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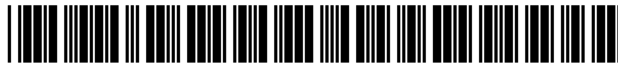

(12) **United States Patent**
Miller

(10) **Patent No.: US 8,236,108 B1**
(45) **Date of Patent: Aug. 7, 2012**

(54) **INERTIAL MASKING ASSEMBLY**

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(73) Assignee: **University of South Florida**, Tampa, FL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 685 days.

(21) Appl. No.: **12/430,327**

(22) Filed: **Apr. 27, 2009**

Related U.S. Application Data

(60) Provisional application No. 61/047,781, filed on Apr. 25, 2008.

(51) **Int. Cl.**
C23C 16/00 (2006.01)

(52) **U.S. Cl.** **118/721**; 118/213; 118/301; 118/406; 118/504

(58) **Field of Classification Search** 118/721, 118/213, 301, 406, 504
See application file for complete search history.

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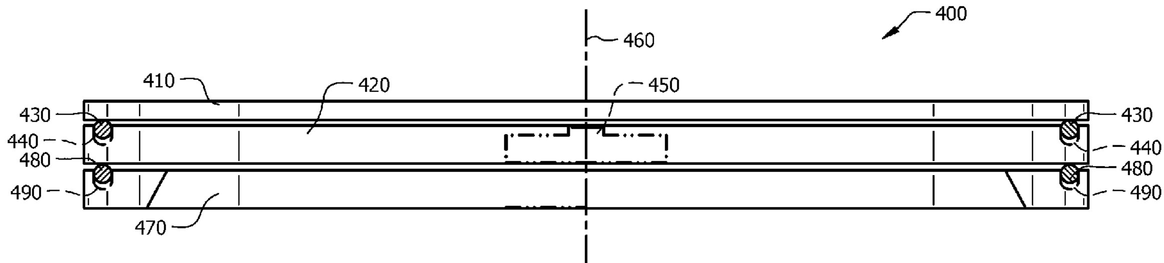
Primary Examiner — Keath Chen
(74) *Attorney, Agent, or Firm* — Nilay J. Choksi; Courtney M. Dunn; Smith & Hopen, P.A.

(57) **ABSTRACT**

An inertial masking assembly that allows multiple thin film structures to be deposited on a single substrate by rotation of a shadow mask relative to the substrate. The assembly rotates the position of the shadow mask by the conservation of momentum. The substrate is seated on means for rotating the substrate in a confined orbit within the mask. Abruptly changing the angular velocity of the mask causes the mask to rotate under the substrate, which is mediated by a combination of friction and the substrate's inertia.

19 Claims, 12 Drawing Sheets



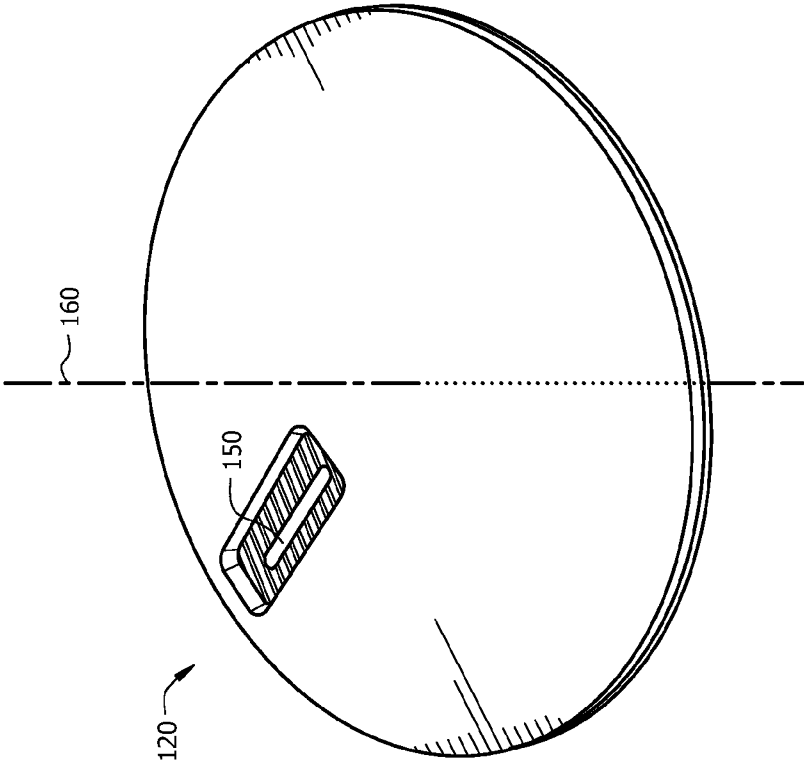


FIG. 1B

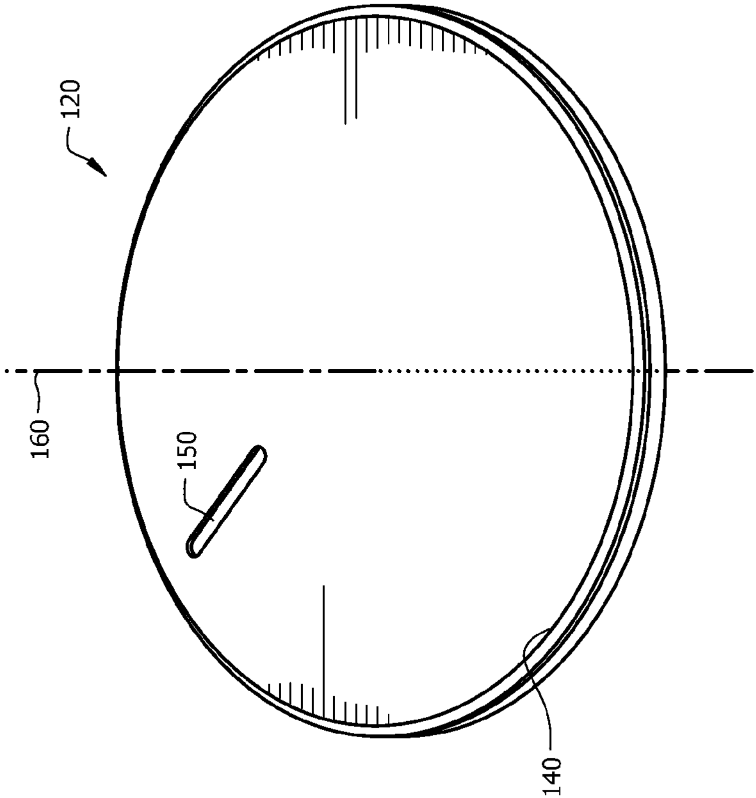


FIG. 1A

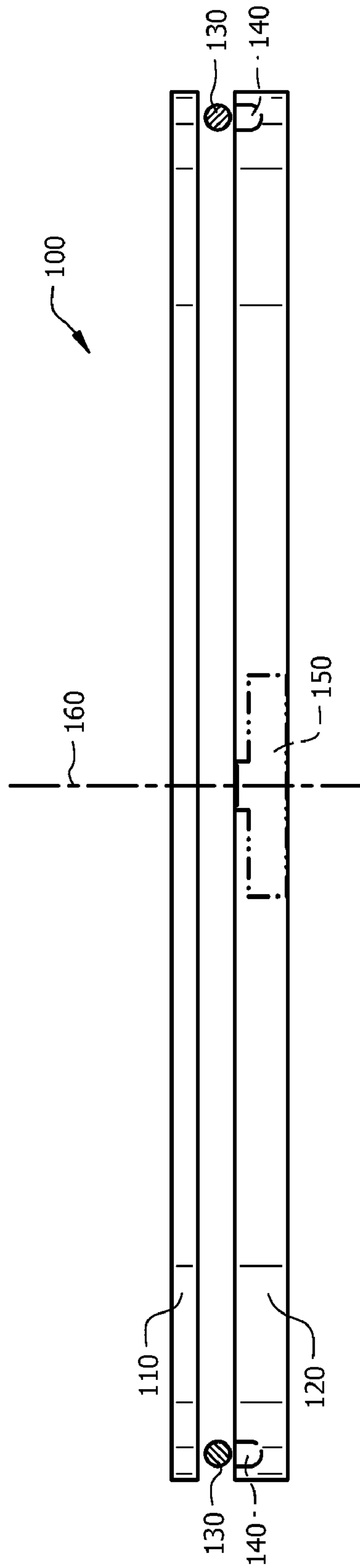


FIG. 2A

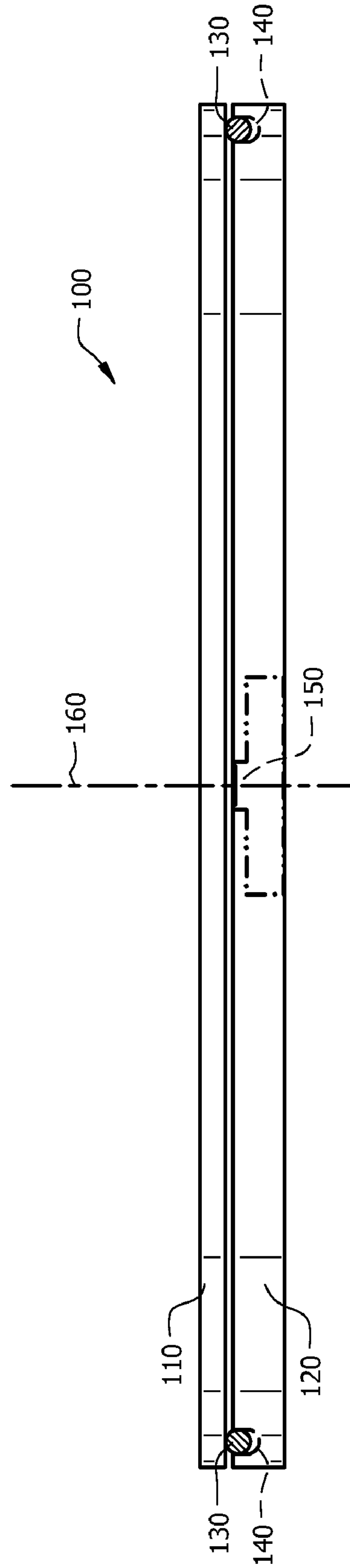


FIG. 2B

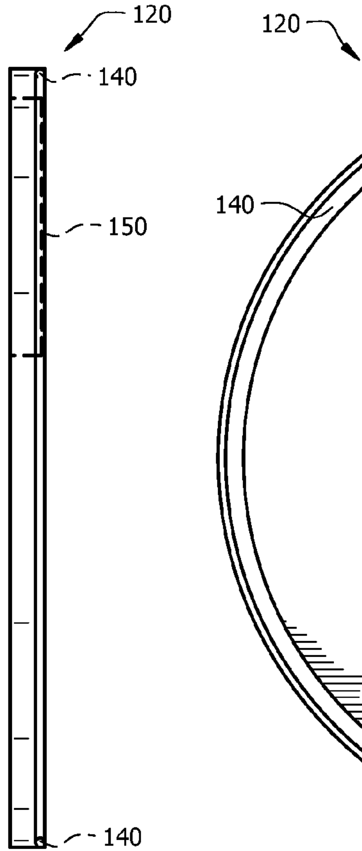


FIG. 3B

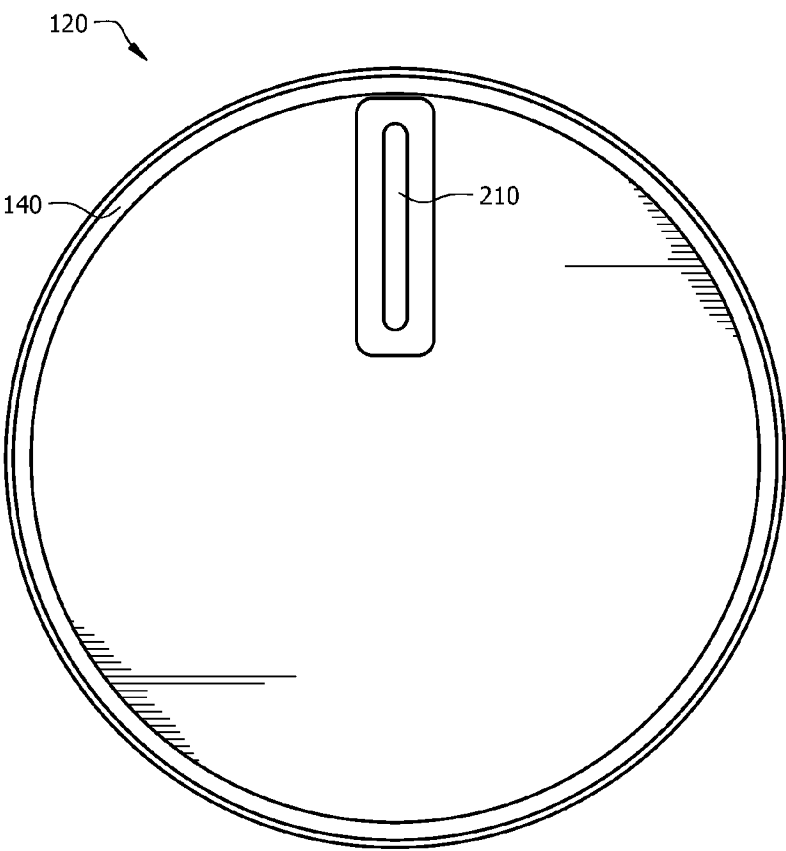


FIG. 3A

FIG. 3C

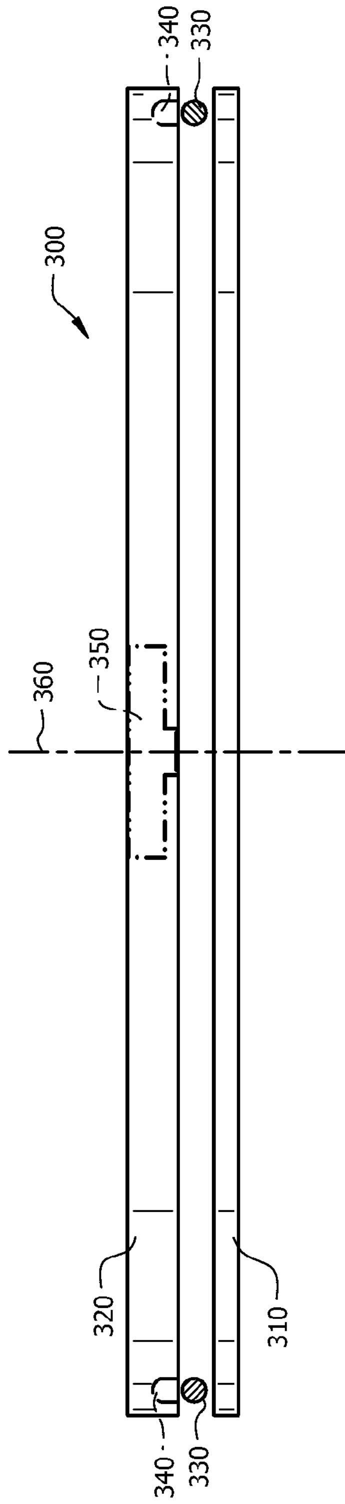


FIG. 4A

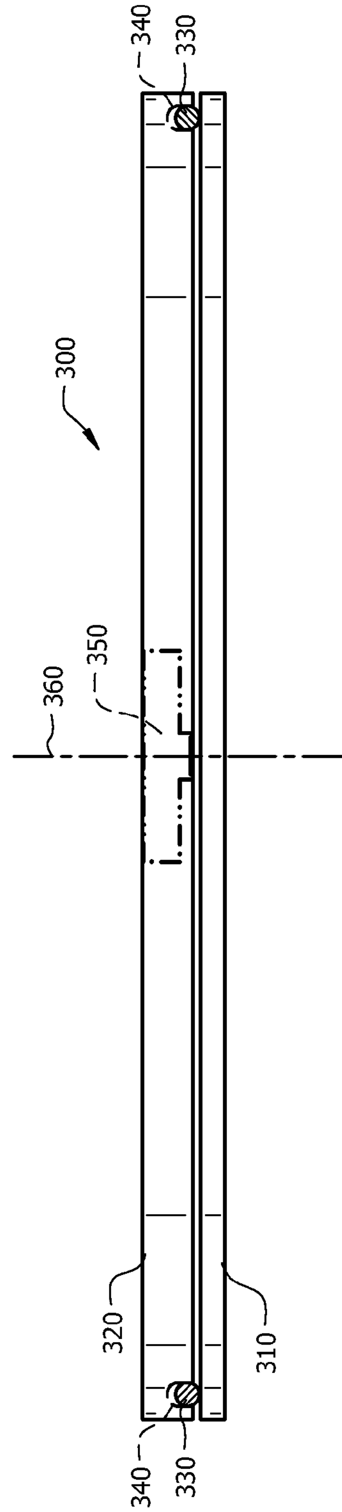


FIG. 4B

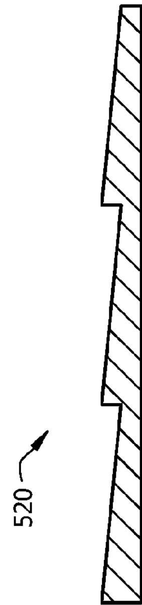


FIG. 5B

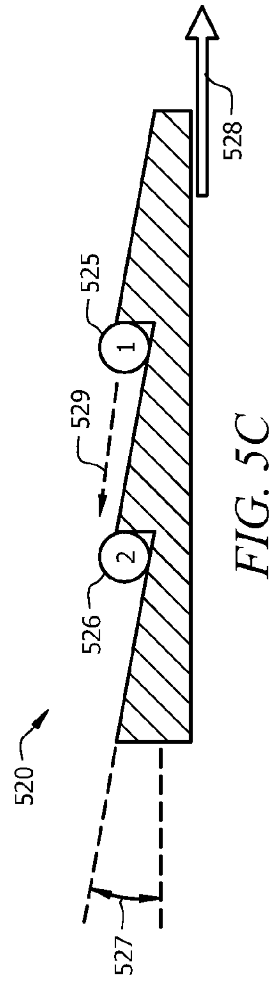


FIG. 5C

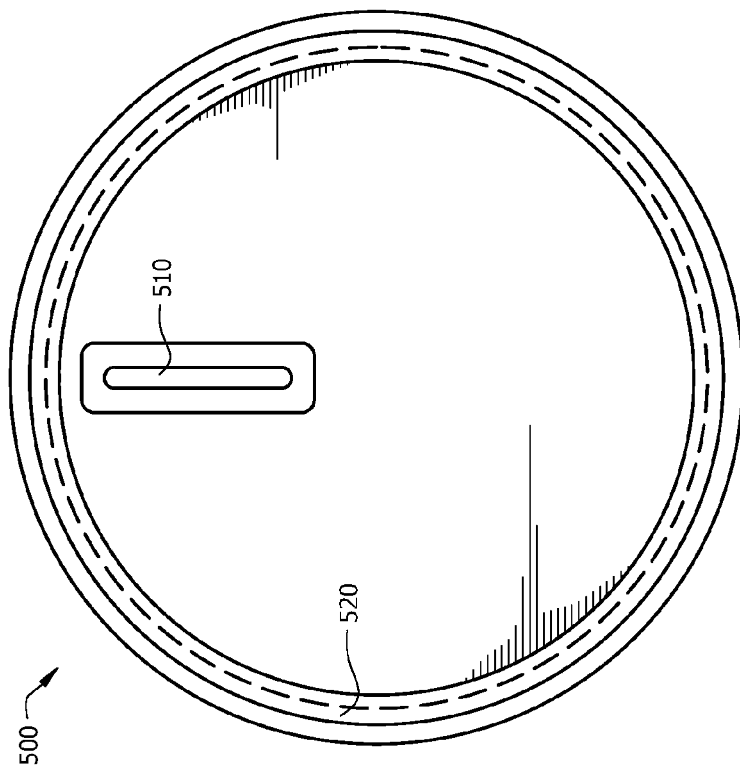


FIG. 5A

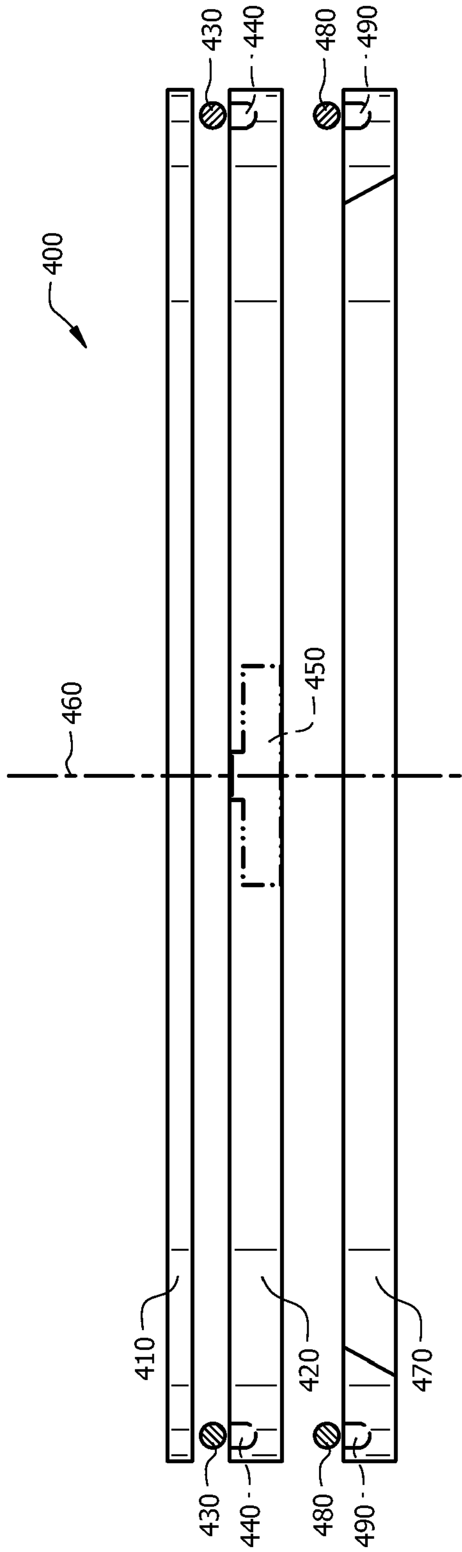


FIG. 6A

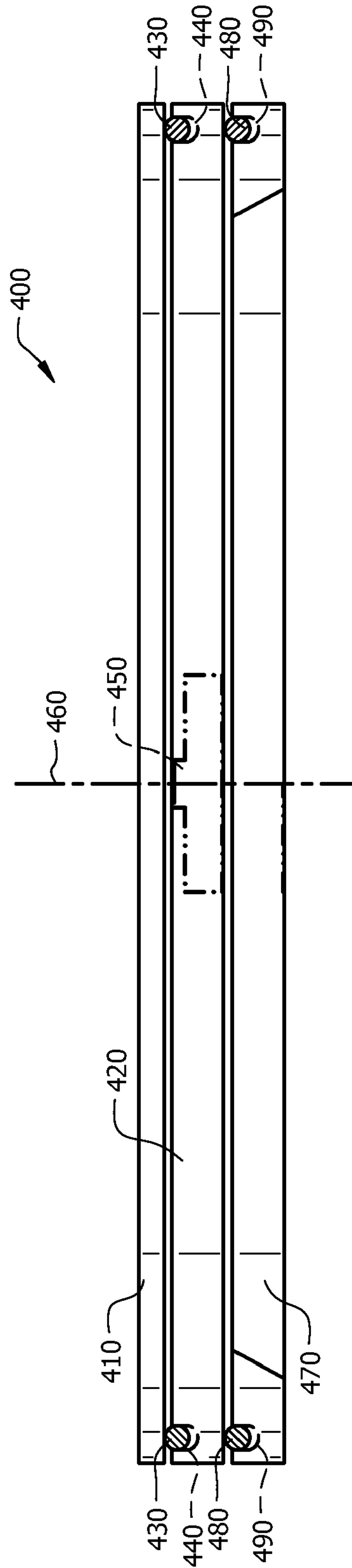


FIG. 6B

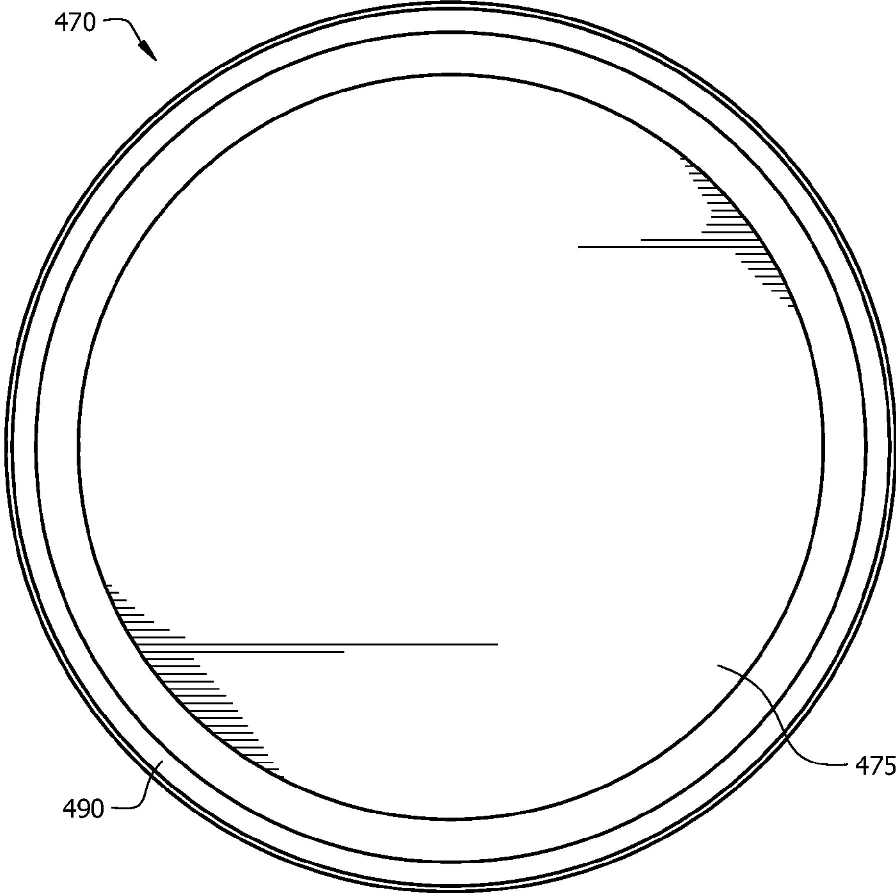


FIG. 7A

FIG. 7B

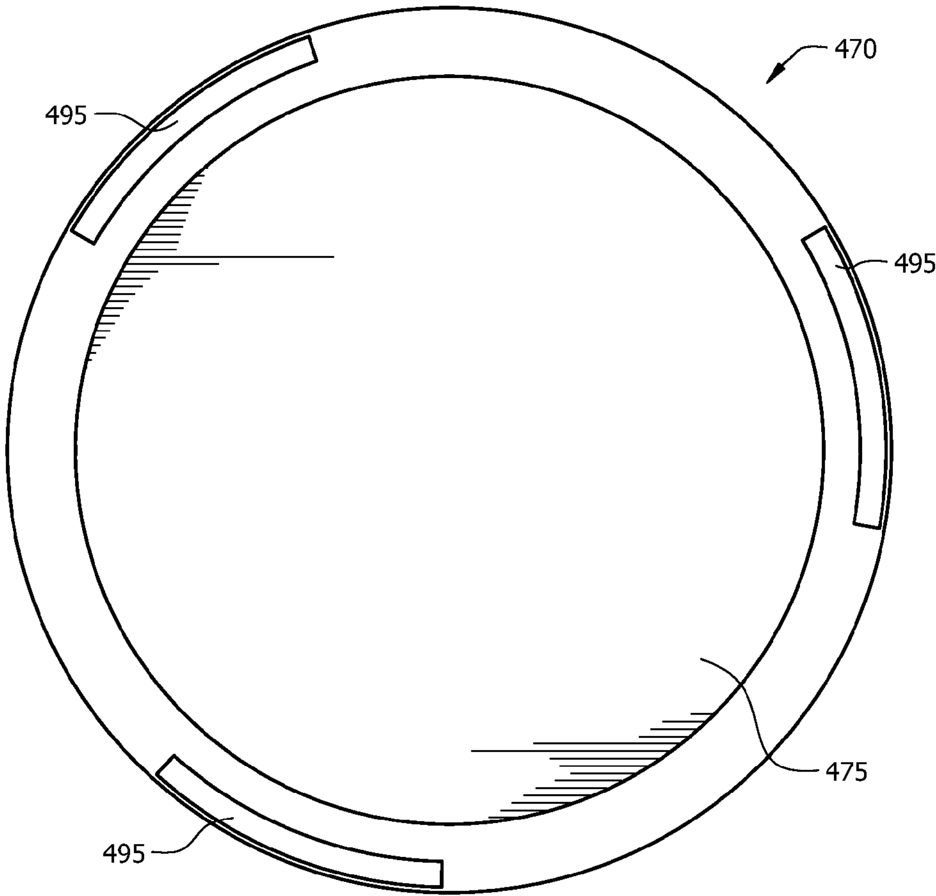


FIG. 8

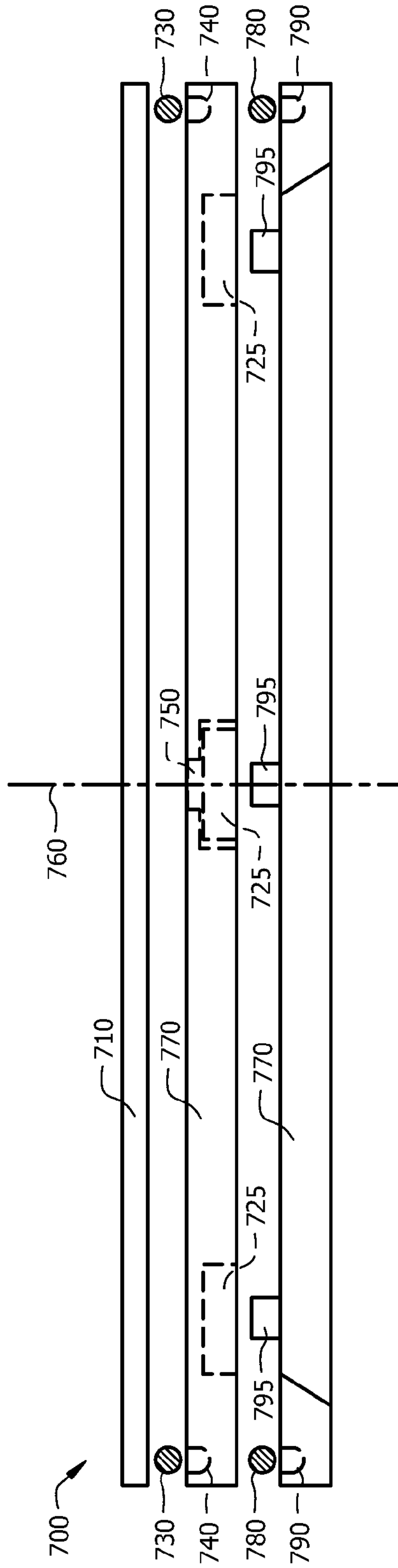

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FIG. 9A

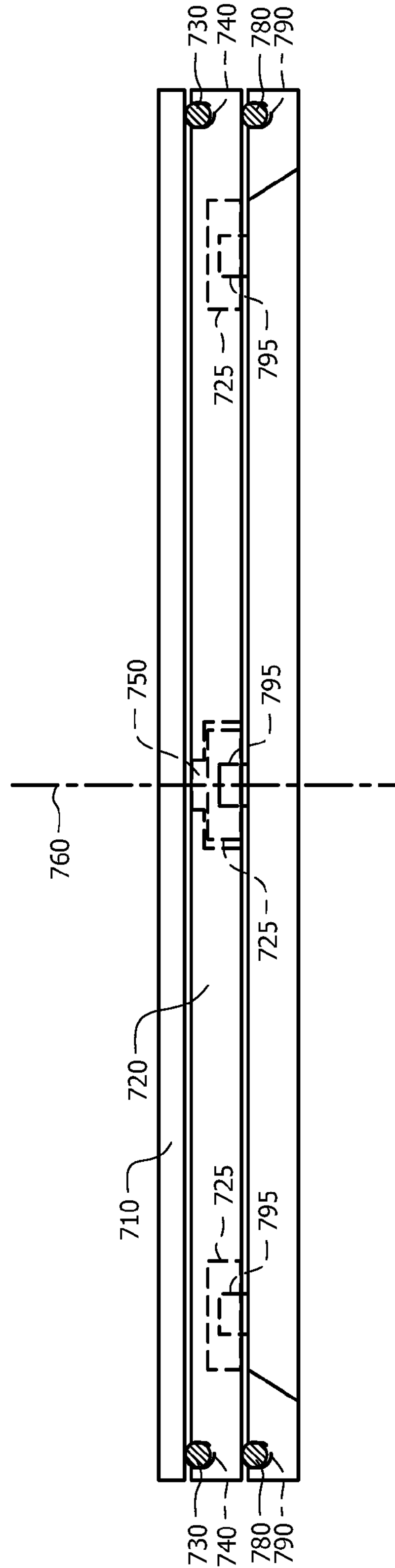
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FIG. 9B

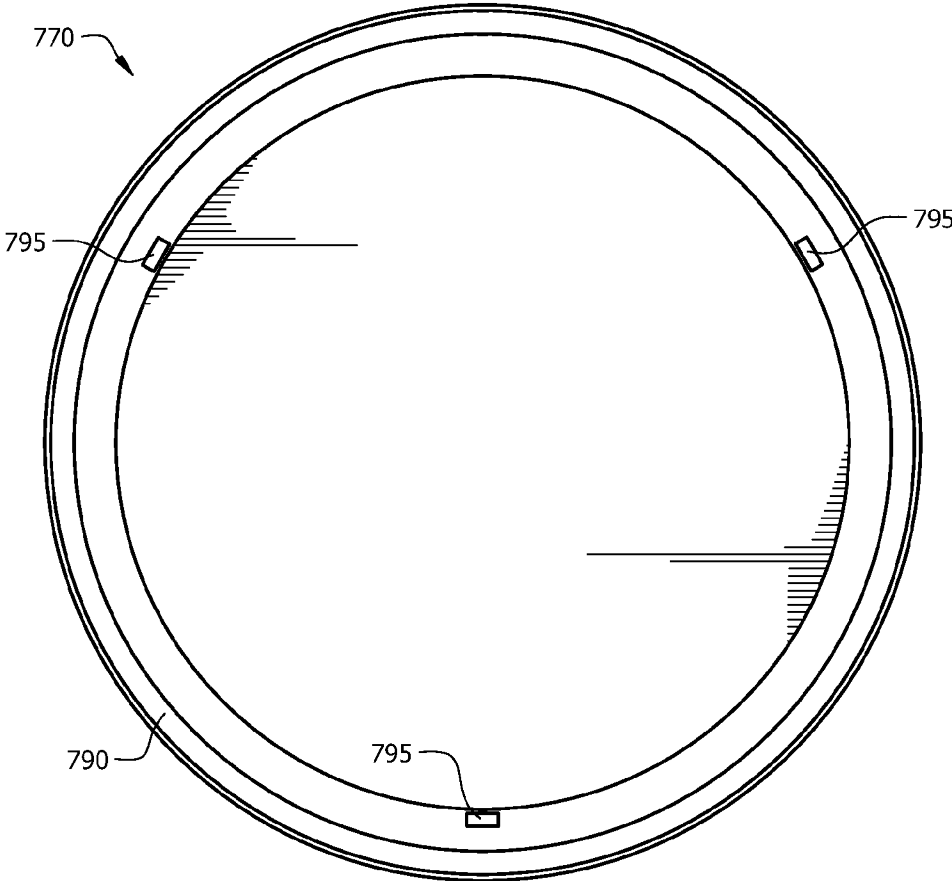

FIG. 10A

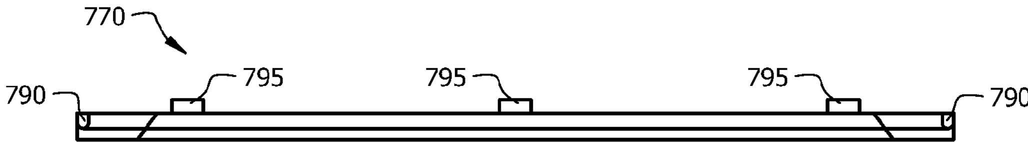

FIG. 10B

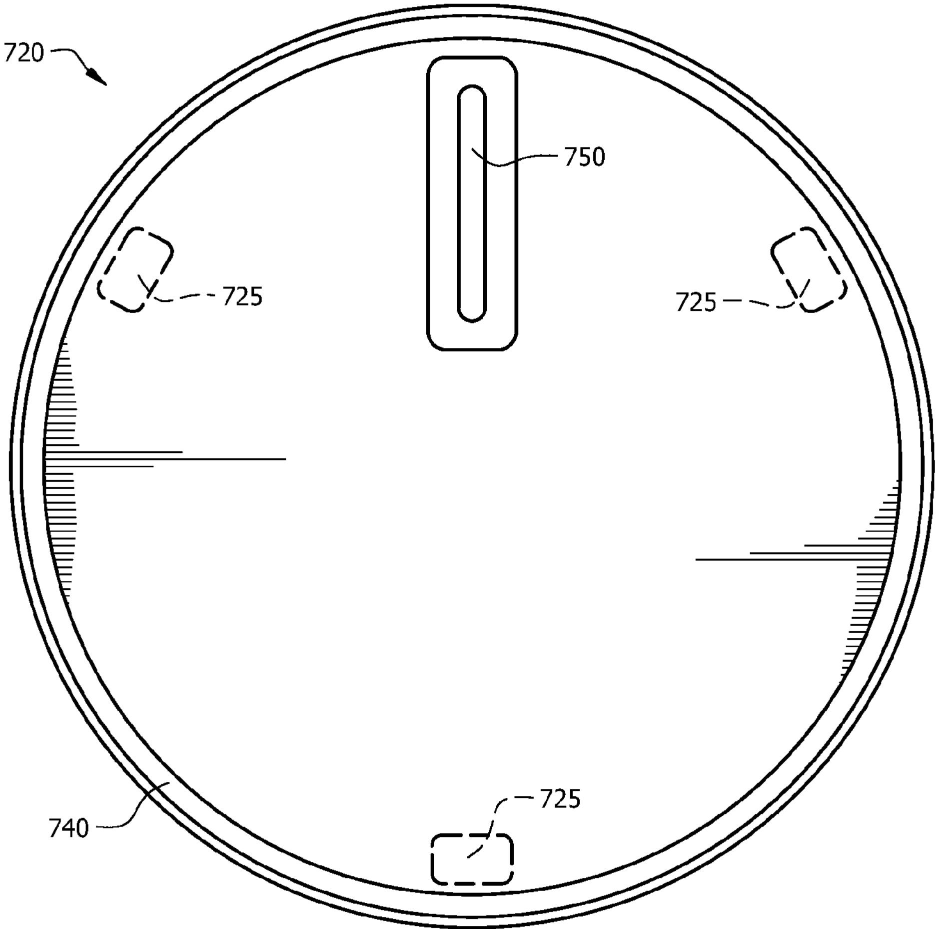

FIG. 11A

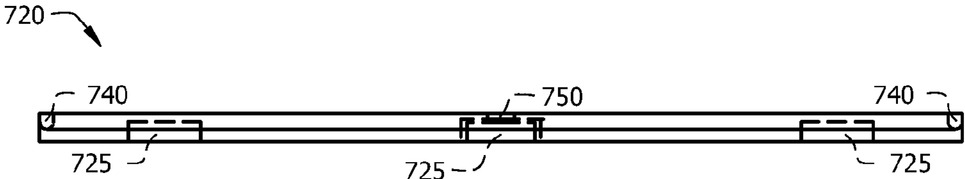

FIG. 11B

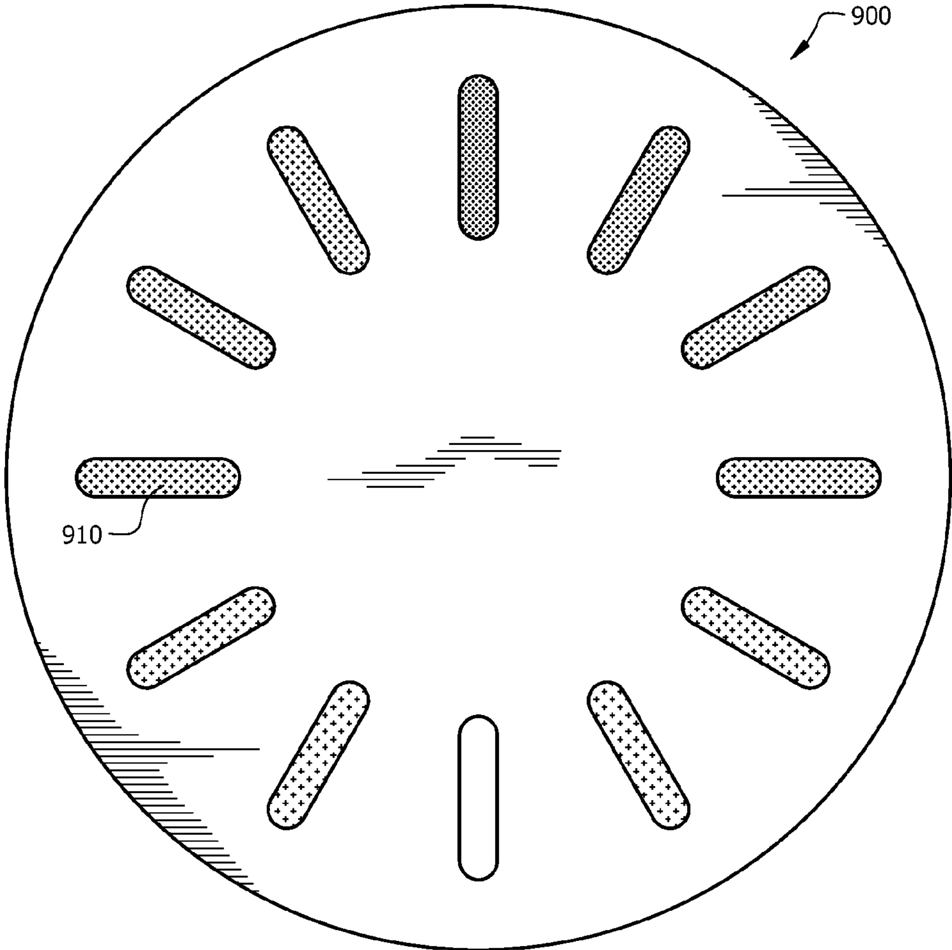

FIG. 12

INERTIAL MASKING ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application No. 61/047,781, filed Apr. 25, 2008.

FIELD OF INVENTION

This invention relates to thin film deposition. Specifically, this invention allows a shadow mask to be rotated relative to a substrate in order to allow several samples to be grown on a single substrate.

SUMMARY OF INVENTION

The present invention includes an inertial masking assembly that rotates the position of a shadow mask relative to a substrate by conservation of momentum. The substrate is seated on ball bearings confined to an orbit within the mask. Abruptly changing the angular velocity of the mask causes the mask to rotate under the substrate, which is mediated by a combination of friction and the substrate's inertia.

In a first embodiment, the inertial masking assembly comprises a mask, and a means for rotating a substrate above and substantially parallel to the mask. The mask has a bearing channel formed on its substrate-facing side. The means for rotating a substrate above and substantially parallel to the mask are positioned in the bearing channel of the mask. The inertial masking assembly may further comprise a substrate. The substrate is seated on the means for rotating a substrate above and substantially parallel to the mask and positioned such that it is above and parallel to the mask. The means for rotating a substrate above and substantially parallel to the mask separate the mask and substrate such that there is no direct contact between the mask and the substrate. In an embodiment, an abrupt change in the angular velocity of the mask causes the mask to rotate relative to the substrate; whereas a gradual change in the angular velocity of the mask causes both the mask and the substrate to rotate. In another embodiment, an abrupt change in the angular velocity of the substrate causes the substrate to rotate relative to the mask; whereas a gradual change in the angular velocity of the substrate causes both the mask and the substrate to rotate. The channel formed in the mask may be located along the perimeter of the mask. The cross-section of the channel formed in the mask may have a sawtooth shape.

The assembly may further comprise a mask seat and a means for rotating the mask above and substantially parallel to the mask seat. In this embodiment, there is at least one recess located in the evaporant-facing side of the mask. The mask seat is positioned below and parallel to the mask. The mask seat also has a channel formed in the mask-facing side and at least one post on the same side. The means for rotating the mask above and substantially parallel to the mask seat are positioned in the channel of the mask seat and the mask is seated on the means such that the mask and mask seat are substantially parallel to each other and the means are in contact with the evaporant-facing side of the mask. The mask seat and mask are further positioned such that the post of the mask seat is positioned at least partially within the recess of the mask. Rotation of the mask seat causes the post to contact the interior of the recess, such contact causing an impulse to be delivered to the mask, and such impulse causing rotation of the mask.

Alternatively, the assembly may further comprise a mask seat and means for rotating the mask above and substantially parallel to the mask seat. In this embodiment, the mask seat is positioned below and parallel to the mask. The mask seat also has a channel formed in the mask-facing side. The means for rotating the mask above and substantially parallel to the mask seat are positioned in the channel of the mask seat and the mask is seated on the means such that the mask and mask seat are parallel to each other and the means are in contact with the evaporant-facing side of the mask. The position of the mask seat may be fixed.

In another embodiment, the inertial masking assembly comprises a mask and a means for rotating the mask above and substantially parallel to a substrate. The mask has a bearing channel formed on its substrate-facing side. The means for rotating the mask above and substantially parallel to a substrate are positioned in the bearing channel of the mask. The inertial masking assembly may further comprise a substrate. The substrate is in contact with the means for rotating the mask above and substantially parallel to a substrate and positioned such that it is below and substantially parallel to the mask. The means separate the mask and substrate such that there is no direct contact between the mask and the substrate. In an embodiment, an abrupt change in the angular velocity of the mask causes the mask to rotate relative to the substrate; whereas a gradual change in the angular velocity of the mask causes both the mask and the substrate to rotate. In another embodiment, an abrupt change in the angular velocity of the substrate causes the substrate to rotate relative to the mask; whereas a gradual change in the angular velocity of the substrate causes both the mask and the substrate to rotate. The channel formed in the mask may be located along the perimeter of the mask.

The assembly may further comprise a mask seat and a means for rotating the mask seat above and substantially parallel to the mask. In this embodiment, there is at least one recess located in the evaporant-facing side of the mask. The mask seat is positioned above and parallel to the mask. The mask seat also has a channel formed in the mask-facing side and at least one post on the same side. The means for rotating the mask seat above and substantially parallel to the mask are positioned in the channel of the mask seat and the mask is seated on the ball bearing such that the mask and mask seat are parallel to each other and the means are in contact with the evaporant-facing side of the mask. The mask seat and mask are further positioned such that the post of the mask seat is positioned at least partially within the recess of the mask. Rotation of the mask seat causes the post to contact the interior of the recess, such contact causing an impulse to be delivered to the mask, and such impulse causing rotation of the mask.

Alternatively, the assembly may further comprise a mask seat and means for rotating the mask seat above and substantially parallel to the mask. In this embodiment, the mask seat is positioned above and substantially parallel to the mask. The mask seat also has a channel formed in the mask-facing side. The means for rotating the mask seat above and substantially parallel to the mask are positioned in the channel of the mask seat and the mask is in contact with the means such that the mask and mask seat are substantially parallel to each other. The position of the mask seat may be fixed.

In a further embodiment, the inertial masking assembly comprises a mask, and a means for rotating a substrate above and substantially parallel to the mask. The means for rotating a substrate above and substantially parallel to the mask are positioned on the substrate-facing side of the mask. The inertial masking assembly may further comprise a substrate. The

substrate is seated on the means for rotating a substrate above and substantially parallel to the mask and positioned such that it is above and parallel to the mask. The means for rotating a substrate above and substantially parallel to the mask separate the mask and substrate such that there is no direct contact between the mask and the substrate. In an embodiment, an abrupt change in the angular velocity of the mask causes the mask to rotate relative to the substrate; whereas a gradual change in the angular velocity of the mask causes both the mask and the substrate to rotate. In another embodiment, an abrupt change in the angular velocity of the substrate causes the substrate to rotate relative to the mask; whereas a gradual change in the angular velocity of the substrate causes both the mask and the substrate to rotate. The means for rotating a substrate above and substantially parallel to the mask may be located along the perimeter of the mask.

The assembly may further comprise a mask seat and a means for rotating the mask above and substantially parallel to the mask seat. In this embodiment, there is at least one recess located in the evaporant-facing side of the mask. The mask seat is positioned below and substantially parallel to the mask. The mask seat has at least one post on the mask-facing side. The means for rotating the mask above and substantially parallel to the mask seat are also positioned on the mask-facing side of the mask seat. The mask is seated on the means such that the mask and mask seat are substantially parallel to each other and the means are in contact with the evaporant-facing side of the mask. The mask seat and mask are further positioned such that the post of the mask seat is positioned at least partially within the recess of the mask. Rotation of the mask seat causes the post to contact the interior of the recess, such contact causing an impulse to be delivered to the mask, and such impulse causing rotation of the mask.

Alternatively, the assembly may further comprise a mask seat and means for rotating the mask above and substantially parallel to the mask seat. In this embodiment, the mask seat is positioned below and parallel to the mask. The means for rotating the mask above and substantially parallel to the mask seat are positioned on the mask-facing side of the mask seat. The mask is seated on the means such that the mask and mask seat are substantially parallel to each other and the means are in contact with the evaporant-facing side of the mask. The position of the mask seat may be fixed.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the invention, reference should be made to the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. **1**A is a perspective view of substrate-facing side of a mask in accordance with an embodiment of the present invention.

FIG. **1**B is a perspective view of evaporant-side of a mask in accordance with an embodiment of the present invention.

FIG. **2**A is a side-view diagram showing the unassembled component parts of an inertial masking assembly including a substrate, ball bearings, and mask in a deposit-up configuration in accordance with an embodiment of the present invention.

FIG. **2**B is a side-view diagram showing an assembled inertial masking assembly including a substrate, ball bearings, and mask in a deposit-up configuration in accordance with an embodiment of the present invention.

FIG. **3**A is a top-view diagram of a mask having a bearing channel and a deposition window.

FIGS. **3**B and **3**C are side-view diagrams of the mask of FIG. **3**A.

FIG. **4**A is a side-view diagram showing the unassembled component parts of an inertial masking assembly including a substrate, ball bearings, and mask in a deposit-down configuration in accordance with an embodiment of the present invention.

FIG. **4**B is a side-view diagram showing an assembled inertial masking assembly including a substrate, ball bearings, and mask in a deposit-down configuration in accordance with an embodiment of the present invention.

FIG. **5**A is a top-view diagram of a mask having a sawtooth-shaped bearing channel and a deposition window.

FIG. **5**B is a cross-sectional view of a sawtooth-shaped bearing channel taken along the dashed line in the center of the channel of the mask of FIG. **5**A.

FIG. **5**C is a cross-sectional view of a sawtooth-shaped bearing channel as shown in FIG. **5**B illustrating the ratcheting movement of a ball bearing in the channel and the angle of each elevation along the channel.

FIG. **6**A is a side-view diagram showing the unassembled component parts of an inertial masking assembly including a substrate, mask, mask seat, and two sets of ball bearings in accordance with an embodiment of the present invention.

FIG. **6**B is a side-view diagram showing an assembled inertial masking assembly including a substrate, mask, mask seat, and two sets of ball bearings in accordance with an embodiment of the present invention.

FIG. **7**A is a top-view diagram of a mask seat having a bearing channel and a hollow center in accordance with an embodiment of the present invention.

FIG. **7**B is a side-view diagram of the mask seat of FIG. **7**A.

FIG. **8** is a top-view diagram of a mask seat having multiple arch-shaped bearing channels and a hollow center in accordance with an embodiment of the present invention.

FIG. **9**A is a side-view diagram showing the unassembled component parts of an inertial masking assembly including a substrate, a mask having multiple recesses, a mask seat having multiple posts, and two sets of ball bearings in accordance with an embodiment of the present invention.

FIG. **9**B is a side-view diagram showing an assembled inertial masking assembly including a substrate, a mask having multiple recesses, a mask seat having multiple posts, and two sets of ball bearings in accordance with an embodiment of the present invention.

FIG. **10**A is a top-view diagram of a mask seat having a bearing channel, multiple posts, and a hollow center in accordance with an embodiment of the present invention.

FIG. **10**B is a side-view diagram of the mask seat of FIG. **10**A.

FIG. **11**A is a top-view diagram of a mask having a bearing channel, multiple recesses, and a deposition window.

FIG. **11**B is a side-view diagram of the mask seat of FIG. **11**A.

FIG. **12** is a top-view diagram of a substrate with multiple thin film structure deposited thereon.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings, which form a part hereof, and within which are shown by way of illustration specific embodiments by which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the invention.

The present invention includes an inertial masking assembly that allows multiple thin film structures to be deposited on

a single substrate by in situ rotation of a shadow mask relative to the substrate. The assembly rotates the position of the shadow mask by the conservation of momentum. The substrate is seated on ball bearings confined to an orbit within the mask. Abruptly changing the angular velocity of the mask causes the mask to rotate under the substrate, which is mediated by a combination of rolling friction and the substrate's inertia.

As illustrated in the perspective views of FIGS. **1**A and **1**B, mask **120** includes channel **120** which receives ball bearings (not pictured) and deposition window **150** to allow material to contact the substrate. FIG. **1**A shows the substrate-facing side of mask **120** and FIG. **1**B shows evaporant-facing side of mask **120**. In FIG. **1**A, channel **140** is located near the perimeter of mask **120**. This shape allows the ball bearing confined within channel **140** to have an orbit concentric with axis of rotation **160**.

In an embodiment, as shown in the diagrams of FIGS. **2**A and **2**B, inertial masking assembly **100** comprises substrate **110**, mask **120**, and set of ball bearings **130**. Substrate **110** is seated on ball bearings **130**, located at substrate's **110** perimeter. Ball bearings **130** are confined within channel **140** in mask **120**. Mask **120** also contains deposition window **150**.

Mask **120** and substrate **110** may be capable of rotation around axis of rotation **160**. Further, mask **120** may be fixed to something that can be rotated ex situ, such as a shaft connected to a motor. An impulse or abrupt change in the angular velocity of mask **120** (e.g., via a motor) causes mask **120** to rotate. The inertia of substrate **110** keeps substrate **110** essentially static. This is mediated by the rolling friction associated with ball bearings **130**, which effectively decouples substrate **110** from mask **120**, allowing them to rotate independently.

Although substrate **110** is rotated and elevated above mask **120** by free-moving ball bearings **130** in the above embodiment, there are other means for rotating substrate **110** above and parallel to substrate **110**. For example, ball bearings **130** may be affixed by glue or other affixing means in channel **140**. Here, static and kinetic friction replaces rolling friction. Static and kinetic friction are favorable in situations where rolling friction is too low, which can cause substrate **110** to rotate around several times before stopping. Alternatively, substrate **110** may be seated on small fixed objects, or posts, protruding from channel **140** or from the surface of mask **120**. In addition, channel **120** may be replaced by a flat-top elevated surface onto which substrate **110** would be seated. The elevated surface may be of any appropriate shape including a ring, like channel **140** shown in FIG. **3**A, and a series of arches, like arch-shaped channels **495** shown in FIG. **8**. These alternatives also provide for increased static and kinetic friction instead of rolling friction.

As an example, if mask **120** has deposition window **150** as a small hole near its perimeter located at twelve o'clock, the impulse causes the hole to rotate to the one o'clock position. Any final position can be obtained in a piecewise manner via sequential impulses. Assembly **100** can be rotated in synchronization when the angular velocity is changed slowly.

Alternatively, substrate **110** may be removably affixed to something that can be rotated ex situ, such as a shaft connected to a motor. Here, an impulse or abrupt change in the angular velocity of substrate **110** (e.g., via a motor) causes substrate **110** to rotate. The inertia of mask **120** keeps mask **120** essentially static. This is mediated by the rolling friction associated with ball bearings **130**, which effectively decouples substrate **110** from mask **120**, allowing them to rotate independently.

One of mask **320** and substrate **310** may also be fixed such that there is no rotation around axis of rotation **360** by that particular layer of the assembly.

Substrate **110** may be a flat circular disc (e.g., a silicon wafer) or any other shape, such as a square; however, some sizes and shapes may require the use of a substrate holder. Substrate **110** may be weighted down by a ring or plate placed on top of it suitable for the process.

The material chosen for ball bearings **130** should be appropriate for the process (UHV, High Temperature). In an exemplary embodiment, sapphire is used. However, in another embodiment, which requires that substrate **110** be electrically grounded to the sample holder, SS**304** is used. (equally spaced in angle)

Diagrams showing three views of mask **200** are shown in FIGS. **3**A, **3**B, and **3**C. FIG. **3**A is a top-view of mask **120** having deposition window **150** and channel **140**. FIGS. **3**B and **3**C are side views of mask **120**.

The embodiment shown in FIGS. **2**A and **2**B is utilized for deposit-up tools. The present invention can also be utilized for deposit-down tools. As shown in FIGS. **4**A and **4**B, inertial masking assembly **300** comprises substrate **310**, mask **320**, and set of ball bearings **330**. Ball bearings **330** are confined within channel **340** in mask **320**. Mask **320** also contains deposition window **350**. Substrate **310** is positioned below and parallel to mask **320**. Substrate **310** is in contact with ball bearings **330** at its perimeter.

Mask **320** and substrate **310** may be capable of rotation around axis of rotation **360**. Further, substrate **310** may be removably affixed to something that can be rotated ex situ, such as a shaft connected to a motor. An impulse or abrupt change in the angular velocity of substrate **310** (e.g., via a motor) causes substrate **310** to rotate. The inertia of mask **320** keeps mask **320** essentially static. This is mediated by the rolling friction associated with ball bearings **330**, which effectively decouples substrate **310** from mask **320**, allowing them to rotate independently.

Alternatively, mask **320** may be fixed to something that can be rotated ex situ, such as a shaft connected to a motor. Here, an impulse or abrupt change in the angular velocity of mask **320** (e.g., via a motor) causes mask **320** to rotate. The inertia of substrate **310** keeps substrate **310** essentially static. This is mediated by the rolling friction associated with ball bearings **330**, which effectively decouples substrate **310** from mask **320**, allowing them to rotate independently.

One of mask **320** and substrate **310** may also be fixed such that there is no rotation around axis of rotation **360** by that particular layer of the assembly.

In an additional embodiment, illustrated in FIGS. **5**A, **5**B, and **5**C, channel **520** may also be designed to allow a ratcheting mode (i.e., a shape that allows relative motion for only one sense of rotation) and/or a lifting of the substrate from mask **500**. The ratcheting mechanism is facilitated by the sawtooth shape of channel **520**. The sawtooth shape is shown in FIG. **5**B, which is a cross-sectional view of channel **520** along the dotted line shown in FIG. **5**A.

The ratcheting mechanism is further illustrated in FIG. **5**C, which shows the sawtooth shape of bearing channel **520**, the slant angle **527** of the sawtooth shape, a first position **525** and, a second position **526** of the bearing ball, direction **528** of the impulse, and direction **529** of the ball bearing. The delivery of an impulse in direction **528** causes mask **500** to rotate beneath the ball bearing. This causes a ball bearing to move in direction **529** from first position **525** to second position **526**. An impulse delivered in the opposite direction will not result in the ball bearing changing positions because of bearing chan-

nel's **520** sawtooth shape. The size of slant angle **527** depends on the ball bearing size and the magnitude of the impulse.

In another embodiment, as illustrated in FIGS. **6**A and **6**B, inertial masking assembly **400** comprises substrate **410**, first set of ball bearings **430**, mask **420**, second set of ball bearings **480**, and mask seat **470**. A top-view of mask seat **470** is shown in FIG. **7**A. FIG. **7**B shows a side view of mask seat **470**. Mask seat **470** has channel **490** located at or near its perimeter and is hollow at its center **475**.

As shown in FIGS. **6**A and **6**B, mask **420** is seated on ball bearings **480**, which are confined within channel **490**. Mask **420** has deposition window **450** and channel **440**. Substrate **410** is seated on ball bearings **430**, which are confined within channel **440**.

Substrate **410**, mask **420**, and mask seat **470** may each be free to rotate about center of rotation **460** or one or more of the layers may be fixed. In addition, one or more of substrate **410**, mask **420**, and mask seat **470** may be held rigidly to a rotating shaft (not shown) or other rotating means as known in the art. In one embodiment, substrate **410** and mask seat **470** are fixed and mask **420** is free to rotate. Rotation is facilitated by ball bearing **430** and ball bearings **480**. This embodiment allows a sample positioned on substrate **410** to be connected electrically.

In another embodiment, ball bearings **480** have a confined length of travel. This may be achieved by placing one or more barriers in channel **490** or replacing channel **490** with a series of arch-shaped channels **495**, as shown in FIG. **8**. Confining the length of travel of the ball bearing **480** induces an impulse. This impulse would rotate mask **440** relative to substrate **410**.

In an additional embodiment, as shown in FIGS. **9**A and **9**B, an impulse is created by pillars **795** protruding from mask seat **770** and into recesses **725** formed in mask **720**. Mask **720** sits on ball bearings **780** located in channel **790** of mask seat **770**, with pillars **795** of mask seat **770** inserted into corresponding recesses **725** in the bottom of mask **720**. Mask seat **770** may be held rigidly to a rotating shaft (not shown) or other rotating means known in the art. When mask seat **770** rotates, mask **720** initially remains stationary (mediated by rolling friction of ball bearings **780**) until pillars **795** make contact with the interior of recesses **725**. Contact between pillars **795** and the interior of recesses **725** delivers an impulse to mask **720**. This impulse is sufficient to result in a significant relative rotation of mask **720** with respect to substrate **710**.

Example locations and relative sizes of pillars **795** are illustrated in FIGS. **10**A (top view) and **10**B (side view). FIGS. **11**A (top view) and **11**B (side view) show corresponding recesses **725** in mask **720**. The location of recesses **725** are shown in FIG. **11**A as dotted lines as they are located on bottom, or evaporant-facing side, of mask **720** and FIG. **11**A is a top view.

FIG. **12** shows an example of substrate **900** with sequential film deposits **910** with different physical characteristics (indicated by different shades of gray here) as produced by the present invention.

The present invention provides for lowered monetary expenses by utilizing a single substrate for multiple samples and increased efficiency/productivity by obviating the time and contamination incurred by inserting/removing individual substrates for the same number of samples. The deposition system also provides a simplified method for depositing multiple samples on one substrate while otherwise retaining all functionality of the tool (e.g., simultaneous rotation, heating, and rf biasing). Present techniques that allow the same end goal involve multiple motors, excessive computer control, and limit the general functionality of the tool (e.g., limited to room temperature operation).

The present invention may be used with any vacuum-based physical deposition tool such as sputtering, electron-beam evaporation, molecular beam epitaxy, pulsed laser deposition, laser ablation, and pulsed electron deposition. It is also applicable for non-vacuum-based deposition tools such as electrodeposition.

It will be seen that the advantages set forth above, and those made apparent from the foregoing description, are efficiently attained and since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matters contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall there between.

What is claimed is:

1. An apparatus for thin film deposition, the apparatus comprising:
- a mask having a substrate-facing side;
- a channel formed in the mask on the substrate-facing side; and
- a means for rotating a substrate above and substantially parallel to the mask, the means positioned in the channel of the mask.

2. The apparatus of claim **1**, further comprising:
- a substrate seated on the means for rotating a substrate above and substantially parallel to the mask such that the mask and the substrate are not in direct contact.

3. The apparatus of claim **1**, wherein the channel formed in the mask is located along the perimeter of the mask.

4. The apparatus of claim **1**, wherein the cross-section of the channel formed in the mask has a saw-tooth shape.

5. The apparatus of claim **1**, further comprising
- an evaporant-facing side of the mask;
- at least a first recess located in the evaporant-facing side of the mask;
- a mask seat positioned below and substantially parallel to the mask and having a mask-facing side;
- at least a first post positioned on the mask-facing side of the mask seat;
- a channel formed in the mask-facing side of the mask seat;
- an additional means for rotating the mask above and substantially parallel to the mask seat, the means positioned in the channel of the mask seat and in contact with the evaporant-facing side of the mask; and
- wherein the mask seat and the mask are arranged such that the at least first post of the mask seat is positioned at least partially within the at least first recess of the mask.

6. The apparatus of claim **1**, further comprising:
- an evaporant-facing side of the mask;
- a mask seat positioned below and substantially parallel to the mask and having a mask-facing side;
- a channel formed in the mask-facing side of the mask seat; and
- an additional means for rotating the mask above and substantially parallel to the mask seat, the means positioned in the channel of the mask seat and in contact with the evaporant-facing side of the mask.

7. The apparatus of claim **6**, wherein the position of the mask seat is fixed.

8. An apparatus for thin film deposition, the apparatus comprising:
- a mask having a substrate-facing side;

a channel formed in the mask on the substrate-facing side; and

a means for rotating the mask above and substantially parallel to a substrate, the means positioned in the channel of the mask.

9. The apparatus of claim **8**, further comprising:

a substrate in contact with the means for rotating the mask above and substantially parallel to a substrate and positioned below and substantially parallel to the mask such that the mask and the substrate are not in direct contact.

10. The apparatus of claim **8**, wherein the channel formed in the mask is located along the perimeter of the mask.

11. The apparatus of claim **8**, further comprising:

an evaporant-facing side of the mask;

at least a first recess located in the evaporant-facing side of the mask;

a mask seat positioned above and substantially parallel to the mask and having a mask-facing side;

at least a first post positioned on the mask-facing side of the mask seat;

a channel formed in the mask-facing side of the mask seat;

an additional means for rotating the mask seat above and substantially parallel to the mask, the means positioned in the channel of the mask seat and in contact with the evaporant-facing side of the mask; and

wherein the mask seat and the mask are arranged such that the at least first post of the mask seat is positioned at least partially within the at least first recess of the mask.

12. The apparatus of claim **8**, further comprising:

an evaporant-facing side of the mask;

a mask seat positioned above and substantially parallel to the mask and having a mask-facing side;

a channel formed in the mask-facing side of the mask seat; and

an additional means for rotating the mask seat above and substantially parallel to the mask, the means positioned in the channel of the mask seat and in contact with the evaporant-facing side of the mask.

13. The apparatus of claim **12**, wherein the position of the mask seat is fixed.

14. An apparatus for thin film deposition, the apparatus comprising:

a mask having a substrate-facing side; and

a means for rotating a substrate above and substantially parallel to the mask, the means positioned on the substrate-facing side of the mask.

15. The apparatus of claim **14**, further comprising:

a substrate seated on the means for rotating a substrate above and substantially parallel to the mask such that the mask and the substrate are not in direct contact.

16. The apparatus of claim **14**, wherein the means for rotating a substrate above and substantially parallel to the mask is located along the perimeter of the mask.

17. The apparatus of claim **14**, further comprising

an evaporant-facing side of the mask;

at least a first recess located in the evaporant-facing side of the mask;

a mask seat positioned below and substantially parallel to the mask and having a mask-facing side;

at least a first post positioned on the mask-facing side of the mask seat;

an additional means for rotating the mask above and substantially parallel to the mask seat, the means positioned on the mask-facing side of the mask seat and in contact with the evaporant-facing side of the mask; and

wherein the mask seat and the mask are arranged such that the at least first post of the mask seat is positioned at least partially within the at least first recess of the mask.

18. The apparatus of claim **14**, further comprising:

an evaporant-facing side of the mask;

a mask seat positioned below and substantially parallel to the mask and having a mask-facing side; and

an additional means for rotating the mask above and substantially parallel to the mask seat, the means positioned on the mask-facing side of the mask seat and in contact with the evaporant-facing side of the mask.

19. The apparatus of claim **18**, wherein the position of the mask seat is fixed.

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