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Toyonaga et al.

[11] **3,819,408**

[45] **June 25, 1974**

[54] **METHOD FOR MANUFACTURING VAPOR DEPOSITED ELECTRODE**

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[30] **Foreign Application Priority Data**

May 27, 1971 Japan 46-36498

[52] **U.S. Cl.** .... **117/201,** 117/7, 117/106 R, 117/106 A, 117/106 C, 117/107, 117/107.1, 117/107.2 R, 118/48, 118/49, 118/49.1, 118/49.5

[51] **Int. Cl.** **B44d 3/18,** B44c 1/18

[58] **Field of Search**. 117/201, 106 R, 107, 107.2 R, 117/107.1, 106 A, 106 C; 118/48–49.5, 117/7

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[57] **ABSTRACT**

A method for manufacturing secondary emission electrode deposited on a thin supporting film by vacuum evaporation, wherein a rigid body is arranged adjacent to a surface of the thin film opposite to the vaporizing surface. The opposite surfaces of the rigid body and the thin film may be arranged in parallel and at a distance, for example, about 0.05 mm or they may be so arranged to increase the distance at locations radially more distant from the central portion of the thin film. An evaporating material is vapor deposited onto the supporting surface, thus a secondary emission electrode layer having a uniform thickness can be obtained.

6 Claims, 10 Drawing Figures

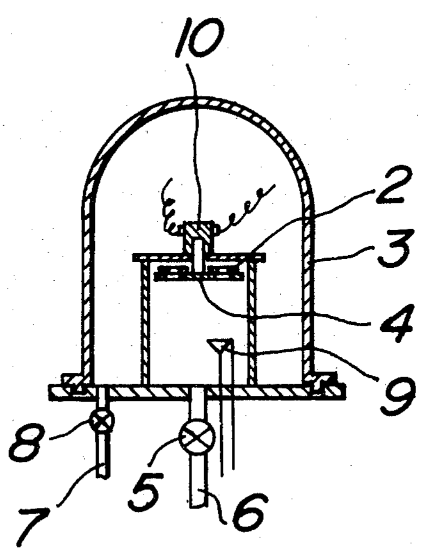


FIG_1A

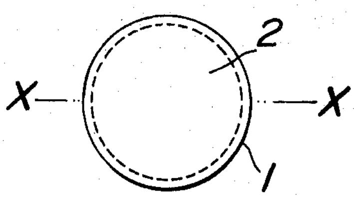


FIG_1B

FIG_2

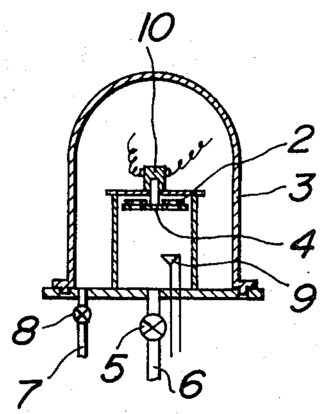


FIG_3

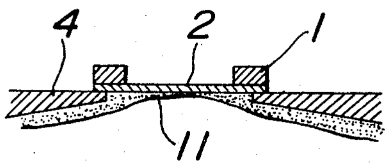

4
2
1
11

FIG_4

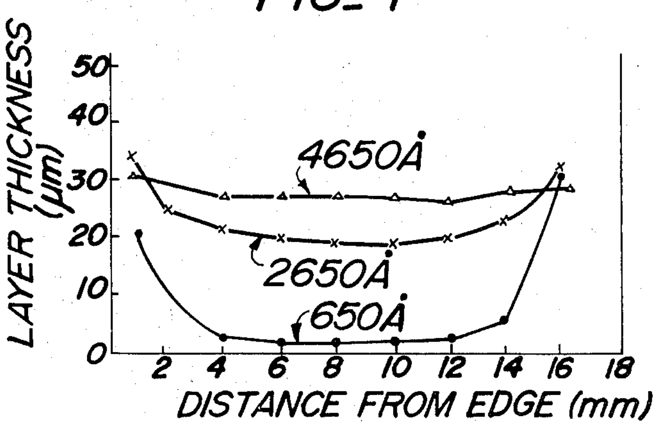

LAYER THICKNESS (μm)
50
40
30
20
10
0
4650Å
2650Å
650Å
2
4
6
8
10
12
14
16
18
DISTANCE FROM EDGE (mm)

FIG_5

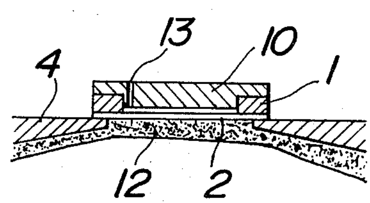

13
10
4
1
12
2

FIG_6

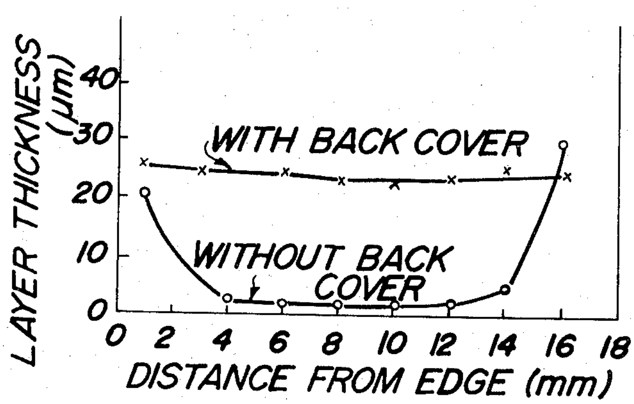

LAYER THICKNESS (μm)
40
30
20
10
0
WITH BACK COVER
WITHOUT BACK COVER
0 2 4 6 8 10 12 14 16 18
DISTANCE FROM EDGE (mm)

FIG_7

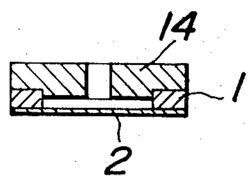


FIG_9

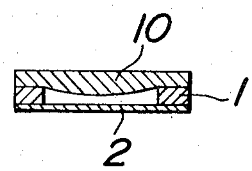
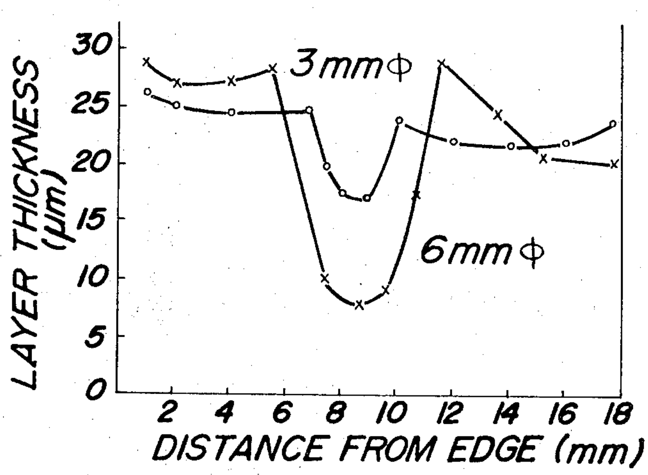


FIG_8



METHOD FOR MANUFACTURING VAPOR DEPOSITED ELECTRODE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method for manufacturing vapor deposited electrodes in which a porous electrode layer is formed on a thin supporting film in a vacuum chamber by vaporization. More particularly, the present invention relates to a method for manufacturing vapor deposited electrodes which is able to form a vapor deposited electrode layer having a substantially uniform thickness.

2. Description of the Prior Art

Heretofore, there has been proposed a method for forming a vapor deposited electrode layer on a thin supporting film, in which the thin supporting film is stretched and is supported with a metal frame and the thus supported thin film is placed and fixed in an evaporation chamber where a desired evaporating material is deposited from an evaporating source on the surface of the thin film by vaporization.

An embodiment of a conventional manufacturing practice of a secondary electron multiplier target for a television camera tube having a secondary electron multiplying function will be explained below. As shown in FIGS. **1A** and **1B**, a film **2**, functioning as a target base electrode and signal electrode and consisting mainly of aluminium is supported with a metal frame **1** made of a nichrome material (Ni—Cr). Then, this assembly (**1, 2**) is held on a rotary supporting plate **4** in a bell jar **3** of an evaporator as shown in FIG. **2**.

Next, air in the bell jar **3** is exhausted from an outlet **6** through a main valve **5** and thereafter, argon or nitrogen gas is introduced thereinto from an inlet **7** through an inlet valve **8** so as to maintain the inert gas atmosphere in a vacuum of about 1 to 2 Torr. A sintered body of cryolite and magnesium oxide ($Na_3AlF_6 \cdot MgO$) is previously charged into an evaporating source **9** in the bell jar **3** and then evaporated by heating so as to deposit a porous secondary electron multiplier target on the surface of the film.

In FIG. **2**, **10** represents a motor for driving the rotary supporting plate **4**.

The vapor deposited layer **11** obtained by the above mentioned conventional method shown in FIG. **3** has a disadvantage that the thickness of the obtained layer is not uniform and it has the most thin portion at center of the film **2** and becomes thicker from the central portion toward the circumference of the film **2** or the metal frame **1**. In some cases, there will be the further disadvantage that no vapor deposited layer is formed on the central portion of the film **2**.

Such a phenomenon is troublesome in the manufacture of camera tubes as explained below. Namely, when such a vapour deposited layer having an uneven thickness is used as a secondary electron multiplier target for a secondary electron conduction type camera tube, the secondary electron gain, the dark current and the afterimage time are different in the central portion and in the surroundings of the vapor deposited layer, so that an unevenness of sensibility is caused and it is difficult to operate the whole surface of the target in a high gain; and further an improvement of performance of the camera tube cannot be expected.

FIG. **4** shows experimental results with respect to the ununiformity of the thicknes of the vapor deposited layer obtained by the conventional method, wherein the evaporating material consisting of cryolite magnesium oxide ($Na_3AlF_6 \cdot MgO$) is deposited on the signal electrode film consisting mainly of aluminium to form the secondary electron multiplier target.

In this figure, an ordinate shows the thickness (μm) of the secondary electron multiplier target, that is, the vapor deposited layer, while an abscissa shows the distance (mm) from one side of the circular signal electrode film having a diameter of 18 mm, i.e. the electrode supporting film.

The variation of the thickness of the vapor deposited layer is indicated by curved lines connecting symbols Δ, x and o with respect to the supporting film having the thicknes of 4,650 A., 2,650 A. and 650 A., respectively.

As seen from FIG. **4**, there is a tendency that the thicker the thickness of the supporting film, the more the uniformity of the vapor deposited layer is improved.

For instance, in case of a secondary electron multiplier target for a camera tube, however, the transmission loss of photoelectron increases as the supporting film becomes thicker, so that it is necessary to use a sufficiently thin supporting film.

In the conventional method, there are disadvantages as described above when a target electrode for a camera tube is formed by vapor deposition, so that it was very difficult to manufacture a vapor deposited electrode having a uniform thickness.

Although the causes for said tendency are not clarified, the following may be considered: the thermal conduction around the target supporting film is comparatively high because the circumference of the supporting film is provided with an annular rigid frame, while the thermal conduction in the central portion of the supporting film is low because at the central portion there is only a thin supporting film having a thickness of about 500 to 2,000 A. Therefore, the temperature rises at the central portion of the supporting film and the target material is scarcely deposited on the said central portion, or since the target supporting film is very thin as described above, a collision of heated gas molecules or particles of evaporating material is caused by convection of atmospheric gas during the evaporation, whereby the film is particularly vibrated at its central portion, and hence comparatively less target material is vapor deposited on the said central portion.

It has been experimentally confirmed that said tendency occurs not only when evaporating a target material or secondary electron multiplier material such as $Na_3AlF_6 \cdot MgO$ and the like but also with other metals such as aluminium, magnesium, etc. in an inert gas atmosphere, or when evaporating metals such as magnesium and the like under high vacuum.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method for manufacturing vapor deposited electrodes, in which a vapor deposited layer having a uniform thickness is evaporated on a sufficiently thin supporting film being capable of causing the above mentioned phenomenon.

Another object of the present invention is to provide a method for the manufacture of secondary electron multiplier targets, in which a thin film working as a signal electrode is used as a supporting film and a vapor deposited layer consisting of a secondary emissive material can easily be formed thereon in a uniform thickness.

The present invention is fundamentally the improvement of the conventional method for manufacturing a vapor deposited layer on a supporting film by vapor deposition.

The present invention has been obtained based on the recognition of such production of unevenness of vapor deposited electrodes in the conventional method for manufacturing secondary electron multiplier target by vapor deposition as described above. In accordance with the present invention, a rigid body having low gas discharging characteristics, such as copper or glass is arranged in close proximity of the back surface opposite to the vapor depositing surface of the signal electrode film and vapor deposition is carried out in this assembled state, whereby the vapor deposited layer can be formed to be thicker on the surface of the supporting film opposite to the area close to the rigid body in other portions.

The present invention provides a method for manufacturing vapor deposited electrode comprising steps of oppositely arranging an evaporation source for evaporating electrode material and a thin supporting film on the front surface of which said electrode is vapor deposited in an evaporating chamber, providing a back cover made of a rigid body in close proximity of the rear surface of the thin supporting film, evaporating said electrode material, and vapor depositing said evaporated electrode material onto said front surface of the thin supporting film to form a vapor deposited electrode.

According to the present invention, it is an advantage that the thickness of the vapor deposited layer can be varied depending upon the relative distance between the back cover and the thin supporting film. Thus, by making the back cover in a proper form, vapor deposited layers having not only a uniform thickness but also any desired configuration can easily be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

For better understanding of the invention, reference is made to the accompanying drawings, in which:

FIG. 1A is a front view showing an embodiment of a thin supporting film to have a vapor deposited layer formed thereon;

FIG. 1B is a cross-sectional view of the thin supporting film taken on the line X—X in FIG. 1A;

FIG. 2 is a perspective view of an evaporating apparatus used for practicing a conventional vapor deposition method;

FIG. 3 is a cross-sectional view illustrating a deposition state of a porous layer on the thin supporting film according to the conventional method;

FIG. 4 is a graph showing a relation between the thickness of the thin supporting film and the thickness of the target layer (porous layer) deposited thereon according to the conventional method;

FIG. 5 is a cross-sectional view illustrating the deposition state of the porous layer according to the present invention;

FIG. 6 is a graph showing the variations of thickness of the porous target layer deposited on the thin supporting film having a thickness of 650 A according to the present method and the conventional method;

FIG. 7 is a cross-sectional view of an embodiment of a back cover used for illustrating the effect of the present invention;

FIG. 8 is a graph showing the thickness of the target layer (porous layer) obtained by using the back cover of FIG. 7; and

FIG. 9 is a cross-sectional view of an embodiment of the back cover to be used in the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **5**, **1** represents an annular rigid supporting frame made of, for example, nichrome material and **2** represents an electroconductive metal film adhered to the supporting frame **1** in a stretched state by any well-known means. For instance, in the manufacture of a target for a camera tube, a metal film consisting mainly of aluminium, or an alumina film formed by depositing aluminium on a signal electrode film, or an aluminium metal film reinforced with a net with small meshes may be used.

Generally, said thin supporting film **2**, on which a vapor deposited layer is formed, is retained in a stretched state with the supporting frame **1** as previously explained with respect to FIGS. **1A** and **1B**.

According to the present invention, a rigid body **10** such as metal, glass or the like, used as a back cover is arranged in close proximity with the back surface opposite to the surface of the thin film **2** having the vapor deposited layer formed thereon. This assembly (**1**, **2**, **10**) is placed on a fixed or rotary supporting plate **4** in a conventional evaporating apparatus as shown in FIG. **2**. In this case, the vapor depositing surface of the thin supporting film **2** is faced to an evaporating source for a target material **9** through holes provided in the supporting plate **4**.

The present invention will be explained by taking an example that a porous vapor deposited layer having a uniform thickness is formed on the surface of the thin supporting film as a secondary electron multiplier electrode for camera tube. A sintered body consisting of cryolite (Na_3AlF_6) and magnesium oxide (MgO) in a weight ratio of 1 : 1 is, for example, used as an evaporating material and charged into the evaporating source **9**. Then, a main valve **5** is opened and air in a bell jar **3** is exhaustd from an outlet **6**. After evacuation of the bell jar **3** in high vacuum, the main valve **5** is closed, while an inlet valve **8** is opened and an inert gas such as argon or nitrogen is introduced into the bell jar **3** through an inlet **7**. When the inside of the bell jar **3** reaches a pressure required for evaporation, for example, about 1 to 2 Torr, the inlet valve **8** is closed. Thereafter, an electric current is passed through a heater element of the evaporating source **9** for the target material to raise the temperature, whereby the target material is evaporated and deposited to form a target layer **12** on the surface of the thin supporting film **2** facing the evaporating source **9** as shown in FIG. **5**. In this case, the target layer **12** becomes porous because the evaporation is carried out in the inert gas atmosphere. In this figure, **13** represents a small aperture for escaping gas.

The thickness of the porous vapor deposited layer formed on the thin supporting film by the above mentioned method was measured at the central portion and at circumference thereof to obtain a result as shown in the following table which also shows that of the conventional method in comparison.

In this example, a signal electrode film having a diameter of 18 mm and a thickness of 300 A, which is reinforced with a copper net having 1,000 mesh per inch, was used as the thin supporting film to have a vapour deposited layer formed thereon, and a back cover having a flat surface facing the thin supporting film was used.

Distance between target supporting film and back cover	Thickness of target layer	
	central portion	circumference
no back cover	6 μm	25 μm
close proximity	20 μm	20 μm
0.1 mm	20 μm	20 μm
0.3 mm	20 μm	20 μm
1.0 mm	15 μm	25 μm

As seen from the above table, the target layer can be deposited without unevenness of the thickness when the back cover is arranged in proximity or close to the back surface of the thin supporting film. Thus, in order to obtain a vapor deposited layer having a uniform thickness, it is necessary to arrange the back cover over back surface of the thin supporting film. Furthermore, if the distance between the back cover and the thin supporting film is adequately set in connection with the position of the thin supporting film, it is easy to vary the thickness of the vapor deposited layer having desired uniformity.

In order to make the effect of the present invention more clear, FIG. **6** shows a result measured with respect to the thickness of the vapor deposited layer formed on the thin supporting film of 650 A. thick. A curved line denoted by symbol *o* is the case of the conventional method and that of symbol *x* is the case of the present invention. As seen from this figure, the vapor deposited layer having a uniform thickness can be easily formed according to the present invention using the back cover, while in the conventional method the central portion and the circumference of the vapor deposited layer are considerably different in thickness and it is impossible to obtain a vapor deposited layer having a satisfactorily uniform thickness.

In order to prove the above mentioned fact, the central portion of the back cover **14** is provided with an aperture having a diameter of 3 mm or 6 mm as shown in FIG. **7.** Then, a vapor deposited electrode layer is manufactured by using the perforated back cover **14** in the same manner as described above except that the distance between the back cover and the thin supporting film is 0.1 mm. The thickness of the thus vapor deposited electrode layer was measured to obtain a result as shown in FIG. **8.**

In this figure, an ordinate is the thickness of the vapor deposited electrode layer, and an abscissa is the distance from one side of the vapor deposited electrode supporting film having a diameter of 18 mm. A curved line of symbol *o* shows a result obtained by using the back cover with the aperture of 3 mm dia., and that of symbol *x* shows a result obtained by using the back cover with the aperture of 6 mm dia.

As seen from FIG. **8,** the target layer deposited on the supporting film corresponding to the area of the aperture is thinner than that corresponding to the area of the back cover. Namely, it can be seen that when using the back cover according to the present invention, the deposition amount at the central portion, which is apt to be lacking in the conventional method, may easily be increased and consequently unevenness of the thickness in the vapor deposited layer can be eliminated.

The present invention is not intended to be limited to the above mentioned embodiments, and it will be understood by those skilled in the art that many modifications and variations thereof may be employed without departing from the scope of the invention. For instance, if the thin electrode supporting film is reinforced with a mesh or the like and is provided sufficient strength and thermal conductivity, the back cover may be made in a convex form so that the central portion is located closer to the said thin supporting film than the circumference thereof as shown in FIG. **9.** As a practical embodiment, evaporation treatment is carried out in the same manner as described above, while arranging the center distance between the back cover and the thin supporting film to be 0.1 mm and to be 1 mm at the circumference, the obtained thickness of the vapor deposited electrode layer is 20 μm at the central portion and 18 μm at the circumference thereof. This shows that a vapor deposited layer having a uniform thickness can be deposited on the thin supporting film by making the surface of the back cover facing the thin supporting film in an adequate shape depending upon the nature and strength of the thin supporting film and desired thickness of the vaporized electrode. A great advantage can be obtained by this specific feature of the present invention.

According to this particular feature, it is possible to obtain a target electrode formed on a thin film by vapor deposition having a predetermined pattern, such as provided with lines or dots target so as to generate secondary electrons to a certain extent by properly arranging a corresponding pattern on the back cover in concave or convex form thereon and selecting the depth thereof appropriately. When using such a patterned back cover, a target electrode layer having the same pattern to that of the back cover, the thickness of which is varied according to the pattern, can easily be obtained.

The above explanation is made with respect to the example for manufacture of the vapor deposited layer using cryolite and magnesium oxide as an evaporating material, but the present invention is not limited only to such evaporating materials. In brief, the present invention lies in that the vapor deposited layer having uniform thickness or any desired shape can easily be obtained by arranging the back cover in proximity with the thin supporting film to be provided with a deposition layer and applying the vapor deposition.

For instance, in the manufacture of target electrodes for secondary electron conduction type (SEC-type) vidicon tubes, electron image multipliers and the like, a light absorption layer having a uniform thickness, for example, a black aluminium layer, is deposited on the surface opposite to the vapor depositing surface of the target electrode supporting film in an inert gas atmosphere according to the present invention, and then the target electrode layer is formed on the deposition surface of the supporting film as described above. When the thus obtained target electrode is integrated in the above mentioned electronic tube, light passing through the photoconductive surface is absorbed by the target electrode supporting film and is not reflected. Therefore, there is no degradation of resolution and contrast based on the secondary emission due to reincidence of reflected light to the photoconductive surface caused by using a target electrode supporting film having a glossy surface. Furthermore, since the thickness of the obtained target electrode is uniform, electronic tubes of the above mentioned type having excellent and sufficiently even properties in secondary electron gain, dark current, afterimage and the like can be manufactured.

According to the conventional vapor deposition method, it has been difficult to deposit a porous black aluminium layer on a target electrode supporting film because the supporting film is very thin, while according to the present invention the black aluminium layer can be easily formed because it deposits the evaporating material on the portion of the thin supporting film adjacent to the back cover as previously explained.

Alternatively, when magnesium is deposited under high vacuum and oxidized to form an MgO target for an image orthicon of high lifetime, if the back cover of the present invention is used, a very homogeneous magnesium deposit layer having uniform thickness can be formed on the thin supporting film.

Moreover, it is obvious that the present invention is applicable to a method of manufacturing vapor deposited electrode layers required for various purposes in uniform thickness on the supporting thin film.

According to the present invention, by arranging back cover in the proximity or close to the thin supporting film, deposition of the evaporating material on the undesirable side of the thin supporting film is prevented, and at the same time even if the thin supporting film is very thin, the vapor deposited layer having desirable uniform thickness can be deposited on the desired side of the thin supporting film. Especially, it is advantageous that when a porous layer is to be used as a target layer, such target electrodes having excellent properties in secondary electron gain, dark current, afterimage time and the like can be obtained.

What is claimed is:

1. A method for manufacturing a vapor deposited porous electrode layer, comprising:

stretching a thin supporting film for said electrode on a rigid frame,

arranging a back cover comprising a rigid body spaced adjacent the rear side of said supporting film at a distance of less than about 0.3 mm in an evaporator,

evaporating electrode material from an evaporation source at the front surface of said supporting film, while maintaining said back cover spaced adjacent the rear side of said film, thereby forming a porous layer of said electrode material of substantially uniform thickness on the front surface of said film.

2. A method for manufacturing a vapor deposited electrode as claimed in claim **1**, wherein said film is about 300 A. thick.

3. A method for manufacturing a vapor deposited electrode as claimed in claim **1**, wherein said film is about 650 A. thick.

4. A method for manufacturing a vapor deposited electrode as claimed in claim **1**, wherein the surface of the back cover facing the thin supporting film is convex toward said film.

5. A method for manufacturing a vapor deposited electrode as claimed in claim **1**, wherein the back cover is provided with at least one small aperture for allowing gas present between the back cover and the thin supporting film to escape.

6. A method for manufacturing vapor deposited electrode as claimed in claim **1**, wherein a surface of the back cover facing the rear surface of the thin supporting film is flat.

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