

CLEAN TRANSFER METHOD AND SYSTEM THEREFOR

This invention relates to a clean transfer method and a system therefor, and more particularly to a transfer method which permits components or elements required for the processing and/or assembling of a product associated with a semiconductor to be transferred while being kept clean and a system therefor.

A conventional clean transfer method is generally practiced in such a manner as shown in Figs. 1 and 2. More particularly, a closed space 110 is divided into a maintenance room 112 and a clean room 114 by means of a partition 116. The maintenance room 112 is open to an ambient atmosphere and provided therein with various apparatus 118 used for a precision thin film-forming process required for manufacturing a semiconductor.

The clean room 114 is kept at an air cleanliness ranging from class 100 to class 10. The words "class 100" used herein indicate a cleanliness having 100 or less particles of 0.5 μ m or larger in size contained in one cubic foot of air and the words "class 10" indicate a cleanliness having 10 or less particles of 0.5 μ m or larger in size contained in one cubic foot of air. An air stream is blown down from a ceiling of the clean room 114 through a filter 120 into the clean room. The air stream is then outwardly exhausted through a floor 122 formed into a grating construction. In the so-constructed clean room 114 a clean shuttle 124 which is kept at a cleanliness ranging from classes 10 to 1 is movably arranged. The words "class 1" indicate a cleanliness having 1 or less particle of 0.5 μ m or larger in size contained in one cubic foot of air. The apparatus 118 are each provided with a transfer port which is open to the surface of the partition facing the clean room 114. A vicinity 126 of each transfer port opening is locally kept at a cleanliness ranging from classes 10 to 1.

The delivery of an object 128 such as a semiconductor wafer or the like between the clean shuttle 124 and the apparatus 118, as shown in Fig. 2, is carried out by introducing the object 128 from the

clean shuttle 124 through the vicinity 126 of the periphery of the transfer port locally kept at a cleanliness ranging from classes 10 to 1 to a load lock chamber 130 of the apparatus 118 serving as a preliminary vacuum chamber, closing a shutter of the transfer port on the side of the apparatus to evacuate the preliminary vacuum chamber, and transferring the object 128 to a vacuum chamber 132 of the apparatus 118.

In the conventional clean transfer method shown in Figs. 1 and 2, the clean room 114 must be kept at a cleanliness as high as classes ranging from 100 to 10 and formed so as to define a large space therein. Unfortunately, much cost is required to keep the clean room 114 at a high cleanliness while maintaining the large space therein. Also, in the conventional clean transfer method, it is required to provide the load lock chamber 130 for receiving the object on the side of the apparatus 118 provided with the vacuum chamber 132, as well as to evacuate the load lock chamber 130 to vacuum. This causes the side of the apparatus to be complicated in structure. In addition, it is substantially impossible to improve the cleanliness to a degree sufficient to render the number of airborne particles substantially near zero. In particular, there is a possibility that particles will contaminate the object during the delivery of the object between the clean shuttle 124 and the apparatus 118.

Another conventional clean transfer method has been proposed and comprises a multi-chamber system as shown in Fig. 3. The multi-chamber system is so constructed that a single load lock chamber provided for accessing an object such as a semiconductor wafer or the like therethrough is commonly used for a sputtering apparatus 134, a CVD apparatus 136, an etching apparatus 138 and the like.

Unfortunately, a clean transfer method using the multi-chamber system shown in Fig. 3 has the following disadvantages: it is impossible to increase the number of apparatus to be arranged in the system, the apparatus cannot be freely arranged, and maintenance is troublesome.

We proposed a clean transfer method as

disclosed in Japanese Patent Application Laid-Open Publication No.28047/1988. However, the publication fails to consider the degree of vacuum in a clean chamber.

We have found that in processes relating to a semiconductor such as vapor deposition, sputtering, ion implantation and the like, an improvement in degree of vacuum to 1 Torr or less effectively prevents floating of particles.

In accordance with one aspect of the present invention, a clean transfer method is provided. The clean transfer method comprises the step of transferring an object such as a semiconductor wafer or the like between a vacuum clean box kept at a vacuum of 1 Torr or less and a vacuum chamber while keeping transfer ports of the vacuum clean box and vacuum chamber air-tightly connected to each other, wherein said vacuum chamber is arranged in a first room open to an ambient atmosphere and said vacuum clean box is arranged in a second room isolated from said first room, and said second room has a smaller concentration of airborne particles than said first room.

In accordance with another aspect of the invention, a clean transfer system is provided. The clean transfer system comprises a vacuum clean box which, in use, is kept at a vacuum of 1 Torr or less and a vacuum chamber which are each provided with transfer ports through which they can be air-tightly connected to each other, wherein said vacuum chamber is arranged in a first room open to an ambient atmosphere and said vacuum clean box is arranged in a second room isolated from said first room, and said second room has a smaller number of airborne particles than said first room.

Embodiments of the present invention can variously provide a clean transfer method and system capable of safely transferring an object such as a semiconductor wafer or the like to various apparatus each provided with a vacuum chamber while keeping the environment clean;

a clean transfer method and system capable of being effectively directed to various applications, such as the formation of a thin film with high precision;

a clean transfer method and system capable of being efficiently applied to the manufacturing of a super-precision component to improve the yields thereof; and

a clean transfer method and system capable of exhibiting flexibility sufficient to permit diversified small-quantity production to be accompanished. The method of the present invention can permit the system used for practicing the method to be simplified in structure.

In the present invention the object is transferred between the vacuum clean box kept at a vacuum of 1 Torr or less and the vacuum chamber while air-tightly connecting the respective transfer ports of the vacuum clean box and vacuum chamber to each other, so that it is not required to keep a clean room in which the vacuum clean box having a good cleanliness is moved. More specifically, the clean room may merely require to be kept at a cleanliness as low as class 10,000. The words "class 10,000" indicate a cleanliness having 10,000 or less particles of 0.5 μ m or larger in size contained in one cubic foot of air. Thus, the clean room can have a simplified structure. More particularly, the present invention permits the above-described floor of grating configuration required in the prior art to be eliminated from the clean room, resulting in the structure of the clean room being highly simplified so that its cost can be reduced. Also, the present invention permits the object to be carried while keeping the environment in which the object

is transferred clean, to thereby realize the formation of a thin film with high precision. Further, the present invention does not restrict the way that the apparatus for processing or treating the transferred object is arranged, thereby exhibiting flexibility sufficient to accomplish diversified small-quantity production.

The invention is illustrated, by way of example, by the following detailed description to be considered in connection with the accompanying drawings, wherein :

Fig. 1 is a plan view showing a conventional clean transfer method and a system therefor;

Fig. 2 is a schematic side elevation view of the clean transfer system shown in Fig. 1;

Fig. 3 is a plan view showing a conventional multi-chamber system;

Fig. 4 is a schematic plan view showing an embodiment of a clean transfer method and a system therefor according to the present invention;

Fig. 5 is a schematic side elevation view of the clean transfer system shown in Fig. 4;

Fig. 6 is a side elevation view showing a vacuum clean box and a vacuum chamber prior to the connection therebetween;

Fig. 7 is a side elevation view showing a vacuum clean box and a vacuum chamber which are connected to each other;

Fig. 8 is a graphical representation showing relationships between the number of airborne particles floating in a chamber and the degree of vacuum of the chamber; and

Fig. 9 is a graphical representation showing the number of airborne particles when air leakage occurs in a chamber kept vacuum-sealed.

In Figs. 4 to 9, like reference numerals designate like or corresponding parts throughout. In the embodiment of the invention

shown in Figs. 4 to 7, a closed space 10 is divided into a maintenance room 12 open to or communicating with an ambient atmosphere and a simplified clean room 14 by means of a partition 16. The clean room 14 may be kept at a cleanliness somewhat higher than the maintenance room 12. In the maintenance room 12 various apparatus 18 used for precision thin film formation and the like carried out for the manufacturing of a semiconductor are arranged. The apparatus 18 are each provided with a vacuum chamber 20.

The cleanliness of the simplified clean room 14 may be kept as low as about class 10,000; therefore, it is not necessary for the clean room 14 to be provided with such a floor of a grating structure as required in the prior art shown in Fig. 2. Thus, it is merely required to provide the clean room 14 with simple dust-proof means. The partition 16 is provided on the surface thereof facing the simplified clean room 14 with a flanged transfer port 22 for the apparatus 18. In the simplified clean room 14 a vacuum clean box 24 is movably arranged and mounted on a carriage 26 or the like. Thus, the simplified clean room 14 is used as a transfer room for transferring an object. Alternatively, the vacuum chamber 20 or both the vacuum chamber 20 and vacuum clean box 24 may be movably arranged. The vacuum clean box 24 is evacuated to a vacuum of 1 Torr or less, to thereby keep it clean. For this purpose, the vacuum clean box 24 per se may be provided with a vacuum evacuation system. Alternatively, a vacuum evacuation means may be separately arranged so as to communicate with the vacuum clean box 24, resulting in the vacuum clean box being evacuated to a vacuum of 1 Torr or less when use of the box 24 is started. Also, the vacuum chamber 20 as well as the vacuum clean box 24 may be kept at a vacuum of 1 Torr or less.

As shown in Figs. 6 and 7, in the flanged transfer port 22 of each apparatus 18 provided with the vacuum chamber 20 is fittedly arranged a shutter 28 in an air-tight manner. The vacuum clean box 24 is provided with a transfer port 30, in which a shutter 32 is fittedly

arranged in an air-tight manner. For the purpose of assuring air-tightness between the shutter 28 and the transfer port 22 and between the shutter 32 and the transfer port 30, the shutters 28 and 32 are provided with O-rings 34 and 36, respectively. Also, the transfer port 22 on the side of the apparatus 18 is provided on an abutting surface thereof or a flange surface thereof with an O-ring 38. Further, the flange of the transfer port 22 is provided on the rear surface thereof with lock members 40 for locking the shutter 28 with respect to the port 22. In addition, the shutter 28 is provided on an abutting surface thereof with an O-ring 42 and likewise the shutter 32 is provided on an abutting surface thereof with an O-ring 44. Moreover, in the shutters 28 and 32 are embedded permanent magnets 46 and 48, respectively, through which the shutters are connected to each other as desired. The transfer ports 22 and 30 provided respectively with the shutters 28 and 32 may each be formed into a double-gate valve structure.

The vacuum in the vacuum clean box 24 is kept at a level of 1 Torr or less. Now, reference will be made to Figs. 8 and 9. Fig. 8 shows the number of airborne particles of 10 μ m, 5 μ m, 3 μ m, 1 μ m and 0.5 μ m in size counted when an experimental chamber open to an ambient atmosphere was closed at 0 minute and then evacuated to vacuum through a vacuum evacuation system. As will be noted from the results shown in Fig. 8, floating of particles in the experimental chamber is observed when it is evacuated to 20 Torr or 5 to several Torr; however, floating of particles is never observed when the chamber is evacuated to 1 Torr or less. Fig. 9 shows the number of airborne particles counted immediately after a slight amount of air was introduced, by leakage, into the experimental chamber which was vacuum-sealed. This first leakage results in the pressure in the chamber rapidly increasing to 8 Torr, then to 15 Torr after a second leakage, and finally to 20 Torr after a third leakage, the number of airborne particles being counted immediately after each leakage. Fig. 9 indicates that an increase in pressure in the chamber to several Torr or more due to introduction of air into the chamber by

leakage causes floating of particles to occur therein.

Thus, as can be seen from Figs. 8 and 9, the evacuation of the chamber to 1 Torr or less prevents the floating of particles in the chamber, however, an increase in pressure in the chamber to more than 1 Torr, for example, several to 5 or 8 Torr, causes particles to float in the chamber.

The manner of transferring an object 50 such as a semiconductor wafer will be described hereinafter. First, the vacuum clean box 24 is previously evacuated to a vacuum as good as 1 Torr or less to prevent any particles from floating in the chamber. Then the object 50, as shown in Fig. 6, is put on a support 52 arranged in the vacuum clean box 24. Then, as shown in Fig. 7, the transfer port 22 of the vacuum chamber 20 on the side of the apparatus 18 is pressedly contacted with the transfer port 30 on the side of the clean box 24 through their abutting surfaces, so that transfer ports 22 and 30 may be connected to each other in an air-tightly sealed manner. Concurrently, the above causes the shutters 28 and 32 to face each other through their abutting surfaces by the action of the permanent magnets 46 and 48, so that the O-rings 42 and 44 cause air between the abutting surfaces of the shutters 28 and 32 to be sealedly held therebetween. Then, the lock members 40 are released to remove the mutually connected shutters 28 and 32 as indicated by phantom lines in Fig. 7, to thereby cause the transfer ports 22 and 30 to communicate with each other. Subsequently, the object 50 on the side of the vacuum clean box 24 is moved to a predetermined position on the side of the apparatus 18 such as, for example, onto a holder 54 arranged in the vacuum chamber 20 on the side of the apparatus. The transfer of the transferred object 50 from the side of the apparatus to the side of the vacuum clean box likewise may be carried out in substantially the same manner while keeping the transfer ports 22 and 30 air-tightly connected to each other as shown in Fig. 7.

The shutters 28 and 32 can be removed while being air-tightly held together, so that the removal of the shutters does not cause leakage of air into the system. Also,

the vacuum chamber 20 on the side of the apparatus 18 is kept at high vacuum of 1 Torr or less; thus, the communication between the vacuum chamber 20 on the side of the apparatus and the vacuum clean box 24 does not cause the degree of vacuum in the vacuum clean box 24 to be more than 1 Torr, resulting in the vacuum clean box being effectively used for transferring the next object without being further evacuated.

As can be seen from the foregoing, the present invention permits an object such as a semiconductor wafer or the like to be carried while keeping the transfer port of the vacuum clean box at a

vacuum of 1 Torr or less and the transfer port of the vacuum chamber air-tightly connected to each other, so that the transfer of the object may be carried out while keeping the environment clean or free of any airborne particle. Thus, the present invention can be effectively applied to the high precision formation of a thin film and the like, and thus it can be fully applied to the manufacturing of a super-precision element, such as the type of semiconductor expected in the future, while improving the yields thereof. Also, the present invention permits the number of vacuum clean boxes and vacuum chambers to be varied as desired, resulting in it exhibiting flexibility sufficient to permit diversified small-quantity production to be attained. Further, in the present invention, the cleanliness of the chamber in which the vacuum clean box is moved can be kept at a relatively low level, to thereby significantly simplify the structure. Moreover, the object is carried directly from the vacuum clean box to the vacuum chamber, so that the load lock chamber required in the prior art or the like may be eliminated, to thereby further simplify the structure.

While a preferred embodiment of the invention has been described with a certain degree of particularity with reference to the drawings, obvious modifications and variations are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.



CLAIMS :

- 5 1. A clean transfer method comprising the step of transferring an object between a vacuum clean box kept at a vacuum of 1 Torr or less and a vacuum chamber while keeping transfer ports of said vacuum clean box and vacuum chamber air-tightly connected to each other, wherein said vacuum
10 chamber is arranged in a first room open to an ambient atmosphere and said vacuum clean box is arranged in a second room isolated from said first room, and said second room has a smaller concentration of airborne particles than said first room.
- 15 2. A clean transfer method according to claim 1 wherein said transfer port of said vacuum chamber is arranged on a side of said second room.
- 20 3. A clean transfer method as defined in claim 2 wherein said first room and second room are a maintenance room and a transfer room respectively and are isolated from each other by a partition, said transfer port of said vacuum chamber being arranged on a side of said partition facing said second room.
- 25 4. A clean transfer method as defined in claim 1, 2 or 3 wherein at least one of said vacuum clean box and vacuum chamber is movable.
- 30 5. A clean transfer method as defined in claim 4 wherein said vacuum clean box is movably arranged.
- 35 6. A clean transfer method as defined in claim 5 wherein said vacuum clean box is movably arranged with respect to a plurality of said vacuum chambers, and said vacuum clean box is capable of being selectively air-tightly connected with each of said vacuum chambers.
- 40 7. A clean transfer method as defined in any preceding claim wherein said vacuum chamber is kept at a vacuum of 1 Torr or less.



8. A clean transfer method as defined in any preceding claim wherein said vacuum chamber is arranged in an apparatus for processing said object.

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9. A clean transfer method as defined in any preceding claim wherein said transfer ports of said vacuum clean box and vacuum chamber are provided with shutters for operating said vacuum clean box and vacuum chamber, respectively, said method further comprising the step of removing said shutters from said vacuum clean box and vacuum chamber while said shutters are air-tightly connected together to result in said vacuum clean box and vacuum chamber communicating with each other.

10. 10. A clean transfer method as defined in claim 9 wherein said removing step includes disposing said coupled shutters in one of said vacuum clean box and vacuum chamber.

11. A clean vacuum transfer system comprising a vacuum clean box which, in use, is kept at a vacuum of 1 Torr or less and a vacuum chamber which are each provided with a transfer port through which they can be air-tightly connected to each other, wherein said vacuum chamber is arranged in a first room open to an ambient atmosphere and said vacuum clean box is arranged in a second room isolated from said first room, and said second room has a smaller number of airborne particles than said first room.

12. A clean transfer system according to claim 11 wherein said transfer port of said vacuum chamber is arranged on a side of said second room.

13. A clean transfer system as defined in claim 12 wherein said first room and second room are a maintenance room and a transfer room respectively and are isolated from each other by a partition, said transfer port of said vacuum chamber being arranged on side of said partition facing said second room.

14. A clean transfer system as defined in claim 11, 12 or 13 wherein at least one of said vacuum clean box and vacuum chamber is movable.



15. A clean transfer system as defined in claim 14 wherein said vacuum clean box is movably arranged.
- 5 16. A clean transfer system as defined in claim 15 comprising a plurality of said vacuum chambers and wherein said vacuum clean box is capable of being selectively air-tightly connected with each of said vacuum chambers.
- 10 17. A clean transfer system as defined in any one of claims 11 to 16 wherein said vacuum chamber is kept at a vacuum of 1 Torr or less.
- 15 18. A clean transfer system as defined in any one of claims 11 to 17 wherein said vacuum chamber is arranged in an apparatus for processing said transferred object.
- 20 19. A clean transfer system as defined in any one of claims 11 to 18 wherein said transfer ports of said vacuum clean box and vacuum chamber are provided with shutters for operating said vacuum clean box and vacuum chamber, respectively, said shutters being removable from said vacuum clean box and vacuum chamber while being air-tightly connected together to result in said vacuum clean box and vacuum chamber communicating with
- 25 each other.
20. A clean transfer method substantially as hereinbefore described with reference to Figs.4 to 7 of the accompanying drawings.
- 30 21. A clean transfer system substantially as hereinbefore described with reference to Figs.4 to 7 of the accompanying drawings.