Three-Dimensional Fluid Simulation of an AC-PDP Cell

Hyun Chul Kim, Sung Soo Yang, and Jae Koo Lee, *Member, IEEE*

***Abstract*—Using a three-dimensional fluid model, we present top-views of AC-PDP cells with three different electrode shapes—a conventional electrode cell, a T-shaped electrode cell, and an asymmetric electrode cell. Figures include the contours of consumed power and photon generation power that are time averaged over the half period and space averaged over the direction that is not shown.**

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

PLASMA display panels (PDPs) are a promising technology for wall hanging high definition color television (HDTV). However, there remain technical issues to be solved, such as improvement of PDP efficiency, reducing power consumption, and increasing the lifetime. Optimizing the properties of PDP can be aided by understanding the microdischarge physics inside a PDP cell.

Direct experimental access and diagnostics of the discharge are limited because of the small system size. Numerical simulation can, therefore, be a useful tool to provide detailed information on the microdischarge characteristics in a PDP cell. There have been many one- and two-dimensional (1-D, 2-D) numerical models of PDP discharges reported over the last a few years [1]. One-dimensional models are sufficient for simulating the matrix-type PDP, while the coplanar-type PDP requires at least 2-D modeling. Because of its high computational burden, three-dimensional (3-D) simulations are not common, though 3-D variations of the cell structure are widely observed in experiments. Examples are PDPs with T-shaped electrodes [2] and delta tricolor arrangement (DelTA) cell structures with meander barrier ribs [3], which have higher luminous efficiency. Therefore, 3-D simulations are considered important for further optimization and proposing new designs of PDP cells.

In this paper, we report on a 3-D fluid code for PDP. Our model is based on the solution of transport equations (continuity and momentum transfer using a drift-diffusion approximation) for particles (electron, ions (Xe^+ and Ne^+), and excited species ($Xe^*(^3P_1)$, $Xe^*(^3P_2)$, $Xe_2^*(O_u^+)$, $Xe_2^*(^1\sum_u^+)$, $Xe_2^*(^3\sum_u^+)$, and Xe^{**})), and Poisson's equation for the electric potential. The source functions and transport parameters are computed using the local field approximation (LFA) [1]. The semi-implicit coupling of Poisson's equation and the continuity equation makes it possible to increase the simulation time step above that of the dielectric relaxation time [4].

Using this code, we can investigate the effects of 3-D parameters, such as shaped electrodes, barrier ribs, and the width of the address electrode, which cannot be included in the usual 2-D simulations. In this paper, we focus on the effects of the electrode shape which substantially affects discharge characteristics of the PDP cell.

In general, the discharge efficiency is increased by decreasing the electron temperature or the electric field [1]. As the ratio of the discharge in the small electric field region to the discharge in the large electric field region increases, the efficiency increases. That is, a cell with a wide or longer path discharge has higher discharge efficiency.

The parameters used in this simulation are as follows. The cell pitch is 1140 μm and the height of barrier rib is 180 μm. The gap between the sustain electrodes is 70 μm. The square pulses of 200 V and 100 kHz are applied during the sustain mode. The neutral gas is a neon–xenon (96/4%) mixture at 500 torr gas pressure.

Figs. 1(a)–(c) are top-views of a conventional electrode cell, a T-shaped electrode cell, and an asymmetric electrode cell, respectively. The left and right figures are, respectively, photon-generation power (consumed power for generating photons) and consumed power. They are averaged over a half cycle during the sustaining pulse and the other direction in space. Nearly the same number of photons are generated near the two electrodes, while the power consumption is larger near the cathode than the anode. Thus, the local efficiency (ratio of photon generation power to consumed power at each position) near the anode is higher than near the cathode. We also notice that the discharge efficiency near the center of the anode is higher than near the edge of the anode and barrier ribs. The plasma distributions in the T-shaped electrode cell and the asymmetric electrode cell are more elongated along the anode electrode than that in the conventional electrode cell. As expected from the general statements above, the luminous efficiencies of two cases are about 20% higher than that of a conventional cell. Since the electrode area of the conventional cell is larger, its power consumption and luminance are higher than those of the others. Even in the case of a conventional cell with smaller electrode, which has the same power consumption as a T-shaped electrode, its luminance and efficiency are lower than those of T-shaped electrode cells.

In conclusion, we simulated three AC-PDP cells with different electrode shapes using a 3-D fluid model. The contours of power consumption and photon generation power were obtained for each cell by using a commercial tool, MATLAB (version 5.1).

Manuscript received April 7, 2001; revised October 30, 2001. This work was supported by LG Electronics and by the Ministry of Education of Korea under its BK 21 program.

The authors are with the Department of Electronic and Electrical Engineering, Pohang University of Science and Technology, Pohang 790-784, South Korea (e-mail: jkl@postech.ac.kr).

Publisher Item Identifier S 0093-3813(02)03316-7.

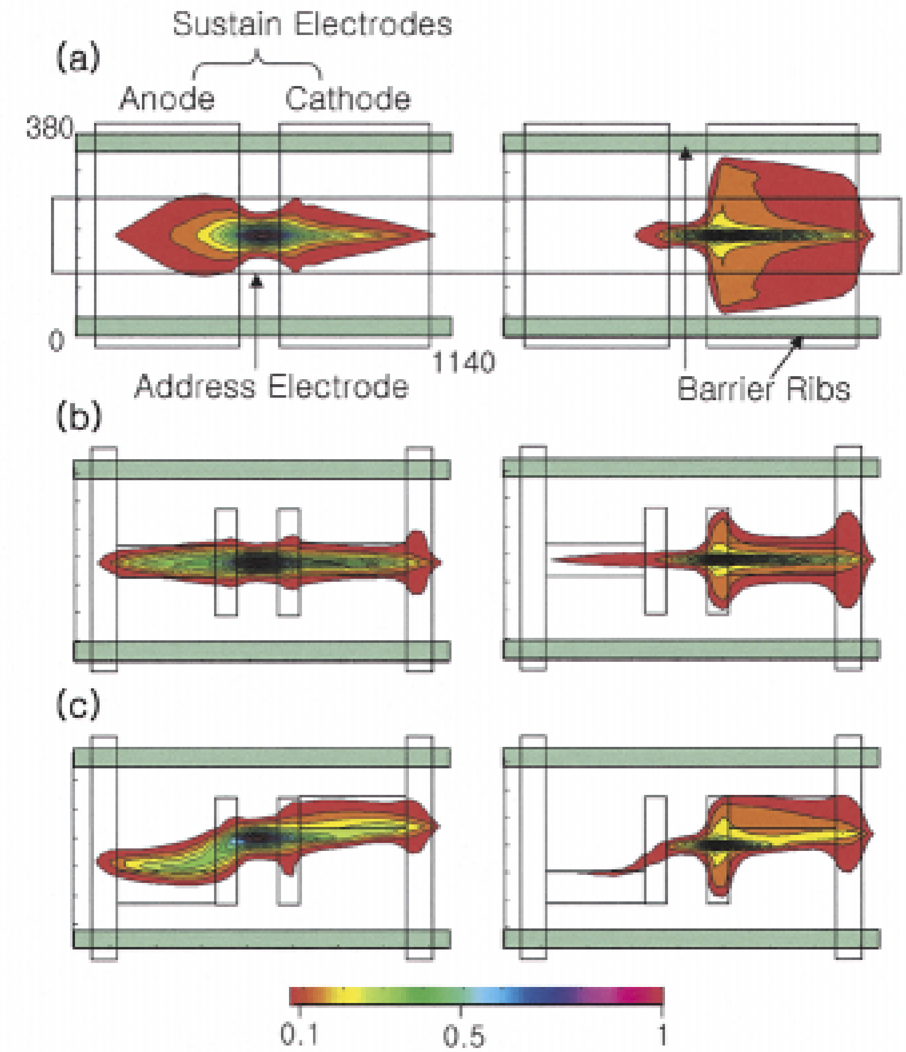

Fig. 1. The top views of (a) a conventional electrode cell, (b) a T-shaped electrode cell, and (c) an asymmetric electrode cell. The left and right figures are photon-generation power and consumed power over a half cycle during the sustain mode, respectively. (Maximum values in the left and right figures are (a) 2.2×10^6 and 1.1×10^7, (b) 1.2×10^6 and 7.2×10^6, and (c) 6.1×10^5 and 4.1×10^6 W/cm^2, respectively.)

REFERENCES

[1] J. Meunier, P. Belenguer, and J. P. Bouef, "Numerical model of an ac plasma display panel cell in neon-xenon mixtures," *J. Appl. Phys.*, vol. 78, p. 731, 1995.

[2] K. Amemiya, T. Komaki, and T. Nishio, "High luminance efficiency and high definition coplanar ac-PDP with T-shaped electrodes," in *Proc. IDW'98*, Kobe, Japan, 1998, p. 531.

[3] O. Toyoda, T. Kosaka, F. Namiki, A. Tokai, H. Inoue, and K. Betsui, "A high performance delta arrangement cell PDP with meander barrier ribs," in *Proc. IDW'99*, Sendai, Japan, 1999, p. 599.

[4] P. L. G. Ventzek, R. J. Hoekstra, and M. J. Kushner, "Two-dimensional modeling of high plasma density inductively coupled sources for materials processing," *J. Vac. Sci. Technol.*, vol. B 12, p. 461, 1994.