ADHERENT FILM RECOVERING DEVICE AND METHOD OF RECOVERING ADHERENT FILM

FIELD OF THE INVENTION

The present invention relates to an adherent film recovering device for recovering an adherent film made of metal or metal compound adhered to an anti-adherent plate, mask, a substrate tray, or other depositing jig adopted in a vacuum deposition device for use in forming a thin film made of metal or metal compound by the sputtering method, the vacuum deposition method, the ion-plating method, or the CVD method, and also relates to the method of recovering such adherent film.

BACKGROUND OF THE INVENTION

In recent years, an increase in electronic apparatuses, in particular, information-related apparatuses become even more striking in the convergence toward the mass producing and mass waste-producing society. Such an electric apparatus includes as essential members, a semiconductor, a flat display panel including a liquid crystal panel, solar battery, a semiconductor device, memory, etc.

The foregoing electric apparatus is manufactured by the vacuum deposition device using the sputtering method, the vacuum deposition method, the ion-plating method, or other vacuum deposition method, and materials containing rare metal are typically adopted in forming films.

With an increasing demand for such electronic apparatuses which adopt films made of rare earth, in particular, indium, tantalum, etc., a problem of exhaustible resources therefore becomes an issue. In response, development of techniques and concrete method of recovering and recycling such rare metal, which permits a reduction in an amount of waste produced in stages of both production and use is strongly demanded.

Examples of such rare metal can be listed in order from the smallest amount of deposit as: indium (In) < rhenium (Re) < tantalum (Ta) < gold (Au) < platinum group (Pt) < serene (Se) < cesium (Cs) < gallium (Ga) < bismuth

(Bi) < mercury (Hg) < silver (Ag).

In the described vacuum deposition method, adopted are i) an anti-adherent plate for preventing an adherent film from thick adhering to other parts than a deposition substrate, for example, a vacuum container, ii) a mask for forming a film only at a predetermined part as desired of the substrate (wafer), iii) a substrate tray for transporting the substrate, etc. Hereinafter, these members are referred to as a general term of depositing jigs (parts for depositing). To such depositing jig also, an adherent film made of a material of the same composition or almost the same composition as the thin film formed on the substrate is to be adhered.

Furthermore, since the foregoing depositing jig is subjected to repetitive use, the adherent film adhered thereto is liable to become thicker than that of the thin film formed on the substrate. When the adherent film adhering to the depositing jig becomes of some thickness, it is released in pieces from the depositing jig due to internal stress of the adherent film or recurring heat history, and the adherent film pieces as released from the depositing jig are adhered to the substrate, which causes a local defect in thin film (this defect is generally known as "particle contamination").

In order to counteract the foregoing problem, the

depositing jig is periodically taken out of the vacuum deposition device before the adherent film becomes of such thickness that the foregoing problem of particle contamination is liable to occur, and the depositing jig as taken out is subjected to cleaning to remove therefrom the adherent film and also to the surface finishing to be reusable.

Here, the above-mentioned depositing jig will be explained in detail. For a material of the depositing jig adopted in the vacuum deposition device, adopted is a metal which hardly adsorbs gas and which permits gas to be discharged with ease, in order to maintain the inside of the device vacuum. Examples of such metal include: stainless (SUS), $Ni_{42}Fe_{58}$(42 alloy) or other alloy of nickel-iron, aluminum, titanium, copper, etc.

The foregoing depositing jig is generally finished with surface roughness for the purpose of increasing the adhesive force, so that the required cleaning of the depositing jig can be performed at longer intervals. For example, the depositing jig made of iron series material is finished with surface roughness of around several microns, that made of aluminum is finished with surface roughness of around several tens microns by the surface treatment of the aluminum spray deposit, and that made of copper is finished with surface roughness of around

several tens m by embossing a sheet made of a material containing copper as a main component.

Conventionally, for the foregoing cleaning of the depositing jig, the sand-blast method is adopted wherein the adherent film is released and removed by the impact force exerted when the depositing jig is hit by so-called "sand particles", such as alumina particles or silicon carbide particles of around several hundreds microns ϕ, using air pressure. In some cases, the wet-etching method is also adopted. Japanese Unexamined Patent Application No. 11-198344/1999 (Tokukaihei 11-198344, published on July 27, 1999) discloses the method of removing adhesive or tape adhering to a screen frame by the abrasive-blasting method.

In the foregoing processing method, however, a large amount of sand-blast debris or waste acid solution is discharged, which contain adherent film pieces only at low ratio, for example, for the in sand-blast debris, adherent film pieces are contained only at around 0.1 to 5 percents by weight, and in the waste acid solution for etching, only at around 0.2 to 1.1 g/ℓ (10^3 cm^3).

With the foregoing method, it is therefore not economically viable to recover such adherent film pieces of low content or density, and the adherent film pieces are therefore disposed as waste without being recovered.

In response, the development of new processing method which eliminates the problem associated with the conventional method by reducing the amount of waste at low cost is strongly desired. Further, it is desirable that the adherent film pieces as removed be recycled. Particularly for those containing such rare metal as indium or tantalum, the effective utilization of such rare metal is therefore an important issue.

On the other hand, for a pixel electrode, a counter electrode, an electrode of PDP (Plasm Display Panel) or an organic or inorganic EL, an electromagnetic wave filter for the PDP, a touch panel, solar battery for use in liquid crystal panels as transparent electrically conductive films, rare metal of ITO (Indium Tin Oxide) are typically adopted for its beneficial characteristics of high transmittance (transparency), and low electric resistance (specific resistance).

However, indium contained in ITO is a metal of small amount of deposit called "rare metal", and the consumption of such liquid crystal panels adopting such rare metal, only for those produced domestically, already accounts for over 40 percent of the total consumption in the world, and is still rapidly increasing by 16 percent/year. In view of this situation, the recovering and recycling of indium is a critical issue.

For the preparation of thin films of ITO, the sputtering method, the vacuum deposition method, ion-plating method, or other vacuum deposition method is typically adopted. For example, a thin film of a transparent electrode made of ITO for use in, for example, a liquid crystal display, is prepared by the sputtering method.

In the sputtering method, for example, as illustrated in Fig. 6, a reusable amount of the target is around 30 percent by weight of the total amount of the target, and an amount of the target adhering to the depositing jig is estimated to be around a half of the above reusable amount (around 15 percent by weight of the total amount). At present, unused target which occupies around 70 percent by weight is returned to a manufacturer to be recycled; however, the remaining target is wasted without being recycled. As is clear from Fig. 6, if the ITO can be recovered and recycled, an amount of use of ITO, namely, an amount of use of indium would be practically reduced to around half.

On the other hand, for example, some methods for recovering indium to be recycled by carrying out a chemical extraction by dissolving ITO contained in the sand-blast debris with hydrochloric acid and nitric acid have been proposed; however, these methods have not come

into practical use for recycling the ITO for the following reason. That is, the ratio of the content of ITO in the sand-blast debris or waste acid solution is too low, and it is not economically viable to recover the ITO by such methods. Specifically, for example, for the sand-blast debris, adherent film pieces are contained only at around 0.1 to 5 percent by weight, and for the waste acid solution of etching, only at around 0.2 to 1.1 g/ℓ.

In view of the foregoing, the development of processing techniques for cleaning the depositing jig, which permits the recovering of a material with high content of ITO at low cost, is critical to realize the economically viable recycling of the adherent film pieces and carry the recycling of the rare metal forward.

On the other hand, for the sand-blasting method, when processing, a part of sand particles is also crashed into small pieces, and the processing ability is lowered. In response, the resulting small pieces of sand particles as crushed and film pieces are removed using a cyclone separator. In this stage, a large amount of sand-blast debris is produced as waste, and the disposition of such waste takes a lot of trouble. In response, the development of the cleaning method which produces less waste is desired.

Conventionally, the method of removing dust particles (grime), a coating film, a label of a can, etc., using the water-jet device of the aqua system, or of the abrasive system using abrasive particles are known.

The foregoing conventional methods, however, have been adopted for obtaining a clean base material of an iron plate or a can, etc., by removing therefrom an extraneous material such as dust particles on the surface, a coating film, a label of the can, etc., which has smaller rigidity than that of the base material of the iron plate or the can, etc., and have never been applied for cleaning the depositing jig.

Here, it can be assumed that an attempt to apply the foregoing methods to the cleaning of the depositing jig has not been made mainly for the following two reasons:

i) the material of adherent film adhering to the depositing jig is typically of high rigidity, and it would therefore be difficult to remove such adherent film by the conventional water-jet method of aqua system with relatively low water pressure; and

ii) the sand-blast method of a relatively simple method has been available.

In practice, when adopting the water-jet method, city water is used without being subjected to

pre-cleaning to a sufficient level, and therefore, calcium ions contained in the city water are liable to be deposited as calcium carbonate within a high-pressure water producing device or a cleaning gun, etc., which may cause a failure of the device, or another problem of corrode with chloride may also occur. The foregoing methods are therefore not suitable for the cleaning of the depositing jig.

Besides, in the method of removing labels from cans, etc., adopted is a device of a simple structure which is merely provided with an enclosure for preventing workers from directly receiving high-pressure water. Therefore, adherent film pieces fly in all directions with water within the enclosure, and it is therefore not possible to effectively recover the adherent film pieces.

Known solid-liquid separation methods applicable to the suspension include: the precipitation method, the filtration method, the centrifuge separation method, the film separation method, etc., and an optimal method is to be selected according to the purpose of use, according to, for example, a particle size of the suspension or an amount of the suspension to be treated, etc.

However, when adopting the described conventional method of cleaning the depositing jig such as the sand-

blast method or the etching method using acid, problems arise in that sand-blast debris, or waste acid solution are produced in a large amount; and adherent film pieces contained in the sand-blast debris or waste acid solution are too small to be recovered with ease, and it is therefore not economically viable to recycle the adherent film pieces. As described, particularly for the cleaning of the depositing jig having adhered thereto an adherent film made of a material containing rare metal such as indium or tantalum, etc., it is critical to effectively recover and reutilize (recycle) such rare metal; however, the effective way out of the foregoing problems has not been found.

SUMMARY OF THE INVENTION

It is an object of the present invention is to provide an adherent film recovering device and a method of recovering an adherent film which expedite the recycling use of an adherent film by simplifying the process of recovering the adherent film, while suppressing production of sand-blast debris or acid waste water.

In order to achieve the above object, an adherent film recovering device of the present invention, for recovering an adherent film from a depositing jig mounted

on a holding plate, is characterized by including:

a liquid-jet section which sprays liquid-jet against the depositing jig, for recovering therefrom the adherent film.

According to the foregoing structure, the liquid-jet section for spraying high-pressure liquid-jet is provided, and it is therefore possible to increase the rate of recovering of the adherent film pieces, and at the same time, to provide improved safety for workers.

Moreover, with the above structure, the depositing jig is less ground in the cleaning process as compared to the case of adopting the conventional sand-blast method, and the depositing jig can therefore be reused a greater number of times, i.e., a longer life of the depositing jig can be ensured.

Furthermore, according to the above-structure, the adherent film adhering to the depositing jig can be removed in form of adherent film pieces, and these target adherent film pieces to be recovered can be made larger in size as compared to the case of adopting the conventional sand-blast method. It is therefore possible to surely recover the adherent film pieces in a simpler manner at low cost. As a result, the foregoing structure of the present invention expedites the recycling use of the adherent film.

In order to achieve the above object, a method of recovering an adherent film, for removing and recovering an adherent film adhered to an anti-adherent plate, a mask, a substrate tray or other depositing jig for use in a vacuum deposition device adopting the sputtering method, the vacuum deposition method, the ion-plating method, or other vacuum deposition method, is characterized in that:

a liquid-jet method using water or liquid is adopted for removing the adherent film adhered to the depositing jig.

According to the foregoing method, the liquid-jet method using water or liquid is adopted for removing the adherent film adhered to the depositing jig, and thus the depositing jig is less ground in the cleaning process as compared to the case of adopting the conventional sand-blast method. As a result, the depositing jig can be reused a greater number of times, i.e., a longer life of the depositing jig can be ensured.

Furthermore, according to the above method, the adherent film adhered to the depositing jig can be removed in form of adherent film pieces, and these target adherent film pieces to be recovered can be made larger in size as compared to the case of adopting the conventional sand-blast method. It is therefore possible

to surely recover the adherent film pieces in a simpler manner at low cost. As a result, the foregoing method of the present invention expedites the recycling use of the adherent film.

For a fuller understanding of the nature and advantages of the invention, reference should be made to the ensuing detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a typical depiction illustrating essential parts of a water-jet device as an adherent film recovering device in accordance with the first embodiment of the present invention.

Fig. 2 is a typical depiction illustrating essential parts of a water-jet device as an adherent film recovering device in accordance with the second embodiment of the present invention.

Fig. 3 is a cross-sectional view illustrating essential parts of a sputtering device as one example of a vacuum deposition device wherein an adherent film is adhered to a depositing jig which is subjected to cleaning by the adherent film recovering device.

Fig. 4 is a cross-sectional view illustrating one example of a conventional sand-blast device for removing

an adherent film.

Fig. 5 is a cross-sectional view illustrating essential parts of one example of a liquid crystal panel wherein a thin film is formed by the vacuum deposition device.

Fig. 6 is a graph showing a breakdown of a discharged material of the sputtering device.

Fig. 7 is an explanatory view which explains a method of recovering an adherent film in accordance with the first embodiment of the present invention, and is a flowchart showing operations of the water-jet device of Fig. 1.

Fig. 8 is a typical depiction illustrating essential parts of one example of a water-jet device as an adherent film recovering device in accordance with the third embodiment of the present invention.

Fig. 9 is an explanatory view which explains a method of recovering an adherent film in accordance with the third embodiment of the present invention, and is a flowchart showing operations of the water-jet device of Fig. 8.

Fig. 10 is a side view illustrating a cross-sectional view of essential parts of a cleaning gun of a water-jet device in accordance with respective embodiments of the present invention.

Fig. 11 is an explanatory view showing the size or purity of adherent film pieces as recovered by the water-jet device according to a scanning electron microscope (SEM).

DESCRIPTION OF THE EMBODIMENTS

Referring to Fig. 1 through Fig. 11, the following will describe embodiments of an adherent film recovering device and an adherent film recovering method according to the present invention. First, a sputtering device as shown in Fig. 3 is described below as an example of a vacuum deposition device, in which an adherent film deposits on a depositing jig used in the adherent film recovering device and an adherent film recovering method.

As shown in Fig. 3, a sputtering device 11 includes a deposit room 12 which is provided with a pipe A for supplying discharge gas and a pipe B connected to an evacuator to evacuate the deposit room 12. In the deposit room 12 is provided a target 14 on a target carrier 13 which is electrically separated from the deposit room 12. An anode 15 is also provided in the deposit room 12, surrounding the target 14 and the target carrier 13. On the outside of the deposit room 12 is disposed a magnet 16 in the vicinity of the target 14 with the target carrier 13 in between.

A substrate 17, on which a thin film deposits, is detachably provided on a substrate tray 18 which is electrically separated from the deposit room 12 on the opposite side of the target 14. The substrate tray 18 is detachably provided in the deposit room 12.

On a front surface (surface facing the target 14) of the substrate 17 is placed a mask 19 which is detachably provided to cover a portion of the substrate 17 where no film is required. Further, an anti-adherent plate 20 is detachably provided along the inner surface of the deposit room 12 and along the anode 15 on the side of the target 14.

The following describes operations of the sputtering device 11. First, discharge gas, which is a mixture of inert gas such as argon and optionally reactive gas such as oxygen or nitrogen is drawn into the deposit room 12 through the pipe A. The discharge gas is ionized between the target 14 and the anode 15 under applied high voltage, using the target 14 as a cathode. The target 14 is bombarded with the ionized discharge gas to sputter the target material. The target material deposits on the substrate 17 to form a thin film.

Here, the target material not only deposits on the substrate 17 but also adheres to the other components in the deposit room 12 to form an adherent film thereon. The

adherent film, when exceeds a certain thickness and subjected to the internal stress or recurring thermal stress of the film, detaches itself from the surface and becomes dust (pieces of the film) to cause defects on the thin film formed on the substrate 17. It is therefore required to regularly remove the adherent film.

The anti-adherent plate 20 is provided to help this procedure. The depositing jig, such as the substrate tray 18, the mask 19, and the anti-adherent plate 20 requires regular cleaning to remove an adherent film adhered thereon. Generally, the depositing jig is unfastened from the sputtering device 11 and cleaned after the adherent film has grown to a thickness of 100 μm to 300 μm in the case of ITO, or a greater thickness in the case of metal such as tantalum.

Conventionally, the depositing jig has been cleaned by a method called sand-blast method. Fig. 4 is a cross section showing a relevant part of an example of a sand-blast device used in the sand-blast method.

The following describes a configuration and operations of the sand-blast device. First, a robot 21 is provided in a work room 22 surrounded by a protective wall. The robot 21 has a nozzle 23 on its tip. The nozzle 23 is connected to a compression mixer 24 which mixes sand with air for injection from the nozzle 23.

A depositing jig 25 is placed in the work room 22 with the film-adhered-surface facing the nozzle 23. The robot 21 moves the nozzle 23 from one place to another, and the sand in the compressed air is ejected on the surface of the depositing jig 25 where the film is adhered, so as to detach and remove the adherent film by the force of impact.

The sand is generally particles of hard alumina or particles of silicon carbide. The size of the particles is suitably selected according to a desired processing rate and finishing touch, and it is usually in the range of from 100 μm to 800 μm.

Some of the sand collided on the adherent film on the depositing jig 25 break into smaller pieces and lose their ability to detach the adherent film. This is counter-measured by drawing the sand down into a cyclon 27, which is commercially available, through holes of a table 26. The cyclon 27 separates the mixture of the sand and pieces of the adherent film into the sand of a near original size and the sand of a reduced size, where the former is recycled into the compression mixer 24 and the latter is discharged as debris of sand blast in the direction of arrow C in Fig. 4.

The conventional method therefore produced a large amount of sand-blast debris, and the proportion of pieces

of the adherent film was as small as 0.1 weight percent to 5 weight percent with respect to the debris of sand blast. This made the separation of the two economically impractical.

Fig. 5 shows an example of a liquid crystal panel as the substrate 17 to form a thin film in the vacuum deposition device. The liquid crystal panel shown in Fig. 5 incorporates an active element such as TFT (Thin Film Transistor). The present invention is also applicable to duty liquid crystal display devices, such as a TN (Twisted Nematic) liquid crystal panel and a STN (Super Twisted Nematic) liquid crystal panel. The invention is further applicable to flat display panels other than the liquid crystal panel, such as an inorganic EL panel, an organic EL panel, and a PDP, as well as an electromagnetic wave filter for PDPs, and a touch panel.

The liquid crystal panel has a structure, as shown in Fig. 5, in which transparent glass substrates 31a and 31b having a thickness of, for example, 0.7 mm or 1.1 mm are combined with each other via a seal member 32 on the periphery of the glass substrates 31a and 31b, and liquid crystal fills a space therebetween to make up a liquid crystal layer 33. The substrate 17 of Fig. 3 corresponds to the glass substrates 31a and 31b of Fig. 5.

On the respective surfaces of the glass substrates

31a and 31b opposite the liquid crystal layer 33 are provided polarizers 34, each having a thickness of, for example, 0.2 mm to 0.4 mm, which are bonded on the glass substrates 31a and 31b with an adhesive. The thickness of the liquid crystal layer 33--the distance between the glass substrates 31a and 31b--is generally 4 μm to 6 μm. Note that, the glass substrates 31a and 31b, the polarizers 34, and the liquid crystal layer 33 can have a thickness other than the foregoing values as exemplified above.

The glass substrate 31a on the side of the liquid crystal layer 33 is provided with: a color filter 35 of chiefly organic material of orderly disposed R, G, B; a counter electrode 37, which is a transparent ITO film containing indium; and an alignment film of organic material, which are stacked in this order toward the liquid crystal layer 33.

The glass substrate 31b on the side of the liquid crystal layer 33 is provided with: a gate bus electrode 39; a gate insulating film 40; a silicon semiconductor film 41; a source bus electrode 42; a drain electrode 43; a pixel electrode 44, which is a transparent ITO film containing indium; and an alignment film 38 of organic material.

The gate bus electrode 39, the source bus electrode

42, and the drain electrode 43 are metal thin films which are made of, for example, tantalum, aluminium, or titanium, or a metal compound of these metals. These electrodes, as well as the counter electrodes 37 and the pixel electrode 44, are formed by a vacuum deposition method, for which sputtering is usually used.

Referring to Fig. 1 and Fig. 2, the following will describe examples of adherent film recovering devices for cleaning depositing jigs, according to embodiments of the present invention. Fig. 1 and Fig. 2 are diagrams showing relevant part of the adherent film recovering devices.

Fig. 1 illustrates a water-jet device which is provided as an adherent film recovering device according to one embodiment of the present invention. As shown in Fig. 1, the water-jet device includes a work room 22 which is provided in the form of a box, surrounding and covering a table 26, which is an operation table for cleaning. The work room 22 is provided with doors on the sides so that the depositing jig 25, which is a target of cleaning, can be placed in and out of the work room 22 on the table 26.

The work room 22 can be sealed so that droplets of water-jet do not leak during cleaning, and has an inner protective wall which is preferably hydrophilic.

In the work room 22, a robot (mobile member) 21 with

a multi-joint arm is provided. The robot 21, which is hung on an upper portion (ceiling) of the work room 22, has multi-joints including a plurality of swivel joints to make up part of piping for pressurized water.

The multi-joint arm of the robot 21 with a plurality of swivel joints enables the tip of the robot 21 to move three-dimensionally along the shape of the adherent film on the depositing jig 25 being cleaned (cleaning target) while carrying pressurized water.

On the tip of the arm of the robot 21 is attached a cleaning gun (liquid-jet section) 51 in the form of a circular pillar, concentrically with the arm tip, so that the cleaning gun 51 can freely rotate around its axis.

Outside and in the vicinity of the work room 22 is provided a pressurized water generator (high-pressure liquid producing section) 52 for generating pressurized water. The pressurized water generator 52 is linked to the cleaning gun 51 via the robot 21 to supply pressurized water thereto. The pressurized water generator 52 is usually of a booster type which creates pressurized water in the secondary booster, using the pressure created in the hydraulic unit of the primary booster.

The pressurized water generator 52 is connected to a pure water producing device (purified liquid producing

section) 61 which supplies water to the pressurized water generator 52. The pure water producing device 61 produces water by deionizing city water by ion exchange to remove ions such as calcium ion or chlorine ion.

The robot 21 with the multi-joint arm is programmed to clean the depositing jig under the control of a controller of a teaching playback system (not shown) by repeating the movement which is taught beforehand according to the shape of the depositing jig 25 to be cleaned.

Fig. 10 is a longitudinal cross section showing relevant part of the cleaning gun 51 as an example. Only nozzle sections 69 are shown in cross section. The nozzle sections 69 are in the form of a near cylinder with a narrowing inner diameter toward the tip, and are linked to the pressurized water generator 52 via the cleaning gun 51.

For example, seven nozzle sections 69 are attached on a tip surface of the cleaning gun 51, the tip surface being a surface orthogonal to the rotational axis of the cleaning gun 51, and are disposed such that respective central axes of the nozzle sections 69 are parallel to one another. One of the nozzle sections 69 is concentric to the rotational axis of the cleaning gun 51.

Alternatively, for example, six nozzle sections 69

may be disposed into adjacence at the same intervals on the tip surface of the cleaning gun 51 along the circumference of a virtual circle centered by the rotational axis of the cleaning gun 51. The diameter of the virtual circle is defined to be 200 times to 2500 times, or more preferably 400 times to 1500 times larger than diameter D of the nozzle opening at the tip of the nozzle sections 69.

The nozzle sections 69 on the virtual circle can rotate clockwise with the cleaning gun 51 about the rotational axis of the cleaning gun 51, as viewed into the tip of the nozzle section 69 (direction E in Fig. 10). As the driving source of rotation, an air motor, an oil hydraulic motor, or a water hydraulic motor is used. The rotational speed is in the range of from 500 rpm to 2000 rpm, or more preferably 1000 rpm to 2000 rpm.

The nozzle sections 69 have a structure which is suitable for constantly jetting pressurized water. For example, the inner wall surface of the nozzle sections 69 has a mirror-finish, and in order to improve wear resistance and workability, a sapphire chip or a diamond chip (neither is shown) is embedded in the opening of the nozzle tip.

The distance between the nozzle sections 69 of the cleaning gun 51 and the depositing jig 25 is adjusted

within a range called impact domain, i.e., within L/D = 50 to 300, where L is a distance between the tip of the nozzle sections 69 of the cleaning gun 51 and the surface of the depositing jig 25, and D is a diameter of the opening at the nozzle tip of the nozzle sections 69.

It is preferable that the robot 21 sets the nozzle sections 69 in such a way that the respective central axes of the nozzle sections 69 are substantially orthogonal to the surface of a cleaning target on the depositing jig 25.

As required, the central axes of the nozzle sections 69 may be tilted, for example, by about 10°, with respect to a direction normal to the surface of the cleaning target on the depositing jig 25. In this way, the pressurized water from the nozzle sections 69 rotating on the virtual circle, by being tilted with respect to the adherent film, forms a pseudo pulsating current in which the force of impact fluctuates back and forth within a predetermined range by the tilt with respect to the adherent film. This may be effective in detaching pieces of the adherent film.

In the case where the depositing jig 25 has a relatively simple shape such as a rectangle or the like, the robot 21 with the multi-joint arm may be realized by an XY robot, which may be provided inexpensively, and the

controller may be of a numerical control system. Further, using an XY stage for example, the depositing jig 25 may be moved instead of the nozzle sections 69.

The inner wall of the work room 22 is made of hydrophilic material, and the ceiling of the work room 22 has a nebulizer or a shower (humidifier) 59 to keep the inner wall of the work room 22 wet.

In such an adherent film recovering device, the depositing jig 25 is placed on a table (holding plate) 26 in the work room 22 with the surface of the adherent film facing the cleaning gun 51. The robot 21 moves the cleaning gun 51 from one place to another to jet pressurized water onto the adherent film, so as to detach and remove the adherent film by the force of impact. The depositing jig 25 may be cleaned on a cleaning member platform (support member) 53 which has been shaped into a desired shape in advance, as will be described later.

Though not shown in the Figure, the depositing jig 25 and the cleaning member platform 53 are placed on a cart to move on a guide rail on the table 26 in the work room 22 and stop at a predetermined position on a stopper.

Referring to Fig. 1, a centrifugal separator (solid-liquid separator) 57 is disposed below the table 26 having a large number of holes in the form of a mesh. The

centrifugal separator 57 includes a fixing container 54 in the form of a cylinder with a closed bottom, and a rotary container 56, also in the form of a cylinder with a closed bottom, which rotates at high speed concentrically in the fixing container 54. The rotary container 56 has a large number of holes through its barrel, and the inner surface of the rotary container 56 is covered with a filter 55 so as to cover the holes.

The pressurized water which strikes the depositing jig 25 becomes a suspension of pieces of the adherent film detached from the depositing jig 25. The suspension mixes with the water which has fallen on the suspension via the inner surface of the work room 22 and directly from the nebulizer or the shower 59, and flows down into the rotary container 56 through the holes of the table 26. In the rotary container 56, the suspension in water is separated into pieces of the adherent film and drained water by the centrifugal separator 57.

Note that, the suspension or drained water may contain, for example, an anti-rusting agent and/or a liquid polymer to improve grinding force, so long as water is the main composition (50 weight percent or more). Further, the centrifugal separator 57 may be a centrifugal settling device employing a centrifugal precipitation method.

The bottom surface of the fixed container 54 has a drain 58. The drain 58 extends into a pipe 77 which is linked to the pressurized water generator 52 via a tank (not shown) for adjusting a flow rate, so as to return the drained water separated by the centrifugal separation to the pressurized water generator 52. This makes it possible to also recycle the drained water, which has the effect of at least reducing the amount of waste, or avoiding generation of wastes altogether.

According to the second embodiment of the present invention, as shown in Fig. 2, a precipitation tank (solid-liquid separator) 60 in the form of a cylinder with a closed bottom is provided instead of the centrifugal separator 57, below the table 26 having holes, so as to recover a suspension falling through the holes of the table 26. The precipitation tank 60 has a drain 58 on a side at a predetermined height. The drained water from the drain 58 through the pipe 77 returns to the pressurized water generator 52 via a tank (not shown) for adjusting a flow rate.

Note that, the pipe 77 which extends from the drain 58 as shown in Fig. 1 and Fig. 2 may be linked to the pure water producing device 61, instead of the pressurized water generator 52, via the tank (not shown) for adjusting a flow rate.

Fig. 7 is a flowchart which explains a recovering method of an adherent film in the adherent film recovering device shown in Fig. 1. First, the depositing jig 25 is positioned on a cart outside of the work room 22 at home position, and a start switch of a control box is switched ON (Step 1; "Step" will be abbreviated to "S" hereinafter).

Next, one of the doors of the work room 22 opens (S2), and the cart moves into the work room 22 on a guide rail (S3). The cart comes to stop at a work position (S4) and fixed in position on a stopper, and the door of the work room 22 closes (S6). The cart is stopped at a stop position which is detected by a limit switch or other means. The rotary container 56 of the centrifugal separator 57 is in operation by the time the door of the work room 22 is closed, so that a predetermined rotational speed is reached before the centrifugal separation is started (S5).

The ceiling of the work room 22 has a exhaust fan 62 which is operated at least during cleaning of the depositing jig to create a state of slightly reduced pressure in the work room 22 (negative pressure relative to outside of the work room 22). This is to prevent droplets of water containing pieces of the adherent film leaking from the work room 22 due to jetting of

pressurized water.

Next, a valve of the shower 59 is released to start showering (S7), and the pressure pump of the pressurized water generator 52 and the air motor of the cleaning gun are operated to start supplying pressurized water (S8). Showering is started before the robot 21 comes into operation to wet the inner wall surface of the work room 22 in advance. Further, the pressurized water is supplied in advance to obtain a constant flow rate of the pressurized water ejected from the cleaning gun 51. In this way, a stable cleaning condition of the depositing jig can be obtained. The time to start cleaning of the depositing jig is pre-set by a timer (not shown).

When the inner wall surface of the work room 22 becomes wet and the flow rate of the pressurized water becomes constant, the robot 21 comes into operation as instructed by a pre-taught movement according to the shape of the depositing jig 25 (S9). When the cleaning of the depositing jig 25 is finished, the pressure pump and the air motor of the cleaning gun stop operating to stop supply of pressurized water (S10). The robot 21 then returns to the home position (S11), and the shower 59 stops showering (S12).

Thereafter, the door of the work room 22 opens (S13), and the cart moves out of the work room 22 (S14).

The cart is stopped at the home position (S15) and the door of the work room 22 closes (S16). The rotary container 56 of the centrifugal separator 57 then stops operating (S17) to end the cleaning procedures of the depositing jig (S18).

The foregoing description based on the flowchart of Fig. 7 is merely one example of the present invention and various modifications are possible to the extent where the series of procedures is not disrupted. For example, the operation of the rotary container 56 of the centrifugal separator 57 may be started before the door opens, or depending on the performance of the pressurized water generator 52, showering and supply of pressurized water may be started in a reversed order.

The following describes an adherent film recovering device according to the Third Embodiment of the present invention with reference to Fig. 8, which is diagram showing relevant part of the adherent film recovering device. In the adherent film recovering device of the present embodiment, a robot 21 with a multi-joint arm is placed in a work room 22 which is provided with an automatic door 68 and protective walls. The robot 21 has a cleaning gun 51 on its tip. The cleaning gun 51 is connected to a pressurized water generator 52 which is realized by a triplet plunger pump, and to a pure water

producing device 61.

The robot 21 is programmed to clean the depositing jig under the control of a controller of the teaching playback system (not shown) by repeating a pre-taught movement.

The ceiling of the work room 22 has the exhaust fan 62. On a floor 65 of the work room 22 are provided a guide rail 64 for moving and positioning a cart 63 to a predetermined position, and limit switches LS1 and LS2. On the cart 63 is provided a table 70 which carries and holds the depositing jig 25 thereon and rotates 90° or 180° about a rotational axis in a direction normal to the surface of the cart 63 carrying the table 70. The provision of the rotary table 70 enables the robot 21 to move in a narrower moving range, which reduces cost. As a matter of design choice, the robot 21 may be provided on the floor.

The floor 65 of the work room 22 has a drain opening 66. The drain opening 66 is connected to a precipitation tank 60 either directly or via piping. A suspension flown into the precipitation tank 60 forms a precipitation layer 67 as the pieces of the adherent film precipitate in the precipitation tank 60. A clear portion is drained off from the drain 58.

Fig. 9 is a flowchart which explains a recovering

method of an adherent film in the adherent film recovering device shown in Fig. 8. In response to activation of a control box by switching ON a switch (S21), the exhaust fan 62 starts operating (S22), the automatic door 68 opens (S23), and the pressure pump comes into operation (S24). With the start of operation of the pressure pump, the cart 63 moves out of the work room 22 (S25) and moves to a position where the limit switch LS1 is switched ON. The cart 63 is fixed at this position in a standby state (S26).

Next, the depositing jig 25 is fastened on a predetermined position of the cart 63, e.g., on the table 70 (S27), and a cleaning start switch (Not shown) is switched ON (S28). In response, the cart 63 moves into the work room 22 (S29) to a position where the limit switch LS2 becomes ON (S30). The cart 63 is fixed at this position and the automatic door 68 closes (S31).

Thereafter, while the robot 21 is at the home position, the valve of the pressurized water generator 52 is released to load the pressure pump, i.e., pressurized water is supplied from the pressurized pump to the cleaning gun 51 to start ejection of pressurized water from the cleaning gun 51 (S32). Almost concurrently with this operation, the air motor of the cleaning gun becomes ON to start rotating a plurality of nozzle sections 69 of

the cleaning gun 51 individually but in a synchronized manner (S33).

In response to the start of loading of the pressure pump, the first timer operates for pre-set duration of time to send a time-up signal (S34). After the ejection of the pressurized water is stabilized this way, the robot 21 comes into operation according to the pre-taught movement to clean the depositing jig (S35).

Subsequently, the pressure pump is unloaded to stop ejection of the pressurized water (S36), the air motor of the cleaning gun is switched OFF (S37), and the robot 21 is moved to the home position away from the cart 63 (S38).

In the case where the depositing jig 25 is large, or ejection of pressurized water toward the automatic door 68 is not desired for the safety of the operator, a half or a quarter of the depositing jig 25 is cleaned first in a direction from the center of the depositing jig 25 toward the end (opposite side of the automatic door 68) of the work room 22, and then the depositing jig 25 is rotated 180° or 90° on the rotary table 70 on the cart 63 (S39). This procedure is repeated until the depositing jig is cleaned entirely (S32 through S40).

Though not described in detail in the drawing, the movement of the robot 21 cleaning the depositing jig may

be different from the previously described one when the depositing jig 25 is rotated 90° or depending on the shape of the depositing jig 25 (especially when the depositing jig 25 is asymmetrical).

With the finish of cleaning the depositing jig, a second timer comes into operation (S41). After an elapsed period of time to completely remove the water vapor resulting from the droplets in the work room 22, the automatic door 68 opens (S42) and the cart 63 moves out of the work room 22 to a position where the limit switch LS1 becomes ON (S43). The cart 63 is fixed at this position in a standby state (S44). Fastening (S45) and unfastening (S46) of the depositing jig 25 are repeated to repeat the procedures of S27 through S45 until all the depositing jigs are cleaned.

After all the depositing jigs have been cleaned, an end switch of the control box is switched ON to indicate end of procedures (S46). In response, the pressure pump stops operating (S47) and the cart 63 moves into the work room 22 (S48) to a position where the limit switch LS2 becomes ON. The cart 63 is fixed on this position (S49). Then, the automatic door 68 closes (S50), and the exhaust fan 62 stops (S51) to finish the cleaning procedures of the depositing jig (S52).

The cart 63 stays in the work room 22 after the

procedures to prevent pieces of the adherent film from scattering out of the work room 22 from the cart 63 which has dried.

Note that, the foregoing described the case where the adherent film on the depositing jig of the vacuum depositing device is recovered. However, the present invention is not just limited to this example and also applicable in recovering thin films of metal such as indium or tantalum, or a metal compound of such metals, contained in electrical devices, for example, such as a disposed liquid crystal panel.

[Example 1]

With use of an adherent film recovering device according to the present invention, which is an aquatic water-jet device, cleaning was performed on an SUS430 substrate tray 18 having a thickness of 5 mm and having a surface finish roughness of approximately 20 μm, which was used as the depositing jig 25 in the sputtering device (Figure 3) for depositing a thin film of ITO for the pixel electrodes and the counter electrodes of the liquid crystal panel.

A surface finish roughness in a range of from 3 μm to 50 μm on the surface of the substrate tray 18 increases adhesion of the substrate tray 18 for an adherent film so that the adherent film does not easily

detach from the substrate tray 18. This prevents the adherent film from becoming dust until it grows to a certain thickness, thereby allowing the substrate tray 18 to be used for an extended period of time and thus less often cleaning the depositing jig bearing the adherent film.

An ITO adherent film adhered on the substrate tray 18 was removed with use of a cleaning gun 51 provided with a plurality of nozzle sections 69 with a nozzle hole diameter of 1mm or less, under the conditions where the distance between the cleaning gun 51 and the depositing jig 25 was in an impact domain, for example, 100 mm, and the pressure of high-pressure water varied in the range of from 30 MPa to 200 MPa. After removing the ITO adherent film, the surface of the substrate tray 18 was observed and a degree of warp was evaluated.

When the diameter of the nozzle hole ranged from 0.1 mm to 1.0 mm, removal of the adherent film required a long time at a low pressure of 30 MPa. However, at a pressure ranging from 30 MPa to 200 Mpa, the adherent film was detached and removed desirably and the surface condition of the substrate tray 18 was also desirable. A warp on the substrate tray 18 also did not exceed a measurement limit. In terms of workability, a pressure in the range of from 60 MPa to 200 MPa is more preferable.

Thereafter, a surface finishing process was performed by the sand-blast method to remove rust formed on the surface of the substrate tray 18, followed by ultrasonic cleaning and a rinsing finish before brief drying. Approximately 2 μm of the substrate tray 18 was ground in the cleaning according to the present invention, which is less than approximately 20 μm ground in the cleaning of the depositing jig by the sand-blast method.

A plurality of nozzle sections 69 provided in the cleaning gun 51 aim for simplifying the movement of the robot 21 because an area of the depositing jig 25 on which the adherent film is adhered is usually as wide as several centimeters or so. It is therefore preferable to select the number and position of the nozzle sections 69 according to the shape of the depositing jig 25 to be used.

Use of water with a rust preventive such as hydrazine or polyphosphoric acid can omit the surface finishing process by the sand-blast method for removing rust formed on the surface. This is also applicable to Example 2 and Example 3 described later.

The depositing jig 25 thus cleaned was used in the sputtering device, so as to check for presence or absence of a warp on the depositing jig 25, the amount of dust

produced, and presence or absence of defects on the film deposited on the substrate 17. As a result, it was found that the depositing jig 25 was no different from that cleaned by the sand-blast method and caused no problem for use.

Also, pieces of the adherent film deposited in the precipitation tank 60 (Fig. 2) placed below the water-jet device were also recovered in this Example. As a result, approximately 64% of the pieces of the ITO adherent film detached and removed was recovered as a precipitate. The loss was due to some pieces of the adherent film scattering out of the precipitation tank 60 and an insufficient time to precipitate.

Since the specific gravity of ITO is as large as approximately 7, the recovery rate of pieces of the ITO adherent film can be increased to nearly 100% by guiding the scattered pieces of the ITO adherent film out of the precipitation tank 60 back into the precipitation tank 60 with running water from a nebulizer or the shower 59, or by designing the precipitation tank 60 such that a longer precipitation time could be provided, or by using the centrifuge separation method.

Figure 11 shows a result of measurement by a SEM (scanning electron microscope) on the recovered pieces of the ITO adherent film. As shown in Figure 11, the

recovered pieces of the ITO adherent film were highly pure, containing a high proportion of large particle sizes ranging from several microns to several ten microns. Also, hardly measured was impurities other than iron and chromium included in SUS430 of the substrate tray 18 as the depositing jig 25. The recovered pieces of the ITO adherent film help post-processes of recovering and recycling indium, and are economically superior.

[Example 2]

With use of the aquatic water-jet device, cleaning was performed as in Example 1 for an SUS430 anti-adherent plate 20 having a thickness of approximately 2 mm, which was used in the sputtering device 11 (Figure 3) for depositing a thin film of ITO for the pixel electrodes and counter electrodes of the liquid crystal panel. The cleaning was performed at varying pressures in the range of from 30 MPa to 200 MPa.

At a pressure in the range of from 90 MPa to 120 MPa, the anti-adherent plate was deformed and warped on the part of its surface struck by the high-pressure water. This is deemed to have been caused by the high pressure exerted by water, which is higher than the pressure in the sand-blast method.

As a counter-measure, a jig table (53 in Fig. 1 or Fig. 2) was made. First, the anti-adherent plate was

placed in a tray-shaped metallic container (Figure 1 and Figure 2) so that the adherent film side of the anti-adherent plate faced upward. Then, a silicon resin for molding, which was prepared by mixing and defoaming a 1:1 ratio of silicon resins SH-850A and SH850-B, was put into the metallic container to mold along the opposite side (inner side) of the anti-adherent plate. Prior to this injection of the silicon resin, a tape such as a polyimide tape or an alminium tape was stuck around the adherent film side of the anti-adherent plate to create a ridge, so as to prevent the silicon resin from spreading to the adherent film side of the anti-adherent plate. Thereafter, the molded silicon resin was hardened at room temperature. Alternatively, to further increase hardness, the molded silicon resin may be hardened in an oven which is set at a predetermined temperature of not more than 150°C.

Such a molded silicon resin body, which is used as the jig table after the tape is removed, has great elasticity and comparatively high durability against the high-pressure water from the aquatic water-jet device. Moreover, the metallic container, tightly holding the jig table inside, functions to increase the strength of the jig table.

The anti-adherent plate was then placed on the jig

table in such a manner that the inner surface of the anti-adherent plate was elastically supported on the upper surface of the jig table. The anti-adherent plate was cleaned under this condition as in Example 1 at a pressure ranging from 30 MPa to 120 MPa.

As a result, the adherent film was detached and removed from the anti-adherent plate desirably, and the surface condition of the anti-adherent plate was also desirable. Further, the problem of deformation was not posed on the anti-adherent plate, i.e., the depositing jig 25. Thereafter, a surface finishing process was performed on the anti-adherent plate by the sand-blast method, followed by ultrasonic cleaning and a rinsing finish before brief drying.

The anti-adherent plate thus cleaned was used in the sputtering device (Fig. 3), so as to check for an amount of dust produced and presence or absence of defects on the film deposited on the substrate 17. As a result, it was found that the anti-adherent plate was no different from that cleaned by the sand-blast method and caused no problem for use.

Further, the precipitation tank 60 was placed below the water-jet device to recover pieces of the adherent film precipitated therein. The result was as desirable as that of Example 1.

[Example 3]

With use of the aquatic water-jet device used in Example 1, cleaning was performed on an alminium mask finished with alminium spray deposit, which was used in the sputtering device (Figure 3) for depositing a thin film of tantalum compound (tantalum nitride) and tantalum for the gate bus line 39 (Figure 5) of the liquid crystal panel.

The adherent film was removed with use of the cleaning gun 51 provided with a plurality of rotary nozzle sections 69, under the conditions where the distance between the cleaning gun 51 and the depositing jig 25 was adjusted to several centimeters, and a nozzle hole diameter of the nozzle sections 69 was varied in the range of from 0.1 mm to 1.0 mm to vary the water pressure. Thereafter, the condition of the adherent film after detachment and removal and the degree of grinding of the mask base material were examined.

At a pressure as low as 50 MPa and at the moving speed of the cleaning gun 51 two meters per minute or faster, some part of the adherent film did not detach from the alminium sprayed film of the mask and remained thereon. Further, when the pressure was increased to around 200 MPa, the alminium mask was ground. Still further, at a pressure in the range of from 60 MPa to 150

MPa, the adherent film was desirably detached from the alminium-sprayed film with few amount of the ground alminium mask.

Thereafter, the aluminium mask, after finished with rinsing, drying, and aluminium spray deposit, was used in the sputtering device to check for presence or absence dust or defects on the thin film deposited on the substrate 17. As a result, it was found that the alminium mask was no different from that cleaned by the sand-blast method, without contamination of the thin film with chlorine. Thus, the aluminium mask did not pose any problem in use.

Also, the precipitation tank 60 was placed below the water-jet device to recover pieces of the adherent film. Since the specific gravity of tantalum is as large as 16.6, the yield of pieces of the tantalum adherent film from the precipitate, which is a mixture of about 70 % tantalum and 30 % aluminium, was close to 100 %. Also, hardly measured was impurities other than alminium contained in the recovered pieces of the tantalum adherent film. The recovered pieces of the tantalum adherent film help post-processes of recovering and recycling tantalum, and are economically superior.

The present invention has found that the aquatic water-jet method using pure water can be used to clean a

depositing jig (1) to obtain desirable cleaning effect, (2) to reduce the ground amount of the depositing jig after cleaning to the level of the sand-blast method, and (3) to increase a proportion of large particle sizes (several microns to several ten microns) in pieces of the detached and removed adherent film of metal or metal compound (easier recovery), when the water pressure in the usual range of 10 MPa and up to 30 MPa is increased to the range of from not less than 30 MPa to not more than 200 MPa, or more preferably not less than 60 MPa to not more than 200 MPa.

Further, the present invention took advantage of a higher specific gravity of metal or metal compound, which is generally 2 or larger, than that of water to recover adherent films in high purity and at low cost by a simple solid-liquid separation method such as a filtration method, a precipitation method, or a centrifugal separation method.

Further, the present invention has found that the amount of impurities other than water can be greatly reduced when the aquatic water-jet method is combined with a solid-liquid separation method, which makes recovery and recycle of the metal easier and less expensive in post-processes.

In order to attain the foregoing objects, an

adherent film recovering device of the present invention for recovering an adherent film from a depositing jig mounted on a holding plate includes: a water (liquid)-jet section which sprays water (liquid)-jet against the depositing jig, for recovering therefrom the adherent film.

With this arrangement, the ground amount of the depositing jig in cleaning can be reduced to the level of the conventional sand-blast method. It is therefore possible to extend life of the depositing jig.

Further, with the foregoing arrangement, the adherent film on the depositing jig can be removed in the form of pieces of the adherent film by water-jet. In addition, the pieces of the adherent film are larger in size than those obtained in the conventional sand-blast method. Thus, the pieces of the adherent film can easily be recovered without fail, thereby attaining low cost. Therefore, with the foregoing arrangement, it is possible to promote recycle of the adherent film.

The adherent film recovering device preferably includes a high-pressure water (liquid) producing section which produces high-pressure water (liquid) with hydraulic pressure within a range of 30 MPa to 200 MPa, and supplies high-pressure water (liquid) as produced to the water (liquid)-jet section.

With this arrangement, since the hydraulic pressure is within a range of 30 MPa to 200 MPa, or more preferably 60 MPa to 200 MPa, the recovery rate of the adherent film can be improved.

It is preferable in the adherent film recovering device that a work room is sealed so as to prevent droplets resulting from the water (liquid)-jet sprayed by the water (liquid)-jet section from sputtering outside of the work room.

Further, the adherent film recovering device preferably includes an exhaust fan for use in setting the work room to have negative room pressure. With this arrangement, since the exhaust fan for creating negative pressure in the work room is provided, the pieces of the adherent film, which are likely to be air-borne, are prevented from leaking out of the work room, thereby further improving recovery rate of the adherent film pieces and at the same time safety of the operator.

The adherent film recovering device preferably includes a purified water (liquid) producing section which deionizes water (liquid) and supplies water as deionized to the high-pressure water producing section for the water-jet to be sprayed by the water-jet section.

With this arrangement, since the purified water producing section produces pure water for the high-

pressure water producing section, impurities contained in water such as calcium ion are less likely to form precipitates such as calcium carbonate, thereby preventing malfunction of the device.

The adherent film recovering device may be provided with a support member mounted on the holding member, for elastically supporting the depositing jig from below.

With this arrangement, by the provision of the support member, the depositing jig will not deform even when the thickness of the depositing thin film is thin as in the case of the anti-adherent film. That is, because the support member elastically supports the depositing jig, the pressure of the high-pressure water exerted by water-jet on the depositing jig to remove the adherent film thereon is dispersed by the support member elastically supporting the depositing jig. In fact, other pressure applied on the depositing jig can also be dispersed by the support member, thus preventing deformation of the depositing jig due to applied pressure.

It is preferable in the adherent film recovering device that the holding plate has a hole section for dropping therethrough suspension containing adherent film pieces as removed from the depositing jig by the water-jet sprayed by the water-jet section; and a

solid-liquid separator is provided for separating the adherent film pieces from the suspension as dropped through the hole section of the holding plate.

With this arrangement, since the holding plate is provided with holes through which a suspension containing pieces of the adherent film removed from the depositing jig by water-jet escapes, the suspension can easily be transported out of the work room. Further, with the foregoing arrangement, by the provision of the solid-liquid separator, the pieces of the adherent film can easily be removed from the suspension, thereby improving recovery of the adherent film pieces.

The adherent film recovering device preferably includes a pipe for returning therethrough waste water resulting from separating the adherent film pieces by the solid-liquid separator, to the high-pressure water producing section. Further, in order to more thoroughly remove the adherent film pieces, the drained water of solid-liquid separation may be returned to the high-pressure water producing section after membrane separation such as microfiltration, ultrafiltration, and reverse filtration.

With this arrangement, since the adherent film pieces removed by water-jet are relatively large in size, they can be removed almost completely from the water

drained off by solid-liquid separation such as a precipitation process or centrifugal separation. This makes it possible to suppress wear of the nozzle holes of, for example, the cleaning gun to the level which does not present serious problems in actual use.

Therefore, in the foregoing arrangement, use of the drained water in water-jet does not pose any problem. This allows the drained water to be recycled to enable cleaning which produces substantially no waste. As a result, it is possible to further reduce cost and improve environmental friendliness.

It is preferable in the adherent film recovering device that a humidifier for use in wetting an internal surface of the work room is provided other than the water-jet section.

With this arrangement, by the provision of the humidifier such as a nebulizer or a shower, it is possible to prevent the problem of the conventional water-jet method that the high-pressure water scatters with pieces of the adherent film and sticks to various parts of the work room, such as the inner surface of the work room. The humidifier can wash out such pieces of the adherent film to prevent the adherent film pieces from drying and scattering out of the work room, thereby improving recovery rate of the adherent film pieces.

It is preferable that the adherent film recovering device includes: a water (liquid)-jet cleaning gun for spraying water-jet; a mobile member provided in the work room, for altering a direction of the water-jet to be sprayed from the water-jet cleaning gun; and a control section for controlling the mobile member to move according to the teaching playback system or the numerical control system.

In this arrangement, the cleaning gun is attached to the mobile member (tip of the robot arm), and the cleaning gun automatically cleans only a predetermined portion of the depositing jig (adherent film surface on the depositing jig) to detach and remove the adherent film therefrom under the control of a control section (controller). As a result, the adherent film pieces can be recovered both efficiently and easily.

A method of recovering an adherent film of the present invention is for removing and recovering an adherent film adhered to an anti-adherent plate, a mask, a substrate tray or other depositing jig for use in a vacuum deposition device adopting the sputtering method, the vacuum deposition method, the ion-plating method, or other vacuum deposition method, wherein: a water (liquid)-jet method using water or liquid is adopted for removing the adherent film adhered to the depositing jig.

According to this method, the adherent film on the depositing jig is detached by the water-jet method which uses water or liquid. This makes it possible to reduce the ground amount (an amount of wear) of the depositing jig cleaned, compared with the conventional sand-blast method. As a result, life of the depositing jig can be prolonged.

Further, with the foregoing method, the adherent film of the depositing jig can be removed in pieces by the water-jet method. In addition, the pieces of the adherent film are larger in size than that by the conventional sand-blast method. As a result, the pieces of the adherent film can easily be removed without fail at low cost, thus making it possible to promote recycle of the adherent film.

Further, because the method employs the water-jet method which uses water or liquid, the pieces of the adherent film can be recovered inexpensively to allow economical recycling and reuse of drained water. That is, it is possible to realize an environmentally friendly depositing jig cleaning method which produces hardly any waste.

It is preferable that the foregoing method includes the step of purifying city water to be adopted in the water-jet method so as to reduce a content of at least

calcium carbonate.

With the foregoing method, since the content of calcium carbonate in the water or liquid used in the water-jet method is reduced, calcium carbonate is less likely to form precipitates in the water-jet method and malfunction of the device is less likely to occur. As a result, the adherent film can be recovered without fail.

It is preferable that the foregoing method includes the step of removing and recovering adherent film pieces from suspension resulting from the water-jet method by a solid-liquid separation method.

With this method, because the pieces of the adherent film are recovered by the solid-liquid separation method such as a centrifugal separation method or a precipitation method, the adherent film can easily be recovered without fail.

It is preferable in the foregoing method that target adherent film pieces to be recovered are made of metal or metal compound. With this method, with the use of metal or metal compound for the adherent film, there will be a large difference in specific gravity between the water or liquid used in the water-jet method and the pieces of the adherent film. This makes it easier to separate and recover the pieces of the adherent film from the suspension containing the pieces of the adherent film.

In the foregoing method, the adherent film pieces adhered to the depositing jig may contain at least indium, tantalum or other rare metal, or a compound thereof. Further, in the foregoing method, the depositing jig may be provided for a sputtering device; and the adherent film adhered to the depositing jig may be made of Indium Tin Oxide.

With the foregoing methods, rare metal such as indium or tantalum can be recovered at low cost, and it is possible to promote recycle of such rare metal. Thus, the foregoing methods can relieve the problem of scarce rare metal resource.

In the foregoing method, the adherent film adhered to the depositing jig may be removed and separated by reutilizing water or liquid after carrying out the solid-liquid separation method. With this method, since the water or liquid used in the water-jet method is reused, the amount of waste produced in the cleaning of the depositing jig can be reduced greatly or may be eliminated completely.

It is preferable in the foregoing method that the depositing jig is made of stainless, titanium, copper or an alloy of nickel-iron; and at least surface of the depositing jig, to which the adherent film is adhered, is finished with roughness within a range of from 3 μm to 50

μm.

In the foregoing method, the depositing jig may be made of aluminum; and at least surface of the depositing jig, to which the adherent film is adhered, may be finished with aluminum spray deposit.

With this method, stainless steel, titanium, copper, iron-nickel alloy, or aluminium absorbs less amount of gas and easily releases gas, and they can be suitably used for the depositing jig of the vacuum deposition device.

Further, with the foregoing method, since the surface of stainless steel, titanium, copper, iron-nickel alloy, or aluminium is finished with roughness in the range of from 3 μm to 50 μm, or finished with aluminium spray deposit, the adhesion of the metal surface for the adherent film can be improved.

Thus, with the foregoing methods, dust (the adherent film pieces) is produced less often from the adherent film in the vacuum deposition device. This makes the method suitable for the deposing jig of the vacuum deposition device.

Further, with the foregoing method, the ground amount of the depositing jig in the cleaning of the depositing jig can be reduced. This makes the method suitable for removing the adherent film formed on the

depositing jig used in the vacuum deposition device.

The invention being thus described, it will be obvious that the same way may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

WHAT IS CLAIMED IS:

1. An adherent film recovering device for recovering an adherent film from a depositing jig mounted on a holding plate, comprising:

a liquid-jet section which sprays liquid-jet against said depositing jig, for recovering therefrom said adherent film;

a sealed work room so as to prevent droplets resulting from the liquid-jet sprayed by said liquid-jet section from sputtering outside of said work room; and

an exhaust fan for use in setting said work room to have negative room pressure.

2. The adherent film recovering device as set forth in claim 1, further comprising:

a purified liquid producing section which deionizes liquid and supplies liquid as deionized to be sprayed by said liquid-jet section.

3. The adherent film recovering device as set forth in claim 1 or 2, further comprising:

a support member mounted on said holding plate, for elastically supporting said depositing jig from below.

4. The adherent film recovering device as set forth

in any one of claims 1 to 3, wherein:

said holding plate has a hole section for dropping therethrough suspension containing adherent film pieces as removed from said depositing jig by the liquid-jet sprayed by said liquid-jet section; and

a solid-liquid separator is provided for separating said adherent film pieces from said suspension as dropped through said hole section of said holding plate.

5. The adherent film recovering device as set forth in claim 4, further comprising:

a pipe for returning therethrough waste liquid resulting from separating said adherent film pieces by said solid-liquid separator, to said high-pressure liquid producing section.

6. The adherent film recovering device as set forth in any one of claims 1 to 5, wherein:

a humidifier for use in wetting an internal surface of said work room is provided other than said liquid-jet section.

7. The adherent film recovering device as set forth in any one of claims 1 to 6, further comprising:

a liquid-jet cleaning gun for spraying liquid-jet;

a mobile member provided in said work room, for altering a direction of the liquid-jet to be sprayed from said liquid-jet cleaning gun; and

a control section for controlling said mobile section to move according to the teaching playback system or the numerical control system.

8. An adherent film recovering device for recovering an adherent film from a depositing jig mounted on a holding plate, comprising:

a liquid-jet section which sprays liquid-jet against said depositing jig, for recovering therefrom said adherent film;

a sealed work room so as to prevent droplets resulting from the liquid-jet sprayed by said liquid-jet section from sputtering outside of said work room; and

a purified liquid producing section which deionizes liquid and supplies liquid as deionized to be sprayed by said liquid-jet section.

9. The adherent film recovering device as set forth in claim 8, further comprising:

a support member mounted on said holding plate, for elastically supporting said depositing jig from below.

10. The adherent film recovering device as set forth in claim 8 or 9, wherein:

said holding plate has a hole section for dropping therethrough suspension containing adherent film pieces as removed from said depositing jig by the liquid-jet sprayed by said liquid-jet section; and

a solid-liquid separator is provided for separating said adherent film pieces from said suspension as dropped through said hole section of said holding plate.

11. The adherent film recovering device as set forth in claim 10, further comprising:

a pipe for returning therethrough waste liquid resulting from separating said adherent film pieces by said solid-liquid separator, to said high-pressure liquid producing section.

12. The adherent film recovering device as set forth in any one of claims 8 to 11, wherein:

a humidifier for use in wetting an internal surface of said work room is provided other than said liquid-jet section.

13. The adherent film recovering device as set forth in any one of claims 8 to 12, further comprising:

a liquid-jet cleaning gun for spraying liquid-jet; a mobile member provided in said work room, for altering a direction of the liquid-jet to be sprayed from said liquid-jet cleaning gun; and

a control section for controlling said mobile section to move according to the teaching playback system or the numerical control system.

14. An adherent film recovering device for recovering an adherent film from a depositing jig mounted on a holding plate, comprising:

a liquid-jet section which sprays liquid-jet against said depositing jig, for recovering therefrom said adherent film;

a sealed work room so as to prevent droplets resulting from the liquid-jet sprayed by said liquid-jet section from sputtering outside of said work room; and

a support member mounted on said holding plate, for elastically supporting said depositing jig from below.

15. The adherent film recovering device as set forth in claim 14, wherein:

said holding plate has a hole section for dropping therethrough suspension containing adherent film pieces as removed from said depositing jig by the liquid-jet

sprayed by said liquid-jet section; and

a solid-liquid separator is provided for separating said adherent film pieces from said suspension as dropped through said hole section of said holding plate.

16. The adherent film recovering device as set forth in claim 15, further comprising:

a pipe for returning therethrough waste liquid resulting from separating said adherent film pieces by said solid-liquid separator, to said high-pressure liquid producing section.

17. The adherent film recovering device as set forth in any one of claims 14 to 16, wherein:

a humidifier for use in wetting an internal surface of said work room is provided other than said liquid-jet section.

18. The adherent film recovering device as set forth in any one of claims 14 to 17, further comprising:

a liquid-jet cleaning gun for spraying liquid-jet; a mobile member provided in said work room, for altering a direction of the liquid-jet to be sprayed from said liquid-jet cleaning gun; and

a control section for controlling said mobile

section to move according to the teaching playback system or the numerical control system.

19. An adherent film recovering device for recovering an adherent film from a depositing jig mounted on a holding plate, comprising:

a liquid-jet section which sprays liquid-jet against said depositing jig, for recovering therefrom said adherent film; and

a sealed work room so as to prevent droplets resulting from the liquid-jet sprayed by said liquid-jet section from sputtering outside of said work room, wherein:

said holding plate has a hole section for dropping therethrough suspension containing adherent film pieces as removed from said depositing jig by the liquid-jet sprayed by said liquid-jet section; and

a solid-liquid separator is provided for separating said adherent film pieces from said suspension as dropped through said hole section of said holding plate.

20. The adherent film recovering device as set forth in claim 19, further comprising:

a pipe for returning therethrough waste liquid resulting from separating said adherent film pieces by

said solid-liquid separator, to said high-pressure liquid producing section.

21. The adherent film recovering device as set forth in claim 19 or 20, wherein:

a humidifier for use in wetting an internal surface of said work room is provided other than said liquid-jet section.

22. The adherent film recovering device as set forth in any one of claims 19 to 21, further comprising:

a liquid-jet cleaning gun for spraying liquid-jet;

a mobile member provided in said work room, for altering a direction of the liquid-jet to be sprayed from said liquid-jet cleaning gun; and

a control section for controlling said mobile section to move according to the teaching playback system or the numerical control system.

23. An adherent film recovering device for recovering an adherent film from a depositing jig mounted on a holding plate, comprising:

a liquid-jet section which sprays liquid-jet against said depositing jig, for recovering therefrom said adherent film;

a sealed work room so as to prevent droplets resulting from the liquid-jet sprayed by said liquid-jet section from sputtering outside of said work room; and

an humidifier for use in wetting an internal surface of said work room.

24. The adherent film recovering device as set forth in claim 23, further comprising:

a liquid-jet cleaning gun for spraying liquid-jet; a mobile member provided in said work room, for altering a direction of the liquid-jet to be sprayed from said liquid-jet cleaning gun; and

a control section for controlling said mobile section to move according to the teaching playback system or the numerical control system.

25. An adherent film recovering device for recovering an adherent film from a depositing jig mounted on a holding plate, comprising:

a liquid-jet section which sprays liquid-jet against said depositing jig, for recovering therefrom said adherent film;

a sealed work room so as to prevent droplets resulting from the liquid-jet sprayed by said liquid-jet section from sputtering outside of said work room;

a liquid-jet cleaning gun for spraying liquid-jet; a mobile member provided in said work room, for altering a direction of the liquid-jet to be sprayed from said liquid-jet cleaning gun; and

a control section for controlling said mobile section to move according to the teaching playback system or the numerical control system.

26. The adherent film recovering device as set forth in any one of claims 1 to 25, further comprising:

a high-pressure liquid producing section which produces high-pressure liquid with hydraulic pressure within a range of 30 Mpa to 200 Mpa, and supplies high-pressure liquid as produced to said liquid-jet section.

27. A method of recovering an adherent film, for removing and recovering an adherent film adhered to an anti-adherent plate, a mask, a substrate tray or other depositing jig for use in a vacuum deposition device adopting the sputtering method, the vacuum deposition method, the ion-plating method, or other vacuum deposition method, wherein:

a liquid-jet method using water or liquid is adopted for removing said adherent film adhered to said

depositing jig.

28. The method of recovering an adherent film as set forth in claim 27, comprising the step of:

purifying city water to be adopted in said liquid-jet method so as to reduce a content of at least calcium carbonate.

29. The method of recovering an adherent film as set forth in claim 27 or 28, comprising the step of:

removing and recovering adherent film pieces from suspension resulting from said liquid-jet method by a solid-liquid separation method.

30. The method of recovering an adherent film as set forth in claim 29, wherein:

said solid-liquid separation method is the centrifuge separation method or the precipitation method.

31. The method of recovering an adherent film as set forth in any one of claims 27 to 30, wherein:

target adherent film pieces to be recovered are made of metal or metal compound.

32. The method of recovering an adherent film as

set forth in any one of claims 27 to 31, wherein:

adherent film pieces adhered to said depositing jig contain at least indium, tantalum or other rare metal, or a compound thereof.

33. The method of recovering an adherent film as set forth in any one of claims 27 to 32, wherein:

said depositing jig is provided for a sputtering device; and

said adherent film adhered to said depositing jig is made of Indium Tin Oxide.

34. The method of recovering an adherent film as set forth in any one of claims 27 to 33, wherein:

said adherent film adhered to said depositing jig is removed and separated by reutilizing water or liquid after carrying out the solid-liquid separation method.

35. The method of recovering an adherent film as set forth in any one of claims 27 to 34, wherein:

said depositing jig is made of stainless, titanium, copper or an alloy of nickel-iron; and

at least surface of said depositing jig, to which said adherent film is adhered, is finished with roughness within a range of from 3 microns to 50 microns.

36. The method of recovering an adherent film as set forth in any one of claims 27 to 35, wherein:

said depositing jig is made of aluminum; and

at least surface of said depositing jig, to which said adherent film is adhered, is finished with aluminum spray deposit.