Characteristics of an Address Discharge in ac Plasma Display Panels

Bhum Jae Shin, *Member, IEEE*, Kyung Cheol Choi, *Member, IEEE*, Heung-Sik Tae, *Member, IEEE*, and Sang Sik Park

***Abstract*—In this study, the basic characteristics of an address discharge have been investigated on the dependence of an address pulse voltage and its characteristics were analyzed by the wall voltage measurement method. During the address operation, the discharge between an address electrode and a scan electrode is first generated by an address pulse voltage and then the discharge between a scan electrode and a common electrode is induced. The resultant wall voltage between the address electrode and a scan electrode is strongly dependent on an address pulse voltage while the resultant wall voltage between a scan electrode and a common electrode is roughly independent on an address pulse voltage.**

***Index Terms*—Address discharge, wall voltage, wall voltage measurement method.**

I. Introduction

PLASMA display panels (PDPs) have been rapidly commercialized for high definition television due to their large size, slim structure, and self-emissive color image quality. However, several critical issues remain regarding their low luminous efficiency and poor image quality [1]–[3]. One of the great advances related to PDPs is the ramp reset driving scheme, which not only reduces the light emission of the reset discharges, but also standardizes a wall voltage resulted in low voltage address operation [4], [5]. Although various studies have attempted to elucidate the operation mechanism of this driving scheme, it is still not fully understood at this time due to the numerous parameters that affect the operation [6]–[9].

Among them, the characteristics of an address discharge are important to study on not only low-voltage address operation but also high-speed address operation. Furthermore, the characteristics of jitter have been intensively studied, which might be mainly related to the address operation. In this study, the basic characteristics of an address discharge have been investigated on the dependence of the address voltage and its characteristics were analyzed by the wall voltage measurement method.

II. Experimental Conditions

The cell structure of the test panel is a conventional reflective three-electrode surface discharge type of alternating current (ac)

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B. J. Shin and S. S. Park are with the Department of Electronics Engineering, Sejong University, Seoul 143-747, Korea (e-mail: hahusbj@sejong.ac.kr).

K. C. Choi is with the Department of Electrical Engineering and Computer Science, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 305-701, Korea.

H.-S. Tae is with the School of Electronic and Electrical Engineering, Kyungpook National University, Daegu 702-701, Korea.

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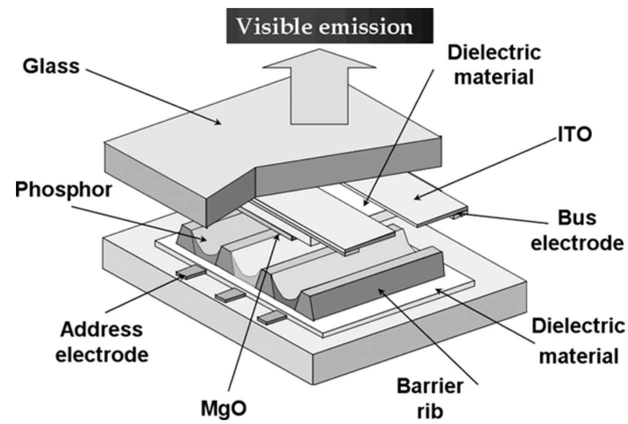

Fig. 1. Schematic diagram of conventional reflective 3-electrode surface discharge type of ac PDPs.

PDP, as shown in Fig. 1, where the transparent conductive electrodes with a bus electrode, normally called the common electrode (X) and scan electrode (Y), are responsible for the sustain discharge, while the address electrodes (A) are responsible for the address discharge. The discharge gas composition is used Ne + Xe (5%) gas mixtures and gas pressure is 450 torr. The pixel pitch is 0.81 mm $\times$ 0.81 mm, as designed for a 50$''$ WXGA (1386 $\times$ 768) display format. This study uses two major measurement variables: the light emission which is measured using a photosensor amplifier (Hamamatsu C6386) and the current which is measured using a current probe amplifier (Tektronix AM503B) [10].

Fig. 2 shows the test driving scheme to investigate the basic characteristics of the address discharge. It is designed based on a conventional ADS scheme with ramp reset pulses. The total period is 1 ms, which was selected for measurement convenience. The total number of sustain pulses is 12, which is rather small to minimize the thermal effect due to strong sustain discharges. However, since the discharges during the sustain period are stabilized within a few sustain pluses under proper operation conditions, the final wall voltage resulting from the sustain discharge is definitely stabilized. Both the address pulsewidth and sustain pulsewidth are set to 5 μs to guarantee a stable operation, plus the width of the first sustain pulse is set to 20 μs for the same reason.

The wall voltage measurement method was briefly described in previous study [11]. Since the discharge driven by a ramp pulse with sufficiently low ramp slop is occurred when an internal wall voltage plus externally applied voltage is equal to a firing voltage, the ramp pulse can be used as a detecting pulse for the wall voltage. [12]–[16] In this study, since the object is investigating the characteristics of the wall voltage during the

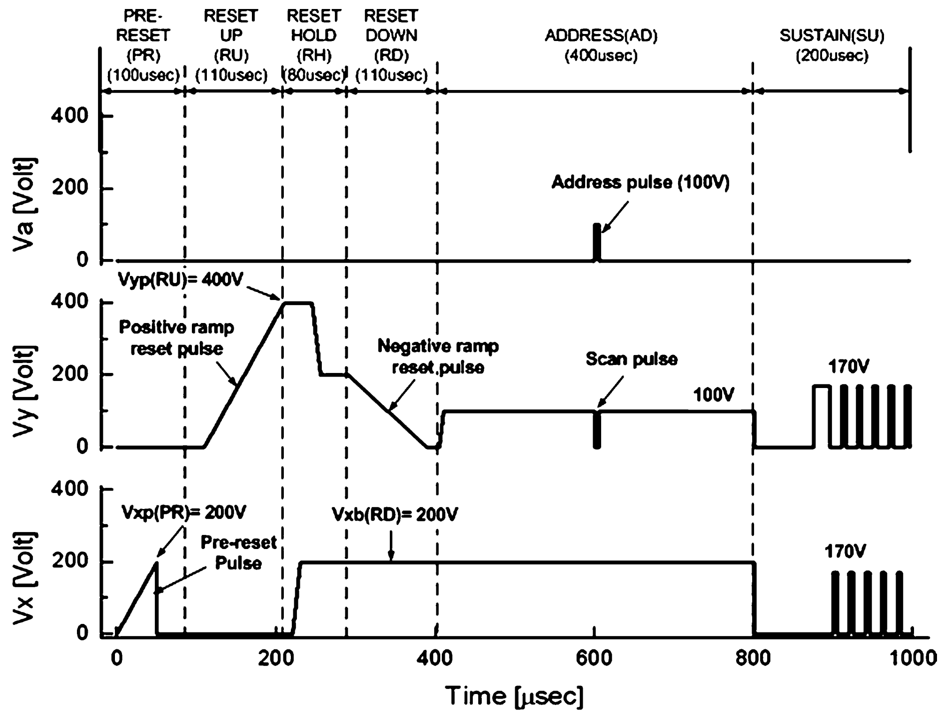

Fig. 2. Test driving scheme.

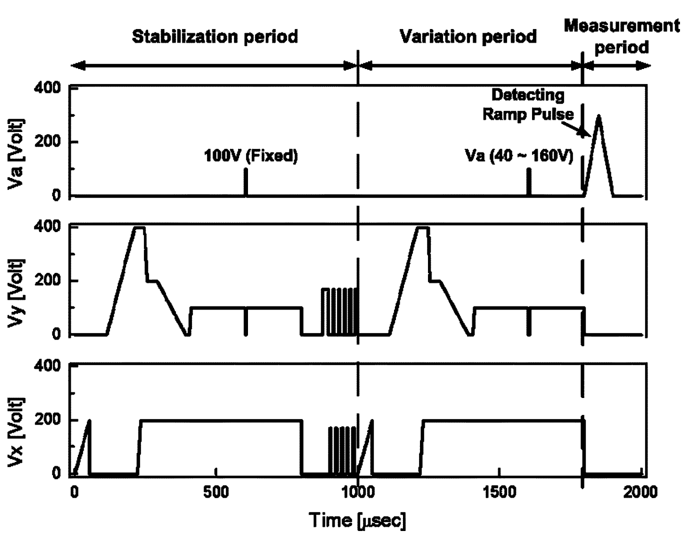

Fig. 3. Measurement driving scheme for the wall voltage between the A and X electrode.

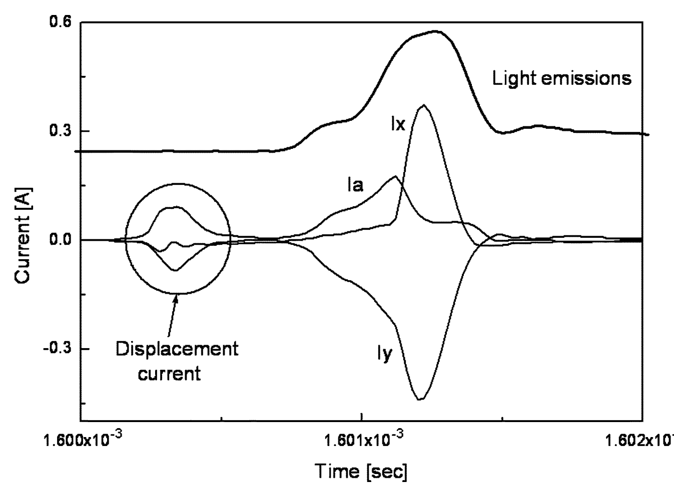

Fig. 4. Light emissions and currents of an each electrode driven by the test driving scheme.

address period, the measurement driving scheme was designed as shown in Fig. 3. The wall voltage is stabilized during the first stabilization period and it is varied during the second variation period where the driving pulse scheme is necessary to adjusted to the objective of the measurement. In this experiment, the address pulse voltage is varied from 40 to 160 V, as shown in Fig. 3. And, finally, it was measured by the detecting ramp pulse in the measurement period.

The stabilization period is very important to correctly measure the wall voltage. It is to stabilize not only the wall voltage for each electrodes before the variation period, but also the panel temperature due to the sustain discharges. Since the measurement variables such as the light emissions and currents are very sensitive to the panel temperature, it is important to build up the stabilization conditions [10]. The graphical presentation of the wall voltage measurement method will be descried in later section.

III. Results and Discussion

Fig. 4 shows the light emissions and currents of an each electrode driven by the test driving scheme shown in Fig. 2. The address discharges are composed with the AY discharge (discharge between the A and Y electrode) and the XY discharge (discharge between the X and Y electrode). The AY discharge is first generated by an address pulse voltage and then the XY discharge is induced by the AY discharge. Therefore, the AY discharge might be strongly dependent on the address pulse voltage and

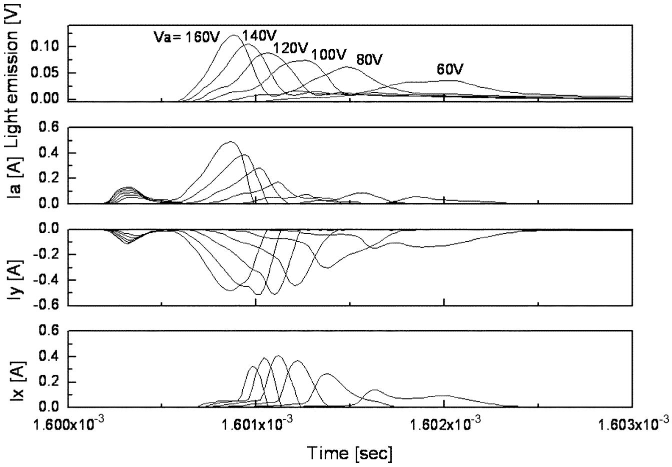

Fig. 5. Light emissions and currents on the dependence of the address voltage.

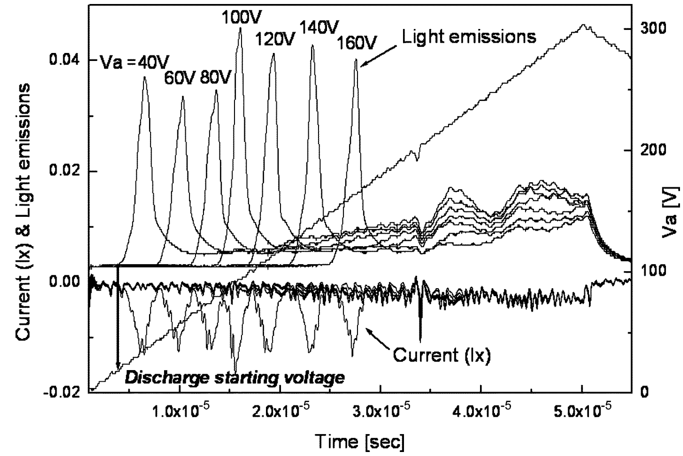

Fig. 6. Graphical representation of the wall voltage measurement method between the A and X electrode.

the XY discharge might be related to the AY discharge which is resulting in the generation of priming particles and changing in the wall voltages of the each electrode, especially the Y electrode. Therefore, in this study, the characteristics of the address discharge were mainly investigated on the dependence of the address pulse voltage.

A. Light Emissions and Currents as a Function of the Address Voltage

Fig. 5 shows the light emissions and currents on the dependence of the address voltage. Considering the light emissions, the address discharges are fast generated and also the peak intensities are sharply increased as increasing the address voltage. In order to analyze the effects of the address voltage on the AY discharge and XY discharge, the currents were measured for each electrode.

As shown in Fig. 5, the current waveforms of the Y electrode (Iy) are quite corresponding to the waveforms of light emissions because the Y electrode participates in generating both the AY and XY discharges. The currents of the A electrode (Ia) is also sharply increased as increasing the address voltage. However, the current of the X electrode (Ix) is not increased, though the XY discharges are fast generated as increasing the address voltage. Furthermore, when the address voltage is higher than 120 V, it is slightly decreased with increasing the address voltage. Since the Y electrode is acted as a cathode during the AY discharge, the resultant wall voltage is changed as positive voltage. Therefore, the XY discharge might be decreased, however it needs further study.

B. Wall Voltage Variation as a Function of the Address Voltage

The wall voltage measurement method was applied to analyze the effects of the address voltage on the address discharge. Since the initial wall voltage conditions of the address discharge is generated by the reset period, it is helpful to know the wall voltage states which are generated during the reset period. Therefore, brief explanations are as follows.

According to the ramp reset driving scheme, without the coupling effect between the AY and XY discharges during the reset period, the wall voltage between the X and Y electrode [Wxy] is determined by Vbs–Vxb(RD) while the wall voltage between the A and Y [Way] is determined by Vyp(RU)–Vba after the reset period; where Vbs is a firing voltage between the X and Y electrode, Vba is a firing voltage of the A and Y electrode, and Vxb(RD) and Vyp(RU) can be founded in Fig. 2. Since Vbs is 220 V and Vba is 200 V in the test panel used in this experiment, Wxy is roughly 20 V and Way is roughly 200 V driven by the test driving scheme. Consequently, the wall voltage of the A electrode is much positive than that of the Y electrode and it is slightly positive than that of the X electrode.

However, once an address discharge was occurred, Way would be changed due to the AY discharge and also Wxy would be changed due to the XY discharge. The resultant Wxy would be negative voltage which means the wall voltage of the X electrode is negative to that of the Y electrode. Therefore, as shown in Fig. 3, the detecting ramp pulse applied to the A electrode is generating the discharge between the A and X electrode.

Fig. 6 shows the graphical representation of the wall voltage measurement method between the A and X electrode. As shown in Fig. 6, the light emissions and discharge currents (Ix) are measured as increasing the address voltage. The discharge starting voltage, which is defined as the firing voltage by the detecting ramp pulse, can be obtained. Since the AX discharge is generated when the wall voltage between the A and X electrode (Wax) plus the discharge starting voltage of the detecting ramp pulse is equal to the firing voltage between the A and X electrode (Vba), Wax is easily calculated. Similarly, the wall voltage between the Y and X electrode (Wyx) can be easily measured by the detecting ramp pulse which is applied to the Y electrode instead of the A electrode. And the wall voltage between the A and Y electrode (Way) can be easily calculated with Wax and Wyx.

Fig. 7 shows the wall voltage variation as a function of the address voltage. As shown in Fig. 7, Way is strongly dependent on the address voltage. However, though Wyx is sharply changed by the address discharge, it is not strongly dependent on the address voltage; on the contrary, it is nearly constant as increasing the address voltage. Consequently, as increasing the address voltage, Way is strongly decreased while Wyx is slight

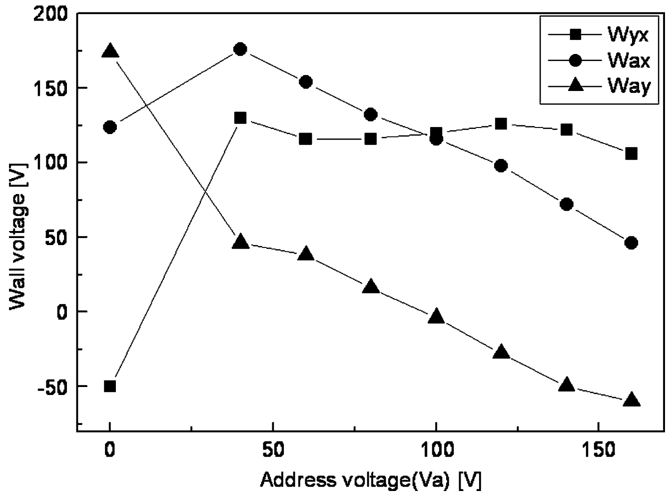

Fig. 7. Wall voltage variation as a function of the address voltage.

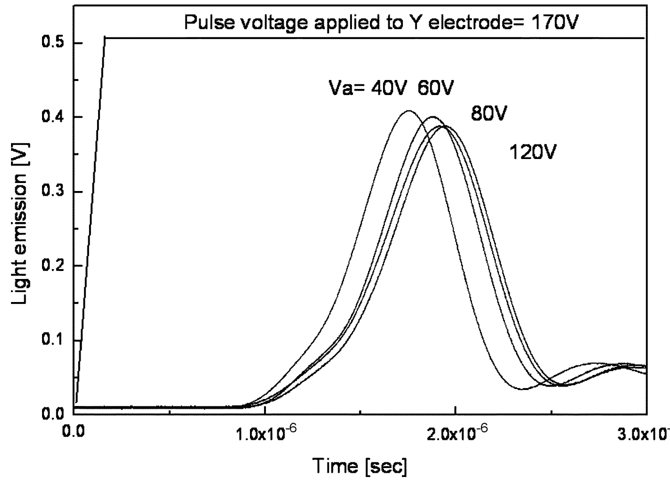

Fig. 8. Light emissions of the first sustain discharge (between the Y and X electrode) on the dependence of the address voltage driven by test driving scheme.

changed. The result of Fig. 7 is quite corresponding to that of Fig. 5.

As increasing the address voltage, the intensity of the AY discharge is increased, which is resulted in generating the positive wall voltage on the Y electrode. Therefore, the intensity of the XY discharge induced by the AY discharge is decreased; however, it needs further studies. Consequently, Wyx is automatically generated at a fixed voltage level regardless of increasing the address voltage because the XY discharge is decreased with increasing the address voltage.

C. Influence of the Address Voltage During the Sustain Period

Since the wall voltages are fast stabilized by the sustain discharges [11], the wall voltage states which were generated by address discharges are only meaningful within a first few sustain pulses. Especially, the first sustain discharge is strongly related to the wall voltage states generated by the address discharges. Fig. 8 shows the light emissions of the first sustain discharge (XY discharge) on the dependence of the address voltage driven by test driving scheme, as shown in Fig. 2. As shown in Fig. 8, the first sustain discharge is not largely changed but roughly independent on the address voltage. Since the intensity of the light emissions is dependent on Wyx, it is quite corresponding to the results of Fig. 7.

In order to verify the change of Wax due to the address voltage, the driving scheme of Fig. 2 was slightly modified to generate the discharge between the A and X electrode (AX discharge) as like a first sustain discharge shown in Fig. 8. The driving scheme for this experiment is almost same as the test driving scheme shown in Fig. 2, while the first sustain pulse is applied to the A electrode instead of the Y electrode which voltage is 100 V. Fig. 9 shows the light emissions of the AX discharge as a function of the address voltage. As shown in Fig. 9, the AX discharge is strongly dependent on the address voltage and it is not generated when the address voltage is higher than 100 V which is quite corresponding to the results of Fig. 7.

Recently, there have been intensively studied on the auxiliary pulse applied to the address electrode during the sustain period

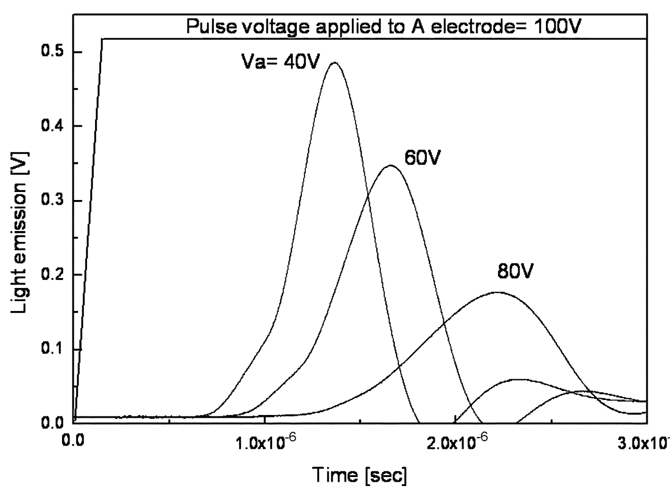

Fig. 9. Light emissions of the discharge between the A and X electrode on the dependence of the address voltage driven by test driving scheme.

to improve the discharge characteristics and luminous efficiency [17]–[20]. Since the address electrodes only play a role in the reset and address period, this approach might be useful. Therefore, these results and the wall voltage measurement method might be helpful to study on the effects of the auxiliary address pulse.

IV. Conclusion

In this study, the basic characteristics of the address discharge were investigated on the dependence of the address voltage. The wall voltage between the A and Y electrode is strongly dependent on the address voltage and it is sharply decreased as increasing the address voltage. Though the wall voltage between the X and Y electrode is largely changed due to the address discharge, it is not strongly dependent on the address voltage but it is roughly constant. It might be caused by the decreased the XY discharge due to the positive wall charge of the Y electrode which is resulted by the AY discharge.

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Bhum Jae Shin (M'03) received the B.S. degree from the Department of Electrical Engineering, and the M.S. and Ph.D. degrees in plasma engineering from Seoul National University, Seoul Korea, in 1990, 1992, and 1997, respectively.

He worked on the development of PDPs as a Senior Researcher in the PDP team of Samsung SDI, Korea, from 1997 to 2000. He worked on the capillary discharges as a Visiting Researcher in the Physics Department, Stevens Institute of Technology, Hoboken, NJ, from 2000 to 2001. In 2002, he returned to Korea, and following a one-year postdoctoral at Seoul National University, he has been working as a Research Professor in the Department of Electronics Engineering, Sejong University since 2003. His research interests include high efficiency PDP cell structure and driving scheme.

Dr. Shin is a Member of the Society for Information Display.

Kyung Cheol Choi (M'04) received the B.S. degree from the Department of Electrical Engineering, and the M.S. degree and Ph.D. degrees in plasma engineering from Seoul National University, Seoul Korea, in 1986, 1988, and 1993, respectively.

He was with the Institute for Advanced Engineering, Seoul, from 1993 to 1995, where his work focused on the design of field emission display devices. He was a Research Scientist in the Microbridge Plasma Display panel of Spectron Corporation of America, Summit, NJ, from 1995 to 1996. He was a Senior Research Scientist at Hyundai Plasma Display, Hawthorne, NY, from 1996 to 1998, where his work was to continue on developing plasma display technology. From 1998 to 1999, he was involved in the development of an ac 40-in plasma display panel at Advanced Display Research and Development Center, Hyundai Electronics Industries, Gyounggi-do, South Korea as a Senior Research Scientist. From 2000 to 2004, he had been an Associate Professor in the Department of Electronics Engineering, Sejong University, Seoul, Korea. He also was in charge of the Information Display Research Center supported by Korean Ministry of Information and Communication. Since February 1, 2005, he has been an Associate Professor in the Department of Electrical Engineering and Computer Science, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea. His research interests include plasma display panel, information displays, and microplasma applications for laser and bio-electronics.

Dr. Choi is a Member of the Society for Information Display and the Korean Information Display Society.

Heung-Sik Tae (M'00) received the B.S. degree in electrical engineering, and the M.S. and Ph.D. degrees in plasma engineering from Seoul National University, Seoul, Korea, 1986, 1988, and 1994, respectively.

Since 1995, he has been an Associate Professor in Kyungpook National University, Daegu, Korea. His research interests include the optical characterization and driving circuit of plasma display panels (PDPs), the design of millimeter wave guiding structures, and electromagnetic wave propagation using meta-material.

Dr. Tae is a Member of the Society for Information Display (SID). He has been serving as an editor for the IEEE TRANSACTIONS ON ELECTRON DEVICES, Special Section on Flat Panel Display, since 2005.

Sang Sik Park received the B.S., M.S., and Ph.D. degrees in electronics engineering from Seoul National University, Seoul, Korea, in 1984, 1986, and 1989, respectively.

In 1989, he joined Samsung Electronics as a Senior Engineer and has been engaged in research on the CCD and CMOS image sensor. Since 2000, he has worked in Sejong University as Associate Professor. His research interests include image sensor, field emission displays, semiconductor devices, and processing.