STOCKER

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Claim of Priority

This application claims priority under 35 U.S.C. §119(e) to U.S. Provisional Patent Application No. 60/697,616, entitled "Improved Stocker and Controls for Use with Conveyor," which was filed with the U.S. Patent & Trademark Office on July 8, 2005, and which is incorporated in its entirely by reference herein.

Related Application

This application is related to U.S. Patent Application No. 11/433,980, entitled "Modular Terminal for High-Throughput AMHS," which was filed with the U.S. Patent & Trademark Office on May 15, 2006, and which is incorporated in its entirety by reference herein.

Field of the Invention

The present invention generally comprises a container storage system. More specifically, the present invention comprises a stocker having multiple container input/output systems.

Background of the Invention

It is costly to deliver containers **2**, such as Front Opening Unified Pods (FOUPs) and Standard Mechanical Interface (SMIF) pods, to processing tools **10** and load ports **12** in a semiconductor fabrication facility (fab). One method of delivering FOUPs and SMIF pods between processing tools is an Automated Material Handling System (AMHS).

An AMHS or transport system moves containers or cassettes of semiconductor wafers or flat panels (all referred to as containers herein) in a fab. Container movement within the fab may be within each tool bay (e.g., bays **B1** and **B2** in Fig. 1) (intrabay

AMHS – generally comprises a transport system that moves containers within a bay and delivers containers to tool locations.) and between tool bays (interbay AMHS – generally comprises a transport system that moves containers along a main aisle that connects bays of processing tools.). Fabs often include stockers for storing containers. It is desirable to decrease delays in AMHS traffic by delivering containers directly from processing tool to processing tool as much as possible. Inadequate throughput capability in any part of the AMHS may cause other parts of the AMHS to have throughput that is below potential because the inadequate component is serially connected to the other parts.

Containers are often delivered to a stocker after a process step is completed and then later removed and delivered to another tool when the tool is ready. The limited throughput of a conventional stocker limits the entire throughput capacity of the systems that deliver and remove containers from a stocker. Thus, the overall throughput capacity of the AMHS is limited to the stocker throughput. For example, peak interbay transport throughput for a particular stocker may be 700 container or AMHS moves per hour. If this stocker is accessed by two material handling systems for bidirectional transport, a potential peak interbay move rate of 1400 container moves per hour for that particular stocker may theoretically be achieved. If this stocker is further connected to another tool bay having an intrabay AMHS or other transport system with a 700 container moves per hour peak capacity, the peak moves rate for the stocker could reach up to 2100 container moves per hour. A conventional stocker can only make one container move every twenty seconds on average - limiting the peak throughput of the stocker to 180 container moves per hour, which is well below what may be required by the fab.

Even if only considering the throughput of the bay, and the stocker only handles container flow into the bay, the peak requirement could be 1400 moves per hour (700 moves per hour from interbay, 700 moves per hour to intrabay). This situation would cause the high potential throughput of the intrabay to be severely limited by the stocker.

One type of conventional AMHS or transport system is an overhead transport (OHT) system. In an OHT system, an OHT vehicle, lowers a FOUP onto the kinematic plate of the load port at approximately 900mm height from the fabrication facility floor. An OHT system uses sophisticated ceiling mounted tracks and cable hoist vehicles to

deliver FOUPs to these load ports. The combination of horizontal moves, cable hoist extensions, and unidirectional operation, must be coordinated for transporting FOUPs quickly between processing tools. For optimum efficieny within an OHT system. an OHT vehicle must be available at the instant when a processing tool needs to be loaded or unloaded. This is not always possible.

Other non-conveyor AMHS or transport systems that use a vehicle to move containers throughout the fab (*e.g.*, automated guided vehicle (AGV) system, rail guided vehicle (RGV) systems, overhead shuttle (OHS) systems) require the AMHS scheduling system to manage the movement and availability of empty vehicles as well as the loaded vehicles that are making deliveries. This heavy burden on the scheduling system often results in container pick-up delays because empty vehicles are directed to the pick-up location and added traffic congestion results due to non-productive empty vehicle movement. Similar delays occur with OHT vehicles. The OHT vehicle may take, for example, fifteen seconds to complete the container pick-up or drop-off step, and during this pick-up/drop-off time, container traffic is blocked at that location of the AMHS. These factors combine to limit vehicle based intrabay AMHS to, for example, 100-200 moves per hour in many cases. This does not present a large mismatch with conventional stocker capabilities. However, many tool bays require much higher throughput that cannot be met with the conventional stocker/OHT architecture.

Therefore, there is a need for improved high-throughput stocker or container storage system within a fab. The present invention provides such a stocker and system.

Summary of the Invention

One aspect of the present invention is to provide a stocker that minimizes the amount of time a container waits or idles on the ceiling-based interbay conveyor after the container arrives at the stocker. In one embodiment, the stocker includes a ceiling-based input conveyor adjacent the ceiling-based interbay conveyor. The input conveyor may, for example, store multiple containers at one time; allowing a container arriving at the stocker to be transferred immediately to the input buffer conveyor. In another embodiment, the ceiling-based interbay conveyor comprise a dual level conveyor system. In this case, the

stocker may have a ceiling-based input conveyor dedicated to each level of the ceiling-based interbay conveyor.

Another aspect of the present invention is to provide a stocker that includes input and output buffering capabilities dedicated to either a ceiling-based interbay conveyor or a floor-based intrabay conveyor. In one embodiment, the stocker includes a floor-based output conveyor for moving containers out of the stocker's container storage area and onto the floor-based intrabay conveyor. The stocker may also include a floor-based input conveyor for moving a container from the floor-based intrabay conveyor into the stocker's container storage area. A ceiling-based input conveyor is able to move containers either into the stocker's container storage area or to a vertical module (effectively bypassing the stocker). In one embodiment, the ceiling-based input conveyor may store multiple containers; providing a buffering area for containers moved off the ceiling-base interbay conveyor. The stocker may also include a ceiling-based output conveyor for buffering containers exiting the stocker, but before the container is moved to the ceiling-based interbay conveyor.

Yet another aspect of the present invention is to provide a stocker that supports the express delivery of high priority containers. In one embodiment, the stocker includes a vertical module that moves a container directly from the ceiling-based interbay conveyor or ceiling-based input conveyor to the floor-based intrabay conveyor. In other words, the container does not have to enter the stocker's container storage area in order to be transferred to the floor-based conveyor. In another embodiment, the vertical module is also able to move a container placed on a shelf from an OHT vehicle directly to the floor-based conveyor.

Another aspect of the present invention is to provide a method of synchronizing and delivering groups of containers from a ceiling-based interbay conveyor to the stocker.

Brief Description of the Drawings

FIGURE 1 provides a plan view of a representative system, according to one embodiment of the present invention;

FIGURE 2 provides a plan view of a representative system, according to another embodiment of the present invention;

FIGURE 3 provides a perspective view of one embodiment of a stocker, according to the present invention; and

FIGURE 4 provides a perspective view of another embodiment of a stocker, according to the present invention.

Detailed Description of the Invention

For exemplary purposes only, the present invention will be described herein in conjunction with transporting FOUPs. The various embodiments of the present invention may also be used and/or adapted for systems handling SMIF pods, reticle containers, flat panel display transport devices, or any other container or processing tool. Container is defined as any structure for supporting an article including, but not limited to, a semiconductor substrate of any size (*e.g.*, 50mm to 500mm wafers). By way of example only, a container includes a structure that comprises an open volume whereby the article can be accessed (*e.g.*, FPD transport) or a container having a mechanically openable door (*e.g.*, bottom opening SMIF pod and FOUP). Load port is defined as any interface equipment that handles containers.

The present invention will also be described in conjunction with conveyors for ease of describing the various embodiments. The present invention may also operate, of course, with other AMHS or other transport system such as an OHT vehicle, an overhead shuttle (OHS), an RGV or an AGV. For purposes of describing the various embodiments of the present invention, "ceiling-based" is intended to define any height equal to or above the container loading height of a load port. And "floor-based" is intended to define any height below the container loading height of a load port, including under the fab floor.

Fig. 1 illustrates an AMHS **100** utilizing various components of the present invention to improve the overall throughput of containers **2** within the fabrication facility. The AMHS **100** includes a first ceiling-based interbay conveyor **20a**, a second ceiling-based interbay conveyor **20b**, multiple floor-based intrabay conveyors **30**, two tool bays **B1** and **B2**, multiple ceiling-based buffer conveyors **122** and multiple lane jumpers **120**.

In this embodiment, the two ceiling based conveyors **20** are vertically stacked and each moves containers **2** in one direction (as shown by the arrows in Fig. 1). Each ceiling-based conveyor **20** may also be bidirectional. Each tool bay shown in Fig. 1 includes a process tool **10** having two load ports **12**. Each tool bay may have more than one process tool **10**, and each process tool may have any number of load ports **12**.

A conveyor may comprise any system of wheels, rollers, belts or slides that can push a container in a guided linear manner. For example, the ceiling-based conveyors **20** may be asynchronous; comprising individual segments that can each have their speed and direction independently controlled to move containers at different rates, or even to be stationary while other containers are moving on the conveyor.

Fig. 1 illustrates four floor-based conveyors **30**. Floor-based conveyor **30A** provides a path to the ceiling-based conveyor **20** from the tool bay **B1**. Floor-based conveyor **30B** provides a path from the ceiling-based conveyor **20** to the tool bay **B2**. These two intrabay conveyors **30A** and **30B** each also transport containers between load ports **12** within its respective tool bay **B1** and **B2**. Floor-based conveyor **30C** and **30D** operate in a similar manner. Floor-based conveyor **30C** provides a path to the ceiling-based conveyor **20**. Floor-based conveyor **30D** provides a path away from the ceiling-based conveyor **20**.

Fig. 1 also illustrates four vertical modules **102**. Each vertical module **102** moves containers between a ceiling-based conveyor **20** and a floor-based conveyor **30**. A vertical module may also move containers **2** between a conveyor (ceiling or floor based) and a storage shelf. Various embodiments of a vertical module **102** are described in U.S. Application No. 11/433,980, entitled "Modular Terminal for High-Throughput AMHS," which has been assigned to Asyst Technologies, Inc, and is incorporated herein by reference. The vertical module **102A** transfers containers **2** between either ceiling-based conveyor **20** and the floor-based conveyor **30A**. The vertical module **102B** transfers containers **2** between either ceiling-based conveyor **20** and the floor-based conveyor **30B**. The vertical module **102C** transfers containers **2** between either ceiling-based conveyor **20** and the floor-based conveyor **30C**. The vertical module **102D** transfers containers **2** between either ceiling-based conveyor **20** and the floor-based conveyor **30D**.

The system **100** also contains three buffer conveyors **122**. Each buffer conveyor **122** is adjacent a ceiling-based conveyor **20** so that a container **2** may be easily transferred between a buffer conveyor **122** and a ceiling-based conveyor **20**. If the ceiling-based conveyor **20** comprises a dual level conveyor, as shown in Fig. 1, a buffer conveyor **122** may be located adjacent each conveyor level. In this configuration, a first buffer conveyor **122A** is located at a height adjacent the ceiling-based conveyor **20a**, and is horizontally aligned (from a plan view) between vertical module **102A** and vertical module **102B**. A second buffer conveyor **122B** is also located at a height adjacent the ceiling-based conveyor **20a**, and is horizontally aligned such that one end **124** of the buffer conveyor **122B** is located near the vertical module **102B**. A third buffer conveyor **122C** is located at a height adjacent the ceiling-based conveyor **20a**, and is horizontally aligned (from a plan view) between vertical module **102C** and vertical module **102D**.

A lane jumper **120** moves containers **2** between the ceiling-based conveyor **20** and a buffer conveyor **122**. A lane jumper **120** may comprise any mechanism that transfers a container between two parallel conveyors. For example, any mechanism whereby the container on the first conveyor is gripped and lifted, then moved over the second conveyor, where it is lowered onto the second conveyor. These movements may be accomplished by a single or multi-segmented arm, or by a linear slide. In addition, a separate mechanism could be used to lift the container from underneath, allowing more variations in the design of the lateral transfer mechanism.

Fig. 1 illustrates a lane jumper **120A** for moving containers from the ceiling-based conveyor **20** onto the buffer conveyor **122A** and a lane jumper **120B** for moving containers from the buffer conveyor **122A** onto the ceiling-based conveyor **20**. Buffer conveyor **122B** includes one lane jumper **120C** for moving containers from the ceiling-based conveyor **20** onto the buffer conveyor **122B**. Lane jumper **120D** moves containers from the ceiling-based conveyor **20** onto the buffer conveyor **122C** and a lane jumper **120E** for moving containers from the buffer conveyor **122A** back onto the ceiling-based conveyor **20**.

Each lane jumper **120** is preferably located at the input end of the input buffer **122** for lifting an incoming container off the interbay conveyor **20** independent of the operation

of the vertical module **102** located at the other end of the buffer conveyor **122**. A lane jumper **120** minimizes the delay to interbay conveyor traffic because traffic is blocked only while the lane jumper **120** is lifting the container **2** and shifting it laterally clear of the interbay traffic. The lane jumper lateral motion may include sensors or position monitoring circuits that can signal when the transferring container is clear of interbay traffic, even before the lateral motion has reached the buffer conveyor **122**.

The length of the input buffer, for example, buffer conveyor **122B**, is preferably long enough to allow the queuing of multiple containers. The ability to buffer multiple containers adjacent the ceiling-based conveyor **20** accommodates periods of time when the unloading rate of containers from the interbay conveyor **20** exceeds the rate at which containers exit the buffer conveyor **122B** through the vertical module **120B**. For example, the vertical module **102B** may, temporarily, not be able to keep up with the rate of container transfer from the ceiling-based conveyor **20** to the buffer conveyor **122B** or the facility control system is not requesting that tools be loaded at as high a rate as it is requesting the loading of the buffer conveyor **122B**.

The system provides other buffering features. For example, containers **2** exiting the tool bay **B1** may queue on the floor-based conveyor **30A** in front of the exit vertical module **102A**, if necessary. The exit vertical module **102A** can transfer the containers **2** up to the buffer conveyor **122A** located between the vertical modules **102A** and **120B**. The container **2** can eventually be transferred back the interbay conveyor **20** by lane jumper **120B** at a time that causes minimal, or no traffic delays on the interbay conveyor **20**. These sections of conveyor located between the vertical modules **102** (e.g., buffer conveyors **122A** and **122C**) could also be used as an entrance position for high priority ("hot lot") containers or for transferring a container to the input vertical module (e.g., vertical modules **102B** and **120D**) for processing by another tool in the bay. It is also possible for containers to flow in a continuous loop in this manner, until they are loaded onto a tool.

Fig. 2 illustrates the system **100** shown in Fig. 1 with a stocker **200** (discussed in more detail later) in place of the buffer conveyor **122B**. The stocker **200** includes many of the basic functions of a conventional stocker. In one embodiment, the stocker **200**

includes a robotic mechanism (not shown) that moves vertically and horizontally to access walls of storage shelves positioned within the stocker **200** (*e.g.*, a container storage area). Such a robotic mechanism is well known in the semiconductor industry and therefore, a further description of the robotic mechanism is not necessary. One disadvantage of a conventional stocker is that the robotic mechanism may be transferring containers within the container storage area at the time that a container arrives at the stocker on the interbay conveyor **20**. For example, if the stocker's robotic mechanism just started a transfer operation right before the container arrived, it may be 10 to 30 seconds before the robotic mechanism is free to retrieve the container waiting at the interbay conveyor **20**. During that waiting time, the interbay traffic would be stopped and likely backed up on the conveyor **20**. This inefficiency can greatly reduce the inherent high throughput of the conveyor **20**.

Fig.2 illustrates the stocker **200** in operation with the floor-based conveyor **30B** that moves containers into tool bay **B2**. The stocker **200** may also be placed adjacent the floor-based conveyor **30A** that moves containers out of tool bay **B1**. It is also within the scope of the present invention to place a stocker **200** in operation with both the floor-based conveyors **30A** and **30B**.

Fig. 3 illustrates the stocker **200** in more detail. In the Fig. 3 embodiment, the stocker **200** includes a housing **202**, a first ceiling-based input conveyor **204**, a second ceiling-based input conveyor **206** and a floor-based conveyor **208**. Containers are stored within the housing **202**, which provides a container storage area. Container storage within a stocker device (*e.g.*, storage shelves) is well known within the semiconductor art and therefore, no further description is necessary. By way of example only, the container storage area may comprise a system similar to that disclosed in U.S. Patent No. 6,579,052, entitled "SMIF Pod Storage, Retrieval and Delivery System," which is assigned to Asyst Technologies, Inc., and is incorporated in its entirety herein.

The stocker **200** includes a ceiling-based input conveyor dedicated to each interbay conveyor **20**. The first ceiling-based input conveyor **204** is preferably located at the same height or elevation as the interbay conveyor **20a**. The second ceiling-based input conveyor **206** is preferably located at the same height or elevation as the interbay

conveyor **20b**. Each input conveyor may be located at other heights. Locating the input conveyor **204** at substantially the same height as the interbay conveyor **20a** does, however, require fewer moves by the lane jumper **120** to transfer containers **2** between the input conveyor **204** and the interbay conveyor **20a**.

The input conveyors **204** and **206** preferably extend into the stocker's container storage area. For example, input conveyor **204** includes a first section **204a** located outside or external to the housing **202** and a second section **204b** located within the housing **202**. This way, the stocker's robotic mechanism (not shown) may access a container located in the internal section **204b** of the input conveyor **204**. The input conveyor **206** preferably includes the same features as the input conveyor **204**. Other configurations of the input conveyors **204** and **206** may exist, and each input conveyor does not have to be identical or have the same features.

The input conveyor **204** is able to move a container either into the stocker housing **202** (see arrow **220**) through the opening **203** or away from the stocker housing **202** (see arrow **222**). Once a container **2** is inside the housing **202**, the stocker's robotic mechanism is primarily responsible for moving the container between the input conveyors **204** and **206**, the floor-based conveyor **208** and the storage shelves (not shown) located within the container storage area or housing **202**.

The floor-based conveyor **208** may either comprise an output conveyor or an input conveyor. Either way, the floor-based conveyor **208** is preferably located at substantially the same height or elevation as the floor-based conveyor **30**. If the conveyor **208** comprises an output conveyor, the stocker's robotic mechanism delivers a container **2** onto the output conveyor **208**, and the output conveyor **208** moves the container **2** onto the intrabay conveyor **30** through the opening **224**. If the conveyor **208** comprises an input conveyor, the input conveyor **208** moves a container **2** from the intrabay conveyor **30** into the stocker's container storage area through the opening **224**. The stocker's robotic mechanism may then proceed to move the container within the stocker's container storage area.

Fig. 3 illustrates that the intrabay conveyor **30** is a bidirectional conveyor (see arrow **33**). Thus, the conveyor **208** may also comprise a bidirectional conveyor. If the

conveyor **30** comprises a unidirectional conveyor, then the conveyor **208** will comprise an input or output conveyor depending on the direction of the intrabay conveyor **30**. The output conveyor **208** may also comprise any length, and in a preferred embodiment, may simultaneously store more than one container at a time.

Each of the stocker's conveyors may also provide a container buffer system similar to the buffer conveyors **122** shown in Figs. 1-2. In a preferred embodiment, the input conveyors **204** and **206** and the conveyor **208** may each store more than one container at a time. The length of each stocker conveyor may vary.

The Fig. 3 embodiment of the stocker **200** includes a vertical module **102**. The vertical module **102** transports containers **2** between the input conveyor **204**, the input conveyor **206** and the floor-based conveyor **30**. After a container **2** is placed on, for example, the input conveyor **204**, the input conveyor **204** may deliver the container **2** inside the stocker **200** or to the vertical module **102**. Transferring the container **2** to the vertical module **102** bypasses the stocker **200** and provides an express transfer to the floor-based conveyor **30**. Otherwise, the container **2** must travel through the stocker **200** to get to the floor-based conveyor **30**. The vertical module **102** also eliminates the need for a separate lane jumper **120** or other transfer device for transferring a container directly from the input conveyor **204** or **206** to the vertical module **102**. The stocker **200** also preferably includes a transition conveyor **226** for moving a container **2** between the vertical module **102** and the conveyor **208**.

A conventional stocker includes a single opening that both entering and exiting containers must pass through. To optimize the throughput efficiency of the stocker **200**, the stocker **200** includes a conveyor control system responsible for coordinating container traffic at the points where the output conveyor **208** loads containers **2** onto the floor-based conveyor **30** (or conveyor **208** inputs containers into the container storage area) and containers are loaded onto the input conveyors **204** and **206**.

Fig. 4 illustrates a stocker **300**. The stocker **300** is shown in operation with a bi-directional floor-based conveyor **30**. The stocker **300** includes a housing **301** and several ceiling-based buffer conveyors: a first input buffer conveyor **304**, a second input buffer conveyor **306**, a first output conveyor **312** and a second output conveyor **314**. The stocker

300 also includes two floor-based buffer conveyors: and output conveyor **308** and a floor-based input conveyor **310**. The stocker **300** may have any combination of these conveyors.

In this embodiment, the stocker **300** includes a ceiling-based input buffer conveyor and an output buffer conveyor at both levels of the ceiling-based conveyor **20**. The first input buffer conveyor **304** is located at the same height of, and is adjacent to, the ceiling-based conveyor **20a**. The second input buffer conveyor **306** is located at the same height of, and is adjacent to, the ceiling-based conveyor **20b**. The first output buffer conveyor **312** is located at the same height of, and is adjacent to, the ceiling-based conveyor **20a**. The second output buffer conveyor **314** is located at the same height of, and is adjacent to, the ceiling-based conveyor **20b**.

Each ceiling-based conveyor includes a section external to the stocker housing **302** and a section internal to or within the stocker housing **302**. For example, the input conveyor **304** includes a section **304a** external to the stocker housing **302** and a section **304b** located within the stocker housing **302**. As disclosed above, the stocker's robotic mechanism is able to access a container **2** seated anywhere on the internal section **304b** of the input conveyor **304** or the internal section **306b** of the input conveyor **306**. The stocker's robotic mechanism may also place a container **2** anywhere on the internal section **312b** of the output conveyor **312** or the internal section **314b** of the output conveyor **314**.

Each of the input and output buffer conveyors, in a preferred embodiment, includes at least one dedicated lane jumper **120**, for transferring containers between the input or output buffer conveyor and the respective ceiling-based conveyor **20**. In a preferred embodiment, and as previously described above, the input conveyors **304** and **306** and the output conveyors **312** and **314** each extend into the stocker at least one shelf location to allow the stocker's robotic mechanism (not shown) access to each conveyor. The input buffer conveyor **304** is preferably longer than the output buffer conveyor **312** to accommodate a period when a lane jumper **120** is loading containers from the ceiling-based conveyor **20** onto the input buffer conveyor **304** at a rate that is higher than the stocker **300** can accept. This situation will occur when the stocker robotic mechanism cannot move containers **2** from the input buffer conveyor **304** into the stocker **300** at the

same rate as containers are bring placed on the input buffer conveyor **304**. The input conveyor **306** preferably has the same features as the input conveyor **304**.

The stocker **300** is not required to include two floor-based buffer conveyors. The stocker **300** may, for example, include a single bidirectional floor-based buffer conveyor (*e.g.*, conveyor **308** may be bidirectional). However, the efficiency of the stocker **300** is improved by having a dedicated floor-based input and output conveyor. In a preferred embodiment, the stocker **300** includes two floor-based conveyors: an input buffer conveyor **310** and a floor based output buffer conveyor **308**. The output conveyor **308** moves a container, placed on it by the stocker's robotic mechanism, onto the floor-based conveyor **30**. The input conveyor **310** moves containers from the floor-based conveyor **30** into the stocker housing **302**.

The floor-based buffer conveyors **308** and **310** allow containers **2** to be collected in a group without interfering with the container traffic on the floor-based conveyor **30**. For example, multiple containers **2** may be transferred on the floor-based conveyor **30** in groups into the tool bay (*e.g.*, away from the director **D1**), and then transfer the multiple containers back to the stocker **300** all at the same time. Another efficient container transfer method is to send a container **2** from the stocker **300** into the tool bay, and then allow a container waiting in the tool bay to be transferred back to the stocker **300** as soon as the outgoing container has passed the waiting container. There may be times when the floor-based conveyor **30** has some sections moving in opposite direction (*e.g.*, asynchronous conveyor). The stocker **300** may support either container transfer method.

The stocker **300** includes a director **D1** located adjacent the floor-based output conveyor **308**, a director **D2** located adjacent the floor-based input conveyor **310** and a transition conveyor **320** for transferring containers **2** from the director **D1** to the director **D2**. The director **D1** is able to rotate a container **2** exiting the output conveyor **308** before the intrabay conveyor **30** transports the container **2** to the tool bay. The director **D2** is able to rotate a container **2** exiting the transition conveyor **208** before the container is transported into the stocker housing **302** by the input conveyor **310**.

The floor-based buffer conveyors **308** and **310** may also be of any length, and the length of each conveyor, in part, determines how many containers **2** may be returned from

the tool bay at one time. For example, for the most efficient stocker **300**, the number of containers **2** returning from the tool bay at once should not be more that the total number of containers that can be stored on the floor-based input buffer conveyor **310**, the transition conveyor **320** and the director **D2**. If more containers are returned than can be stored on the input conveyor **310**, the transition conveyor **320** and the director **D2**, containers will back up to the point where the containers **2** will block the exit **322** of the output conveyor **308**. If this happens, the output buffer conveyor **308** cannot move any containers onto the intrabay conveyor **30** and into the tool bay.

Preferably, as soon as the last of the returning containers **2** passes the director **D1** and reaches the transition conveyor **320**, the output conveyor **308** may start moving outgoing containers onto the intrabay conveyor **30** and into the tool bay. While the outgoing containers are traveling on the intrabay conveyor **30**, the stocker's robot mechanism is free to load containers from the input conveyor **310**, the input conveyor **304** or the input conveyor **306** into the stocker **300**, if any containers are waiting. The stocker's robotic mechanism preferably moves containers from the input conveyor **310** into the stocker **300** until at least one container space is available on the transition conveyor **320** before moving outgoing containers onto the floor-based outgoing conveyor **308**.

Containers may also be sent into the tool bay and back to the stocker **300** one at a time. For example, when an outgoing container traveling on the floor-based conveyor **30** clears or passes another container waiting to return to the stocker **300** (*e.g.*, seated on a tool waiting to return to the stocker), the waiting container may be loaded onto the floor-based conveyor **30** and begin traveling towards the stocker **300**. Each waiting container may start its movement back towards the stocker **300** as soon as the conveyor section between its position and the stocker **300** is clear of the last outgoing container. Ideally, by the time all of the containers return to the stocker's input buffer conveyor **310**, the next set of outgoing containers have been staged on the output buffer conveyor **308**, and this cycle would start again.

Figs. 1-4 each illustrate the interbay conveyor **20** as vertically stacked conveyors **20a** and **20b** because a stacked configuration eliminates delays experienced by

conventional planar interbay conveyors. Conventional interbay AMHS deliver containers most efficiently through uni-directional motion. Thus, multiple, parallel interbay conveyors increase the interbay AMHS throughput capacity. Planar interbay conveyor architecture does not, however, allow the containers from the more distant conveyor (*e.g.*, conveyor located further from the tool bay) to enter a tool bay without crossing over the conveyor that is closer to the tool bay. These positions where conveyor flow is diverted or where conveyor flow crosses another conveyor requires a device such as a director. Interbay throughput would be degraded by the traffic interruptions.

The various embodiments of stockers disclosed herein could work with planar interbay conveyors. However, the efficiency of the system **100** would be reduced. If the system **100** contained planar interbay conveyors, directors would be installed to connect the far interbay conveyor to the position where a lane jumper **120** would remove a container **2** from the near interbay conveyor. It is even possible for the ceiling-based interbay conveyor **20** to interface with the stocker **200** or **300** without lane jumpers. The lane jumpers could be replaced by, for example, directors on the buffer conveyors **122**, and container traffic would be connected to the position where the lane jumper had been, through another director on the adjacent interbay conveyor.

The various embodiments of stockers disclosed herein could also work with an OHS interbay AMHS. For example, the lane jumper **120** that would have interfaced with the interbay conveyor **20** would load and unload the containers **2** to and from the OHS vehicle. If the OHS vehicle had a transfer arm, it could directly load and unload containers to and from the buffer conveyors **122**.

An interbay conveyor **20** may also be required to interface with conventional stockers that do not have the improved buffer architectures described above. In this case, container traffic on the interbay conveyor **20** will be blocked when a container is waiting on the conveyor **20** to be transferred to the stocker. Other containers traveling on the ceiling-based conveyor **20** cannot pass the stocker until the container is removed from the conveyor **20**. The container may sit in the conveyor **20** while the stocker's robotic mechanism is, for example, moving a container within the stocker. These delays will reduce the throughput on the interbay conveyor **20**.

One method of reducing these throughput delays on the interbay conveyor **20** is to have an interbay AMHS controller calculate when a container will arrive at the conventional stocker and provide that information to the stocker. The stocker will then know ahead of time when a container will arrive. Ideally, the stocker will not start a new operation that cannot be completed prior to the arrival of the container. The stocker's robotic mechanism or other robotic mechanism will therefore be ready to transport the container into the stocker when the container arrives. This method places a priority on the servicing of interbay containers at the expense of potential inefficiency of the stocker (e.g., the stocker robotic mechanism may wait prior to the arrival of the container instead of starting to move a container within the stocker).

Reducing delays and obstructions on the interbay conveyor **20** while containers are moving on the interbay conveyor **20** is important. An interbay controller would preferably reduce or eliminate obstructions due to containers being loaded onto the interbay. This could be accomplished by having the interbay conveyor **20** alternate between times when container motion is stopped so that containers may be loaded onto the interbay conveyor **20**, and times when the containers are moving to their destinations on the interbay conveyor **20**. To optimize the efficiency of the ceiling-based conveyor **20**, the time period while containers are loaded onto the interbay conveyor **20** is preferably as short as possible because this period requires obstructing the conveyor. To shorten the amount of time required to load containers onto the conveyor **20**, it is preferable to use multiple loading devices or mechanisms, in parallel, as possible. For example, multiple lane jumpers or directors at each loading bay could be used in parallel from loading containers onto the conveyor **20**. Alternately, the containers may be queued on a buffer conveyor; allowing a single mechanism to load the containers onto the interbay conveyor **20** as quickly as possible.

The container loading period could end, by way of example only, either when a time interval was complete (*e.g.*, load as many containers as possible onto the conveyor **20** in one minute), when all containers are loaded onto the conveyor **20**, or when a maximum number of containers have been loaded onto the conveyor **20**. After any of these periods, the containers loaded onto the conveyor **20** could begin moving. All the containers may

move along the conveyor **20** until a time interval was complete or until all of the containers have been unloaded from the interbay conveyor **20** onto, for example, the stocker's ceiling-based input conveyor **204**. If the containers move for a predetermined time period, any containers that have not yet been unloaded from the conveyor when the time period expires may move forward to another position that does not obstruct container loading operations, and stop. In this scenario, the container loading period would then begin again.

The above embodiments of a stocker are described and illustrated in operation with ceiling-based conveyors **20** and floor-based conveyors **30**. It is within the scope and spirit of the present invention for the stocker to operate in conjunction with other material transport systems. For example, the ceiling-based conveyors **20** may instead be replaced by an overhead hoist transport (OHT) system or an overhead shuttle (OHS) system. Similarly, the floor-based conveyors **30** may instead be replaced by a rail guided vehicle (RGV), an automated guided vehicle (AGV) and so on.

It should be appreciated that the above-described stocker and methods for FOUP transport are for explanatory purposes only and that the invention is not limited thereby. Having thus described a preferred embodiment of a stocker and method for coordinating FOUP transportation, it should be apparent to those skilled in the art that certain advantages of the within system have been achieved. It should also be appreciated that various modifications, adaptations, and alternative embodiments thereof may be made within the scope and spirit of the present invention. For example, the use of conveyors has been illustrated in a semiconductor fabrication facility, but it should be apparent that many of the inventive concepts described above would be equally applicable to be used in connection with other non-semiconductor manufacturing applications.

We claim:

1. A stocker within a fabrication facility having a ceiling-based interbay material transport system for moving a container between tool bays and a floor-based intrabay material transport system for moving a container within a tool bay, the stocker comprising:

a container storage area for storing at least one container;

a ceiling-based input conveyor being adapted to receive a container from the ceiling-based interbay material handling system and moving the container into said container storage area;

a floor-based conveyor for moving a container between said container storage area and the floor-based intrabay material handling system; and

a robotic mechanism for moving a container between said ceiling-based input conveyor, said container storage area and said floor-based conveyor.

2. The stocker as recited in claim 1, wherein said container storage area comprises a plurality of container storage shelves.

3. The stocker as recited in claim 2, wherein said robotic mechanism also moves containers between said plurality of container storage shelves.

4. The stocker as recited in claim 1, further including a vertical transfer module for transferring a container between said ceiling-based input conveyor and the floor-based intrabay material handling system.

5. The stocker as recited in claim 1, wherein said floor-based conveyor comprises an input conveyor for moving a container from the floor-based intrabay material handling system into said container storage area.

6. The stocker as recited in claim 1, wherein said floor-based conveyor comprises an output conveyor for moving a container from said container storage area onto the floor-based intrabay material handling system.

7. The stocker as recited in claim 4, wherein said ceiling-based input conveyor further being adapted to move a container onto said vertical transfer module.

8. A stocker within a fabrication facility having a ceiling-based interbay material handling system for moving a container between tool bays and a floor-based intrabay material handling system for moving a container within a tool bay, comprising:

a container storage area;

a ceiling-based input conveyor for receiving a container from the ceiling-based interbay material handling system and moving the container into said container storage area;

a ceiling-based output conveyor for moving a container out of said container storage area;

a floor-based input conveyor for moving a container from the floor-based intrabay material handling system into said container storage area; and

a floor-based output conveyor for moving a container from said container storage area onto the floor-based intrabay material handling system; and

a robotic mechanism for moving a container between said ceiling-based input conveyor, said ceiling based output conveyor, said floor-based input conveyor, said floor-based output conveyor and within said container storage area.

9. The stocker as recited in claim 8, wherein said container storage area comprises a plurality of container storage shelves.

10. The stocker as recited in claim 9, wherein said robotic mechanism moves containers between said plurality of container storage shelves.

11. A method for optimizing container movement along a material handling system between a loading zone portion of the material handling system and a stocker, comprising the steps of:

(a) preparing the loading zone portion of the material handling system for receiving multiple containers;

(b) loading multiple containers, in parallel, onto the loading zone portion of the material handling system;

(c) moving the containers loaded in said step (b) proximate to a stocker; and

(d) loading the containers moved to the stocker in said step (c) from the material handling system to the stocker.