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Ernsthausen et al.

[11] **3,836,393**

[45] **Sept. 17, 1974**

[54] **PROCESS FOR APPLYING STRESS-BALANCED COATING COMPOSITE TO DIELECTRIC SURFACE OF GAS DISCHARGE DEVICE**

[75] Inventors: **Roger E. Ernsthausen**, Luckey; **Brooke R. Emch**, Toledo, both of Ohio

[73] Assignee: **Owens-Illinois, Inc.**, Toledo, Ohio

[22] Filed: **July 14, 1971**

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[52] U.S. Cl..... **117/217**, 117/DIG. 12, 117/106 R, 117/211, 117/215, 117/219, 117/221, 117/222, 117/223, 117/224, 117/229, 313/188, 313/220, 313/221

[51] **Int. Cl.**..... **B44d 1/18**, B44d 1/16

[58] **Field of Search** 117/219, 217, 106, 221, 117/222, 223, 229, 211, 224; 313/220, 221, 188

[56] **References Cited**

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Primary Examiner—Cameron K. Weiffenbach
Attorney, Agent, or Firm—Donald Keith Wedding

[57] **ABSTRACT**

There is disclosed a process for applying a stress-balanced coating composite to each dielectric surface of a multiple gaseous discharge display/memory panel having an electrical memory and capable of producing a visual display, the panel being characterized by an ionizable gaseous medium in a gas chamber formed by a pair of opposed dielectric material charge storage members, each of which is respectively backed by an array of electrodes, the electrodes behind each dielectric material member being oriented with respect to the electrodes behind the opposing dielectric material member so as to define a plurality of discrete discharge volumes constituting a discharge unit.

The surface of each dielectric material charge storage member is selectively coated with a first layer of at least one compound of Group IIA, Al, Si, Ti, Zr, Hf, or mixtures thereof; a second layer of at least one compound of Group IIA, Al, Si, Ti, Zr, Hf, or mixtures thereof which is chemically different from the first layer; and a third layer of an electron-emissive material; the combination of the first and second layers being sufficient to prevent ion migration from the dielectric to the third layer and sufficient to provide a thermally and structurally stable base for the third layer; and the second layer being chemically inert relative to the third layer.

39 Claims, 6 Drawing Figures

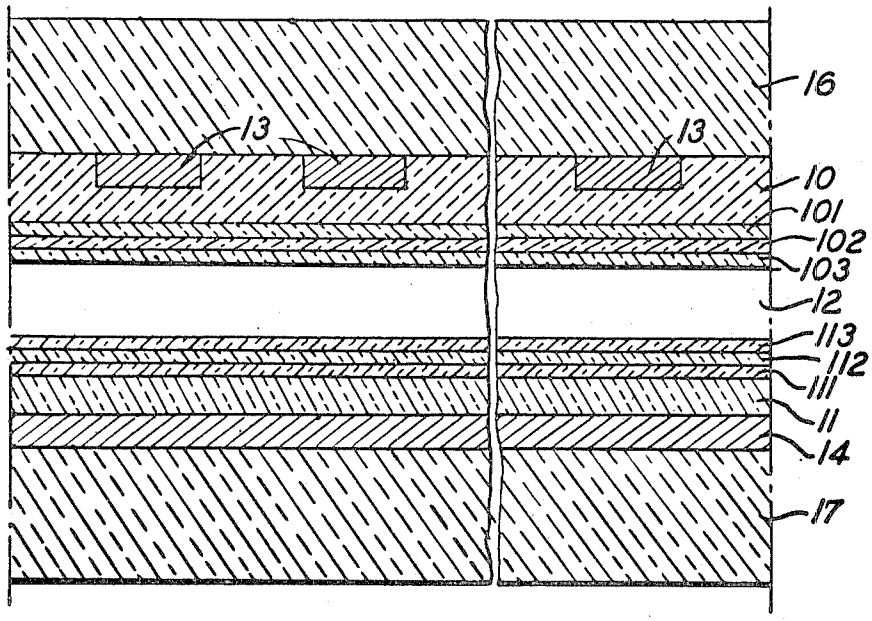


FIG. 2

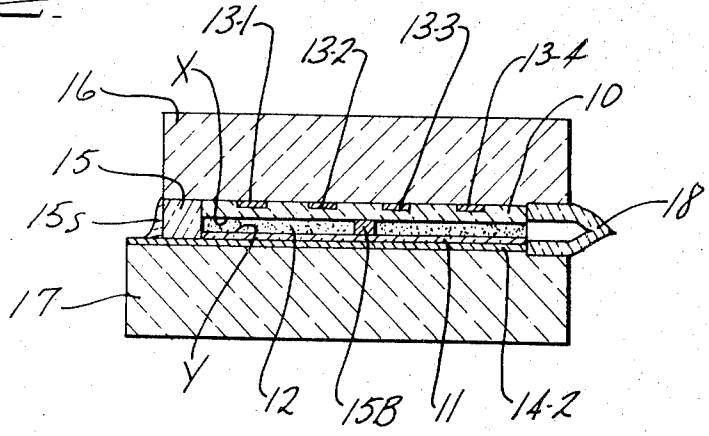

13-1
13-2
13-3
13-4
X
16
10
15
15s
18
17
Y
12
15B
11
14-2

FIG. 1

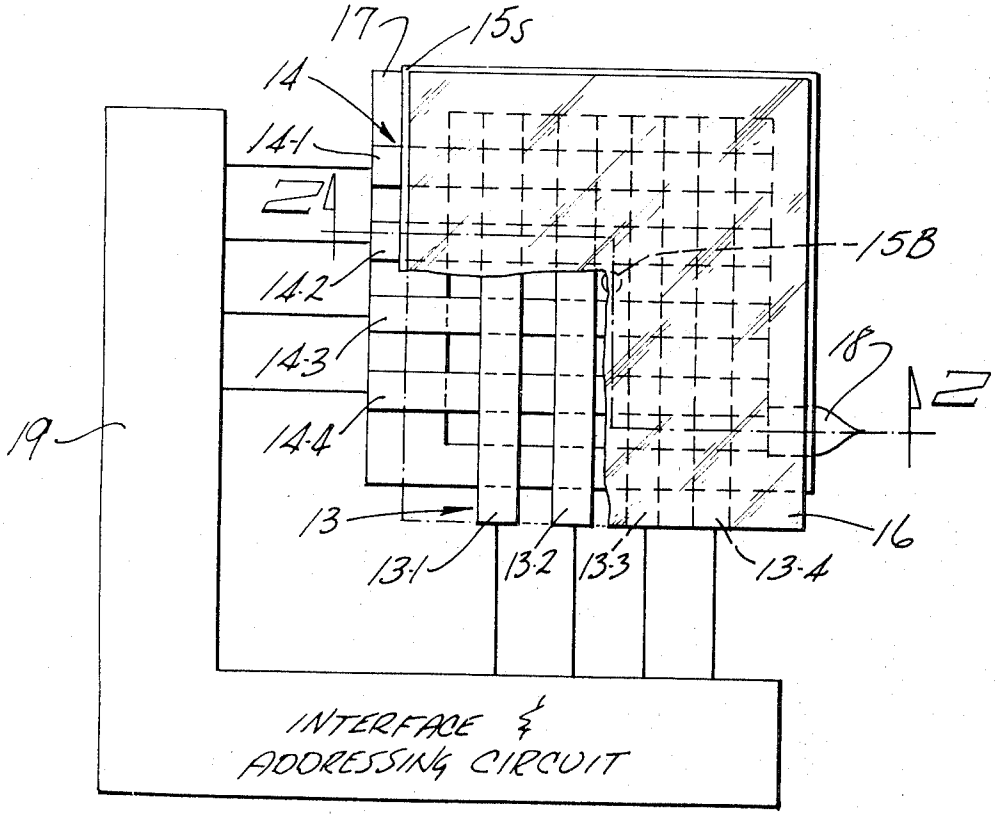

17
15s
14
14-1
2
14-2
14-3
14-4
15B
18
2
19
13
16
13-1
13-2
13-3
13-4
INTERFACE & ADDRESSING CIRCUIT

FIG. 3

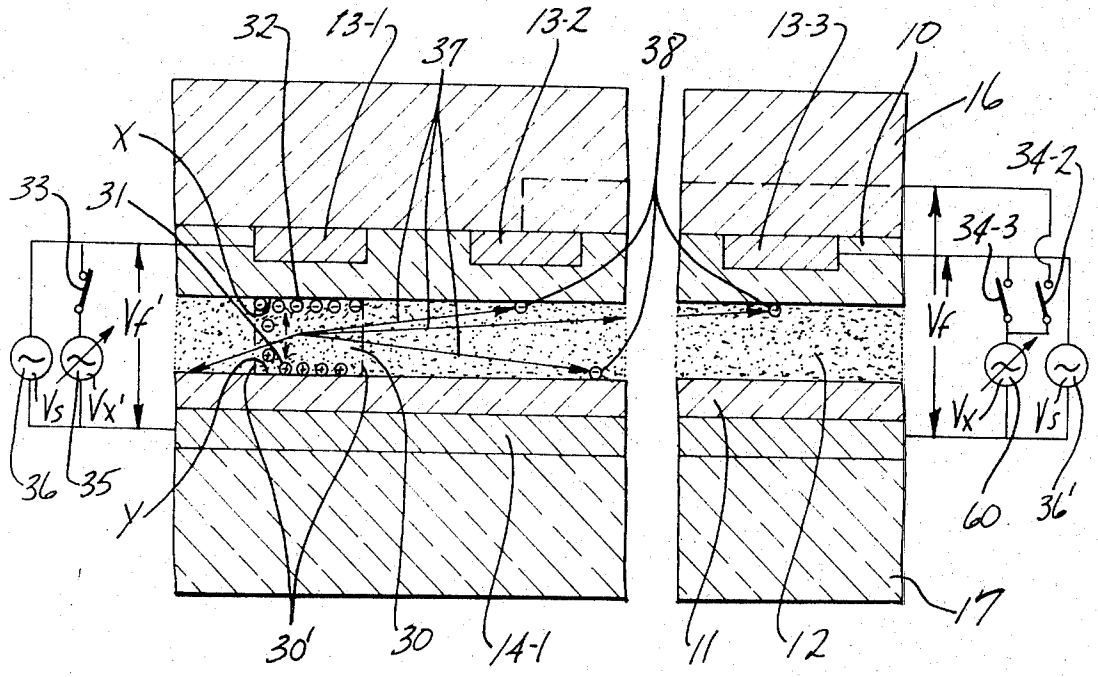
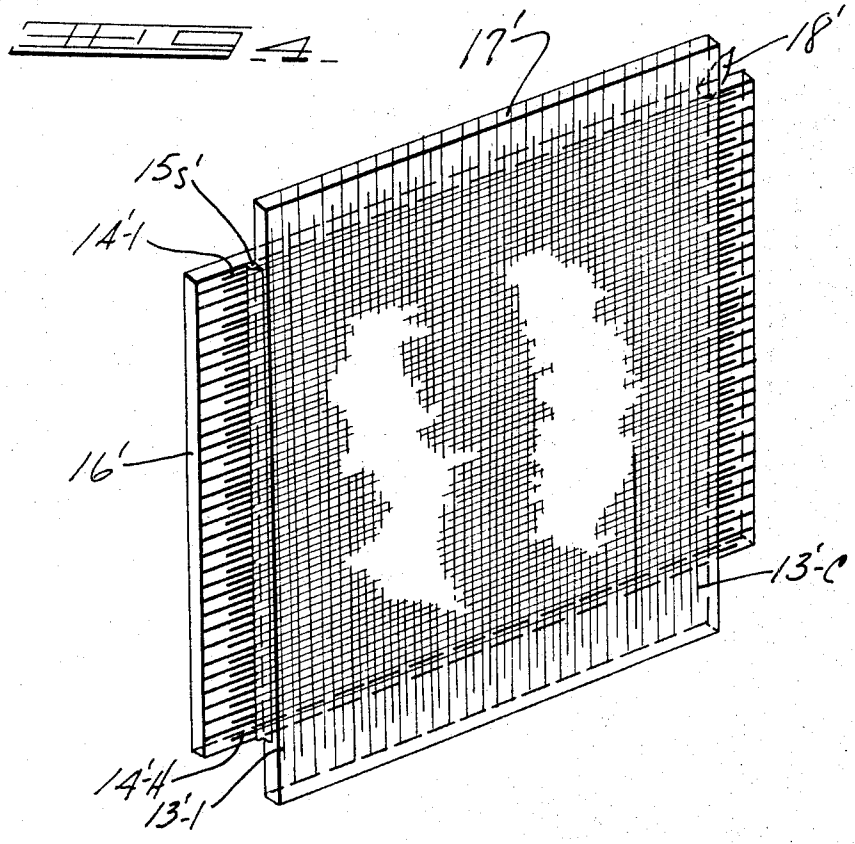

32
13-1
37
13-2
38
13-3
10
16
34-2
34-3
X
33
31
Vf'
Vf
Vs
Vx'
Vx
Vs
36
35
60
36'
Y
30'
30
14-1
11
12
17

FIG. 4


17'
18'
15s'
14'-1
16'
13'-C
14'-H
13'-1

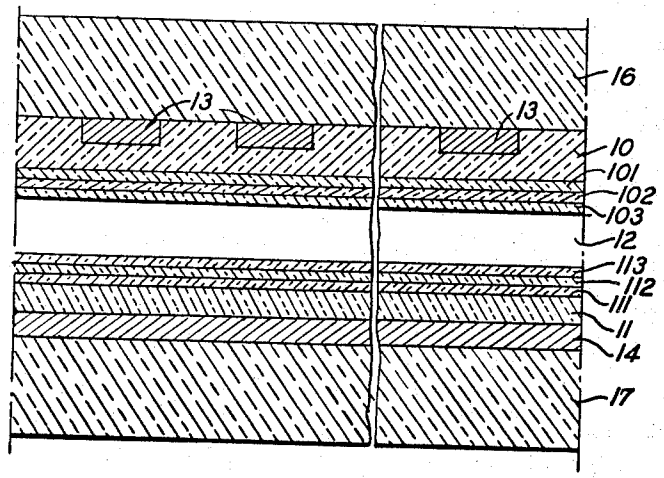

16
13
13
10
101
102
103
12
113
112
111
11
14
17

FIG. 5

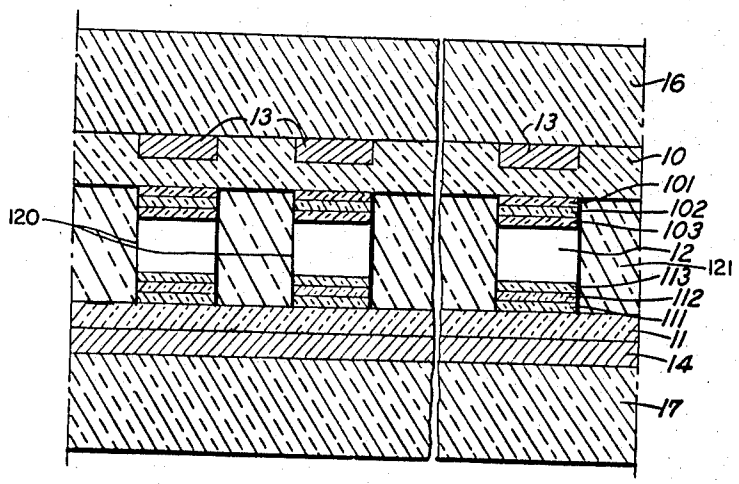

16
13
13
10
101
120
102
103
12
121
113
112
111
11
14
17

FIG. 6

PROCESS FOR APPLYING STRESS-BALANCED COATING COMPOSITE TO DIELECTRIC SURFACE OF GAS DISCHARGE DEVICE

THE INVENTION

This invention relates to novel multiple gas discharge display/memory panels or units which have an electrical memory and which are capable of producing a visual display or representation of data such as numerals, letters, television display, radar displays, binary words, etc.

Multiple gas discharge display and/or memory panels of the type with which the present invention is concerned are characterized by an ionizable gaseous medium, usually a mixture of at least two gases at an appropriate gas pressure, in a thin gas chamber or space between a pair of opposed dielectric charge storage members which are backed by conductor (electrode) members, the conductor members backing each dielectric member typically being transversely oriented to define a plurality of discrete discharge volumes and constituting a discharge unit. In some prior art panels the discharge units are additionally defined by surrounding or confining physical structure such as by cells or apertures in perforated glass plates and the like so as to be physically isolated relative to other units.

In either case, with or without the confining physical structure, charges (electrons, ions) produced upon ionization of the gas of a selected discharge unit, when proper alternating operating potentials are applied to selected conductors thereof, are collected upon the surfaces of the dielectric at specifically defined locations and constitute an electrical field opposing the electrical field which created them so as to terminate the discharge for the remainder of the half cycle and aid in the initiation of a discharge on a succeeding opposite half cycle of applied voltage, such charges as are stored constituting an electrical memory.

Thus, the dielectric layers prevent the passage of any conductive current from the conductor members to the gaseous medium and also serve as collecting surfaces for ionized gaseous medium charges (electrons, ions) during the alternate half cycles of the A.C. operating potentials, such charges collecting first on one elemental or discrete dielectric surface area and then on an opposing elemental or discrete dielectric surface area on alternate half cycles to constitute an electrical memory.

An example of a panel structure containing non-physically isolated or open discharge units is disclosed in U.S. Pat. No. 3,499,167 issued to Theodore C. Baker et al.

An example of a panel containing physically isolated units is disclosed in the article by D. L. Bitzer and H. G. Slottow entitled "The Plasma Display Panel — A Digitally Addressable Display With Inherent Memory," Proceeding of the Fall Joint Computer Conference, IEEE, San Francisco, Calif., Nov. 1966, pages 541–547. Also reference is made to U.S. Pat. No. 3,559,190 to Bitzer et al.

In the operation of the panel, a continuous volume of ionizable gas is confined between a pair of dielectric surfaces backed by conductor arrays forming matrix elements. The cross conductor arrays may be orthogonally related (but any other configuration of conductor arrays may be used) to define a plurality of opposed pairs of charge storage areas on the surfaces of the dielectric bounding or confining the gas. Thus, for a conductor matrix having H rows and C columns the number of elemental discharge volumes will be the product $H \times C$ and the number of elemental or discrete areas will be twice the number of elemental discharge volumes.

In addition to the matrix configuration, the conductor arrays may be shaped otherwise. Accordingly, while the preferred conductor arrangement is of the crossed grid type as shown herein, it is likewise apparent that where an infinite variety of two dimentional display patterns are not necessary, as where specific standardized visual shapes (e.g., numerals, letters, words, etc.) are to be formed and image resolution is not critical, the conductors may be shaped accordingly.

The gas is one which produces light (if visual display is an objective) and a copious supply of charges (ions and electrons) during discharge. In an open cell Baker et al. type panel, the gas pressure and the electric field are sufficient to laterally confine charges generated on discharge within elemental or discrete volumes of gas between opposed pairs of elemental or discrete dielectric areas within the perimeter of such areas, especially in a panel containing non-isolated units.

As described in the Baker et al. patent, the space between the dielectric surfaces occupied by the gas is such as to permit photons generated on discharge in a selected discrete or elemental volume of gas to pass freely through the gas space and strike surface areas of dielectric remote from the selected discrete volumes, such remote, photon struck dielectric surface areas thereby emitting electrons so as to condition other and more remote elemental volumes for discharges at a uniform applied potential.

With respect to the memory function of a given discharge panel, the allowable distance or spacing between the dielectric surfaces depends, inter alia, on the frequency of the alternating current supply, the distance typically being greater for lower frequencies.

While the prior art does disclose gaseous discharge devices having externally positioned electrodes for initiating a gaseous discharge, sometimes called "electrodeless discharges," such prior art devices utilize frequencies and spacings or discharge volumes and operating pressures such that although discharges are initiated in the gaseous medium, such discharges are ineffective or not utilized for charge generation and storage at higher frequencies; although charge storage may be realized at lower frequencies, such charge storage has not been utilized in a display/memory device in the manner of the Bitzer-Slottow or Baker et al. inventions.

The term "memory margin" is defined herein as

$$\text{M.M.} = (V_f - V_E)/V_{f/2}$$

where V_f is the half amplitude of the smallest sustaining voltage signal which results in a discharge every half cycle, but at which the cell is not bi-stable and V_E is the half amplitude of the minimum applied voltage sufficient to sustain discharges once initiated.

It will be understood that basic electrical phenomena utilized in this invention is the generation of charges (ions and electrons) alternately storable at pairs of opposed or facing discrete points or areas on a pair of dielectric surfaces backed by conductors connected to a source of operating potential. Such stored charges result in an electrical field opposing the field produced by

the applied potential that created them and hence operate to terminate ionization in the elemental gas volume between opposed or facing discrete points or areas of dielectric surface. The term "sustain a discharge" means producing a sequence of momentary discharges, one discharge for each half cycle of applied alternating sustaining voltage, once the elemental gas volume has been fired, to maintain alternate storing of charges at pairs of opposed discrete areas on the dielectric surfaces.

The features and advantages of the invention will be better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

FIGS. 1–4 and the description of these figures are from the above mentioned Baker et al. U.S. Pat. No. 3,499,167.

FIG. 1 is a partially cut-away plan view of a gaseous display/memory panel as connected to a diagrammatically illustrated source of operating potentials,

FIG. 2 is a cross-sectional view (enlarged, but not to proportional scale since the thickness of the gas volume dielectric members and conductor arrays have been enlarged for purposes of illustration) taken on the lines 2—2 of FIG. 1,

FIG. 3 is an explanatory partial cross-sectional view similar to FIG. 1 (enlarged, but not to proportional scale),

FIG. 4 is an isometric view of a larger gaseous discharge display/memory panel, and

FIGS. 5 and 6 are explanatory partial cross-sectional views similar to FIG. 3 showing different embodiments of the present invention.

The invention utilizes a pair of dielectric films or coatings 10 and 11 separated by a thin layer or volume of a gaseous discharge medium 12, said medium 12 producing a copious supply of charges (ions and electrons) which are alternately collectable on the surfaces of the dielectric members at opposed or facing elemental or discrete areas X and Y defined by the conductor matrix on nongas-contacting sides of the dielectric members, each dielectric member presenting large open surface areas and a plurality of pairs of elemental X and Y areas. While the electrically operative structural members such as the dielectric members 10 and 11 and conductor matrixes 13 and 14 are all relatively thin (being exaggerated in thickness in the drawings) they are formed on and supported by rigid nonconductive support members 16 and 17 respectively.

Preferably, one or both of nonconductive support members 16 and 17 pass light produced by discharge in the elemental gas volumes. Preferably, they are transparent glass members and these members essentially define the overall thickness and strength of the panel. For example, the thickness of gas layer 12 as determined by spacer 15 is under 10 mils and preferably about 5 to 6 mils, dielectric layers 10 and 11 (over the conductors at the elemental or discrete X and Y areas) is between 1 and 2 mils thick, and conductors 13 and 14 about 8,000 angstroms thick (tin oxide). However, support members 16 and 17 are much thicker (particularly larger panels) so as to provide as much ruggedness as may be desired to compensate for stresses in the panel. Support members 16 and 17 also serve as heat sinks for heat generated by discharges and thus minimize the effect of temperature on operation of the device. If it is desired that only the memory function be utilized, then none of the members need be transparent to light although for purposes described later herein it is preferred that one of the support members and members formed thereon be transparent to or pass ultraviolet radiation.

Except for being nonconductive or good insulators the electrical properties of support members 16 and 17 are not critical. The main function of support members 16' and 17 is to provide mechanical support and strength for the entire panel, particularly with respect to pressure differential acting on the panel and thermal shock. As noted earlier, they should have thermal expansion characteristics substantially matching the thermal expansion characteristics of dielectric layers 10 and 11. Ordinary ¼ inch commercial grade soda lime plate glasses have been used for this purpose. Other glasses such as low expansion glasses or transparent devitrified glasses can be used provided they can withstand processing and have expansion characteristics substantially matching expansion characteristics of the dielectric coatings 10 and 11. For given pressure differentials and thickness of plates the stress and deflection of plates may be determined by following standard stress and strain formulas (see R. J. Roark, Formulas for Stress and Strain, McGraw-Hill, 1954).

Spacer 15 may be made of the same glass material as dielectric films 10 and 11 and may be an integral rib formed on one of the dielectric members and fused to the other members to form a bakeable hermetic seal enclosing and confining the ionizable gas volume 12. However, a separate final hermetic seal may be effected by a high strength devitrified glass sealant 15S. Tubulation 18 is provided for exhausting the space between dielectric members 10 and 11 and filling the space with the volume of ionizable gas. For large panels small bead like solder glass spacers such as shown at 15B may be located between conductors intersections and fused to dielectric members 10 and 11 to aid in withstanding stress on the panel and maintain uniformity of thickness of gas volume 12.

Conductor arrays 13 and 14 may be formed on support members 16 and 17 by a number of well known processes, such as photoetching, vacuum deposition, stencil screening, etc. In the panel shown in FIG. 4, the center to center spacing of conductors in the respective arrays is about 30 mils. Transparent or semitransparent conductive material such as tin oxide, gold or aluminum can be used to form the conductor arrays and should have a resistance less than 3,000 ohms per line. It is important to select a conductor material that is not attacked during processing by the dielectric material.

It will be appreciated that conductor arrays 13 and 14 may be wires or filaments of copper, gold, silver or aluminum or any other conductive metal or material. For example 1 mil wire filaments are commercially available and may be used in the invention. However, formed in situ conductor arrays are preferred since they may be more easily and uniformly placed on and adhered to the support plates 16 and 17.

Dielectric layer members 10 and 11 are formed of an inorganic material and are preferably formed in situ as an adherent film or coating which is not chemically or physically effected during bake-out of the panel. One such material is a solder glass such as Kimble SG–68 manufactured by and commercially available from the assignee of the present invention.

This glass has thermal expansion characteristics substantially matching the thermal expansion characteristics of certain soda-lime glasses, and can be used as the dielectric layer when the support members **16** and **17** are soda-lime glass plates. Dielectric layers **10** and **11** must be smooth and have a dielectric strength of about 1,000 v. and be electrically homogeneous on a microscopic scale (e.g., no cracks, bubbles, crystals, dirt, surface films, etc.). In addition, the surfaces of dielectric layers **10** and **11** should be good photoemitters of electrons in a baked out condition. However, a supply of free electrons for conditioning gas **12** for the ionization process may be provided by inclusion of a radioactive material within the glass or gas space. A preferred range of thickness of dielectric layers **10** and **11** overlying the conductor arrays **13** and **14** is between 1 and 2 mils. Of course, for an optical display at least one of dielectric layers **10** and **11** should pass light generated on discharge and be transparent or translucent and, preferably, both layers are optically transparent.

The preferred spacing between surfaces of the dielectric films is about 5 to 6 mils with conductor arrays **13** and **14** having center to center spacing of about 30 mils.

The ends of conductors **14–1** . . . **14–4** and support member **17** extend beyond the enclosed gas volume **12** and are exposed for the purpose of making electrical connection to interface and addressing circuitry **19**. Likewise, the ends of conductors **13–1** . . . **13–4** on support member **16** extend beyond the enclosed gas volume **12** and are exposed for the purpose of making electrical connection to interface and addressing circuitry **19**.

As in known display systems, the interface and addressing circuitry or system **19** may be relatively inexpensive line scan systems or the somewhat more expensive high speed random access systems. However, it is to be noted that a lower amplitude of operating potentials helps to reduce problems associated with the interface circuitry between the addressing system and the display/memory panel, per se. Thus, by providing a panel having greater uniformity in the discharge characteristics throughout the panel, tolerances and operating characteristics of the panel with which the interfacing circuitry cooperate, are made less rigid.

One mode of initiating operation of the panel will be described with reference to FIG. **3**, which illustrates the condition of one elemental gas volume **30** having an elemental cross-sectional area and volume which is quite small relative to the entire volume and cross-sectional area of gas **12**. The cross-sectional area of volume **30** is defined by the overlapping common elemental areas of the conductor arrays and the volume is equal to the product of the distance between the dielectric surfaces and the elemental area. It is apparent that if the conductor arrays are uniform and linear and are orthogonally (at right angles to each other) related each of elemental areas X and Y will be squares and if conductors of one conductor array are wider than conductors of the other conductor array, said areas will be rectangles. If the conductor arrays are at transverse angles relative to each other, other than 90°, the areas will be diamond shaped so that the cross-sectional shape of each volume is determined solely in the first instance by the shape of the common area of overlap between conductors in the conductor arrays **13** and **14**. The dotted lines **30'** are imaginary lines to show a boundary of one elemental volume about the center of which each elemental discharge takes place. As described earlier herein, it is known that the cross-sectional area of the discharge in a gas is affected by, inter alia, the pressure of the gas, such that, if desired, the discharge may even be constricted to within an area smaller than the area of conductor overlap. By utilization of this phenomena, the light production may be confined or resolved substantially to the area of the elemental cross-sectional area defined by conductor overlap. Moreover, by operating at such pressure charges (ions and electrons) produced on discharge are laterally confined so as to not materially affect operation of adjacent elemental discharge volumes.

In the instant shown in FIG. **3**, a conditioning discharge about the center of elemental volume **30** has been initiated by application to conductor **13–1** and conductor **14–1** firing potential V_x' as derived from a source **35** of variable phase, for example, and source **36** of sustaining potential V_s (which may be a sine wave, for example). The potential V_x' is added to the sustaining potential V_s as sustaining potential V_s increases in magnitude to initiate the conditioning discharge about the center of elemental volume **30** shown in FIG. **3**. There, the phase of the source **35** of potential V_x' has been adjusted into adding relation to the alternating voltage from the source **36** of sustaining voltage V_s to provide a voltage V_x', when switch **33** has been closed, to conductors **13–1** and **14–1** defining elementary gas volume **30** sufficient (in time and/or magnitude) to produce a light generating discharge centered about discrete elemental gas volume **30**. At the instant shown, since conductor **13–1** is positive, electrons **32** have collected on and are moving to an elemental area of dielectric member **10** substantially corresponding to the area of elemental gas volume **30** and the less mobile positive ions **31** are beginning to collect on the opposed elemental area of dielectric member **11** since it is negative. As these charges build up, they constitute a back voltage opposed to the voltage applied to conductors **13–1** and **14–1** and serve to terminate the discharge in elemental gas volume **30** for the remainder of a half cycle.

During the discharge about the center of elemental gas volume **30**, photons are produced which are free to move or pass through gas medium **12**, as indicated by arrows **37**, to strike or impact remote surface areas of photoemissive dielectric members **10** and **11**, causing such remote areas to release electrons **38**. Electrons **38** are, in effect, free electrons in gas medium **12** and condition each other discrete elemental gas volume for operation at a lower firing potential V_f which is lower in magnitude than the firing potential V_f' for the initial discharge about the center of elemental volume **30** and this voltage is substantially uniform for each other elemental gas volume.

Thus, elimination of physical obstructions or barriers between discrete elemental volumes, permits photons to travel via the space occupied by the gas medium **12** to impact remote surface areas of dielectric members **10** and **11** and provides a mechanism for supplying free electrons to all elemental gas volumes, thereby conditioning all discrete elemental gas volumes for subsequent discharges, respectively, at a uniform lower applied potential. While in FIG. **3** a single elemental volume **30** is shown, it will be appreciated that an entire row (or column) of elemental gas volumes may be

maintained in a "fired" condition during normal operation of the device with the light produced thereby being masked or blocked off from the normal viewing area and not used for display purposes. It can be expected that in some applications there will always be at least one elemental volume in a "fired" condition and producing light in a panel, and in such applications it is not necessary to provide separate discharge or generation of photons for purposes described earlier.

However, as described earlier, the entire gas volume can be conditioned for operation at uniform firing potentials by use of external or internal radiation so that there will be no need for a separate source of higher potential for initiating an initial discharge. Thus, by radiating the panel with ultraviolet radiation or by inclusion of a radioactive material within the glass materials or gas space, all discharge volumes can be operated at uniform potentials from addressing and interface circuit **19.**

Since each discharge is terminated upon a build up or storage of charges at opposed pairs of elemental areas, the light produced is likewise terminated. In fact, light production lasts for only a small fraction of a half cycle of applied alternating potential and depending on design parameters, is in the nanosecond range.

After the initial firing or discharge of discrete elemental gas volume **30** by a firing potential V_f', switch **33** may be opened so that only the sustaining voltage V_s from source **36** is applied to conductors **13–1** and **14–1.** Due to the storage of charges (e.g., the memory) at the opposed elemental areas X and Y, the elemental gas volume **30** will discharge again at or near the peak of negative half cycles of sustaining voltage V_s to again produce a momentary pulse of light. At this time, due to reversal of field direction, electrons **32** will collect on and be stored on elemental surface area Y of dielectric member **11** and positive ions **31** will collect and be stored on elemental surface area X of dielectric member **10.** After a few cycles of sustaining voltage V_s, the times of discharges become symmetrically located with respect to the wave form of sustaining voltage V_s. At remote elemental volumes, as for example, the elemental volumes defined by conductor **14–1** with conductors **13–2** and **13–3,** a uniform magnitude or potential V_x from source **60** is selectively added by one or both of switches **34–2** or **34–3** to the sustaining voltage V_s shown as **36'**, to fire one or both of these elemental discharge volumes. Due to the presence of free electrons produced as a result of the discharge centered about elemental volume **30,** each of these remote discrete elemental volumes have been conditioned for operation at uniform firing potential V_f.

In order to turn "off" an elemental gas volume (i.e., terminate a sequence of discharge representing the "on" state), the sustaining voltage may be removed. However, since this would also turn "off" other elemental volumes along a row or column, it is preferred that the volumes be selectively turned "off" by application to selected "on" elemental volumes a voltage which can neutralize the charges stored at the pairs of opposed elemental areas.

This can be accomplished in a number of ways, as for example, varying the phase or time position of the potential from source **60** to where that voltage combined with the potential form source **36'** falls substantially below the sustaining voltage.

It is apparent that the plates **16–17** need not be flat but may be curved, curvature of facing surfaces of each plate being complementary to each other. While the preferred conductor arrangement is of the crossed grid type as shown herein, it is likewise apparent that where an infinite variety of two dimensional display patterns are not necessary, as where specific standardized visual shapes (e.g., numerals, letters, words, etc.) are to be formed and image resolution is not critical, the conductors may be shaped accordingly.

The device shown in FIG. **4** is a panel having a large number of elemental volumes similar to elemental volume **30** (FIG. **3**). In this case more room is provided to make electrical connection to the conductor arrays **13'** and **14'**, respectively, by extending the surfaces of support members **16'** and **17'** beyond scale **15S'**, alternate conductors being extended on alternate sides. Conductor arrays **13'** and **14'** as well as support members **16'** and **17'** are transparent. The dielectric coatings are not shown in FIG. **4** but are likewise transparent so that the panel may be viewed from either side.

In accordance with this invention, there is provided a novel process for the preparation of a gas discharge panel which comprises selectively applying a stress-balanced, three-layer, coating composite to each dielectric charge-storage surface of a gas discharge device.

More especially, there is provided a gas discharge display/memory panel manufacturing process which comprises thermally evaporating and depositing upon each dielectric material charge-storage surface a continuous, relatively-flaw free, three-layer, stress-balanced composite.

In one particular manufacture of a gas discharge display/memory device and with reference to FIG. **5,** each dielectric **10, 11** is applied to a glass substrate **16, 17** to which the electrode conductors **13, 14** have been previously applied. The dielectric layer **10, 11** is typically applied directly to the electrode side of the substrate **16, 17**; that is, each dielectric is applied in direct contact with and over its respective electrode array.

A sealing composition is appropriately applied, such as by a printing method, around or near the outer edge (perimeter or circumference) of one or both substrates. The substrates are then sealed together, dielectric surface to dielectric surface. If the dielectric extends out to the edges of the substrate, the sealing composition will be on top of the outer surface portion of such dielectric.

In the preferred practice hereof, the three-layer composite is applied while each dielectric (including any supporting substrate) is at a temperature of about 150°F to about 600°F.

In still another preferred practice hereof, the deposition of the composite is after the seal has been applied to one or both of the support substrates.

In accordance with the specific practice of this invention, there is deposited a first layer **101, 111** of at least one compound of Group IIA, Al, Si, Ti, Zr, Hf, or mixtures thereof; a second layer **102, 112** of at least one compound of Group IIA, Al, Si, Ti, Zr, Hf, or mixtures thereof which is chemically different from the first layer; and a third layer **103, 113** of electron-emissive material; the combination of the first and second layers being sufficient to prevent ion migration from the dielectric to the third layer and sufficient to provide a thermally and structurally stable base for the third

layer; and the second layer being chemically inert relative to the third layer.

Typical compounds contemplated for the first and second layers include the oxides, nitrides, fluorides, borides, and carbides of the Group IIA elements, Al, Si, Ti, Zr, Hf, or mixtures thereof. By mixtures thereof, it is intended that a given layer may comprise a mixture of two or more compounds (of the same or different element) and/or may comprise a single compound containing two or more elements.

The combination of the first and second layers should provide a thermally and structurally stable base for the top layer; that is, the first two layers must be such that there is a minimum formation of cracks, fissures, flaws, crazes, crevices, etc., especially during the thermal sealing of the panel.

As used herein Group IIA is defined as including the elements Be, Mg, Ca, Sr, and Ba. Likewise, Ra is intended although economics may prohibit common usage.

The three layers are preferably non-conductive. However, conductive materials may be utilized if such are applied in islandlike geometric patterns so as to be structurally and electrically isolated from the electrodes and/or gaseous medium. FIg. 6 is a cross-sectional view of a panel as described in U.S. Pat. No. 3,559,190 to Bitzer et al. wherein perforations or cells **120** in an inner insulating member **121** physically isolate each discharge unit. The island-like three layers are located on the dielectric layers **10, 11** at each cell site.

As used herein, electron-emissive refers to the processes of photoemission, secondary electron emission of ion and/or electron bombardment, and thermionic electron emission.

Typical conductive or semi-conductive materials which may be utilized such as in an isolated geometric arrangement, comprise GaAs, GaP, InAs, InSb, InP, NiO, AgOCs, and AuOCs.

Preferably there is used a non-conductive substance such as CsF, CsI, lead oxide, and/or magnesium oxide.

In a specific embodiment of this invention, each dielectric surface is thermally evaporated and deposited with a first layer of silica, a second layer of aluminum oxide, and a third layer of lead oxide.

In another specific embodiment, there is thermally evaporated and deposited a first layer of silica, a second layer of zirconium oxide, and a third layer of lead oxide.

A further specific embodiment comprises the thermal evaporating and depositing of a first layer of magnesium oxide, a second layer of zirconium oxide, and a third layer of lead oxide.

Still another specific embodiment comprises thermally evaporating and depositing a first layer of Si_3N_4, a second layer of silica, and a third layer of lead oxide.

Another embodiment comprises thermally evaporating and depositing a first layer of magnesium oxide, a second layer of aluminum oxide, and a third layer of lead oxide.

Another embodiment comprises thermally evaporating and depositing a first layer of silica, a second layer of aluminum oxide, and a third layer of magnesium oxide.

Another embodiment comprises thermally evaporating and depositing a first layer of silica, a second layer of zirconium oxide, and a third layer of magnesium oxide.

Another embodiment comprises thermally evaporating and depositing a first layer of magnesium oxide, a second layer of zirconium oxide, and a third layer of magnesium oxide.

Another embodiment comprises thermally evaporating and depositing a first layer of Si_3N_4, a second layer of silica, and a third layer of magnesium oxide.

Another embodiment comprises thermally evaporating and depositing a first layer of magnesium oxide, a second layer of aluminum oxide, and a third layer of magnesium oxide.

In accordance with this invention, the composite layers are applied by a thermal evaporation and deposition process wherein a source of the layer material is thermally evaporated and condensated as a thin solid continuous film or layer. The process is preferably done under a vacuum.

Examples of thermal evaporation, also known as physical vapor deposition, include resistive heating which comprises heating the selected material with a resistively heated filament; laser evaporation; and RF or induction heating evaporation.

One highly preferred thermal evaporation process is electron beam evaporation which comprises electron bombardment of the selected material so as to heat and evaporate it. As already noted, the evaporation and deposition are preferably under vacuum.

In the typical practice hereof, the first two layers are oxides.

In one embodiment of such practice, one or both oxide layers is applied directly to the surface of the dielectric material, or preceding layer, via the aforementioned processes.

In another embodiment thereof, at least one of the oxide layers is formed in situ on the dielectric surface, e.g., by applying the elemental metal or metalloid (or a source thereof) to the dielectric surface followed by oxidation. One such in situ process comprises applying metal or metalloid melt to the dielectric followed by oxidation of the melt during the cooling thereof so as to form the oxide layer. Another in situ process comprises applying an oxidizable source of the elemental metal or metalloid to the surface. Typical of such oxidizable sources include minerals and/or compounds containing the metal or metalloid, especially those organometals or organometalloids which are readily heat decomposed or pyrolyzed.

In the usual practice hereof, each of the three layers is applied to or formed on the dielectric material surface to a thickness of at least about 100 angstrom units per layer with a range of about 200 angstrom units per layer up to about 1 micron (10,000 angstrom units) per layer.

As used herein, the terms "film or layer" are intended to be all inclusive of other similar terms such as deposit, coating, finish, spread, covering, etc.

In the fabrication of a gaseous discharge panel, the dielectric material is typically applied to and cured on the surface of a supporting glass substrate or base to which the electrode or conductor elements have been previously applied. The glass substrate may be of any suitable composition such as a soda lime glass composition. Two glass substrates containing electrodes and

cured dielectric are then appropriately heat sealed together so as to form a panel. As noted hereinbefore, in the preferred practice of this invention, each of the three layers is applied to the surface of the cured dielectric before the panel heat sealing cycle, with the dielectric and substrate at a temperature of about 150°F to about 600°F.

Gaseous discharge display/memory panels prepared in accordance with the practice of this invention have the advantage of decreased aging cycle time, lower operating voltages, and substantially uniform operating voltages; that is, operating voltages which are essentially stable as a function of total panel operating time. As used herein, voltage is defined as any voltage required for operation of the panel including firing and dynamic sustaining voltages as well as any other voltages used for manipulation of a cell discharge.

Also this invention has the further important advantage of providing a gas discharge device dielectric surface which will consistently remain continuous and coherent through the thermal cycling required in the panel sealing operations, that is, there results a sufficiently stress-balanced three coating composite which avoids film cracking, crazing, etc. Prior art thin films deposited at the dielectric discharge surface possess a marked tendency to craze when subjected to conventional sealing cycles. The advantage of using an essentially stress-balanced composite of films is that it permits conventional sealing with commercial solder glasses. Another advantage is that the stress-balanced composite is much less sensitive to substrate imperfections and to substrate temperature during deposition.

The following examples are intended to illustrate some of the best embodiments contemplated by the inventor in the practice of this invention.

EXAMPLE I

Using a ¼ inch thick soda-lime silicate base glass substrate containing gold conductors and a bulk glass dielectric of about 1 mil thickness, a composite of coatings is sequentially deposited by vacuum deposition techniques using electron beam evaporation. On the bulk glass dielectric, about 700 A. of magnesium oxide is first deposited followed by a second layer of about 1,000 A. of alumina. Onto this a third layer of about 1,000 A. of lead oxide is deposited to form the discharge-memory surface. Subsequent sealing of substrates coated in this way with commercial solder glasses repeatedly demonstrates the thermal stability of the three-layer composite.

EXAMPLE II

The procedure of EXAMPLE I is repeated using the thicknesses and oxides summarized in the TABLE I hereinafter. All of the thicknesses are in angstrom units.

TABLE I

COMBINATION	1ST LAYER	2ND LAYER	3RD LAYER
A	550 magnesium oxide	850 aluminum oxide	1000 lead oxide
B	550 magnesium oxide	1150 aluminum oxide	1000 lead oxide
C	850 magnesium oxide	850 aluminum oxide	1000 lead oxide
D	850 magnesium oxide	1150 aluminum oxide	1000 lead oxide

Subsequent sealing of glass substrates coated with each combination demonstrates the thermal stability of each three-layer composite.

We claim:

1. In a process for manufacturing a gaseous discharge display/memory device containing dielectric charge storage members, the improvement which comprises thermally evaporating and depositing a three-layer composite on the charge storage surface of each dielectric member; the first layer consisting of at least one compound of Group IIA, Al, Si, Ti, Zr, Hf, or mixtures thereof; the second layer consisting of at least one compound of Group IIA, Al, Si, Ti, Zr, Hf, or mixtures thereof which is chemically different from the first layer; and the third layer consisting of an electron-emissive material; the combination of the first and second layers being sufficient to prevent ion migration from the dielectric to the third layer and sufficient to provide a thermally and structurally stable base for such third layer; and the second layer being chemically inert relative to the third layer.

2. The process of claim 1 wherein each layer is applied by means of electron beam evaporation.

3. The process of claim 1 wherein each dielectric member is heated to a temperature of about 150°F to about 600°F and the three-layer composite applied thereto.

4. The process of claim 1 wherein the thickness of each layer is about 200 angstrom units to about 10,000 angstrom units.

5. The process of claim 1 wherein the third layer is selected from GaAs, GaP, InAs, InSb, InP, NiO, AgOCs, and AuOCs.

6. The process of claim 1 wherein all three layers are oxides.

7. The process of claim 6 wherein the third layer is selected from magnesium oxide and lead oxide.

8. The process of claim 1, wherein the compounds of the first and second layers are selected from oxides.

9. The process of claim 8, wherein the third layer is selected from CsF, CsI, lead oxide and magnesium oxide.

10. The process of claim 1 wherein the thickness of each layer is at least 100 angstrom units.

11. The process of claim 10, wherein said first, second, and third layers are silica, aluminum oxide and lead oxide respectively.

12. The process of claim 10, wherein said first, second, and third layers are silica, zirconium oxide, and lead oxide respectively.

13. The process of claim 10, wherein said first, second, and third layers are magnesium oxide, zirconium oxide, and lead oxide respectively.

14. The process of claim 10, wherein said first, second, and third layers are Si_3N_4, silica, and lead oxide respectively.

15. The process of claim 10, wherein said first, second, and third layers are magnesium oxide, aluminum oxide, and lead oxide respectively.

16. The process of claim 10, wherein said first, second, and third layers are silica, aluminum oxide, and magnesium oxide respectively.

17. The process of claim 10 wherein said first, second, and third layers are silica, zirconium oxide, and magnesium oxide respectively.

18. The process of claim 10 wherein said first, second, and third layers are magnesium oxide, zirconium oxide, and magnesium oxide respectively.

19. The process of claim 10 wherein said first, second, and third layers are Si_3N_4, silica, and magnesium oxide respectively.

20. The process of claim 10 wherein said first, second, and third layers are magnesium oxide, aluminum oxide, and magnesium oxide respectively.

21. In a process for manufacturing a gaseous discharge display/memory device wherein an array of electrodes is applied to a glass substrate and a dielectric layer is applied over the electrodes, and wherein a pair of glass substrates are sealed, dielectric to dielectric, to form a chamber which is filled with an ionizable gas, the improvement which comprises electron beam evaporating and depositing upon the surface of each dielectric a three-layer composite; the first layer consisting of at least one compound of Group IIA, Al, Si, Ti, Zr, Hf, or mixtures thereof; the second layer consisting of at least one compound of Group IIA, Al, Si, Ti, Zr, Hf, or mixtures thereof which is chemically different from the first layer; and the third layer consisting of an electron-emissive material; the combination of the first and second layers being sufficient to prevent ion migration from the dielectric to the third layer and sufficient to provide a thermally and structurally stable base for the third layer; and the second layer being chemically inert relative to the third layer.

22. The process of claim 21 wherein a sealing composition is applied to the perimeter of each substrate prior to the applying of the composite.

23. The process of claim 21 wherein the thickness of each layer is at least 100 angstrom units.

24. The process of claim 21 wherein the thickness of each layer is about 200 angstrom units to about 10,000 angstrom units.

25. The process of claim 21 wherein the third layer is selected from GaAs, GaP, InAs, InSb, InP, NiO, AgOCs, and AuOCs.

26. The process of claim 21 wherein said first, second, and third layers are silica, aluminum oxide and lead oxide respectively.

27. The process of claim 21 wherein said first, second, and third layers are silica, zirconium oxide, and lead oxide respectively.

28. The process of claim 21 wherein said first, second, and third layers are magnesium oxide, zirconium oxide, and lead oxide respectively.

29. The process of claim 21 wherein said first, second, and third layers are Si_3N_4, silica, and lead oxide respectively.

30. The process of claim 21 wherein said first, second, and third layers are magnesium oxide, aluminum oxide, and lead oxide respectively.

31. The process of claim 21 wherein said first, second and third layers are silica, aluminum oxide, and magnesium oxide respectively.

32. The process of claim 21 wherein said first, second and third layers are silica, zirconium oxide, and magnesium oxide respectively.

33. The process of claim 21 wherein said first, second, and third layers are magnesium oxide, zirconium oxide, and magnesium oxide respectively.

34. The process of claim 21 wherein said first, second, and third layers are Si_3N_4, silica, and magnesium oxide.

35. The process of claim 21 wherein said first, second, and third layers are magnesium oxide, aluminum oxide, and magnesium oxide respectively.

36. The process of claim 22 wherein each layer is applied while each substrate is at a temperature of about 150°F to about 600°F.

37. The process of claim 36 wherein the first layer is magnesium oxide, the second layer is aluminum oxide, and the third layer is selected from magnesium oxide or lead oxide.

38. The process of claim 21 wherein the compounds of the first and second layers are selected from oxides.

39. The process of claim 38 wherein the third layer is selected from CsF, CsI, lead oxide and magnesium oxide.

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