Title: SUBSTRATE CONTAINER WITH OUTBOARD KINEMATIC COUPLING STRUCTURE

Abstract: A substrate container having a set of kinematic coupling grooves defined in the periphery of a horizontally extending skirt portion around the periphery of the container portion. This set of kinematic coupling grooves, being located outside the periphery of the container portion, enables the container to be positioned relatively closer to the Horizontal Datum Plane of wafer processing equipment. This can provide vertical space conservation along with greater stability than provided by the conventional location of kinematic coupling grooves. The container may also include a set of conventionally located kinematic coupling grooves.
SUBSTRATE CONTAINER WITH OUTBOARD KINEMATIC COUPLING STRUCTURE

RELATED APPLICATIONS

The application claims the benefit of U.S. Provisional Application No. 60/839,397, entitled SUBSTRATE CONTAINER, filed August 22, 2006, hereby fully incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates to carriers and containers for substrates and more specifically, to carriers for sealingly enclosing substrates during storage or transportation.

BACKGROUND OF THE INVENTION

Semiconductor and magnetic components used in electronic devices are typically manufactured from "substrates," meaning silicon wafers, magnetic substrates or the like. Sealable enclosures, generally termed transport modules or substrate carriers, have been used in the industry for a number of years for storing and transporting substrates between processing steps and/or between facilities. Semiconductor wafers are stored and transported in such containers because they are notoriously vulnerable to damage from contaminants such as particles. Extraordinary measures are taken to eliminate contaminants in clean rooms and other environments where semiconductor wafers are stored or processed in circuits.

Capability for processing semiconductors has increased dramatically in recent years, resulting in much higher circuit densities and larger wafers. Quality control issues relating to particulate and other contaminants have grown proportionally. Conventional wafer carriers and FOUPs for large diameter wafers, for example 300 millimeter wafers, typically have load capacities of twenty-five (25) wafers. Due to the large number of processing steps to be performed on each wafer and the capability of processing equipment to handle only a limited number of wafers for each processing step, many wafers will sit for extended periods of time not being processed when transported in such large capacity wafer containers. This is financially imprudent due to significant expense associated with each wafer and the resultant tying up of the significant capital involved. Moreover, limiting the number of wafers in a particular container limits the potential damages if some catastrophic event causes destruction of the contents of a particular
carrier. The industry has therefore contemplated front opening wafer containers having a minimal capacity such as one or two wafers.

The operational characteristics and needed features of such wafer containers, however, vary from those of traditional large capacity front opening wafer containers. Their minimal mass enables them to be moved with greater rapidity, and their reduced size requires different configurations of, for example, the locking and sealing mechanisms.

U.S. Patent Nos. 5,271,516, 5,291,923 and 5,295,522 disclose examples of prior substrate carriers for accommodating a minimal number of wafers. These prior carriers, however, exhibit certain drawbacks. Typically, the doors of these carriers are handled robotically in use with suction cups on a processing tool that engage and hold the door during insertion and removal. These suction cups may become contaminated and dirty, and sometimes need to be maintained or replaced. The processing equipment or the door opening equipment must be taken out of service in order to accommodate this maintenance, thereby causing costly downtime and delays.

Another drawback of prior carriers relates to the machine interface aspects thereof. Carriers are typically precisely located on processing equipment with a machine interface on the bottom of the carrier known as a kinematic coupling. The kinematic coupling generally presents three convergingly oriented grooves that mate with corresponding pins on the processing equipment to locate the carrier thereon. Conventionally, the kinematic coupling is a separate component that attaches to the bottom of the carrier. The vertical space occupied by this kinematic coupling can result in the substrate being positioned at some distance above the Horizontal Datum Plane of the wafer processing equipment. With the smaller mass of a lesser capacity carrier, the stability of the carrier may be compromised if this distance is too large.

Accordingly, what is still needed in the industry is a simple, lower cost, stable front-opening carrier for a small number of wafers.

**SUMMARY OF THE INVENTION**

Carriers according to embodiments of the invention meet the need of the industry for a simple, lower cost, stable front-opening carrier for a small number of wafers. A front opening wafer container having a capacity of one or a few wafers or other substrates has certain features for operability and functionality specifically applicable to a low profile
design. Several of these features and characteristics also may be applicable to conventional higher capacity front opening wafer containers.

The carrier of certain embodiments according to the invention has a set of kinematic coupling grooves defined in the periphery of a horizontally extending skirt portion around the periphery of the container portion. This set of kinematic coupling grooves, being located outside the periphery of the container portion, enables the container portion to be positioned relatively closer to the Horizontal Datum Plane of the wafer processing equipment. This can provide vertical space conservation along with greater stability than provided by the conventional location of the kinematic coupling grooves. In certain embodiments, this set of kinematic coupling grooves are molded directly into the container shell itself, thereby avoiding the use of secondary components and reducing the cost and complexity of the container. The container may have another conventionally located set of kinematic coupling grooves on the bottom of the container.

Additional features on the bottom surface of the carrier can include mating structure to receive the robotic lifting flange of a vertically adjacent carrier on which the carrier is stacked, and infopad apertures on a lower fin extending horizontally from the container portion or on "ear" structures extending laterally at the front opening of the container portion. Further, carriers according to certain embodiments may include a robotic flange mounted on the top of the container portion that may be delta-shaped with apertures therein for manual grasping. Flexibility in providing coding is thereby provided.

The front opening of the container portion carriers according to certain embodiments may include a snap-in or other separate ring secured therein. The ring may have an over-molded portion made from thermoplastic elastomer to assure sealing between the ring and the container portion. The ring may provide an undercut surface for which to accept and readily capture a removable door placed therein. The door may includes a combination sealing portion and latching portion provided by way of an expandable elastomeric seal extending around the periphery of the door. Retraction of the seal to allow insertion and removal from the container portion may be provided by way of inlets removably connectable to the door.

According to an embodiment, elastomeric suction cups or other ring shaped sealing structures are made part of the door. These structures sealingly engage the inlet that may simply be an aperture in a planar surface of the processing tool. The suction cup attaches to the planar surface of the tooling. Alternatively, the door portion may include a blow
molded body portion with the seal wrapped around the periphery and suitably attached thereto.

Advantageously, the above configuration of the door enables the door to be consumable upon each use of the container. When, for example, the door components become contaminated or dirty, these components or the entire door can be simply discarded after each use, thereby eliminating the need for cleaning or replacing sealing portions on the interface equipment. The container door is simply replaced prior to the next use of the container.

According to an embodiment a wafer container includes a container portion having a front opening and a door for closing said front opening. Shelves in the interior of the container portion support wafers or other substrates thereon. The container portion may be formed principally of a static dissipative material with insert molded transparent plastic window portions, that in preferred embodiments, include the shelves as well as overmolded static dissipative wafer contact portions as well as pathways to ground. Visibility of the wafers as well as static dissipation is provided thereby.

According to an embodiment of the invention, a substrate container includes an enclosure portion having a top, a bottom, a pair of opposing sidewalls, a back and a door frame defining an open front. The enclosure portion further includes a substrate support structure for supporting at least one substrate in the enclosure portion and a door assembly selectively engagable in the door frame to seal the open front. A machine interface on the bottom of the enclosure portion includes an apron extending laterally outwardly from each of the opposing sidewalls and the back of the enclosure portion, the apron defining a plurality of kinematic coupling structures.

In certain embodiments of the invention, the kinematic coupling structures are grooves. Each of the grooves may present an outboard end, wherein the outboard end is open. The machine interface of the container may further include a second plurality of kinematic coupling structures, wherein each one of the second plurality of kinematic coupling structures is disposed laterally inwardly from the sidewalls and the back of the enclosure portion. The apron may define at least one information aperture. In some embodiments, the container may include a robotic handling flange on the top of the enclosure portion, and the machine interface may include nesting structure for receiving the robotic handling flange of a vertically adjacent substrate container.
In an embodiment, a substrate transport system includes at least one substrate, an enclosure portion having a top, a bottom, a pair of opposing sidewalls, a back and a door frame defining an open front. The enclosure portion further includes a substrate support structure for supporting the at least one substrate in the enclosure portion, a door assembly selectively engagable in the door frame to seal the open front, and a machine interface on the bottom of the enclosure portion. The machine interface includes an apron extending laterally outwardly from each of the opposing sidewalls and the back of the enclosure portion, the apron defining a plurality of kinematic coupling structures, which may be grooves. Each of the grooves may present an outboard end, wherein the outboard end is open. In further embodiments, the machine interface further may further include a second plurality of kinematic coupling structures, disposed laterally inwardly from the sidewalls and the back of the enclosure portion.

In an embodiment, a substrate container includes an enclosure portion having a top, a bottom, a pair of opposing sidewalls, a back and a door frame defining an open front, the enclosure portion further including a substrate support structure for supporting at least one substrate in the enclosure portion. The container further includes a door assembly selectively engagable in the door frame to seal the open front, and means for kinematically coupling the container to processing equipment. The means for kinematically coupling the container to processing equipment may include a machine interface on the bottom of the enclosure portion, wherein the machine interface includes an apron extending laterally outwardly from each of the opposing sidewalls and the back of the enclosure portion, the apron defining a plurality of kinematic coupling structures.

Further objects and advantages of particular embodiments of the present invention may become apparent to those skilled in the art upon review of the figures and descriptions of the present invention herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be more completely understood in consideration of the following detailed description of various embodiments of the invention in connection with the following drawings, in which:

FIG. 1 is a perspective view of a substrate container according to an embodiment of the invention;

FIG. 2 is a bottom perspective view of the container of FIG. 1;
FIG. 3 is an exploded perspective view of the container depicted in FIG. 1;

FIG. 4 is a fragmentary exploded perspective view of a consumable door assembly and carrier according to an embodiment of the invention;

FIG. 5 is a fragmentary cross-sectional view of the consumable door assembly and carrier depicted in FIG. 4;

FIG. 6 is a perspective view of a consumable door assembly according to an alternative embodiment of the invention;

FIG. 7 is an exploded view of the consumable door assembly depicted in FIG. 6;

FIG. 8 is a bottom perspective view of an alternative embodiment of a substrate container according to an embodiment of the invention;

FIG. 9 is a cross-sectional view of the rear kinematic coupling structure of the embodiment of FIG. 8, taken at section 9-9 of FIG. 10;

FIG. 10 is a bottom plan view of the container of FIG. 8 depicting two kinematic coupling pins engaged in the grooves;

FIG. 11 is a fragmentary perspective view of the container of FIG. 8 taken from inset 11 of FIG. 8; and

FIG. 12 is a fragmentary perspective view of the container of FIG. 8 taken from inset 12 of FIG. 8.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to now to FIGs. 1-5 a low-profile substrate container 20 according to embodiments of the present invention is depicted. Container 20 generally includes enclosure portion 22 and door assembly 24. Enclosure portion 22 generally includes top wall 26, bottom wall 28, sidewalls 30, 32, rear wall 34, and door frame 36 defining open front 38. Sidewalls 30, 32, define apertures 40, 42, for receiving wafer supports 44, 46. Each wafer support 44, 46, generally includes wall portion 48, which may be formed from
transparent polycarbonate, and integral shelves 50 with wafer contact portions 52 formed from a static dissipative plastic over-molded on wall portion 48. "Over-molding" means a process wherein a first polymer portion is molded and then placed in a second mold wherein a second polymer portion is molded with the first portion. In certain cases, a mold insert may be removed allowing the first molded portion to remain in place during the second molding operation. Wall portion 48 may, in turn, be over-molded in sidewalls 30, 32.

Advantageously, wafer supports 44, 46, may provide an electrical path to ground for wafers in container 20 through static dissipative wafer contact portions 52. In certain embodiments, the balance of enclosure portion 22 is molded from static dissipative polymer, such as carbon fiber filled polycarbonate, which will typically be opaque. The transparency of wall portions 48 enables visibility of wafers in position on wafer supports 44, 46, from outside container 20 when door assembly 24 is in place. Enclosure portion 22 may be grounded by way of resting on the kinematic coupling pins of processing equipment, or through a robotic flange on top of the container, if the robotic flange is molded from static dissipative material. The term "static dissipative" as used herein is intended to also encompass electrically conductive properties, and means that the subject material is able to dissipate an electrical charge.

Enclosure portion 22 may also include robotic handling flange 54 extending from bosses 56 on top wall 26. Robotic handling flange 54 is generally triangular or delta shaped and defines arcuate apertures 58 on either side of central aperture 60. Door frame 36 may include laterally extending vertical information pads 61, which define information apertures 61.1 for conveying coded information regarding container 20 and its contents according to techniques known to those of skill in the art.

As depicted in FIG. 2, bottom wall 28 generally includes a machine interface 62, including apron 64 with lateral horizontal wall portions 66 and rear horizontally extending wall portion 68. Apron 64 extends laterally outwardly beyond sidewalls 30, 32, and rear wall 34 of enclosure portion 22. Bottom wall 28 defines conventional kinematic coupling grooves 70. Lateral horizontal wall portions 66 each define an outboard kinematic coupling groove 72, which corresponds with outboard kinematic coupling groove 74 defined in rear horizontally extending wall portion 68. Outboard kinematic coupling grooves 72, 74, extend vertically alongside enclosure portion 22, their depth not being constrained by bottom wall 28. Consequently, outboard kinematic coupling grooves 72,
74, enable container 20, and wafers or substrates contained therein, to be positioned lower
and relatively closer to the Horizontal Datum Plane of wafer processing equipment than is
possible with conventional kinematic coupling grooves 70. This enables a vertically more
compact configuration. Moreover, the lower center of gravity of enclosure portion 22
relative to the processing equipment provides more positional stability for container 20
than when container 20 is supported with conventional kinematic coupling grooves 70,
which are located within the periphery of container portion 22. In an embodiment,
horizontally extending wall portion 64 including outboard kinematic coupling grooves 72,
74, may be molded integrally with enclosure portion 22, thereby avoiding the use of any
secondary components and reducing the cost and complexity of container 20.

As also depicted in FIG. 2, rear horizontally extending wall portion 68 may include
information pad apertures 76 that, according to techniques known to those of skill in the
art, may be used to convey coded information regarding container 20 and its contents.
Bottom wall 28 may further define receptacles 78 for receiving purging components such
as filters or cartridges, and robotic flange nesting structures 80, for receiving a robotic
flange 54 of a vertically adjacent container 20 when the containers are stacked.

Referring now to FIGs. 3, 4, and 5, door assembly 24 generally includes front
panel 82, suction cup elastomeric couplings 84, expandable elastomeric seal member 86,
seal support frame 88, door body 90, and wafer cushion 92. Door frame liner 94 is
received in door frame 36, with tab 96 received in forwardly facing recess 98. Door frame
liner 94 may be molded from thermoplastic elastomer material such that a seal of high
integrity is formed between door frame 36 and door frame liner 94. It will be appreciated
that, in certain embodiments, door frame liner 94 may be over-molded in door frame 36.
Otherwise, the separate components of the door typically will be injection molded.

Expandable elastomeric seal member 86 defines channel 100, which receives
outer flange 102 of seal support frame 88. Flanges 104 of elastomeric seal member 86
abut inner flange 106 of seal support frame 88. Air passageways 108 are defined in outer
flange 102, inner flange 106, and web 110 of seal support frame 88. Elastomeric seal
member 86 and seal support frame 88 are disposed between seal retention ring 112
extending outwardly from door body 90 and seal retention ring 114 extending inwardly
from front panel 82. Front panel 82 defines apertures 116 for receiving suction cup
elastomeric couplings 84. Couplings 84 are held in place with barbed portion 118. Door
assembly 24 may be held together by way of interference fit between the various components, with fasteners (not depicted), adhesives, or any other means known in the art.

As depicted in FIG. 5, elastomeric seal member 86 is in a retracted position not in contact with door frame liner 94. In use, such a position is achieved by application of partial vacuum to suction cup elastomeric couplings 84, causing air to be drawn from channel 100 through air passageways 108. When suction is removed from suction cup elastomeric couplings 84, air flows through air passageways 108 into channel 100, causing elastomeric seal member 86 to expand, thereby engaging and sealing with door frame liner 94. Door frame liner 94 may have a suitable undercut 120 which receives the expanded seal when the door is in the latching position.

U.S. Patent Numbers 5,271,516, 5,291,923 and 5,295,522, all assigned to IBM, disclose an isolation structure with an expandable seal for latching, certain characteristics of which may be suitable for application in the container of the present invention, and are hereby incorporated herein by reference in their entirety. Referring now to FIGs. 6 and 7, an alternative embodiment of an expandable door assembly 24 is depicted. Alternative door assembly 24 generally includes hollow body portion 122 that may be formed by blow-molding, and elastomeric seal member 124 having a similar configuration to elastomeric seal member 86 earlier described. Elastomeric seal member 124 is retained around periphery 126 of hollow body portion 122 with securing rings 128. Suction cup elastomeric couplings 130 extend into hollow body portion 122 and suitable air passages are provided in periphery 126 of hollow body portion 122 to enable retraction of elastomeric seal member 124 with partial vacuum applied to suction cup elastomeric couplings 130 as before.

It will be appreciated by those of ordinary skill that conventional door latching and sealing mechanisms may also be employed with substrate container 20 according to embodiments of the invention. Examples of suitable latching and sealing mechanisms that may be adapted for use in embodiments of the invention are disclosed in U.S. Patent Nos. 7,168,587; 7,100,772; and 6,955,382, all owned by the owners of the present invention, and hereby fully incorporated herein by reference.

Referring now to FIGs. 8-12, a further alternative embodiment of a substrate container 20 according to the invention is depicted. Container 20 generally includes enclosure portion 132 for containing substrates 133, and having apron 134 extending laterally outwardly from lower periphery 136. Apron 134 defines forward kinematic
coupling structures 138, 140, and rear kinematic coupling structure 142. Each of forward
kinematic coupling structures 138, 140, and rear kinematic coupling structure 142 is made
elongate so as to accommodate outer 144 and inner 146 kinematic coupling pins
simultaneously.

Rear kinematic coupling structure 142 generally includes outer groove portion 148
defined by converging inclined surfaces 150, 152, and inner groove portion 154 defined by
ribs 156, 158. Converging inclined surfaces 150, 152, enable gross alignment of container
20 relative to outer pin 144 and ribs 156, 158, together define surfaces oriented along
plane X-X to enable gross alignment of container 20 relative to inner pin 146.

Advantageously, the structure of rear kinematic coupling structure 142 including ribs 156,
158, enables enclosure portion 132 and apron 134 to be molded from polymer material in
a single integral piece by eliminating excessive material in the recesses between ribs 156,
158.

Similarly, forward kinematic coupling structures 138, 140, generally include outer
groove portion 160, defined by converging inclined surfaces 162, 164, and inner groove
portion 166, defined by rib structure 168. Again, converging inclined surfaces 162, 164,
enable gross alignment of container 20 relative to outer pin 144 and rib structure 168,
along with rear incline 170, define surfaces 172, 174, oriented along a common plane to
enable gross alignment of container 20 relative to inner pin 146.

The embodiments above are intended to be illustrative and not limiting. Additional
embodiments are encompassed within the scope of the claims. Although the present
invention has been described with reference to particular embodiments, those skilled in the
art will recognize that changes may be made in form and detail without departing from the
spirit and scope of the invention. For purposes of interpreting the claims for the present
invention, it is expressly intended that the provisions of Section 112, sixth paragraph of 35
U.S.C. are not to be invoked unless the specific terms "means for" or "step for" are recited
in a claim.
CLAIMS

What is claimed is:

1. A substrate container comprising:

   an enclosure portion having a top, a bottom, a pair of opposing sidewalls, a back and a door frame defining an open front, the enclosure portion further including a substrate support structure for supporting at least one substrate in the enclosure portion;

   a door assembly selectively engagable in the door frame to seal the open front; and

   a machine interface on the bottom of the enclosure portion, the machine interface including an apron extending laterally outwardly from each of the opposing sidewalls and the back of the enclosure portion, the apron defining a plurality of kinematic coupling structures.

2. The substrate container of claim 1, wherein the kinematic coupling structures are grooves.

3. The substrate container of claim 2, wherein each of the grooves presents an outboard end, and wherein the outboard end is open.

4. The substrate container of claim 1, wherein the machine interface further comprises a second plurality of kinematic coupling structures.

5. The substrate container of claim 4, wherein each one of the second plurality of kinematic coupling structures is disposed laterally inwardly from the sidewalls and the back of the enclosure portion.

6. The substrate container of claim 1, wherein the apron defines at least one information aperture.

7. The substrate container of claim 1, further comprising a robotic handling flange on the top of the enclosure portion, and wherein the machine interface includes nesting structure for receiving the robotic handling flange of a vertically adjacent substrate container.
8. A substrate transport system comprising:

   at least one substrate;

   an enclosure portion having a top, a bottom, a pair of opposing sidewalls, a back
   and a door frame defining an open front, the enclosure portion further including a substrate
   support structure for supporting the at least one substrate in the enclosure portion;

   a door assembly selectively engagable in the door frame to seal the open front; and

   a machine interface on the bottom of the enclosure portion, the machine interface
   including an apron extending laterally outwardly from each of the opposing sidewalls and
   the back of the enclosure portion, the apron defining a plurality of kinematic coupling
   structures.

9. The system of claim 8, wherein the kinematic coupling structures are
    grooves.

10. The system of claim 9, wherein each of the grooves presents an outboard
     end, and wherein the outboard end is open.

11. The system of claim 8, wherein the machine interface further comprises a
    second plurality of kinematic coupling structures.

12. The system of claim 11, wherein each one of the second plurality of
    kinematic coupling structures is disposed laterally inwardly from the sidewalls and the
    back of the enclosure portion.

13. The system of claim 8, wherein the apron defines at least one information
    aperture.

14. The system of claim 8, further comprising a robotic handling flange on the
    top of the enclosure portion, and wherein the machine interface includes nesting structure
    for receiving the robotic handling flange of a vertically adjacent substrate container.

15. A substrate container comprising:

   an enclosure portion having a top, a bottom, a pair of opposing sidewalls, a back
   and a door frame defining an open front, the enclosure portion further including a substrate
   support structure for supporting at least one substrate in the enclosure portion;
a door assembly selectively engagable in the door frame to seal the open front; and
means for kinematically coupling the container to processing equipment.

16. The container of claim 15, wherein the means for kinematically coupling the container to processing equipment comprises a machine interface on the bottom of the enclosure portion, the machine interface including an apron extending laterally outwardly from each of the opposing sidewalls and the back of the enclosure portion, the apron defining a plurality of kinematic coupling structures.

17. The container of claim 16, wherein the kinematic coupling structures are grooves.

18. The container of claim 16, wherein the machine interface further comprises a second plurality of kinematic coupling structures.

19. The container of claim 18, wherein each one of the second plurality of kinematic coupling structures is disposed laterally inwardly from the sidewalls and the back of the enclosure portion.

20. The container of claim 16, wherein the apron defines at least one information aperture.