

[54] **PROCESS FOR APPLYING A NON-SELF-SUPPORTING METAL LAYER ATOP A PLATE SURFACE**

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[22] Filed: **March 15, 1971**

[21] Appl. No.: **124,108**

[52] U.S. Cl. **117/46 CA**, 117/107, 117/227,
156/150, 156/155, 156/237, 264/215,
264/259, 264/298

[51] Int. Cl. **C23c 17/00**

[58] Field of Search 156/150, 155, 237; 264/215,
264/298, 259; 117/113, 107, 102, 95, 120,
66, 119, 33.5 C, 33.5 CS, 71 R, 39, 43, 6, 46
CA

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[57] **ABSTRACT**

The process of coating or placing a fragile thin non-self-supporting metal layer upon a surface of a flat platelike body, such as a microchannel plate as disclosed comprises the steps of placing a thin self-supporting layer of lacquer upon the surface of the platelike body, thereupon depositing over and atop said lacquer layer a sufficient metal to the desired thickness, suitably by vacuum deposition techniques, to form a layer of the metal, and then placing the entire structure in an oven to bake off the lacquer in an air atmosphere and allow the thin non-self-supporting metal layer to settle against the end surface of the plate. An additional process provides for the formation of the lacquer layer in which the plate remains dry by spreading liquid lacquer over the surface of a fluid in which is submerged a support ring, allowing the lacquer to harden, draining the fluid to permit the lacquer to drape over the support ring, removing the latter assembly and applying the lacquer layer to the platelike body.

8 Claims, 6 Drawing Figures

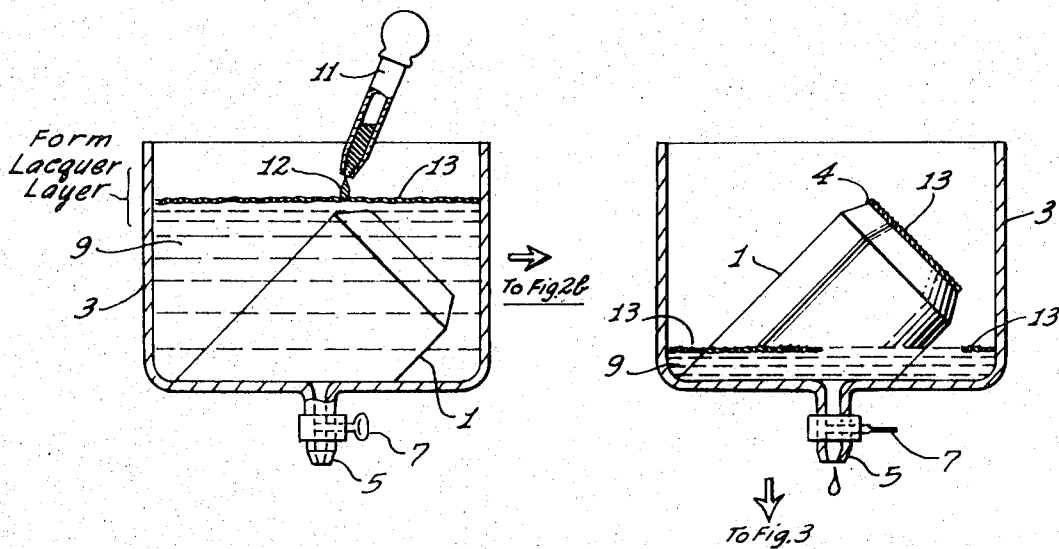


Fig. 1

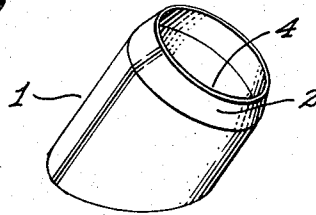
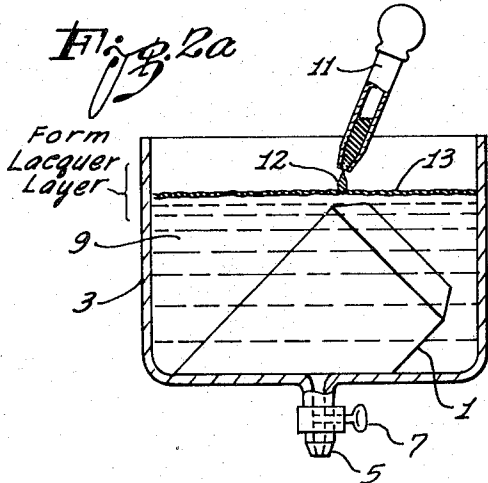
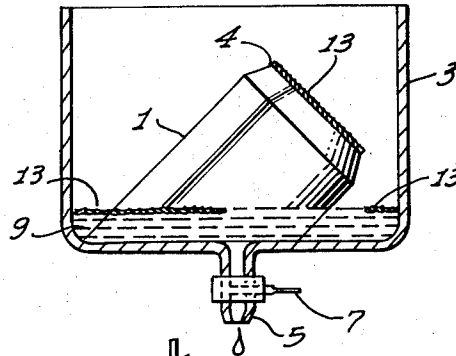


Fig. 2a



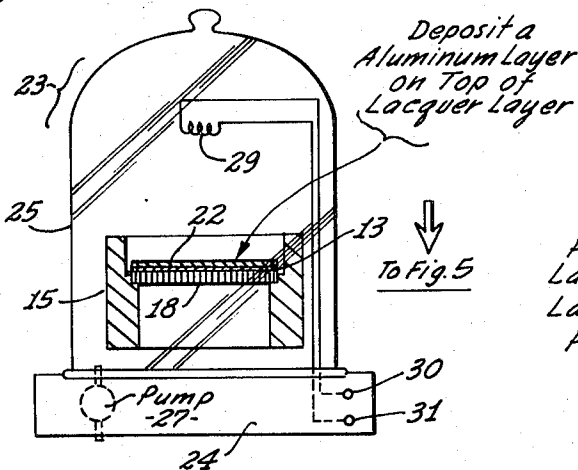
To Fig. 2b

Fig. 2b



To Fig. 3

Fig. 4



To Fig. 4

Fig. 3

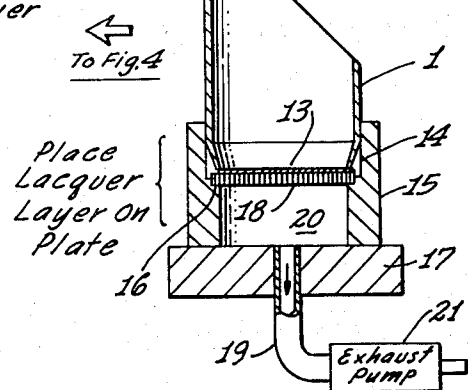
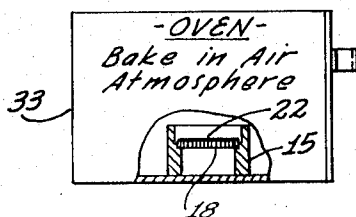


Fig. 5



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PROCESS FOR APPLYING A NON-SELF-SUPPORTING METAL LAYER ATOP A PLATE SURFACE

This invention relates to a process of coating or placing a fragile thin non-self-supporting layer of metal material in place atop a flat surface and, more particularly, to a process by which a thin continuous layer of aluminum of a thickness of within the range of 100 to 200 Å and preferably 400 Å is formed into a continuous layer and mounted upon a flat surface of a porous platelike body to form an improved electrical component.

BACKGROUND OF THE INVENTION

Various processes have been heretofore known in which thin layers or coatings of materials are formed and attached or bonded to the surfaces of other materials. Those processes provide the means by which the thin layers of metal are formed, positioned and placed on other surfaces; layers so thin and therefore so fragile that they are non-self-supporting and would crumble or fall apart by ordinary manipulation or if separated from the surface to which they are attached. The customary and widely known techniques of chemical deposition, electro-chemical plating or vacuum deposition methods provide examples of the conventional processes by which such layers are formed. However in other environments and under more limited conditions such conventional processes are unacceptable and fail.

As an example, one type of component to which a metal layer is to be applied is a microcapillary multiplier matrix, commonly termed a microchannel plate. The microchannel plate is a body of a disk or platelike geometry with substantially flat front and back surfaces and of a lead glass composition. However, a large number of minute open passages, in excess of 100,000, extend through and between the front and back surfaces thereof over an area of approximately 1 square inch. Typically such microchannel plates are formed by fusing together a large bundle of minute hollow glass tubes. As is brought out in the co-pending patent application of Bernard C. Einstein, Ser. No. 124,107, filed Mar. 15, 1971, concurrently with this application, for an invention in: "Light Amplifier Device Having an Ion and Low Energy Electron Trapping Means," and now abandoned the microchannel plate functions as an electron multiplying element. The walls of the minute internal passages are coated with a lead oxide-lead coating which although electrically conductive is of a high electrical resistivity, approaching the electrical characteristics of an insulator, and which exhibits high secondary emission properties. Moreover, the front and back surfaces of the plate are coated with a metal which covers the surface area surrounding the passage openings. The metal coating is electrically conductive and serves to function normally as electrical electrodes so as to permit in operation an electric field to be applied between the front and back surfaces of the plate.

In the operation of the microchannel plate electrons traveling toward the plate from the front travel into the passages and collide with the passage walls. In colliding with the walls the electron knocks out at least two additional electrons as a result of the high secondary emission characteristic of the lead oxide coated walls, a process which continues in each passage to provide

electron multiplication and is more fully brought out in said cited patent application and which is otherwise conventional in the art. The degree of electrical resistivity of the passage walls is carefully controlled by the manufacturer. The microchannel plate, being formed of lead glass, is initially rich in lead oxide, PbO, a composition having good electrical secondary emission characteristics. Typically the lead oxide layer is "reduced" by hydrogen firing under carefully controlled conditions to provide a lead, Pb, coating of the desired electrical conductivity. Obviously any treatment or handling of the plate which could chemically convert the lead, Pb, back to lead oxide, PbO, is not recommended.

To apply or place a thin non-self-supporting metal layer, suitably aluminum, atop one of the surfaces of the microchannel plate so as to cover the surface and the ends of the passages therethrough, requires different methods: The widely known techniques for plating, etc. are obviously unsuited for the described application. Because the metal layer to be applied is on the order of only 400 Å in thickness, it is essentially non-self-supporting, a factor which precludes its placement atop the microchannel plate by direct manipulation and bonding techniques.

Chemical deposition and vacuum deposition are obviously unsuitable in that instead of covering up the surface with a continuous layer the precipitated metal would, instead, proceed into the minute passages and hence would render the functional aspects of the microchannel plate inoperative. Moreover, as is apparent, any chemical bath in which the microchannel plate would be placed would react deleteriously with the lead coating on the walls of the passage and affect the electrical conductivity of the passage walls.

A widely known process used in the manufacture of cathode ray tubes which permits the formation of a non-self-supporting layer of material on the surface of another element is referred to as the screen phosphor filming techniques. In this technique the body on which the layer is to be placed is placed in a container of water and submerged beneath the water surface. A thin layer of lacquer is spread onto the surface of the water, there dried, and then settled onto the body by draining the water from the container. Subsequently metal is deposited atop the lacquer and thereafter the lacquer is vaporized by baking in an oven in an air atmosphere. This phosphor filming technique used in making cathode ray tubes does not suggest itself as a method for depositing a metal layer on an electron multiplying microchannel plate for two reasons: The technique requires immersion of the microchannel plate in water during part of the processing time. The water, as claimed by microchannel plate manufacturers, is detrimental to the operation of the microchannel plate and all manufacturers recommend that microchannel plates not be immersed in water. Secondly, the technique requires baking the microchannel plate in an air atmosphere, an oxidizing atmosphere, which could oxidize the lead, Pb, coating the passage walls in the microchannel plate thereby to change the critical electrical conductivity of the lead coating. This is the type of handling that the microchannel plate manufacturer suggests avoiding. A second approach is to take a thick self-supporting film of aluminum oxide produced by

conventional means such as anodization and then evaporate the metal layer on to the front side of the aluminum oxide film. The laminate so formed can then be picked up and placed atop the microchannel plate. For adhesion the film and plate may be fused together by simply passing electrical current between the film and the plate. Such an approach, although different from my invention, provides a plausible technique for the application specified in the cited co-pending patent application of Bernard C. Einstein, but obtains results that are less desirable than that obtained from the practice of the present invention.

OBJECTS OF THE INVENTION

Accordingly, it is an object of the invention to form and install a thin non-self-supporting layer on another surface.

It is another object of the invention to provide a novel process for fabricating an improved electronic component.

It is an additional object of the invention to provide a process by which a continuous aluminum layer of approximately 400 Angstroms in thickness is formed and installed on top of a surface of a microcapillary multiplier matrix without the use of chemical baths or other electroplating techniques and without immersing the multiplier matrix in water.

It is still another object of the invention to provide a process by which an ion trapping low energy level electron absorbing metal layer is fabricated and installed upon a surface of a microcapillary multiplier matrix type of electron multiplying element.

And it is a further object of the invention to provide a process of fabricating a thin non-self-supporting aluminum layer in place on a surface of a microcapillary multiplier matrix without damage to its electrical or physical properties.

BRIEF SUMMARY OF THE INVENTION

Briefly, in accordance with our invention the process of coating or placing a fragile thin non-self-supporting metal layer upon a surface of a flat platelike body comprises the steps of: placing a thin self-supporting layer of lacquer, such as nitrocellulose, upon the surface of a microcapillary multiplier matrix, thereupon forming a thin non-self-supporting layer of the desired metal material to the desired thickness to cover the lacquer layer, and then placing the assembly so formed in an oven maintained in an air atmosphere to bake off the lacquer and allow the thin non-self-supporting metal layer to settle against and couple to the end surface of the matrix without adversely affecting the mechanical or electrical properties of the matrix.

In accordance with another aspect of our invention a layer of lacquer is first formed by dropping a sufficient quantity of liquid lacquer into a vessel of fluid, such as water, where it spreads out over the surface thereof, allowing the lacquer to harden, draining the fluid gradually so as to lower the lacquer layer down upon a support ring submerged in the vessel, and thereafter by manipulation of the support ring placing said lacquer layer on the surface of the body to thereby set the lacquer layer in place without immersing the body in water.

In accordance with an additional aspect of the invention, a vacuum pump is attached to one surface of the microcapillary multiplier matrix to provide suction at the other surface thereof which assists placing the lacquer layer atop the other surface of the microchannel plate.

The foregoing and other objects and advantages of the invention together with modifications, substitutions, and equivalents thereof, and other variations and additional advantages thereto become more readily apparent from consideration of the following detailed description together with the figures of the drawing, in which:

DESCRIPTION OF DRAWINGS

FIG. 1 illustrates a film support ring used to support the lacquer layer in the process of the invention;

FIG. 2a illustrates an initial step in the formation of the lacquer layer in the process of the invention;

FIG. 2b illustrates a subsequent step in the formation of the lacquer layer in which the lacquer is situated upon the film support ring of FIG. 1;

FIG. 3 illustrates the step of the invention by which the lacquer layer is placed onto a surface of a microchannel plate;

FIG. 4 illustrates the step of the invention in which the aluminum metal layer is formed; and

FIG. 5 illustrates the step of the invention in which the lacquer layer is removed and the metal layer is installed upon the microchannel plate.

DETAILED DESCRIPTION OF INVENTION

A thin self-supporting layer of lacquer or other thin film forming material, suitably nitrocellulose, is first formed to be placed in position in the practice of the invention. AS illustrated in FIG. 1 a film support ring 1 is provided. This support ring is of a hollow cylindrical geometry of a metal material. A border portion or tapered rim 2 is tapered inwardly about one end of the cylindrical body so as to form a circular knife edge support 4. The base of this cylindrical body is formed by cutting the right cylindrical shape at a 45° angle to the cylindrical axis. Thus when placed upon its base the support edge 4 is in a plane approximately 45° to the horizontal. It is here noted that where elements are common to more than one figure, the numerals identifying such common elements are the same in all figures so as to permit continuity of understanding between the figures.

As is illustrated in FIG. 2a support ring 1 is then placed in a vessel or crystallizing dish 3. Crystallizing dish 3 includes a drain spout 5 and a valve or spigot 7 which opens or closes the drain. A quantity of de-ionized water 9, conventionally obtained, is poured into the crystallizing dish and completely submerges the film support ring.

A glass capillary tube 11 is filled with a sufficient quantity of lacquer 12 by conventional techniques and then held over the crystallizing dish. By conventional technique the top of the capillary tube is opened slightly. This allows the contents of tube 11, namely lacquer 12, to drip onto the surface of water 9. While the specific gravity of lacquer is greater than that of water, the lacquer is emptied onto the water surface gradually in such a manner that the weight of the

lacquer is insufficient to break through the surface tension of the meniscus normally formed at the surface of water. Consequently the lacquer spreads out over the top of the water to form a continuous lacquer film or layer 13 of the desired thickness. Lacquer 13 is allowed to coagulate or "dry" on the top of the water. The lacquer has dried to the desired consistency, as a general rule, when the color changes from clear over the rainbow spectrum twice and then back to clear, which depending on temperature takes about 5 minutes.

Spigot 7 is then turned to an open position as illustrated in FIG. 2b to allow water 9 in crystallizing dish 3 to escape or drain gradually via drain 5. As the water level descends gradually from the level illustrated in FIG. 2a a portion of the film of lacquer 13 contacts the edge of support ring 1. As the layer 13 continues to descend with the water level the overlying portion of the lacquer is gradually "draped" and stretched across edge 4 of the support ring.

The remaining portions of the lacquer layer outside the periphery of edge 4 are torn away from the edge, rides down with the water and settles to the bottom of the dish. Lacquer layer 13 thus appears on the top of the support ring 1 as a stretched membrane. The support ring and supported lacquer film 13 are then removed from the crystallizing dish and allowed to dry. As is apparent from the foregoing description, the support ring can be made of any desired geometry. The basic requirement is that there be a continuous edge which borders an opening over which a lacquer film can be draped or stretched. To the layman this is analogous to the wire loop which holds a soapy film in the children's sport of blowing bubbles.

In FIG. 3 there is illustrated in cross section a microchannel plate support collar 15, which is of a generally hollow cylindrical geometry. The collar is seated upon a collar base or seat 17, illustrated in cross section. The seat contains a passage therethrough through which an exhaust pipe 19 extends. In turn, the exhaust pipe is connected to a vacuum or exhaust pump 21 as symbolically illustrated in the figure. Support collar 15 contains a first bore in its inner wall which enlarges the inner diameter of the collar and forms a film support ring guide surface 14. In addition, a second bore of smaller diameter is included and forms a rim or edge about the cylindrical passage through support collar 15, which is illustrated as rim 16. Rim 16 forms a seat for the electrical component, the conventional microchannel plate 18, symbolically illustrated in cross section.

After drying, above referred to support ring 1, illustrated in cross section in FIG. 3, is inverted and inserted into the ring guide 14 and lowered so that lacquer layer 13 rests in contact with the upper surface of microchannel plate 18.

By suitable means, not illustrated, exhaust pump 21 is operated (after insertion) and creates a slight vacuum condition in the center passage 20 of ring collar 15.

Inasmuch as the microchannel plate 18 contains a very large number of minute passages which extend from the front to the back surfaces and penetrate those surfaces, a vacuum condition also exists at the upper surface of the microchannel plate 18. This vacuum

serves to suck in, hold, and retain in place, the lacquer layer 13. The film support ring 1 is then removed leaving the lacquer layer 13 held in place by the vacuum force atop microchannel plate 18.

Normal inherent electrostatic forces thereupon cause the thin lacquer layer to adhere immediately to the microchannel plate surface. In this manner layer 13 is independently maintained in place or coupled atop the microchannel plate and the exhaust pump 21 is turned off to remove the assisting vacuum forces.

The assembly of the collar 15, microchannel plate 18 containing lacquer layer 13, is then taken and placed in a bell jar assembly, 23, as illustrated in FIG. 4. The bell jar assembly is a well-known piece of equipment and includes a base 24, a glass bulb or envelope 25, and a vacuum pump 27, so that the region within the glass envelope 25 may be evacuated of air 27.

The bell jar provides the means by which the layer of aluminum of the desired thickness is formed on top of lacquer layer 13. Thusly, an aluminum vaporization heater, 29, is installed within the confines of the bell jar 23, and is connected by suitable electrical leads 30 and 31 to a source of electrical current, not illustrated. The current heats the vaporizing material at heater 29. The vacuum pump is operated and evacuates the bell jar of air and places the region within the glass cover in vacuum.

As is conventional operation in vaporization, the heating imparts large kinetic energies to the atoms of the aluminum contained thereon. With such kinetic energy the aluminum atoms depart from the surface of the heater 29 into the confines of the bell jar. These atoms travel until they use their kinetic energy such as by colliding with another surface. Generally they travel in a straight line and not deflected unless there is an excess of gas in the vacuum chamber.

By this conventional apparatus a layer of aluminum 22 is built up and formed on top of the lacquer layer 13. In accordance with the practice of this invention the aluminum may be built up to any depth in the range of 20 to 2000 Å (as measured by conventional means such as a crystal oscillator thickness monitor), and is preferably 400 Å in thickness. Thereafter the entire assembly of ring collar 15, microchannel plate 18 and supported layers is then removed from the bell jar 23 and placed in an oven 33 as illustrated in FIG. 5. The oven contains an air atmosphere. The entire assembly is baked in oven 33 for approximately 1 hour at a temperature of 325° Centigrade.

We have found that in so baking the lacquer layer is completely vaporized and the aluminum layer 20 settles down in place in contact with and atop microchannel plate 18. Moreover, we have found that the air atmosphere in the oven does not oxidize in any significant degree the lead coating on the passage walls in the microchannel plate 18, and does not appreciably affect subsequent performance of the microchannel plate even though handling the plate in this way is contrary to the microchannel plate manufacturer's recommendations regarding its handling, based on the danger of further oxidizing the lead coating on the microchannel plate. At the same time it appears essential that the air atmosphere be used to vaporize the lacquer.

Then, too, it is seen that at no time during the described process is the microchannel plate immersed

in water. Accordingly, there is no possibility of causing water damage to the microchannel plate.

The electrical component constructed in the manner herein taught has proven itself with results. When incorporated as element of the tube specified in said pending application of Bernard C. Einstein, and operated, this component served to increase the contrast resolution of the tube and provide longer life. The tubes which incorporated the microchannel plate, constructed in accordance with the teachings of this invention, have been tested and provide normal operating lives of some 400 hours without any degeneration in the tube or the microchannel plate. It is believed that such results are in no small part a direct result of the process of manufacture described in this specification and that other methods available in the prior art for placing the metal layer on the microchannel plate would not perform as well or for as long a period of time.

The foregoing detailed description and illustration of our invention has been presented solely for the purpose of explanation and not by way of limitation. As is apparent to those skilled in the art, upon reading this specification many modifications, substitutions and equivalents to the details can be made without departing from the spirit and scope of our invention.

It is therefore understood that the invention is to be broadly construed, limited only by the breadth and scope of the appended claims.

What is claimed is:

1. The improved method of positioning a very thin non-self-supporting layer of a given composition upon a surface of a body of a different composition, said given composition being of such physical characteristics that it vaporizes at a higher temperature than another material, lacquer, comprising the steps of:

- a. submerging a support ring in a fluid confined within a fluid reservoir, said support ring comprising a rim portion bordering an open space,
- b. depositing a lacquer in liquid form upon the surface of said fluid to form on said fluid surface a first layer of a predetermined thickness,
- c. permitting said lacquer to stand for a predetermined period of time whereby said lacquer changes to a solid state and forms a self-supporting layer,
- d. draining said reservoir to gradually reduce the fluid level therein beneath the level of said support ring whereby said lacquer layer rides down with said fluid and a portion thereof settles down upon said support ring and drapes across the opening in said support ring,
- e. removing said support ring and supported lacquer layer from said reservoir,
- f. manipulating said support ring so that said lacquer layer is in contact with the surface of said body whereby said lacquer layer adheres to said surface,
- g. detaching and removing said support ring so as to leave said lacquer layer on said surface,
- h. inserting said body and attached lacquer layer into a vacuum deposition chamber and depositing upon said lacquer layer a very thin non-self-supporting second layer of said given composition,
- i. thereafter placing said body and supported lacquer layer and second layer in an oven,

- j. baking said body and supported layers in said oven in an air atmosphere at a predetermined temperature and for a predetermined time to bake off said lacquer layer without baking off said second layer whereby said second non-self-supporting layer settles down onto said surface of said body,

wherein said non-self-supporting layer of said given composition is positioned on said surface without the necessity of immersing said body in said fluid.

2. The improved method of positioning a very thin non-self-supporting layer of aluminum upon a surface of a microchannel plate without immersing said microchannel plate in water, comprising the steps of:

- a. submerging a support ring in de-ionized water confined within a water reservoir, said support ring comprising a rim portion bordering an open space,
- b. depositing lacquer in liquid form upon the surface of said water to form upon said water surface a first layer of a predetermined thickness,
- c. permitting said lacquer to stand for a predetermined period of time whereby said lacquer changes to a solid state and forms a self-supporting layer,
- d. draining said reservoir to gradually reduce the water level therein beneath the level of said support ring whereby said lacquer layer rides down with said water and a portion thereof settles down upon said support ring and drapes across the opening in said support ring,
- e. removing said support ring and supported lacquer layer from said reservoir,
- f. manipulating said support ring so that said lacquer layer is in contact with the surface of the microchannel plate whereby said lacquer layer adheres to said surface,
- g. detaching and removing said support ring so as to leave said lacquer layer on said surface,
- h. inserting said microchannel plate and attached lacquer layer into a vacuum deposition chamber and depositing atop said lacquer layer a very thin non-self-supporting second layer of aluminum,
- i. thereafter placing said microchannel plate with said supported lacquer layer and aluminum layer in an oven,
- j. baking said body and supported layers in said oven in an air atmosphere at a predetermined temperature and for a predetermined time to bake off said lacquer layer without baking off said aluminum layer whereby said second non-self-supporting aluminum layer settles down onto said surface of said microchannel plate,

wherein said non-self-supporting aluminum layer is positioned on said surface of the microchannel plate without the necessity of immersing said plate in said water.

3. The invention as defined in claim 2 further comprising connecting a vacuum pump to one surface of said microchannel plate for creating a suction force on the other surface, the surface on which said lacquer layer is placed, to assist attaching said lacquer layer to said plate surface.

4. The improved method of positioning a very thin non-self-supporting layer of a given composition upon a surface of a microchannel plate, which avoids immersion of said plate in a fluid, said given composition

being of such physical characteristics that it vaporizes at a higher temperature than another material, lacquer, comprising the steps of:

- a. submerging a support ring in a fluid confined within a fluid reservoir, said support ring comprising a rim portion bordering an open space,
- b. depositing a lacquer in liquid form upon the surface of said fluid to form a first layer of a predetermined thickness,
- c. permitting said lacquer to stand for a predetermined period of time whereby said lacquer changes to a solid state and forms a self-supporting layer,
- d. draining said reservoir to gradually reduce the fluid level therein beneath the level of said support ring whereby said lacquer layer rides down with said fluid and a portion thereof settles down upon said support ring and drapes across the opening in said support ring,
- e. removing said support ring and supported lacquer layer from said reservoir,
- f. manipulating said support ring so that said lacquer layer is in contact with the surface of said microchannel plate whereby said lacquer layer adheres to said surface,
- g. detaching and removing said support ring so as to leave said lacquer layer on said surface,
- h. inserting said microchannel plate and attached lacquer layer into a vacuum deposition chamber and depositing upon said lacquer layer a very thin non-self-supporting second layer of said given composition,
- i. thereafter placing said microchannel plate and supported lacquer layer and second layer in an oven,
- j. baking said microchannel plate and supported layers in said oven in an air atmosphere at a predetermined temperature and for a predetermined time to bake off said lacquer layer without baking off said second layer whereby said second non-self-supporting layer settles down onto said surface of said microchannel plate,

wherein said non-self-supporting layer of said given composition is positioned on said surface without the necessity of immersing said microchannel plate in said fluid.

5. The invention as defined in claim 4 further comprising connecting a vacuum pump to one surface of said microchannel plate for creating a suction force on the other surface, the surface on which said lacquer layer is placed, to assist attaching said lacquer layer to said plate surface.

6. The method of coupling a very thin non-self-supporting layer of metal upon the surface of a microcapillary multiplier matrix comprising the steps of:

forming a thin self-supporting layer of lacquer material, including the steps of placing a support ring in a crystallizing dish and submerging said support ring therein in de-ionized water so as to form a floating layer of lacquer, gradually draining said crystallizing dish so that said lacquer layer moves downward and drapes across said support ring to form thereon the desired lacquer layer; placing said lacquer layer on the surface of said matrix;

forming a thin non-self-supporting layer of metal material on top of said lacquer layer, including the steps of placing said microcapillary multiplier matrix and supported lacquer layer in a bell jar, exhausting said bell jar of air to form a vacuum region thereon, and depositing by vapor deposition said metal layer on top of said lacquer layer; and baking said assembly of said matrix and layers in an air atmosphere at a predetermined temperature for a predetermined period of time so as to bake off said lacquer layer without baking off said metal layer; whereby said non-self-supporting metal layer settles onto said matrix surface.

7. The invention as defined in claim 6 wherein the step of placing said lacquer layer on said matrix comprises further the steps of placing said matrix on a hollow support collar; operating and maintaining a vacuum on the bottom surface of said matrix so as to create a sucking action at the top surface thereof; inverting said support ring and moving same into said collar so as to place said lacquer layer in contact with said upper surface of said matrix.

8. The invention as defined in claim 7 wherein said predetermined temperature comprises approximately 325° C. and said predetermined time comprises approximately 1 hour.

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