

NOZZLE SOURCE FOR THERMAL EVAPORATION PROCESS

BACKGROUND OF THE INVENTION

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1. Field of the Invention

The present invention relates to a nozzle source for a thermal evaporation process, and more particularly, to an evaporation source for use in a thermal evaporation process for manufacturing semiconductor devices, flat panel display devices and the like, wherein when
10 a material in the source is deposited on a substrate during the thermal evaporation process, the evaporated material can be uniformly deposited on the substrate and heat can be uniformly applied to the material within a crucible of the source.

Accordingly, the present invention relates to a conically-disposed nozzle source for a thermal evaporation process, wherein the uniformity of the thickness of a material layer
15 deposited on a substrate, particularly, upon manufacture of a large substrate can be improved, the deposition rate of a material can be prevented from being rapidly decreased with time, and the use rate of the material can be increased.

2. Description of the Related Art

20 A thermal evaporation process is a process widely used for manufacturing semiconductor devices, flat panel display devices and the like. To coat a substrate with a chemical material for use in manufacturing semiconductor devices and flat panel display devices, a crucible containing the chemical material is heated so that the chemical material can be evaporated from the surface thereof and the evaporated material can be then deposited on
25 the substrate placed above the crucible, thereby making a thin layer of the chemical material on the substrate. At this time, the thermal evaporation process is generally performed in a vacuum vessel to control a deposition rate and ensure efficient deposition.

In such a thermal evaporation process, a most important part is an evaporation source for evaporating the chemical material by heating the material. The source comprises a
30 crucible, a heating portion and an opening portion.

Such evaporation sources include point evaporation sources, linear evaporation sources, and the like. Among them, point evaporation sources have been most widely used.

A typical structure of a point evaporation source is shown in FIG. 1. As shown in the figure, an opening portion 2 that narrows in the form of a gourd bottle and then flares is provided at an upper portion of a cylindrical crucible 1 with a closed lower end that can contain a chemical material, a heating portion 3 for heating the crucible 1 is installed around the crucible 1, and a nozzle portion 4 is further installed at the opening portion 2 so that the chemical material can be spread widely.

Then, the material is deposited on a substrate 5 by heating the material using the heating portion 3 in a state where the point evaporation source is spaced apart by a predetermined distance from the substrate 5.

The point evaporation source with such a structure has been widely used since it can be easily manufactured and used. However, there is a disadvantage in that it is difficult to apply the point evaporation source to manufacture of a large substrate.

Since substrates for semiconductor devices are gradually enlarged and it is required to enlarge the screens of TVs and improve productivity, particularly, in case of flat panel display devices, there is a need for a deposition apparatus capable of supporting manufacture of large substrates. To construct a deposition apparatus for manufacturing large substrates, a variety of technical problems should be solved. Among the problems, it is a most important problem to develop an evaporation source for use in manufacturing large substrates.

In a case where a point evaporation source is used for manufacturing a large substrate, the point evaporation source should be spaced apart by about 1 m from a substrate, e.g., a substrate with a size of 370 x 470 mm, in order to perform deposition on the substrate while maintaining the uniformity of the thickness of a thin film in a tolerance range of 5 % or less.

Therefore, there are problems in that the size of a deposition apparatus is increased and the use rate of a material is greatly lowered.

To solve the problems, methods of placing the substrate 5 to be inclined with respect to the center of the source or rotating the substrate 5 as shown in FIG. 2 have been employed.

However, the methods have not yet considerably solved the problems of the conventional point evaporation source.

Further, in the case where the point evaporation source is used for manufacturing the large substrate, the crucible 1 for containing the chemical material should be enlarged in order to increase the capacity thereof. If the size of the crucible 1 is increased, heat cannot be well transferred to a portion of the chemical material at the center of the crucible 1. Thus, as shown in FIG. 3, only a portion of the chemical material 6 in the vicinity of an inner surface of the crucible 1 is first evaporated. Accordingly, even though the chemical material 6 remains in the crucible 1 in great amounts, the deposition rate is considerably lowered. Consequently, there are problems in that it is difficult to control the deposition rate and the chemical material 6 should be frequently filled into the crucible.

SUMMARY OF THE INVENTION

The present invention is conceived to solve the problems. An object of the present invention is to provide a nozzle source for a thermal evaporation process, wherein the uniformity of the thickness of a material layer deposited on a substrate, particularly, upon manufacture of a large substrate can be improved, the deposition rate of a material can be prevented from being rapidly decreased with time, and the use rate of the material can be increased.

A nozzle source of the present invention comprises an insertion portion in which nozzles for determining evaporation directions of a chemical material are conically arranged; a crucible that is in the form of a cylinder with an opened upper end and formed with a catching step by which the insertion portion can be caught at the upper end of the crucible; a filament disposed around the crucible to heat the crucible; a reflecting plate disposed around the filament to minimize heat loss; and a heat conducting portion inserted into the crucible to transfer heat from the filament to the interior of the crucible.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become apparent from the following description of preferred embodiments given in

conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic view showing an example of the use of a conventional point evaporation source for a thermal evaporation process;

5 FIG. 2 is a schematic view showing another example of the use of the conventional point evaporation source for the thermal evaporation process;

FIG. 3 is a schematic view showing the interior state of a crucible of the conventional point evaporation source for the thermal evaporation process;

FIG. 4 is a sectional view showing a crucible of a nozzle source for a thermal evaporation process according to the present invention;

10 FIG. 5 is a sectional view showing a first embodiment of the nozzle source for the thermal evaporation process according to the present invention;

FIGS. 6 to 8 are sectional views taken along line A-A' in FIG. 4, wherein FIG. 6 is a view showing a first embodiment of a heat conducting portion in the present invention, FIG. 7 is a view showing a second embodiment of the heat conducting portion in the present invention, and FIG. 8 is a view showing a third embodiment of the heat conducting portion in the present invention;

FIG. 9 is a sectional view showing a first embodiment of an insertion portion of the nozzle source for the thermal evaporation process according to the present invention;

FIG. 10 is a sectional view taken along line B-B' in FIG. 9;

20 FIG. 11 is a sectional view showing a second embodiment of the insertion portion of the nozzle source for the thermal evaporation process according to the present invention;

FIGS. 12a and 12b are enlarged views showing portion B in FIG. 11;

FIG. 13 is a sectional view of a second embodiment of the nozzle source for the thermal evaporation process according to the present invention;

25 FIG. 14 is a sectional view of a third embodiment of the nozzle source for the thermal evaporation process according to the present invention;

FIG. 15 is a sectional view of a fourth embodiment of the nozzle source for the thermal evaporation process according to the present invention;

30 FIG. 16 is a sectional view of a fifth embodiment of the nozzle source for the thermal evaporation process according to the present invention;

FIG. 17 is a sectional view of a sixth embodiment of the nozzle source for the thermal evaporation process according to the present invention; and

FIG. 18 is a schematic view illustrating a deposition method using the fifth embodiment of the nozzle source for the thermal evaporation process according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

FIG. 4 is a sectional view showing a crucible of a nozzle source for a thermal evaporation process according to the present invention, and FIG. 5 is a sectional view showing an embodiment of a conically-disposed nozzle source for a thermal evaporation process according to the present invention. The nozzle source of the present invention comprises an insertion portion 10 in which nozzle 11 for determining evaporation directions of a chemical material are uniformly formed along a conical shape; a crucible 20 that is in the form of a cylinder with an opened upper end and formed with a catching step 21 by which the insertion portion 10 can be caught at the upper end of the crucible; a filament 30 disposed around the crucible 20 to heat the crucible 20; a reflecting plate 40 disposed around the filament 30 to minimize heat loss; and a heat conducting portion 50 inserted into the crucible 20 to transfer heat from the filament 30 to the interior of the crucible 20.

The insertion portion 10 is including a plurality of evaporation tubes 12 (FIG. 11) vertically formed to communicate with a lower portion thereof and a nozzle 11 that connect with the evaporation tubes 12 conically arranged along an outer circumference of an upper side thereof.

In order to prevent leak of the evaporated material at a connection of the insertion portion with the catching step 21, the connection can be sealed by screwing using a thread or by a gasket, which is not shown in the figures.

FIG. 6 is a sectional view taken along line A-A' in FIG. 4, showing an example of the heat conducting portion of the nozzle source for the thermal evaporation process according to

the present invention.

That is, the heat conducting portion 50 is formed with a plurality of fins 51 that come into contact with an inner surface of the crucible 20, have tips directed to the center of the crucible and extend vertically. The heat conducting portion 50 defines spaces 52b surrounded by the fins 51 and a space at the center of the crucible 20 in which the chemical material is put. The heat conducting portion 50 serves to effectively transfer heat from the filament 30 around the crucible 20 even to the chemical material put in the interior of the crucible.

With the heat conducting portion 50 of the example shown in FIG. 6, the space at the center of the crucible 20 substantially takes the shape of a hexagon, the spaces surrounded by the fins 51 substantially take the shapes of octagons, and the spaces 52a and 52b communicate with one another. However, it is possible to construct a variety of heat conducting portions as shown in FIGS. 7 and 8.

That is, the fins 51 shown in FIG. 7 are constructed such that the spaces 52a and 52b substantially take the shapes of circles. The fins 51 shown in FIG. 8 are constructed in the form of walls extending toward the center of the crucible such that the spaces 52 surrounded by the fins 51 substantially take the shapes of triangles.

However, the structure of the heat conducting portion 50 is not limited to those shown in FIGS. 6 to 8. It will be apparent that a variety of structures thereof can be implemented.

In some cases, it is preferred in view of the efficiency of heat conduction that the heat conducting portion 50 be formed integrally with the crucible 20.

FIG. 9 is a sectional view showing a first embodiment of the insertion portion of the nozzle source for the thermal evaporation process according to the present invention, and FIG. 10 is a sectional view taken along line B-B' in FIG. 9. It is preferred that the insertion portion 10 be constructed such that a plurality of evaporation tubes 12 are formed vertically to communicate with at a lower portion thereof and the nozzles 11 are uniformly arranged in the form of a cone extending from outer sides of the evaporation tubes 12 to the upper end of the insertion portion 10.

Further, it is preferred that a circular reflecting plate 13 be further provided above the insertion portion 10 to improve thermal efficiency and to prevent the chemical material from being accumulated in the nozzles of the insertion portion 10.

If necessary, a plurality of circular reflecting plates 13 may be stacked one above another.

A shielding plate 60 may be further installed on a post 61 with a predetermined height extending from the top of the circular reflecting plate 13 to control a stream of the chemical material directed to the center of the substrate.

FIG. 11 is a sectional view showing a second embodiment of the insertion portion of the nozzle source for the thermal evaporation process.

That is, the insertion portion 10 is constructed such that an outer peripheral surface 10a of the insertion portion 10 is depressed, thereby more facilitating heat transfer to the evaporation tubes 12 and the nozzles 11. Thus, it is possible to more effectively prevent the chemical material from being accumulated in the evaporation tubes 12 and the nozzles 11.

FIGS. 12 and 12b are enlarged views of portion B in FIG. 11. Each nozzle 11 may have a constant width in a longitudinal direction thereof as shown in FIG. 12a or an increasing width in the longitudinal direction as shown in FIG. 12b.

FIGS. 13, 14 and 15 show other embodiments of the nozzle source for the thermal evaporation process according to the present invention.

FIG. 13 shows a second embodiment of the conically-arranged nozzle source for the thermal evaporation process according to the present invention, wherein a cylindrical hollow portion 70 is formed to penetrate through the centers of the insertion portion 10 and the crucible 20, and a central heating portion 31 is installed within the hollow portion 70. Both of the filament 30 and the central heating portion 31 may be simultaneously installed or only the central heating portion 31 may be installed.

FIG. 14 shows a third embodiment of the present invention obtained by modifying the embodiment of FIG. 13, wherein a small evaporation source 80 of which an upper portion takes the same shape as the insertion portion is further provided at an upper end of the central hollow portion 70 shown in FIG. 13 so that another material can be contained in the small evaporation source 80. Thus, the nozzle source of the third embodiment can be applied to the process of simultaneously depositing two materials.

At this time, it is possible to provide a cooling portion (not shown) for thermal interference between the central small evaporation source 80 and the outer large conically-

arranged nozzle source.

Further, shadow effects that may occur upon manufacture of a large substrate can be minimized by increasing the diameter of the cylinder constructing the hollow portion 70, as shown in FIG. 15.

5 That is, when a substrate is manufactured through the thermal evaporation process, in order to determine a desired deposition pattern on the substrate, a thin mask perforated according to the desired deposition pattern is generally in close contact with the bottom of the substrate. In a case of a conventional point evaporation source, a stream of an evaporated material reaches edges of the substrate at certain angles, which may produce shadow effects
10 of the mask.

However, if the hollow portion 70 is constructed of a cylinder with a large diameter as shown in FIG. 15, the evaporated material reaches the entire portions of the substrate in a substantially normal direction thereto. Thus, there is an advantage in that it is possible to minimize the shadow effects which may occur upon manufacture of a large substrate.

15 When the size of the hollow portion 70 is increased as such, it is preferred that the filaments 30 be installed at both sides of a material containing portion 22.

Meanwhile, the insertion portion 10 may be formed integrally with the crucible 20. If necessary, the crucible 20 may be constructed by connecting separate intermediate and lower portions.

20 Hereinafter, the operation and effects of the present invention will be described with reference to FIGS. 4 to 15.

First, a general operation principle of the nozzle source of the present invention will be explained.

25 The filament 30 for heating the crucible 20 is preferably disposed at the upper portion of the crucible 20, as shown in FIG. 5. This is to prevent the evaporation tubes 12 and the nozzles 11 from being clogged due to accumulation of the evaporated material by increasing the temperature of the upper portion over that of the lower portion of the crucible 20 from which the material is evaporated.

30 Further, the filament 30 may extend at a certain ratio toward the lower portion to uniformly heat the upper and lower portions of the crucible 20.

Moreover, in order to ensure uniform evaporation of the chemical material from the surface of the crucible, the material is evaporated by using radiant heat generated from a material constructing the insertion portion 10 through heating of the upper portion of the crucible 20 without directly heating an outer surface of the material containing portion of the crucible 20. In order to uniformly spread the radiant heat, the bottom of the insertion portion 10 is preferably formed to take the shape of a cone with an upward vertex.

With the installation of the shielding plate 60 above the insertion portion 10, a stream of the evaporated material directed to the center of the substrate can be controlled by adjusting the size of the shielding plate 60 while the thermal evaporation process is performed using the nozzle source of the present invention. Accordingly, the uniformity of a deposited thin film can be further controlled and thus more improved.

Next, an operation principle for ensuring the uniformity of the deposited thin film using the insertion portion 10 will be explained.

In case of a conventional point evaporation source, it can be considered that the evaporated material starts from one point and spreads upward in all directions in the form of a hemisphere. A slightly larger stream of the evaporated material is established at a central portion of the hemisphere rather than outer portions thereof. Since the substrate on which the deposition is actually performed is substantially flat, the distance from the source to the substrate is increased from the center to the outer portions of the substrate. Thus, since the angle between the direction of the stream of the evaporated material and the surface of the substrate is increased, the thickness of the deposited thin film is decreased from the center to the outer portions of the substrate.

Since the nozzles 11 of the insertion portion 10 are arranged conically toward the outer portions of the substrate in the nozzle source of the present invention, larger streams of the evaporated material are established at the outer portions of the substrate while the effects of the distance between the source and the substrate and the effects of the angle between the directions of the streams of the evaporated material and the surface of the substrate thicken the thin film at the center of the substrate. Therefore, the two phenomena are offset by each other, thereby maintaining the uniformity of the thickness of the evaporated thin film on the substrate as a whole.

At this time, angle A between an axis of each of the conically arranged nozzles and a centerline of the source is a value properly selected from a range, $0 < A \leq 90$ degrees, according to the distance to the substrate or a used material.

Further, the plurality of circular reflecting plates 13 are installed above the insertion portion 10 to improve reflectivity, so that thermal efficiency can be improved, and at the same time, it is possible to prevent the nozzles 11 from being clogged by the evaporated material accumulated in the nozzles due to the temperature of the nozzles 11 of the insertion portion 10 which is lower than that of the upper portion of the crucible 20.

The nozzles 11 or crucible 20 in the present invention can be made of high density carbon, ceramic, and materials such as molybdenum, tungsten, tantalum and titanium that are not easily sublimated at high temperature. In addition, a variety of alloys may be used.

FIG. 16 shows a fifth embodiment of the nozzle source for the thermal evaporation process according to the present invention. In the fifth embodiment and a deposition method using the same, as shown in FIGS. 16 and 18, the nozzle source having the insertion portion 10 formed with an asymmetric nozzle 90 directed to the outer portions of the substrate is placed at a position corresponding to or in the vicinity of the center of the substrate 5 and the thermal evaporation process is then performed while the substrate is rotated. That is, although the nozzle is asymmetric to be directed only in one direction, it is possible to obtain the same effects as the conically arranged nozzles by rotating the substrate 5.

As for a nozzle directed in one direction, there is an inclined nozzle 91 shown in FIG. 17 in addition to the asymmetric nozzle 90 in FIG. 16. Any structure of the nozzle capable of controlling the discharge direction of the evaporated material can be used. The inclined angle of the nozzle 90 or 91 with respect to vertical centerline A can be within a range of 5 to 90 degrees. The angle can be selected to maximize the uniformity of the deposited thin film in consideration of the level of the substrate 5, the distance to the center of the substrate and the like.

According to the nozzle source for the thermal evaporation process according to the present invention, the uniformity of the thickness of a material layer deposited on a substrate, particularly, upon manufacture of a large substrate can be improved, the deposition rate of a material can be prevented from being rapidly decreased with time, and the use rate of the

material can be increased.

Although the present invention has been described by way of examples in connection with the aforementioned embodiments, the scope of the present invention should not be construed as being limited to the embodiments illustrated in the accompanying drawings.

WHAT IS CLAIMED IS:

1. A nozzle source for a thermal evaporation process, comprising:
an insertion portion for determining evaporation direction of a chemical material, the insertion portion including a plurality of evaporation tubes formed to communicate with a lower portion thereof and a nozzle that connect with the evaporation tubes conically arranged along an outer circumference of an upper side thereof;
a crucible that takes the shape of a cylinder with an opened upper end and is formed with a catching step by which the insertion portion can be caught at the upper end thereof;
and
a filament that is disposed around the crucible to heat the crucible.
2. The nozzle source as claimed in claim 1, wherein a heating conducting portion is formed with a plurality of vertically extending fins that come into contact with an inner surface of the crucible and have tips directed to the center of the crucible so that spaces surrounded by the fins and a space positioned at the center of the crucible for putting the chemical material are defined within the crucible.
3. The nozzle source as claimed in claim 2, wherein the fins of the heat conducting portion are formed at a regular interval so that the heat conducting portion takes the shape of an axisymmetric figure as viewed from above.
4. The nozzle source as claimed in claim 2, wherein the heat conducting portion is integrally formed with the crucible.
5. The nozzle source as claimed in claim 1, wherein an angle(A) between an axis of each nozzle of the insertion portion and a centerline of the source is $0^{\circ} < A \leq 90^{\circ}$.
6. The nozzle source as claimed in claim 1, wherein the insertion portion includes a plurality of tubular nozzles which communicate with the lower portion thereof and are arranged in the form of a cone so that an angle(A) between an axis of each tubular

nozzle and a centerline of the source is $0^\circ < A \leq 90^\circ$.

7. The nozzle source as claimed in claim 1, wherein a circular reflecting plate is further provided around an upper side of the insertion portion to improve thermal efficiency and to prevent the chemical material from being accumulated in the nozzles of the insertion portion.

8. The nozzle source as claimed in claim 1, wherein an outer peripheral surface of the insertion portion is depressed to improve heat transfer to the evaporation tubes and nozzles and to prevent the evaporation tube and nozzles from being clogged due to the accumulation of an evaporated material onto the evaporation tubes and nozzles.

9. The nozzle source as claimed in claim 1, wherein a shielding plate is further installed on a post with a predetermined height extending from the top of the circular reflecting plate to control a stream of the chemical material directed to the center of a substrate.

10. The nozzle source as claimed in claim 1, wherein the bottom of the insertion portion is concave to take the shape of a cone thereon.

11. The nozzle source as claimed in claim 1, wherein the filament is disposed around an upper portion of the crucible to heat the upper portion of the crucible.

12. The nozzle source as claimed in claim 1, wherein the filament is distributed at a predetermined ratio around the upper and lower portions of the crucible to maintain uniform temperatures at the upper and lower portions of the crucible.

13. The nozzle source as claimed in claim 1, wherein a thread is formed at or both a thread and a gasket are used in the catching step so that a connection between the insertion portion and the crucible can be hermetically sealed.

14. The nozzle source as claimed in claim 1, wherein a central heating portion is further

provided in a cylindrical hollow portion that is formed to penetrate through the center of the insertion portion and the crucible so that the chemical material can be heated by using both the filament and the central heating portion or by using only the central heating portion.

15. The nozzle source as claimed in claim 14, wherein a small source of which an upper portion takes the same shape as the insertion portion is further provided at an upper end of the central hollow portion so that another material can be contained in the small source and two materials can be simultaneously deposited.

16. The nozzle source as claimed in claim 1, wherein the insertion portion is formed integrally with the crucible, or the crucible is constructed by connecting separate intermediate and lower portions thereof.