Operation of a Coplanar-Electrode Plasma Display Panel Cell

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***Abstract*— Plasma display panels (PDP's) are composed of miniature gas discharge devices sustained in noble gas mixtures. In this paper, the dynamics of a coplanar-electrode PDP cell are described using results from a two-dimensional computer simulation. During the first voltage pulse, the discharge takes place between the top and bottom electrodes. Due to charging of the bottom dielectric during the first discharge pulse, a surface discharge takes place between the top coplanar electrodes on successive pulses.**

***Index Terms*—Gas discharge displays, plasma devices.**

PLASMA display panels (PDP's) are a promising technology for large-area (~1 m^2) flat panel displays [1]. A PDP cell typically consists of a mixture of noble gases (e.g., Xe/Ne/He) sealed between dielectric plates on whose exterior surfaces are electrodes. Typical cell dimensions are a few hundred microns and typical gas pressures are 0.5–1.0 atmosphere. Light is generated by an electric discharge initiated by applying voltage pulses of 100–200 V to the electrodes. Due to charging of the dielectrics, the discharge is terminated in 10–100s ns. This process can be repeated indefinitely using voltage pulses of opposite polarity. Color PDP cells generally produce ultraviolet (UV) photons that are converted to visible light using phosphors. It can be anticipated that the efficiency of visible light generation is a function of the PDP cell dimensions, materials, gas composition, gas pressure, and voltage pulse characteristics. Computer simulations can be useful for the nontrivial task of optimizing the display performance as a function of these variables [2], [3].

In this paper, results from a two-dimensional computer simulation are used to illustrate the operation of a coplanar-electrode PDP cell. The model implicitly integrates the coupled set of Poisson's equation and continuity equations for charged species using sparse matrix techniques. The density of electrically neutral species is computed using explicit time integration. Electron transport coefficients and source functions are computed using either the local field approximation or in terms of a self-consistently computed electron temperature. The model also has a Monte Carlo simulation for fast secondary electrons and a radiation transport model for computing visible light emission.

We consider the coplanar-electrode PDP cell shown in Fig. 1 with He/Ne/Xe $= 70/26/4$ at a pressure of 400 torr. During the first pulse, whose results are not shown here, electrodes B and C are kept at ground potential and a 200 V pulse is applied to electrode A. The resulting discharge deposits negative charge on the dielectric surface under A and positive charge on the dielectric under B and on the lower dielectric surface above C. On the second pulse, the voltage on A is brought back to ground potential, and starting at 4 μs, 180 V is applied to B for 2 μs. The electron density, Xe^+

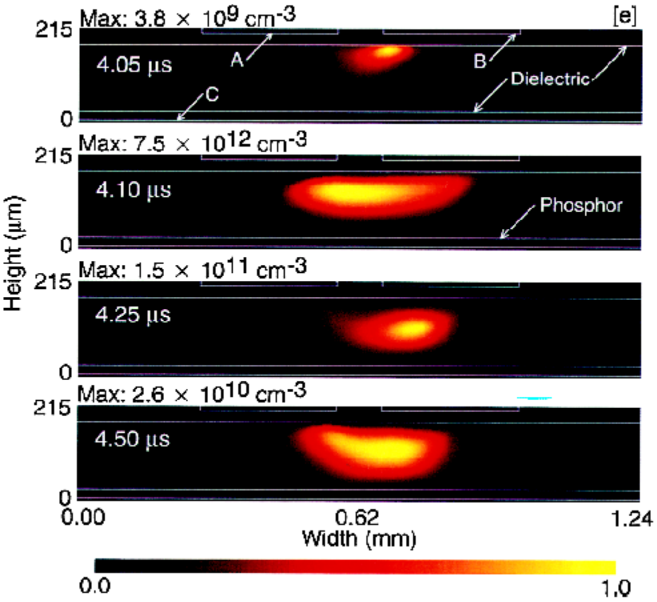

Fig. 1. Electron density during the second pulse when 180 V is applied to electrode B from 4–6 μs. Gas pressure is 400 torr with an He/Ne/Xe $= 70/26/4$ mixture. All panels are scaled independently.

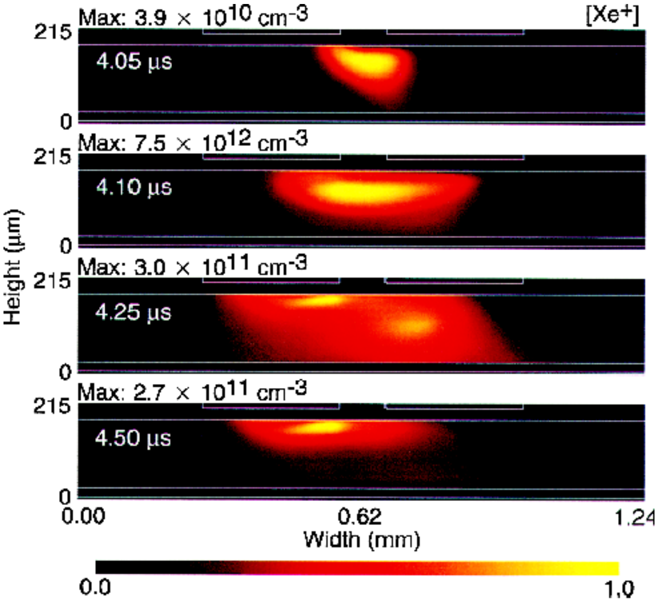

Fig. 2. Xe^+ density for the conditions of Fig. 1. All panels are scaled independently.

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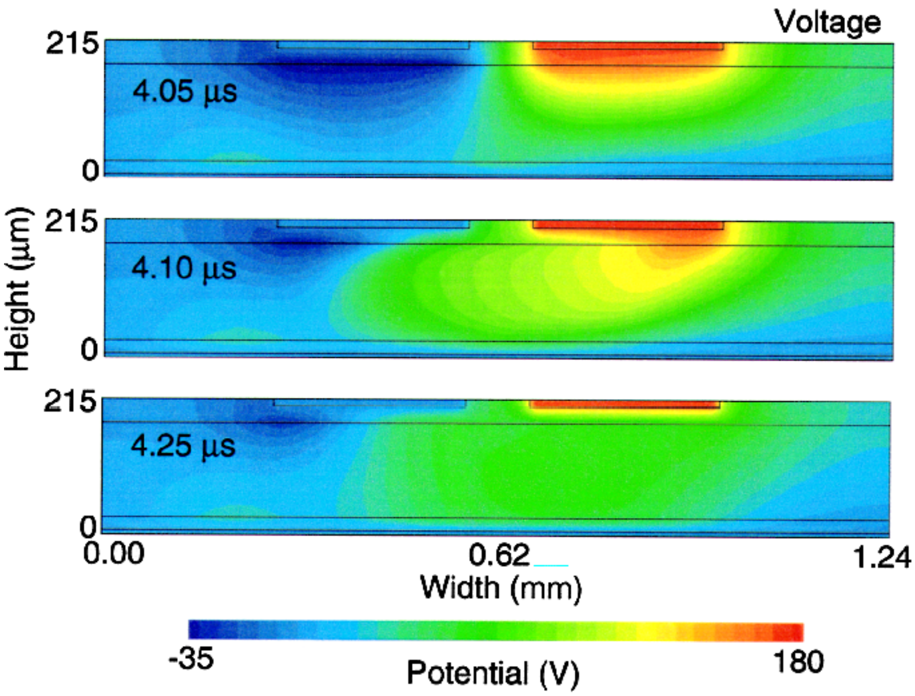

Fig. 3. Electrical potential for the conditions of Fig. 1.

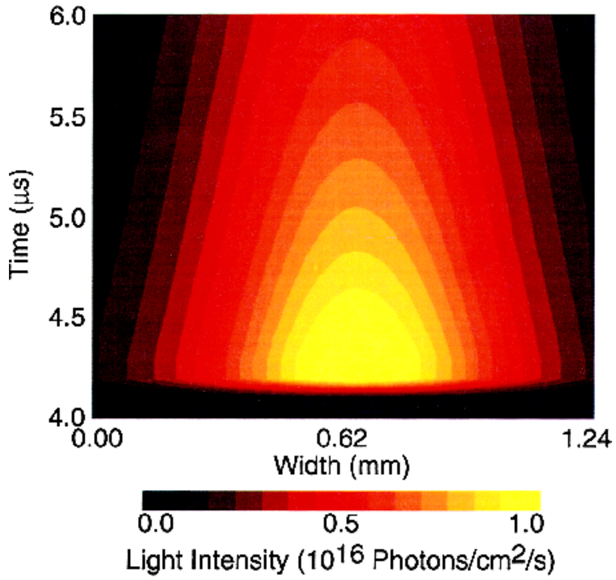

Fig. 4. Light emission from the top of the PDP cell.

(the dominant ion) density, and electrical potential are shown in Figs. 1–3, respectively, at different times during this pulse. A discharge is initiated after some delay and the peak electron density rises to around 7×10^{12} cm^{-3} at 4.1 μs. As the peak electric field is in the region between A and B, ionization dominantly occurs there and electrons are swept toward B. The subsequent charging of the dielectric under B reduces the gap voltage below the threshold for the discharge to self sustain, and the electron density decreases sharply.

These phases are reflected in the potential profiles. At 4.05 μs, the discharge has just been initiated and the potential profile is essentially that in vacuum. Once the discharge takes place, the charging of the dielectrics reduces the voltage drop within the cell. The plasma density is not sufficient to shield out the applied voltage early in the pulse and so the ions drift toward A. At 4.1 μs, the plasma density is large enough to require charge neutrality. As the plasma decays, ambipolar forces decrease and charge separation occurs. The visible light coming out of the top of the cell is shown in Fig. 4. The phosphor which generates the visible light from incident UV emission is coated on the lower dielectric. The visible light emission peaks when the plasma density is largest. However, visible light emission extends beyond the time that the electrons and ions decay to small densities since the lifetime of the Xe metastables, precursors for generation of UV light, is many microseconds.

The images shown here were generated in TIFF format using Tecplot©, and were assembled on a Macintosh using Clarisdraw©.

REFERENCES

[1] A. Sobel, “Television’s bright new technology,” *Sci. Amer.* vol. 278, pp. 70–77, May 1998.

[2] C. Punset, J. P. Boeuf, and L. C. Pitchford, “Two-dimensional simulation of an AC matrix plasma display cell,” *J. Appl. Phys.*, vol. 83, no. 4, pp. 1884–1897, 1998.

[3] R. B. Campbell, R. Veerasingam, and R. T. McGrath, “A 2-dimensional multispecies fluid model of the plasma in an AC plasma display panel,” *IEEE Trans. Plasma Sci.*, vol. 23, pp. 698–708, Aug. 1995.