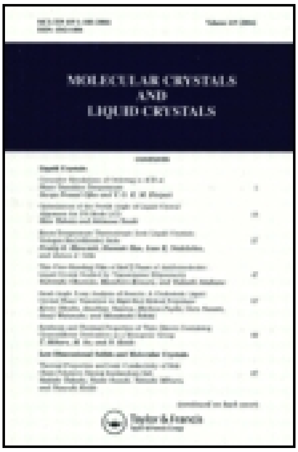

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A New Reset Waveform for Stable Discharge Under Variable Panel Temperatures in AC-Plasma Display Panel

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The discharge characteristics, especially the reset discharge characteristics, were examined relative to the panel temperature from -5 to 65°C in an ac-plasma display panel. As the panel temperature decreased, the reset discharge became unstable, due to a decrease in the exo-electron emission from the MgO surface by the thermal activation, thereby inducing the unstable address discharge at a low panel temperature. To stabilize the reset discharge, the effects of the ramp-slope rates during the reset period on the reset discharge were examined under variable panel temperatures. Based on the experimental observation, the new temperature-adaptive reset waveform is proposed to produce a stable reset discharge irrespective of variable panel temperatures.

Keywords reset discharge; variable panel temperatures; exo-electron emission; ramp-slope rate

1. Introduction

The main purpose of the reset discharge is to standardize the wall voltage for enabling the subsequent address discharge to be stable [1–5]. However, since the reset discharge is strongly affected by the panel temperature, the low panel temperature would cause an unstable reset discharge problem. This phenomenon would be deeply related to the exo-electron emissions that play a role of producing the priming electrons for the discharge [6–8]. The electrons produced by the sustain discharge are trapped at shallow trap levels located beneath the edge of the conduction band of MgO during the sustain period. The trapped electrons are emitted from the trap levels into the discharge space by a thermal excitation process during the reset and address periods [9]. Recently it has been reported that the exo-electron emission tends to decrease with a decrease in the panel temperature [10]. The reduction of the exo-electron emission could cause the unstable reset discharge due to the lack of priming electrons in the discharge cell, thereby resulting in inducing the unstable ensuing address discharge.

Accordingly, this paper investigated the discharge characteristics during a reset, address, and sustain period relative to the panel temperature in order to explain the temperature dependence on the discharge characteristics. In particular, the effects of the ramp-slope rates during the reset period on the reset discharge characteristics were examined under variable

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panel temperatures. Based on the experimental observation, the new temperature-adaptive reset waveform was proposed to produce a stable reset discharge irrespective of variable panel temperatures.

2. Experimental Setup

Figure 1 shows a schematic diagram of the experimental setup used for measurement. A 7-in. test panel with a gas pressure of 420 Torr was employed in this research, and its structure and dimensions were exactly the same as those of a conventional 50-in. wide XGA grade PDP with a box-type barrier rib. The gas mixtures used were He (35%)-Ne-Xe (11%). As shown in Fig. 1, the panel temperature of the test panel was varied from -5 to 65°C by controlling the temperature on the glass of the rear panel with an external cooler or heater. Figure 2 shows the driving waveform used to investigate the effects of the panel temperatures on the reset-, address-, and sustain-discharge characteristics during the reset, address, and sustain period, respectively.

3. Results and Discussion

3.1 Effects of Panel Temperatures on Reset, Address, and Sustain Discharge Characteristics

Figure 3 shows the infrared (IR: 828 *nm*) intensities emitted during the reset discharge measured from the test panel when varying the panel temperature form -5 to 65°C. At a low panel temperature (−5°C) condition, the IR intensities showed large peaks, and their fluctuations were increased, implying that the continuous weak discharges during the reset discharge were hard to maintain at a low panel temperature condition.

Accordingly, at a low panel temperature, the stable reset discharge was very difficult to produce. This phenomenon is deeply related to the presence of priming electrons in the discharge cell [11]. It has already been known that the priming electrons are supplied

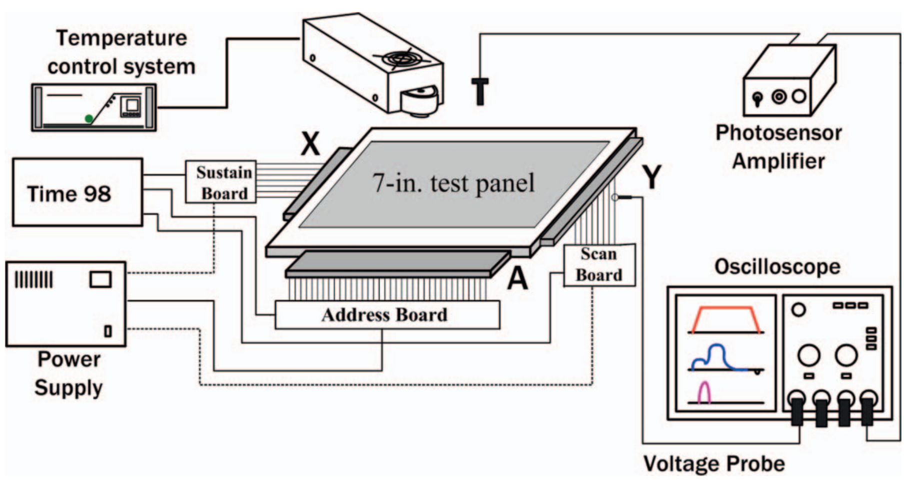

Figure 1. Schematic diagram of experimental setup used for measurement. 7-in. panel with three electrodes was used as test panel where X is common, Y is scan, and A is address electrode.

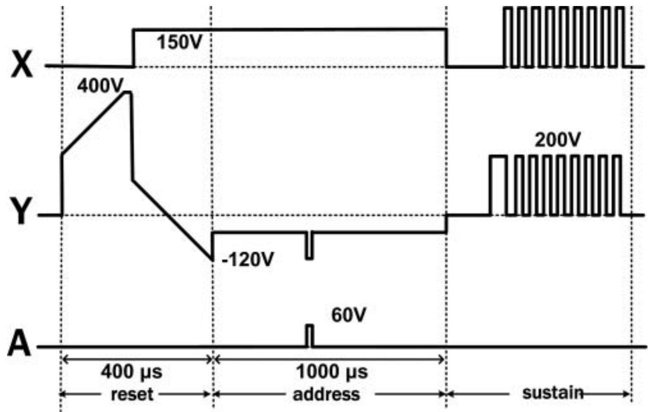

Figure 2. Driving waveform employed to measure discharge characteristics during reset, address, and sustain period.

by the exo-electron emission from the MgO surface [6–8]. As the panel temperature was decreased, the exo-electron emission was also decreased. Consequently, the reset discharge was observed to become unstable in inversely proportion to the panel temperature, presumably due to the reduction of the priming electrons. In contrast, at a high panel temperature (65°C) condition, the reset discharge became stable presumably due to the sufficient exo-electron emission by the thermal activation. These temperature dependent reset discharges would affect the subsequent address discharge relative to the panel temperature, meaning that the unstable reset discharge results in the unstable address discharge.

Figure 4 shows the changes in the IR (828 *nm*) intensities emitted during the address discharge at the three different panel temperatures of (a) −5°C, (b) 25°C, and (c) 65°C.

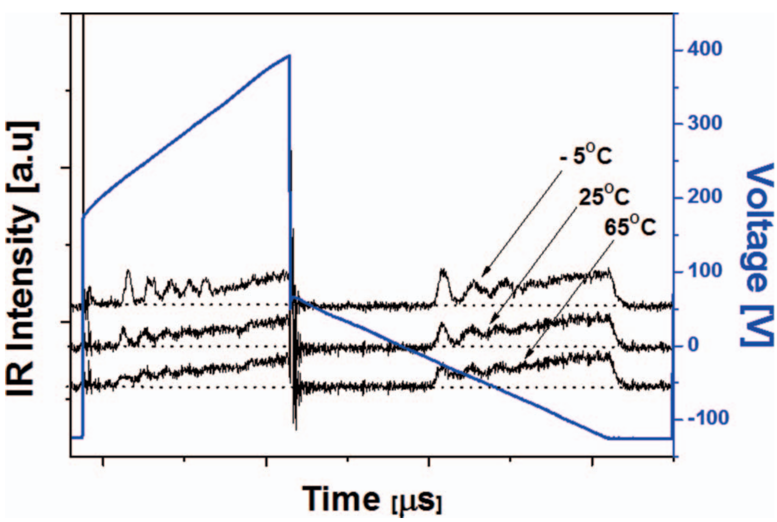

Figure 3. IR (828 *nm*) intensities emitted during reset discharge measured from test panel under variable panel temperatures.

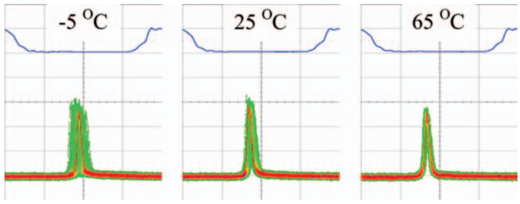

Figure 4. IR (828 *nm*) intensities emitted during address discharge at three different panel temperatures: (a) −5°C, (b) 25°C, and 65°C.

To measure the temporal dispersion of the address discharge, the IR emissions were measured repeatedly during the continuous 500-turn-address discharge, so that the IR intensity profiles in Fig. 4 indicated the overlapped IR emission images. When decreasing the panel temperature from 65°C to −5°C, the dispersion of the IR emission was increased, indicating that the address discharge became unstable at a low panel temperature. This phenomenon would be related to the reset discharge depending on the priming condition according to the panel temperature. For a closer investigation of the address discharge relative to the panel temperature, the address discharge delay times were measured 500 times under the same experimental conditions, as shown in Fig. 5. As the panel temperature was decreased, the statistical delay time was increased, presumably due to the decrease in the exo-electron emission according to the panel temperature [10]. Whereas, the formative delay time was increased due to the unstable reset discharge. The unstable reset discharge did not standardize the wall voltage at a low panel temperature condition. As a result, the formative delay time was increased due to the nonstandard wall voltage after the reset discharge at a low panel temperature condition.

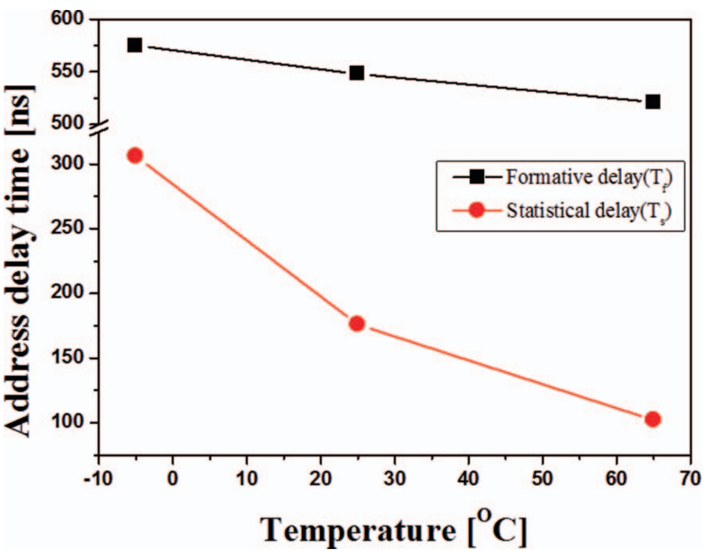

Figure 5. Changes in address discharge delay times measured during address discharge from test panel relative to panel temperature.

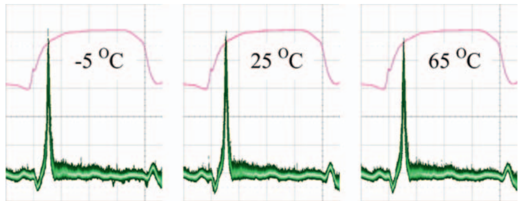

Figure 6. IR (828 *nm*) intensities emitted during sustain discharge at three different panel temperatures: (a) −5°C, (b) 25°C, and 65°C.

Figure 6 shows the IR (828 *nm*) intensities emitted during the sustain discharge at the three different panel temperatures of (a) −5°C, (b) 25°C, and (c) 65°C. As shown in Fig. 6, the IR intensities were almost the same despite the variation in the panel temperature, which means that the panel temperature had little influence on the sustain discharge.

As previously described, at a low panel temperature condition emitting the lesser exo-electrons into the discharge space, the reset discharge became unstable due to the lack of priming electrons in the discharge cell. In addition, the formative delay time of the address discharge was increased due to the unstable reset discharge. Thus, to maintain a stable reset discharge irrespective of variable panel temperatures, the conventional reset waveform needs to be modified to compensate the exo-electron emissions depending on the panel temperature.

3.2 Temperature-Adaptive Reset Waveform for Stable Discharge Under Variable Panel Temperature

To stabilize the reset discharge relative to the panel temperature, the influences of the ramp-slope rates during the reset period on the reset discharge under variable panel temperatures, were examined, as shown in Fig. 7. At the low panel temperature condition emitting the lesser exo-electrons into the discharge space, the unstable reset discharge occurred due to the lack of priming electrons, as shown in Fig. 7 (a). However, when increasing the ramp-slope rate from 0.50 to 0.63 V/μs during the reset period, the reset discharge was observed to be stable. This means that in order to maintain the continuous weak discharge under the insufficient exo-electron emission at a low temperature, the more intensive electric field intensity is required.

On the other hand, at a high panel temperature condition emitting the greater emitting exo-electrons in the discharge space, the reset discharge was little influenced by the ramp-slope rate thanks to the presence of sufficient priming electrons in the discharge space. These results indicate that the reset discharge is closely related to the ramp-slope rate as well as the priming electrons in the discharge space. Thus, to maintain a stable reset discharge under variable panel temperatures, a new reset waveform with a variable ramp-slope rate adaptive to the panel temperature is proposed, as shown in Fig. 8. The basic idea of the proposed reset waveform for producing a stable reset discharge is to apply an adaptive ramp-slope rate according to the panel temperature in order to compensate the lack of the priming electron in the discharge cell. The adaptive ramp-slope rates during

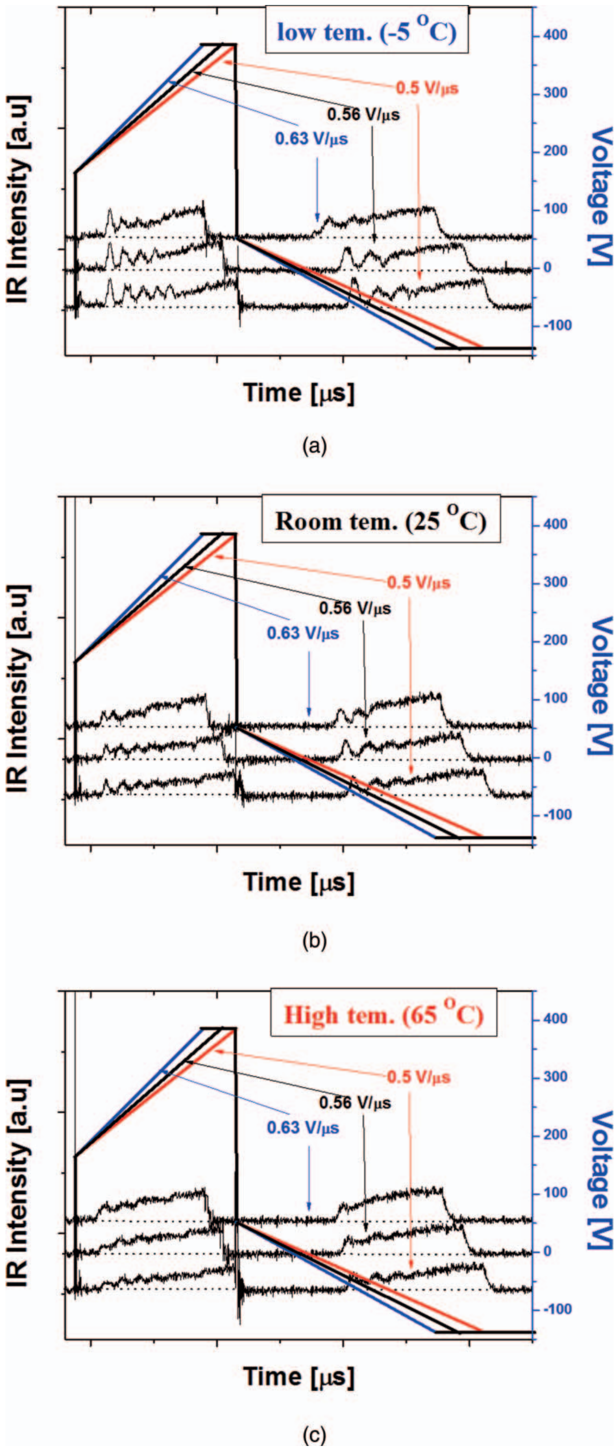

Figure 7. Changes in reset discharge characteristics relative to ramp-slope rate during reset period at three different panel temperatures: (a) −5°C, (b) 25°C, and 65°C.

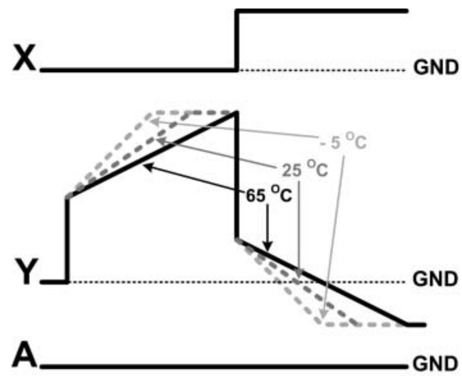

Figure 8. Proposed reset waveform with multi ramp-slope rate relative to panel temperature.

the reset period according to the panel temperature are given in Table 1. Figure 9 shows the infrared (IR: 828 *nm*) intensities emitted during the reset discharge measured under variable panel temperatures when applying the proposed reset waveform in Fig. 8. The peaks and fluctuations of IR intensities were decreased, and the stable reset discharges were continuously maintained irrespective of variable panel temperatures. As a result, the address discharge delay time was reduced at a low panel temperature condition, thereby improving the address discharge under variable panel temperatures, as shown in Laue plot of Figure 10 [12, 13]. In particular, the formative delay time was noticeably reduced thanks to the wall voltage standardized by the stable reset discharge. Consequently, the proposed reset waveform with temperature-adaptive ramp-slope rate was confirmed to stabilize the reset discharge and as such improve the address discharge delay under variable panel temperatures. Nonetheless, the background luminance was slightly increased from 1.15 to 1.31 cd/m^2 at a low panel temperature condition due to the slight increase in the IR intensities during the reset period.

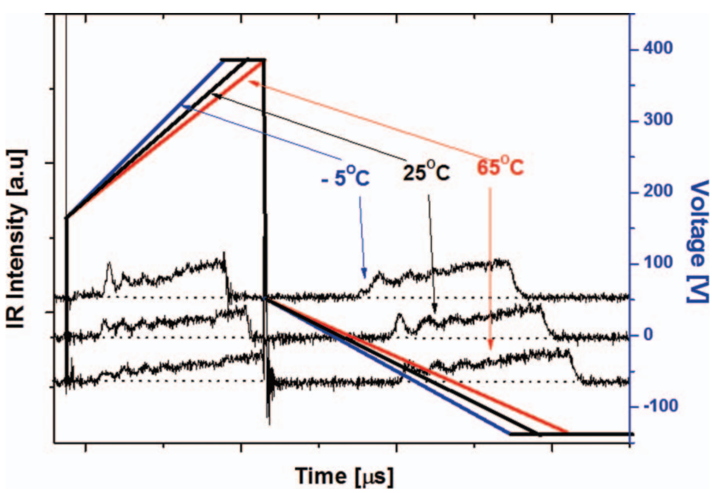

Figure 9. IR (828 *nm*) intensities emitted during reset discharge measured from test panel under variable panel temperatures when adopting proposed reset waveform.

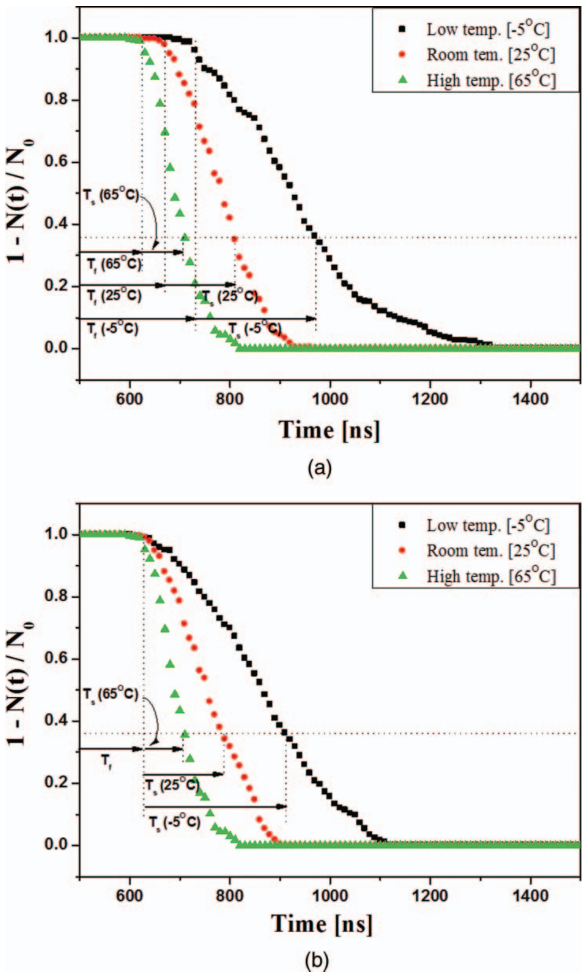

Figure 10. Laue plots of address discharge delay times measured under variable panel temperatures when applying (a) conventional reset waveform and (b) proposed reset waveform.

Conclusion

For the address discharge stability under variable panel temperatures, this paper investigated the relation between the reset discharge characteristics and panel temperature. Our

Table 1. Temperature-adaptive reset waveform with multi ramp-slope rate relative to panel temperature

Panel temperature	Ramp slope rate
−5°C	0.63 V/μs
25°C	0.56 V/μs
65°C	0.5 V/μs

experiments showed that when decreasing the panel temperature, the reset discharge became unstable due to a decrease in the exo-electron emissions from the MgO surface. It should be noted that the reset discharge was influenced by the priming particles as well as the ramp-slope rate during the reset period. The experimental results showed that the proposed reset waveform with multi ramp-slope rate during the reset period adaptive to the panel temperature was able to stabilize the reset discharge irrespective of the panel temperature. Consequently, the proposed reset waveform was demonstrated to improve the address discharge under variable panel temperatures.

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