# A Packaging Apparatus And Method For Transferring Integrated Circuits To A Packaging

## FIELD OF THE INVENTION

The present invention relates to a packaging apparatus and method for transferring integrated circuits to packaging, in particular, packaging equipment for semiconductor chips.

## B ACKGROUND

At present, packaging equipment for semiconductor chips or integrated circuits can perform placement of a limited number of integrated circuits simultaneously or one circuit at a time into a packaging.

High precision is required to transfer, align and place each circuit into an allocated seat in the packaging and to ensure that the job could be done in the shortest time and with the highest yield. The circuits are usually transferred from a tray containing them to the packaging. To ensure accuracy of transfer and placement, typically, two solutions are applied individually or in combination.

One of the solutions is to use vision guided feedback mechanisms for precise pick-up and alignment of the circuits during the transfer process. Vision guided compensation is carried out to achieve the acceptable alignment.

The other solution is to use components (e.g. a transfer unit having a pick-up arm) for transferring the circuits that are fabricated with high precision. It is possible to skip vision guided compensation (i.e. uncompensated placement) if the components are machined with high precision.

However, a problem of existing packaging equipments is that the maximum number of transfer units that could be used to transfer circuits simultaneously is limited. The two solutions mentioned are not practical for achieving the required high precision in machine component fabrication as well as in pitch adjustment axis and rotation about a central axis of each circuit for the placement of a large number of circuits (e.g. more than 6 circuits) simultaneously.

Currently, known use of vision guided compensation for transferring multiple circuits and/or high precision transfer units for uncompensated placement (no vision guidance compensation) of multiple circuits, can only achieve an uncompensated placement of a maximum number of 3 circuits into a packaging simultaneously, and the placement of a maximum number of 6 circuits into a packaging simultaneously with vision guided compensation.

**SUMMARY**

In accordance with an aspect of the present invention, there is provided a packaging apparatus for transferring integrated circuits to a packaging, the apparatus comprising: a carrier for carrying a plurality of integrated circuits and moving the plurality of integrated circuits between a location of a first packaging and a first location, the first packaging being configured for holding a plurality of integrated circuits; a first plurality of transfer units, the first plurality of transfer units being configured for transferring one or more integrated circuits from the first packaging to the carrier; and a second plurality of transfer units, the second plurality of transfer units being configured for transferring one or more integrated circuits from the carrier in the first location to one or more respective holders in a second packaging, said carrier comprising a plurality of seats for receiving integrated circuits, said carrier being configured for adjusting each received integrated circuit to assume a predetermined orientation if misalignment from the predetermined orientation occurs.

The apparatus may comprises a second carrier for carrying a plurality of integrated circuits and moving the plurality of integrated circuits between the first packaging and a second location, the first plurality of transfer units being configured to transfer one or more integrated circuits from the first packaging to the second carrier when the carrier is at the first location, the second plurality of transfer units being configured for transferring one or more integrated circuits from the second carrier in the second location to one or more respective holders of the packaging, wherein said second carrier comprising a plurality of seats for receiving integrated circuits, said second carrier being formed for adjusting each received integrated circuit to assume a predetermined orientation if misalignment from the predetermined orientation occurs.

The second location may be adjacent to the first location.

The second plurality of transfer units may be transferring one or more integrated circuits from the second carrier in the second location to one or more respective holders of the second packaging when the first plurality of transfer units is transferring one or more integrated circuits from the first packaging to the carrier.

The first plurality of transfer units may be configured for making adjustments to pitch distance between the transfer units of the first plurality of transfer units.

A transfer unit of the first plurality of transfer units may be configured for making adjustments to orientate an integrated circuit being transferred by rotation about a longitudinal axis of said transfer unit of the first plurality of transfer units.

The second plurality of transfer units may be configured for making adjustments to pitch distance between the transfer units of the second plurality of transfer units.

A transfer unit of the second plurality of transfer units may be configured for making adjustments to orientate an integrated circuit being transferred by rotation about a longitudinal axis of said transfer unit of the second plurality of transfer units.

The second plurality of transfer units may be mounted on a replaceable head that is detachable from the apparatus.

The transfer units of the second plurality of transfer units may be spaced apart by a fixed pitch distance.

The apparatus may comprise an actuator coupled to a connector configure for coupling to the replaceable head, and the actuator may be configured to lock the replaceable head in position on the apparatus and to release the replaceable head for removal from the apparatus.

Each of the plurality of seats may comprise side walls sloped in a manner to cooperate with gravity to enable an integrated circuit to orientate and assume the predetermined orientation in the seat when edges of the integrated circuit contact the slopes.

Each of the plurality of seats may comprise side walls that are moveable to orientate an integrated circuit to assume the predetermined orientation in the seat.

The plurality of seats may comprise a seat for placing a defective integrated circuit.

Each of the plurality of seats may comprise a stepped portion surrounding the perimeter of the predetermined orientation and the stepped portion is located at a foot of the sloping side walls.

The apparatus may further comprise one or more inspection stations for inspecting the integrated circuits, a holding station for holding the first packaging for transferring to the second packaging and a reject station for handling rejected integrated circuits, and the one or more inspection stations, the holding station and the reject station may be arranged sequentially in a straight line.

The apparatus may further comprise one or more inspection stations for inspecting the integrated circuits; a holding station for holding the first packaging for transferring to the second packaging; a reject station for handling rejected integrated circuits; and one or more transfer mechanism for transferring the integrated circuits between said stations, wherein each of said stations may be arranged in a lane with the one or more transfer mechanism residing between the lanes.

The apparatus may further comprise a conveyor for moving the first packaging containing one or more integrated circuits along the straight line.

Axis of movement of the carrier and axis of movement of the second plurality of transfer units for transferring one or more integrated circuits from the carrier in the first location to one or more respective holders in the second packaging may be orthogonal to each other.

In accordance with another aspect of the present invention, there is provided a packaging method for transferring integrated circuits to a packaging, the method comprising: carrying a plurality of integrated circuits and moving the plurality of integrated circuits between a location of a first packaging and a first location using a carrier, the first packaging being configured for holding the plurality of integrated circuits; transferring one or more integrated circuits from the first packaging to the carrier using a first plurality of transfer units; transferring one or more integrated circuits from the carrier in the first location to one or more respective holders in a second packaging using a second plurality of transfer units, and adjusting a integrated circuit received by the carrier to assume a predetermined orientation if misalignment from the predetermined orientation occurs using a carrier, said carrier comprising a plurality of seats for receiving integrated circuits.

The method may comprise carrying a plurality of integrated circuits and moving the plurality of integrated circuits between the first packaging and a second location using a second carrier, transferring one or more integrated circuits from the first packaging to the second carrier when the carrier is at the first location using the first plurality of transfer units, transferring one or more integrated circuits from the second carrier in the second location to one or more respective holders of the packaging using the second plurality of transfer units, and adjusting each integrated circuit received by said second carrier to assume a predetermined orientation if misalignment from the predetermined orientation occurs using said second carrier, wherein said second carrier comprising a plurality of seats for receiving integrated circuits.

The method may comprise transferring one or more integrated circuits from the second carrier in the second location to one or more respective holders of the second packaging when the first plurality of transfer units is transferring one or more integrated circuits from the first packaging to the carrier using the second plurality of transfer units.

The method may comprise making adjustments to pitch distance between the transfer units of the first plurality of transfer units using the first plurality of transfer units.

The method may comprise making adjustments to orientate an integrated circuit being transferred by rotation about a longitudinal axis of a transfer unit of the first plurality of transfer units.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Various embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings in which:
Figure 1 shows a layout of an apparatus for transferring integrated circuits to a packaging.

Figure 2 is a perspective view of a first pick and place assembly in the apparatus.

Figure 3 shows a tray containing circuits to be transferred by the apparatus.

Figure 4 shows a perspective view of a carrier in the apparatus.

Figure 5 shows a top view, a perspective view and a cross-sectional view of of a seat in the carrier.

Figure 6 is a perspective view of a second pick and place assembly in the apparatus.

Figure 7 shows a layout of the apparatus together with inspection stations and a reject station.

Figure 8 shows a layout of the apparatus when the first pick and place assembly is depositing integrated circuits into a carrier.

Figure 9 shows a layout of the apparatus when the carrier is moving towards a second transfer station.

Figure 10 shows a layout of the apparatus when a second pick and place assembly is picking up the integrated circuits on the carrier.

Figure 11 shows a layout of the apparatus when the second pick and place assembly is depositing the integrated circuits on a strip of packaging.

Figure 12 shows a block diagram of a control unit of the apparatus.

Figure 13 shows diagrams illustrating a strip of packaging.

Figure 14 shows a block diagram illustrating the first pick and place assembly.

Figure 15 shows a block diagram illustrating the second pick and place assembly.

Figure 16 shows an enlarged view of a portion of the first pick and place assembly.

Figure 17 shows an exploded view of the second pick and place assembly.

Figure 18 shows a side view of Figure 15.

Figure 19 shows a replaceable head component of the second pick and place assembly.

Figure 20 shows a top view of a replaceable head component of the second pick and place assembly.

Figure 21 shows a perspective view of a second example of a carrier of the apparatus.

Figure 22 shows a top view of the second example of the carrier of the apparatus.

Figure 23 illustrates a second example of a tray containing circuits to be transferred by the apparatus.

Figure 24 shows a top view and a cross-sectional view of a seat in the second example of the carrier.

**DETAILED DESCRIPTION**

Figure 1 shows a layout of a packaging apparatus 100 for transferring a plurality of integrated circuits (also known as chips, semiconductor chips, semiconductor units, integrated chips and the like) from a location of a first packaging (e.g. 301 in Figure 3 or 2300 in Figure 23) located at a holding station 3 to a second packaging 6 and/or 12. In this case, the first packaging is in the form of a tray (e.g. 301 in Figure 3). The second packaging 6 and 12 come in a spool and are standard tape and reel packaging. Each of the first and second packaging includes a plurality of holders for holding integrated circuits. It is appreciated that other similar types of packaging may be used, for instance, the first packaging may be a standard tape and reel packaging and the second packaging may be a tray. It could also be that the first packaging and the second packaging are of the same type.

The example in Figure 1 is capable of accurately placing multiple integrated circuits simultaneously in the packaging 6 and 12. One limitation in existing apparatus for transferring integrated circuits from a first packaging to a second packaging is the necessity for a high precision pitch and rotation adjustment device to align each integrated circuit in an orientation fit for placement in a holder of the second packaging during the transfer process. Such high precision pitch and rotation adjustment device may include a vision guided feedback mechanism for precise pick-up and alignment of the circuits. As the high precision pitch and rotation adjustment device proactively adjusts the orientation of each circuit, much time is required to adjust each circuit. This adjustment time taken is one of the limiting factors for faster transfer. Furthermore, a high precision pitch and rotation adjustment device

is complex in design and costly. Also, it is appreciated that the high precision pitch and rotation adjustment device may not even fully compensate for misalignment problems arising from the dimensional tolerances of the first type of packaging and the second type of packaging.

However, the example in Figure 1 allows an arbitrary number of integrated circuits to be placed in the second packaging 6 or 12 simultaneously at high speed. One factor for achieving that is by having a modular design. There could be various kits for supporting a higher number of simultaneous circuit transfers. Each kit comprises a first carrier 8 and a second carrier 9, a first plurality of transfer units 2 for transferring the integrated circuits from the first packaging at the holding station 3 to the first carrier 8 or second carrier 9 and a second plurality of transfer units 10 for transferring the integrated circuits from the first carrier 8 or second carrier 9 to the holders of the second packaging 6 or 12. It is appreciated that the apparatus 100 can operate with just one carrier instead of two carriers. Each carrier 8 or 9 is capable of enabling orientation of each integrated circuit for sitting in one of the holders of the second packaging 6 or 12 when the integrated circuit is transferred from the first packaging at the holding station 3 to the carrier 8 or 9 by the first plurality of transfer units 2.

In Figure 1, the packaging 6 and 12 are reeled and guided by carrier guides 5 and 13 respectively. The packaging 6 and 12 are reeled out by the carrier guides 5 and 13 to expose empty holders or pockets in the packaging 6 and 12 for holding the integrated circuits at a rate synchronised with the movement of the second plurality of transfer units 10 so that the integrated circuits can be transferred from the first carrier 8 or second carrier 9 to the empty holders in the second packaging 6 or 12.

With reference to Figures 2 and 14, the first plurality of transfer units 2 in Figure 1 could be part of a pick and place assembly or device with eight pickers or probes (also known as the transfer units) positioned with a pitch distance *a* 204 from one another, or more specifically, longitudinal axes 205 of the pickers or probes are evenly spaced by a distance *a* 204 from one another. It is appreciated that the first plurality of transfer units 2 is scalable to support more or less pickers or probes. The first plurality of transfer units 2 is constructed in modular form such that individual pickers or probes can be mounted on if there is a demand for higher number of pickers or probes.

Each transfer unit of the first plurality of transfer units 2 is used for picking an integrated circuit to be transferred. The first plurality of transfer units 2 is capable of auto pitching and there is included a pitching motor 202 for adjusting the distance of the pitch distance *a* 204

between each of the transfer units 2. In this example, all transfer units in the first plurality of transfer units 2 have similar construction. One of the transfer units 2 is selected as a datum or a reference point for adjusting the pitch distance *a* 204. Usually, when facing the transfer units 2, the rightmost or leftmost located transfer unit is selected as the datum. In this case, the rightmost transfer unit 211 is the datum. There is another motor 210 (not shown in Figure 2 but shown in Figure 14) for moving the first plurality of transfer units 2 to a position for picking up one or more integrated circuits from the holding station 3 in Figure 1 and moving the first plurality of transfer units 2 to a location for placing the integrated circuit(s) in the carrier 8 or 9. Representing each transfer unit of the first plurality of transfer units 2, a transfer unit 201 in Figures 2 and 14 has a suction cup 203 for adhering, through suction (operating on vacuum principles), to a surface of the integrated circuit to pick up the integrated circuit. The surface of the integrated circuit is exposed when it is in the first packaging at the holding station 3 in Figure 1. The suction cup 203 is generally known as a vacuum tip and is made of plastic or other suitable material. Placement of an integrated circuit is achieved by performing an air purge through the suction cup 203 to release the suction. After air is purged, the integrated circuit would drop from the suction cup 203 onto a desired surface on which the integrated circuit is to be placed.

Furthermore, each suction cup 203 can be rotated about its longitudinal axis 205 to adjust the orientation of the integrated circuit it carries. The rotation is enabled by a pneumatic cylinder 206 in connection with a rack 208 and a pinion 209. It is appreciated that the rotation can also be achieved by using a motor that is connected up with suitable mechanical parts. Again, using transfer unit 201 to represent each transfer unit of the first plurality of transfer units 2, there is an actuator 207 (Each transfer unit has one of such actuator 207) mounted above the suction cap 203 for moving the transfer unit 201 in directions along the longitudinal axis 205. The transfer unit 201 can be disabled by the actuator 207 by moving the transfer unit 201 from an extended (operational) configuration to a stowed configuration.

Figure 16 is an enlarged view of the transfer unit 201 showing more clearly the structure of the pneumatic cylinder 206, the rack 208 and the pinion 209. The pneumatic cylinder 206 is coupled to the rack 208 and arranged to move the rack 208 depending on how the pneumatic cylinder 206 is activated. The rack 208 is coupled to the pinion 209 and is arranged to rotate the pinion 209 when the pneumatic cylinder 206 is pulling the rack 208 or when the pneumatic cylinder 206 is pushing the rack 208 accordingly. The pinion 209 is coupled to the suction cup 203 and is arranged to rotate the suction cup 203 when the rack 208 is pulled or pushed by the pneumatic cylinder 206. The rack 208 and pinion 209 comprise teeth for meshing each other and for converting the linear motion of the pneumatic

cylinder 206 into rotary motion to rotate the suction cup 203, which in turn rotates an integrated circuit picked up by the suction cup 203.

Although the first plurality of transfer units 2 is capable of auto pitching and changing integrated circuit orientation, it is still desirable to perform fine pitch adjustment of the integrated circuit with the help of adjustment capabilities of the carrier 8 and 9.

It is appreciated that the construction of the first plurality of transfer units 2 is not limited to the example disclosed herein. Other similar constructions are possible.

With reference to Figure 3, the first packaging at the holding station 3 in Figure 1 is a tray 301 having a plurality of holders 303. The plurality of holders 303 are in an array arrangement having a predetermined number of rows and columns (i.e. 3 holders in a row and 7 columns of holders, in total 21 holders). Each holder can contain an integrated circuit 302, which is generally square or rectangular in shape with a width *a* and a length *b*. In Figure 3, the integrated circuit 302 when placed in the first packaging at the holding station 3 would be oriented with its top surface exposed. It is appreciated that the integrated circuit 302 can also be oriented with its bottom surface exposed.

With reference to Figure 23, there is shown another example of the first packaging at the holding station 3 in Figure 1. The first packaging in this case is a tray 2301 having a plurality of holders 2303 (only one is pointed out in Figure 23), more specifically, 14 holders in a row and 27 columns of holders (i.e. in total 378 holders). Hence, the tray 2301 holds 14 units of integrated circuits in a row. Figure 23 further shows a partial cross-sectional view 2307 of the tray 2301 taken along an axis AA' 2308 parallel to each row of the tray 2301. It is shown in Figure 23 that each holder 2303 contains the integrated circuit 302 in Figure 3. In this case, the integrated circuit 302 has a width *c* 2305 of 4.0 +/- 0.1 mm. Each holder has a width *f* 2304 of 4.2 +- 0.08 mm. The pitch distance *g* 2302 between centres of two holders in the tray 2301 is 9.2 +- 0.1 mm.

The packaging 6 and 12 are further illustrated in Figure 13. Figure 13 shows a top view 1304 of a partial strip 1307 of the second packaging 6 or 12, a cross-sectional view 1305 of the partial strip 1307 of the second packaging 6 or 12 along a central longitudinal axis BB' 1308 of the partial strip 1307 of the second packaging 6 or 12 and a cross-sectional view 1306 of the partial strip 1307 of the second packaging 6 or 12 along an axis AA' 1309 perpendicular to the central longitudinal axis BB' 1308 of the partial strip 1307 of the second packaging 6 or 12. The axis AA' 1309 cuts through a holder 1305 of the packaging 6 or 12. The partial

strip 1307 has a row of holders 1302 that are evenly spaced with respect to one another. Each of the holders 1302 is for containing an integrated circuit like 302 in Figure 3. The row of holders 1302 has two sleeve portions 1301 and 1303 extending away from the holders 1302 along the length of the partial strip 1307. The sleeve portions 1301 and 1303 each includes a plurality of holes that are evenly spaced along the length of the partial strip 1307. The plurality of holes is used for moving or indexing the second packaging 6 or 12. In Figure 13, the holder 1305 has a width *e* 1311 (marked out on another holder in Figure 13) of 4.35 +- 0.01 mm. The pitch distance *d* 1310 between centres of two holders in the second packaging 6 or 12 is 8.0 +- 0.1 mm.

The first carrier 8 in Figure 1 is shown in Figure 4. The second carrier 9 in Figure 1 would look similar to the first carrier 8 and the description as follows would also apply for the construction of the second carrier 9. In Figure 4, the first carrier 8 comprises a plurality of 13 seats 401 lined up in a straight line. Each seat, e.g. 402, is a recess in the first carrier 8 for receiving an integrated circuit transferred from the first packaging at the holding station 3 in Figure 1 to the carrier 8 by the first plurality of transfer units 2 in Figure 1. In more detail, each seat, e.g. 402, is an indentation that is generally square or rectangular in shape with four side walls 403. The side walls 403 are sloped in a manner to cooperate with gravity to enable an integrated circuit (e.g. 302 in Figure 3) to orientate and assume a predetermined or desired sitting orientation in the seat 402 when edges of the integrated circuit (e.g. 302 in Figure 3) contact the slopes. If it so happens that the integrated circuit (e.g. 302 in Figure 3) is placed in the right orientation by the first plurality of transfer units 2, there would not be any orientation compensation provided by the slopes when the edges of the integrated circuit (e.g. 302 in Figure 3) contacts the slopes. The desired orientation ensures optimum alignment conditions for the second plurality of transfer units 10 to transfer the integrated circuits from the first carrier 8 or second carrier 9 to the holders of the second packaging 6 or 12.

Figure 5 shows details of an example of the seat 402 in Figure 4. The seat 402 is representative of all the seats in the carrier 8 in Figure 4. Figure 5 has three separate drawings 501, 502 and 503 illustrating the seat 402 in detail. The first drawing 501 shows a perspective view of the seat 402. The seat 402 is generally rectangular in shape and comprises a flat bottom surface 504, the four sloping side walls 403 in Figure 4, the four corners 404 in Figure 4, a centrally located circular shaped aperture 405 and four steps 406 located at the foot (located within the seat 402) of each of the four sloping side walls 403.

Drawing 502 is a top view looking into the recessed portion of the seat 402. Depending on the size of the integrated circuit (e.g. 302 in Figure 3) to be transferred by the apparatus 100 in Figure 1, suitable dimensions for the seat 402 may include a length of 8.1mm (with length tolerance in the range of about +0.01 to +0.03mm; excluding the width of the four sloping side walls 403) and a breath of 7.5mm. It is noted that the length of 8.1mm should not have negative tolerance. Each of the four corners 404 may be formed with a curved edge 505 instead of a sharp corner. Each of the four corners 404 may be shaped in the form of a cylindrical flat bottom hole 506 with a diameter of about 2mm and a depth of 1.6mm (shown more clearly in Drawing 503). The purpose of the cylindrical flat bottom hole 506 is for ease of machining the seat 402 during the making of the first or second carriers 8 and 9. Throughout the depth of the cylindrical flat bottom hole 506, the curved edge 505 of each corner 404 is part of the surface area of the cylindrical flat bottom hole 506. The four sloping side walls 403 are not within the volume of the cylindrical flat bottom hole 506. The aperture 405 may be a circular through hole having a diameter of 1.5mm with diameter size tolerance of -0.006mm. The aperture 405 is for releasing air pressure when an integrated circuit is dropped or placed into the seat 402.

Drawing 503 shows a cross-sectional view of the seat 402 taken along an axis A-A in Drawing 502, which cuts through the centre of the aperture 405. An angle 508 is shown in Drawing 503. The angle 508 is indicative of an extent of sloping of each of the four sloping side walls 403. The angle 508 is formed with respect to an axis 507, which is perpendicular to the flat bottom surface 504 of the seat 402. The angle 508 in the example of Drawing 503 is 25 degrees. It is appreciated that other suitable angles may be used provided that the effect of adjustment or alignment is present when an integrated circuit is placed into the seat 402. The slopes of the four side walls 403 have to be sufficiently steep to allow the edges of a slightly misplaced integrated circuit placed into the seat 402 to slide over the slopes under gravity and adjust its orientation by following the contours of the slope of the four side walls 403.

Each of the four steps 406 located at the foot of each of the respective four sloping side walls 403 in the example of Drawing 503 is about 0.20mm. The steps 406 (i.e. stepped portion) surround the perimeter of the desired seating arrangement (i.e. predetermined orientation) of the integrated circuit in the seat 402. The four sides of the generally square or rectangular shaped integrated circuit (e.g. 302 in Figure 3) would be confined by walls 403 of the steps 406 when the integrated circuit (e.g. 302 in Figure 3) is held in the desired orientation in the seat 402. The steps 406 also prevent any unacceptable movement of the integrated circuit in the seat 402. In precise placement of an integrated circuit into the seat

402, the integrated circuit would be fully placed within the area confined by the walls 403 of the steps 406.

It is appreciated that the four sloping side walls 403 of the seat 402 could be made moveable for adjusting an integrated circuit that is placed into the seat 402 such that the integrated circuit is orientated to assume a predetermined orientation in the seat 402. Suitable machinery and configurations would be required to move the walls 403. For instance, the four sloping side walls 403 may be mounted to one or more pneumatic cylinders driven to push or withdraw the walls towards or away respectively from an integrated circuit placed in an area on the first carrier 8 or second carrier 9 in Figure 1. The integrated circuit would be guided into the right alignment by the pushing provided by the walls.

With reference to Figures 6 and 15, the second plurality of transfer units 10 in Figure 1 is part of a second pick and place assembly or device with eight pickers or probes positioned with a pitch distance *a* 604 from one another, or more specifically, longitudinal axes 605 of the pickers or probes are evenly spaced by a distance *a* 604 from one another. It is appreciated that the second plurality of transfer units 10 is scalable to support more or less pickers or probes. The second plurality of transfer units 10 is fixed on a replaceable head 606. The replaceable head 606 has a fixed number of pickers or probes (i.e. the transfer units) that are spaced apart by a fixed pitch distance. The replaceable head 606 can be exchanged with another replaceable head having a different number of pickers or probes if there is a demand for higher or lower number of pickers or probes. The replaceable head 606 can also be exchanged with another replaceable head having a different pitch distance *a* 604 value between the pickers or probes. Furthermore, the replaceable head 606 may be snapped on to machinery 607 that drives the second plurality of transfer units 10.

Figures 17 to 20 illustrate how the replaceable head 606 could be detachably mounted to the machinery 607 that drives the second plurality of transfer units 10.

With reference to Figures 6 and 17 to 20, the machinery 607 includes two pneumatic cylinders 602 and 608 (i.e. actuators), which are used to aid in the locking of the replaceable head 606 to the machinery 607 that drives the second plurality of transfer units 10. Generally, the pneumatic cylinders 602 and 608 are configured to lock the replaceable head 606 in position on the apparatus 100 in Figure 1 and to release the replaceable head 606 for removal from the apparatus 100 in Figure 1. It is appreciated that one and not two pneumatic cylinders or more than two pneumatic cylinders may be used in another example.

There are two connectors 1702 and 1704 that are moveable under the control of the two pneumatic cylinders 602 and 608 respectively. Each of the connectors 1702 and 1704 is an elongate structure (i.e. in this case, a generally cylindrical shaft) with one end coupled to the pneumatic cylinders 602 and 608 respectively. The other end of the connectors 1702 and 1704 are configured to be received by two slots 1701 and 1703 located on the replaceable head 606 respectively. The connectors 1702 and 1704 each has a section with a narrower diameter 1802 and 1804 configured for fitting into the slots 1701 and 1703 respectively. Each of the slots 1701 and 1703 has an open end that is sufficiently large to receive the sections 1802 and 1804 respectively. The open ends of the slots 1701 and 1703 however would not be able to receive any other portions of the connectors 1702 and 1704 other than the at the sections 1802 and 1804 respectively.

The pneumatic cylinders 602 and 608 and the respective connectors 1702 and 1704 are located at opposite sides of the machinery 607. Accordingly, the two receiving slots 1701 and 1703 are located at opposite sides of the replaceable head 606 beneath the pneumatic cylinders 602 and 608.

The replaceable head 606 is locked to the pneumatic cylinders 602 and 608 by first slotting the sections 1802 and 1804 into the slots 1701 and 1703 and activating the pneumatic cylinders 602 and 608 to withdraw the connectors 1702 and 1704 thereafter. To release the replaceable head 606, the pneumatic cylinders 602 and 608 are activated to extend the connectors 1702 and 1704. With the construction as described with reference to Figures 6 and Figures 17 to 20, an advantage is that the replaceable head 606 can be quicklydetached, removed and replaced by a new head with for instance, different pitch distance and number of transfer units 2.

In Figures 6 and 15, each transfer unit of the second plurality of transfer units 10 is used for picking an integrated circuit to be transferred. In this example, all transfer units in the second plurality of transfer units 10 have similar construction. There is another motor (not shown in Figures 6 and 15) for moving the second plurality of transfer units 10 to a position for picking up one or more integrated circuits from the first carrier 8 or the second carrier 9 in Figure 1 and for moving the picked up integrated circuit(s) to the second packaging 6 or 12. Representing each transfer unit of the second plurality of transfer units 10, a transfer unit 601 of the second plurality of transfer units 10 has a suction cup 603 for adhering, through suction, to a surface of the integrated circuit to pick up the integrated circuit. The surface of the integrated circuit is exposed when it is sitting in the carrier 8 or 9. The construction and operation of the suction cup 603 is similar to the suction cup 203 in Figure 2.

It is appreciated that the construction of the second plurality of transfer units 10 is not limited to the example disclosed herein. It is further appreciated that the second plurality of transfer units 10 may have instead the same construction as the first plurality of transfer units 2 in Figure 1. That is, the second plurality of transfer units 10 could be configured for making adjustments to pitch distance between the transfer units of the second plurality of transfer units 10 and one or more of the transfer units of the second plurality of transfer units could be configured for making adjustments to orientate an integrated circuit being transferred by rotation about a longitudinal axis of the one or more of the transfer units of the second plurality of transfer units. Other similar constructions are also possible.

Misalignment or misplacement of an integrated circuit or in other words variations of the integrated circuit from a desired pitch distance and orientation for purposes of packaging may result from one or more of the following problems. The list is not exhaustive.

1) Variation in dimensional tolerance of the pitch distance *a* 204 of the first or second plurality of transfer units 2, 10 in Figure 14.
2) Variation in machine part dimensional tolerances of the first or second plurality of transfer units 2, 10 in Figure 3 that may result in imperfect orientation adjustments of integrated circuits or misalignment in picking actions.
3) Variation in dimensional tolerance of the seat 402 in Figure 4 and the first carrier 8 or the second carrier 9 in Figure 1.
4) Variation in dimensional tolerance of the first packaging (e.g. 301 in Figure 3) and the second packaging 6 or 12 and its holders.

The arrangement and configuration of the apparatus 100 in Figure 1 together with the use of the first carrier 8 and the second carrier 9 attempt to address some or all of the above problems.

Figure 7 shows the layout 700 of the apparatus 100 in Figure 1 when it is combined with two inspection stations 703, 705 and a reject station 702 for handling rejected integrated circuits.

The holding station 3 in Figure 3 of the apparatus 100 in Figure 1 is located between the reject station 702 and an inspection area 704 comprising the two inspection stations, namely a top inspection station 703 for inspecting top view defects and/or 2 Dimensional or 3 Dimensional metrology (based on the inspection settings made) of one or more integrated circuits and a bottom inspection station 705 for inspecting bottom view defects and/or 2

Dimensional or 3 Dimensional metrology (based on the inspection settings made) of one or more integrated circuits. A conveyor 707 is operated to move a tray 708 (i.e. similar to the first packaging in the holding station 3 in Figure 1 and 301 in Figure 3) containing integrated circuits in the direction from the bottom inspection station 705 to the reject station 702. The tray 708 (i.e. a first packaging) is moveable by the conveyor 707 pass the vicinity of the bottom inspection station 705, followed by the top inspection station 703, the holding station 3 and finally the vicinity of the reject station 702 in that order.

In the example, the bottom inspection station 705, the top inspection station 703, the holding station 3 and the reject station 702 are arranged sequentially in a straight line. The conveyor 707 includes a straight track with a pair of rails 716 and a pair of dual pickers 715 for holding on to two opposite sides of the tray 708 respectively. The dual pickers 715 are driven by a motor (not shown in Figure 7) to move the tray 708 along a longitudinal axis 714 parallel to the straight line formed by the arrangement of the bottom inspection station 705, the top inspection station 703, the holding station 3 and the reject station 702. It is appreciated that the construction of the conveyor 707 is not limited to the example disclosed herein. Other similar constructions are possible.

It is appreciated that in another example, the bottom inspection station 705, the top inspection station 703, the holding station 3 and the reject station 702 may each be arranged in a dedicated lane (not shown in the Figures). Each dedicated lane may be a straight track with a pair of rails (similar to 716 in Figure 7) and a pair of dual pickers (similar to 715 in Figure 7) for holding on to two opposite sides of a tray (similar to 708 in figure 7) respectively. One or more pick and place assembly (also known as a transfer mechanism) similar to the first plurality of transfer units (2 in Figure 1) may be provided to reside between the dedicated lanes of the bottom inspection station 705, the top inspection station 703, the holding station 3 and the reject station 702. The one or more pick and place assembly is responsible for transferring the integrated circuits between the stations. It could be that the one or more pick and place assembly transfers the entire tray (similar to 708 in figure 7) and/or it could be that the one or more pick and place assembly transfers the integrated circuits individually or in groups from a tray or from a holding medium to another tray or holding medium at each station.

A pick and place device 706 is activated to pick up the integrated circuits from the tray 708 when the conveyor 707 has moved the tray 708 to the bottom inspection station 705. The pick and place device 706 moves the integrated circuits that are picked up along a longitudinal axis of a first guiding member 709 towards a bottom inspection area 710 of the

bottom inspection station 705 for inspection and moves the integrated circuits back along the same longitudinal axis of the first guiding member 709 from the bottom inspection area 710 to the tray 708 after inspection. The pick and place device 706 comprises a plurality of pickers (not shown in Figure 7). Each picker is used for picking an integrated circuit for transferring it between the bottom inspection area 710 and the tray 708. The bottom inspection area 710 includes an optical device (not shown in Figure 7) for capturing images of the integrated circuits being inspected for defects. It could include a transparent glass sheet where an integrated circuit is placed or just presented without placing on top of the glass sheet for inspection. One or more optical devices could be located beneath the transparent glass sheet for capturing the bottom of the integrated circuit that is placed or presented above the transparent glass sheet.

The top inspection station 703 includes an optical device 714 moveable along a longitudinal axis of a second guiding member 711 to capture images of integrated circuits seated in the tray 708 when the conveyor 707 moves the tray 708 to the top inspection station 703 for inspection. It is appreciated that the top views of the integrated circuits in the tray are exposed. In the example of Figure 7, the conveyor 707 would move the tray 708 to the holding station 3 after top inspection is carried out.

If defective integrated circuits are found at the inspection stations 703 and 705, a computer (not shown in Figure 7) connected to the inspection stations 703 and 705 would be updated with information on the location of the defective integrated circuits in the tray. This information would be utilised by the holding station 3, which would activate the first plurality of transfer units 2 in Figure 1 to transfer all the non-defective integrated circuits to the second packaging 6 or 12. The remaining integrated circuit(s) in the tray should be defective.

After all non-defective integrated circuits are moved out of the tray 708, the conveyor 707 moves the tray 708 to the reject station 702. The reject station 702 includes a buffer sorter device 712, which could be in the form of a robotic arm or picker, for picking out the remaining integrated circuit(s) in the tray 708 and transferring them to a reject tray 713.

In more detail, the operation of the example as illustrated in Figure 7 is as follows.

The tray 708 is first loaded with integrated circuits for inspection and transferring to the second packaging 6 or 12 in Figure 1. Thereafter the conveyor 707 moves the tray 708 in a direction towards the pick and place device 706.

The pick and place device 706 picks up a plurality of integrated circuits and moves in along the longitudinal axis of the first guiding member 709 to the bottom inspection area 710. After inspection at the bottom inspection area 710, the plurality of integrated circuits are moved back from the bottom inspection and are 710 placed back into the tray 708 by the pick and place device 706. The pick and place device 706 continues to pick up a plurality of integrated circuits in the tray 708 for inspection at the bottom inspection area 710 by moving along the longitudinal axis of the first guiding member 709 between the location of the tray 708 and the location of the bottom inspection area 710 until all the integrated circuits in the tray 708 have completed inspection at the bottom inspection station 705. It is appreciated that the pick and place device 706 could also be capable of transferring just one integrated circuit for inspection by the bottom inspection station 705.

After the integrated circuits in the tray 708 have completed inspection at the bottom inspection station 705, the conveyor 707 moves the tray 708 in a direction towards the optical device 714. The optical device 714 moves along the longitudinal axis of the second guiding member 711 over the tray 708 to inspect all the top surfaces of the integrated circuits in the field of view of the optical device 714. The field of view of the optical device 714 could include one or more rows of holders in the tray 708. The conveyor 707 may be constructed to index the tray 708 (i.e. move the tray 708 stepwise) to align the top surfaces of one or more integrated circuits to fit within the field of view of the optical device 714 for capturing images of the top surfaces of the one or more integrated circuits. The captured images are later processed for defect analysis. Top surface inspection ends after the optical device 714 has captured images of all the desired integrated circuits in the tray 708 that are required for defect analysis of each integrated circuit.

After the integrated circuits in the tray 708 have completed inspection at the top inspection station 703, the conveyor 707 moves the tray 708 in a direction towards the holding station 3. At the holding station 3, the non-defective integrated circuits determined by the bottom inspection station 705 and the top inspection station 703 are then transferred to the second packaging 6 or 12 in Figure 1. The details of the transfer to the second packaging 6 or 12 would be covered later. Thereafter, the tray 708 left over with rejected integrated circuits would be moved towards the buffer sorter device 712 by the conveyor 707. The rejected integrated circuits in the tray 708 are then transferred to the reject tray 713 for disposal or for any other purpose.

The operation of the apparatus 100 in Figure 1 for transferring integrated circuits to a packaging is described with reference to Figures 1, 7 to 11 as follows. Figures 1, 8 to 11 illustrate the movements of the same apparatus 100.

After the integrated circuits in the tray 708 have completed inspection at the top inspection station 703, the conveyor 707 moves the tray 708 in a direction towards the holding station 3. At the holding station 3, the first plurality of transfer units 2 picks up the non-defective integrated circuits determined by the bottom inspection station 705 and the top inspection station 703 and transfers them from the tray 708 to the first carrier 8 in Figure 1.

In the example of Figures 1, 7 to 11, the first carrier 8 and the second carrier 9 are configured to alternate their movements to a location 802 in Figure 8 sufficiently close to the holding station 3 for the first plurality of transfer units 2 to pick up the non-defective integrated circuits from the tray 708 in the holding station 3 and transfer them to whichever one of the first carrier 8 or the second carrier 9 that is at the location 802. More specifically, the first carrier 8 and the second carrier 9 are moved to positions in the location 802 that are adjacent to one another. Figure 1 shows the instance when the first plurality of transfer units 2 is picking up the non-defective integrated circuits from the tray 708 in the holding station 3 for transferring to the first carrier 8, which has been moved to the location 802 close.

Figure 8 shows the instance when the first plurality of transfer units 2 is depositing the non-defective integrated circuits picked up from the tray 708 as shown in Figure 1 into the first carrier 8. As the first carrier 8 and the second carrier 9 enable fine adjustments to the sitting orientation of the integrated circuits, a non-defective integrated circuit placed in one of their seats (E.g. 402 in Figure 4) would be led to adjust its sitting arrangement to the predetermined sitting orientation in the seat (E.g. 402 in Figure 4) by the self adjusting design of the seat (E.g. 402 in Figure 4) if misalignment from the predetermined sitting orientation occurs. The non-defective integrated circuit would adjust, align or orientate to sit in the predetermined orientation if it happens that a transfer unit of the first plurality of transfer units 2 that is holding on to the non-defective integrated circuits is slightly misaligned from placing the non-defective integrated circuit precisely into a seat (E.g. 402 in Figure 4) of the first carrier 8 or the second carrier 9. The first carrier 8 or the second carrier 9 are capable of compensating for small pitches and angle differences when each of the non-defective integrated circuits are placed into a respective seat in the first carrier or the second carrier 9 by the first plurality of transfer units 2.

For better accuracy in placement of the integrated circuit into the first carrier 8 or second carrier 9, the first plurality of transfer units 2 may be configured to make pitch adjustments to match the seat profile of the first carrier 8 or the second carrier 9 prior to placing the integrated circuits into the seats of the first carrier 8 or the second carrier 9. Thereafter, the first carrier 8 or the second carrier 9 can compensate for small pitches and angle differences when the non-defective integrated circuits are placed into a respective seat in the first carrier or the second carrier 9 by the first plurality of transfer units 2.

After the integrated circuits are placed into the first carrier 8 as shown in Figure 8, the first carrier 8 is moved, in this case, linearly along an axis, in particular, a horizontal axis 903 (i.e. the axis of movement of the first carrier 8) in Figure 9 with respect to Figures 1 and 8 to 11, to a first location 902 in Figures 9, 10 and 11 for transferring the integrated circuits held in the first carrier 8 to the packaging 6 or packaging 12. The packaging 6 and 12 are located a distance away from the first location 902 for transferring the integrated circuits held in the first carrier 8 to the packaging 6 or packaging 12.

Figure 10 shows the second plurality of transfer units 10 being activated to pick up the integrated circuits from the first carrier 8 to the second packaging 6 or 12 when the first carrier 8 is at the first location 902.

In the example illustrated by Figures 1 and 8 to 11, the second plurality of transfer units 10 is configured to move linearly along an axis, in particular, a vertical axis 1002 in Figure 10 (i.e. the axis of movement of the second plurality of transfer units 10 for transferring one or more integrated circuits from the first carrier 8 or second carrier 9 in the first location 902 to one or more respective holders in the second packaging 6 or 12) with respect to Figures 1 and 8 to 11 that is orthogonal to the horizontal axis 903 in Figure 9, to the second packaging 6 or 12 located away from the first location 902.

Figure 11 shows the second plurality of transfer units 10 being activated to place or deposit the integrated circuits picked up from the first carrier 8 at location 902 in holders of the packaging 6. The packaging 6 has been reeled out and straightened for placing the integrated circuits into its holders by suitable machinery. Conventional machinery for the same purpose may be used.

It is appreciated that the second plurality of transfer units 10 may be configured to transfer the integrated circuits from the first carrier 8 to the packaging 12 rather than from the first

carrier 8 to the packaging 6. One possible configuration is the operating sequence having the steps as follows.

Step 1: The first carrier 8 is moved to a location 802 closed to the holding station 3.

Step 2: The first plurality of transfer units 2 transfers one or more integrated circuits from the holding station 3 to the first carrier 8. At the same time or any time after the second plurality of transfer units 10 has been through the state for depositing integrated circuits in the second packaging 6 or 12, the second plurality of transfer units 10 is moved back to the location 902.

Step 3: After transfer is completed by the first plurality of transfer units 2 at step 2, the first carrier 8 containing the one or more transferred integrated circuits moves to the location 902.

Step 4: The second plurality of transfer units 10 transfers the one or more integrated circuits from the first carrier 8 at the location 902 to the packaging 6. At the same time or any time after the second plurality of transfer units 10 has been through the state for picking up one or more integrated circuits from the second carrier 9, the second carrier 9 is moved to the location 802 closed to the holding station 3.

Step 5: The first plurality of transfer units 2 transfers one or more integrated circuits from the holding station 3 to the second carrier 9. At the same time or any time after the second plurality of transfer units 10 has been through the state for depositing integrated circuits in the second packaging 6 or 12, the second plurality of transfer units 10 is moved back to the location 902.

Step 6: After transfer is completed by the first plurality of transfer units 2 at step 5, the second carrier 9 which contains the one or more transferred integrated circuits moves to the location 902.

Step 7: The second plurality of transfer units 10 transfers the one or more integrated circuits from the second carrier 9 at the location 902 to the packaging 12. At the same time or any time after the second plurality of transfer units 10 has been through the state for picking up one or more integrated circuits from the first carrier 8, the first carrier 8 is moved to the location 802 closed to the holding station 3.

After step 7, steps 1 to 7 are repeated until the apparatus 100 is powered down.

It is appreciated that at Step 7 the second plurality of transfer units 10 could transfer the one or more integrated circuits from the second carrier 9 at the location 902 to the packaging 6 instead. Likewise, at Step 4, the second plurality of transfer units 10 could transfer the one or more integrated circuits from the first carrier 8 at the location 902 to the packaging 12 instead.

It is further appreciated that the apparatus 100 may have only one carrier 8 or 9 working at every instance in its operation. With reference to Figures 21 and 22, there is shown another example of the first carrier 8 in Figure 1. The second carrier 9 in Figure 1 could also have the same construction. It is noted that the carrier 8 in this example is constructed to work with the tray 2301 in Figure 23 and the second packaging 6 or 12 as described with reference to Figure 13. In Figures 21 and 22, the first carrier 8 comprises a plurality of 14 seats 2103 lined up in a straight line. Each seat, e.g. 2101, is a recess in the first carrier 8 for receiving an integrated circuit transferred from the first packaging at the holding station 3 in Figure 1 to the carrier 8 by the first plurality of transfer units 2 in Figure 1. In more detail, each seat, e.g. 2101, is an indentation that is generally square or rectangular in shape with four side walls 2104 (only one wall is pointed out in Figure 21). The side walls 2104 are sloped in a manner to cooperate with gravity to enable an integrated circuit (e.g. 302 in Figure 3) to orientate and assume a predetermined or desired sitting orientation in the seat 2101 when edges of the integrated circuit (e.g. 302 in Figure 3) contact the slopes. If it so happens that the integrated circuit (e.g. 302 in Figure 3) is placed in the right orientation by the first plurality of transfer units 2, there would not be any orientation compensation provided by the slopes when the edges of the integrated circuit (e.g. 302 in Figure 3) contacts the slopes. The desired orientation ensures optimum alignment conditions for the second plurality of transfer units 10 to transfer the integrated circuits from the first carrier 8 or second carrier 9 to the holders of the second packaging 6 or 12 in Figure 1. The pitch distance 2201 between two seats of the plurality of seats 2103 that are arranged adjacent each other is 8mm in this case.

In Figures 21 and 22, there is an additional seat 2102 i.e. a 15th seat located a distance away from the 14 seats 2103 that are lined up in a straight line on the carrier 8. The 15th seat 2102 is used for handling defective integrated circuits. If visual inspection is performed at the packaging 6 or 12 of Figure 1 and it is discovered at that time that there is a defective integrated circuit in the packaging 6 or 12, an additional machine arm (not shown in the Figures) comprising one or more picker or probes may be activated to pick up the defective integrated circuit and place it into the 15th seat 2102.

If the carrier 8 returns to the location 802 in Figure 8 or location 902 in Figure 9, another machine arm or the additional machine arm (not shown in the Figures) can pick up the defective integrated circuit from the 15th seat 2102 and place it back into the first packaging e.g. the tray 708 in Figure 7.

Figure 24 shows details of an example of the seat 2101 in Figure 21. Figure 24 has two separate drawings 2401 and 2407 illustrating the seat 2101 in detail. The seat 2101 is representative of all the seats in the carrier 8 in Figure 21.

The first drawing 2401 shows a top view looking into the recessed portion of the seat 2101. The seat 2101 is generally square in shape and comprises a flat bottom surface 2408, the four sloping side walls 2104 in Figure 21, four corners 2402 and a centrally located circular shaped aperture 2406. Depending on the size of the integrated circuit (e.g. 302 in Figure 3) to be transferred by the apparatus 100 in Figure 1, suitable dimensions for the seat 2101 may include a length 2405 of 4.10mm (with length tolerance in the range of about +0.01 to +0.03mm; excluding the width of the four sloping side walls 2104). It is noted that the length 2405 of 4.10mm should not have negative tolerance. Each of the four corners 2402 may be formed with a curved edge 2409 instead of a sharp corner. Each of the four corners 2402 may be shaped in the form of a cylindrical flat bottom hole with a diameter of about 1.5mm and a depth of 1.6mm. The purpose of the cylindrical flat bottom hole is for ease of machining the seat 2101 during the making of the first or second carriers 8 and 9. Throughout the depth of the cylindrical flat bottom hole, the curved edge 2409 of each corner 2402 is part of the surface area of the cylindrical flat bottom hole. The four sloping side walls 2104 are not within the volume of the cylindrical flat bottom hole. The aperture 2406 may be a circular through hole having a diameter of 1.5mm with diameter size tolerance of -0.006mm. The aperture 2406 is for releasing air pressure when an integrated circuit is dropped or placed into the seat 2101.

Drawing 2407 shows a cross-sectional view of the 15th seat 2102 in Figures 21 and 22 taken along an axis D-D in Figure 22, which cuts through the centre of the aperture 2406. It is noted that the construction of the 15th seat 2102 in Figure 21 is similar to that of seat 2101. An angle 2403 is shown in Figure 2407. The angle 2403 is indicative of an extent of sloping of each of the four sloping side walls 2104. The angle 2403 is formed with respect to an axis 2410, which is perpendicular to the flat bottom surface 2408 of the seat 2102 or 2101. The angle 2403 in the example of drawing 2407 is 30 degrees. It is appreciated that other suitable angles may be used provided that the effect of adjustment or alignment is present when an integrated circuit is placed into the seat 2102 or 2101. The slopes of the four side

walls 2104 have to be sufficiently steep to allow the edges of a slightly misplaced integrated circuit placed into the seat 2102 or 2101 to slide over the slopes under gravity and adjust its orientation by following the contours of the slope of the four side walls 2104. The end to end length of the square seat 2102 or 2101 is about 5.49mm including the width of the slopes of the four side walls 2104.

It is appreciated that the dimensions of the carriers 8 or 9, including the seat dimensions, may be dimensioned in a manner so as to accommodate the dimensions of specific types of integrated circuits.

Certain relationships that could be derived from the dimensions provided in Figures 13, 21 to 24 are that ideally the relationship *e* (1311 in Figure 13) > *f* (2304 in Figure 23) > *c* (2305 in Figure 23) should be achieved. The apparatus 100 in Figure 1 attempts to solve misplacement of integrated circuits that may occur when *e* (1311 in Figure 13) is less than or equal to *f* (2304 in Figure 23). In the construction of the apparatus 100, *e* (1311 in Figure 13) should be made to have dimension greater than *f* (2304 in Figure 23) and *f* (2304 in Figure 23) should have dimension greater than *c* (2305 in Figure 23).

In addition, the apparatus 100 in Figure 1 includes a control unit (not shown in Figure 1). The control unit **may be a computer 1200, schematically shown in Figure 12, or more than one of such computer 1200. In the case of more than one computer, the computers may communicate with one another via technologies like ethernet and the like. There may be provided software, such as one or more computer applications, programs or routines being executed within the computer 1200, and instructing the computer 1200 to operate, amongst other things, the top and bottom surface inspection for integrated circuits, the handling of rejected integrated circuits, the controlling of the first and second plurality of transfer units 2 and 10, movement of the first and second carriers 8 and 9, movement of the reel of the packaging 6 and 12, movement of the tray (e.g. 708 in Figure 7) in the holding station 3, Steps 1 to 7 herein described with reference to the Figures, and the displaying of information relating to, for instance, operation and user control of the apparatus 100 on a display.**

**The computer 1200 comprises a processing unit 1202 for processing the one or more computer programs, and includes input modules such as a computer mouse 1236, keyboard/keypad 1204, and/or a plurality of output devices such as a display 1208.**

The processing unit 1202 may be connected to a computer network 1212 via a suitable transceiver device 1214 (i.e. a network interface), to enable access to e.g. the Internet or other network systems such as a wired Local Area Network (LAN) or Wide Area Network (WAN). The processing unit 1202 may also be connected to one or more external wireless communication enabled devices 1234 via a suitable wireless transceiver device 1232 e.g. a WiFi transceiver, Bluetooth module, Mobile telecommunication transceiver suitable for Global System for Mobile Communication (GSM), 3G, 3.5G, 4G telecommunication systems, or the like.

The processing unit 1202 in the example includes a processor 1218, a Random Access Memory (RAM) 1220 and a Read Only Memory (ROM) 1222. The processing unit 1202 also includes a number of Input/Output (I/O) interfaces, for example I/O interface 1238 to the computer mouse 1236, I/O interface 1224 to the display 1208, and I/O interface 1226 to the keyboard 1204.

The components of the processing unit 1202 typically communicate via an interconnected bus 1228 and in a manner known to the person skilled in the relevant art.

The computer programs may further include one or more software applications for e.g. instant messaging platform, audio/video playback, internet accessibility, operating the computer 1200 (i.e. operating system), network security, file accessibility, database management, which are applications typically equipped on a desktop or portable computer. The computer programs may be supplied to the user of the computer system 1200 encoded on a data storage medium such as a CD-ROM, on a flash memory carrier or a Hard Disk Drive, and are to be read using a corresponding data storage medium drive of a data storage device 1230. Such application programs may also be downloaded from the computer network 1212. The application programs are read and controlled in its execution by the processor 1218. Intermediate storage of program data may be accomplished using RAM 1220.

Furthermore, one or more of the steps of the computer programs may be performed in parallel rather than sequentially. One or more of the computer programs may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a general purpose computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the Wireless LAN (WLAN) system. The computer program when

loaded and executed on such a general-purpose computer effectively results in an apparatus that implements the steps of the computing methods in examples herein described.

It is appreciated that the mention of a chip or chips herein refers to integrated circuit or chips respectively, which are also known by other respective names such as integrated circuit circuits, microchip or microchips, micro circuit or micro circuits and the like.

Although references have been made to the transfer of more than one integrated circuit in many areas of the present description, it is appreciated that the apparatus 100 in Figure 1 is also capable of transferring just one integrated circuit from the holding station 3 in Figure 1 to the second packaging 6 or 12 in Figure 1.

It is appreciated that all pneumatic cylinders (e.g. 206 in Figure 2, and 602 and 608 in Figures 6) referred to herein are known generally as actuators and could also be operated based on hydraulics or a combination of pneumatic and hydraulic. Electrical actuators may also be used.

Many modifications and other examples can be made to the packaging apparatus and method for transferring integrated circuits to a packaging by those skilled in the art having the understanding of the above described disclosure together with the drawings. Therefore, it is to be understood that the packaging apparatus and method for transferring integrated circuits to a packaging is not to be limited to the above description contained herein only, and that possible modifications are to be included in the claims of the disclosure.

**CLAIMS**

1. A packaging apparatus for transferring integrated circuits to a packaging, the apparatus comprising:

a moveable carrier for carrying a plurality of integrated circuits and moving the plurality of integrated circuits between a location of a first packaging and a first location, the first packaging being configured for holding a plurality of integrated circuits;

a first plurality of transfer units, the first plurality of transfer units being configured for transferring one or more integrated circuits from the first packaging to the carrier when the carrier is at the location of the first packaging; and

a second plurality of transfer units, the second plurality of transfer units being configured for transferring one or more integrated circuits from the carrier at the first location to one or more respective holders in a second packaging,

said carrier comprising a plurality of seats for receiving integrated circuits, said plurality of seats being configured for adjusting each received integrated circuit to assume a predetermined orientation if misalignment from the predetermined orientation occurs, said predetermined orientation being orientation of each integrated circuit for sitting in one of the holders of the second packaging.

2. The apparatus as claimed in claim 1, the apparatus comprising:

a moveable second carrier for carrying a plurality of integrated circuits and moving the plurality of integrated circuits between the location of the first packaging and a second location;

the first plurality of transfer units being configured to transfer one or more integrated circuits from the first packaging to the second carrier when the second carrier is at the location of the first packaging; and

the second plurality of transfer units being configured for transferring one or more integrated circuits from the second carrier at the second location to one or more respective holders of the second packaging,

wherein said second carrier comprising a plurality of seats for receiving integrated circuits, said plurality of seats of second carrier being configured for adjusting each received integrated circuit to assume a predetermined orientation if misalignment from the predetermined orientation occurs, said predetermined orientation being orientation of each integrated circuit for sitting in one of the holders of the second packaging.

3. The apparatus as claimed in any one of the preceding claims, wherein a transfer unit of the first plurality of transfer units or the second plurality of transfer units is configured for making adjustments to orientate an integrated circuit being transferred by rotating the integrated circuit about a longitudinal axis of said transfer unit of the first plurality of transfer units or said transfer unit of the second plurality of transfer units respectively.

4. The apparatus as claimed in any one of the preceding claims, wherein the second plurality of transfer units is made to have a fixed pitch distance between the transfer units of the second plurality of transfer units.

5. The apparatus as claimed in any one of the preceding claims, wherein each of the plurality of seats comprises side walls sloped in a manner to cooperate with gravity to enable an integrated circuit to orientate and assume the predetermined orientation in the seat when edges of the integrated circuit contact the slopes.

6. The apparatus as claimed in any one of claims 1 to 5, wherein each of the plurality of seats comprises side walls that are moveable to orientate an integrated circuit to assume the predetermined orientation in the seat.

7. The apparatus as claimed in claim 2, wherein the second packaging comprises separate packaging located at different locations and the second plurality of transfer units is configured to transfer integrated circuits from the carrier at the first location or the second carrier at the second location to one or more holders in each of the separate packaging..

8. The apparatus as claimed in any one of the preceding claims, wherein each of the plurality of seats comprises a stepped portion surrounding the perimeter of the predetermined orientation and the stepped portion is located at a foot of the sloping side walls.

9. The apparatus as claimed in any one of the preceding claims, the apparatus further comprising: one or more inspection stations for inspecting the integrated circuits; a holding station for holding the first packaging for transferring to the second packaging; and a reject station for handling rejected integrated circuits, the one or more inspection stations, the holding station and the reject station being arranged sequentially in a straight line.

10. The apparatus as claimed in any one of the preceding claims, the apparatus further comprising: one or more inspection stations for inspecting the integrated circuits; a holding station for holding the first packaging for transferring to the second packaging; a reject station for handling rejected integrated circuits; and one or more transfer mechanism for transferring the integrated circuits between said stations, wherein each of said stations is arranged in a lane with the one or more transfer mechanism residing between the lanes.

11. The apparatus as claimed in any one of the preceding claims, wherein the first plurality of transfer units is configured for making adjustments to pitch distance between the transfer units of the first plurality of transfer units to match each seat profile of the plurality of seats prior to placing each integrated circuit into each seat and the second plurality of transfer units is made to have a fixed pitch distance between the transfer units of the second plurality of transfer units.

12. A packaging method for transferring integrated circuits to a packaging, the method comprising:

carrying a plurality of integrated circuits and moving the plurality of integrated circuits between a location of a first packaging and a first location using a moveable carrier, the first packaging being configured for holding the plurality of integrated circuits, said carrier comprising a plurality of seats for receiving integrated circuits;

transferring one or more integrated circuits from the first packaging to the carrier using a first plurality of transfer units when the carrier is at the location of the first packaging;

transferring one or more integrated circuits from the carrier at the first location to one or more respective holders in a second packaging using a second plurality of transfer units;

adjusting a integrated circuit received by the carrier to assume a predetermined orientation if misalignment from the predetermined orientation occurs using a plurality of seats of said carrier, said predetermined orientation being orientation of each integrated circuit for sitting in one of the holders of the second packaging; and

making adjustments to pitch distance between the transfer units of the first plurality of transfer units to match each seat profile of the plurality of seats prior to placing each integrated circuit into each seat.

13. The method as claimed in claim 12, the method comprising:

carrying a plurality of integrated circuits and moving the plurality of integrated circuits between the first packaging and a second location using a second carrier wherein said second carrier comprising a plurality of seats for receiving integrated circuits;

transferring one or more integrated circuits from the first packaging to the second carrier when the second carrier is at the location of the first packaging using the first plurality of transfer units;

transferring one or more integrated circuits from the second carrier at the second location to one or more respective holders of the second packaging using the second plurality of transfer units; and

adjusting each integrated circuit received by said second carrier to assume a predetermined orientation if misalignment from the predetermined orientation occurs using said plurality of seats of the second carrier, and said predetermined orientation being orientation of each integrated circuit for sitting in one of the holders of the second packaging.

14. The method as claimed in claim 13, wherein the second packaging comprises separate packaging located at different locations, the method further comprising:

transferring the integrated circuits from the carrier at the first location or the second carrier at the second location to one or more holders in each of the separate packaging using the second plurality of transfer units.

15. The method as claimed in any one of claims 12 to 14, the method comprising:

making adjustments to orientate an integrated circuit being transferred by rotating the integrated circuit about a longitudinal axis of a transfer unit of the first plurality of transfer units or the second plurality of transfer units.