

Relationships Between Impurity Gas and Luminance/Discharge Characteristics of AC PDP

Jeong-Eun Heo[a], Sung-Hyun Lee[a], Young-Kee Kim[a**], Jooh-Hong Shin[b], Choong-Hee Yoo[b], and Chung-Hoo Park[a*]**

Abstract

The luminance and discharge characteristics of an AC PDP may be significantly affected by a small amount of impurity gas in working gas. Impurity gases such as O_2, O, C and H_2 can be mixed in the manufacturing and /or discharge processes. In this paper, a small amount of impurity gas in AC PDP are introduced intertimally and the relationship between the amount of impurity gas and the luminance/discharge characteristics are investigated. The luminous efficiency decreased seriously with the increase in the partial pressure of impurity gases, especially in H_2, O_2 and CO_2. Under the condition of the impurity gas ratio of 2×10^{-3} for Ar, N_2, H_2, CO_2 and O_2, the luminous efficiency decreased to about 8 %, 8 %, 32 %, 36 % and 50 %, respectively.

Keywords : AC PDP, impurity gas, luminance/discharge characteristics

1. Introduction

AC plasma display panel(PDP) is a flat panel display, which utilizes gas discharge. Fig. 1 shows the principle structure of a discharge cell in AC PDP. The size of a discharge cell is about 0.3 mm×1 mm×0.15 mm (height). The tri-primary colors(R, G, B) are obtained from RGB phosphors excited by vacuum ultra-violet photons emitted from gas discharge. AC PDP is now considered to be one of the most leading candidates for the large area wall hanging TVs.

It still has yet to be improved, however, in terms of cost, luminous efficiency and so on[1~15]. Especially, one of the serious problems is the decrease of the luminance and luminous efficiency caused by contamination of the working gas.

The working gas in PDP should be chemically stable and should emit an large amount of UV(Ultra-Violet)[16]. In order to meet these conditions, He, Ne or Xe mixture gases are used at pressures between 300 and 500 Torr. If the impurity gases such as O_2, O, CO_2 and H_2 are included in working gas, they can increase the discharge voltage, contaminate the MgO layer and decrease the UV intensity, thus affecting the PDP's performance. The impurity gases are mainly generated from the manufacturing process and discharge process [17].

In this study, we investigated the effects of impurity gases on luminance, luminous efficiency and discharge characteristics in AC PDP after introducing impurity gases such as Ar, N_2, O_2, H_2 and CO_2.

2. Experimental

Table 1 shows the specification of 4-inch test PDP

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* Member, KIDS ; ** Student Member, KIDS.
Corresponding Author : Jeong-Eun Heo
a. Department of Electrical Engineering, Pusan National University Mt. 30, Jang-jeon Dong, Keum-jeong Gu, Pusan, 609-735, Korea.
b. Department of Electrical Engineering, Dong Eui University, Pusan 614-714, Korea.
E-mail : Indian_heo@hanmail.net **Tel** : +51 510 1544
Fax : +51 513 0212

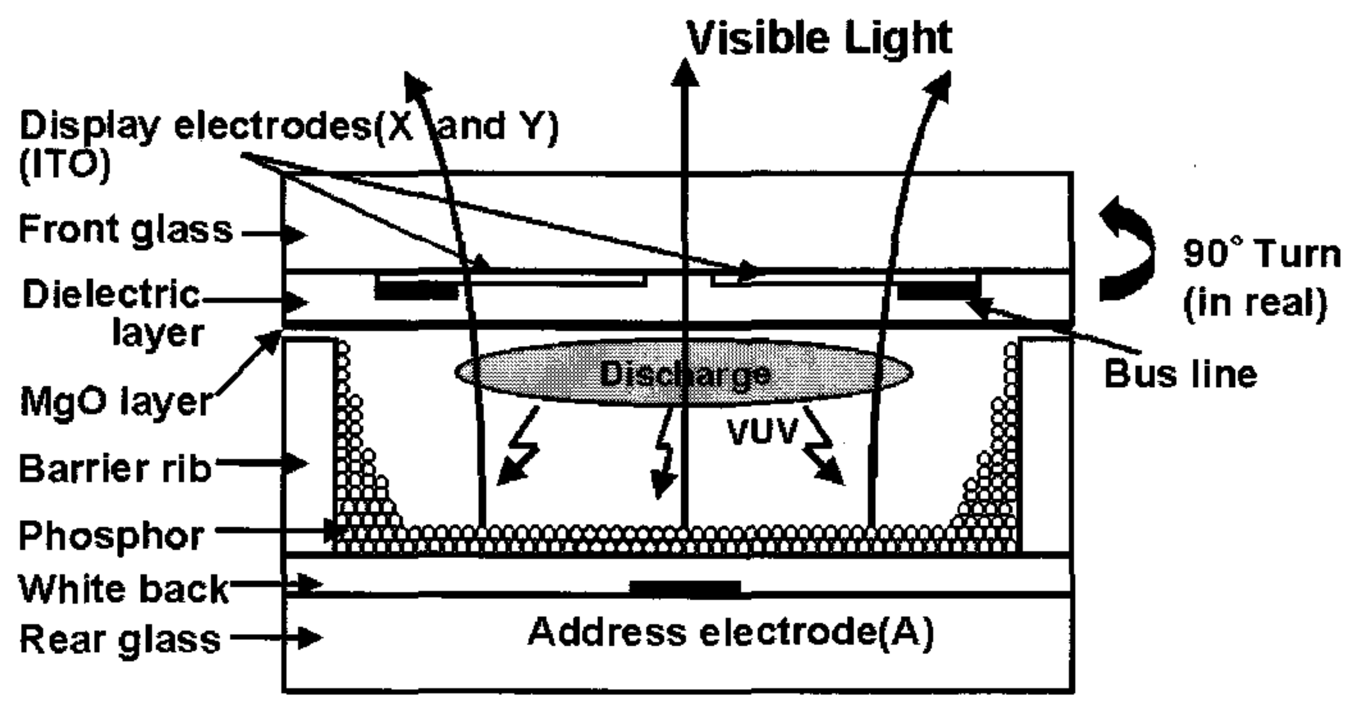

Fig. 1. Principal structure of a discharge cell in AC PDP.

Table 1. Specification of 4-inch AC PDP.

Front panel		Rear panel	
ITO width	310 μm	Address electrode width	100 μm
ITO gap	60 μm	White back thickness	15 μm
Bus width	100 μm	Rib height	150 μm
Dielectric thickness	25 μm	Rib pitch	360 μm
MgO thickness	5000 Å	Rib width	70 μm
		Phosphor thickness	20 μm

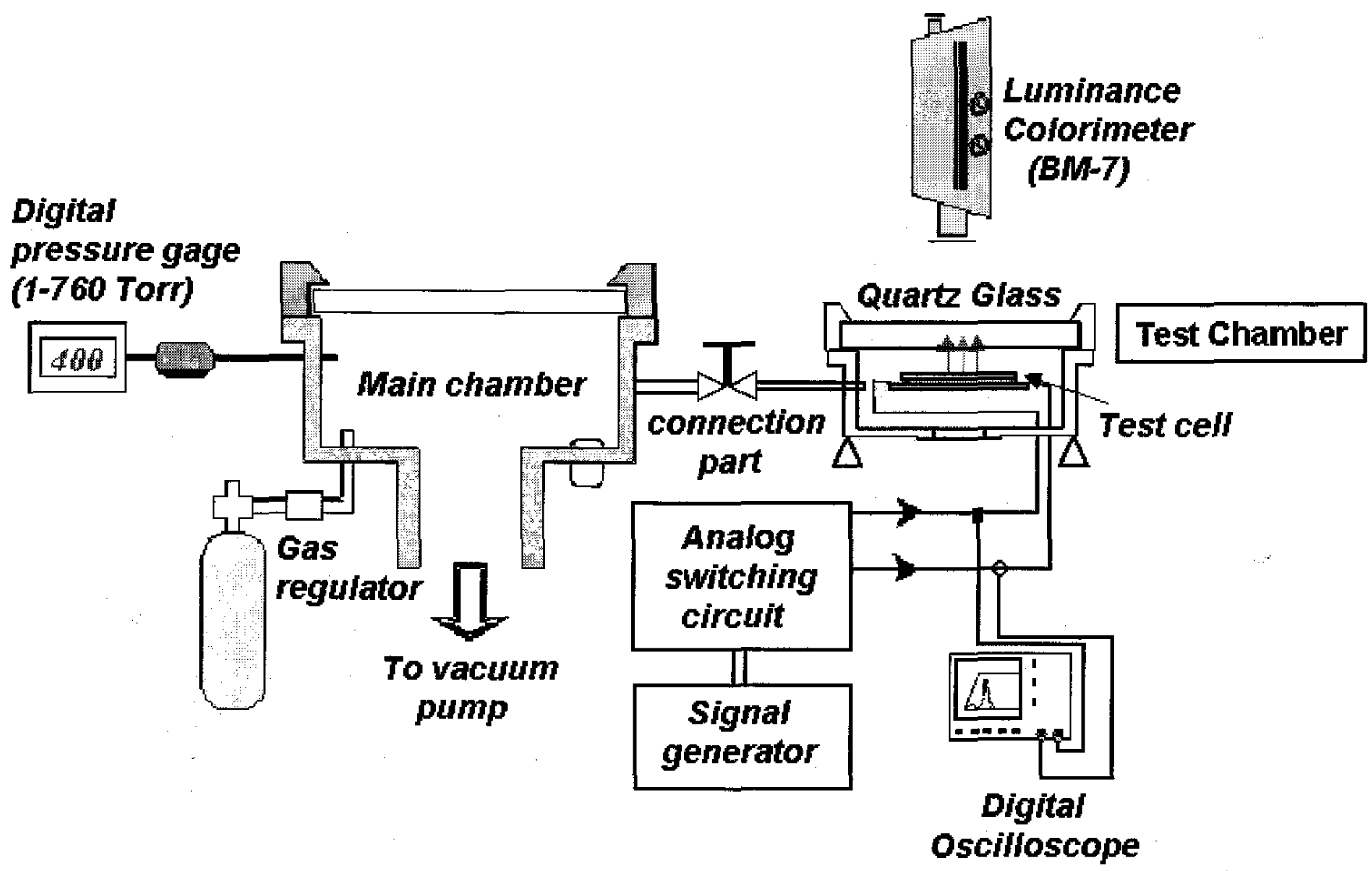

Fig. 2. The schematic diagram of test chamber for testing.

used in this study with VGA resolution.

Fig. 2 shows the schematic diagram of discharge test chamber and driving circuit for measuring the electrical and optical characteristics of test panel. The test chamber is connected to the main chamber, which is a cylindrical type with the diameter of 200 mm and the height of 80 mm with molecular pump vacuum system. The upper part of test chamber has a quartz window for investigating the optical characteristics.

The panel in the test chamber were baked in vacuum at 350℃ for two hours, exhausted up to ~10^{-7} Torr by molecular pump, and then at a given impurity gas ratio and working gas(He+Ne 70 %+Xe 4 %) were injected. The ratio of impurity gas to the working gas were varied in the range of $2\times10^{-3} \sim 10\times10^{-3}$. After the test chamber was filled with discharge gas of 400 Torr, the firing voltage, sustaining voltage, luminance and discharge current waveform of the test panels are tested.

The applied ac pulse voltage was 210 V with 50 kHz and the duty ratio was 0.5.

The luminous efficiency was calculated using the following formula [17].

Luminous efficiency(lm/W)

$$= \frac{\pi \times \text{Luminance}(cd/m^2) \times \text{Display Area}(m^2)}{\text{Power consumption}(W)} \quad (1)$$

Power consumption(W)

$$= 2f\int_0^{T/2} v_s(t)(i_{on}(t) - i_{on}(t))dt \quad (2)$$

Where, f is the frequency, T is the period, i_{on} is the total current and i_{off} is the displacement current.

3. Results and Discussions

Fig. 3 shows the effect of impurity on the discharge voltage compared with that of the pure working gas, as a standard. As shown in Fig. 3, the discharge voltage increased significantly with the partial pressure of O_2 and CO_2 gases, whereas slightly with Ar, N_2 and H_2. Especially the sudden decrease in the discharge voltage with Ar at 400 Torr may because to be due to the Penning effect with Ne gas[18].

Under the condition of the impurity gas ratio of 2×10^{-3}, the discharge voltage for the impurity gas of CO_2, O_2, N_2, H_2 and Ar increased to about 15 %, 12 %, 4 %, 2.5 % and –8 %, respectively.

The effect of impurity gases such as CO_2 and O_2 on the electrical and luminous characteristics of AC PDP may come from the negative-ion formation by the electro-negative gases[19]. It is well known that the negative ions formation gas suppresses the spark breakdown by forming negative ions. However, in the discharge plasma, CO_2 gas reacts with MgO, to form $MgCO_3$, which is an irreversible reaction. Furthermore, the $MgCO_3$ has a low γ-coefficient than MgO. The highest discharge voltage of CO_2, as shown in Fig. 3, may be due to the $MgCO_3$ on the MgO surface[20].

Fig. 4 shows the effect of impurity gases on the luminance. As shown in Fig. 4, the luminance decreased significantly with the increase in the impurity gases, especially in H_2, O_2 and CO_2. Under the condition of the impurity gas ratio of 2×10^{-3} for the Ar, N_2, H_2, CO_2 and O_2, the luminance decreased to about 10 %, 10 %, 40 %, 45 % and 60 %, respectively.

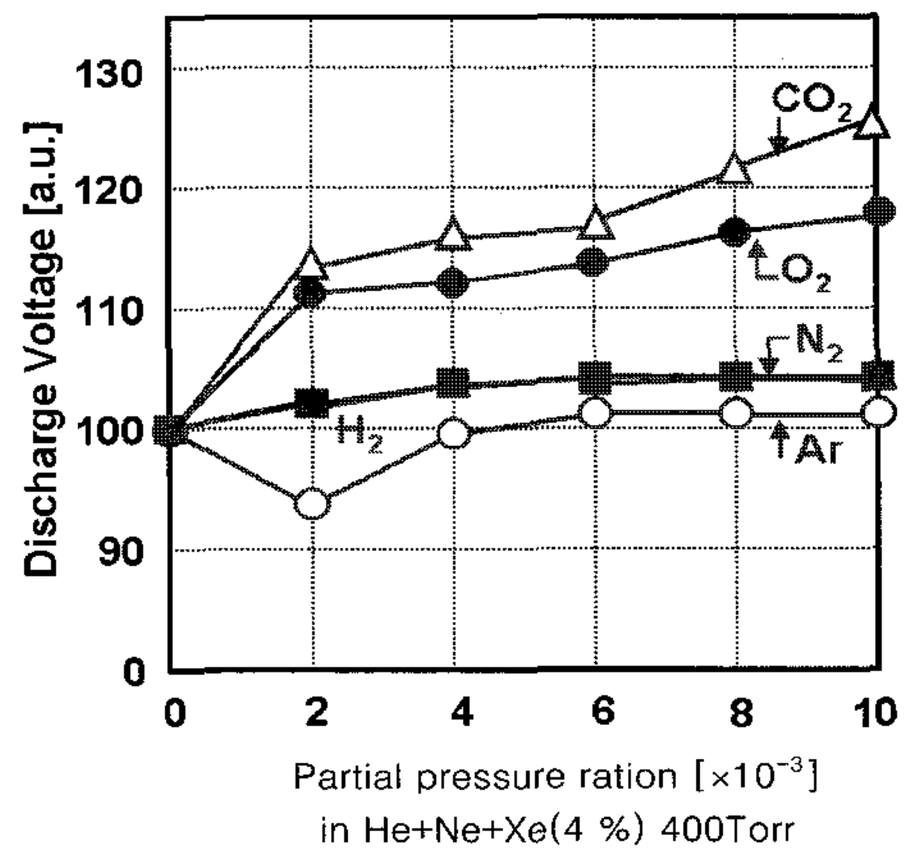

Fig. 3. Effect of impurity gas on the discharge voltage of AC PDP.

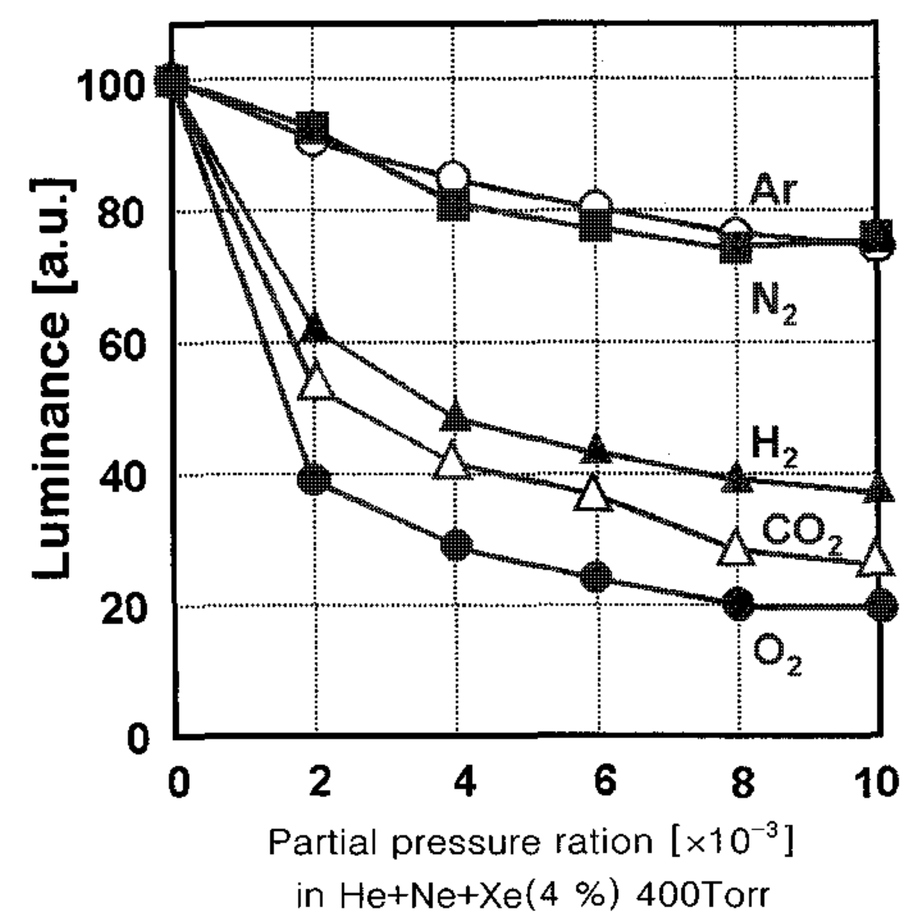

Fig. 4. Effect of impurity gas on the luminance of AC PDP.

Fig. 5 shows the effect of the given impurity gas on the luminous efficiency, which are very similar to those shown in Fig. 4. With the presence of impurity gas ratio of 2×10^{-3} for the impurity gas of Ar, N_2, H_2, CO_2 and O_2, the luminous efficiency decreased to about 8 %, 8 %, 32 %, 36 % and 50 %, respectively.

As mentioned above, the effect of impurity gas such as CO_2, O_2, and H_2 on the discharge voltage, luminance and luminous efficiency are very significant. Here, it may be worth pointing out whether the characteristics of discharge voltage and luminance of AC PDP is recovered or not when the contaminated gas was changed with a new working gas.

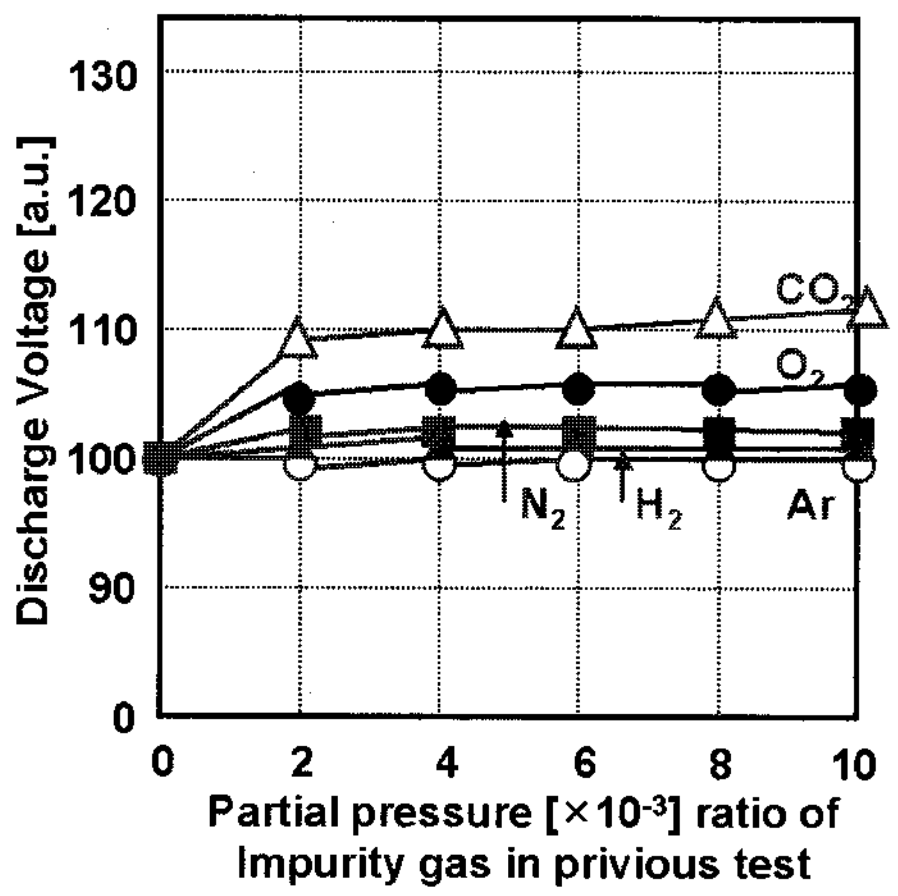

Fig. 6. Discharge inception voltage characteristics when the given contaminated gas is changed with new working gas after testing.

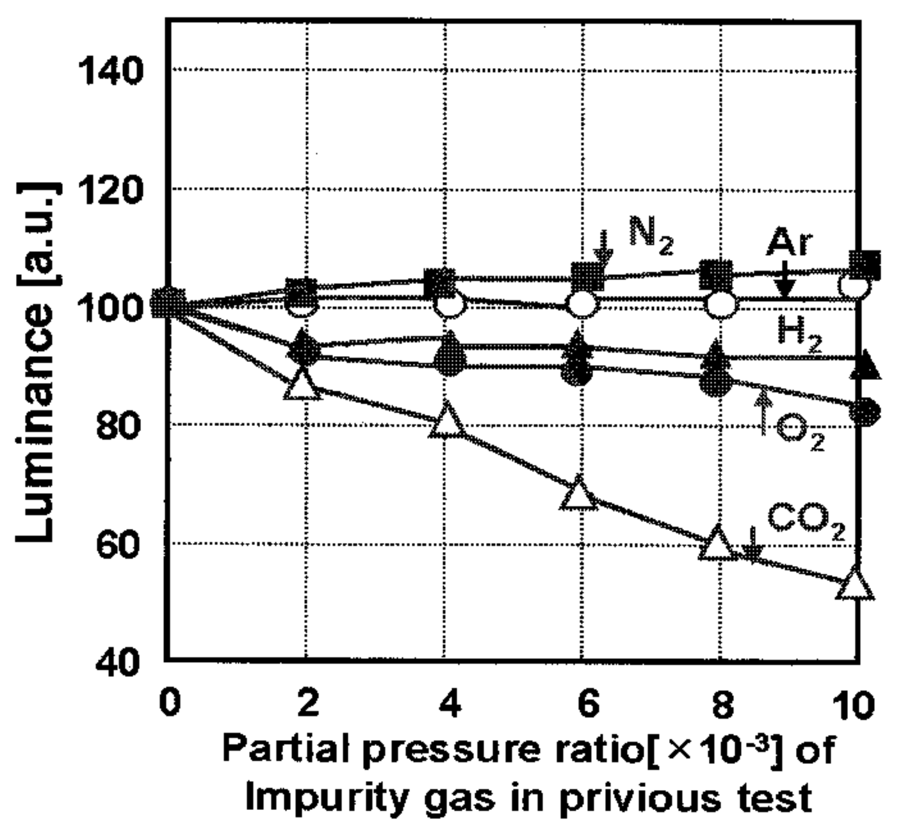

Fig. 7. Luminance characteristics when the given contaminated gas is changed with new working gas after testing.

Figs. 6 and 7 show the discharge voltage and luminance characteristics when the contaminated working gas is degassed and refilled with a new working gas of He+Ne 70 %+Xe 4 % with 400 Torr.

As shown in Figs. 6 and 7, the discharge voltage and luminance characteristics with N_2, Ar and H_2 are almost recovered, whereas those with O_2 and CO_2 are not. The reasons may be due to the following assumptions.

As mentioned in Fig.3, the CO_2 gas makes $MgCO_3$ on the MgO. Furthermore, this reaction is irreversible [20]. Therefore, the discharge and luminance characteristics are not recovered.

Especially, O_2 gas also degasses mostly with other impurity gasses. However, the O_2, or O gas from the dissociation of O_2 gas in the discharge plasma have high electron affinity coefficient as shown in Table 2. Therefore, the small amount of O_2 gas affects signify-cantly influences the discharge voltage and luminance characteristics.

Table 2. Electron affinity of some important gases.

Kind of atom or molecule	Electron affinity [eV]
F	3.94
B	3.70
Br	3.54
I	3.22
O	3.80
O_2	~1.0
H	0.75
H_2	0.76
N	~0.04
N_2	0.04
Inert gases	≒ 0

4. Conclusion

In this paper, a small amount of impurity gas in AC PDP was introduced quantitatively and the relationship between the amount of impurity gas and the luminance/ discharge characteristics were investigated.

The luminous efficiency decreased seriously with increase in the partial pressure of impurity gases, especially in H_2, O_2 and CO_2. With the addition of the impurity gas ratio of 2×10^{-3} for Ar, N_2, H_2, CO_2 and O_2, the luminous efficiency decreased to about 8 %, 8 %, 32 %, 36 % and 50 %, respectively.

It is considered that the impurity gas, effect on PDP characteristics result from the negative- ion formation in the case of O_2 and H_2, and irreversible $MgCO_3$ formation on the MgO surface in the case of CO_2.

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