United States Patent

[11] 3,607,680

[72] Inventors Yoshihiro Uno
Machida-shi;
Hidehiko Kawakami, Kawasaki-shi, both of
Japan
[21] Appl. No. 762,047
[22] Filed Sept. 24, 1968
[45] Patented Sept. 21, 1971
[73] Assignee Matsushita Electric Industrial Co., Ltd.
Kadoma-shi, Osaka, Japan
[32] Priority Oct. 3, 1967
[33] Japan
[31] 42/64193

[54] METHOD FOR PRODUCING A DEVICE FOR TRANSMITTING AN ELECTRON BEAM
6 Claims, 9 Drawing Figs.

[52] U.S. Cl. 204/24,
156/8, 204/15, 313/74
[51] Int. Cl. C23b 5/48,
B29c 17/08, H01j 33/00
[50] Field of Search 204/143,
15, 24; 156/3

[56] References Cited
UNITED STATES PATENTS
2,978,389 4/1961 Turnbull 204/24
3,089,235 5/1963 Boulet et al. 204/140
FOREIGN PATENTS
1,182,379 6/1959 France
1,131,481 6/1962 Germany

Primary Examiner—Howard S. Williams
Assistant Examiner—T. Tufariello
Attorney—Stevens, Davis, Miller & Mosher

ABSTRACT: A device pervious to an electron beam having a partition through which the electron beam is led from one atmosphere to another. The partition is in the form of a thin film of an electron-beam pervious metal oxide such as alumina which has a high mechanical strength that can withstand the pressure difference between the two atmospheres.

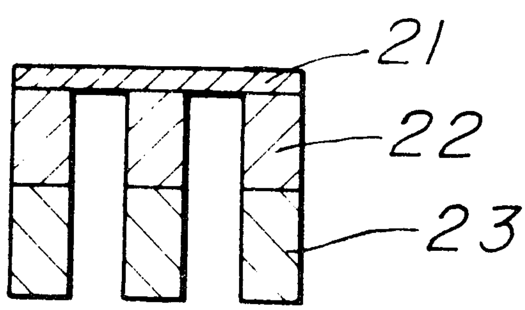


FIG. 1a

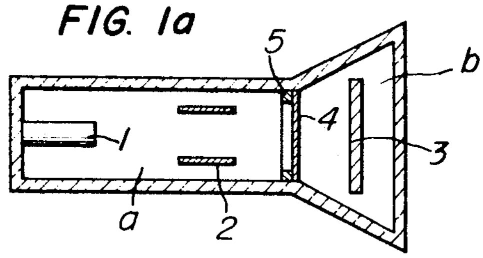


FIG. 1b

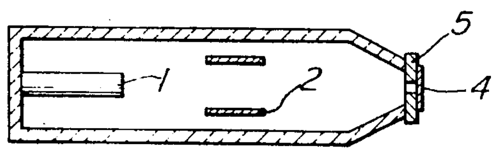


FIG. 2a

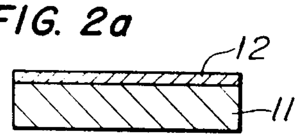


FIG. 2b

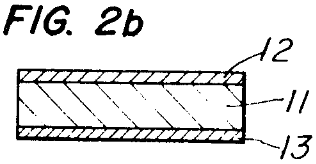


FIG. 2c

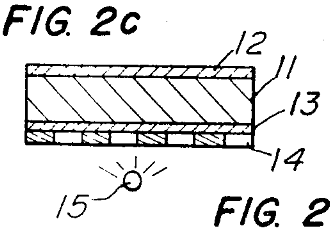


FIG. 2d

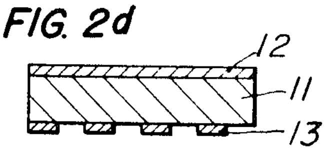


FIG. 2e

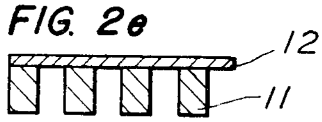


FIG. 3

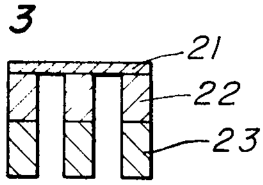
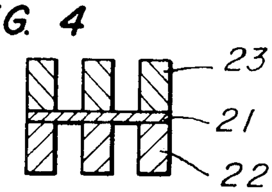


FIG. 4



INVENTORS
YOSHIHIRO UNO,
HIDEHIKO KAWAKAMI

BY Stevens, Davis, Miller & Mosher

ATTORNEYS

METHOD FOR PRODUCING A DEVICE FOR TRANSMITTING AN ELECTRON BEAM

This invention relates to a device pervious to an electron beam which employs a thin film of a metal oxide such as alumina (Al_2O_3) singly or a unitary structure comprising such a film and a reinforcing member of aluminum or other metal.

A substance irradiated by an electron beam undergoes various physical and chemical changes depending on the electric charge and energy possessed by the electron beam. The properties of the electron beam giving rise to such changes in a substance are utilized in many apparatus including medical applicances, electronic measuring apparatus and electronic recording apparatus.

It is a primary object of the present invention to provide a device pervious to an electron beam which comprises a partition in the form of a thin film of a metal oxide such as alumina (Al_2O_3) through which an electron beam can be led out of one atmosphere into another atmosphere. The partition may be a single film of alumina or the like or may be a unitary structure having such a film backed up by a supporting member having a series of slits or an array of fine holes or a meshlike form.

The above and other objects, features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1*a* is a schematic sectional view of an embodiment of the present invention when it is used as a partition between a high vacuum chamber and a low vacuum chamber;

FIG. 1*b* is a schematic sectional view of another embodiment of the present invention when it is used as a partition between a high vacuum chamber and the atmosphere;

FIG. 2*a* shows how to manufacture one form of the device of the present invention as shown in FIG. 1*a* which comprises a single film of alumina;

FIGS. 2*b* through 2*e* show a series of steps for manufacturing another form of the device of the present invention as shown in FIG. 1*b* which comprises a unitary structure of a thin film of alumina and a reinforcing member of aluminum;

FIG. 3 is a schematic sectional view of a still further embodiment which is obtained by further reinforcing the structure of FIG. 2*e* with another metal; and

FIG. 4 is a schematic sectional view of a modification of the structure shown in FIG. 3.

Referring to FIG. 1*a*,the device according to the present invention comprises a thin film **4** of a metal oxide such as alumina which is used as a partition between a high vacuum chamber A and a low vacuum chamber B. An electron gun **1** and a deflecting plat assembly **2** are disposed within the high vacuum chamber A for the emission and deflection of an electron beam. A medium **3** which is acted upon by the electron beam is disposed within the low vacuum chamber B. The medium **3** may be a phosphor, a photographic film, an electrostatic recording sheet, a high molecular material, a thermoplastic film or a crystal of an alkali halide which, when acted upon by an electron beam, develops some sort of changes therein and needs replacement or generates a gas. The medium **3** can be replaced by any known method, but it will be seen that a simplified device can be employed for exhausting the interior of the chamber B and replacing the medium **3** in the chamber B. The partition **4** is backed up by an annular supporting member **5**.

Referring to FIG. 1*b*, a thin film **4** of a metal oxide such as alumina is shown as used a partition between a high vacuum chamber and the atmosphere. In this embodiment, the surface area of the alumina film **4** can not be made so large because the atmospheric pressure is imparted to the film **4**. Accordingly, the alumina film **4** is bodily backed up by a supporting member **5** having a series of slits or an array of fine holes or a meshlike form. When the alumina film **4** has the series of slits or an array of fine holes a medium (not shown) acted upon by an electron beam is moved perpendicularly with respect to the row of slits or an array of fine holes and the electron beam sweeps across the medium in the same direction,

thereby connecting a signal into the corresponding pattern. It is known that an electron beam penetrates through an alumina film of a thickness less than several μm when it is accelerated with an accelerating voltage of 20 to 30 kV. From the viewpoint of scattering angles and energy of incident electron beam, film thickness is preferably 1 μm or less.

It is said that alumina made by anodic oxidation is about five times as strong as metallic aluminum. In the case of a thin film of aluminum backed by a supporting member having a series of fine holes, its thickness t should be larger than the value determined by $t_{Al}=r\times10^{-2}$ where t_{Al} is the thickness of the thin film of aluminum in cm, and r is the radius of the fine holes in cm, so that the thin film of aluminum can withstand a pressure difference of 1 atmosphere. On the other hand, in the case of a thin film of alumina backed by a similar supporting member, its thickness t which can sufficiently withstand the above pressure difference is given by $t_{Al_2O_3}=2r\times10^{-3}$. Through comparison of the required thickness described above, it is apparent that an alumina film having a very small thickness can satisfactorily be used for the purpose.

FIG. 2*a* is an explanatory view to illustrate an exemplary process for the manufacture of such an alumina film. The alumina film is made by anodic oxidation. A sheet **11** of aluminum (preferably having a purity of at least 99.99% of suitable thickness is subjected to a pretreatment including immersing the sheet in a 5% to 10% sodium hydroxide solution for 1 minute at 60 to 80° C., neutralizing the sodium hydroxide by immersing the sheet in a 5% to 10% cold nitric acid solution, and immersing the sheet in a **60** to **70%** chromium sulfate solution for 10 to 20 minutes for the sake of defatting. The aluminum sheet **11** is employed as the anode and is dipped in an electrolyte in such a manner that one of its surfaces worked to a smooth finish is solely dipped in the electrolyte. The electrolyte may have a composition consisting of a 10% boric acid solution and a 0.1% sodium borate solution. The electrolyte is heated up to 80 to 100° C. and current is passed thereacross to effect the anodic oxidation on the aluminum sheet **11** thereby to obtain a structure as shown in FIG. 2*a*. The structure thus obtained is then dipped in an etching solution for dissolving away the aluminum to obtain an alumina film **12** as final product. The etching solution may be hydrochloric acid or mixture of hydrochloric acid and a ferric chloride solution.

FIGS. 2*b* through 2*e* show an exemplary process for the manufacture of a unitary structure comprising such an alumina film and a supporting member therefor. The photoresist technique may be employed to make an electron-beam pervious window in which the alumina film is backed up by a supporting member having a series of fine holes. This structure is advantageous in that the prior art procedure for carefully bonding the alumina film to the support therefor is unnecessary and therefor the alumina film is more strongly fixed to the supporting member than hitherto.

In FIG. 2*b*,a photoresist layer **13** is shown as coated on a structure comprising an aluminum sheet **11** having the required thickness and an alumina layer **12** of predetermined thickness formed on the aluminum sheet **11** by anodic oxidation. In FIG. 2*c*, a mask **14** of a predetermined pattern is placed on the photoresist layer **13** and ultraviolet light is directed from an ultraviolet light source **15** for the exposure. In FIG. 2*d*, the photoresist layer **13** is developed to leave those portions of the photoresist layer **13** which conform to the predetermined pattern. The structure is the soaked in an etching solution to leave those portions of the aluminum sheet **11** in the predetermined pattern. These portions of the aluminum sheet **11** serve as a supporting member for the alumina film **12**.

The supporting member may be made by electrodeposition. For example, a conductive pattern may be made by deposited on the alumina film **12** in FIG. 2*a* by printing, vacuum evaporation or photoresist technique and a metal is electrodeposited on the conductive pattern until it acquires a predetermined thickness. Aluminum is then etched away by an etching solution.

Referring to FIG. 3, another embodiment of the device according to the present invention comprises a thin film 21 of alumina, a perforated supporting member 22 for the alumina film 21, and a reinforcing member 23 of a metal such as iron, chromium or nickel which is deposited by electrodeposition. In a modification shown in FIG. 4, the supporting member 22 of aluminum and the reinforcing member 23 of iron, chromium, nickel or the like are disposed on opposite surfaces of the alumina film 21.

From the foregoing description it will be understood that the present invention provides an electron-beam pervious partition of a metal oxide such as alumina. The use of alumina, for example, is advantageous over metallic aluminum. More precisely, an electron beam has such a nature that it penetrates more easily through a substance having a small atomic number than through a substance having a larger atomic number. Alumina which consists of aluminum and oxygen has a man atomic number of

[(atomic number of aluminum $\times 2$ + atomic number of oxygen $\times 3$)/5] which is approximately 10. Thus, alumina permits penetration of an electron beam more easily than any other substance. Moreover, alumina is stronger than metals when it is compared with metals in terms of mass. For instance, alumina is about five times as strong as metallic aluminum. In the application of a thin film of a metal oxide such as alumina as an electron-beam pervious window for an electronic tube, heating is required in order to effect bonding of the film to the glass envelope and evacuation of the interior of the glass envelope. A metal oxide such as alumina is preferred in this respect too since alumina which is chemically stable is not subject to damage or deterioration when exposed to heat.

We claim:

1. A method of making a device pervious to an electron beam having a unitary structure of an electron pervious thin film and a perforated support having a plurality of holes defined therein, comprising the steps of: first, oxidizing one side surface portion of a base metal sheet; forming said electron pervious thin film from a layer of metal oxide; and

thereafter removing unoxidized portions of said metal sheet by chemical etching thereof to form said perforated support.

2. A method of making a device pervious to an electron beam as defined in claim 1, comprising the further step of forming a photoresist mask of a desired pattern before said chemical etching step, wherein said chemical etching is performed with an etching solution selected from the group consisting of hydrochloric acid, and a mixture of hydrochloric acid and ferric chloride solution.

3. A method of making a device pervious to an electron beam as defined in claim 1, comprising the further step of depositing a metal reinforcing member selected from the group consisting of iron, chromium and nickel on the end surface of said support in the direction opposite to said thin film by a electrodeposition.

4. A method of making a device pervious to an electron beam as defined in claim 1, comprising the further steps of: depositing a conductive film in the pattern of said support on said metal oxide layer; and electrodepositing a metal on said conductive film to form a further support on the surface of said oxide layer opposite to the support formed by said chemical etching.

5. A method of making a device pervious to an electron beam having a unitary structure of an electron pervious thin film and a perforated support defining a plurality of holes therein comprising the steps of: first, oxidizing one side portion of a base metal sheet to form a layer of thin film metal oxide; depositing a conductive film on said metal oxide layer in a desired pattern of said support; electrodepositing a metal on said conductive film to a thickness necessary for forming said support; and removing an unoxidized portion of said metal sheet by chemical etching.

6. A method of making a device pervious to an electron beam as defined in claim 5, wherein said oxidizing step comprises anodic oxidation; said conductive film-depositing step comprises vacuum evaporation; and said chemical etching step comprises etching with a solution selected from the group consisting of hydrochloric acid, and a mixture of hydrochloric acid a ferric chloride solution.