Single Substrate AC Plasma Display

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The advantages of ac gas discharge panels having internal memory for character or graphics display are well established especially for panels of roughly 4" to 8" in linear dimension with from 10^4 to 10^6 dot resolution.[1] The difficulty of maintaining a uniform gap of a few mils between two glass substrate planes at every discharge site and maintaining this gap despite ambient pressure/temperature variations may preclude the economic development of much larger or higher resolution panels. The present study seeks to overcome this difficulty by applying all the active electrodes and dielectric layers to a single substrate plane. With this geometry, glows are provided by fringing fields. A second transparent glass cover is applied with arbitrary spacing above the substrate merely to seal in the gas and proivde a viewing window. As shown in Fig. 1 each display dot then presents both half-cyclic cathode glows with no optical masking of either from the viewer by solid electrodes. The optical efficiency of such a scheme is therefore inherently much better than the conventional two-substrate approach and additionally the troublesome discharge-gap is permanently "printed-in" by the original deposition mask. Thus in larger panels the need for beads or glass-fiber gap-fixing elements distributed over the display area is avoided along with the resulting fixed brights spots produced therewith by internal reflections. In the following, initial laboratory results with small, 10x 10 line, single substrate arrays are reported.

Operation of the device when an initial write pulse is applied to a cell can be understood from the cross-sectional diagram of a single cell in Fig. 2. Assuming a coincident selection of the cell with V_W volts (shown with the bottom conductor at a reference voltage) the field in both the dielectric and the gas can be determined by solving Laplace's equation giving typical equipotential contours as shown.[2] By maintaining a small value of t_1 relative to the width W of the upper metal electrode a large proportion of the drive potential is obtained along the dielectric-gas surface. Field studies for typical thick film layer thicknesses (~.001") and conductor widths (.010") indicate surface potential drops of 85% V_W along electric flux lines such as "S_1" in Fig. 2 approximately .005" in length. Similar field analysis for the conventional two-substrate ac panel indicates a gas potential drop of 95% V_W for typical dielectric thickness and gap of .004-.005". Thus slightly higher write voltages may be expected for the single substrate panel. No difficulty arises due to spurious or low voltage write phase discharges along very short electric field paths such as S_0 since insufficient numbers of ionizing collisions occur along such paths to produce a sustained avalanche.

For the sustain phase of operation, field patterns are substantially modified due to surface charges as suggested in Fig. 2b. External current measurements coupled with high speed photo-multiplier studies of the glow dynamics for a single cell indicate that sustain discharges apparently begin along short high field paths such as R_0 shown in Fig. 2b, then spread as glowing cathode bands radially outwards as surface charges and potentials are successively reversed. To limit the spread of the glow and to avoid a double-lobed total glow area a dielectric barrier roughly 2-4 t_1 in thickness is deposited over half the top conductor extending halfway to the next discharge site. The experimental device cross-section is shown in Fig. 3 along with the measured brightness profile of a single cell. Note that essentially no reduction in brightness is observed in the central area where alternate cathode glows from top and bottom electrodes conveniently overlap.

Experimental results are reported for early 10x10 test arrays such as shown in Fig. 4 with .040" dot spacings. These used a solder-glass dielectric (Electro-Science Laboratories type 4608) applied to an opaque (Fosterite) substrate in an all-glass sealed structure. Frontal brightness values of 1 footlambert (peak) per kHz are obtained at normal operating sustain levels with 1% A_r, 99% N_e gas mixtures at 500 Torr pressure. Operating margins such as shown in Fig. 5 were obtained with a thin film coating of CeO_2 on top of the dielectric surface for anti-sputtering and to improve emission.[3] Similar structures using low-cost glass substrates as well as low melting point dielectrics have also been operated successfully.

The single substrate design enhances panel efficiency and should reduce fabrication difficulties. However, thus far, no attempt has been made to minimize inter-electrode capacity or to achieve dot densities equivalent to commercial panels. The use of standard multilayer thick film "via" techniques and the optimization of cell geometry to achieve low parasitic capacity and high resolution appears likely to follow in the near future.

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References

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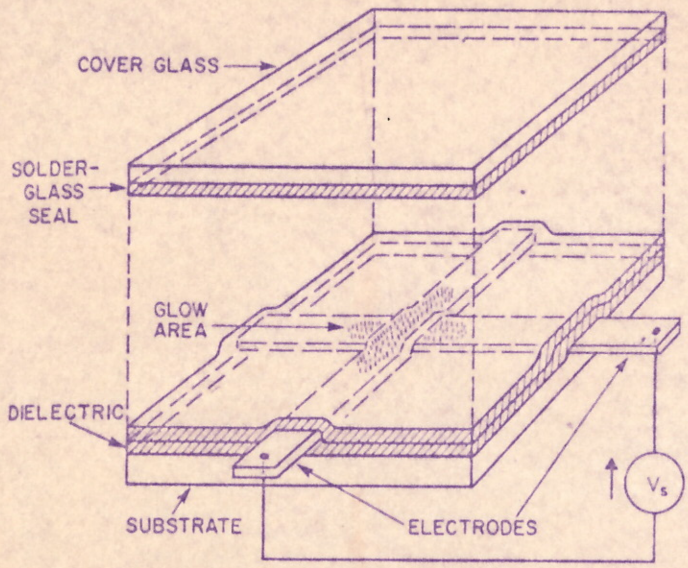

Fig. 1. Single Substrate Display Construction (single dot).

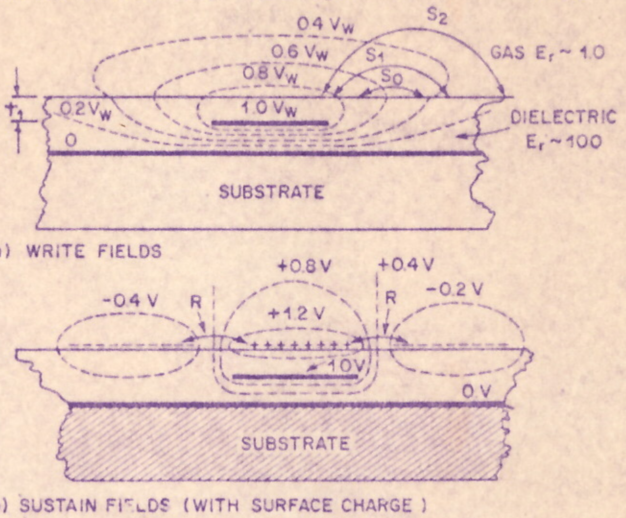

Fig. 2. Typical Field Configuration Showing Equipotentials ----.

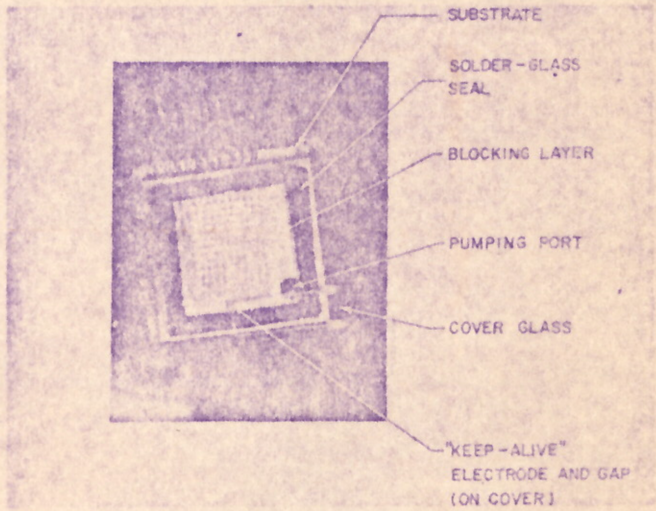

Fig. 4. Experimental 10x10 Cell Array.

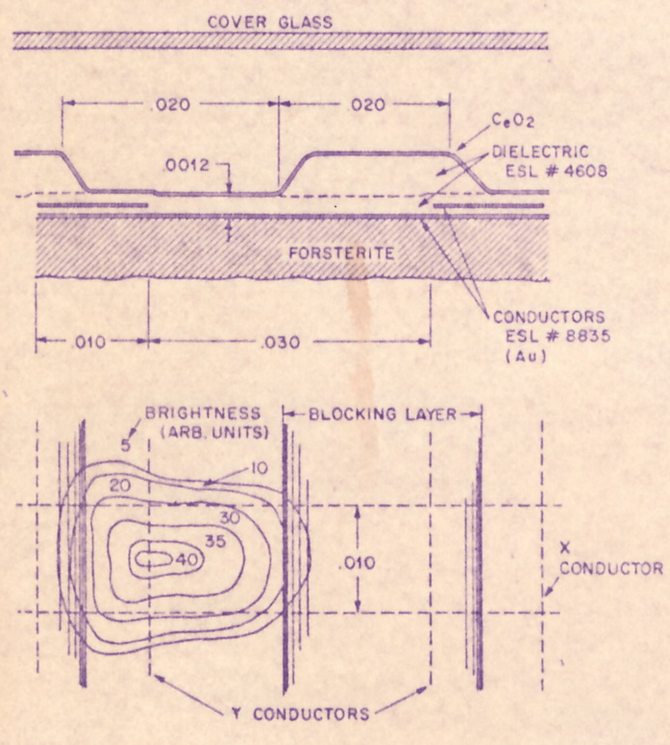

Fig. 3. Cell Geometry with Blocking Stripes and Brightness Profile.

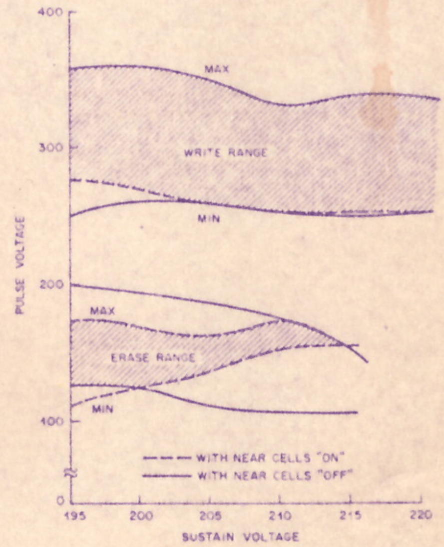

Fig. 5. Drive Voltage Margins for Experimental Array.