Spatiotemporal behavior of excited Xe atoms density in Counter discharged type AC-PDP

Young June Hong, Phil Yong Oh, Se hoon Jeong, Jong Hwa Hong, Jung Hyun Kim, Yong Gyu, Seok Ho Cho, Sung Hee Hong, Byoung Hee Hong and Eun Ha Choi

Charged Particle Beam and Plasma Laboratory / PDP research center
Dept. of Electrophysics, Kwangwoon University, Seoul, Korea 139-761
TEL:82-2-940-5662, e-mail:horakhti@hotmail.com

Keywords : laser absorption spectroscopy, counter discharge

Abstract

We have measured the excited Xe atoms density in the $1s_5$ metastable states by laser absorption spectroscopy in counter discharged type AC-PDP. This experiment has shown the characteristic of the excited Xe atoms density which is relation to the visible light efficiency of PDP. The density of counter discharged AC-PDP have measured to be 9.47×10^{13} cm^{-3}. The result has been shown to higher value than 1.45×10^{13} cm^{-3} of conventional AC-PDP.

1. Introduction

PDP uses the phosphor luminescence by VUV photons emitted from the excited Xe atoms in discharge plasma. Conventional type AC-PDP using co-planar discharge have several problems as low brightness, luminous efficiency and so on. Currently, many researchers have studied the advanced various structure to improve the efficiency.[1] One of the progressive type is counlter discharged AC-PDP. Figure 1 shows the schematic structures and dimension of the counter discharged AC-PDP in the experiment. The front plate doesn't need ITO and dielectric layer which decrease the luminance. Because this panel is addition to the reflective phosphor structure on the rear plate and phosphor layer on the front plate, the luminance can be improved. [2] We have measured the spatiotemporal behavior of excited Xe atoms density for the $1s_5$ metastable states in counter discharged type AC-PDP.

2. Experimental

The surface discharged alternating current plasma display panels uses the photoluminescence phenomena of phosphors excited by VUV (Vacuum Ultra Violet) from mixture gas included.

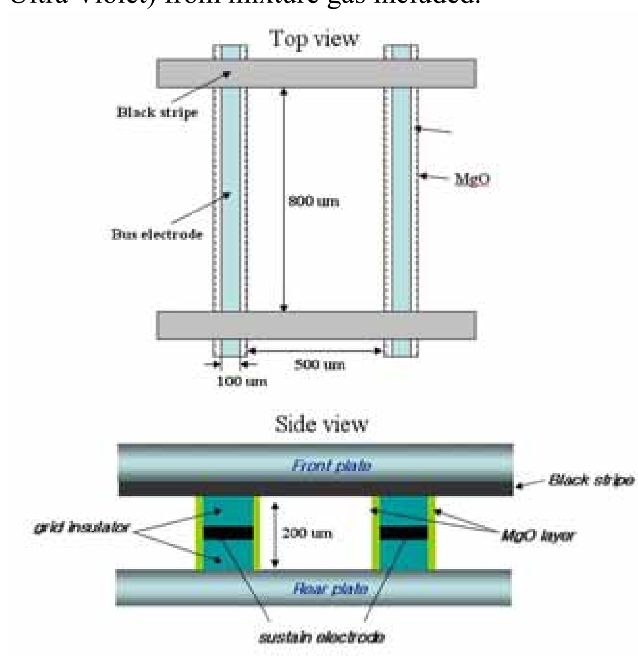

Fig. 1. Counter discharge type AC-PDP

The xenon atoms in the $1s_5$ metastable state generate 173 nm of VUV light in Xe plasma. The intensity of VUV 173 nm emission is proportional to that of the IR 823 nm emission. We have studied the excited Xe atoms density in AC-PDP by laser absorption spectroscopy (LAS).[3] The basic parameter of excited Xe atoms density is connected with high luminous efficiency from AC-PDP. Figure 2 is schematics of laser absorption spectroscopy used in this experiment.

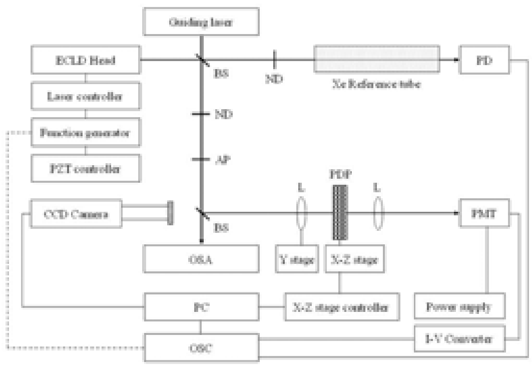

Fig. 2. The schematic of laser absorption spectroscopy

The tunable diode laser system consist of current, temperature, and piezoelectric-transducer (PZT) controllers. For making fine-frequency adjustments, ramp modulation signal with 10 Hz generated from function generator apply for the PZT controller. The laser diode's output frequency is swept in 0.032 nm per one voltage by the PZT controller. In this experiment, the scanning laser frequency of interest is less than 20 GHz. For the whole absorption line profile of Voigt broadening in AC-PDP, 1.4 V from function generator in applied to the PZT controller under center wavelength of 823.1 nm. [4] The measurement of absorption signal is based on the determination of absorption coefficient k_v from the spectral intensity

$$I_v = I_0 \exp(-k_v x) \qquad (1)$$

Which is transmitted through an absorption path length x, where I_0 and I_v are the incident IR probe beam intensity, respectively. An absorption path length x is the height of test panel's barrier rib and k_v , obtained from $-(1/x)\ln(I_v/I_0)$, is the absorption coefficient per unit length over the scanning frequency. When the IR probe beam with I_v is incident on a PDP cell, it occurs absorption from the $1s_5$ metastable state. The level N_1 of excited Xe density expressed as

$$N_1 = \frac{k_0^{'}}{H}\frac{\Delta v_D}{2}\sqrt{\frac{\pi}{\ln 2}}\frac{8\pi}{\lambda_0^2}\frac{g_1}{g_2}\frac{1}{A_{21}} \qquad (2)$$

where λ_0 is center wavelength which is occurring the maximum absorption, g_1 and g_2 which are the statistical weights of the lower and upper levels of the transition.[5] A_{21} is probability per second of a spontaneous jump from upper level to the lower level. Δv_d is Doppler width, H is correction factor and $k_0^{`}$ is maximum absorption coefficient in PDP cell. The unit of N_1 in Eq. (2) is in cm^{-3} and λ_0 is in unit of cm. The absorption coefficient k_v in Eq. (2) shows pressure broadening voigt profile over the scanning frequency range.

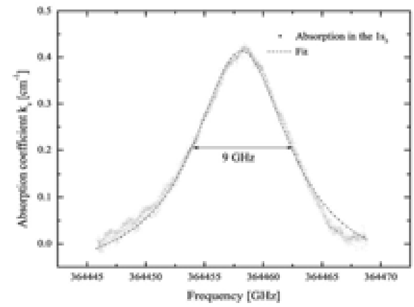

Fig. 3. Voigt absorption line profile in the 1s5 metastable state.

Figure 3 shows pressure broadening of Voigt absorption line profile 823.1 nm in center wavelength for excited Xe atoms in the metastable ($1s_5$). This pressure broadening line width is measured to be 9 GHz in the $1s_5$ metastable states. We have observed the spatio-temporal behavior for metastable states Xe atoms in Counter discharged type AC-PDP which have dimension and structure shown figure 1.

3. Results and discussion

Figure 4 is shown before and after discharge image in Counter discharged type AC-PDP. The PDP cell has been operated by square pulse 208V of the driving frequency 35 kHz with the duty ratio of 25 %. And the discharge space between front and rear panel was filled by mixture gas of Ne-Xe (10%) with pressure of 460 Torr. To transmit the IR laser beam, rear glass has not been used addressing electrodes and phosphor.

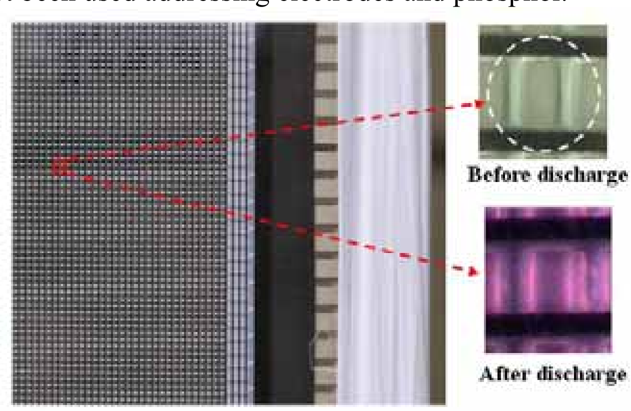

Fig. 4. The discharge image of Counter discharged type AC PDP cell.

It will be able to confirm the discharge features which happen with bus electrode surroundings. The 823 nm laser beam with 30 um diameter size was incident upon one cell in this panel. We obtained the absorption signals for each scanning point shown to figure 5 in PDP cell.

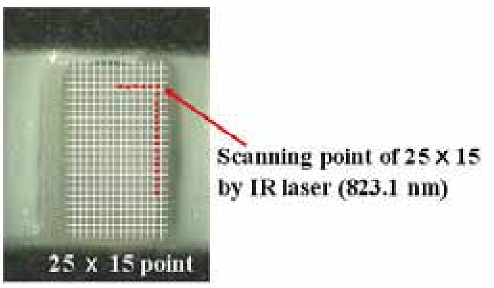

Fig. 5. The scanning points.

The voltage signal shown figure 6 represent to the result after laser absorption for plasma discharge.

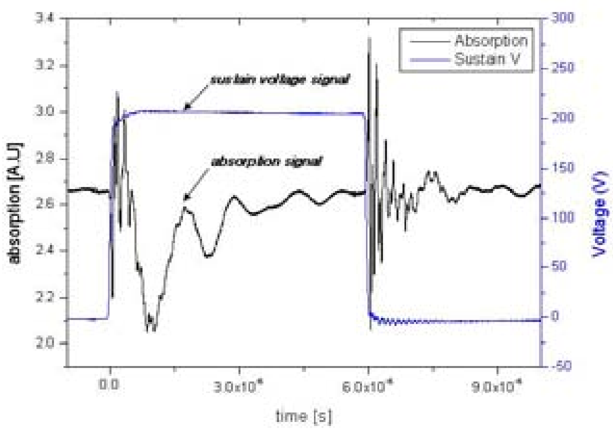

Fig. 6. The voltage signal of laser absorption.

We are able to express the spatiotemporal behavior from the intensity which is transmitted through discharge space in PDP cell. Figure 7 shows the spatiotemporal behavior of excited Xe ($1s_5$) atoms density from 420 ns to 2400 ns. The Xe atoms density comes in sight beside the anode at 460 ns. At 820 ns, the density is measured to be maximum 9.47 x 10^{13} cm^{-3} and decay until 2.5 us. The maximum excited Xe atoms appeared to the earlier time than 1us of co-planar electrode type. But, the decay time was the same as 2.5 us in case of both the counter discharged and co-planar electrode type.[6] The excited Xe atoms decayed more quickly at anode region than cathode. The excited Xe locally crowed around the barrier rib which is included sustain electrode, and then spread out toward inside of discharge unit cell. Figure 8 is time integrated IR emission image. It appeared the same pattern of the spatiotemporal behavior of Xe atom density.

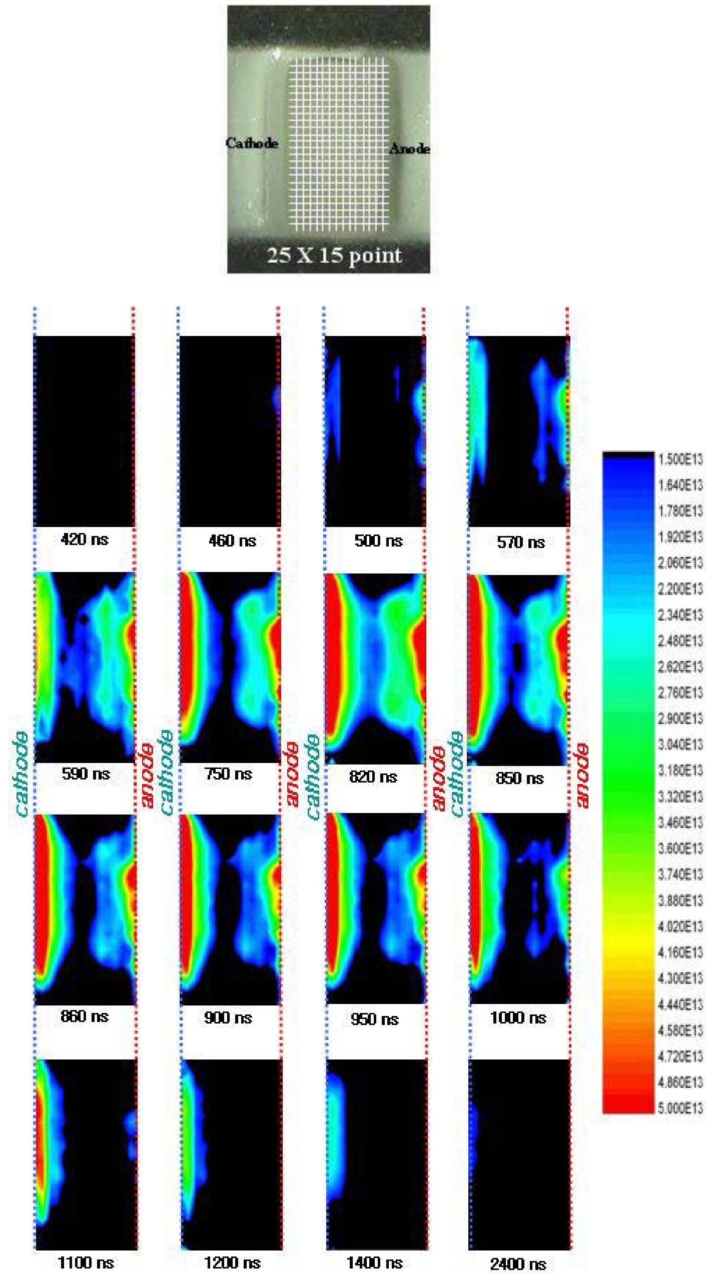

Fig. 7. Spatiotemporal behavior of excited Xe ($1s_5$) atoms density.

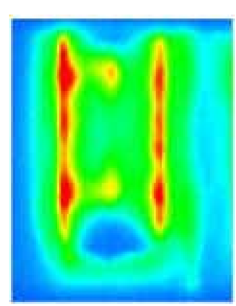

Fig. 8. IR emission image

4. Summary

The Xe atoms maximum density of Counter discharged type was 9.47×10^{13} cm^{-3}. This value is much higher than 1.45×10^{13} cm^{-3} of co-planar electrode type.[7] The discharge pattern appeared around barrier rib which is included sustain electrode. This result can give the important influence on the visible light efficiency.

5. References

1. Se Hoon Jeong, P. Y. Oh, Y. J. Hong, S. B. Lee, M. W. Moon, K. B. Song, H. J. Lee, N. L. Yoo, C. G. Son, Y. G. Han, S. J. Jeong, J. H. Kim, E. Y. Park, and Eun Ha Choi, "Measurement of excited Xe atoms density in accordance with various barrier ribs in AC-PDP by laser absorption spectroscopy", IMID/IDMC `06, pp. 949 ~ 952
2. Naoya Kikuchi, Masayuki Hioshima, Hideyuki Asai, and Susumu Sakamoto, "Development of new Structure AC-PDP using Thick Film Ceramic Sheet Technology", IMID 2003
3. K. Tachibana, S. Feng, and T. Sakai, "spatiotemporal behaviors of excited Xe atoms in unit discharge cell of AC type plasma display panel studied by laser spectroscopic microscopy", J. Appl. Phys, 88, No. 9, pp. 4967 ~ 4974, 2000
4. Phil Yong Oh, Jun Ho Lee, Se Hoon Jeong, Han Seb Moon, Soo Beom Lee, Ki Baek Song, Yoon Jung, Yunki Kim, Gaungsup Cho, Han S. Uhm and Eun Ha Choi, "Measurement of Excited Xe Atoms Density in Alternating Current Plasma Display Panel by Means of Laser Absorption Spectroscopy", IEEE TRANSACTIONS ON PLASMA SCIENCE, VOL. 34, NO. 2, APRIL 2006, pp. 317 ~ 323
5. K. C. Harvey and C. J. Myatt, "External-cavity diode laser using a grazing-incidence diffraction grating", Optics letters, vol. 16, 1991, pp. 910 ~ 912
6. S. H. Jeong, P. Y. Oh, J. H. Hong, J. H. Kim, S. J. Jung, Y. G. Han, M. W. Moon, K. B. Song, C. G. Son, S. B. Lee, N. L. Yoo, Y. J. Hong, E. Y. Park, B. C. Park, B. H. Hong and E. H. Choi, "Measurement of spatiotemporal behavior excited Xe atoms density in the $1s_5$ in accordance with various barrier ribs in AC-PDP", IDW `06, pp. 1135 ~ 1138
7. S. H. Jeong, P. Y. Oh, J. H. Hong, J. H. Kim, S. J. Jung, Y. G. Han, M. W. Moon, K. B. Song, C. G. Son, S. B. Lee, N. L. Yoo, Y. J. Hong, E. Y. Park, B. C. Park, B. H. Hong and E. H. Choi, "Measurement of spatiotemporal behavior excited Xe atoms density in the $1s_5$ in accordance with various barrier ribs in AC-PDP", IDW `06, pp. 1135 ~ 1138