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- [54] **PLASMA PANEL DISPLAY DEVICE**
3 Claims, 2 Drawing Figs.
- [52] **U.S. Cl.**..... **313/108,**
313/221, 313/210
- [51] **Int. Cl.**..... **H01j 63/06,**
H01j 11/00, H01j 15/02
- [50] **Field of Search**..... 313/108,
109.5, 210

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ABSTRACT: A high contrast plasma display device includes transparent and opaque insulator layers spaced and bonded by a plurality of spaced opaque insulator segments forming a plurality of cavities. An insulator substrate having a plurality of spaced conductors on the surface thereof in registry with the cavities and electrical connectors embedded therein is bonded to the opaque insulator layer while a transparent electrode layer is affixed to the transparent insulator layer. An ionizable gas is disposed within the cavities whereby energization of certain conductors alters the device from an opaque to a visual display.

Also, the high contrast plasma display device is fabricated by a process which includes affixing the spaced conductor to a substrate, bonding an opaque insulator layer to the substrate and spaced conductors, attaching spaced opaque insulator segments to a transparent insulator layer, bonding the segments to the opaque insulator layer forming cavities in registry with the spaced conductors, affixing a transparent electrode to the transparent insulator layer, and disposing an ionizable gas within the cavities whereby the device appears opaque until energized to provide a visual display.

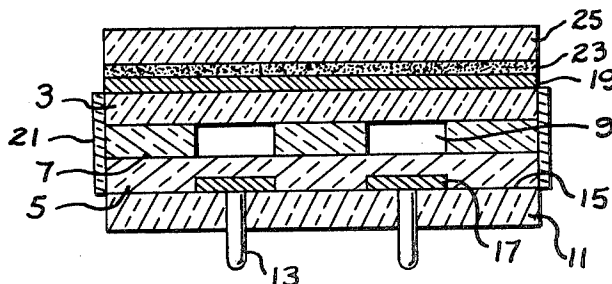


Fig. 1

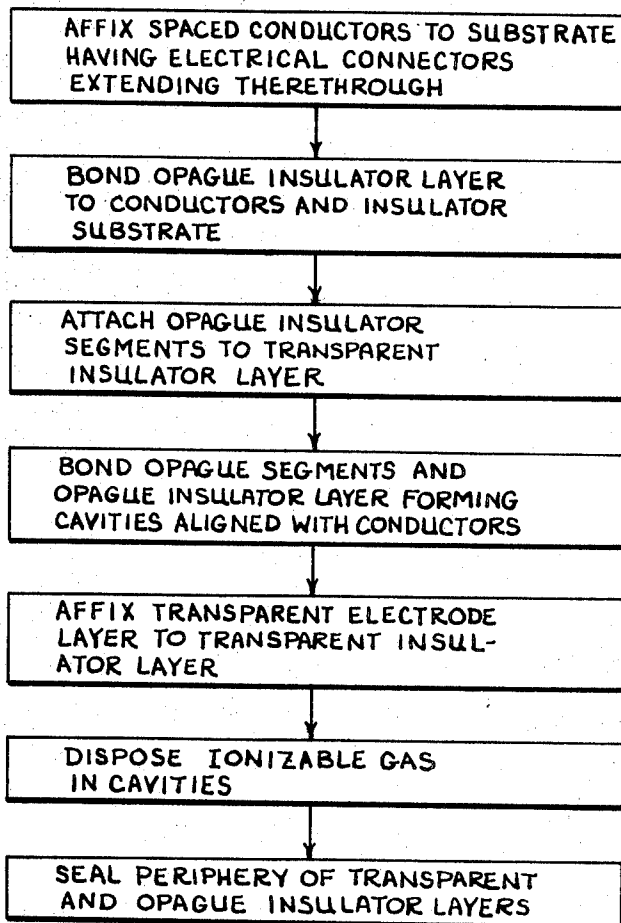
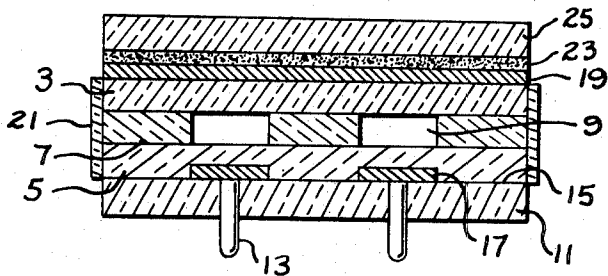


Fig. 2

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PLASMA PANEL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

The prior art suggests numerous types of devices for providing a visual display. For instance, there are vacuum-type display devices such as the cathode ray tube; phosphor type devices such as the well-known electroluminescent devices; discharge tubes of the glow discharge variety, and ordinary light sources disposed in the vicinity of the configuration to be displayed. Also, a relatively new type of display device is the so-called plasma display device which is not only of the solid-state type but also includes a memory capability.

Although each of the above-mentioned types of display device has provided excellent service in numerous applications, it has been found each is limited by one or more features such as relative size, energizing potentials, resolution, and memory. Moreover, all of such display devices are continuously plagued with the problem of lack of contrast between an energized and deenergized state under prevailing ambient lighting conditions.

OBJECTS AND SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to enhance the contrast of a visual display device. Another object of the present invention is to provide an improved plasma display device. Still another object of the invention is to provide a high contrast plasma display device of relatively simple design which is economical of materials and fabrication apparatus and time. A still further object of the invention is to provide an improved process for fabricating a high contrast plasma display device.

These and other objects and advantages are achieved in one aspect of the invention by a plasma display device having transparent and opaque insulator layers separated by spaced opaque insulator segments affixed thereto and forming cavities wherein an ionizable gas is disposed. An insulator support member bonded to the opaque insulator layer has a plurality of electrical connectors embedded therein and extending therethrough and a plurality of spaced conductors affixed to a surface in registry with the cavities. A transparent electrode layer is affixed to the transparent insulator layer.

The plasma display device is fabricated in accordance with a process which includes the steps of affixing a plurality of spaced conductors to an insulator substrate having a plurality of electrical connectors therein, bonding an opaque insulator layer to the substrate, attaching a plurality of spaced opaque insulator segments to a transparent insulator layer, bonding the spaced opaque insulator segments to the opaque insulator layer forming cavities in registry with the spaced conductors, affixing a transparent electrode layer to the transparent insulator layer, and disposing an ionizable gas within the cavities.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a preferred embodiment of the plasma display device of the invention; and

FIG. 2 is a flow chart illustrating a preferred process for fabricating a plasma display device of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the accompanying drawings.

Referring to the drawings, FIG. 1 illustrates a preferred embodiment of a high contrast plasma display device which includes a transparent insulator layer 3, such as glass for instance. Also, an opaque insulator layer 5, which is preferably in the form of a black glass frit, is spaced from the transparent insulator layer by a plurality of spaced opaque insulator segments 7. Thus, the transparent and opaque insulator layers 3 and 5 respectively, and the spaced opaque insulator segments 7, form a plurality of cavities 9, intermediate thereto.

An insulator substrate 11, such as glass for example, has a plurality of electrical connectors 13 embedded therein and extending therethrough. The connectors 13 are at least flush with one surface 15 of the substrate 11, which is bonded to the opaque insulator layer 5, and a plurality of spaced electrical conductors 17 are affixed to the surface 13 in electrical contact with the connectors 13 and in registry with the cavities 9. Also, a transparent electrode layer 19 is affixed to the transparent insulator layer 3 and an ionizable gas is disposed within the cavities 9. Thereafter, a seal 21 is affixed intermediate the periphery of the transparent and opaque insulator layers 3 and 5 respectively. Moreover, a phosphor layer 23, covered by a second transparent insulator layer 25 may be but not necessarily need be affixed to the transparent electrode layer 19.

As to a preferred process for fabricating the above-described high contrast plasma display device, reference is made to the flow chart of FIG. 2, in conjunction with the structure of FIG. 1. As clearly set forth therein, a plurality of spaced electrical conductors 17 of a material such as Nichrome (80percent nickel; 20 percent chrome) which will tolerate a reasonably high firing temperature, are affixed to one surface 15 of an insulator substrate 11, such as glass. The insulator substrate 11 has a plurality of electrical connectors 13 embedded therein and each of the conductors 17 contacts and is electrically connected to at least one of the connectors 13.

Then, an opaque insulator layer 5, of a material such as the well-known and readily available black glass frit, is bonded to and covers the insulator substrate 11 and spaced conductor 17 affixed to the substrate 11. Normally, the opaque insulator layer 5 may be applied to the substrate 11 and conductors 17 by any one of a number of well-known techniques such as silk screening or spraying, and a preferred technique is to employ a cast film. This opaque insulator layer 5 has a thickness dimension, as measured normal to the longitudinal axis of the layer, in the range of about 0.004 to 0.008 inch and a preferred thickness dimension of about 0.006 inch.

Following, a plurality of spaced opaque insulator segments 7 are affixed to a transparent insulator layer 3, such as glass for instance. Again, the segments 7 and the transparent insulator layer 3 each have a thickness dimension of about 0.004 to 0.008 inch and preferably of about 0.006 inch.

Thereafter, the spaced opaque insulator segments 7 having the transparent insulator layer 3 affixed thereto, are bonded to the opaque insulator layer 5 to provide a plurality of cavities 9 which are aligned with or in registry with the above-mentioned spaced conductors 17 affixed to the insulator substrate 11. Then an ionizable gas, such as a neon-nitrogen mixture is disposed within the above-mentioned cavities 9 and the periphery of the transparent and opaque insulator layers 3 and 5 respectively, is sealed by any of the well-known epoxy or metallizing techniques.

A transparent electrode layer 19, such as tin or indium oxide, is applied to the transparent insulator layer 3 by any one of a number of well-known methods. Moreover, the transparent electrode layer 19 may be in segmented form with transparent connectors extending outwardly to the edges of the transparent insulator layer 3.

Additionally, a fluorescent powder layer 23 may be affixed to the transparent electrode layer 19 should a variation in display color be desired. Also, a second transparent insulator layer 25, of glass or plastic, may readily be affixed to the fluorescent powder layer 23 to provide a protective coating in a manner well known in the art.

As to the appearance of the high contrast plasma display device, it is obvious that the opaque insulator segments 7 and opaque insulator layer 5 combine to provide a device having an opaque appearance when viewed through the transparent insulator layer 3. It is also obvious that energization of certain ones of the conductors 17, causing ionization of the gas within the cavity 9 aligned therewith, will provide a visual display of relative high contrast as compared with the opaque appearance of the nonenergized portions.

As to the operation of the high contrast plasma display device, application of an alternating voltage to the transparent electrode layer 19 and certain ones of the conductors 17 in an amount sufficient to fire or ionize the gas within the cavities 9 intermediate thereto, will establish a discharge which develops rapidly into a glow. During this period of glow development, charges flow to the insulator walls of the cavity 9 to provide a so-called "wall charge." The development of this "wall charge" reduces the potential applied across the electrodes and diminishes the glow development such that the discharge is quenched.

However, upon application of a potential of reduced magnitude to the transparent electrode layer 19 and certain ones of the conductors 17 mentioned above, the "wall charge" in conjunction with the applied reduced magnitude of potential causes a discharge to occur and establishment of a glow. Thus, the plasma display device has what might be termed a "memory" in that each cavity is either in an "off" state wherein no so-called "wall charge" is present and application of a full alternating potential is necessary to establish a glow discharge, or an "on" state wherein a "wall charge" is present and a glow discharge is readily established by application of an alternating voltage of reduced magnitude.

Thus, once a cavity has been shifted from an "off" to an "on" state by application of a potential having a magnitude sufficient to cause development of a discharge, the particular cavity can be maintained in the "on" state by an applied slowly varying alternating potential. Also, the particular cavity is readily shifted to a glow discharge display by application of a potential less than firing potential. However, application of a potential less than the firing potential to a cavity in the "off" state has little or no effect thereon.

In review of the above description, it is obvious that the device will present an opaque appearance when viewed through the transparent insulator layer so long as none of the electrical conductors are energized. However, energization of certain ones of the conductors will cause ionization of the gas within the cavity aligned therewith. In turn, a visual display will be provided wherein the energized cavity areas and nonenergized portions have a relatively high level of contrast therebetween.

Additionally, it can readily be seen that a white or colored display may readily be provided by the addition of a fluorescent powder layer 23. In this instance, the energy radiated from a particular energized cavity is utilized to ac-

tivate that portion of the fluorescent powder layer 23 in alignment therewith.

Thus, there has been provided a unique high contrast plasma display device having advantages believed to be unattainable in other known devices. The device is not only of the solid-state type having enhanced reliability, compactness, and resolution, but also is economical of materials, apparatus and time insofar as fabrication is concerned. Moreover, the added relatively high contrast capability is believed to be unattainable in any similar type of device.

While there has been shown and described what is at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention as defined by the appended claims.

We claim:

1. A high contrast plasma display device comprising in combination:

- spaced transparent and opaque insulator layers;
- spaced opaque insulator segments bonded to and separating said layers and forming a plurality of independent cavities intermediate thereto and said layers;
- an insulator substrate affixed to said opaque layer and having plurality of connectors embedded therein and passing therethrough to contact a like plurality of spaced conductors affixed to said substrate in registry with said cavities and embedded in said opaque layer;
- a transparent electrode layer affixed to said transparent insulator layer on the surface remote from said spaced connectors and a phosphor layer affixed to the opposite surface of said transparent electrode layer;
- an ionizable gas disposed within said cavities whereby energization of said spaced conductors causes ionization of said gas within said cavities aligned therewith and alteration in the appearance of said device from opaque to a visual display when viewed through said transparent insulator layer; and
- a seal intermediate the periphery of the spaced transparent and opaque insulator layers.

2. The high contrast plasma display device of claim 1 wherein said ionizable gas is in the form of a nitrogen neon mixture.

3. The high contrast plasma display device of claim 1 wherein said opaque insulator layer and opaque insulator segments are in the form of a black glass frit.