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(54) Title: INTEGRATED NON-CONTACT CLEANING AND INSPECTION SYSTEM AND METHOD FOR ELECTRONIC COMPONENTS

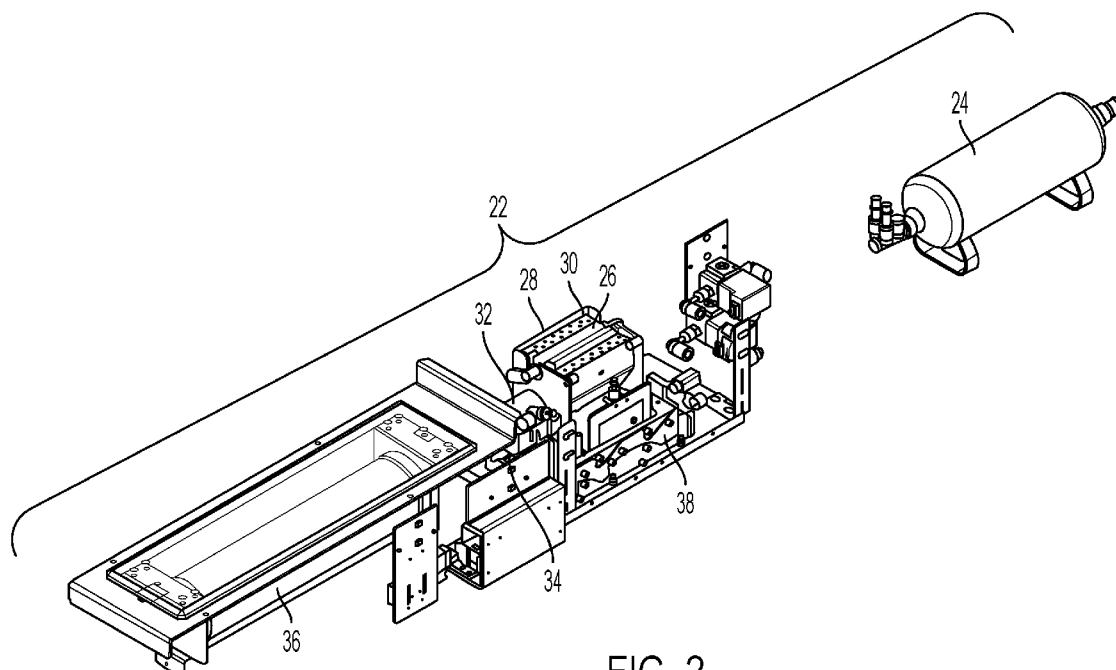


FIG. 2

(57) Abstract: An inspection system for electronic components includes a platform. The inspection system also includes a carrier for supporting an electronic component and moving the electronic component to different locations about the platform. The inspection system further includes an inspection device positioned to inspect the electronic component for a defect when the electronic component is not supported by the carrier. The inspection system yet further includes a cleaning sub-system for cleaning the electronic component with no contact between the cleaning sub-system and the electronic component.



(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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INTEGRATED NON-CONTACT CLEANING AND INSPECTION SYSTEM AND METHOD FOR ELECTRONIC COMPONENTS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefits of priority to U.S. Provisional Patent Application Serial No. 63/542,316, filed October 4, 2023, the disclosure of which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The embodiments described herein relate to cleaning and inspection systems for electronic components.

BACKGROUND

[0003] Inspection processes are used at various steps during a manufacturing process to detect defects on wafers, panels or other electronic components during the manufacturing processes of such electronic components. An indication by the inspection system that the electronic component does not satisfy one or more inspection standards typically requires separating the rejected component from the accepted components, thereby lowering the yield that a wafer or panel manufacturer enjoys.

[0004] The electronic components being inspected are carried by a carrier and brought to a camera or other device positioned to inspect the lower surface of the electronic component resting in the carrier. To reduce the likelihood that an electronic component fails inspection of the lower surface thereof, a cleaning procedure may be performed on the lower surface of the electronic component.

[0005] One cleaning process includes providing a cleaning mechanism having an air jet positioned to clean the lower surface of the electronic component while resting in the carrier. However, such a cleaner cannot reliably clean the portion of the lower surface of the devices where closed corners and/or edges of the carrier support the electronic component due to blockage of the air jet at these locations. Alternatively, a brushing cleaner may be provided to carry out the cleaning procedure. However, a moving brush undesirably requires contact between the cleaning unit and the

electronic components, which may potentially damage the electronic component. Additionally, brush hair from the cleaning tool may become a source of contamination for the overall system

SUMMARY OF THE DISCLOSURE

[0006] According to one aspect of the disclosure, an inspection system for electronic components includes a platform. The inspection system also includes a carrier for supporting an electronic component and moving the electronic component to different locations about the platform. The inspection system further includes an inspection device positioned to inspect the electronic component for a defect when the electronic component is not supported by the carrier. The inspection system yet further includes a cleaning sub-system for cleaning the electronic component with no contact between the cleaning sub-system and the electronic component.

[0007] According to another aspect of the disclosure, a non-contact cleaning system for cleaning an electronic component during an inspection process of the electronic component. The non-contact cleaning system includes an air knife for expelling a high pressure air curtain toward a lower surface of the electronic component. The non-contact cleaning system also includes a suction block operatively coupled to the air knife for removing particulate matter from the region between the air knife and the lower surface of the electronic component. The non-contact cleaning system further includes air filter fluidly coupled to the suction block to contain the particulate matter removed from the region between the air knife and the lower surface of the electronic component.

[0008] According to yet another aspect of the disclosure, a method of inspecting and cleaning an electronic component is provided. The method includes moving an electronic component within a carrier along a platform. The method also includes removing the electronic component from the carrier for inspection of a lower surface of the electronic component. The method further includes determining if the electronic component is defective based on inspection of the lower surface and categorizing the electronic component as PASS or FAIL. The method yet further includes moving the electronic component to the carrier if the electronic component has been categorized as PASS. The method also includes moving the electronic component to a cleaning sub-

system located on the platform for non-contact cleaning of the lower surface if the electronic component has been categorized as FAIL.

[0009] These aspects and other advantages and features are apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The subject matter that is regarded as embodiments of the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The features and advantages of the disclosed embodiments are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0011] FIG. 1 is a plan view of an integrated non-contact cleaning and inspection system for an electronic component.

[0012] FIG. 2 is a perspective view of the cleaning and inspection system.

[0013] FIG. 3 is a cross-sectional view of the electronic component being cleaned.

[0014] FIG. 4 is schematically illustrates a method of cleaning the electronic component with the cleaning and inspection system.

DETAILED DESCRIPTION

[0015] Referring to the drawings, where the invention will be described with reference to specific embodiments, it is to be understood that the disclosed embodiments are merely examples of the invention that may be embodied in various and alternative forms. The drawings are not necessarily to scale, as some features may be exaggerated, reduced or simplified to show details of particular components. Therefore, specific structural and functional details disclosed herein and illustrated in the drawings are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the invention.

[0016] Referring to FIG. 1, an integrated non-contact cleaning and inspection system is shown and generally referenced with numeral 10. The integrated system 10 includes a cleaning sub-system which is directly integrated with the overall inspection

system and is configured to be used in the manufacture and inspection of electronic components. The electronic component referenced herein may be any suitable wafer, substrate, flat panel for a flat panel display or solar panel, printed circuit board, film layer, reticle, molded components or any other suitable object. Therefore, the term “electronic components”, as used herein, refers generically to any of the aforementioned objects, but is not limited thereto.

[0017] The inspection system 10 includes various components suitable for supporting, moving, and inspecting an electronic component relative to a platform 12. In particular, a carrier 14 supports an electronic component 16 and is moveable in a first direction A. The carrier 14 may be configured to support multiple electronic components 16 at once in some embodiments. The carrier 14 may be any type of container suitable for moving the electronic component 16 to various locations about the platform 12. For example, the carrier 14 may be a tray, a bowl, a metal carrier, a metal boat magazine, a carrier tape, a gel pack, a diced wafer on a film frame. The preceding list is a non-exhaustive list of examples of the carrier 14 and is not limiting of the carrier 14.

[0018] By way of non-limiting example, an embodiment of the disclosure is shown in Figure 1 and described as follows. The carrier 14 moves along a track 18 mounted on, or formed with, the platform 12. The track 18 extends substantially in the first direction A. In some embodiments, multiple tracks 18 are provided on the platform 12, as shown in the illustrated example having a first track 18a and a second track 18b. The carrier 14 is moveable along the track 18 to a position in close proximity to an optical inspection device 20. The optical inspection device 20 may be any inspection device suitable for detecting defects or features of the electronic component 16 which lead to a categorization of the electronic component 16 of unacceptability relative to the requirements of the inspection system 10. For example, the optical inspection device 20 may be a camera or an automated optical device, but other devices may be utilized. Regardless of the particular optical inspection device provided, the optical inspection device 20 is positioned and configured to inspect the lower surface of the electronic component 16 for conditions deemed to be a defect according to programmed standards and/or human judgment. Although the lower surface of the electronic component 16 is described herein as the surface to be

inspected, it is to be appreciated that the disclosure also contemplates inspecting and/or cleaning one or more side surfaces of the electronic component 16.

[0019] Upon the carrier 14 reaching the position in close proximity to the optical inspection device 20, the electronic component 16 is moved from the carrier 14 to a position over the optical inspection device 20 for inspection of the lower surface of the electronic component 16. Movement of the electronic component 16 from the carrier 14 to the position over the optical inspection device 20 may be done with any component suitable for movement in a vertical direction and in a second direction B. For example, the component used for moving the electronic component 16 may be referred to as a pick and place head. In some embodiments the second direction B is substantially perpendicular to the first direction A. The movement directions of the component used for moving the electronic component 16 may be linear in some embodiments, such as an XYZ stage or rotationally moved on a circular turret in other embodiments.

[0020] If the electronic component 16 is rejected upon completion of the inspection of the lower surface of the electronic component 16, the electronic component 16 is moved to a cleaning sub-system 22 for cleaning of the electronic component 16. This differs from an inspection system which simply rejects an electronic component due to initial inspection failure. The embodiments disclosed herein provide the non-contact cleaning sub-system 22 which is integrated into the inspection system 10 to efficiently attempt to remedy a failed inspection due to dust or other particulate matter. In some cases, simply cleaning the electronic component 16 leads to an acceptable inspection of the electronic component 16. Inspection systems which simply discard electronic components after an initial failure can significantly and unnecessarily reduce the yield achieved by manufacturers of the electronic components 16.

[0021] Although FIG. 1 and the associated description discloses an example of the type of platform 12 and movement of the carrier 14 along a track 18, it is to be understood that various other types of platforms and movement systems are within the scope of the disclosure. In particular, the carrier 14 containing the electronic component(s) 16 may move on the platform 12 two-dimensionally on a longitudinal track, which may be referred to as a XY table, or three-dimensionally on a XYZ table.

Additionally, the carrier 14 may be associated with a rotating platform. Accordingly, a track 18 may not be required in some embodiments. Due to the different types of platforms and carrier movement encompassed by this disclosure, it should be understood that movement in the directions referenced as A and B in FIG. 1 are merely illustrative and not limiting, as movement at angles to directions A and B and in a vertical direction are additionally contemplated.

[0022] Regardless of the manner in which the carrier 14 is moved relative to the platform 12 and the direction(s) which the component (e.g., pick and place head) that picks up the electronic component 16 out of the carrier 14, upon completion of the initial inspection of the lower surface of the electronic component 16, a categorization of PASS or FAIL is assigned to the electronic component 16. A PASS categorization leads to the electronic component 16 being returned to the carrier 14 for further inspection and/or processing within the overall manufacturing process. A FAIL categorization leads to the electronic component 16 being moved to the cleaning sub-system 22. In the illustrated embodiment, the cleaning sub-system 22 is located at a position on the platform 12 which overlaps with the optical inspection device 20 along an axis parallel to the first direction A and the tracks 18. Accordingly, the electronic component 16 – when categorized with an inspection FAIL – is moved in the second direction B from the position over the optical inspection device 20 to the cleaning sub-system 22. Although the cleaning sub-system 22 is shown in the illustrated embodiment as being positioned on the platform 12 between the first track 18a and the second track 18b, it is to be understood that the cleaning sub-system 22 may be positioned in any suitable location on the platform relative to the optical inspection device 20.

[0023] Upon completion of non-contact cleaning of the lower surface of the electronic component 16, the electronic component 16 is moved back to a position over the optical inspection device 20 for a subsequent inspection. The subsequent inspection again leads to a PASS or FAIL categorization and the electronic component may be sent back to the cleaning sub-system for an additional cleaning step. This process is a loop which has a user-definable number of iterations. Therefore, the process may be repeated any number of times before an ultimate determination of FAIL is made, leading to discarding of the electronic component 16.

[0024] While initial inspection of the electronic component 16 is described as occurring prior to cleaning of the electronic component 16, it is contemplated that the electronic component 16 may be cleaned prior to the initial inspection, with the remaining process looping in the manner described above.

[0025] While movement of the electronic component 16 over the cleaning sub-system 22 is illustrated and described herein, it is to be appreciated that the cleaning sub-system 22 may be moved to a position under the electronic component 16 in some embodiments.

[0026] Referring now to FIG. 2, the cleaning sub-system 22 is illustrated in detail. The cleaning sub-system includes 22 includes a pressurized air source container 24 fluidly coupled to an air knife 26 via one or more air lines and one or more valves. The air knife 26 is arranged to expel a curtain of airflow at the lower surface of the electronic component 16 when the electronic component 16 is positioned over the cleaning sub-system 22 for cleaning thereof. While an air knife 26 is illustrated and described herein as the component utilized for expelling the air curtain for cleaning the lower surface of the electronic component 16, it is contemplated that other air expulsion components may be included. For example, any suitable air nozzle, air jet or the like may be used. The size of the air knife 26 – or alternative air curtain expulsion component – may vary depending on the size of the electronic components to be cleaned, as well as on the air flow characteristics desired.

[0027] The air knife 26 is at least partially disposed within a suction block 28. The suction block 28 is formed by 3D printing in some embodiments, but alternative materials and manufacturing methods are within the scope of the disclosure. The suction block 28 includes a vacuum chute 30 and a vacuum ejector 32 to remove dust or other particulate matter from the region proximate the electronic component 16 during cleaning of the lower surface. The cleaning sub-system 22 also includes an ionizer 34 and an air filter 36 for dust removal, as described herein.

[0028] The suction block 28 and the air knife 26 are supported by a stage or the like 38 which is adjustable in a vertical direction to raise or lower the suction block 28 and the air knife 26. This ensures optimized cleaning performance of the electronic component 16.

[0029] Referring now to FIG. 3, a cross-sectional view of a portion of the cleaning sub-system 22 during a cleaning operation of the electronic component 16 is shown. The electronic component 16 is moved over the air knife 26 in the second direction B, as represented by arrow C in the illustrated embodiment, but as described in detail above the movement – or rotation – may be in other directions in some embodiments. In this position, the lower surface 40 of the electronic component 16 is exposed to an air curtain 42 expelled by the air knife 26. The ionizer 34 is connected to the air knife 26 to generate a high regulated air pressure with a low air flow volume to remove dust from the lower surface 40 of the electronic component 16. The suction block 28, with the vacuum chute 30 and the vacuum ejector 32, assures a high flow rate at low pressure to extract dust and other particulate matter from the region proximate the lower surface 40 of the electronic component 16. In particular, the vacuum components 30, 32 control the overall airflow to move the dust removed in a direction from right to left in FIG. 3. The air filter 36 is connected in a sealed manner with the vacuum ejector 32 to capture and contain the extracted dust, as represented with arrow D. Routing the dust to the air filter 36, and containing the dust therein, prevents contamination of the overall inspection system 10.

[0030] Referring now to FIG. 4, pneumatic operation of the cleaning sub-system 22 is schematically depicted. As described herein, the cleaning sub-system 22 includes a cleaning operation and a dust collection operation. These sub-processes are illustrated with their associated componentry, which has been described in detail herein. As shown, a pressurized air supply is provided by the pressurized air source container 24 to both sub-processes of the system. Valves 50, 52, which may be solenoids or any other suitable air flow regulation device, selectively control whether the pressurized air supply is provided to the cleaning operation and the dust collection operation. In particular, one or more valves 50 control whether the pressurized air supply is provided to the ionizer 34 and the air knife 26 for cleaning of the lower surface of the electronic component 16. Additionally, one or more valves 52 controls whether the pressurized air supply is provided to the vacuum ejector 32 for the dust removal and collection operation.

[0031] The schematic illustration of FIG. 4 includes a pressurized air supply of 5.5 bar and various pressures within the fluid lines between the components of the

cleaning sub-system 22. In particular, 5 bar of pressure is provided to valve 52 of the dust collection operation and 2.2 bar to the vacuum ejector 32. Additionally, 4.3 bar of pressure is provided to valves 50 of the cleaning operation, with 3.1 bar provided to one or more ionizers 34 and 1.7 bar provided to the air knife 26. It is to be appreciated that the above-noted pressures are merely one example and are not intended to be limiting of the disclosure. Specifically, the precise pressure of the air provided by the pressurized air source container 24 may be greater or less than the above-specified 5.5 bar. Additionally, the pressure of the air delivered to each component within the cleaning sub-system 22 may differ from that specified above. Each pressure can be modified based on the particular application of use.

[0032] The embodiments disclosed herein provide an integrated cleaning and inspection system for electronic components to increase the number of electronic components which pass inspection, thereby increasing yield and profit for manufacturers. This is achieved while avoiding the need for contact between the cleaning component(s) and the electronic component. Brushes or other contacting cleaning components have the potential to scratch or otherwise damage the electronic components and introduce additional contamination sources due to bristles or other features falling into the system. The cleaning sub-system 22 disclosed herein requires less maintenance compared to brushing cleaners since there are no motors or brush replacements required. Additionally, the cleaning process includes a dust removal and containment operation which prevents contamination of any components of the overall inspection system. The ionizer is integrated with the cleaning sub-system 22 to offer ESD safe protection to the electronic component 16 being cleaned and inspected.

[0033] While the invention has been described in detail in connection with only a limited number of embodiments, it is to be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Moreover, any feature, element,

component or advantage of any one embodiment can be used on any of the other embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description.

CLAIMS

What is claimed is:

1. An inspection system for electronic components comprising:
 - a platform;
 - a carrier for supporting an electronic component and moving the electronic component to different locations about the platform;
 - an inspection device positioned to inspect the electronic component for a defect when the electronic component is not supported by the carrier; and
 - a cleaning sub-system for cleaning the electronic component with no contact between the cleaning sub-system and the electronic component.
2. The inspection system of claim 1, wherein the inspection device inspects a lower surface of the electronic component and the cleaning sub-system cleans the lower surface of the electronic component.
3. The inspection system of claim 2, wherein the cleaning sub-system comprises:
 - an air expulsion device for expelling a high pressure air curtain toward the lower surface of the electronic component;
 - an ionizer operatively connected to the air expulsion device to generate a regulated air pressure to remove dust from the lower surface of the electronic component; and
 - a suction block operatively coupled to the air expulsion device for removing particulate matter from the region between the air expulsion device and the lower surface of the electronic component.
4. The inspection system of claim 3, wherein the air expulsion device is one of an air knife, an air nozzle and an air jet.

5. The inspection system of claim 3, wherein the suction block comprises a vacuum chute and a vacuum ejector.

6. The inspection system of claim 5, wherein the cleaning sub-system further comprises an air filter fluidly coupled to the vacuum ejector to contain the particulate matter removed from the region between the air expulsion device and the lower surface of the electronic component.

7. The inspection system of claim 1, further comprising a track extending longitudinally along the platform in a first direction, wherein the carrier moves the electronic component along the track in the first direction.

8. The inspection system of claim 7, wherein the track which the carrier moves along is located between the inspection device and the cleaning sub-system.

9. The inspection system of claim 1, wherein the inspection device comprises an optical inspection device.

10. The inspection system of claim 1, further comprising a pick and place head positioned to carry the electronic component out of the carrier and move the electronic component to selectively position the electronic component over the inspection device and over the cleaning sub-system.

11. The inspection system of claim 1, further comprising a pick and place head positioned to carry the electronic component out of the carrier and move the electronic component to selectively positions the electronic component over the inspection device, and wherein the cleaning sub-system is moveable along the platform to be positioned under the electronic component while being held stationary by the pick and place head.

12. The inspection system of claim 1, wherein the inspection device inspects at least one side surface of the electronic component and the cleaning sub-system cleans at least one side surface of the electronic component.

13. A non-contact cleaning system for cleaning an electronic component during an inspection process of the electronic component, the non-contact cleaning system comprising:

an air knife for expelling a high pressure air curtain toward a lower surface of the electronic component;

a suction block operatively coupled to the air knife for removing particulate matter from the region between the air knife and the lower surface of the electronic component; and

air filter fluidly coupled to the suction block to contain the particulate matter removed from the region between the air knife and the lower surface of the electronic component.

14. The non-contact cleaning system of claim 13, wherein the suction block comprises a vacuum chute and a vacuum ejector, wherein the air filter is fluidly coupled to the vacuum ejector.

15. The non-contact cleaning system of claim 13, wherein the inspection device comprises an optical inspection device.

16. A method of inspecting and cleaning an electronic component comprising:

moving an electronic component within a carrier along a platform;

removing the electronic component from the carrier for inspection of a lower surface of the electronic component;

determining if the electronic component is defective based on inspection of the lower surface and categorizing the electronic component as PASS or FAIL;

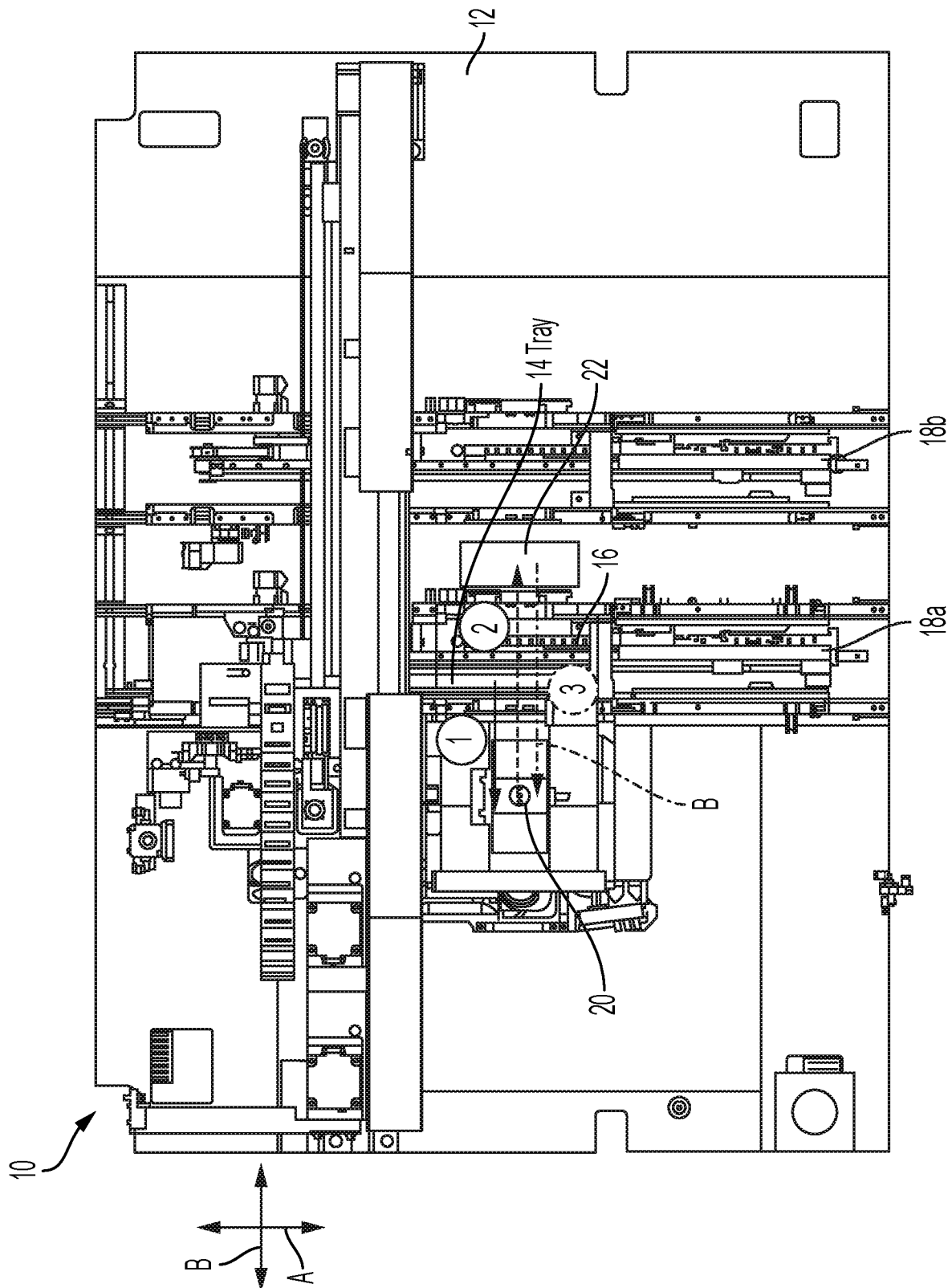
moving the electronic component to the carrier if the electronic component has been categorized as PASS; and

moving the electronic component to a cleaning sub-system located on the platform for non-contact cleaning of the lower surface if the electronic component has been categorized as FAIL.

17. The method of claim 16, wherein the non-contact cleaning of the lower surface includes expelling an air curtain of pressurized air toward the lower surface with an air knife.

18. The method of claim 17, further comprising removing particulate matter from a region between the lower surface and the air knife with a suction block and containing the removed particulate matter with an air filter fluidly coupled to the suction block.

19. The method of claim 16, further comprising repeating the inspection of the lower surface of the electronic component after the non-contact cleaning step is completed.



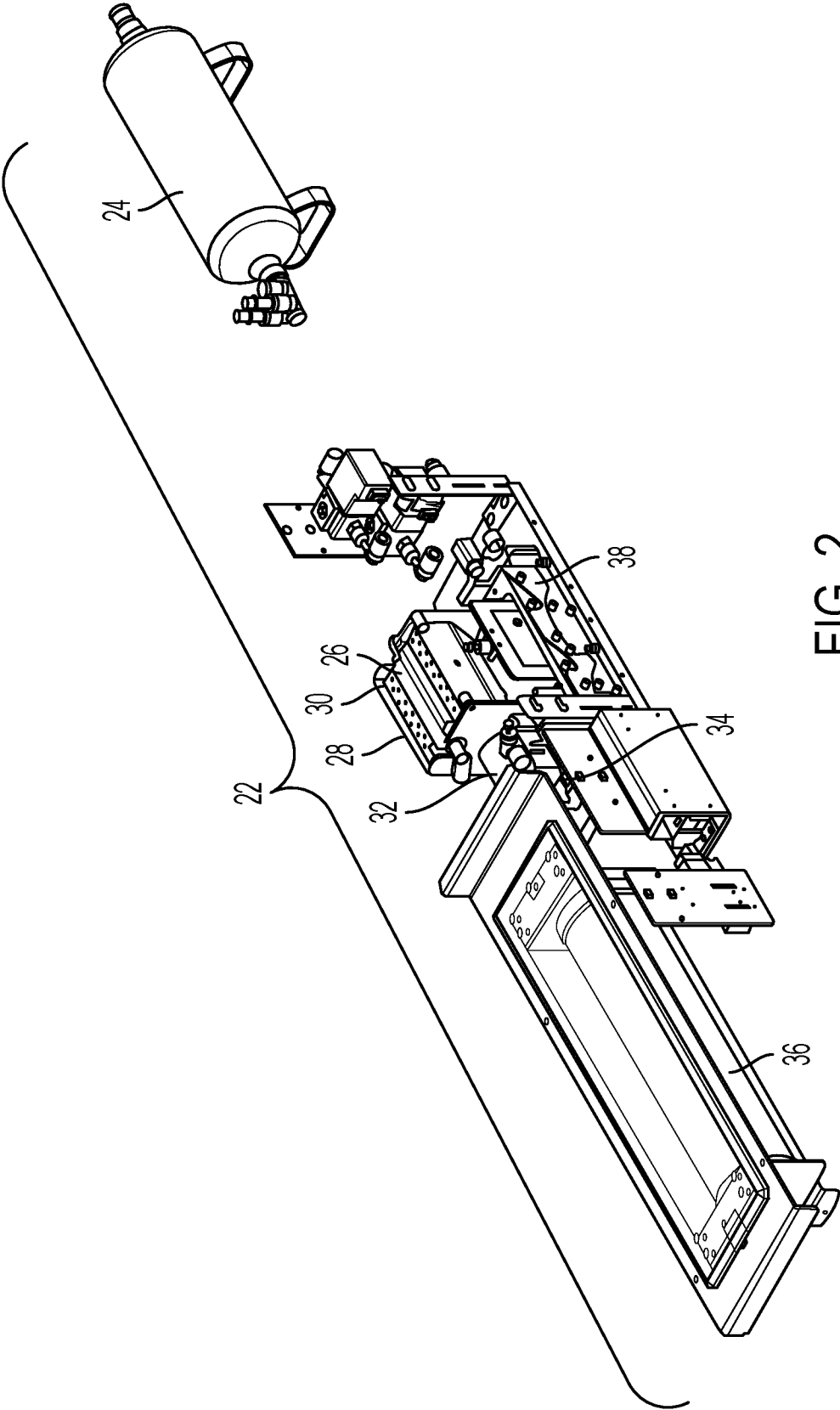


FIG. 2

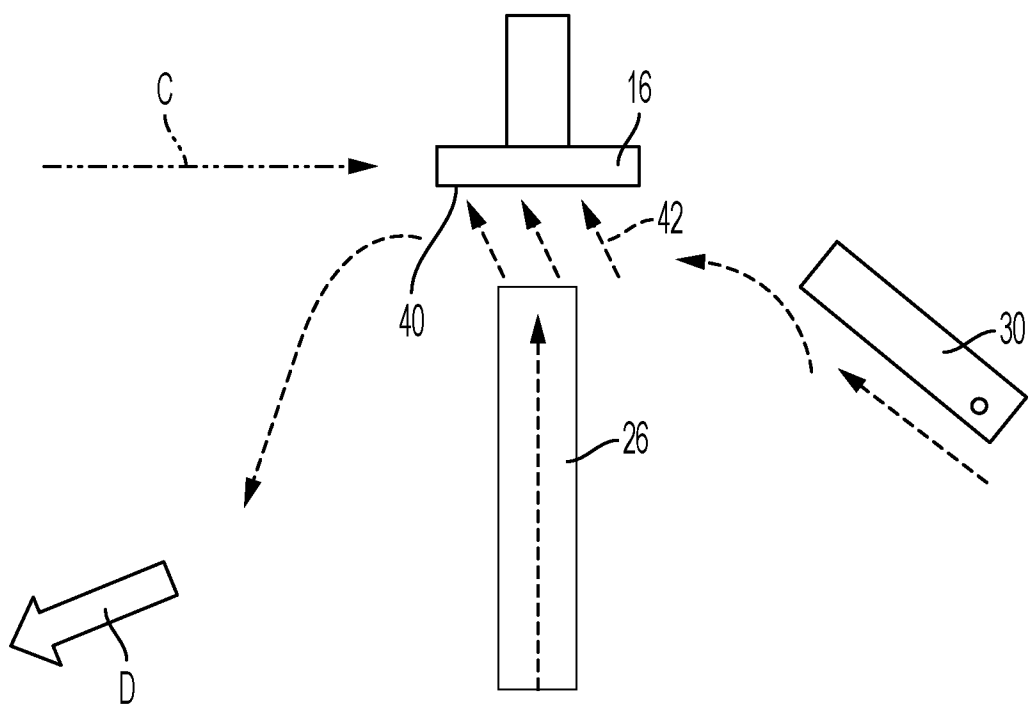


FIG. 3

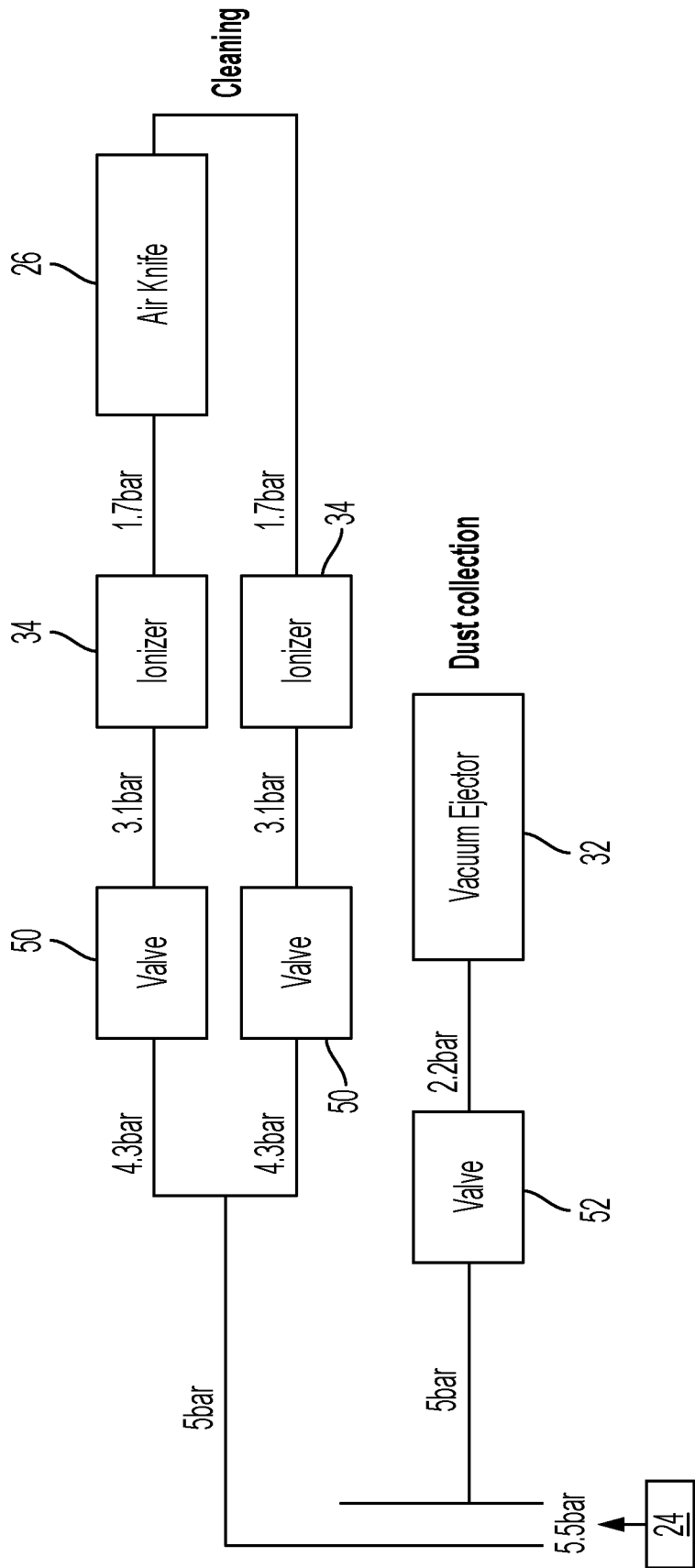


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/036109

A. CLASSIFICATION OF SUBJECT MATTER**H01L 21/67**(2006.01)i; **H01L 21/677**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01L 21/67(2006.01); A47L 5/14(2006.01); A47L 9/08(2006.01); H01L 21/66(2006.01); H01L 21/677(2006.01);
H01L 21/683(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: inspection, platform, carrier, cleaning, air expulsion, ionizer, surtion, vacuum, optical

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014-0078497 A1 (KYU-BUM KIM et al.) 20 March 2014 (2014-03-20) see paragraphs [0029]-[0066] and claims 1-8	1-4,7-12
A		5,6,13-19
Y	US 2022-0344178 A1 (PINK GMBH THERMOSYSTEME) 27 October 2022 (2022-10-27) see paragraphs [0038]-[0039] and claims 15-17	1-4,7-12
Y	US 2021-0307577 A1 (DISCO CORPORATION) 07 October 2021 (2021-10-07) see claims 1-2	3,4
A	WO 2008-111758 A1 (INTEKPLUS CO., LTD. et al.) 18 September 2008 (2008-09-18) see claims 1-2 and figure 1	1-19
A	US 2002-0092368 A1 (JOICHI NISHIMURA et al.) 18 July 2002 (2002-07-18) see paragraphs [0116]-[0121] and claims 9-16	1-19



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

18 October 2024

Date of mailing of the international search report

18 October 2024

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US2024/036109

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