

[72] Inventor **Roger E. Ernsthause**
Luckey, Ohio
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 [73] Assignee **Owens-Illinois, Inc.**

OTHER REFERENCES

Welber, "Gas Display Panel," IBM Technical Disclosure Bulletin, Vol. 12, No. 10, March 1970, pp. 1552, 1553.

Primary Examiner—Roy Lake
 Assistant Examiner—Siegfried H. Grimm
 Attorneys—D. K. Wedding and E. J. Holler

[54] **GAS DISCHARGE DISPLAY/MEMORY PANEL
 HAVING LEAD OXIDE COATED DIELECTRIC
 PLATES WITH DECREASED AGING TIME**
 10 Claims, No Drawings

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References Cited

UNITED STATES PATENTS

3,257,581	6/1966	Lodge et al.	315/169 R
3,499,167	3/1970	Baker et al.	315/169 TV

ABSTRACT: There is disclosed 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 which are respectively backed by a series of parallel-like conductor (electrode) members, the conductor members behind each dielectric material member being transversely oriented with respect to the conductor members behind the opposing dielectric material member so as to define a plurality of discrete discharge volumes constituting a discharge unit, the surface of the dielectric material having a lead oxide applied thereto in an amount sufficient to substantially decrease the preliminary aging time of the panel and to provide stable panel-operating voltages which do not significantly change with panel-operating time.

GAS DISCHARGE DISPLAY/MEMORY PANEL HAVING LEAD OXIDE COATED DIELECTRIC PLATES WITH DECREASED AGING TIME

THE INVENTION

This invention relates to novel multiple gas discharge display/memory panels 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. More particularly, this invention relates to novel gas discharge display/memory panels requiring decreased aging cycle time and having 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 for manipulation of the discharge.

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 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 AC 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 nonphysically isolated or open discharge units is disclosed in U.S. Letters 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, California, Nov. 1966, pages 541-547.

In the operation of the panel, a continuous volume of ionizable gas is confined between a pair of photoemissive 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 HXC and the number of elemental or discrete areas will be twice the number of elemental discharge volumes.

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 nonisolated 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 AC 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 in the manner of the present invention.

The term "memory margin" is defined herein as

$$M.M. = (V_f - V_s) / V_s$$

where V_f is the magnitude of the applied voltage at which a discharge is initiated in a discrete conditioned (as explained in the aforementioned Baker, et al., patent) volume of gas defined by common areas of overlapping conductors and V_s is the magnitude of the minimum applied periodic alternating 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.

In accordance with this invention, it has been surprisingly discovered that the gaseous discharge panel voltage uniformity or stability as a function of gaseous discharge panel operating time may be significantly enhanced and improved by applying at least one lead oxide to the surface of the dielectric material. More particularly, a lead oxide is applied to the dielectric material charge storage surface so as to provide gaseous discharge panel-operating voltages which do not significantly vary or substantially change over a given period of panel operating time and thereby increase the effective and useful operating life of the gaseous discharge panel.

It has been further discovered that the aging time cycle of the panel is also enhanced by the presence of the lead oxide on the dielectric surface. More especially, the required amount of total aging or preliminary operation time of the panel is substantially decreased by the application of the lead oxide to the dielectric surface. Panel aging is defined as the accumulated total-operating time for the panel. Typically a panel requires

at least 25 hours of aging or preliminary operation of the panel, often as long as 50 hours, before preliminary erratic panel operating characteristics begin to stabilize or level off. Likewise, various desired panel characteristics such as memory margin may not be detected until after appropriate panel aging. The practice of this invention has been found to reduce such panel aging time to less than 25 hours, typically less than 10 hours.

In one embodiment hereof, the selected lead oxide is applied directly to the surface of the dielectric material.

In still another embodiment hereof, the lead oxide is formed in situ on the dielectric surface; e.g., by applying the elemental lead (or a source thereof) to the dielectric surface followed by oxidation. One such in situ process comprises applying lead melt to the dielectric followed by oxidation of the melt during the cooling thereof. Another in situ process comprises applying an oxidizable source of the lead to the surface. Typical of such sources include minerals and/or compounds containing the element, especially those organometals which are readily heat decomposed or pyrolyzed.

The lead oxide or elemental lead (including a source thereof) is applied to the dielectric surface by any convenient means including not by way of limitation vapor deposition; vacuum deposition; chemical vapor deposition; wet spraying upon the surface a mixture or solution of the lead oxide or elemental lead suspended or dissolved in a liquid followed by evaporation of the liquid; dry spraying of the lead oxide or elemental lead upon the surface; electron beam evaporation; plasma flame and/or deposition; and sputtering target techniques.

The lead oxide is applied to (or formed on) the dielectric surface as a very thin film or layer, the thickness and amount of such lead oxide film or layer being sufficient to provide stable panel-operating voltages as a function of panel operating time and also substantially decrease panel aging.

More especially, the lead oxide is applied to the dielectric material surface as a thin film or layer having a thickness of at least about 200 angstrom units; e.g., about 200 angstrom units to about 1 micron (10,000 angstrom units).

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.

In the preferred practice of this invention, the lead oxide is applied to the surface of the cured dielectric before the panel heat sealing cycle.

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

EXAMPLE I

A layer of lead oxide was deposited to a relatively uniform thickness of about 1,000 angstrom units on the respective exposed surfaces of two-cured dielectric material layers, each dielectric layer having been previously applied and cured onto (electrodes containing) glass substrates.

The lead oxide was deposited by means of an electron beam evaporation technique. The dielectric composition was a lead borosilicate consisting of 73.3 percent by weight PbO, 13.4 percent by weight B₂O₃, and 13.3 percent by weight SiO₂. The glass substrates were of a soda lime composition containing about 73 percent by weight SiO₂, about 13 percent by weight Na₂O, about 10 percent by weight CaO, about 3 percent by weight MgO, about 1 percent by weight Al₂O₃, and small amounts (less than 1 percent) of Fe₂O₃, K₂O, As₂O₃, and

Cr₂O₃. The electrode lines or conductor arrays were of hanovia gold.

The two substrates were heat sealed together (using a standard solder glass) so as to form a gaseous discharge panel of the open cell Baker et al., kind. After an appropriate vacuum process, the panel was filled with an inert ionizable gas consisting of 99.9 percent atoms of neon and 0.1 percent atoms of argon. After aging of the panel for only about 3 hours during which time the operating (dynamic sustaining) voltage increased by about +10 volts, the voltage leveled off with a change of only +4 volts over the next 570 hours of panel operating time.

EXAMPLE II

The panel fabrication of example I was repeated for 10 panels in order to confirm the reduction of panel-aging time. All of the panels exhibited an aging time of less than 10 hours, an average of about 3 hours, with a change in operating voltage of about ± 2 to about ± 10 volts, an average of about ± 6 . Thereafter, all of the panels leveled off as in example I.

The foregoing examples illustrate that when a layer of lead oxide is applied to the dielectric surface in accordance with this invention, the resulting fabricated gaseous discharge panel has decreased required aging time and, after such appropriate aging, more stable panel operating voltages as a function of operating time and therefore increased panel operation life.

I claim:

1. In a gaseous discharge panel characterized by an ionizable gaseous medium in a gas chamber formed by a pair of opposed dielectric material charge storage surfaces, the improvement wherein each dielectric surface is coated with at least one lead oxide in an amount sufficient to provide stable panel-operating voltages for a given period of panel-operating time.

2. The invention of claim 1 wherein each dielectric surface is coated with a lead oxide thickness of at least about 200 angstrom units.

3. The invention of claim 2 wherein the lead oxide thickness ranges from about 200 angstrom units up to about 10,000 angstrom units.

4. In a gaseous discharge panel comprising an ionizable gaseous medium in a gas chamber formed by a pair of opposed dielectric material charge storage surfaces backed by electrode members, the electrode members behind each dielectric material surface being transversely oriented with respect to the electrode material members behind the opposing dielectric material surface so as to define a plurality of discharge units, the improvement wherein at least one lead oxide is applied to each opposed dielectric material surface in an amount sufficient to substantially decrease required panel aging and to provide stable panel-operating voltages for a given period of panel-operating time.

5. As an article of manufacture, a dielectric material body for a gaseous discharge panel, said dielectric body containing a surface deposit of at least one lead oxide in an amount sufficient to provide gaseous discharge panel-operating voltages which do not substantially change over a given period of panel-operating time.

6. The invention of claim 5 wherein the dielectric body is coated with a lead oxide thickness of at least about 200 angstrom units.

7. The invention of claim 6 wherein the lead oxide thickness ranges from about 200 angstrom units up to about 10,000 angstrom units.

8. In the operation of a gaseous discharge panel characterized by an ionizable gaseous medium in a gas chamber formed by a pair of dielectric material members having opposed charge storage surfaces, which dielectric material members are respectively backed by a series of parallellike electrode members, the electrode members behind each dielectric material member being transversely oriented with respect to

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the electrode members behind the opposing dielectric material member so as to define a plurality of discrete discharge volumes constituting a discharge unit, and wherein the gas is selectively ionized within each discharge unit by operating voltages applied to the transversely oriented electrode members, the improvement which comprises decreasing the required panel-aging time and stabilizing the panel-operating voltages over a given period of panel-operating time so as to increase the effective panel-operating life by coating each op-

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posed dielectric material charge storage surface with a deposit of lead oxide.

9. The invention of claim 8 wherein the dielectric surface is coated with an oxide thickness of at least about 200 angstrom units.

10. The invention of claim 9 wherein the oxide thickness ranges from about 200 angstrom units up to about 10,000 angstrom units.

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