Simulation of Self-Erase Discharge Waveforms in Plasma Display Panels

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***Abstract*—We use a two-dimensional self-consistent fluid model to simulate the operation of a plasma display panel cell when different sustaining voltage waveforms are applied to its electrodes. The discharge path is much longer when a self-erase discharge waveform is used instead of the standard waveform. The longer discharge path results in higher efficiency.**

***Index Terms*—Fluid simulation, plasma display panel.**

THE plasma display panel (PDP) is one of the leading candidates in the competition for large-size high-definition television (HDTV) wall-mounted monitors. One of the most critical remaining issues in ongoing PDP research is the improvement of the luminous efficiency. A number of different approaches have been pursued to improve the efficiency of PDPs including the modification of the electrode shape and cell geometry, the optimization of the gas mixture composition, the use of novel materials, and the modification of the applied voltage waveforms.

PDP cells are small and provide limited access for diagnostic measurements. Therefore, computer-based modeling is essential for understanding PDP physics and optimizing its operation. In this paper, we use a two-dimensional (2-D) self-consistent fluid model to simulate the operation of a PDP cell when different voltage waveforms are applied to its electrodes. Continuity equations are solved for electrons, ions $(\mathrm{Ne}^+, \mathrm{Xe}^+, \mathrm{Ne}_2^+, \mathrm{Xe}_2^+, \mathrm{NeXe}^+)$, and excited species $(\mathrm{Ne}_\mathrm{m}^*, \mathrm{Xe}^*(^3\mathrm{P}_1), \mathrm{Xe}^*(^3\mathrm{P}_2), \mathrm{Xe}^{**}, \mathrm{Xe}_2^*(^3\Sigma_\mathrm{u}^+), \mathrm{Xe}_2^*(^1\Sigma_\mathrm{u}^+), \mathrm{Xe}_2^{**})$. The electric field is self-consistently calculated by solving Poisson's equation. Electron impact reaction rates and transport coefficients are assumed to be functions of the electron mean energy, which is determined by solving the electron energy equation. We use a finite difference method to solve the system of partial differential equations. The continuity equations and the electron energy equation are solved implicitly, while semi-implicit methods are used for the integration of the coupled continuity and field equations, and for the source term in the electron energy equation. In order to calculate the visible light output of the PDP cell, we implement a radiation transport model. The 2-D model has been described in more detail elsewhere [1], [2].

Recently, it was proposed and experimentally verified that a self-erase discharge waveform increases the efficiency of the PDP cell [3]. In Fig. 1, we show the self-erase discharge sustaining waveform used in our simulation. The parameters used are $T = 10\ \mu\mathrm{s}$, $T_s = 2.5\ \mu\mathrm{s}$, $V_s = 270$ V, $T_{se} = 700$ ns, and $V_{se} = 10$ V. We also simulate a standard waveform with $T_s = T/2 = 5\ \mu\mathrm{s}$, $V_s = 270$ V, $T_{se} = 0$. We use a Ne-Xe mixture with 4% Xe at a pressure of 500 torr.

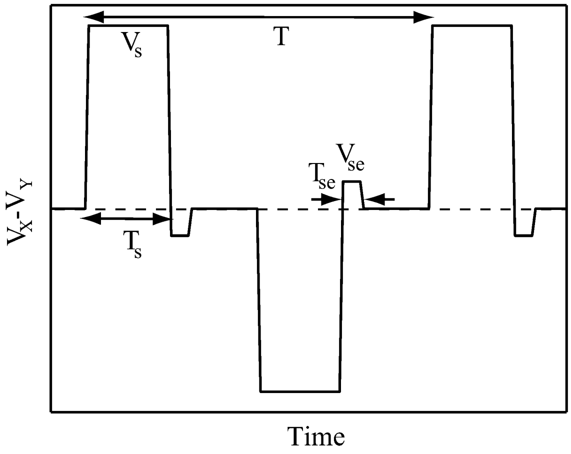

Fig. 1. Self-erase discharge waveform used in the simulations.

In Fig. 2(a) and (b), we show snapshots of the power spent in xenon excitation for the standard waveform and the self-erase discharge waveform, respectively. In the standard waveform case, the initial discharge path is formed below the inner part of the cathode, where the electric field is higher. In the self-erase waveform case, the discharge path is much longer and is initially formed below the outer part of the sustain electrode in the cathode region. The reason for this difference is that in the self-erase waveform case, the assistant negative voltage pulse of magnitude V_{se} (Fig. 1) triggers a self-erase discharge between the two sustain electrodes that partially erases the surface charge deposited by the previous main discharge. The path of the self-erase discharge is formed below the inner part of the cathode, where the electric field is higher, and only the negative surface charge below this part is erased (assuming that V_{se} is low enough to avoid complete erasure). When the subsequent main sustaining pulse of magnitude V_s is applied, the maximum field path is toward the outer part of the cathode, which is covered with negative charge.

The longer discharge path results in higher efficiency [1]. The efficiency when the self-erase waveform is used is ~20% higher than the efficiency when the standard waveform is used for $V_s = 270\ V$. We note that the calculated minimum and maximum sustaining voltages are ~185 and ~275 V, respectively. The improvement in efficiency when the self-erase waveform is used

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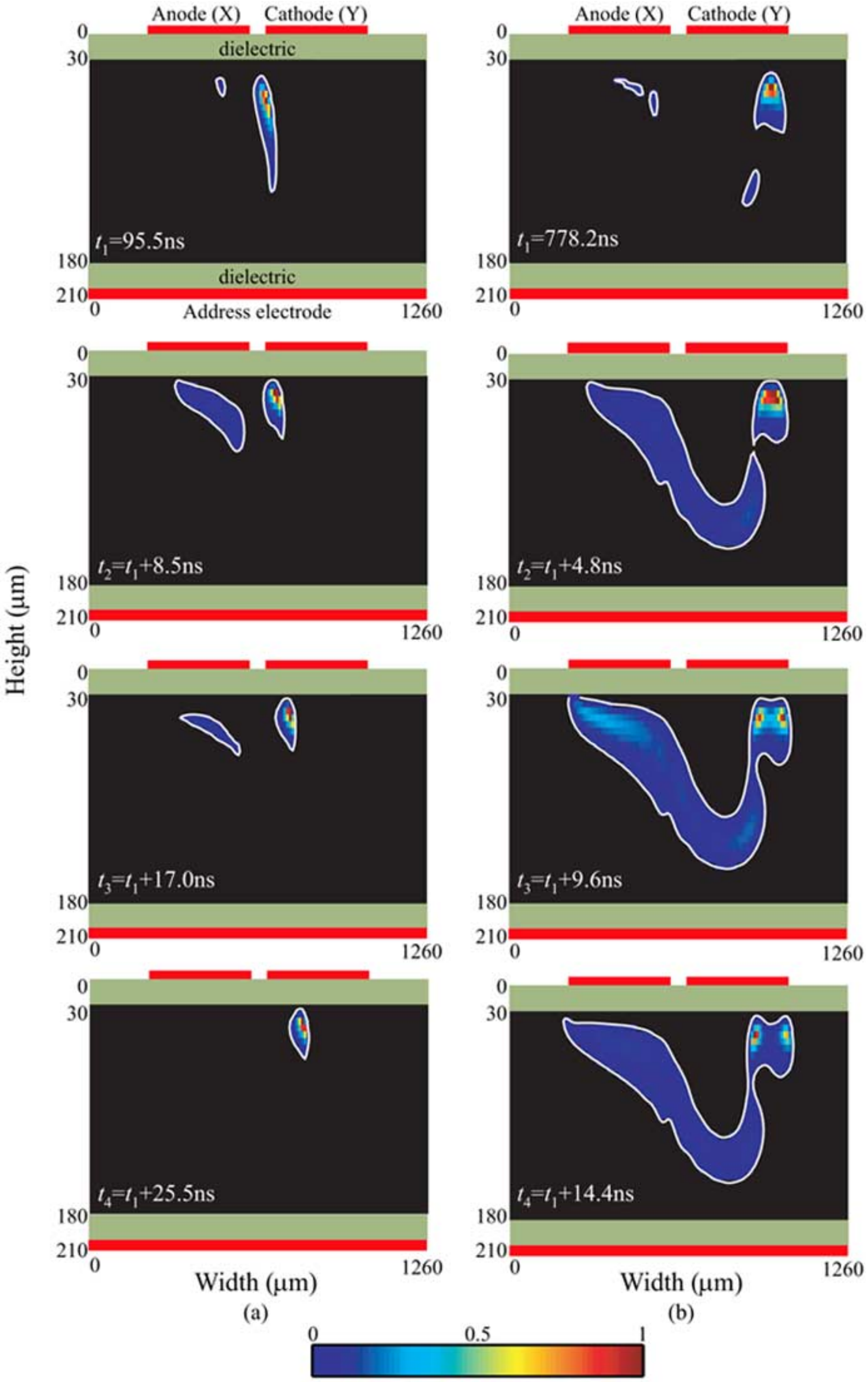

Fig. 2. Power spent in xenon excitation for (a) the standard waveform and (b) the self-erase discharge waveform. All panels are scaled independently. Maximum values from top to bottom are (a) 2.1, 5.8, 4.9, 4.3 and (b) 2.5, 1.6, 0.9, 0.8 in units of 10^{11} W/m^3. In both cases, $t = 0$ corresponds to the onset of a sustaining pulse V_s (Fig. 1). A Ne-Xe mixture with 4% Xe at a pressure of 500 torr is used.

is maximized at high voltages. We present results for a value of V_s close to the firing voltage to clearly show the mechanisms that lead to higher efficiency.

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