Three-Dimensional ICCD Observation of Dual Sustain Discharge Mode in Three-Electrode Microdischarge Cell

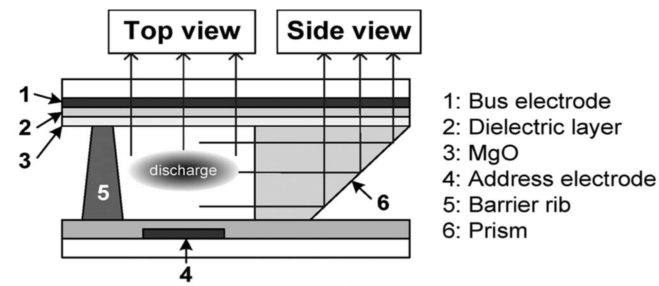
Hyung Dal Park, Soo-Kwan Jang, Jae Hyun Kim, and Heung-Sik Tae, *Senior Member, IEEE*

***Abstract*—The spatiotemporal variations in a 3-D discharge cell are measured using infrared emission images taken with an intensified charge-coupled device (ICCD) camera. The 3-D ICCD analysis of the discharges from the conventional single surface discharge mode and a new dual surface discharge mode revealed that the discharge from the dual surface discharge mode spread toward the MgO layer in the front panel, thereby avoiding the impingement of energetic ions into the phosphor layer.**

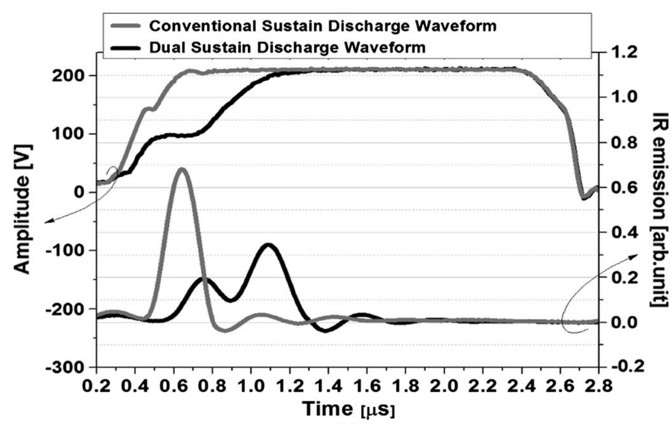
***Index Terms*—Discharge mode, dual discharge mode, intensified charge-coupled device (ICCD) observation, 3-D microdischarge cell.**

IMPROVING the luminous efficiency is critical for realizing low power consumption in ac-plasma display panels, and the sustain discharge mode plays a key role. Meanwhile, minimizing the long-term luminance degradation is important for suppressing certain image problems, such as permanent image sticking [1], [2], which is also strongly connected to the sustain discharge. Accordingly, this paper investigates the conventional single sustain discharge mode and a new dual sustain discharge mode using infrared (IR) images taken with an intensified charge-coupled device (ICCD) camera.

Fig. 1(a) shows the 6-in test panel structure used when taking the top and side images, while Fig. 1(b) shows the IR emissions measured when applying a conventional single sustain waveform and the proposed dual sustain waveform to the test panel in Fig. 1(a). The gas contents were Ne–Xe (7%), and the working pressure was 450 torr. The gap between the ITO electrodes was 70 μm, and the height of the barrier rib was 120 μm. As shown in Fig. 1(a), one of the sidewalls was replaced with a polished glass prism to facilitate the ICCD observation of the single and dual discharge modes in a unit cell. In Fig. 1(b), the conventional single sustain discharge was produced by a sustain pulse with only one voltage level of 210 V and one rising slope, whereas the proposed dual sustain discharge was produced by a sustain pulse with two different voltage levels of 100 and 210 V and two rising slopes. When using the dual sustain discharge mode, the discharge power consumption was reduced by about 18% with only a minimal decrease in the luminance, thereby improving the luminous efficiency by about 20% when compared to the conventional waveform. Fig. 2 shows 3-D ICCD images of the IR (823 nm) from the conventional single and proposed dual sustain discharge modes. The top views in Fig. 2(a) and (b) show the IR emitted from the discharges produced between the X and Y electrodes, while the side views in Fig. 2(a) and (b) show the IR emitted from the discharges produced between the A and X (or Y) electrodes. For the conventional single discharge mode, the peak IR (823 nm) emissions were observed at 600 and 650 ns after applying the single sustain waveform, as shown by the top view in Fig. 2(a). However, the strong surface discharge produced between the X and Y electrodes then spread toward the bus electrode, which caused a reduction in the aperture ratio due to the opacity of the bus electrode, and the energy loss was



(a)



(b)

Fig. 1. (a) Test panel structure used for taking side images and (b) IR emissions measured from sustain waveforms.

Manuscript received November 29, 2010; revised June 7, 2011; accepted June 17, 2011. Date of publication July 25, 2011; date of current version November 9, 2011. This work was supported in part by the Information Display R&D Center, one of the Knowledge Economy Frontier R&D Programs funded by the Ministry of Knowledge Economy of the Korean Government, under Grant F0004072 and in part by the Brain Korea 21.

The authors are with the School of Electronics Engineering, College of IT Engineering, Kyungpook National University, Daegu 702-701, Korea (e-mail: phmoon@ee.knu.ac.kr; waterpipe@ee.knu.ac.kr; kant9058@ee.knu.ac.kr; hstae@ee.knu.ac.kr).

Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org.

Digital Object Identifier 10.1109/TPS.2011.2160654

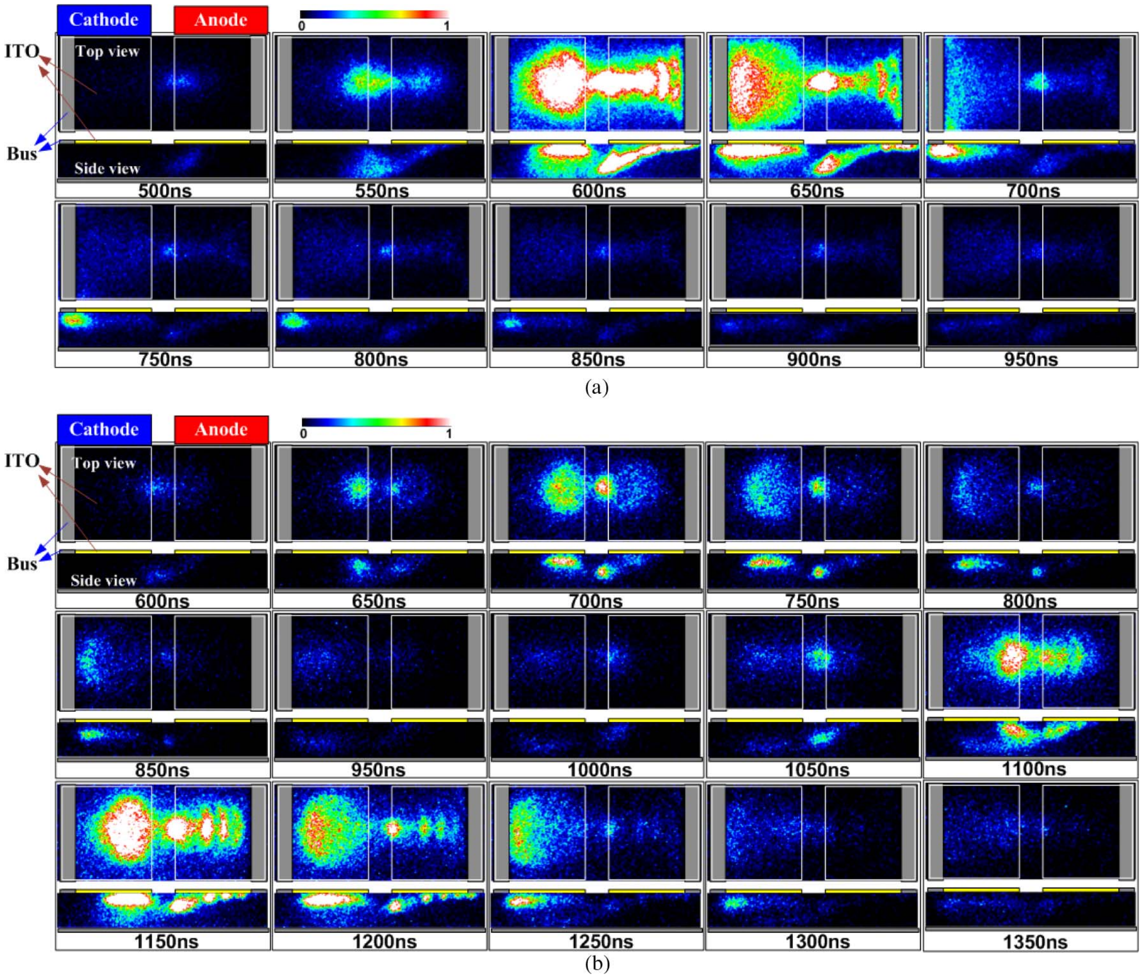


Fig. 2. ICCD images of spatiotemporal IR (823 nm) emissions from 3-D microdischarge cell: (a) Conventional sustain discharge mode and (b) dual sustain discharge mode.

further increased by the barrier rib. Meanwhile, as shown by the side view in Fig. 2(a), the strong discharge also spread in the direction of the phosphor layer on the address electrode, meaning that energetic ions were impinged onto the phosphor layer on the address electrode that had a lower electric potential in relation to the sustain electrode. In contrast, for the dual discharge mode, the peak IR (823 nm) emissions were observed at 700–750 ns during the first weak discharge (600–950 ns) and 1150–1200 ns during the second strong discharge (1000–1350 ns) when applying the dual sustain waveform, as shown by the top view in Fig. 2(b). The first discharge produced a small surface discharge, which then spread toward the inner X–Y electrodes. Another difference from the conventional single discharge was that the weak sustain discharge spread toward the phosphor layer on the address electrode, as shown by the time interval from 900 to 1000 ns in the side view in Fig. 2(b), meaning that positive wall charges were accumulated on the phosphor layer. The second strong surface discharge was then regenerated between the X and Y electrodes and only spread toward the ITO electrodes, thereby avoiding any shrinkage of the aperture ratio or increase in the energy loss. In particular, as shown by the side view in Fig. 2(b), the strong discharge spread toward the MgO layer in the front panel, meaning that the positive wall charges accumulated during the first discharge suppressed any subsequent impingement of energetic ions into the phosphor layer on the address electrode during the second discharge.

REFERENCES

[1] G. Oversluizen, S. T. de Zwart, and T. Dekker, "Plasma display panel design for simultaneous high efficacy and high luminance," *J. Appl. Phys.*, vol. 103, no. 1, p. 013 301, Jan. 2008.

[2] C. H. Ha, B. Y. Han, J. S. Yoo, H. S. Bae, and K.-W. Whang, "Characteristics of phosphor degradation in AC-driven plasma display panels," *J. Electrochem. Soc.*, vol. 155, no. 9, pp. J230–J234, Jul. 2008.