
wherein the first and second panels are adapted to move with respect to one another circumferentially about the target from a first position, in which the panels enclose the target, to a second position in which the panels allow at least a portion of the target to be exposed.

**63.** The shielding apparatus of claim **62**, further comprising a drive sprocket mating with an outer surface of the first arcuate shield panel and an inner surface of the second arcuate shield panel such that rotation of the drive sprocket moves the first panel with respect to the second panel.

**64.** The shielding apparatus of claim **63**, further comprising a motor disposed outside the sputtering chamber and coupled to the drive sprocket to drive the rotation of the drive sprocket.

**65.** The shielding apparatus of claim **62**, further comprising a plurality of sprockets disposed between the first panel and the second panel, each of the plurality of sprocket rotatable to facilitate movement of the first panel with respect to the second panel.

**66.** The shielding apparatus of claim **65**, further comprising a motor disposed outside the sputtering chamber and coupled to at least one of the plurality of sprockets to drive rotation of the at least one sprocket.

**67.** A method for deploying sputtering targets in a sputtering chamber, the method comprising: placing a lid over an opening of a sputtering chamber to seal the opening;

electrically connecting an electrode of a first and a second target disposed within the chamber to a first power supply after the lid is placed;

electrically connecting an electrode of a third and a fourth target disposed within the chamber to a second power supply after the lid is placed;

electrically disconnecting the electrode of the first target and another electrode of one of the second, third and fourth targets, the first of the four targets having been detected as being non-operational; and

electrically grounding the disconnected electrodes;  
wherein the disconnecting and grounding are accomplished after the lid is placed and without removing the lid from the opening; and

the first and second targets form a first pair being spaced apart from the third and fourth targets forming a second pair, such that a substrate being conveyed through the chamber can pass between the first and second pairs of targets.

**68.** The method of claim **67**, wherein the one of the second, third and fourth targets is the third target and further comprising:

electrically disconnecting the electrode of the second target from the first power supply; and

electrically connecting the electrode of the second target to the second power supply;

wherein disconnecting and connecting the electrode of the second target is accomplished after placing the lid and without removing the lid from the opening.

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