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Wafer shift detection

Abstract

A wafer storage elevator and method for detecting wafer position shift. The elevator includes a first storage elevator sidewall, a second storage elevator sidewall, and a storage seat positioned between the first and second storage elevator sidewalls. A first mirror block is coupled to a front side of the storage seat having a mirror positioned on a top surface of the block, and a second mirror block is coupled to the front side of the storage seat having a mirror that is positioned on the top surface of the second mirror block. The mirror of the first mirror block reflects a laser beam from an emission sensor to the second mirror block, and the mirror of the second mirror block reflects the laser beam from the mirror of the first mirror block to a receive sensor. A wafer misalignment is determined based upon an output of the receive sensor.

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Background/Summary

PRIORITY CLAIM AND CROSS-REFERENCE (1) This application claims the benefit of U.S. Provisional Application Ser. No. 63/409,355 filed Sep. 23, 2022, and titled WAFER SHIFT DETECTION which is incorporated herein by reference in its entirety.

BACKGROUND
(1) Semiconductor wafers are often stored and processed in a wafer cassette of some type. The wafers are normally facing in one direction so that the device side of each wafer in the interior of the stack faces the backside of the adjacent wafer. Prior to processing, wafers are stored in storage elevators within a buffer chamber. Wafers are loaded into the storage elevator from carriers and transit from the buffer chamber to a process chamber via robotic arms. Wafers should be properly aligned within the buffer chamber for the robotic arm to retrieve to prevent damage to the wafer.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It is noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.
(2) FIG. **1** is a simplified view of a wafer storage system in accordance with some embodiments.
(3) FIG. **2**A is a front view of a storage elevator in accordance with some embodiments.
(4) FIG. **2**B is a side view of the storage elevator of FIG. **2**A.
(5) FIG. **2**C is a three-dimensional view of the storage elevator of FIGS. **2**A-**2**B.
(6) FIG. **3** is an isometric view of the storage elevator of FIGS. **2**A-**2**C.
(7) FIG. **4** is a three-dimensional view of a storage elevator seat in accordance with some embodiments.
(8) FIGS. **5**A-**5**E are views of a first mirror block in accordance with some embodiments.
(9) FIGS. **6**A-**6**E are views of a second mirror block in accordance with some embodiments.
(10) FIGS. **7**A-**7**B are views of first and second mirror blocks in accordance with some embodiments.
(11) FIG. **8** is a schematic view of a multi-chamber platform utilizing the wafer storage system of FIG. **1** in accordance with some embodiments.

(12) FIG. **9** illustrates a block diagram of a controller in accordance with some embodiments.
(13) FIG. **10** illustrates a flowchart of a method for detecting wafer shift in accordance with some embodiments.

DETAILED DESCRIPTION

(14) The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. For example, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, such that the first and second features may not be in direct contact. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.
(15) Further, spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. The spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. The apparatus may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein may likewise be interpreted accordingly.
(16) In the following description, certain specific details are set forth in order to provide a thorough understanding of various embodiments of the disclosure. However, one skilled in the art will understand that the disclosure may be practiced without these specific details. In other instances, well-known structures associated with electronic components and fabrication techniques have not been described in detail to avoid unnecessarily obscuring the descriptions of the embodiments of the present disclosure.
(17) Unless the context requires otherwise, throughout the specification and claims that follow, the word “comprise” and variations thereof, such as “comprises” and “comprising,” are to be construed in an open, inclusive sense, that is, as “including, but not limited to.”
(18) The use of ordinals such as first, second and third does not necessarily imply a ranked sense of order, but rather may only distinguish between multiple instances of an act or structure.
(19) Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.
(20) As used in this specification and the appended claims, the singular forms “a,” “an,” and “the” include plural referents unless the content clearly dictates otherwise. It should also be noted that the term “or” is generally employed in its sense including “and/or” unless the content clearly dictates otherwise.
(21) Referring now to FIG. **1**, there is shown a wafer position shift detection system **100** in accordance with some embodiments. As illustrated in FIG. **1**, the wafer position shift detection system **100** utilizes a storage elevator **104** disposed within a buffer chamber **102** of a semiconductor manufacturing apparatus (illustrated as the exemplary semiconductor manufacturing system **800** of FIG. **8**, discussed in greater detail below). It will be appreciated that the buffer chamber **102** may correspond to a wafer transfer chamber, wherein a robot unit (not shown) transfers wafers from a cassette to a storage elevator **104** of process chamber. The storage elevator

104 may be implemented as a wafer transfer position, before processing starts and after processing ends, as discussed below. In accordance with one embodiment, the storage elevator **104** includes a storage elevator seat **106** fixed at a bottom of the storage elevator **104**, a first elevator sidewall **107**A and a second elevator sidewall **107**B. As shown in FIG. **1**, the first elevator sidewall **107**A and the second elevator side wall **107**B are positioned on opposite edges of the storage elevator seat **106** and extend perpendicularly upward from the storage elevator seat **106**. In some embodiments the first and second elevator sidewalls **107**A and **107**B are mutually parallel.

(22) In some embodiments, the first and second elevator sidewalls **107**A-**107**B are removably coupled to the storage elevator seat **106**. Suitable attachment mechanisms include, for example and without limitation, screws, nut/bolt, interlocking tabs/slots, or the like. The wafer shift detection system **100** further utilizes a first mirror block **108** and a second mirror block **110** affixed to the storage elevator seat **106**, as illustrated in FIGS. **2**A-**4** and discussed in greater detail below. A more detailed view of the first mirror block **108** and the second mirror block **110** are shown in FIGS. **5**A-**7**B, discussed below. In some embodiments, the mirror blocks **108**, **110** may be fabricated (e.g., integrated molding, casting, milling, etc.) of a suitable materials, e.g., aluminum, aluminum alloy, metal alloy, high density plastic, or the like. Positioned above the first mirror block **108** is at least one emission source, i.e., laser **112** configured to emit light, e.g., a laser beam **113**, down to the first mirror block **108**. The laser **112** may, by way of nonlimiting illustrative example, comprise a helium neon (HeNe) laser, or a semiconductor laser diode or light emitting diode (LED), optionally with collimating refractive and/or reflective optics (e.g., a collimating lens). In accordance with one embodiment, the laser **112** and sensor **114** are implemented as through beam sensors, i.e., a pair of components, with one laser **112** dedicated to transmit the laser beam **113** and one sensor **114** dedicated to receive the laser beam **113**, resulting in more accurate detection than a diffused sensor setup (i.e., single sensor functioning to send and receive). The first mirror block **108**, as indicated in FIG. **1**, directs the light across the storage elevator seat **106** to the second mirror block **110**. Thereafter, the second mirror block **110** directs the light to a receive sensor **114** position above the second mirror block **110**. Accordingly, any wafer **116**A-**116**C out of alignment within the storage elevator **104** will interrupt or block transmission of the laser beam **113** from the laser **112** to the receive sensor **114**. Thus, the laser beam **113** transits an optical path from the emission source or laser **112**, down the first sidewall **107**A to the first mirror **128** of the first mirror block **108**, across the seat **106** to the second mirror **128** of the second mirror block **110**, and up the second sidewall **107**B to the receive sensor **114**. A more detailed view of the storage elevator seat **106** is provided below with respect to FIG. **4**.

(23) The storage elevator **104** further includes one or more storage elevator wafer rails **118** positioned on the interior sides of each of the first elevator sidewall **107**A and second elevator sidewall **107**B, thereby defining a wafer slot **120** configured to hold a wafer therein. FIG. **1** illustrates the presence of one or more wafers **116**A, **116**B, and **116**C positioned in slots **120** of the storage elevator **104**. It will be appreciated that the storage elevator **104** may be configured to store any number of wafers **116**A-**116**C, and the illustration of three wafers **116**A-**116**C is intended solely to illustrate certain aspects of the present embodiment. As shown in FIG. **1**, wafers **116**A and **116**C are in proper position within the storage elevator **104**, whereas wafer **116**B is illustrated as being out of alignment. In some embodiments, detection of the out-of-position or out of alignment of the wafer **116**B is determined in accordance with the output of the sensor **114**, as discussed in greater detail below. In such embodiments, the emission source or laser **112** and the receive sensor **114** are in data communication with a controller **122**, the functioning of which is discussed in greater detail below with respect to FIG. **9**.

(24) Turning now to FIGS. **2**A and **2**B, there are shown, respectively, a front view and a side view of the storage elevator **104** in accordance with some embodiments. As shown in FIG. **2**A, the storage elevator **104** includes a plurality of storage elevator wafer rails **118** located on the inner side (extending inward towards each other) of the first elevator sidewall **107**A and the second elevator

sidewall **107**B to form a plurality of storage elevator slots **120**. The storage elevator wafer rails **118**, as shown in FIG. **2**B, extend perpendicularly across the respective elevator sidewalls **107**A-**107**B and extend laterally outward therefrom.

(25) The storage elevator seat **106**, in accordance with some embodiments, is illustrated in FIGS. **2**A-**2**B with the aforementioned first and second mirror blocks **108**-**110** affixed thereto. As shown in FIG. **2**B, each side of the storage elevator seat **106** includes a pair of mirror blocks, i.e., one first mirror block **108** and one second mirror block **110**. In some embodiments, a pair of emission sources or lasers **112** and a corresponding pair of receive sensors **114** are utilized in the wafer position system **100**, e.g., positioned to interact with corresponding pairs of first and second mirror blocks **108**, **110**. It will be appreciated that, as depicted in FIG. **2**B, each of the mirror blocks **108**-**110** extends laterally and in parallel with the storage elevator wafer rails **118**. In accordance with some embodiments, each mirror block **108**-**110** extends past the end of the storage elevator wafer rails **118**, as illustrated in FIG. **2**B. FIG. **2**B further illustrates the attachment of the storage elevator seat **106** to the storage elevator sidewalls **107**A-**107**B. Further illustrated in FIG. **2**B are attachment points **146** located on the bottom of the sidewalls **107**A-**107**B for use in coupling the storage elevator seat **106** to the sidewalls **107**A-**107**B. In some embodiments, a screw, bolt, friction, etc., fastener (not shown) is inserted through the attachment points **146** so as to secure the storage elevator seat **106** to the bottom **126** of the sidewalls **107**A-**107**B.

(26) FIG. **2**C provides a three-dimensional view of the wafer storage elevator **104** of FIGS. **2**A-**2**B. As shown in FIG. **2**C, each of the wafer storage elevator rails **118** includes a corresponding semi-circular indentation **124** configured to hold a wafer **116**A-**116**C within the storage elevator **104**. It will be appreciated that the radius of the semi-circular indentation **124** is dependent upon the size of the wafer **116**A-**116**C being processed. For example, a six-inch (i.e., 150 mm) diameter wafer will have a smaller semi-circular indentation **124** than an eight-inch (i.e., 200 mm) diameter wafer. Similarly, the radius of the semi-circular indentation **124** for an eight-inch (i.e., 200 mm) diameter wafer will be smaller than the radius of a semi-circular indentation **124** for a twelve-inch (i.e., 300 mm) wafer.

(27) Further illustrated in FIG. **2**C are three of the four mirror blocks **108**-**110** coupled to the storage elevator seat **106**. Each of the mirror blocks **108**-**110** further includes an attachment point **148** for use in securing the mirror blocks **108**-**110** to the storage elevator seat **106**. As illustrated in FIG. **2**C, the attachment points **148** correspond to a hole extending laterally through the corresponding mirror block **108**-**110** into which a fastener may be inserted to secure the mirror block **108**-**110** to the storage elevator seat **106**. In some embodiments, a screw, bolt, friction, etc., fastener (not shown) is inserted through the attachment points **148** so as to secure the mirror blocks **108**-**110** to the storage elevator seat **106**. FIG. **3** provides an isometric view of the storage elevator **104** in accordance with the embodiments set forth in FIGS. **2**A-**2**C.

(28) With reference now to FIGS. **1**-**3**, various relationships between dimensions are discussed in accordance with one exemplary embodiment. As shown in FIGS. **1**-**3**, each mirror **128** positioned on the mirror blocks **108**, **110** includes a mirror angle (A) **130**, i.e., upward reflective surface angle. In accordance with one example embodiment, each mirror **128** has the same mirror angle (A) **130**, e.g., 45 degrees. The skilled artisan will appreciate that other complementary angles may be used so as to direct the laser beam **113** emitted from the laser **112** as shown in FIG. **1**. It will further be appreciated that the mirror angle (A) **130** may depend upon the angle of the emission source or laser **112** and the receive sensor **114**. Accordingly, for example, the mirrors **128** of the first mirror blocks **108** may be implemented as the same angle and the mirrors **128** of the second mirror blocks **110** may be implemented as the same angle that is different from the angle of first mirror blocks **108**. The mirrors **128** may be constructed of any suitable reflective material, including, for example and without limitation, aluminum, silver alloy, aluminum alloy, metal-alloy, etc.

(29) As illustrated in FIG. **2**C, the mirror **128** positioned on the first mirror block **108** has an angle (C) **142** relative to the first mirror block first edge **150**, and the mirror **128** positioned on the second

mirror block **110** has an angle (B) **140** relative to the second mirror block first edge **152**. In accordance with some embodiments, the angle (C) **142** and the angle (B) **140** of the mirror blocks **108**, **110** are equal. The skilled artisan will appreciate that variations in degrees of the angles (B) and (C) **140-142** are capable of being implemented in other embodiments in accordance with different positioning of the laser **112** and sensor **114** so as to ensure that the laser beam **113** transmitted by the emission source or laser **112** transits as shown in FIG. **1** down the first storage elevator sidewall **107**A, across the storage elevator seat **106** and up the second storage elevator sidewall **107**B to the receive sensor **114**. Accordingly, a wafer **116**B out of alignment will block receipt of the laser beam **113** by the receive sensor **114**.

(30) As illustrated in FIG. **1**, each storage elevator slot **120** defined between two vertical storage elevator wafer slot rails **118** may be implemented with a height (E) **138** of a predetermined size. The height (D) **136** of each mirror **128** may be implemented as less than one half the height (E) **138** of the storage elevator slot **120**. In other embodiments, the height (D) **136** of each mirror **128** may be implemented in a range of ⅓ to ½ the height (E) **138** of the storage elevator slot **120**. Further, distance (Y) **134** between the highest edge of the mirrors **128** may be implemented as less than the edge-to-edge distance (Z) **144** of the buffer chamber **102**. Similarly, the distance (X) **132** between the lowest edge of the mirrors **128** may be implemented as greater than the diameter of the wafer **116**A-**116**C, i.e., for an eight-inch (200 mm) wafer, the distance (X) **132** may be greater than eight inches (200 mm).

(31) Turning now to FIG. **4**, there is shown a detailed view of the storage elevator seat **106** in accordance with some embodiments. As illustrated in FIG. **4**, the storage elevator seat **106** is shown prior to attachment to the first elevator sidewall **107**A and the second elevator sidewall **107**B. The storage elevator seat **106** includes a plurality of attachment points **154** located along a first side edge **156** (not shown) and a plurality of attachment points **154** located on a second side edge **158** of the storage elevator seat **106**. In accordance with some embodiments, one or more of the attachment points **154** are suitably aligned with the attachment points **146** located on the bottom **126** of the second sidewall **107**B. Similar alignment occurs between the attachment points **154** on the first side edge **156** of the storage elevator seat **106** and the attachment points **146** located on the bottom **126** of the first sidewall **107**A. In some embodiments, the attachment points **154** are suitably threaded to receive a fastener (not shown) extending through the first and second sidewalls **107**A-**107**B to secure the sidewalls **107**A-**107**B to the storage elevator seat **106**. In other embodiments, friction or other such fasteners may be used to secure the storage elevator seat **106** to the first and second sidewalls **107**A-**107**B.

(32) The first mirror block **108** and the second mirror block **110** are attached to a front side **160** of the storage elevator seat. Similarly, a second pair of first and second mirror blocks **108** and **110** are coupled to a back side **162** of the storage elevator seat **106**, as shown in FIG. **4**. In some embodiments, the storage elevator seat front side **160** and the storage elevator seat back side **162** each include one or more attachment points **154** (as described above) to which the first mirror blocks **108** and the second mirror blocks **110** join to the storage elevator seat **106**. FIG. **3** provides a partial illustration of the aforementioned attachment points **154** to which the mirror blocks **108-110** are affixed. According to some embodiments, the top surface **166** of the first mirror block **108** and the top surface **168** of the second mirror block **110** are level, i.e., coplanar, with the top surface **164** of the storage elevator seat **106**. In accordance with one embodiment, the bottom surface **170** of the first mirror block **108**, the bottom surface **172** of the second mirror block **110**, and the storage elevator seat **106** are substantially coplanar, as shown in FIG. **4**. The skilled artisan will appreciate that portions of the storage elevator seat **106**, as illustrated in FIG. **4**, may extend past the bottom surfaces of the mirror blocks **108**, **110** without affecting the functioning of the wafer position shift detection system **100**.

(33) Referring now to FIGS. **5**A-**5**E, there are shown, respectively, top, bottom, front, back and three-dimensional views of the first mirror block **108** in accordance with one embodiment of the

subject application. As illustrated in FIGS. **5**A-**5**E, the first mirror block **108** includes a first mirror block top surface **166** that is substantially planar and to which is affixed, formed, or otherwise secured a mirror **128**. The mirror **128** is positioned on the top surface **166** along a front side **182** of the first mirror block **108**. The first mirror block back side **178** includes a first mirror block alignment tab **174** configured to engage a corresponding opening or attachment point **154** of the front side **160** or back side **162** of the storage elevator seat **106**. In some embodiments, the first mirror block alignment tab **174** is implemented as cylindrical so as to slide into an attachment point **154** of the storage elevator seat **106**. According to other embodiments, the first mirror block alignment tab **174** is suitably sized to frictionally engage the attachment point **154** of the storage elevator seat **106**. The first mirror block **108** further includes a first mirror block first edge **150** and an opposing first mirror block second edge **151**, each of which are perpendicular to the first mirror block back side **178**.

(34) Turning now to FIGS. **6**A-**6**E, there are shown, respectively, top, bottom, front, back and three-dimensional views of the second mirror block **110** in accordance with one embodiment of the subject application. As illustrated in FIGS. **6**A-**6**E, the second mirror block **110** includes a second mirror block top surface **168** that is substantially planar and to which is affixed, formed, or otherwise secured a mirror **128**. The mirror **128** is positioned on the top surface **168** along a front side **184** of the second mirror block **110**. The second mirror block back side **180** includes a second mirror block alignment tab **176** configured to engage a corresponding opening or attachment point **154** of the front side **160** or back side **162** of the storage elevator seat **106**. In some embodiments, the second mirror block alignment tab **176** is implemented as cylindrical so as to slide into an attachment point **154** of the storage elevator seat **106**. According to other embodiments, the second mirror block alignment tab **176** is suitably sized to frictionally engage the attachment point **154** of the storage elevator seat **106**. FIG. **7**A provides a top view of the four mirror blocks **108**, **110** in position without the storage elevator seat **106**. FIG. **7**B provides a three-dimensional view of the four mirror blocks **108**, **110** in position without the storage elevator seat **106**. The second mirror block **110** further includes a second mirror block first edge **152** and an opposing second mirror block second edge **153**, each of which are perpendicular to the second mirror block back side **180**.

(35) Turning now to FIG. **8**, there is illustrated an exemplary semiconductor manufacturing system **800** utilizing the wafer storage system **100** of FIG. **1** in accordance with one embodiment disclosed herein. As shown in FIG. **8**, the semiconductor manufacturing system **800** includes a platform **802** having a main body **804** and a plurality of processing chambers **806**A, **806**B, **806**C, **806**D, **806**E, **806**F, **806**G, **806**H, and **806**I communicatively coupled to the main body **804** so that semiconductor wafers undergoing processing can be robotically transferred between the various processing chambers. It will be appreciated by those skilled in the art that the number and types of process chambers **806**A-**806**I may vary in accordance with the manufacturing requirements of a particular fab.

(36) As will be appreciated, the system **800** is capable of producing layers of various materials stacked on one another on a substrate without exposing the substrate to the pressure and contaminants of ambient air until the stack is complete. Thus, the process chambers **806**A-**806**I may include at least one metal deposition chamber and at least one dielectric layer deposition chamber for depositing layers in a stack. In other embodiments, one or more of the process chambers **806**A-**806**I may include a sputtering target for depositing material onto the stack.

(37) In the embodiment illustrated in FIG. **8**, the main body **804** includes a first robot buffer chamber **822** housing a first robot **826** and a second robot buffer chamber **824** housing a second robot **828**. In accordance with such an embodiment, each of the first and second robots **826** and **828** may be configured to transfer a wafer/substrate **116**A-**116**C between various process chambers **806**A-**806**I. The main body **804** may further include a pair of intermediate processing or treatment chambers **820**A and **820**B, which further enable transfer of a wafer/substrate **116**A-**116**C between the first and second robot buffer chambers **822** and **824**.

(38) According to one embodiment, the intermediate processing or treatment chamber **820**A is located within a tunnel or passageway **832** connecting the first robot buffer chamber **822** to the second robot buffer chamber **824**. Similarly, the intermediate processing or treatment chamber **820**B is positioned within a separate passageway **834** connecting the first robot buffer chamber **822** to the second robot buffer chamber **824**. In accordance with one embodiment, these separate passageways **832**, **834** between the two robot buffer chambers **822**, **824** permit one passageway to be used for loading and the other passageway for unloading, and vice versa, while the system **800** is being used for wafer processing. According to some embodiments, the intermediate processing or treatment chambers **820**A-**820**B may be configured for pre-treating of a wafer **116**A-**116**C (e.g., remote plasma etch cleaning, heating, etc.) before processing in one or more of the process chambers **806**A-**806**I and/or for post-treating of a wafer **116**A-**116**C (e.g., cool-down) after treatment in one or more of the process chambers **806**A-**806**I.
(39) In accordance with one exemplary embodiment, the platform **802** may utilize a plurality of different process chambers **806**A-**806**I. For example and without limitation, process chambers **806**A and **806**I may be implemented to perform high temperature degas annealing. In such an embodiment, process chambers **806**B and **806**H may be implemented as Collins or pre-clean chambers, e.g., PVD chambers. Further, process chambers **806**C and **806**G may be implemented as silicon-cobalt-nickel (SiCoNi) deposition chambers, whereas process chambers **806**D and **806**E may be implemented as high bottom coverage (HBC) titanium deposition chambers. In such an embodiment, process chamber **806**F may be implemented as a chemical vapor deposition (CVD) titanium nitride (TiN) deposition chamber. The skilled artisan will appreciate that the types of chambers **806**A-**806**I and the processes performed therein (as well as the materials deposited on the wafer **116**A-**116**C) may be modified in accordance with the type of semiconductor device being manufactured, and the description above is intended as one possible configuration of the platform **802** in accordance with varying embodiments of the subject application.
(40) The main body **804** further illustrates one or more load lock chambers, designated in FIG. **8** as “Load Lock A” (LLA) **814**A and “Load Lock B” (LLB) **814**B. In some embodiments, the two load lock chambers **814**A and **814**B are mounted to the first robot buffer chamber **822** and in communication with the interior of the first robot buffer chamber **822** via access ports **816** and associated gate valves **818** and to an equipment front end module (EFEM) **810** of the platform **802**. The EFEM **810** includes a robot **812** that is configured to transfer wafers **116**A-**116**C, e.g., one at a time, from a front opening unified pod (FOUP) **808**A, **808**B, **808**C to the load lock chamber **814**A or **814**B of the main body **804**. In accordance with one embodiment, the EFEM **810** includes one or more wafer shift detection systems **100** positioned therein to receive wafers **116**A-**116**C from a corresponding FOUP **808**A-**808**C.
(41) As mentioned above, the various process chambers **806**A-**806**I are attached around the first robot buffer chamber **822** and the second robot buffer chamber **824**. In FIG. **8**, each of the various process chambers **806**A-**806**I may be adapted for various types of processing, e.g., etching, annealing, deposition, cleaning, etc. As shown in FIG. **8**, access to and from the process chambers **806-806**I may also be accomplished via associated access ports **816** and gate valves **818**. Notably, the arrangement of the various chambers and layout of robotic transfer pathways of the system **800** of FIG. **8** is to be understood to be a nonlimiting illustrative example, and other numbers and arrangements of chambers and other robotic transfer pathway layouts are contemplated.
(42) In some embodiments contemplated herein, the platform **802** may be operated such that each process chamber **806**A-**806**I, robot buffer chamber **822-824**, intermediate processing or treatment chamber **820**A-**820**B, LLA **814**A and LLB **814**B may be isolated from each other by gate valves or the like. Accordingly, it will be appreciated that the internal atmosphere in each of these chambers may be independently controlled, both in terms of gas composition and pressure. In some embodiments, variations in pressure levels may be minimized during wafer transfer via an associated vacuum pump or pumps (not shown), which may be configured to provide a vacuum

gradient across the system from the load locks LLA **814**A and LLB **814**B to the process chambers **806**A-**806**I.

(43) Operation of the platform **802** may be controlled by one or more controllers **122**, shown in FIG. **8** in data communication with the platform **802** via a communications link **838**. The communications link **838** illustrated in FIG. **8** may be any suitable means of wired or wireless communication, including, for example and without limitation, the public switched telephone network, a proprietary communications network, infrared, optical, or other suitable wired or wireless data communications. In some embodiments, the various components of the system **100** are in communication with a distributed computing environment, e.g., a local area network, a wireless local area network, a virtual private network, a wide area network, or the like. In some embodiments, the controller **122** may be configured to control, for example and without limitation, operations of the front end **810** including the operations of the FOUPs **808**A, **808**B, and **808**C, the front end robot **812**, operations of the main body **804** including the first and second robots **826-828**, the various pumps, gas supplies, valves and treatment equipment of the main body **804**, as well as operations of the process chambers **806**A-**806**B. The functioning and controls provided by the controller **122** in accordance with the various embodiments discussed herein will be better understood in conjunction with FIG. **9**, discussed in greater detail below.

(44) In some embodiments, processing of a wafer **116**A-**116**C may be initiated by unloading the wafer **116**A-**116**C from one of the FOUPs **808**A, **808**B, **808**C into the storage elevator **104** of the wafer shift detection system **100** located in the EFEM **810**. One or more emission sources or lasers **112**, in accordance with instructions from the controller **122**, then transmit a laser beam **113** down the first elevator sidewall **107**A to a mirror block **108**, **110** and across to a corresponding mirror block **108**, **110** for transmission (i.e., reflection) up the second elevator sidewall **107**B to the one or more receive sensors **114**. Upon a detection of a wafer **116**B out of alignment (as illustrated in FIG. **1**), the controller **122**, via a speaker, display or other auditory or visual presentation component, generates an alert indicating the alignment issue. That is, upon a detection of a wafer **116**B within the laser beam **113**, i.e., blocking or interrupting transmission thereof to the first mirror block **108**, a determination is made that wafer **116**B is out of alignment. Thereafter a technician or automated component (e.g., robotic arm, etc.) returns the wafer **116**B to proper alignment in the storage elevator **104**. After correction, or upon a negative detection of wafer shift, the wafer **116**A-**116**C is transferred to one of the load lock chambers **814**A, **814**B.

(45) Although illustrated in FIG. **8** as utilizing FOUPs for housing wafers **116**A-**116**C for transport to and from the system **800**, it will be appreciated that other mechanisms for supporting wafers **116**A-**116**C may be used in some embodiments, including, for example and without limitation, cassettes, racks, and the like. The skilled artisan will further appreciate that other mechanisms may be used in place of the EFEM **810** to transfer a wafer **116**A-**116**C to the main body **804**. After reduction of pressure to a suitable vacuum pressure in the load lock chamber (**814**A or **814**B) containing the wafer **116**A-**116**C, the wafer **116**A-**116**C is ready for transfer to an appropriate process chamber or sequence of process chambers for processing. In accordance with one embodiment, the interior pressure of the load lock chamber **814**A or **814**B containing the wafer **116**A-**116**C to be processed is at substantially the same vacuum pressure as the first robot buffer chamber **822**.

(46) Turning now to FIG. **9**, there is shown an illustrative block diagram of a suitable controller **122** associated with the wafer shift detection system **100** and the aforementioned semiconductor manufacturing system **800** in accordance with one embodiment of the subject application. The various components of the controller **122** may be connected by a data/control bus **908**. The processor **902** of the controller **122** is in communication with an associated database **920** via a link **914**. A suitable communications link **914** may include, for example, a switched telephone network, a wireless radio communications network, infrared, optical, or other suitable wired or wireless data communications. The database **920** is capable of implementation on components of the controller

122, e.g., stored in local memory **904**, i.e., on hard drives, virtual drives, or the like, or on remote memory accessible to the controller **122**.

(47) The associated database **920** is representative of any organized collections of data (e.g., process tool information, fabrication information, wafer positioning, material information, etc.) used for one or more purposes. Implementation of the associated database **920** is capable of occurring on any mass storage device(s), for example, magnetic storage drives, a hard disk drive, optical storage devices, flash memory devices, or a suitable combination thereof. The associated database **920** may be implemented as a component of the controller **122**, e.g., resident in memory **904**, or the like. In one embodiment, the associated database **920** may include data corresponding to, for example and without limitation, production scheduling, wafer positioning, process chamber information (e.g., type, position, status, etc.), and the like.

(48) The controller **122** may include one or more input/output (I/O) interface devices **924** and **926** for communicating with external devices. The I/O interface **924** may communicate, via communications link **912**, with one or more of a display device **916**, for displaying information, such estimated destinations, and a user input device **918**, such as a keyboard or touch or writable screen, for inputting text, and/or a cursor control device, such as mouse, trackball, or the like, for communicating user input information and command selections to the processor **902**. The I/O interface **926** may communicate with external devices such as the wafer shift detection system **100**, the semiconductor manufacturing system **800**, emission sensors **112**, receive sensors **114**, a speaker **936**, a visual alert **938** (e.g., flashing light, screen, display, etc.), and the like, via a suitable the communications link **838**.

(49) It will be appreciated that the controller **122** illustrated in FIG. **9** is capable of implementation using a distributed computing environment, such as a computer network, which is representative of any distributed communications system capable of enabling the exchange of data between two or more electronic devices. It will be further appreciated that such a computer network includes, for example and without limitation, a virtual local area network, a wide area network, a personal area network, a local area network, the Internet, an intranet, or any suitable combination thereof. Accordingly, such a computer network comprises physical layers and transport layers, as illustrated by various conventional data transport mechanisms, such as, for example and without limitation, Token-Ring, Ethernet, or other wireless or wire-based data communication mechanisms. Furthermore, while depicted in FIG. **9** as a networked set of components, the controller **122** is capable of implementation on a stand-alone device adapted to interact with the wafer shift detection system **100** and the semiconductor manufacturing system **800** described herein.

(50) The controller **122** may include one or more of a computer server, workstation, personal computer, cellular telephone, tablet computer, pager, combination thereof, or other computing device capable of executing instructions for performing the exemplary method.

(51) According to one example embodiment, the controller **122** includes hardware, software, and/or any suitable combination thereof, configured to interact with an associated user, a networked device, networked storage, remote devices, or the like.

(52) The memory **904** illustrated in FIG. **9** as a component of the controller **122** may represent any type of non-transitory computer readable medium such as random access memory (RAM), read only memory (ROM), magnetic disk or tape, optical disk, flash memory, or holographic memory. In one embodiment, the memory **904** comprises a combination of random access memory and read only memory. In some embodiments, the processor **902** and memory **904** may be combined in a single chip. The network interface(s) **924**, **926** allow the computer to communicate with other devices via a computer network, and may comprise a modulator/demodulator (MODEM). Memory **904** may store data processed in the method as well as the instructions for performing the exemplary method.

(53) The digital processor **902** can be variously embodied, such as by a single core processor, a dual core processor (or more generally by a multiple core processor), a digital processor and

cooperating math coprocessor, a digital controller, or the like. The digital processor **902**, in addition to controlling the operation of the controller **122**, executes instructions **906** stored in memory **904** for performing the method set forth hereinafter.

(54) As shown in FIG. **9**, the instructions **906** stored in memory **904** may include a sensor component **928** configured to control operations of the one or more emission sources or lasers **112** and the one or more receive sensors **114**. According to one embodiment, the sensor component **928** may be programmable via the controller **122** in accordance with the particular size of the wafer **116**A-**116**C being processed, the number of lasers **112** and/or sensors **114** utilized, the angles **130** of the mirrors **128** utilized, and the like. In operation, the sensor component **928**, alone or in conjunction with other components of the controller **122** may be configured to activate laser **112**, and/or sensor **114**, receive output (e.g., signals) from the receive sensors **114** and detect position shift of wafers **116**A-**116**C upon entry and exit of wafers **116**A-**116**C into the storage elevator **104**. In some embodiments, monitoring of wafer position shift may occur at every wafer **116**A-**116**C entry/exit into the storage elevator **104**, upon initial loading of the storage elevator **104**, or at a predetermined frequency, e.g., every 5 seconds, every 7 seconds, every 10 seconds, every 15 seconds, etc.

(55) As illustrated in FIG. **9**, the instructions **906** stored in memory **904** may also include a power control component **930** configured to supply power to the semiconductor manufacturing system **800**, and particularly the various robotic arm assemblies tasked with moving wafers **116**A-**116**C within the system **800**. In some embodiments, the power control component **930** is configured to receive an output from the sensor component **928** indicating that a wafer shift has occurred in one or more storage elevators **104**. Upon receipt of such signal, the power control component **930** may stop movement/processing of wafers **116**A-**116**C in the affected storage elevator **104**.

(56) The instructions **906** stored in memory **904** may further include an alert control component **932** configured to activate and control the visual and auditory alert components, i.e., speaker **936** and visual alert **938**. In some embodiments, the alert control component **932** receives an output from the sensor component **928** indicating that a wafer **116**B has shifted out of alignment within a storage elevator **104**. Upon receipt of such a signal, the alert control component **932** may generate an alarm or other alert sound via the speaker **936** indicating to monitoring personnel that an issue has occurred. The alert control component **932** may further be configured to generate a visual alert **938** on an associated display (**916**), light, flashing/spinning light assembly, etc. In accordance with some embodiments, the visual alert **938** operates in conjunction, i.e., simultaneously or sequentially, with the audible alert through the speaker **936**. In another embodiment, the visual alert **938** includes a display of position, i.e., the particular storage elevator **104** in the EFEM **810** experiencing the wafer shift, and/or a particular wafer storage slot **120** in which the wafer **116**B has shifted. It will be appreciated that variations on these alerts and information provided are contemplated herein.

(57) The various components and hardware described above with respect to FIGS. **1-9** may be configured to perform and implement the methods set forth in greater detail below, e.g., the methods illustrated in the flowchart of FIG. **10**.

(58) The term “software,” as used herein, is intended to encompass any collection or set of instructions executable by a computer or other digital system so as to configure the computer or other digital system to perform the task that is the intent of the software. The term “software” as used herein is intended to encompass such instructions stored in storage medium such as RAM, a hard disk, optical disk, or so forth, and is also intended to encompass so-called “firmware” that is software stored on a ROM or so forth. Such software may be organized in various ways, and may include software components organized as libraries, Internet-based programs stored on a remote server or so forth, source code, interpretive code, object code, directly executable code, and so forth. It is contemplated that the software may invoke system-level code or calls to other software residing on a server or other location to perform certain functions.

(59) Referring now to FIG. **10**, there is provided a method **1000** for detecting wafer shift within a storage elevator **104** in accordance with one embodiment. As shown in FIG. **10**, the method begins at step **1002** with the loading of one or more wafers **116**A-**116**C from a FOUP **808**A-**808**C into the storage elevator **104** of the wafer shift detection system **100** as illustrated in FIG. **8**. At step **1004**, one or more emission sources or lasers **112** and corresponding one or more receive sensors **114**, arranged above the storage elevator **104**, are activated via the sensor component **928** or other suitable component associated with the controller **122**. At step **1006**, a laser beam **113** (or other suitable light emitted by the emission source **112**) transits down a first storage elevator sidewall **107**A to a mirror **128** of a first mirror block **108** (front of storage elevator seat **106**) or to a mirror **128** of a second mirror block **110** (back of storage elevator seat **106**). At step **1008**, the laser beam **113** is reflected (e.g., directed) across the storage elevator seat **106** below the wafers **116**A-**116**C to a corresponding opposite mirror block (i.e., first mirror block **108** directs to a second mirror block **110** and a second mirror block **110** directs to a first mirror block **108**). At step **1010**, the mirror **128** of the receiving mirror block **108**, **110** reflects the laser beam **113** up the second storage elevator sidewall **107**B to a corresponding one or more receive sensors **114**.

(60) A determination is then made at step **1012** whether the one or more receive sensors **114** have received the laser beam **113**. Upon a positive determination at step **1012**, operations proceed to step **1014** whereupon a signal is generated in accordance with an output of the receive sensor **114** indicating that a wafer alignment issue is not present in the wafer storage elevator **104**. Thereafter, at step **1016**, whereupon a determination is made whether processing of the wafers **116**A-**116**C in the storage elevator **104** has completed. Upon a negative determination at step **1016**, operations proceed to step **1018**, whereupon operations of the semiconductor manufacturing system **800** continue. Thereafter, operations return to step **1004**, whereupon the emission sensor(s) **112** emit the laser beam **113** down to the mirror blocks **108**, **110** as described above. Upon a positive determination at step **1014**, operations of the wafer detection system **100** terminate.

(61) Returning to step **1012**, upon a determination that one or more receive sensors **114** have not received the laser beam **113**, operations proceed to step **1020**. That is, transmission of the laser beam **113** from the emission sensor **112** is interrupted or blocked by a wafer **116**A-**116**C out of alignment. Such interruption or blocking may occur between the emission sensor **112** and the first mirror block **108** or between the second mirror block **110** and the receive sensor **114**, as will be appreciated. At step **1020**, the sensor component **928** or other suitable component of the controller **122** signals the power control unit **930** to halt (i.e., stop) wafer processing and movement. Thereafter, at step **1022**, the alert control component **932** activates the speaker **936** and/or the visual alert **938** to indicate the cessation of processing and the misalignment of one or more wafers **116**A-**116**C within the storage elevator **104**. In response to the alert, a process worker will typically inspect the elevator and visually identify the shifted wafer and move it back into position, and then restart the automated wafer processing. The restart will cause the wafer shift detection system **100** to again check for any wafer alignment issue, and if a wafer alignment issue is again detected (for example, if the worker failed to correct the problem) then the alert will again be issued. This could occur multiple times, until the signal indicates no wafer alignment issue at which point operation of the semiconductor manufacturing system will continue in accordance with the signal indicating no wafer alignment issue.

(62) It will be appreciated that wafer shift may occur when a wafer is broken or when a positioning error occurs during robotic operations within the semiconductor manufacturing system. In the limited space of the storage elevator **104** area, diffused sensors (integrated send/receive units) may be used, however these types of sensors are inaccurate. Use of through beam sensors (i.e., separate send and receive units) using the mirror blocks described herein provide greater accuracy and detection of wafer shift. That is, the first and second mirror blocks **108** and **110** provide a mechanism by which directed (i.e., through beam) sensors may be used to accurately identify when a wafer **116**A-**116**C has shifted out of position within the storage elevator **104**. It will further be

appreciated that the wafer shift detection system **100** described herein provides substantial increases in wafer shift detection via the through beam sensors, as opposed to diffused beam sensors, i.e., precise wafer position shift detection. In accordance with such usage, wafer scrap may be reduced by 500 or more pieces per year. Further, the skilled artisan will appreciate that the wafer shift detection system **100** may be implemented in any suitable semiconductor manufacturing system to reduce wafer loss and increase wafer throughput.

(63) In accordance with a first embodiment, there is provided a method for detecting wafer shift. The method includes activating at least one laser to transmit a laser beam into an optical path that passes along a first storage elevator sidewall of a wafer storage elevator in an associated semiconductor manufacturing system to a first mirror arranged to reflect the laser beam to a second mirror arranged to reflect the laser beam along a second storage elevator sidewall to at least one receive sensor. The method further includes generating a signal, in accordance with an output of the receive sensor, indicating whether a wafer alignment issue is present in the wafer storage elevator. The method further includes continuing operation of the associated semiconductor manufacturing system in accordance with the signal indicating no wafer alignment issue.

(64) In accordance with a second embodiment, there is provided a wafer storage elevator that includes a first storage elevator sidewall, a second storage elevator sidewall, and a storage seat positioned between the first and second storage elevator sidewalls. The wafer storage elevator further includes a first mirror block that is coupled to a front side of the storage seat, and which includes a mirror positioned on a top surface of the first mirror block. The wafer storage elevator further includes a second mirror block that is coupled to the front side of the storage seat, and which includes a mirror that is positioned on the top surface of the second mirror block. The mirror of the first mirror block is configured to reflect a laser beam from an emission sensor to the second mirror block, and the mirror of the second mirror block is configured to reflect the laser beam from the mirror of the first mirror block to a receive sensor.

(65) In accordance with a third embodiment, there is provided a wafer shift detection system. The system includes a controller having a processor in communication with memory, one or more emission sensors, and one or more receive sensors. The sensors are in communication with the controller. The system further includes a storage elevator of an associated semiconductor manufacturing system. The storage elevator includes a first elevator sidewall having elevator wafer rails, a second elevator sidewall having elevator wafer rails positioned opposite the first elevator sidewall. The storage elevator further includes a storage elevator seat that is positioned between the bottom of the first elevator sidewall and the second elevator sidewall, a first mirror block coupled to the front side of the storage elevator seat, and a second mirror block coupled to the front side of the storage elevator seat. The memory stores instructions which are executed by the processor to send a signal from the emission sensor to the first mirror block, receive the signal at the at least one receive sensor, and determine a wafer alignment issue based upon an output of the at least one receive sensor. The memory further stores instruction to halt operations of the associated semiconductor manufacturing system in accordance with a determination of a wafer alignment issue.

(66) Some portions of the detailed description herein are presented in terms of algorithms and symbolic representations of operations on data bits performed by conventional computer components, including a central processing unit (CPU), memory storage devices for the CPU, and connected display devices. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is generally perceived as a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals

as bits, values, elements, symbols, characters, terms, numbers, or the like.

(67) It should be understood, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise, as apparent from the discussion herein, it is appreciated that throughout the description, discussions utilizing terms such as “processing” or “computing” or “calculating” or “determining” or “displaying” or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

(68) The exemplary embodiment also relates to an apparatus for performing the operations discussed herein. This apparatus may be specially constructed for the required purposes, or it may comprise a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable storage medium, such as, but is not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), EPROMS, EEPROMs, magnetic or optical cards, or any type of media suitable for storing electronic instructions, and each coupled to a computer system bus.

(69) The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the methods described herein. The structure for a variety of these systems is apparent from the description above. In addition, the exemplary embodiment is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the exemplary embodiment as described herein.

(70) A machine-readable medium includes any mechanism for storing or transmitting information in a form readable by a machine (e.g., a computer). For instance, a machine-readable medium includes read only memory (“ROM”); random access memory (“RAM”); magnetic disk storage media; optical storage media; flash memory devices; and electrical, optical, acoustical or other form of propagated signals (e.g., carrier waves, infrared signals, digital signals, etc.), just to mention a few examples.

(71) The methods illustrated throughout the specification, may be implemented in a computer program product that may be executed on a computer. The computer program product may comprise a non-transitory computer-readable recording medium on which a control program is recorded, such as a disk, hard drive, or the like. Common forms of non-transitory computer-readable media include, for example, floppy disks, flexible disks, hard disks, magnetic tape, or any other magnetic storage medium, CD-ROM, DVD, or any other optical medium, a RAM, a PROM, an EPROM, a FLASH-EPROM, or other memory chip or cartridge, or any other tangible medium from which a computer can read and use.

(72) Alternatively, the method may be implemented in transitory media, such as a transmittable carrier wave in which the control program is embodied as a data signal using transmission media, such as acoustic or light waves, such as those generated during radio wave and infrared data communications, and the like.

(73) The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that

they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

Claims

1. A method for detecting wafer shift of a wafer stored within a wafer storage elevator, comprising: activating at least one laser at a first position to transmit a laser beam into an optical path that passes along a first storage elevator sidewall downward of the wafer storage elevator in an associated semiconductor manufacturing system to a first mirror arranged to reflect the laser beam to a second mirror arranged to reflect the laser beam along a second storage elevator sidewall upward to at least one receive sensor at a second position distinct from the first position; generating a signal, in accordance with an output of the receive sensor, indicating whether a wafer alignment issue is present in the wafer storage elevator; and continuing operation of the associated semiconductor manufacturing system in accordance with the signal indicating no wafer alignment issue; wherein the first mirror and the second mirror are mounted on a storage elevator seat, the storage elevator seat located between a bottom of the first storage elevator sidewall and the second storage elevator sidewall, wherein in the optical path the first mirror is arranged to reflect the laser beam along the storage elevator seat to the second mirror.
2. The method of claim 1, wherein the first mirror is angled to reflect the laser beam passing along the first storage elevator sidewall along a direction perpendicular to the first storage elevator sidewall to the second mirror.
3. The method of claim 2, wherein the first and second storage elevator sidewalls are mutually parallel and the second mirror is angled to reflect the laser beam passing along the direction perpendicular to the first storage elevator sidewall to pass along the second storage elevator sidewall to the at least one receive sensor.
4. The method of claim 1, wherein the signal indicating whether a wafer alignment issue is present in the wafer storage elevator is one of: (i) determination of a wafer alignment issue corresponding to an associated wafer stored in the wafer storage elevator interrupting the laser beam passing along at least one of the first storage elevator sidewall or the second elevator sidewall as the output of the receive sensor indicating the laser beam is not detected or (ii) determination of no wafer alignment issue corresponding to the output of the receive sensor indicating the laser beam is detected.
5. The method of claim 1, further comprising activating at least one alert in accordance with a determination of the wafer alignment issue.
6. The method of claim 5, wherein the at least one alert comprises generating an audible alert via an associated speaker in response to the signal indicating a wafer alignment issue is present in the wafer storage elevator.
7. The method of claim 5, wherein the at least one alert comprises generating a visual alert in response to the signal indicating a wafer alignment issue is present in the wafer storage elevator.
8. The method of claim 1, wherein the first storage elevator sidewall and the second elevator sidewall comprise a plurality of storage elevator rails.
9. The method of claim 8, wherein each opposing pair of storage elevator rails form a corresponding wafer storage slot having a wafer storage slot height defined between each of the plurality of storage elevator rails on the respective first and second storage elevator sidewalls.
10. The method of claim 9, wherein a height of the first mirror and a height of the second mirror are in the range of ⅓ to ½ the wafer storage slot height.
11. The method of claim 10, wherein a distance between a lower edge of the first mirror and a lower edge of the second mirror is greater than a diameter of an associated wafer stored in the wafer storage elevator.
12. A method for detecting wafer shift of a wafer stored within a wafer storage elevator, the wafer storage elevator including a first storage elevator sidewall, a second storage elevator sidewall, and a

storage seat positioned between a bottom of the first and second storage elevator sidewalls, the method comprising: coupling a first mirror block to a front side of the storage seat, the first mirror block including a mirror positioned on a top surface of the first mirror block; coupling a second mirror block to the front side of the storage seat, the second mirror block including a mirror positioned on a top surface of the second mirror block; and using a laser beam emitted from an associated emission sensor located at a first position and aligned with the first mirror block mirror, reflecting the laser beam from the first mirror block to the second mirror block, and reflecting the laser beam from the mirror of the second mirror block to at least one receive sensor located at a second position distinct from the first position; wherein an optical path of the laser beam is downward along the first storage elevator sidewall, along the storage elevator seat and upward along the second storage elevator sidewall.
13. The method of claim 12, wherein the first storage elevator sidewall and the second elevator sidewall have a plurality of storage elevator wafer rails formed therein.
14. The method of claim 13, wherein each opposing pair of storage elevator wafer rails are formed to have a corresponding wafer storage slot having a wafer storage slot height defined between each of the plurality of storage elevator wafer rails on the respective first and second storage elevator sidewalls.
15. The method of claim 14, wherein a height of the mirror of the first mirror block and a height of the mirror of the second mirror block are in the range of ⅓ to ½ the wafer storage slot height.
16. The method of claim 15, wherein a distance between a lower edge of the mirror of the first mirror block and a lower edge of the mirror of the second mirror block is greater than a diameter of a wafer stored therein.
17. A method for operating a wafer shift detection system associated with a wafer stored within a wafer storage elevator, the wafer shift detection system including a controller including a processor in communication with memory, wherein the memory stores instructions which are executed by the processor to perform the method of operating the wafer shift detection system comprising: sending a signal from the at least one emission sensor to a first mirror block, the at least one emission sensor communicatively coupled to the controller; receiving the signal at least one receive sensor, the at least one receive sensor communicatively coupled to the controller; determining a wafer alignment issue in accordance with an output of the at least one receive sensor; and halting operations of an associated semiconductor manufacturing system in accordance with a determination of a wafer alignment issue, wherein the storage elevator is formed to include a first elevator sidewall having a plurality of elevator wafer rails, a second elevator sidewall having a plurality of elevator wafer rails positioned opposite the first elevator sidewall, a storage elevator seat positioned between a bottom of the first elevator sidewall and the second elevator sidewall, a first mirror block coupled to a front side of the storage elevator seat, and a second mirror block coupled to the front side of the storage elevator seat; wherein an optical path of the laser beam is downward along the first storage elevator sidewall, along the storage elevator seat and upward along the second storage elevator sidewall.
18. The method of claim 17, wherein the memory further stores instructions to: activate at least one of a speaker or a visual alert in accordance with a determination of the wafer alignment issue.
19. The method of claim 18, wherein each opposing pair of elevator wafer rails are formed to have a corresponding wafer storage slot having a wafer storage slot height defined between each of the plurality of elevator wafer rails on the respective first and second elevator sidewalls, and wherein a height of a mirror of the first storage block and a height of a mirror of the second mirror block are in the range of ⅓ to ½ the wafer storage slot height.