A method is disclosed for the fabrication of a gas panel which includes disposing parallel lines as electrical conductors on a pair of glass plates, disposing a dielectric coating of lead glass over the parallel lines, placing a sealing material between the glass plates around the periphery thereof, spacing the glass plates a given distance apart with the parallel lines on one plate extending orthogonally to the parallel lines on the other glass plate, firing the assembly in an oven to seal the glass plates together with a chamber therebetween, evacuating the chamber, filling it with an illuminable gas, and removing the dielectric coating of lead glass on each glass plate by immersing one end of each glass plate in an etchant of perchloric acid until the dielectric coating of lead glass is removed thereby to expose the end regions of the parallel lines as electrical contacts.
GAS PANEL CONSTRUCTION

CROSS-REFERENCE TO RELATED APPLICATIONS

Application Ser. No. 214,348 filed on Dec. 30, 1971 for improved Method of Gas Panel Construction by Thomas J. Murphy et al., now abandoned which was replaced by continuation application Ser. No. 405,205 filed Oct. 10, 1973 which in turn matured into U.S. Pat. No. 3,837,724.

BACKGROUND OF THE INVENTION

This invention relates to gas panels and more particularly to a method of constructing gas panels.

The use of gas panels as display devices or storage devices has increased the need for production techniques leading to improved optical, electrical, and mechanical characteristics. At the same time corresponding characteristics of each gas panel should be substantially the same, and the method of fabrication preferably should provide gas panels which are relatively less expensive to manufacture, maintain, and operate. It is to this end that the present invention is directed.

SUMMARY OF THE INVENTION

It is a feature of this invention to provide an improved fabrication technique for the production of gas panels each of which has substantially the same mechanical, electrical, and optical characteristics whereby such gas panels may be employed interchangeably.

It is a feature of this invention to provide an improved method of producing reliable gas panels thereby to reduce the per unit cost of manufacture, upkeep and operation.

In a preferred embodiment of the method according to this invention two glass plates are cut to appropriate dimensions, and a laminate preferably of chromium-copper-chromium is disposed on one side of each glass plate. A coating of photosensitive material is disposed on the laminate and dried. The photosensitive material then is exposed to a light pattern of artwork having alternate light and dark parallel lines. The two glass plates are immersed in a developer until the exposed photosensitive material is removed, and the remaining photosensitive material is in the form of parallel lines. Each glass plate is cleaned and then immersed in a solution which etches away the laminate from regions not protected by the parallel lines of photosensitive material. This etching process leaves a plurality of laminated parallel lines having an outer coating of an unexposed photosensitive material. This photosensitive material is exposed and placed in a developer until it is removed. The two glass plates next are heated in a forming gas atmosphere and water vapor to oxidize the exposed surface of the outer chromium layer of the laminate. This step, termed passivation, renders the laminated parallel lines passive during a subsequent dielectric coating operation. A dielectric composed of lead glass then is disposed over the laminated be removed parallel lines. The lead glass dielectric preferably is a glass frit which is applied to a uniform depth as by precision spraying, and the glass plates then are fired in an oven to reflow the glass frit whereby a lead glass dielectric covers the laminated parallel lines. The two glass plates are spaced apart a given distance and sealed around the periphery thereof to form a chamber therebetween for holding an illu

minable gas. Thereafter the chamber between the two glass plates is evacuated and refilled with an illuminable gas preferably under less than atmospheric pressure. The dielectric coating and the outer chromium layer of the laminate must be removed from the end regions of the parallel lines of each glass plate so that electrical connections can be made to the exposed copper lands. The dielectric coating is removed by immersion in an etching solution of perchloric acid. The outer chromium layer of the laminate is removed by immersion in an etching which preferably is potassium ferri-

cyanide. The fabrication of the gas panel is complete, and it may be operated by applying electrical signals to selected parallel lines on each glass plate thereby to ignite gas cells defined by the coordinate intersections of parallel lines disposed orthogonally to each other.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWING

The sole FIGURE of the drawing is a perspective view of a gas panel constructed according to the method of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A gas panel constructed according to the novel method of this invention includes a first glass plate separated from and sealed to a second glass plate with an intervening chamber therebetween which is filled with an illuminable gas. Electrically conductive parallel lines are disposed on opposing faces of the first and second glass plates immediately adjacent to the sides of the gas-filled chamber, and they serve as electrodes for supplying a given electrical potential to a selected gas cell. The electrically conductive parallel lines on the first glass plate are disposed to extend orthogonally to the electrically conductive parallel lines on the second glass plate. Gas cells are defined as the region of the illuminable gas disposed between the coordinate intersections of the grid network formed by the orthogonally disposed sets of parallel lines. A selected gas cell is ignited by supplying a given electrical signal to one of the parallel lines on the first glass plate and applying a given electrical signal to a selected one of the parallel lines on the second glass plate. The gas cell at the coordinate intersection of the two selected parallel lines is ignited.

A gas panel constructed according to the novel method of this invention is illustrated in the sole FIGURE of the drawing, and it includes an upper glass plate separated from and sealed to a lower glass plate with an intervening chamber which is filled with an illuminable gas. Electrically conductive parallel lines are disposed on the lower side of the glass plate, and they serve as an electrode for supplying a given electrical signal to a selected gas cell.

Electrically conductive parallel lines are disposed on the upper side of the glass plate, and they serve as an electrode for supplying a given electrical signal to the other side of a selected gas cell. Gas cells are defined as the region of the illuminable gas disposed between the coordinate intersections of the upper parallel lines and the lower parallel lines. A selected gas cell is ignited by
supplying a given electrical signal to one of the parallel lines 21 through 28 and applying a given electrical signal to a selected one of the parallel lines 31 through 40. The gas cell at the coordinate intersection of the pair of selected lines is ignited.

The fabrication of the gas panel according to the method of this invention involves numerous operations. The basic steps are described next.

1. The first and second glass plates may be a soda-lime-silica glass cut to the appropriate dimensions according to the desired size of the gas panel. Each glass plate may be ¼ of an inch thick, and each should be free of chips or scratches, flat, and clean.

2. A first thin film of chromium approximately 1,000 Angstroms thick is deposited on one side of each glass plate; a second thin film of copper approximately 10,000 Angstroms thick is deposited on the first thin film of chromium; and a third thin film composed of chromium approximately 1,000 Angstroms thick is deposited on the second thin film of copper. The deposition of these thin films to form a laminate preferably is done by a vacuum metalization technique. The laminate may extend over the entire surface of each glass plate if desired. Preferably it terminates before reaching the edges of the glass plates.

3. A photolithographic process is used to convert the laminate into a plurality of parallel lines which serve as electrical conductors. A liquid photoresist material is applied, as by roller, over the outer thin film of chromium, baked dry, and exposed to a light pattern of artwork having the desired size of parallel lines to be formed. Thereafter the two glass plates are immersed in a developer until the exposed photoresist material is removed, leaving the unexposed areas of the photoresist material undisturbed. Each glass plate is then immersed in a solution which etches away the chromium-copper-chromium laminate from regions not protected by the photoresist material. This etching process leaves a plurality of parallel lines with each line being composed of a chromium-copper-chromium laminate having an outer coat of unexposed photoresist material. This photoresist material is exposed next and then placed in a developer until it is removed. The laminated electrical parallel lines are formed.

4. The two glass plates next are heated in a forming gas atmosphere, preferably composed of 90% nitrogen and 10% hydrogen, and water vapor until the outer chromium film of the laminate is oxidized. The chromium oxide surface prevents attack, dissolution, or pitting of the laminated parallel lines during subsequent coating and firing operations. This step of oxidizing the outer chromium film is referred to as passivation since it renders the laminated parallel lines passive during a subsequent dielectric coating operation which is described next.

5. A dielectric coating of lead glass next is applied over the laminated parallel lines. Preferably a glass frit composed of finely ground lead glass is applied to a uniform depth over each glass plate by spraying. The two glass plates then are fired in an oven to a temperature sufficient to reflow the lead glass frit whereby a dielectric coating of glass completely covers the laminated parallel lines. The lead glass coating serves as a dielectric material which collects a wall charge when the parallel lines subsequently are used as electrodes for operating the gas panel. Also, the dielectric coating of lead glass provides mechanical strength and support for the thin laminated conductors thereby enabling them to withstand thermal and mechanical stress and shock during and after the remaining fabrication process.

6. The two glass plates are spaced apart a given distance and sealed around the periphery thereof to form a gas chamber therebetween for holding an illuminable gas. The sealing material for this purpose preferably is lead glass. It may be finely ground and disposed in a cellulose binder cut in the form of a rectangle to define the display or storage area of the gas panel. The inner periphery of the rectangular frame represents the desired dimensions of the chamber for holding the illuminable gas. The rectangular frame of sealing material is disposed on one of the glass plates on top of the dielectric coating, and this glass plate is heated in an oven until the cellulose binder is baked out of the sealing material. The binder is baked out of the sealing material to avoid blistering or darkening of the sealant. The bake-out is done also to remove possible contaminates which subsequently might invade the illuminable gas. Alternatively, the bond of a cellulose binder may be dispensed with and the finely ground lead glass sealant may be deposited on one of the glass plates as by painting with a brush or spraying with a spray gun after first masking the glass plate to prevent application of the sealant to undesired areas. Glass rods of suitable diameter to maintain proper chamber width are disposed at given intervals around the inner periphery of the sealing material. The spacer rods may be placed about 1/16 of an inch from the inner periphery of the sealing material. The remaining glass plate is disposed on top of the spacer rods with the lead glass dielectric coating facing down in engagement with the sealant and the spacer rods. The assembly is placed in an oven, leveled, and fired until the lead glass sealant material refills thereby uniting the two glass plates with a chamber therebetween which is hermatically sealed.

7. The chamber between the two glass plates is evacuated, using any one of any several well-known techniques, and simultaneously the gas panel is baked thereby to remove moisture from the chamber and any gases which may escape from the lead glass sealing material. After the chamber is evacuated and the bake-off is complete, the chamber is filled with an illuminable gas which may be any one or a combination of several well-known gases used for this purpose. One suitable combination of such gases is an illuminable gas composed of 99.9% neon and 0.1% argon. The evacuated chamber is filled with an illuminable gas preferably under less than atmospheric pressure. Suitable pressure in the chamber may be in a range of 600 to 700 torrs.

8. In order to operate the gas panel it is necessary to convey electrical signals to the copper lands of the laminated parallel lines on each glass plate. To do this it is necessary to remove the dielectric coating and the outer chromium film of the laminated parallel lines whereby electrical connection can be made to the exposed copper frit strip or land of each parallel line. The copper lands of the parallel lines are exposed as electric contacts in the regions at the extreme ends adjacent to the edge of each glass plate. Heretofore the dielectric coating was removed by immersing at least one edge of each glass plate in an etching solution containing hydrochloric acid. However, when this is done a white precipitate of lead chloride is formed. The lead chloride precipitate settles on the surface of the lead
glass dielectric and isolates the etchant from the surface of the dielectric thereby inhibiting further etching by the hydrochloric acid. This makes it necessary to perform the additional steps of (1) removing the glass plate from the hydrochloric acid, and (2) rinsing with water, rubbing and scrubbing to remove the undesirable lead chloride precipitate. After cleaning, the edge of the glass plate again is immersed in the hydrochloric acid, and the etching process continues until the lead chloride precipitate settles on the surface of the lead glass dielectric and again inhibits further etching. The process of etching in hydrochloric acid, then cleaning (by rinsing and scrubbing) was repeated heretofore until the desired portions of the lead glass dielectric coating was removed. This process involved a relatively extensive expenditure of time and labor thereby increasing the production costs.

The removal of the dielectric coating of lead glass on each glass plate at the end regions of the laminated parallel conductors is performed instead by immersing a portion of each glass plate in perchloric acid. A 10% perchloric acid etchant was found to be suitable for this purpose. In this etching arrangement the perchloric acid forms a soluble lead product, and the white precipitate of lead chloride formed by the etchant of hydrochloric acid is prevented. The inhibition of the etching process is eliminated, and the several etching and precipitate removal operations are not necessary. By substituting perchloric acid as an etchant for hydrochloric acid, a soluble by-product of lead perchlorate is formed which easily goes into solution thereby allowing etching of the lead glass dielectric coating to continue without interruption until completed. Thus perchloric acid etchant provides a one-step etching operation, and furthermore the final result is a complete removal of the dielectric coating free and clear of any lead chloride to be scrubbed off. Since their perchloric acid etchant reduces the time required to remove the dielectric coating, there is a saving of time and labor with a consequent reduction in the cost of production. Furthermore a better quality etch is obtained with perchloric acid. In addition to the better quality of etch provided by perchloric acid there is a still further important benefit. With perchloric acid there is no attack on the chrome and copper laminates of the parallel lines under the dielectric coating as is the case with the hydrochloric acid etchant.

9. The exposed outer chromium layer of the laminated parallel lines is removed next. This is done by immersion in another etchant. Potassium ferricyanide is suitable for this purpose. The edge region of each glass plate is immersed in a solution of potassium ferricyanide until the outer chromium layer is removed from the laminated parallel lines thereby exposing the copper lands as electrical contacts.

Some of the operations in steps 1 through 7 of the method according to this invention may be varied, and the order may be changed in many instances without departing from the essence of the invention. The fabrication method lends itself to mass production techniques.

The construction of the panel is complete, and it may be operated by applying electrical signals to the exposed copper regions near the edge of each glass plate. The glass panel is operated in a test mode by applying electrical signals of approximately 180 to 200 volts to all of the laminated parallel lines on each glass plate.

This ignites all gas cells. This permits inspection of each gas cell for operability. The signals are removed to extinguish all gas cells. Thereafter electrical signals are applied to selected ones of the laminated parallel lines on the first and second glass plate to ignite selected gas cells defined by the coordinate intersections of the parallel lines.

It is seen therefore that a novel fabrication technique is provided according to this invention for producing improved gas panels because they have uniformity in their mechanical, electrical and optical characteristics thereby permitting them to be used interchangeably. The fabrication method according to this invention may be adapted to mass production techniques thereby making the gas panels relatively less expensive to manufacture. The resulting superior product correspondingly decreases the cost of maintenance. The gas panels, moreover, are relatively inexpensive to operate as display or storage devices.

While the method of this invention has been particularly described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:
1. A method of fabricating a gas panel, said method including the steps of:
   a. cutting a pair of glass plates to appropriate dimensions to provide an overlap area of a desired size for the gas panel,
   b. disposing parallel lines as electrical conductors on each glass plate with the electrical conductors extending to the edge of each glass plate,
   c. disposing a dielectric coating of lead glass over the parallel lines of each glass plate,
   d. placing on one of the glass plates a glass sealing material, and placing spacers at selected locations near the glass sealing material,
   e. placing the other glass plate on said one glass plate with the parallel lines on said one glass plate extending orthogonally to the parallel lines on the other glass plate,
   f. heating the assembly in an oven on a level surface to reflood the glass sealing material and thereby seal the two glass plates together spaced apart a given distance thereby to form a chamber therebetween,
   g. heating the assembly in an oven and simultaneously evacuating the chamber, thereafter backfilling the chamber with an illuminable gas, and sealing the illuminable gas in said chamber under less than atmospheric pressure, and
   h. removing the dielectric coating of lead glass on each glass plate by immersing the end regions of the parallel lines on each glass plate in an etchant of perchloric acid until the dielectric coating of lead glass is removed thereby to expose the end regions of the parallel lines as electrical contacts.
2. A method of fabricating a gas panel, said method including the steps of:
   a. cutting a pair of glass plates to appropriate dimensions to provide an overlap area of a desired size for the gas panel,
   b. disposing a plurality of parallel lines as electrical conductors on each glass plate,
   c. disposing a dielectric coating of lead glass over the parallel lines of each glass plate,
d. placing on one of the glass plates a sealing material, and placing spacers at selected locations near the sealing material,

d. placing the other glass plate on said one glass plate with the parallel lines on said one glass plate extending orthogonally to the parallel lines on the other glass plate,

f. heating the assembly in an oven on a level surface to cause the sealing material to unite the two glass plates together spaced apart a given distance thereby to form a chamber therebetween,

g. evacuating the chamber, thereafter backfilling the chamber with an illuminable gas, and sealing the illuminable gas in said chamber under less than atmospheric pressure, and

h. removing the dielectric coating of lead glass on each glass plate by immersing the end regions of the parallel lines on each glass plate in an etchant of perchloric acid until the dielectric coating of lead glass is removed thereby to expose the end regions of the parallel lines as electrical contacts.

3. A method of fabricating a gas panel, said method including the steps of:

a. cutting a pair of glass plates to appropriate dimensions to provide a desired size for the gas panel,

b. disposing parallel lines as electrical conductors on each glass plate,

c. depositing a dielectric coating of lead glass over the parallel lines of each glass plate,

d. placing on one of the glass plates a sealing material,

e. placing the other glass plate on the sealing material on said one glass plate with the parallel lines on said one glass plate extending orthogonally to the parallel lines on the other glass plate,

f. heating the assembly in an oven on a level surface to cause the sealing material to unite the two glass plates together spaced apart thereby to form a chamber therebetween,

g. evacuating the chamber, filling the chamber with an illuminable gas, and sealing the illuminable gas in said chamber,

h. removing the dielectric coating of lead glass on each glass plate by immersing the end regions of the parallel lines on each glass plate in an etchant of perchloric acid until the dielectric coating of lead glass is removed thereby to expose the end regions of the parallel lines as electrical contacts.

4. A method of fabricating a gas panel, said method including the steps of:

a. cutting a pair of glass plates to appropriate dimensions to provide a desired size for the gas panel,

b. disposing parallel lines as electrical conductors on each glass plate,

c. depositing a dielectric coating of lead glass over the parallel lines of each glass plate,

d. placing the pair of glass plates adjacent to each other with the parallel lines on said one glass plate extending orthogonally to the parallel lines on the other glass plate, and uniting the two glass plates together spaced apart thereby to form a chamber therebetween,

e. evacuating the chamber, filling the chamber with an illuminable gas, and sealing the illuminable gas in said chamber,

f. removing the dielectric coating of lead glass on each glass plate by immersing the end regions of the parallel lines on each glass plate in an etchant of perchloric acid until the dielectric coating of lead glass is removed thereby to expose the end regions of the parallel lines as electrical contacts.

5. A method of fabricating a gas panel, said method including the steps of:

a. cutting first and second glass plates to a desired size for a gas panel,

b. disposing parallel lines as electrical conductors on each glass plate,

c. disposing a dielectric material composed of lead glass over the parallel lines on each glass plate,

d. placing on the first glass plate a sealing material, and placing spacers at selected locations near the sealing material,

a. placing the second glass plate on the sealing material on said first glass plate with the parallel lines on said first glass plate extending orthogonally to the parallel lines on the second glass plate,

f. heating the assembly in an oven on a level surface to cause the sealing material to unite the first and second glass plates together spaced apart a given distance thereby to form a chamber therebetween,

g. evacuating the chamber, thereafter backfilling the chamber with an illuminable gas, and sealing the illuminable gas in said chamber, and

h. removing the dielectric coating of lead glass over the end regions of the parallel lines on the first and second glass plates by immersing the end regions of the parallel lines on each glass plate in an etchant of perchloric acid until the dielectric coating of lead glass is eliminated thereby to expose the end regions of the parallel lines as electrical contacts.

6. A method of fabricating a gas panel, said method including the steps of:

a. cutting first and second glass plates to a desired size for the gas panel,

b. disposing parallel lines as electrical conductors on each glass plate,

c. disposing a dielectric material composed of lead glass over the parallel lines on each glass plate,

d. securing the first and second glass plates together spaced apart to form a chamber therebetween filled with an illuminable gas, and

e. removing the dielectric coating of lead glass over the end region of the parallel lines on the first and second glass plates by immersing the end regions of the parallel lines on each glass plate in an etchant of perchloric acid until the dielectric coating of lead glass is etched away thereby to expose the end regions of the parallel lines as electrical contacts.

7. A method of fabricating a gas panel, said method comprising the steps of:

a. cutting two glass plates to appropriate dimensions for the desired size of a gas panel,

b. disposing parallel lines as electrical conductors on each glass plate with each parallel line being a laminate composed of a first layer of chromium deposited on each glass plate, a second layer of copper deposited on said first layer, and a third layer of chromium deposited on said second layer,

c. heating each glass plate in an atmosphere of forming gas and water vapor to form a layer of chromium oxide on the outer surface of said third layer whereby the outer layer of chromium oxide renders the laminated parallel lines passive or nonreactive to subsequent firing operations,
d. depositing a dielectric coating of lead glass over the parallel lines of each glass plate,
e. placing on one of the glass plates a sealing material, placing spacers at selected locations near the sealing material,
f. placing the other glass plate on said one glass plate with the parallel lines on said one glass plate extending orthogonally to the parallel lines on the other glass plate,
g. heating the assembly in an oven on a level surface to cause the sealing material to unite the two glass plates together spaced apart a given distance thereby to form a chamber therebetween,
h. evacuating the chamber, thereafter backfilling the chamber with an illuminable gas, and sealing the illuminable gas in said chamber,
i. removing the dielectric coating of lead glass on the first and second glass plates by immersing the end regions of the parallel lines on each glass plate in an etchant of perchloric acid until the dielectric coating of lead glass is etched away thereby exposing the end regions of said third layer of chromium, and
j. removing the exposed end regions of said third layer of chromium by immersing the end regions of the parallel lines on each glass plate in an etchant until the exposed end regions of said third layer of chromium are dissolved thereby exposing the end regions of said second layer of copper as electrical contacts.

8. The method of claim 7 wherein step (j) is performed with potassium ferricyanide as the etchant.

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