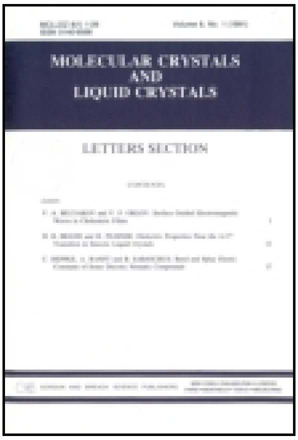

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

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Published online: 08 Jan 2014.

Mol. Cryst. Liq. Cryst., Vol. 585: pp. 34–40, 2013

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421406.2013.852778

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Influence of Surface Contamination on the Electrical Breakdown between Ag Electrodes in AC Plasma Display Panels

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In this study, the surface contamination and related electrical current were examined by TOF-SIMS and Micromanipulators in order to identify the main factors on the electrical short phenomenon between Ag electrodes in the 50-in. full HD AC-PDPs with a various contaminations. The experimental results reveals that such atoms as Na, K, and Cl were detected on both Ag electrode and glass surface as culprits causing sever surface contamination. It was also found that the more severely contaminated the samples were, the more increased the electrical current became. This result confirms that the electric breakdown on the Ag electrode is closely related with its surface contamination.

Keywords Ag electrode; electrical breakdown; full-HD AC-PDP panel; micromanipulators; surface contamination; TOF-SIMS

1. Introduction

Plasma display panels (PDPs) are a promising technology for large area flat panel displays and have reached the early commercialization stage. However, PDPs have some problems, such as lower luminance, luminous efficiency, and cost. It will be of great importance to reduce its cost of manufacture. In order to lower a fabrication cost, most issues are focused on reducing the material cost and manufacture time [1]. In this sense, the current Ag electrode seems important. Thanks to a high electric conductivity, the Ag has been used as an electrode material, so that the Ag electrode has had many applications, such as plasma display devices. In PDP, the Ag electrode is used to complement the low electric conductivity of the ITO transparent electrode on the front panel. The Ag electrode is formed through the procedures, such as a printing, drying, exposure, and developing, and firing [2]. However, the Ag electrode has a few problems, for example, yellowing phenomenon, bubbles around the electrode, edge-curl, and Ag electrode short phenomenon,

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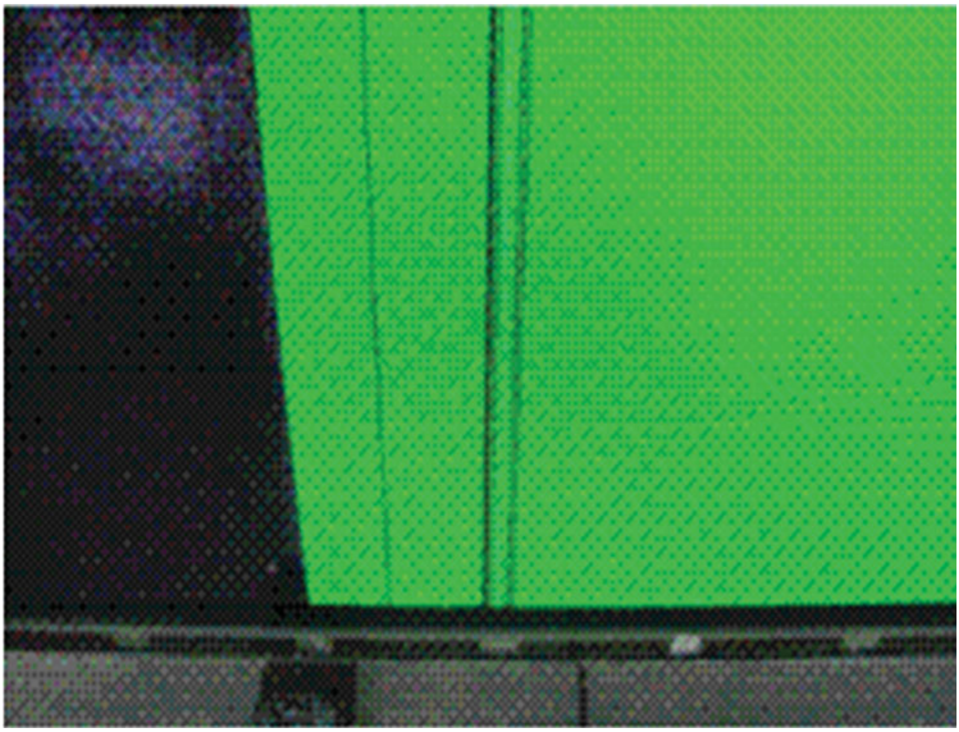

Figure 1. Ag electrode short phenomenon of the full-HD PDP module.

which are generally encountered as a result of an interaction between the glass and Ag electrode. In particular, Ag electrode short phenomenon is originated from the Ag dendrite between the electrode and glass surface, strongly depending on the contamination, humidity, and external temperature. It is possible to make a electrical path as following equations.

$$AgNO_{3(aq)} + NaCl \rightarrow AgCl_{(s)} + NaNO_{3(aq)} \tag{1}$$

$$Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)} \tag{2}$$

$$AgNO_{3(aq)} + HCl_{(aq)} \rightarrow AgCl_{(s)} + HNO3_{(aq)} \tag{3}$$

Table 1. Specifications of 50 inch full-HD AC-PDP used in this study

Front Panel		Rear Panel	
ITO width	200 μm	Barrier rib width	50 μm
ITO gap	75 μm	Barrier rib height	120 μm
Bus width	70 μm	Address width	95 μm
Pixel pitch		576 μm × 576 μm	

Table 2. Surface contamination conditions for measurement

	No	Sample descriptions
Without particles	1N	Without contamination
	11	Contaminated for 1 min
	15	Contaminated for 5 min
	15H	Heated after Contaminated for 5 min
With particles	5N	Without contamination
	51	Contaminated for 1 min
	55	Contaminated for 5 min
	55H	Heated after Contaminated for 5 min

When the Ag electrodes become abruptly electrically short, the electrical breakdown would occur and the resultant PDPs would not work. Therefore, we need a reliable evaluation method for preventing an electrical short between electrodes. In this study, we examined the relation between surface contamination and electrical current by using the time of flight secondary ion mass spectrometry (TOF-SIMS) and Micromanipulators in order to identify the main parameters on the Ag electrode short in PDPs. Moreover, we tried to study systematically on the migration mechanism in terms of surface contamination and related electrical current.

2. Experimental Setup

Figure 1 shows the optical measurement systems and commercial 50 in full-HD test panel with three electrodes used in the experiments, where X is the sustain electrode, Y the scan electrode, and A the address electrode. The detailed panel specifications are listed in Table 1. The surface morphology was measured by a field emission secondary electron microscopy (FE-SEM: JEOL, 6700). The test sample is given in Table 2.

In order to evaluate the surface contamination between Ag electrodes and glass surface, TOF-SIMS measurements were measured with Ion-TOF. The Bi was used as a primary ion source. The Bi ion energy and target current were 25 kV and 1 pA, respectively. The Electrical current was evaluated by Micromanipulators (Kleindiek, MM3A-EM).

Table 3. Resistance results for experimental conditions

	No	Resistance (Ohm)
With particles	1N	$2.8 \times \mathrm{E}^{13}$
	11	$1.43 \times E^{12}$
	15	$1.61 \times E^{11}$
	15H	$4.06 \times E^{10}$
Without particles	5N	$2.37 \times E^{13}$
	51	$1.02 \times E^{13}$
	55	$1.57 \times E^{12}$
	55H	$9.82 \times E^{11}$

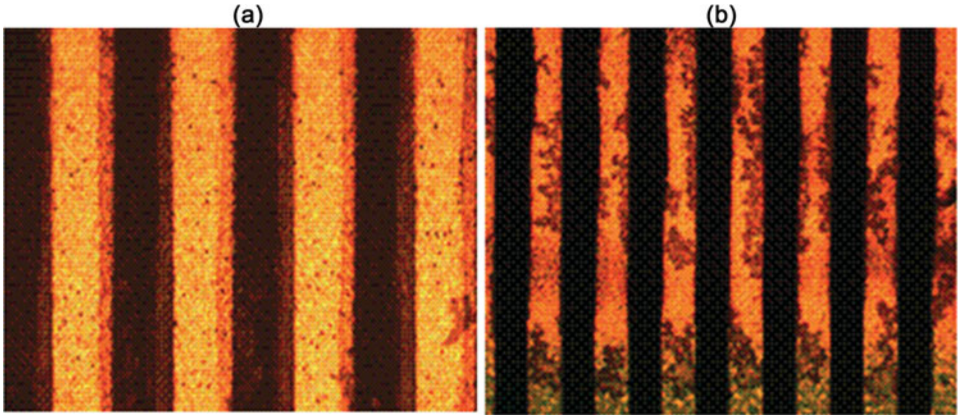

Figure 2. (a) Clean and (b) contaminated surface in the optical microscope.

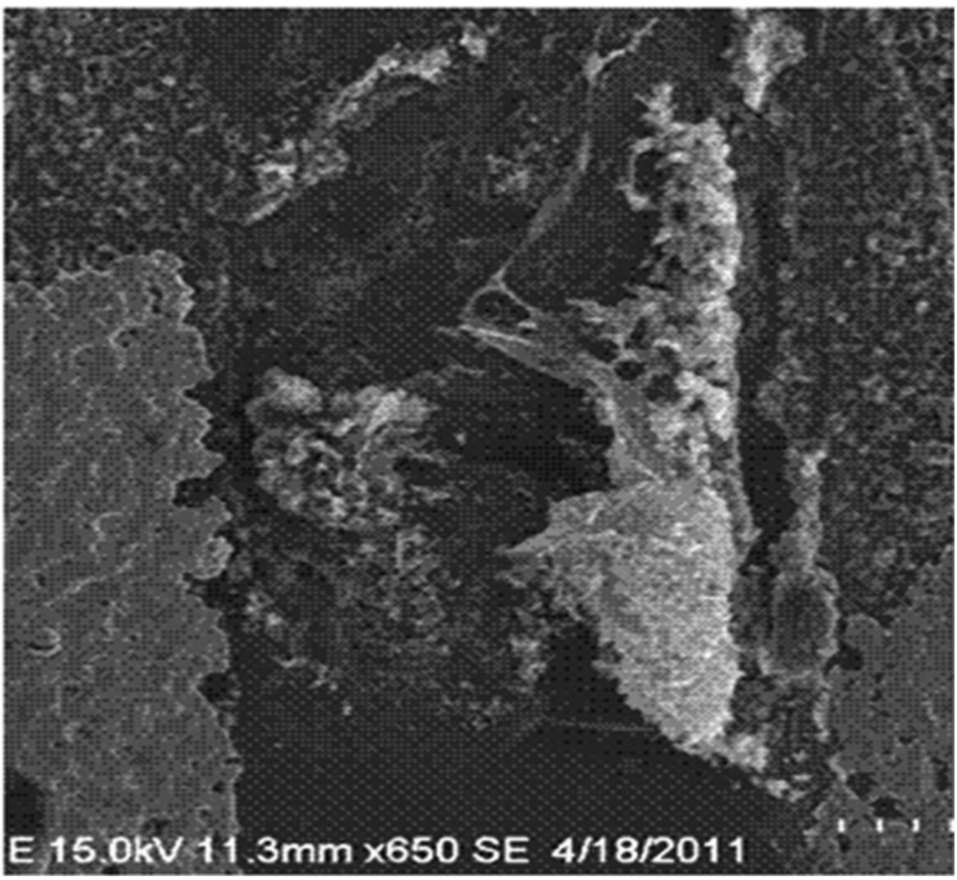

Figure 3. Contaminated surface in FE-SEM image on the electrical short phenomenon with contamination.

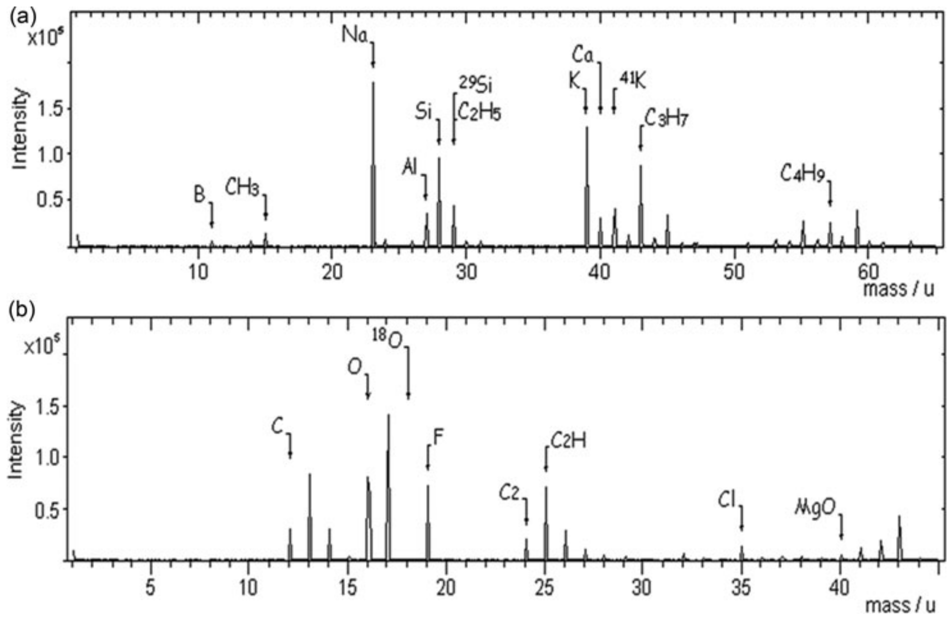

Figure 4. TOF-SIMS (a) positive and (b) negative mass spectra between Ag electrode and glass, in case of the surface contamination.

3. Results and Discussion

The Ag electrode short phenomenon was indicated in the 50″ full-HD PDP module as shown in Fig. 1. In this case, it is a severe failure in mass production line. In order to solve the main reason about this problem and prevent the failure in advance, we try to investigate various experimental tools.

Figure 2(a) clean and 2(b) contaminated surface in the optical microscope.

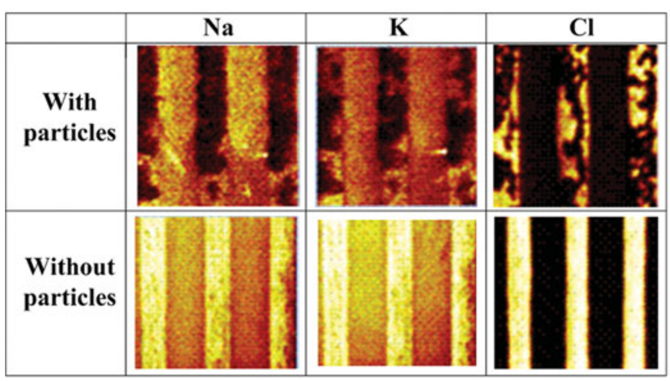

Figure 5. TOF-SIMS image of the Ag electrode and glass surface with respect to contamination conditions.

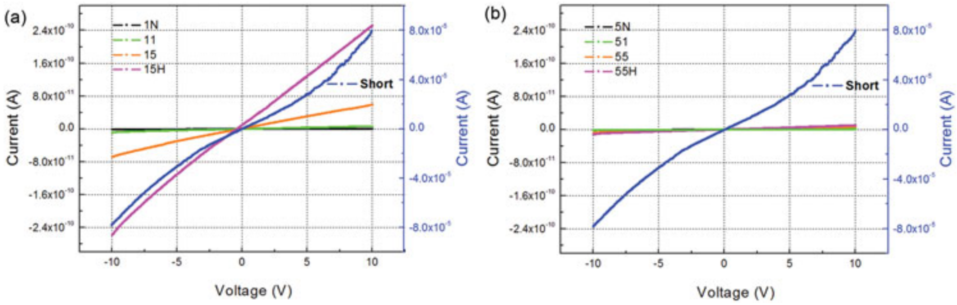

Figure 6. Current-voltage (I-V) curve (a) with and (b) without contamination.

Figure 3 contaminated surface in FE-SEM image on the electrical short phenomenon with contamination. From these results in Figs. 2(a), (b) and 3, there are some surface contamination, such as carbon, hydro-carbon, Na.

In order to indentify about contamination in detail, The TOF-SIMS 4(a) positive and 4(b) negative mass spectra between Ag electrode and glass with respect to various contamination conditions. The measured TOF-SIMS data showed that the contamination elements such as Na, K, Cl, C, and hydrocarbon were detected between the glass surface and Ag electrodes. Figure 5 shows the TOF-SIMS image with respect to contamination elements. The contaminated surface has higher Na, K elements than without surface contamination, thereby inducing a conductive path, such as AgCl, KCl, and NaCl between Ag electrode and glass, under proper temperature and humidity conditions according to physical reaction.

Figure 6(a) shows the characteristics of current-voltage in full-HD PDP panel in case of contamination particles. There is a few current change without particles as shown in Fig. 6(a). However the Fig. 6(b) represents that as the voltage is applied between Ag electrodes without particles, there is no electrical current with a various contamination conditions. The experimental results reveals that such atoms as Na, K, Ca, and Cl were mainly detected on both Ag electrode and glass surface as culprits causing sever surface contamination. It was also found that the more severely contaminated the samples were, the more increased the electrical current became. This result confirms that the electric breakdown on the Ag electrode is closely related with its surface contamination.

Conclusions

In conclusion, both surface contamination and electrical short were examined by TOF-SIMS and Micromanipulators in order to identify the main factors on the Ag migration in plasma display panels. The experimental results show that the surface contaminants such as Na, K, Ca, Cl, carbon, and hydrocarbon were detected on both glass and Ag electrode. In case that the sample was severely contaminated by particles, the electrical breakdown was observed to be more. From these results, we conclude that the electrode short has a close correlation with surface contamination. Additionally, we find a new reliable method for solving these electrical short.

Acknowledgment

This work was supported by Kyungpook National University Research Fund, 2013.

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