SYSTEM AND METHOD FOR FLEXIBLE HIGH SPEED TRANSFER OF SEMICONDUCTOR COMPONENTS

Field of Invention

The present invention relates generally to a system and method for handling a semiconductor component. More specifically, the present invention relates to a system and method for transfer of semiconductor components between different packaging media.

Background of Invention

Semiconductor components, for example semiconductor wafers, dies and integrated circuit (IC) chips, are typically packaged or stored in suitable packaging media (also known as transport media or transfer media) during their transport between different processing stations within a manufacturing plant, as well as during distribution after their manufacture. Packaging media for semiconductor components can generally be classified as loose packaging media and immobilizing packaging media. Loose packaging media used for packaging semiconductor components include, but are not limited to JEDEC trays, TESEC trays, multi-channel metal magazines and tubes. An example of an immobilizing packaging media is tape media.

It is often necessary to transfer semiconductor components between different types of packaging media, for example from a multi-channel metal magazine to a JEDEC tray. The transfer of semiconductor components between different packaging media is typically a significantly time consuming and repetitive process, and is generally not manually performed for technical and/or efficiency reasons (e.g., ESD protection issues, or an increased likelihood of generating bent leads). Accordingly, robotic or automated systems for transferring semiconductor components between packaging media have been devised and manufactured. With the increasing market competition in the semiconductor component fabrication and processing industry, there is a continuous need to increase the speed and throughput of existing systems for transferring semiconductor components between the different packaging media.

Inspection and testing (collectively referred to as processing) of semiconductor components are routinely performed during the overall semiconductor component fabrication process. There are several conventional systems and methods for processing or performing the inspection and testing of semiconductor components. However, the increasing demand for high-throughput manufacture of high quality semiconductor components results in a correspondingly increasing requirement for inspection and testing (i.e. processing) systems and methods capable of inspecting and testing semiconductor components with enhanced speed and accuracy.

Pick and place mechanisms are used for offloading semiconductor components from the processing systems onto packaging media for the onward transport of semiconductor components. However, the demand for increased speed and throughput of semiconductor component manufacturing has resulted in an increasing need for faster and more accurate pick and place mechanisms.

During the fabrication of semiconductor components, the semiconductor components are typically transferred or transported between different processing stations or processing systems. As previously mentioned, the semiconductor components are typically packaged in suitable packaging media or transport media for facilitating transfer between the different processing stations. Semiconductor components being introduced into the processing system is commonly referred to as input semiconductor components. After being processed by the processing system, these semiconductor components are consequently removed from the processing system and transferred to another packaging media. The semiconductor components removed from the processing system can be referred to as output semiconductor components.

The packaging media for input semiconductor components and output semiconductor components are typically determined or selected based on a customer’s or application requirements. Most conventional systems for processing or inspecting and testing semiconductor components provide limited options as to packaging or transport media for packaging the output semiconductor components offloaded from the systems.

Additionally, most conventional systems and methods for processing semiconductor components have an undesirably limited speed and accuracy for the processing of semiconductor components. A need exists for systems and methods that overcome the aforementioned limitations of conventional systems.

Summary

Embodiments of the present invention relate to a system and a method for transferring semiconductor components. The system and the method provided by embodiments of the present invention seek to address at least one of the issues or problems highlighted in the background.

In accordance with a first aspect of the embodiments of the present invention, there is disclosed a first exemplary system for transferring semiconductor components, the first exemplary system comprising a carrier for receiving a plurality of semiconductor components in series. The carrier comprises of a plurality of receivers formed thereon, each of the plurality of receivers for receiving one of the plurality of semiconductor components. The system further comprises a gang pick and place mechanism. The gang pick and place mechanism is operable for collectively receiving the plurality of semiconductor components from the carrier and subsequently collectively transferring the plurality of semiconductor components received thereby to a predetermined packaging media. The use of gang pick and place, results in a significant increase in system throughput (Units per hour or UPH).

In accordance with a second aspect of the embodiments of the present invention, there is disclosed a second exemplary system for transferring semiconductor components, the second exemplary system comprises a turret structure. The turret structure comprises a plurality of pickup heads (or turret heads), each of the plurality of pickup heads configured for rotatable displacement for transferring one of a plurality of semiconductor components from a first position to a second position in series. The turret structure is designed such that the pickup heads are able to move up and down on-the-fly (during each index of the turret structure’s rotary movement**).** This unique feature results in

significant increase in system throughput (UPH). In several embodiments, an entire set or assembly of pickup heads that is circumferentially carried or mounted on the turret structure is configured to rotationally and vertically move in unison as a result of vertical motion of the turret assembly itself (e.g., by way of one or more linear or other type of high speed motors, or another means), which further reduces cycle time and control complexity. The system further comprises a set of carriers for receiving the plurality of semiconductor components from the plurality of pickup heads in series, and a gang pick and place mechanism, the gang pick and place mechanism being operable for collectively receiving the plurality of semiconductor components from the carriers. The gang pick and place mechanism is further operable for collectively transferring the received plurality of semiconductor components therefrom onto a tray packaging media.

In accordance with a third aspect of the embodiments of the present invention, there is disclosed a third exemplary system comprising two carriers, each carrier being movable in cyclical motion with respect to each other, between a first position (position of transferring of components from turret head to the carrier) and a second position (position of transferring components from the carrier to a gang pick and place mechanism). While a first carrier is receiving components from the turret pickup heads at the first position, the second carrier delivers its components to the gang pick and place mechanism at the second position near an output tray. After such component delivery, the second carrier moves down and is positioned below the first carrier. When the first carrier is filled, it moves to the gang pick and place position for unloading. At this stage the second carrier moves up to the loading position under the turret. In other words, the second carrier is waiting under the first carrier to move to the second position, which is a device offload position, and as soon as the first carrier moves away from the position at which it is being loaded with components, the second carrier is moved up and is ready to receive components from the pickup heads. Significant increase in system throughput (UPH) is achieved by this cyclical movement of the two carriers.

Brief Description of the Drawings

The following description of the present invention is provided with reference to the drawings, in which:

FIG. 1 is a schematic overview of an exemplary system for flexible high speed transfer of semiconductor components provided by an embodiment of the present invention.

FIG. 2A is a schematic illustration showing a turret structure having a plurality of pickup heads configured for rotary movement and a plurality of carriers configured for cyclical movement to facilitate high throughput offloading of devices from the system.

FIG. 2B is a top schematic view illustrating an exemplary position of a turret structure within a system configured for flexible high speed transfer of semiconductor components provided by an embodiment of the invention.

FIG. 3 is a pictorial representation of the working of the two carriers and the gang pick and place mechanism.

FIG. 4 is an isometric view of a gang pick and place mechanism for transferring semiconductor components onto a tray carrier.

FIG. 5 is a flowchart illustrating steps of an exemplary method for flexible high speed transfer of semiconductor components as provided by an embodiment of the present invention.

Detailed Description

Fabrication of semiconductor components typically involves multiple processing steps, for example visual defect inspection and electrical testing. Several processing systems have been devised for the processing of semiconductor components. Growing demand for an enhanced quality, speed and throughput of semiconductor component fabrication has resulted in a need for processing systems that are capable of processing semiconductor

components at higher speeds and accuracy. The semiconductor components are offloaded from such processing systems onto an output packaging media, which is also known as transport media or transfer media. Semiconductor components are packaged within, or placed on, the packaging media during transport between processing systems or stations, as well as during distribution upon completion of fabrication. Growing competition in the semiconductor industry has made it increasingly important to provide customers with more options as to available output packaging media for semiconductor components post processing. Embodiments of the present invention provide a system and method for addressing at least one of the above-identified issues.

For purposes of brevity and clarity, the description of exemplary embodiments of the present invention is limited hereinafter to a system and a method for transferring semiconductor components. It will however be understood by a person skilled in the art that this does not preclude the present invention from other applications where fundamental principles prevalent among the various embodiments of the present invention such as operational, functional or performance characteristics are required.

An exemplary system 10 for transferring semiconductor components as shown in FIG. 1 is provided according to a first embodiment of the present invention. The exemplary system 10 comprises a turret structure (turret) or rotary structure 12, a first carrier 14, a second carrier 16 and a gang pick and place mechanism 18.

The system 10 transfers semiconductor components from a first device carrying or packaging media 20 (also known as an input packaging media) to a second device carrying or packaging media 22 (also known as an output packaging media). The packaging media 20, 22 can also be referred to as transport media or transfer media. Semiconductor components are packaged or stored within, or placed on, the packaging media during the transport between processing systems or stations within a semiconductor component fabrication plant, as well as during distribution upon completion of fabrication.

The system 10 also facilitates processing of the semiconductor components during the transfer of the semiconductor components from the first packaging media 20 to the second packaging media 22. Examples of semiconductor components transferred by the system 10 include, but are not limited to, semiconductor wafers, dies and integrated circuit (IC) chips.

The first packaging media 20 is, for example, a tray carrier or a metal magazine. The semiconductor components are disposed, arranged, or packaged on or in the first packaging media 20 when transported to the system 10. The semiconductor components packaged in the first packaging media 20 are subsequently loaded or transferred from the first packaging media 20 to the system 10. Preferably, the system 10 comprises a loading station or loading module 24. The loading station 24 is shaped and dimensioned for receiving the first packaging media 20. Preferably, the semiconductor components are loaded or transferred from the first packaging media 20 to the system 10 at the loading station 24.

The system 10 additionally comprises means, apparatuses or mechanisms for facilitating the loading or transfer of semiconductor components from the first packaging media 20 to the system 10. For example, pick and place mechanisms of varying designs as known in the art may be employed for transferring the semiconductor components from the first packaging media 20 to the system 10. Preferably, the semiconductor components are transferred from the first packaging media 20 onto a conveyor, conveyor system, or conveyor mechanism 11.

The conveyor mechanism 11 can be for example, a tape drive assembly or a belt drive assembly. Preferably, the conveyor mechanism 11 transports the semiconductor components from the loading station 24 towards the turret 12. More specifically, the conveyor mechanism 11 preferably transports the semiconductor components in series from the loading station 24 to the turret 12. Semiconductor components placed onto the conveyor mechanism 11 are displaced by the conveyor mechanism 11 from the loading station 24 to the turret 12. Speed of displacement of the semiconductor components by

the conveyor mechanism 11 can be determined and adjusted as required. For example, operation of the conveyor mechanism 11 can be software controlled.

FIG. 2A is a schematic illustration of the turret structure or turret 12 according to an embodiment of the invention, and FIG. 2B is a top schematic view illustrating an exemplary spatial relationship between a turret structure 12 and other elements of a system 10 configured for flexible high speed transfer of semiconductor components provided by an embodiment of the invention. The turret 12 is alternatively referred to as a rotatory semiconductor component handling mechanism. The turret 12 comprises a fixed central shaft and a rotatable portion coupled to the central shaft. The central shaft preferably defines a first or primary axis (e.g., a vertical or z-axis) about which the rotatable portion is rotatable.

The rotatable structure comprises a number of pickup heads (or turret heads) 26 coupled thereto. The number of pickup heads 26 is, for example, between and including twenty-four and thirty-six. The number of pickup heads 26 may be varied as required (e.g., between two and sixty or more). The pickup heads 26 are spatially arranged in a predetermined configuration. Preferably, the pickup heads 26 are spatially arranged around the central shaft. In addition, the pickup heads 26 are preferably spaced at predetermined distances from each other. Rotation of the rotatable structure or portion about the first axis correspondingly results in rotational displacement of the pickup heads 26 about the first axis. In several embodiments, each pickup head 26 is positioned or disposed at a radius or radial distance r from the first axis.

The system 10 preferably comprises a motor (not shown). The motor is operable for driving the rotatable portion, and correspondingly the pickup heads 26, about the first axis. The motor is preferably coupled to the central shaft. The operation of the motor is preferably software controlled. The operation of the motor causes the rotational displacement of the pickup heads 26 about the first axis along a predetermined travel profile or travel path. It will be appreciated that the predetermined travel profile of the

pickup heads 26 about the first axis can be altered as required using techniques known to a person skilled in the art.

Each pickup head 26 carries or receives one semiconductor component from the conveyor system or mechanism 11 at an uptake position (alternatively known as a first position). In other words, the semiconductor components are transferred in series from the conveyor system to the pickup heads 26 of the turret 12 at the uptake position.

A pickup head 26 includes a component holding or retaining mechanism. Preferably, the pickup heads 26 employ vacuum suction for picking up the components from the conveyor and also for securely holding the components during the motion of the rotary turret 12. It will be understood by a person of ordinary skill in the art that alternative means or mechanisms may be employed for picking up the semiconductor components from the conveyor mechanism 11 and for securing the semiconductor components thereto during the rotational displacement thereof along the predetermined travel profile.

The rotational displacement of the pickup heads 26 displaces them along a circumferential path defined by the turret 12 from the uptake position to an offload position (alternatively known as a second position). The semiconductor components attached to the pickup heads are preferably transferred to the first carrier 14 or the second carrier 16 when the pickup heads 26 are at the offload position.

As further detailed below, the pickup heads 26 are additionally configured for on-the-fly z-axis / up-and-down motion in association with their circumferential displacement about the first axis. In one embodiment, a given pickup head 26 can be vertically displaced during its rotational translation around the first or primary axis, where such vertical pickup head displacement occurs along a second or secondary axis that can be defined with reference to the pickup head 26 itself, which is parallel to the first axis in a manner indicated in FIG. 2A. In other embodiments, an entire assembly (e.g., the turret's rotatable structure) carrying the multiple pickup heads 26 can be vertically displaced along or parallel to the first axis (i.e., in +/- z-axis directions) to provide the on-the-fly

up-down pickup head motion, which minimizes system complexity, simplifies system control overhead, increases system output, and improves system reliability.

The system 10 further comprises a number of processing stations or modules (e.g., in a manner shown in FIG. 2B) that are operable for processing the semiconductor components handled or transferred by the system 10. More specifically, the processing modules facilitate processing of the semiconductor components when the semiconductor components are being displaced from the uptake position toward and to the offload position. The processing modules include, but are not limited to, visual inspection modules such as image capture devices and functional testing modules such as electrical testing modules. The processing modules are arranged in a predetermined spatial configuration. More specifically, the processing modules are arranged in a predetermined spatial configuration about the first axis or central shaft of the turret 12. The spatial configuration of the processing modules can be altered as required. Preferably, the processing modules are spatially configured for enhancing the space-efficiency and throughput of the system 10. Further preferably, the spatial configuration of the processing modules is determined for increasing the number of processing modules useable with the system 10 for processing the semiconductor components.

The number and type of processing modules used with the system 10 may be altered as required. A person skilled in the art will understand that the system 10 enables multiple processing steps to be performed to the semiconductor components while the semiconductor components are being handled or transferred by the system 10 to thereby enhance at least one of speed, accuracy and throughput of the semiconductor component processing by the system 10.

The turret structure 12 is configured to rotatably move or shift its pickup heads 26 from one processing station to another in a synchronized or simultaneous manner. A turret structure rotation from a particular processing station to a next processing station is referred to as a turret index. In general, a turret index is a rotational or circumferential increment of the turret structure 12 corresponding to or correlated with a separation

distance between processing stations. Adjacent pickup heads 26 carried by the turret structure 12 successively arrive at any given processing station by way of the turret structure's rotational indexing. The linear or curvilinear distance (e.g., turret rotation arc length) that the pickup heads 26 travel per turret index can be a configurable or programmable parameter, based upon embodiment details such as a number and/or type of processing stations under consideration.

The turret structure 12 is configured to provide on-the-fly up-down movement of the pickup heads 26 as the turret indexes from one processing station to another. For example, for a first processing station P1 and a second processing station P2 illustrated in FIG. 2A, the turret structure 12 can displace a pickup head 26 positioned at P1 in a vertical direction (e.g., along a second axis, in a direction parallel to the first axis) in an up-down manner, and can additionally vertically displace a pickup head 26 positioned at P2 in an up-down manner. Thus, pickup heads 26 can move up and/or down as part of each turret index, that is, on-the-fly as turret indexing occurs or progresses. In association with the on-the-fly up-down pickup head movement, a given pickup head 26 can transfer a device to and/or remove a device from a station at which the pickup head 26 is positioned. This on-the-fly up-down movement of the pickup heads 26 significantly increases the system's throughput.

In certain embodiments, each pickup head 26 or a set of pickup heads 26 includes or is coupled to a pneumatic actuator such as a solenoid-driven pneumatic cylinder that is configured for vertically displacing the pickup head(s) 26 in a z-axis or secondary axis direction. In various embodiments, the turret structure 12 itself is configured for z-axis displacement, such that pickup heads 26 carried thereby can be vertically shifted up and down in unison by way of the turret structure's z-axis motion. The turret structure 12 can include or be coupled to a pneumatic cylinder, an electronic solenoid, a linear motor, or other device(s) to facilitate such z-axis displacement. Providing up-down on-the-fly movement of pickup heads 26 in such a collective manner reduces system control complexity and increases machine operating speed and system throughput (UPH). Particular embodiments can additionally or alternatively employ z-axis displacement

mechanisms such as cam-driven mechanisms configured to facilitate up-down pickup head motion.

In general, each pickup head 26 includes or is coupled to (e.g., in a wireless or wire-based manner) a set of limit sensors configured to sense a top or uppermost pickup head position and a bottom or lowest pickup head position. In some embodiments, some or all pickup heads 26 can include or be coupled to one or more intermediate limit sensors configured to detect pickup head position(s) between the top and bottom pickup head positions. Particular limit sensor signals can indicate or facilitate the determination of whether the position of a pickup head 26 (a) corresponds to a semiconductor component pickup or release position; and/or (b) satisfies a predetermined clearance or separation distance condition between a distal portion or tip of the pickup head 26 and a processing station (e.g., to indicate that the pickup head 26 has vertically cleared the station, and the turret's rotary transport of the pickup heads 26 can safely continue). Certain embodiments additionally include sensors configured to detect pickup head positions or rotational transitions corresponding to one or more rotary transport sensing locations.

The control of component or device placement at, on, or in any station (e.g., an electrical test station or a visual inspection station) preferably includes two stages. In a first stage, a pickup head 26 is positioned close or very close to the surface of a placement plane associated with a particular station. When the pickup head 26 reaches the station, the pickup head 26 moves a short vertical distance and places the device on the station. This two stage positioning process helps minimize overhead compared to the device moving from a highest or top position to the station. The vertical distance that the pickup heads 26 are moved or displaced can be a programmable parameter that can depend, for instance, on a type or thickness of a component or semiconductor device under consideration.

Typically, the rotational motion of the turret 12 includes a series of short movements that transition the pickup heads 26 from one processing station to another (e.g., P1 to P2). A rotational motion pause or turret wait or delay time between processing stations will

generally be determined by the throughput of a slowest processing station. For instance, in the event that a test station requires approximately 5 seconds to test a device, and an inspection station requires approximately 15 seconds to inspect a device, the turret's wait or delay time between processing stations will be approximately 15 seconds. In various embodiments, the turret wait or delay time is a configurable or programmable parameter.

The moment of inertia of the turret assembly 12 determines a settle time required for the turret's rotatable portion and/or the pickup heads 26 to stabilize such that components can be reliably or precisely picked up and/or placed or released. This moment of inertia depends upon the mass and the vibration characteristics of the turret assembly 12. In general, a settle time can be programmably specified, and an appropriate settle time can be determined in view of embodiment details, a component type under consideration, prior system operation history, and/or trial and error testing.

Referring also now to FIGs. 3 and 4, the semiconductor component is offloaded or detached from the pickup heads 26 and transferred to a carrier 14, 16 at the offload position. As previously mentioned, the system 10 comprises the first carrier 14 and the second carrier 16 (each of the first carrier 14 and the second carrier 16 is also known as a shuttle precisor or a receptacle). Each of the first carrier 14 and the second carrier 16 shuttles (i.e., moves or is displaced) between a first position where it receives semiconductor components from the pickup heads 26 and a second position at which the received semiconductor components are transferred to the gang pick and place mechanism 18.

The carriers 14, 16 are arranged such that while one carrier (for example, carrier 14 in FIG. 4) is receiving devices from the turret 12, the other carrier 16 delivers components to the gang pick and place mechanism 18 and returns to a waiting or ready position just below the carrier 14 that is receiving devices from the turret's pickup heads 26. When the carrier 14 receiving devices from the turret 12 is full of components, this carrier 14 moves to a delivery or emptying position for delivering or providing components to the gang pick and place mechanism 18. As soon as this carrier 14 moves away, the waiting or

ready carrier 16 is lifted up or shifted into the receiving position, and can begin receiving the next set of components from the pickup heads 26. After delivering the components to the gang pick and place mechanism 18, the just emptied carrier 14 is lowered and moved to a waiting or ready position just below the carrier 16 now receiving the components from the pickup heads 26. This cyclical movement of the two carriers 14, 16 ensures that the machine throughput (UPH) is high or extremely high.

The first carrier 14 and the second carrier 16 operate in cyclical motion between the first position (position of transfer of the semiconductor components from the pickup heads 26 of the turret 12 to the carriers 14, 16) and the second position (position of transfer of the components from the two carriers 14, 16 to the gang pick and place mechanism 18). This is illustrated in FIGs. 3 and 4.

Preferably, the use of two carriers (i.e., the first carrier 14 and the second carrier 16) enhances the speed of transfer of the semiconductor components from the pickup heads 26 to the gang pick and place mechanism 18**.** In the event speed of the turret increases and hence more devices are processed, more carriers or shuttle precisors (e.g., 3, 4, 6, or 8) can be introduced and used by the system 10 as required for increasing the speed of transfer of the semiconductor components from the pickup heads 26 to the gang pick and place mechanism 18. Each of the first carrier 14 and the second carrier 16 may be coupled to a mover or a moving mechanism for displacing the first carrier 14 and the second carrier 16 between the first position where it receives semiconductor components from the pickup heads 26 and the second position at which the received semiconductor components are transferred to the gang pick and place mechanism 18.

As indicated in FIG. 4, each of the first carrier 14 and the second carrier 16 comprises a number of receivers 28 (also known as receiving pockets) formed on a top surface thereof. The number of receivers 28 formed on the top surface of each of the first carrier 14 and the second carrier 16 can be varied as required. Each of the number of receivers 28 is shaped and dimensioned for receiving one semiconductor component from the pickup heads 26 of the turret 12. The receivers 28 are arranged in a predetermined

configuration on the carrier 14, 16. Preferably, the receivers 28 are arranged in a straight row or line across the top surface of each of the first carrier 14 and the second carrier 16. The pitch between the receivers 28 is preferably uniform, and can be altered as required. Additionally, the number of rows and/or columns of receivers 28 can be modified or increased in accordance with a desired component carrying capacity for each carrier 14, 16, with any necessary modifications made such that all rows and columns of receivers 28 can be appropriately positioned with respect to the pickup heads 26.

Each of the first carrier 14 and the second carrier 16 is spatially displaced to facilitate the receipt of each consecutive semiconductor component within one of the number of receivers 28. This displacement is preferably facilitated by the mover or moving mechanism coupled to each of the first carrier 14 and the second carrier 16. More specifically, each of the first carrier 14 and the second carrier 16 is spatially displaced by a distance equal to the pitch of the receivers 28 between the receipt of each consecutive semiconductor component within the one of the number of receivers 28. The speed of spatial displacement of the first carrier 14 and the second carrier 16 is preferably the same, and can be altered as required. In addition, the speed of displacement of the first carrier 14 and the second carrier 16 can be software controlled.

As previously mentioned, the first carrier 14 and the second carrier 16 receive the semiconductor components at the first position and are subsequently displaced to the second position. The semiconductor components received by the first carrier 14 and the second carrier 16 are transferred to the gang pick and place mechanism 18 at the second position. Preferably, the gang pick and place mechanism 18 comprises a number of pickup tips 30 extending from a body of the gang pick and place mechanism 18. The pickup tips 30 are arranged in a predetermined configuration. Preferably, the pickup tips 30 are arranged in a linear configuration and have a uniform pitch. Further preferably, the spatial configuration of the pickup tips 30 corresponds with the configuration of receivers 28 of each of the first carrier 14 and the second carrier 16. More specifically, the pitch of the pickup tips 30 is similar to the pitch of the receivers 28 of each of the first carrier 14 and the second carrier 16.

The gang pick and place mechanism 18 illustrated in FIG. 4 is operable for transferring the semiconductor components from each of the first carrier 14 and the second carrier 16 onto the output packaging media 22. The output packaging media 22 is preferably a tray carrier 32 or a tray-type carrier as shown in FIG. 2B. The tray carrier 32 can also be referred to as an output receptacle. Preferably, the gang pick and place mechanism 18 is displaced for collectively receiving or picking up a predetermined number of semiconductor components from each of the first carrier 14 and the second carrier 16. The displacement of the gang pick and place mechanism 18 is preferably parallel to the first axis and perpendicular to the direction of travel of the carriers 14,16 from the first position to the second position. Preferably, the gang pick and place mechanism 18 is coupled to a movement controller for enabling the displacement of the gang pick and place mechanism 18. The gang pick and place mechanism 18 can be moved or displaced in alternatives directions, and at different speeds, as required. The movement of the gang pick and place mechanism 18 is preferably facilitated or controlled by a movement controller.

More specifically, the predetermined number of semiconductor components is received by the pickup tips 30 of the gang pick and place mechanism 18. The predetermined number of semiconductor components is preferably a number equal to or more than two. After receipt of the predetermined number of semiconductor components, the gang pick and place mechanism 18 is further displaced for transferring the predetermined number of semiconductor components onto the tray carrier 32. This displacement is preferably parallel to the first axis and perpendicular to the direction of travel of the carriers 14, 16 from the first position to the second position. More specifically, the pick and place mechanism 18 is displaced for transferring the semiconductor components from the pickup tips 30 onto receiving pockets or receivers 34 on the tray carrier 32. A person skilled in the art will understand that the gang pick and place mechanism 18 facilitates gang transfer or collective transfer of the predetermined number of semiconductor components from each of the first carrier 14 and the second carrier 16 onto the tray carrier 32.

The system 10 of the present invention facilitates conversion from a series transfer of semiconductor components (from the conveyor mechanism 11 to the turret 12, and from the turret 12 to each of the first carrier 14 and the second carrier 16) to a gang or collective transfer of semiconductor components (from each of the first carrier 14 and second carrier 16 onto the tray carrier 32). The ability of the gang pick and place mechanism 18 to collectively transfer the predetermined number of semiconductor components enables tray carriers 32 to be used by the system 10 as an optional output packaging media 22 for the semiconductor components. Accordingly, this enables semiconductor component fabricators or manufacturers to offer the option of tray carriers 32 as a type of output packaging media 22 for their customers. It will be understood by a person of ordinary skill in the art that tray carriers 32 of alternative designs and constructions may be used by the system 10.

Preferably, the system 10 further comprises a programmable controller or a processor (not shown) that is in signal communication with at least one of the conveyer mechanism 11, the turret 12, the processing modules, the first carrier 14, the second carrier 16 and the gang pick and place mechanism 18. Preferably, the programmable controller is programmed for controlling operation of the at least one of the turret 12, the processing modules, the first carrier 14, the second carrier 16 and the gang pick and place mechanism 18. For example, the programmable controller preferably controls the speed and duration of operation of at least one of the turret 12, the processing modules, the first carrier 14, the second carrier 16 and the gang pick and place mechanism 18.

An exemplary method 100 for transferring semiconductor components is also provided according to an embodiment of the present invention. A flowchart of exemplary steps of the method 100 is provided in FIG. 5.

In step 110 of the method 100, the semiconductor components are loaded or introduced into the system 10. As described above, the semiconductor components are loaded to the system at the loading module or loading station 24. More specifically, the semiconductor

components are transferred from the first packaging media 20 to the conveyor mechanism 11 in step 110. This transfer can be mediated by various means or mechanisms known to a person skilled in the art, for example, by utilizing a gang pick and place mechanism 18. In step 120, the conveyor mechanism 11 transports the semiconductor components in series from the loading module 24 to the turret 12.

In step 130, the semiconductor components are transferred in series from the conveyor system 11 to the pickup heads 26 of the turret 12 at the uptake position. More specifically, the semiconductor components are individually transferred in series from a portion of the conveyor mechanism 11 (e.g., a conveyor belt) to consecutive pickup heads 26 of the turret 12. As previously mentioned, each pickup head 26 comprises a channel or airway defined therewithin. Vacuum or suction is applied through the channel for picking up the semiconductor component from the conveyor mechanism 11. Alternative means or mechanisms may also be employed by the pickup heads 26 for picking up the semiconductor components.

In step 140, the semiconductor components carried by the pickup heads 26 are rotationally transitioned to or through a sequence of processing modules (e.g., from an initial or first processing module to a final processing module, where the processing modules can perform electrical testing, optical inspection, and/or other operations) in a manner that facilitates semiconductor component fabrication, testing, and/or verification processes. In step 150, the pickup heads 26 transport the semiconductor components to the offload position (e.g., after such components have been processed at a final processing module). As previously described, the motor drive facilitates the rotational displacement of the pickup heads 26 from the uptake position to the offload position. Displacement of the pickup heads 26 from the uptake position to the offload position follows a predetermined travel profile. The semiconductor components received by the pickup heads 26 are processed as they are displaced from the uptake position to the offload position. Steps 130, 140, and 150 are therefore performed in a continuous or concurrent manner, that is, in parallel, by way of the turret’s ongoing rotational

displacement that spatially transitions pickup heads 26 from one processing module to another.

A significant aspect of the turret mechanism's design is the on-the-fly up-down movement of the pickup heads 26 when the pickup heads 26 are moved from one processing station to another. This results in a significant decrease in index time of the system 10 and a significant increase in system UPH.

The system 10 comprises processing modules, for example one or more visual inspection modules and one or more electrical, optical, or electro-optical testing modules, which are each positioned for processing the semiconductor components during the displacement of the semiconductor components from the uptake position to the offload position. The number and type of processing modules may be varied as required by a user of the system 10. The ability to perform multiple processing steps on the semiconductor components during their displacement from the uptake position to the offload position enhances at least one of speed, accuracy and throughput of fabrication of the semiconductor components.

In step 150, the semiconductor components are transferred in series from the pickup heads 26 of the turret 12 onto the first carrier 14 positioned at the first or receiving position. More specifically, a predetermined number of semiconductor components (also known as a plurality of semiconductor components) is transferred in series from the pickup heads 26 onto or into the first carrier 14 in step 150. Each of the predetermined number of semiconductor components is transferred from one pickup head 26 to one of the number of receivers 28 formed on the first carrier 14 at the first position. Preferably, the pickup heads 26 are displaced by a predetermined distance towards the first carrier 14 during step 150. Further preferably, air is purged through the channel of the pickup heads 26 for facilitating detachment or transfer of the semiconductor components from the pickup heads 26 to the receivers 28 of the first carrier 14. Alternative means or mechanisms may be employed for transferring semiconductor components from the pickup heads 26 to the receivers 28 of the first carrier 14.

The first carrier 14 is preferably spatially displaced between receipt of each consecutive semiconductor component within one of the number of receivers 28 of the first carrier 14. More specifically, the first carrier 14 is preferably spatially displaced by a distance equal to the pitch of the receivers between receipt of each consecutive semiconductor component within one of the number of receivers 28 of the first carrier 14.

In step 160, the system 10 determines whether the first carrier 14 is filled, that is, whether the first carrier 14 should be displaced to the gang pick and place mechanism 18 for emptying. If not, the method 100 continues transferring components to the receiving carrier (the first carrier 14 in this instance) in step 150.

If the first carrier 14 is to be emptied or unloaded, the first carrier 14 is displaced or shuttled from the first position to the second position in step 170, such that the first carrier 14 can be accessed and unloaded by the gang pick and place mechanism 18. Additionally, the second carrier 16 is displaced or shifted to the first or receiving position in step 175 in a manner that is simultaneous or generally simultaneous with the first carrier's displacement in step 170. Once the second carrier 16 is in the first or receiving position (i.e., the component or device offload position, from which components are offloaded from the pickup heads 26 onto or into the carrier 16), components are transferred in series from the turret's pickup heads 26 onto or into the second carrier 16 in step 150.

Once the first carrier 14 is displaced, shifted, or transferred to the gang pick and place mechanism 18 in step 170, a predetermined number of semiconductor components carried by the first carrier 14 is collectively transferred from the first carrier 14 to the gang pick and place mechanism 18, more specifically to the pickup tips 30 of the gang pick and place mechanism 18 in step 180. This is to say, the predetermined number of semiconductor components is transferred simultaneously from the receivers of the first carrier 14 to the pickup tips 30 of the gang pick and place mechanism 18 in step 180. The pickup tips 30 of the gang pick and place mechanism 18 are collectively displaced

towards the first carrier 14 for picking up two or more (e.g., 2, 8, 10, 12, 20, or more**)** semiconductor components from the first carrier 14. Each of distance, speed and direction of displacement of the pickup tips 30 can be controlled by the programmable controller, and can be altered as required.

In association with step 180, the predetermined number of semiconductor components is transferred from the pickup tips 30 of the gang pick and place mechanism 18 to the second or output packing media 22, which in several embodiments is more specifically the tray carrier 32. The tray carrier 32 can also be referred to as a receptacle for the semiconductor components. The pickup tips 30 of the gang pick and place mechanism 18 are displaced towards to the tray carrier 32 during the step 180. The predetermined number of semiconductor components is transferred from the pickup tips 30 of the gang pick and place mechanism 18 to the receiving pockets 34 formed on the surface of the tray carrier 32. The receiving pockets 34 of the tray carrier 32 are spatially arranged in a predetermined configuration. Preferably, the pitch of the receiving pockets 34 of the tray carrier 32 is uniform. More specifically, the pitch of the receiving pockets 34 of the tray carrier 32 corresponds with the pitch of the pickup tips 30 of the gang pick and place mechanism 18, and accordingly the pitch of the receivers of each of the first carrier 14 and the second carrier 16. The corresponding or similar pitch between the receiving pockets 34 of the tray carrier 32, the pickup tips 30 of the gang pick and place mechanism 18 and the receivers 28 of each of the first and second carrier 14, 16 enable accurate transfer of the semiconductor components there between. The use of a gang pick and place mechanism 18 also results in significant increase in system UPH.

As previously described, the gang pick and place mechanism 18 can be displaced in various directions and/or speeds as required for facilitating the transfer of the semiconductor components between the first carrier 14 or second carrier 16 and the tray carrier 32. The displacement of the gang pick and place mechanism 18 can be facilitated by a movement controller, which can be software controlled. In addition, the system 10 can comprise additional pick and place mechanisms 18 and/or carriers 14, 16 (also known as receptacles) depending upon embodiment details. The semiconductor components can

be transferred, either in series or collectively, between the additional pick and place mechanisms and carriers before being offloaded or transferred onto the tray carrier 32. These additional pick and place mechanisms 18 and carriers 14, 16 can be of similar or varying designs and structure.

The first carrier 14 and the second carrier 16 operate in a cyclical arrangement, which significantly increases the system UPH. While the first carrier 14 is receiving components from the pickup heads 26 at the first position, the second carrier 16 delivers its components to the gang pick and place mechanism 18 at the second position, and is lowered down and moved back to the ready or waiting position proximate to the first position, just below the carrier 14 that is currently receiving components from the pickup heads. In other words, the second carrier 16 is waiting for the first carrier 14 to finish picking up its components and move to the second position (device offload position). As soon as the first carrier 14 moves to the offload position, the second carrier 16 is moved up and is ready to receive components from the pickup heads 26. Typically, any time delay associated with vertically moving an empty carrier 16 from the waiting position to the receiving position at which it can receive or be loaded with components from the pickup heads 26 is minimal or negligible.

It is thus ensured that a predetermined number of semiconductor components is being transferred from the pickup heads 26 to the first carrier 14 at the first position, while a corresponding number of semiconductor components is transferred from the second carrier 16 to the gang pick and place mechanism 18 at the second position, and vice versa. The use of the first carrier 14 and the second carrier 16 (i.e., two carriers) enhances speed of transfer of semiconductor components from the pickup heads 26 to the gang pick and place mechanism 18. More carriers can be introduced into the system 10 as required for further enhancing speed of transfer of semiconductor components from the pickup heads 26 to the gang pick and place mechanism 18.

In summary, the exemplary system 10 and the exemplary method 100 provided by the present invention enable the semiconductor components to be output onto tray carriers (i.e. tray-type packaging media) 14, 16 or other types of carrying media. This enables the user of the system to provide customers with an additional semiconductor component output packaging media option. In addition, different input packaging media can also be used with semiconductor components that are to be loaded or introduced into the system. Flexibility of input packaging media and output packaging media enhances ease of use and efficiency of the exemplary system 10 and the exemplary method 100.

Furthermore, the exemplary system 10 and the exemplary method 100 provided by the present invention enable conversion from a series input of individual semiconductor components to a gang or collective output of multiple semiconductor components. Furthermore, the exemplary system 10 and method 100 provided by the present invention enable multiple processing steps to be preformed to the semiconductor components as the semiconductor components are being transferred between different packaging media. The ability to perform multiple processing steps upon the semiconductor components during transfer thereof by the system 10 increases at least one of speed, throughout, and accuracy of semiconductor component fabrication. In addition, the use of the turret 12 helps to enhances the space efficiency of the system 10.

A person of ordinary skill in the art will understand that systems 10 according to the present invention can additionally or alternatively be configured for unloading components, where output packaging media 22 is treated as input packaging media 20, and devices flow in a reverse order into the input packaging media 20. This can be particularly relevant in situations in which components or devices require re-inspection, and the component carrying media 20, 22 used prior to and following re-inspection are different.

In the foregoing manner, an exemplary system and an exemplary method for transferring semiconductor components as provided by embodiments of the present invention are described. The exemplary system and method addresses at least one of the issues or

problems faced during semiconductor component fabrication as mentioned above. It will however be understood by a person skilled in the art that the present invention is not limited to specific forms, arrangements or structures of the embodiments described above. It will be apparent to a person skilled in the art in view of this disclosure that numerous changes and/or modifications can be made without departing from the scope and spirit of the invention.