Discharge Characteristic of Microdischarge Cell with Counter Sustain Electrodes and Twin Auxiliary Electrodes

M. Hashimoto*, J.-S. OH , K. Tachibana, H. Asai, N. Kikuchi**, and S. Sakamoto****
Department of Electronic Science and Engineering, Kyoto University,
Kyoto-Daigaku Katsura, Nishikyo-ku, Kyoto, Japan
****Engineering and Development Group, Noritake Co., Ltd.,**
2160, Minami, Yasu-cho, Asakura-gun, Fukuoka 838-0205, Japan
***Phone: +81-75-383-2289, E-mail: masakih@plasma1.kuee.kyoto-u.ac.jp**

Abstract
*Twin Auxiliary Electrodes were applied to the counter sustain electrode structure plasma display panels for the improvement of luminous efficiency. In advanced, we investigated the spatiotemporal behaviors of excited Xe**(2p) atoms in that structure unit cell with various applied voltage conditions for the auxiliary electrodes .The near-IR emissions were observed by an ICCD camera combined with narrow band pass filter. As a partial result, the intensity of IR emissions and the response time were improved with the proposed twin auxiliary electrodes.*

1. Introduction
Improvement of luminous efficiency is the most important purpose to competition with other large size flat panel displays (FPDs) such as a TFT-LCD [1]. For the achievement of this purpose, many approaches (gas mixture, electric circuit, cell structure, materials, and so on) have been investigated. Especially, counter sustain electrodes structure panels with an auxiliary electrode introduced the good performance of the luminous efficiency in microplasmas [2]. The structures are well-known for the TFCS (Thick Film Ceramic Sheet). The structural details of counter electrode are presented at our previous works [2, 3].

In this work, we examined the microdischarge performances of the emissions in a unit discharge cell containing the twin auxiliary electrodes for a counter electrode structure panel. The spatiotemporal behaveiors of the near-IR emissions were investigated by an optical emission measurement technique, an intensified charged couple device (ICCD), in PDPs [4, 5].

2. Experimental details
Figure 1 shows the cross sectional view of a microdischarge unit cell structure of a counter sustain electrode type with twin auxiliary electrodes on the front glass plate. Auxiliary electrodes were made of indium tin oxide (ITO) as similar to conventional coplanar electrodes structure. Others sustain electrodes, address (or data) electrode, and thick film ceramic sheet (TFCS) were formed by a developed technology [3, 6]. For the optical access of laser beam, fluorescent materials were not preformed on the plates of front and back. Electrode gap and effective discharge gap are 550 and 450 µm respectively. The length of a cell along sustain electrodes is 700 µm, and gas gap is 230 µm. The width of auxiliary electrodes is 100 µm, and the gap between two auxiliary electrodes is 150 µm. The width of data electrodes is 200 µm. Binary gas mixture of Ne-Xe (15%) is filled in the cell at a total pressure of 450 Torr.

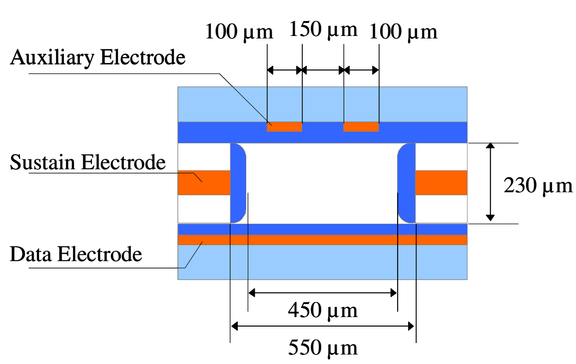

Figure 1 The cross sectional view of a counter sustain electrode type cell with twin auxiliary electrodes.

Figure 2 shows the operating waveforms of the pulse trains applied to the two sustain electrodes, V_{S1} and V_{S2}, the auxiliary electrode, V_Z, and the data electrode, V_D. The amplitude of V_S (= V_{S1} = V_{S2}) was fixed at 250V, while the width and period were fixed at 10 μs and 24 μs. The auxiliary and data pulses relative to the rise of the sustain pulses (t = 0) was fixed at 0 μs, and the pulse width and the amplitude were changed from 0.5 μs to 1.0 μs and 150V to 250V, respectively. In this paper, mainly six selected combinations of V_Z and V_D were tested as listed in table 1.

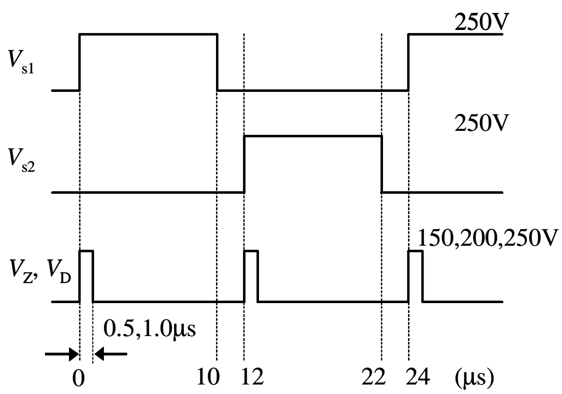

Figure 2 Driving voltage waveforms applied to the sustain electrodes, V_{S1} and V_{S2}, and to the data or auxiliary electrode, V_D or V_Z, with a variable width.

Table 1 Experimental conditions for a panel with data and auxiliary electrodes.

Case	Auxiliary electrode, V_Z (V)	Data electrode, V_D (V)	Pulse width
1	ground	ground	none
2	250	ground	0.5
3	250	ground	1.0
4	ground	250	0.5
5	ground	250	1.0
6	Connected with neighboring sustain electrode	ground	none

The optical methods are the same as those described previously [3]. In short, the optical emission spectroscopy (OES) measurements were performed using a gated CCD camera equipped with a band pass filter centered at 820 nm for observation of the near-IR emission from the excited Xe^{**}(2p) atoms in the 2p state. The gate width was set at 10 ns and the timing was scanned to cover a whole emission period.

3. Results and discussion

For this series of study, a microdischarge cell with the twin auxiliary and data electrodes was used, of which the cell size and the gas conditions was showed in the experimental details. Figure 3 shows images of the IR emission from Xe^{**}(2p) atoms taken at different operating conditions in table 1.

In the Case 1 of grounded the auxiliary and data electrodes, weak discharge starts at the edge of the data electrode near the anode. Discharge turns up and shifts to the cathode side by degrees. However, the area around date electrode is dark. It is because date electrode is grounded. Discharge reaches an emission peak at 520 ns, and negative glow region is observed. Then discharge decays gradually.

For the Case 2 and 3 of applied the additional pulses V_Z to the auxiliary electrodes, the discharge starts at the edge of an auxiliary electrode near the cathode. It means that the auxiliary electrode is working as the anode due to the combined effects of the applied positive potential and the accumulated positive charge of the preceding phase. As time proceeds, the glow between the auxiliary electrode and the cathode increases and moves towards the cathode. In the meantime, another glow appears in the region of the auxiliary electrode and expands towards the anode along the right edge of data electrode. It seems that electric field intensity at the intersection of auxiliary electrode with data electrode is large. In case 3, there is glow in the region of the auxiliary electrode along the right edge of data electrode, and weak glow can be seen along the left edge of data electrode. It is because pulse width of auxiliary electrodes has an effect on the accumulated positive charge on auxiliary electrodes.

For the Case 4 and 5 of applied additional pulses V_D to data electrode, the appearance changes drastically; the discharge starts from the cathode area on the data electrode and expands towards the anode area along the data electrode. This shows that the data electrode is playing the role of the anode. Then, the glow at the anode starts being enhanced, moving back towards the cathode side. The emission of the negative glow region near the cathode is weak and concentrated in the area over the data electrode.

In the Case 6 of connected auxiliary electrode to a neighboring sustain electrode, discharge starts earlier than that of Case 1. Discharge reaches a peak at 210 ns. What is more, discharge spreads more widely than that of Case 2, 3, 4 and 5. Especially IR emission around the auxiliary electrode next to the anode is observed in addition to negative glow. It is because discharge between sustain electrodes is encouraged sustain discharge by discharge between the auxiliary electrodes.

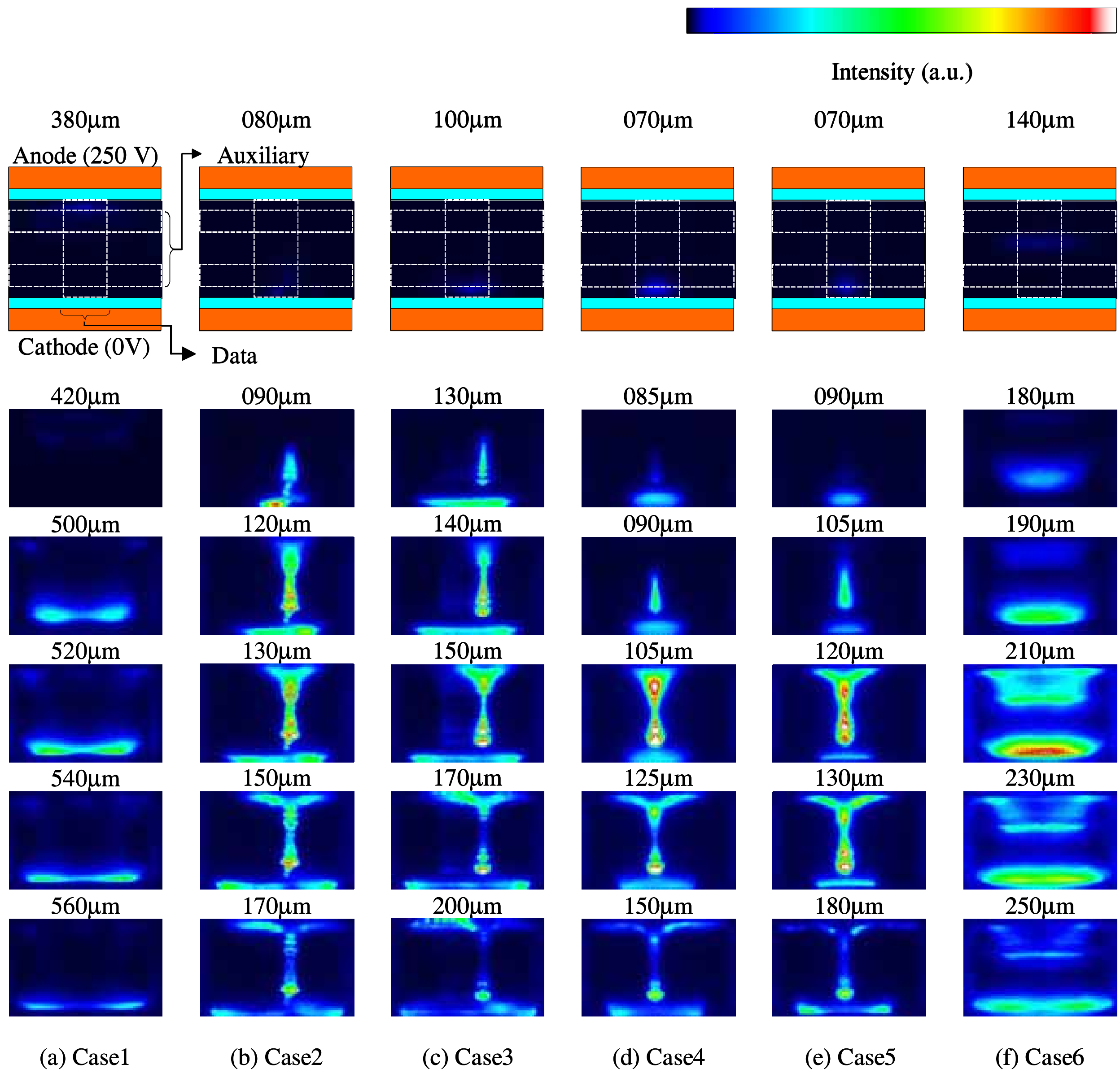

Figure 3 Spatiotemporal behavior of IR emission at 823 nm and 828 nm in a cell. Experimental conditions are showed in table 1.

4. Conclusion

Spatiotemporal behaviors of excited Xe^* atoms in the new type cell were observed by using the optical emission. It was found interaction between auxiliary and data electrodes has an influence on discharge aspect. Specifically, for the Case 2 and 3, glow in the region of the auxiliary electrodes expanded along the edge of data electrode. In the Case 6 of connected an auxiliary electrode to a neighboring sustain electrode, IR emission was spread overall in a cell with fast response and strong intensity. Especially, IR emission around the auxiliary electrode next to the anode was observed

5. Acknowledgements

This work is partially supported by Development Group of Noritake Co.Ltd. and also by the Grants-in-Aid for Scientific Research on the Priority Area of Microplasmas from the Japanese Ministry of Education, Culture, Sports, Science and Technology.

6. References

[1] J. P. Boeuf, J. Phys. D **36**, R53 (2003).

[2] S. Kawai, Master thesis, Kyoto University 2005.

[3] K. Tachibana, S. Kawai, H. Asai, N. Kikuchi and S. Sakamoto, J. Phys. D **38**, 1739 (2005).

[4] K. Tachibana, Feng. S and T.Sakai, J.Appl. Phys. **88**, 4967 (2000).

[5] K. Tachibana, K.Mizokami, N. Kosugi and T. Sakai, IEEE Trans. Plasma Sci. **31**, 68 (2003).

[6] H. Asai, S. Ajisaka, A.Oku, K.Ikesue, S. Mori, K. Tanaka, N. Kikuchi, M. Hiroshima and S. Sakamoto, IDW'03, p897 (2003)