

TRANSFER SYSTEM FOR FLIPPING AND MULTIPLE CHECKING OF ELECTRONIC DEVICES

FIELD OF THE INVENTION

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[0001] The following description relates generally to a transfer system for transferring and changing the orientation of electronic devices such as semiconductor chips, and more specifically, to a system for transferring and flipping chips that provides additional operation space and greater efficacy than conventional systems.

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BACKGROUND

[0002] Semiconductor device fabrication is the process used to create the integrated circuits that are present in everyday electrical and electronic devices. In typical semiconductor fabrication, integrated circuits ("ICs" or "chips") are built in large quantities on a single large wafer of semiconductor material, typically silicon. The individual chips are patterned with small pads of metal near their edges that serve as connections to a mechanical carrier. The chips are then cut out of the wafer and attached to carriers, typically via wire bonding such as thermosonic bonding. The wires used in the wire bonding eventually lead to pins on the outside of the carriers, which are attached to circuitry making up the electronic system.

[0003] A flip chip pin grid array (FCPGA) is a form of pin grid array in which the die faces downwards on the top of the substrate with the back of the die exposed. The term "flip chip" can also refer to a controlled collapse chip connection which is a method for interconnecting semiconductor devices, such as IC chips and microelectromechanical systems (MEMS), to external circuitry with solder bumps that have been deposited onto the chip pads. The process is similar to conventional integrated circuit fabrication, but includes a few additional steps. Toward the end of the manufacturing process, attachment pads are metalized to make them more receptive to solder. Metalization typically includes several treatments. A small dot of solder is

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deposited on each metalized pad. The chips are then cut out of the wafer. To attach the flip chip into a circuit, the chip is inverted to bring the solder dots down onto connectors on underlying electronics or a circuit board. The solder is then re-melted to produce an electrical connection, typically using a thermosonic bonding, or alternatively, a reflow solder process.

[0004] During production, individual semiconductor chips are typically oriented such that their leads face away from the receiving surface. It may be necessary to "flip" the chips with a flipping mechanism before the chips are transferred for subsequent processes, such as function testing or visual integrity checking. Conventional flipping mechanisms increase the frequency by which the semiconductor packages are picked and placed, which increases the likelihood that packages are dropped and/or damaged.

[0005] For example, **FIG. 1** depicts related art in which a pivoting part **3** is used for detaching individual semiconductor chips from a wafer or from its substrate **1** by means of a die ejector **2**. The pivoting part **3** enables a flip head **5** to swivel by virtue of a pivotal point **4**. A pickup element **6** is arranged on the flip head **5** out of an optical connection line **1c** between a first optical facility **7** and the wafer surface. The related art shown in **FIG. 1** comprises a pickup position **1a** for the chip to be picked up and a deposit position **1b** for a placing facility **8**. The placing facility **8** includes a pickup element **9**, which may take the form of a vacuum pipette, in order to place the turned chip within a smart card module, for example, by moving the placing facility **8**. This system is impractical for industrial use because it has only one pickup element and relies on a time-consuming sequential method process.

[0006] **FIG. 2**, depicts a device for checking and rotating semiconductor chips according to another related art. The device includes a wafer (not shown) and an associated substrate **11** with a wafer surface **11a**, from which individual semiconductor chips are ejected upwards with a die ejector **12** from below. A pivoting part **14** is arranged such that that it rotates in an executed rotation as indicated by arrows **15**, **16** about a pivotal point **17**, which is arranged above the chip to be picked

up. The wafer can be moved with the substrate **11** in an X direction as indicated by arrows **13**. The wafer can also be moved in a Y direction.

[0007] The pivoting part **14** includes cheek projections **18a** and **18b** and two
5 opposite pickup elements **19, 20**, which may take the form of vacuum pipettes. The
pickup elements **19, 20** enable simultaneous picking up and depositing of two
semiconductor chips. The first vacuum pipette **19** is configured to pick up a
semiconductor chip from the substrate **11**, while the pickup element **20** is configured to
deposit another semiconductor chip on a placing facility **21**. The placing facility **21** may
10 be equipped with a vacuum pipette **22**. In operation, the placing facility **21** is moved
sideways as indicated by the double arrow **24**. At almost the same time, the pivoting
part **14** rotates about its pivotal point **17**, this time in the opposite direction. After a 90°
rotation of the pivoting part **14**, an opening (not shown) is created in the pivoting
part **14** to form a sight channel **23a**. The sight channel **23a** runs vertically through the
15 part **14** from a first optical facility **23** to the surface **11a** of the substrate **11**, which
is covered with a wafer of a second semiconductor chip.

[0008] This sight channel **23a** enables the optical facility **23** to record the step of the
second semiconductor chip being picked up on the substrate **11**, and enables the
20 surface and position of the second semiconductor chip to be checked. As soon as the
pivoting part **14** has finished a 90° rotation followed by a 180° rotation, pickup of the
second semiconductor chip is executed by the second vacuum pipette **20**. A second
optical facility (not shown) may take the form of a die positioned on the fly
camera **25** and may be configured to check a flip offset of the previously rotated chip. In
25 the event that there is a flip offset, the second optical facility calculates corresponding
correction data and passes the data to the self-adjusting place element **21**. The place
element **21** then deposits the chip in an indexer **26**. The position of the place element
21 is checked by a second camera **27**. The device of **FIG. 2** uses only two vacuum
pipettes to flip the chip, hence the device is only capable of flipping a limited number of
30 units per hour (UPH).

[0009] Related art US 20140328652 A1 discloses a transfer apparatus for transferring electronic devices from a wafer to a test handler. The transfer apparatus comprises a rotary device rotatable about an axis and a plurality of holders configured to hold the electronic devices for transfer from the wafer to the test handler. The holders
5 are coupled to, and extendable from, the rotary device to pick the electronic devices from the wafer. Specifically, the plurality of holders are arranged circumferentially around, and inclined with respect to, the axis of the rotary device, so as to change an orientation of the electronic devices on the wafer to a desired orientation of the electronic devices on the test handler. Because the transfer apparatus uses a vertical
10 wafer table, chips are prone to falling from the wafer and becoming damaged.

[0010] Another related art, WO 2003058708 A1, discloses a flip bonder having a pick-up turret assembly with a number of pick-up nozzles, and a placing turret assembly with a number of placing nozzles. Each pick-up nozzle picks a die by its bumped
15 surface, and indexes the picked die to the transfer location, thereby flipping the picked die. At the transfer location, the picked die is transferred to a placing nozzle, with die now held by its back surface. The placing nozzle is indexed to a fluxing location where flux is applied to the die, and further indexed to a placing location, where the fluxed die is placed on a target location on a lead frame, with the bumps abutting lead portions of
20 the lead frame. The multiple nozzles allow concurrent operations with each die, thus supporting an improved throughput. However, because there is only one vertical flipper, it is only possible to have one check station.

[0011] A need, therefore, exists for a system capable of quickly and accurately
25 picking, flipping and transferring chips without dropping or damaging them. It should also provide increased operation space so that chips can be examined or checked by multiple devices such as cameras.

SUMMARY OF THE INVENTION

5 [0012] The following summary is provided to facilitate an understanding of some innovative features and is not intended to be a full description. An appreciation of the various aspects disclosed herein can be gained by considering the specification, claims, drawings, and abstract.

10 [0013] A transfer system for flipping and checking electronic devices includes a wafer table inclined about a first angle with respect to a horizontal axis. A first rotary device is rotatable about a second angle, and the first rotary device includes a plurality of first transfer heads circumferentially arranged around the first rotary device and inclined with respect to an axis of said first rotary device. The transfer heads are configured to pick and hold the electronic devices from the wafer table
15 and transfer the electronic devices to a second rotary device.

[0014] The second rotary device is rotatable about a horizontal axis, and includes a plurality of second transfer heads vertically arranged on a circumference of the second rotary device. The rotary device is configured to pick the electronic
20 devices from the first rotary device and transfer the electronic devices to a handling device.

[0015] The transfer system further includes a first imaging device configured to inspect the electronic devices to be picked from the wafer table. A second imaging
25 device is configured to inspect the electronic devices to be placed on the handling device. A plurality of check stations positioned around the first and second rotary devices are configured to check at least one parameter of the electronic devices held by at least one of the first and second transfer heads after picking the electronic devices from the wafer table.

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[0016] Each of the first transfer heads is configured to pick the electronic devices and place the electronic devices on one of the second transfer heads at an interval of 180 degrees of rotation.

[0017] In one aspect, the electronic devices include semiconductor chips.

[0018] In another aspect, the first angle is in the range of 1 to 89 degrees.

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[0019] In another aspect, the second angle is in the range of 1 to 89 degrees.

[0020] In another aspect, the first imaging device includes a camera, a first light source, and a first reflecting device.

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[0021] In another aspect, the camera is a downward facing camera positioned above the wafer table.

[0022] In another aspect, the first imaging device and the first light source are positioned along an axis of the first imaging device.

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[0023] In another aspect, the first reflecting device is configured to increase an inspection time of the electronic devices when picking the electronic devices from the wafer table.

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[0024] In another aspect, the first reflecting device is configured to reflect light from the light source to an axis of one of the transfer heads.

[0025] In another aspect, the transfer system further includes at least one first suction device connected to the first transfer heads. The suction device is configured to provide suction force to each one of the first transfer heads when picking the electronic devices from the wafer table.

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[0026] In another aspect, the transfer system further includes at least one second suction device connected to the second transfer head. The second suction device is configured to provide suction force to each of the plurality of second transfer heads

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when picking the electronic devices from the second transfer heads.

In another aspect, the first suction device is configured to provide sufficient suction force to hold the electronic devices during a flipping process.

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[0027] In another aspect, the second suction device is configured to provide sufficient suction force to hold the electronic devices during a flipping process.

[0028] We also describe a transfer apparatus for flipping and checking electronic devices, comprising a wafer table for placing electronic devices, a first rotary head positioned at a right angle the said wafer table for picking the electronic devices from the wafer, the first rotary head composed of a plurality of first transfer heads. A second rotary head is positioned substantially vertically, for picking the electronic devices from the first rotary head. The second rotary head is also composed of a plurality of second transfer heads. A handling device receives electronic devices from the second rotary head. One or more imaging devices are configured to inspect the electronic devices and one or more check stations are configured to check at least one parameter of the electronic devices. The electronic devices are rotated 180 degrees when transferred from the first rotary head to the second rotary head.

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[0029] The electronic devices include integrated circuits and semiconductor chips. The imaging devices can be comprised of a camera, a first light source and a first reflecting device. Further, the camera can be a downward facing camera positioned above the wafer table. The first imaging device and the first light source can be positioned along an axis of the first imaging device. A first suction device can be connected to the first transfer heads, configured to provide suction force to each of the transfer heads when picking electronic devices from the wafer table. A second suction device can be connected to the second transfer heads, configured to provide suction force to each of the second transfer heads.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The summary above, as well as the following detailed description of illustrative embodiments, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the present disclosure, exemplary constructions of the disclosure are shown in the drawings. However, the disclosure is not limited to specific methods and instrumentalities disclosed herein. Moreover, those in the art will understand that the drawings are not to scale. Wherever possible, like elements have been indicated by identical numbers.

[0031] FIG. 1 shows a schematic front view of a device for checking and rotating semiconductor chips according to related art.

[0032] FIG. 2 shows a schematic front view of a device for checking and rotating semiconductor chips according to related art.

[0033] FIG. 3 shows a schematic front view of an inclined wafer table and first rotary device for flipping and checking electronic devices.

[0034] FIG. 4 shows a schematic front view of a second rotary device for flipping and checking electronic devices.

[0035] FIG. 5 shows a schematic front view of a handling device for receiving a flipped electronic device from second rotary device of FIG. 4.

[0036] FIG. 6 shows a schematic front view of a transfer system for flipping and checking electronic devices.

[0037] FIG. 7 shows a schematic side view of the transfer system depicted in FIG. 6.

DETAILED DESCRIPTION OF THE INVENTION

[0038] The particular values and configurations discussed in the following non-limiting examples can be varied, are cited merely to illustrate at least one embodiment, and are not intended to limit the scope thereof.

[0039] Without intent to further limit the scope of the disclosure, examples of instruments, apparatus, methods and their related results according to the embodiments of the present disclosure are given below. Note that titles or subtitles may be used in the examples for convenience of a reader, which in no way should limit the scope of the disclosure. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions, will control.

[0040] The term “ball grid array” or “BGA” as used herein, refers to type of surface-mount packaging (a chip carrier) used for integrated circuits.

The term “electronic device,” as used herein, refers to a single chip or a die cut from a semiconductor wafer.

The term “integrated circuit,” as used herein, refers to a small complex of electronic components and their connections that is produced in or on a small slice of material such as silicon.

The term “operation space,” as used herein, refers to the space available to test, examine, photograph, alter or manipulate an electronic device during the fabrication process.

The term “pick and place” or “PnP” as used herein, refers to surface mount technology (SMT) component placement systems, which are robotic machines used to place surface-mount devices (SMDs) onto a printed circuit board (PCB).

The term “semiconductor chip,” as used herein, refers to an integrated circuit or monolithic integrated circuit (also referred to as an IC, a chip, or a microchip) which is

a set of electronic circuits on one small plate ("chip") of semiconductor material, normally silicon.

The term "wafer table," as used herein, refers to a type of handling system, which must reliably, securely, and selectively position and hold a wafer or chip relative to elements of a processing system.

[0041] It will be appreciated that terms such as "front," "back," "top," "bottom," "side," "short," "long," "up," "down," and "below" used herein are merely for ease of description and refer to the orientation of the components as shown in the figures. It should be understood that any orientation of the components described herein is within the scope of the present invention.

[0042] Other technical terms used herein have their ordinary meaning in the art that they are used, as exemplified by a variety of technical dictionaries.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0043] The invention includes a transfer system for flipping and checking electronic devices. The design presents several advantages over conventional systems including:

- (1) a higher speed of operation (increased number of units per hour (UPH),
- (2) a better optical line by inserting a mirror and lighting device between the rotating chips to increase the inspection time,
- (3) increased operation space due to the angled turret and wafer table,
- (4) the opportunity to place multiple checking stations around the heads,
- (5) the ability to easily observe the operation and condition of the machine, and
- (6) a greater efficacy over conventional designs as chips are less prone to being dropped or damaged.

[0044] FIG. 3 shows a schematic front view of a wafer table 21 and a first rotary device 20 for flipping and checking of electronic devices. The first rotary device 20 has a plurality of circumferentially arranged first transfer heads 30, 31, 32, 33, 34 and 35.

The wafer table **21** is inclined at a first angle with respect to a horizontal axis and the first rotary device **20** is inclined at a second angle with respect to the horizontal axis. The wafer table **21** can include a collection of electronic devices to be flipped. The first transfer head **30** of the first rotary device **20** is configured to pick an electronic device **40** to be flipped from the wafer table **21**. It should be noted that the first transfer heads **31**, **32** and **33** already hold the electronic devices **41**, **42** and **43** to be flipped, respectively. **FIG. 3** also shows a plurality of check stations **22**, **23** and **24** that are positioned around the first rotary device **20**. In the exemplary embodiment shown in **FIG. 3**, the check stations **22** and **23** are arranged in front of the first transfer heads **31** and **32**. The check stations **22** and **23** are configured to check at least one parameter of the electronic devices **41** and **42** held by the first transfer heads **31** and **32**, after picking the electronic devices **41** and **42** from the wafer table **21** via the respective first transfer heads **31** and **32**.

[0045] In one embodiment, the first angle ranges from 1 to 89 degrees, preferably between 10 and 84 degrees, or more preferably 30 degrees. The angle of the wafer table is an important consideration for optimal use of the system. With a higher angle (more vertical), the electronic device is more likely to fall. With a lower angle there is less operation space. For example, with an angle of 45 degrees from horizontal, the wafer table may not be able to support the weight of the electronic device. When the first angle is between 35 degrees and 40 degrees, the electronic device can slip. When the angle is below 30 degrees, there is less operation space for arranging the devices used for flipping and checking the electronic devices. Hence, an optimal first angle is 30 degrees.

[0046] In another embodiment, the second angle ranges from 1 to 89 degrees. Although the embodiment of the first rotary device shown in **FIG. 3** is an angled turret having six transfer heads, a skilled artisan will recognize that a similar design with a different number of heads could also be used without limitation.

[0047] **FIG. 4** shows a schematic front view of a second rotary device **50** utilized in

flipping and checking the electronic devices. Similar to the first rotary device **20**, the second rotary device **50** has a plurality of circumferentially arranged transfer heads **36**, **37**, **38** and **39**. Although the embodiment of **FIG. 4** includes four heads, any number of heads can be used. The second rotary device **50** is configured to rotate about its vertical axis. Each first transfer head **30**, **31**, **32**, **33**, **34** and **35** is configured to rotate 180 degrees and to place the electronic devices on the plurality of second transfer heads **36**, **37**, **38** and **39** of the second rotary device **50**, after picking the electronic devices from the wafer table **21**. In one embodiment, the second rotary device **50** has six second transfer heads.

[0048] According to the embodiments shown in **FIG. 3** and **FIG. 4**, when the first rotary device **20** is rotated about its axis, the first transfer head **30** is configured to pick the electronic device **40** from the wafer table **21**. The first transfer heads **31** and **32** are configured to hold the already picked electronic device **41** and **42**, and the first transfer head **33** is configured to place the electronic device **43** on the second transfer head **36** of second transfer device **50**.

[0049] It should be noted that to flip the electronic devices, each first transfer head is rotated 180 degrees after picking the electronic devices. Furthermore, the electronic device **43** is placed at 180 degrees on the second transfer head **36** of the second rotary device. As shown in **FIG. 4**, the second transfer head **36** of the second rotary device **50** is configured to receive the electronic device **43** from the first transfer heads **33** of the first rotary device **20**. It will be recognized by those skilled in the art that the first and second rotary devices **20** and **50** can have an equal or different number of transfer heads for flipping the electronic devices. Depending on the number of transfer heads in the first and second rotary devices **20** and **50**, rotational speed of the first and second rotary devices **20** and **50** are adjusted such that the electronic devices picked by the first transfer head **30**, **31**, **32** or **33** of first rotary devices **20** are transferred to the second transfer head **36**, **37**, **38** or **39** of the second rotary device **50**.

[0050] In one embodiment, the check station **24** is arranged in front of the second

transfer head **37**. As shown in **FIG. 4**, the check station **24** is configured to check at least one parameter of the electronic devices **44** held by the second transfer head **37** after receiving the electronic devices **44** from one of the first transfer heads **30, 31, 32, 33, 34** or **35** of the first rotary device **20**. The check stations **22, 23** and **24** are stationary and are configured to check at least one parameter of the electronic device when the electronic device is held by at least one of first transfer heads **30, 31, 32, 33, 34** or **35** or the second transfer head **36, 37, 38** or **39** travels in front of the respective check stations **22, 23** or **24**. Flipping accuracy and the condition of the electronic device can be determined from measured parameters.

[0051] The second rotary device **50** may be a Pick and Place (PnP) turret with six transfer heads, although other devices may also be used without limitation. The check station **22, 23** and **24** may comprise one or more sensors, cameras, and the like, to check at least one parameter of the electronic device.

[0052] **FIG. 5** shows a schematic front view of a handling device **60** configured to receive the flipped electronic device from the second rotary device **50**. The handling device **60** has an upper portion **62** on which the flipped electronic device can be placed or transferred. The handling device **60** has one or more conveyors **63** for moving the upper portion **62**. The upper portion **62** is configured to unload the electronic device whenever the second transfer head **36, 37, 38** or **39** of the second rotary device **50** places the electronic device on the upper portion **62**. The handling device **60** can be, for example, a track system or a carrier tape. The carrier tape can include a pocket to contain the electronic device (i.e. die).

[0053] **FIG. 6 and FIG. 7** depict an embodiment of a transfer system **70** for flipping and checking electronic devices. The transfer system **70** includes the wafer table **21**, the first rotary device **20**, the second rotary device **50**, and the handling device **60**. The first transfer heads **30, 31, 32, 33, 34** or **35** are configured to pick any combination of the electronic devices **40, 41, 42** or **43** from the wafer table **21**. After rotating 180 degrees, first transfer heads **30, 31, 32, 33, 34** or **35** can transfer the electronic device

to one of the second transfer heads **36, 37, 38** or **39** of the second rotary device **50**. The second transfer head **36, 37, 38** or **39** of the second rotary device **50** can then transfer the flipped electronic device onto the upper portion **61** of the handling device **60**.

5 **[0054]** As shown in the embodiment of **FIG. 7**, the transfer system **70** can use at least one first imaging device **64** positioned above the wafer table **21** to image and inspect the electronic device to be picked from the wafer table **21**. The first imaging device **64** comprises at least one camera **26**, at least one first light source **27**, and at least one first reflecting device **28**. The camera **26** and the first light source **27** are
10 positioned along same axis. The first reflecting device **28** is configured to increase the inspection time of electronic devices while the electronic devices are picked from the wafer table **21**. The first reflecting device **28** reflects the light from the first light source **27** to an axis of the first transfer head **30** that picks the electronic device **40**. The first imaging device **64** may be configured to inspect whether the electronic device and the
15 first transfer head are properly aligned for pickup.

[0055] The camera **26** is configured to image the electronic device from above when the wafer table is picked for inspection. In one embodiment, the first reflecting device **28** is a mirror. However, other reflecting devices can also be used without
20 limitation.

[0056] Similar to the first imaging device **64**, the transfer system **70** can also have a second imaging device **25**. The second imaging device **25** can include a camera, which may be, for example, an upward facing camera configured to inspect the flipped
25 electronic device placed on the handling device **60**. In one embodiment, the second imaging device **25** also includes at least one light source, at least one reflecting device, and at least one camera.

[0057] The first imaging device **64** and the second imaging device **25** can include
30 any number of cameras. In one embodiment, at least one downward facing camera is

used to check the position of the electronic device to facilitate picking the electronic device. If one of the first transfer heads **30, 31, 32, 33, 34** or **35** is set to be a check station, then there can also be a camera for that station.

5 **[0058]** In one embodiment, the first imaging device **64** and the second imaging device **25** act as a check station. Images obtained from the cameras of the check station can be used to detect the position of the chip on the check station for adjustment before placing the electronic device into the handling device. The images can also be used to test a weld ball on a top face of the electronic device (die) or the side face of the
10 electronic device (die), etc., without limitation.

[0059] **FIG. 7** shows a first suction device **29** connected to the first transfer head **30** of the first rotary device **20**. The first suction device **29** is configured to provide sufficient force to the transfer head **30** when picking the electronic device **40** from the wafer table
15 **21**. It should be noted that the system **70** can have a single first suction device **29** connected to all first transfer heads **30, 31, 32, 33, 34** and **35** can provide controlled suction force for picking the electronic devices **40, 41, 42** or **43** from the wafer table **21**. Further, the first suction device **29** also allows the first transfer heads **30, 31, 32, 33, 34** and **35** to hold the electronic devices **40, 41, 42** or **43** during 180 degree rotation, and
20 also provides sufficient force to place the electronic devices **40, 41, 42** or **43** on the second transfer heads **30, 31, 32, 33, 34** or **35** of the second rotary device **50**. In one embodiment, the first suction device **29** comprises a pick pusher force control device.

[0060] In one embodiment, each first transfer head **30, 31, 32, 33, 34** and **35** is
25 connected to a first suction device **29** to provide controlled suction force for picking the electronic device **40, 41, 42** or **43** from the wafer table **21**. The first suction device **29** allows the respective first transfer heads **30, 31, 32, 33, 34**, and **35** to hold the electronic device **40, 41, 42** or **43** during 180 degree rotation and also provides force necessary to place the electronic device **40, 41, 42** or **43** on the second transfer head
30 **36, 37, 38** or **39** of the second rotary device **50** during the flipping process. The suction

force can be created by a vacuum.

[0061] FIG. 4 depicts suction devices **51, 52, 53** and **54** connected to the second transfer head **39, 38, 37** and **36** of the second rotary device **50**, respectively. The suction devices **51, 52, 53** and **54** are configured to provide force to the second transfer head **39, 38, 37** and **36** when picking the electronic device **40** from the first rotary device **20**. It should be noted that the system **70** can have a single suction device connected to all second transfer heads **36, 37, 38**, and **39** to provide controlled suction to pick the electronic device **40, 41, 42** or **43** from the first rotary device **20**. Further, the single suction device allows the second transfer heads to hold the electronic device **40, 41, 42** or **43** during 180 degree rotation and is configured to provide sufficient force to place the electronic device **40, 41, 42** or **43** on the handling device **60**. In one embodiment, each second transfer head **36, 37, 38, 39** is connected to one suction device **51, 52, 53** or **54** to provide controlled suction force to pick the electronic device from the first rotary device **20**. Individual suction devices allow the respective second transfer heads **36, 37, 38**, and **39** to hold the electronic device **40, 41, 42** or **43**, and also to provide sufficient force to place the electronic device **40, 41, 42** or **43** on the handling device **60** during the flipping process. A vacuum can be used to create the suction force. In one embodiment, the suction devices **51, 52, 53** and **54** are connected to one or more vacuum pipettes **55** and **56** to provide sufficient vacuum force to hold, pick, and/or place the electronic device during the flipping process.

[0062] The transfer system **70** can be controlled by a controller (not shown) via manual operation or software to perform flipping and checking of the electronic devices **40, 41, 42** and **43**. The inclined first rotary device **20** and inclined wafer table **21** increase the operation space of the transfer system **70**. The inclined first rotary device **20** can be configured to provide space for multiple checking stations **22, 23** and **24** during flipping, or index rotation, of the electronic device **40, 41, 42** or **43**, and allow the operator to clearly and easily observe the operating condition of the transfer system **70**. As the transfer system **70** uses two rotary devices **20** and **50** with multiple transfer heads, the flipping process can be performed at higher speeds, which in turn increases

the UPH. The inclined wafer table **21** provides space for the first imaging device **64**, such that the first light source **27** and the first reflecting device **28** increase the inspection time of the electronic devices **40**, **41**, **42** or **43** when picking from the wafer table **21**.

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[0063] It should be noted that in one embodiment, the wafer table **21** is oriented at an angle (α°) from horizontal, as depicted in **FIG. 7**. The surface of the wafer table **21** is at a substantially right angle with respect to the axis of the first transfer head **30** configured to pick the electronic device **40**. The second transfer heads **36**, **37**, **38** and **39** of the second rotary device **50** are vertically oriented. In another embodiment, the transfer system **70** has a home sensor to eliminate the error in every rotation. This prevents cumulative errors which can occur with other systems, particularly those that use more heads **70**.

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[0057] It will be appreciated that variations of the embodiments disclosed above and other features and functions, or alternatives thereof, may be combined into many other different systems or applications. It will also be appreciated by those skilled in the art that various other modifications, variations or improvements may be made.

[0058] Although the embodiments set forth in the current disclosure have been described in considerable detail to cover certain aspects, those skilled in the art will recognize that other versions of the embodiments set forth herein are also possible.

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CLAIMS

What is claimed is:

1. A transfer system for flipping and checking electronic devices, said transfer system comprising:

5 a wafer table inclined about a first angle with respect to a horizontal axis;
a first rotary device positioned at a second angle with respect to a horizontal axis, said first rotary device comprising a plurality of first transfer heads circumferentially arranged around said first rotary device, said first transfer heads configured to pick and hold said electronic devices from said wafer table and transfer
10 said electronic devices to a second rotary device;

the second rotary device being rotatable about a horizontal axis, said second rotary device comprising a plurality of second transfer heads vertically arranged on a circumference of said second rotary device, said second rotary device configured to pick said electronic devices from said first rotary device and transfer said electronic
15 devices to a handling device;

a first imaging device to inspect said electronic devices to be picked from the wafer table;

a second imaging device to inspect said electronic devices to be placed on the handling device;

20 a plurality of check stations positioned around said first and second rotary devices, said plurality of check stations configured to check at least one parameter of said electronic devices held by at least one of said first and second transfer heads;
and

wherein said wafer table is at a substantially right angle with respect to the
25 axis of said first transfer heads.

2. The transfer system of claim 1, wherein said first angle is 30 degrees.

3. The transfer system of claim 1, wherein said first rotary device flips said
30 electronic devices 180 degrees.

4. The transfer system of claim 1, wherein said electronic devices include

integrated circuits and semiconductor chips.

5. The transfer system of claim 1, wherein said first angle is between 1 and 89 degrees.

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6. The transfer system of claim 1, wherein said second angle is between 1 and 89 degrees.

7. The transfer system of claim 1, wherein said first imaging device comprises a camera, a first light source, and a first reflecting device.

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8. The transfer system of claim 7, wherein said camera is a downward facing camera positioned above said wafer table.

9. The transfer system of claim 7, wherein said first imaging device is positioned along a horizontal axis.

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10. The transfer system of claim 7, wherein said first reflecting device is configured to increase an inspection time of said electronic devices when picking said electronic devices from said wafer table.

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11. The transfer system of claim 8, wherein said first reflecting device is configured to reflect light from the light source to an axis of one of said transfer heads.

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12. The transfer system of claim 1, further comprising at least one first suction device connected to said first transfer heads, said suction device configured to provide suction force to each one of said first transfer heads when picking said electronic devices from said wafer table.

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13. The transfer system of claim 1, further comprising at least one second suction device connected to said second transfer heads, said second suction device

configured to provide suction force to each one of said plurality of second transfer heads when picking said electronic devices from said second transfer heads.

14. The transfer system of claim 12, wherein the first suction device is configured to provide sufficient suction force to hold said electronic devices during a flipping process.

15. The transfer system of claim 13, wherein the second suction device is configured to provide sufficient suction force to hold said electronic devices during a flipping process.

16. An apparatus for transferring electronic devices, comprising:

- a. a wafer table for placing and storing electronic devices, said wafer table positioned at a 30 degree angle below horizontal;
- b. a first rotary head positioned at a 90 degree angle from the wafer table for picking electronic devices from the wafer table, said first rotary head composed of a plurality of first transfer heads positioned around the circumference of the first rotary head;
- c. a second rotary head positioned horizontally, for receiving electronic devices from the first rotary head, said second rotary head composed of a plurality of second transfer heads positioned around the circumference of the second rotary head;
- d. a handling device for receiving electronic devices from said second rotary head;
- e. one or more imaging devices configured to inspect the electronic devices; and
- f. one or more check stations configured to check at least one parameter of the electronic devices,

wherein said electronic devices are flipped 180 degrees when transferred from said wafer table to said second rotary head.

17. The apparatus of claim 16, wherein said electronic devices include integrated circuits and semiconductor chips.

18. The apparatus of claim 16, wherein said one or more imaging devices is comprised of a camera, a first light source, and a first reflecting device.

19. The apparatus of claim 18, wherein said camera is a downward facing camera
5 positioned above said wafer table.

20. The apparatus of claim 18, wherein said first imaging device is positioned on a horizontal plane.

10 21. The apparatus of claim 16, further comprising at least one first suction device provides suction force to each of said first transfer.

22. The apparatus of claim 16, further comprising at least one second suction device to provide suction force to each of said plurality of second transfer heads.