

STORAGE CASE

The present invention relates to a storage case suitable for temporarily storing materials, blanks and parts such as semiconductor wafers, photo-masks and so forth to help prevent contamination by dust during the
5 production of various semiconductor devices.

As is well known to those skilled in the art, the production of various semiconductor devices is conducted in a so-called "clean" room in which the air is low in
10 contaminants such as dust and the temperature and humidity of the air are controlled to fall within pre-determined ranges.

Apparatus for producing semiconductor devices is usually placed at a position in the clean room where the
15 highest cleanliness of air is obtained, and the production of the semiconductor devices is conducted by operators who are stationed in front of the apparatus.

Generally, the production process for semiconductor devices, particularly (Large Scale Integrated Circuits
20 (LSIs) employs a large number of successive steps in each of which semiconductor wafers are processed by a separate apparatus.

In most cases, these successive steps are not carried out continuously. Thus, the semiconductor wafers
25 processed in a certain step are usually accumulated and temporarily stored before they are sent to the next step.

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Usually, the temporary storage of the semiconductor wafers employs a clean bench adapted to store cassettes each of which carries a predetermined number of semiconductor wafers, or a case for containing the cassettes
5 and provided with a lid which can perfectly seal the interior of the case.

These conventional methods of temporary storage of the semiconductor wafers, however, cannot prevent the contamination of the wafers and other parts satisfactorily. Namely, it is often experienced that the
10 wafer and other parts under the temporary storage are contaminated by dusts and other contaminants, resulting in a reduction of yield of the semiconductor devices.

To solve these problems, the invention provides
15 a storage case for temporarily storing materials, blanks and parts such as semiconductor wafers or photo-masks comprising: a case body placed in a clean room and defining a storage space; an air filter having a dust collection efficiency higher than that of an air filter
20 used for keeping a predetermined degree of cleanliness of the air in the whole space of said clean room; means for introducing a gas from the upper side of said case body into said storage space through said air filter of higher dust collection efficiency, and discharge means
25 for allowing the gas introduced into said storage space to be discharged into the clean room from the lower side of said case body without circulation in the storage space

whereby a higher degree of cleanliness of atmosphere is maintained in said storage space than in the whole space in said clean room.

An embodiment of the invention will now be described by way of example, with reference to the accompanying drawing, in which the sole figure is a schematic illustration of an essential part of a storage case embodying the present invention.

An experimental measurement was conducted to investigate the conditions in which contaminants become attached to silicon wafers in the course of production of semiconductor devices. The measurement showed that the attaching of contaminants is heavy particularly in the following three cases: a first case in which a part
15 of the

body of an operator comes into the area within 10 cm from the silicon wafer, a second case in which the operator works at the upstream side of the semiconductor device as viewed in the direction of flow of the semiconductor wafer, and a third case in which the wafers are taken into and out of the cassette. It proved also that, when the semiconductor wafer is positioned in parallel with the flow of the air, the amount of attaching or deposition of contaminants such as dust and other particles is as small as about 1/3 of that observed when the wafer is positioned perpendicularly to the flow of air. It is also understood that the storage of the semiconductor wafers in a case having a lid is not preferred because of the production of dust and other contaminants due to wear in the frictional parts during repeated opening and closing of the lid.

It is clear that an enhancement of the cleanliness of air in the clean room is effective in diminishing the attaching of the dust and other contaminants to the wafers during the storing.

The enhancement of cleanliness of the air, however, requires the use of an air filter having a higher collection efficiency. The higher collection efficiency, however, is accompanied by a greater resistance and, hence, a larger pressure drop across the air filter. For maintaining the necessary air flow rate through a filter having a higher collection efficiency, therefore, it is

necessary to increase the rate of air supply thereby to compensate for the reduction of the flow rate caused by the pressure drop across the filter.

In order to extremely enhance the cleanliness of the air in the clean room, therefore, it is necessary to employ a large number of air filters having high collection efficiency, resulting in a rise of not only the installation cost but also the running cost of the clean room.

10 Although in recent years remarkable progress has been made in the automation of production of semiconductor integrated circuits, the total time length of storage of silicon wafers between successive steps of the process
15 is more than 50% of the time length required by the whole process. In the case of the photo-masks, the waiting or storage time is more than 95% of the whole process time.

From this point of view, clearly, the
20 diminishing of attaching of dust and other contaminants to the silicon wafers and photo-masks in the stored or waiting condition is quite an important factor for improving the yield of the semiconductor integrated circuit. To this end, it
25 is effective to store the silicon wafers and photo-masks within air of the highest cleanliness. It is also clear that the cost will be remarkably saved if only the air around the stored silicon

wafers and photo-masks is to be maintained at the highest cleanliness, as compared with the case in which whole air in the clean room is maintained at the highest cleanliness.

5 This concept of the invention will be fully realized from the following description of the preferred embodiments.

Referring first to the sole figure showing a first embodiment of the invention, a storage case embody-
10 ing the invention has a case body 1 which may be formed from a metallic or a synthetic resinous material. In the described embodiment, the case body 1 is made of stainless steel. The upper side of the storage case is kept opened and is connected
15 through a flange 6 to a duct 4 which is provided at its upper end with an air filter 2 having a high collection efficiency. The duct 4 is disconnectable from the case body 1 so that, in the case of accident such as propagation of bacteria or micro-
20 organism within the case body 1, it is easy to take necessary countermeasures such as washing by aqueous solution of hydrogen peroxide, formalin or the like, after the separation of the dust from the case body 1.

25 The lower or bottom wall of the case body 1 is provided with a multiplicity of small apertures which permits an easy permeation by air.

Therefore, as a blower (not shown) mounted on

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the air filter 2 is operated, the air 3' in the clean room is induced by the fan. After removal of dust and other contaminants by the air filter 2, this air of an extremely high cleanliness is introduced into the case body 1 through the duct 4 and is finally discharged to the outside of the case body 1 through the apertures in the bottom wall of the case body.

On the other hand, the silicon wafers 16 conveyed along a wafer path 7 are successively loaded in a buffer cassette 9 after being stopped by a vacuum stopper 8.

After the loading of the buffer cassette with a predetermined number of silicon wafers, a cassette frame 11 on the end of a support rod 10 is rotated 90° as indicated by an arrow 15 so that the buffer cassette 9 is turned from the upright position to a horizontal position. Subsequently, a support base 12 carrying the support rod 10 is moved towards the case body 1 along rails or a guide 13 so that the buffer cassette 9 carried by the support frame 11 is also moved and comes into the case body 1 through an opening 14 formed in one side wall of the case body 1. The buffer cassette 9 and, hence, the wafers 16 in the cassette 9 are stored in the case body 1 until they are sent to the next step of the process. Needless to say, the silicon wafers 16 can be taken out of

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the case body by taking a reverse procedure. The buffer cassette 9 in the case body 1 can be moved in quite a gentle and delicate manner by a mechanism on the support rod 10 so that no dust
5 nor other particles are produced when the buffer cassette 9 is moved and stopped.

In the described embodiment, the storage case was placed in a clean room the air in which was cleaned to a degree of class 100, i.e. to a
10 degree in which the number of particles of sizes greater than $0.5 \mu\text{m}$ is less than 100 pieces per cubic foot (pieces/ft³) (approx 3500 pieces/m³), by means of a HEPA High Efficiency Particulate Air) filter which has a collection efficiency of 99.99% for dust
15 particles greater than $0.3 \mu\text{m}$. This type of filter is the most widely used for clean rooms.

On the other hand, a filter using an extremely fine glass fiber was used as the air filter 2 of high collection efficiency mounted on
20 the top of the duct 4. This filter could arrest 99.995% of fine particles of sizes of $0.1 \mu\text{m}$. It was confirmed that, by supplying the air to the case body 1 through this filter at a rate of 300 substitutional cycles per hour, the air in the storage
25 case was maintained at a degree of cleanliness of class 1 (number of particles greater than $0.5 \mu\text{m}$ being less than 1 per cubic foot - less than approx. 35 per m³) which is much higher than the degree of cleanliness of

air outside the storage case.

An experiment was conducted in which silicon wafers 16 of 3 inches (approx. 76 mm) in diameter were placed in a vertical position as shown in the figure within the case body 1 in which the air was conditioned as stated above. After leaving the wafers 16 in this state for 2 hours, the number of particles greater than 0.3 μm were measured but no such particle was found in any of the silicon wafers.

By way of comparison, silicon wafers of 3 inches in diameter were placed in the vertical position at the outside of the storage case, i.e. within the atmosphere of the clean room, and were held for 2 hours. A subsequent measurement showed, as a mean value, 6 particles of size greater than 0.3 μm on each silicon wafer. From this fact, it is clear that the storage case of the invention is quite effective in preventing attaching of dust and other contaminants to the surface of the silicon wafers.

The air filter 2 on the top of the duct 4 of the storage case of the invention exhibited a pressure drop of 24 mm Aq which is about 20% greater than that caused by the aforementioned HEPA filter used for cleaning the air for the clean room as a whole.

However, since the filter 2 is used

not for the whole air in the clean room but only for the small volume of air which is circulated through the storage case, the rise of the cost incurred by the increase in the pressure drop is extremely small and is
5 materially negligible.

Although in the described embodiment air of high cleanliness is circulated through the storage case, the invention does not exclude the use of an inert gas such as nitrogen gas in place
10 of the air to prevent oxidation of the surface of the silicon wafer. Needless to say, in this case also, the cleanliness of the atmosphere in the storage case is maintained at an extremely high level to prevent attaching of the dust and other particles.

15 The use of stainless steel as the material of the duct and the case body is not essential, and the duct and the case body may be produced from other materials such as polyvinyl chloride and acrylic resin, or other kind of material
20 such as quartz. The use of a metallic material, however, is preferred because the use of a metallic material is effective in preventing electrostatic charge of the case body.

Obviously, in some cases, the silicon
25 wafers are stored in the storage case for a period longer than two hours, although in the experiment the silicon wafers were held for two hours within

the storage case.

If the supply of the clean air into the storage case is suspended, dust particles and other contaminant will be accumulated on the inner surfaces of the case body and the duct. It is, therefore, necessary to sufficiently clean the inner surfaces of the case body and the duct in advance to the storage of the wafers. Therefore, when the storage case of the invention is used in the actual production of the semiconductor devices, it is preferred that the cleaned air is continuously supplied into the storage case without suspension even when the wafers are not stored, i.e. even when the storage case is vacant.

Although silicon wafers are mentioned specifically in the foregoing description of the embodiment, no attaching of the dust or other particles greater than $0.3 \mu\text{m}$ was confirmed also when the storage case of the invention stored photo-masks in place of the silicon wafers.

As has been described, air of the highest cleanliness is circulated not through the whole part of the clean room but only through the small volume of the storage case. Therefore, the rise in the installation cost and running cost is extremely small and materially negligible, despite the use of an air filter of a high collection efficiency which causes a large pressure drop.

Furthermore, since the silicon wafers and the photo-masks are made to stay or stored within the storage case held at the highest cleanliness for a long time which well exceeds a half of
5 the whole processing time until the semiconductor device is completed, the contamination of the silicon wafers and photo-masks are much reduced as compared with the conventional technique to ensure a remarkable improvement in the yield.

10 In general, the higher density of integration of the semiconductor integrated circuit requires a higher degree of cleanliness of the air in the clean room, which in turn necessitates an air filter having a higher collection efficiency.
15 However, with the present embodiment, it is possible to cope with the demand for the higher degree of integration of the semiconductor circuits, because the specifically high cleanliness of air is required only for the storage case which has a
20 volume much smaller than the volume of the whole clean room.

In addition, since the interior of the storage case in which the silicon wafers and photo-masks are stored is shielded from the exterior of
25 the same, the silicon wafers and photo-masks are effectively protected from contamination by the workers or operators in the clean room. In

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consequence, the limitation of the number of the
workers or operators, as well as the restriction
of the movement of the workers or operators, is made
less severe to a great advantage from the practical
5 point of view.



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CLAIMS:

1. A storage case for temporarily storing materials, blanks and parts such as semiconductor wafers or photo-masks comprising: a case body placed in a clean room and defining a storage space; an air filter having a dust collection efficiency higher than that of an air filter
5 used for keeping a predetermined degree of cleanliness of the air in the whole space of said clean room; means for introducing a gas from the upper side of said case body into said storage space through said air filter of higher dust collection efficiency and discharge means for allowing the gas introduced into said storage space to be discharged
10 into the clean room from the lower side of said case body without circulation in the storage space whereby a higher degree of cleanliness of atmosphere is maintained in said storage space than in the whole space in said clean room.
2. A storage case according to claim 1 further comprising a duct
15 detachably attached to the upper side of said case body, said duct carrying at its upper part said air filter of higher dust collection efficiency.
3. A storage case according to either one of claims 1 and 2,
further comprising means for automatically bringing said materials,
20 blanks and parts such as semiconductor wafers or photomasks into and out of said storage space.
4. A storage case according to any one of claims 1, 2 and 3, wherein said discharge means has a plurality of small apertures formed in the bottom wall thereof.
- 25 5. A storage case according to any one of claims 1 to 4, having means for holding semiconductor wafers or photo-masks in said storage space disposed



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such that their major surfaces are positioned in parallel with the direction of flow of the gas introduced into said storage space through said filter of higher dust collection efficiency.

5 6. A storage case substantially as described herein with reference to the accompanying drawings.

7. A method of manufacturing semiconductor devices, using a storage case according to any one of the preceding claims, in which semiconductor wafers are subjected to
10 various processes within said clean room, and wherein between said processes the wafers are stored in said storage case within said clean room.

8. A method of manufacturing semiconductor devices, using a storage case according to any one of claims
15 1 to 6, in which photo-masks are used to process semiconductor wafers within said clean room, and wherein the photo-masks are stored in said storage case within said clean room when not in use.

9. A method according to claim 7 or claim 8 wherein
20 said means for introducing gas into said storage space through said air filter of higher dust collection efficiency is kept operational even when there are no wafers or photo-masks within the storage space.

10. A method of manufacturing semiconductor devices
25 according to claim 7 or claim 8, and substantially as described herein.
