Measurement of excited Xe(1s$_4$) and Xe(1S$_5$) atoms by laser absorption spectroscopy in coplanar AC-PDP

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ABSTRACT

The laser absorption spectroscopy has been used for measuresurement of the xenon atoms in the resonant 1S$_4$ and metastable 1S$_5$ states in coplanar AC PDP. For the purpose of improving VUV luminous efficiency and optimization of PDP cells, it is important to study behavior of excited Xe atoms in a micro-discharge cell of a coplanar AC-PDP. We measured the xenon excited density of 1S$_5$ and 1S$_4$ state under mixture gas of Ne-Xe(10%) with gas pressure of 350 Torr and sustaining gap distance of 150 um .

INTRODUCTION

Plasma display panels have been adopted in commercial display market. However, some important problems are still disadvantageous than CRTs. To be overcome improving PDP$_S$ luminous efficiency, it is need to research optimization of PDP cells design and gas condition. The xenon atoms in the resonant 1S$_4$ and metastable 1S$_5$ generate the VUV rays related to the excited Xe* (147nm) and Xe$_2^*$ (173nm) dimers in Xe plasma, respectively. It is found that the intensity of VUV 147nm emission is proportional to that of the IR 828 nm emission, and the VUV 173nm emission is roughly proportional to that of the IR 823nm emission[1,2].

In this study, we use a diode laser to carry out laser absorption spectroscopy of excited Xe atoms. This enable to measure the hyperfine splittings of one of the excited states of Xe. Tunable diode laser has been employed for optical spectroscopy because of its narrow linewidiths, large tuning ranges and stable outputs. Laser absorption spectroscopy(LAS) is based on the optical absorption when probe IR beam is passed through the PDPs cell [3]. We have measured absorption spectra for absorption coefficient from the spectral intensity transmitted through an finite path length of the PDP's micro discharge plasma.

Experimental Configuration

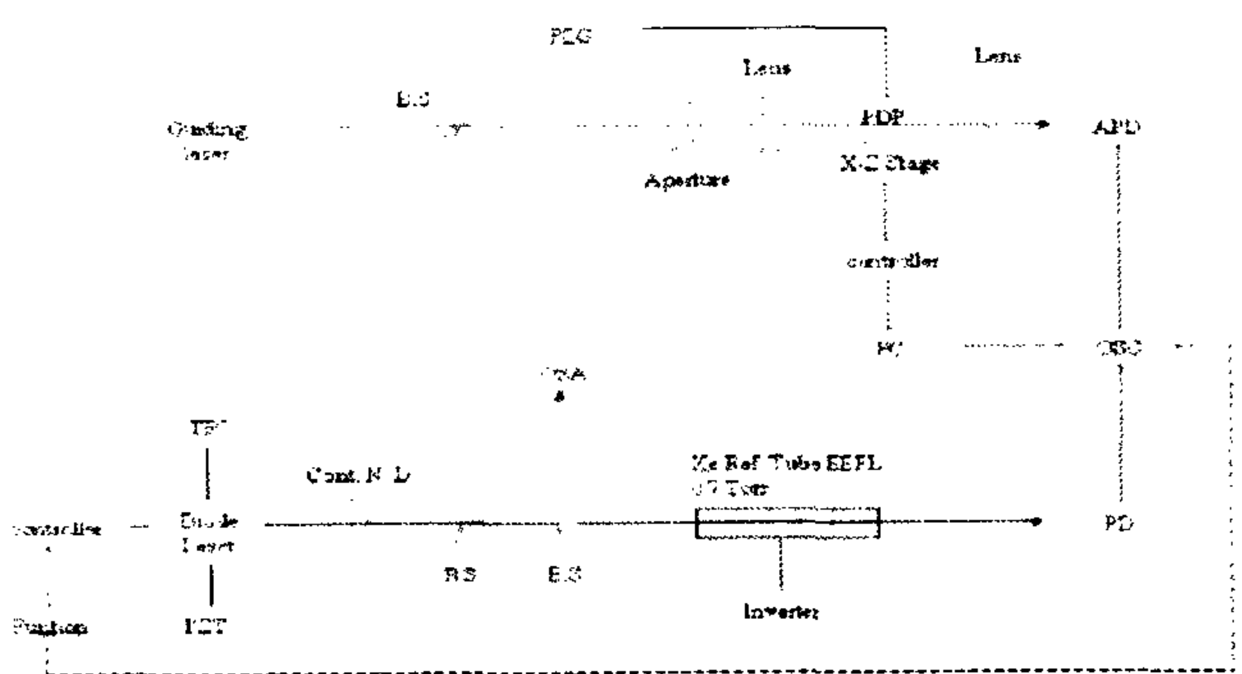

Fig. 1. The schematic of laser absorption spectroscopy.

Figure 1 shows experimental schematics of laser absorption spectroscopy used in this experiment. Diode laser system consists of current, temperature, and piezoelectric-transducer(PZT) controllers. The PZT controller is employed for fine tuning of wavelength. We make use of Littman type which is tuned by a rotating mirror with high reflectivity along with a fixed diffraction grating in the external cavity. Modulation method of laser is useful for making fine-frequency adjustments. We make use of sawthooth wave modulation signal with 10 Hz generated from function generator. Probe IR beam is splitted into two directions by beam splitter. The first beam is sent into a Xe reference tube made of external electrode fluorecent tube (EEFL), which is used to monitor the laser's frequency during absorption processes. The EEFL Xe reference tube is filled with pure Xe gas of 0.7 Torr. The second IR probe beam has been transmitted through a PDPs cell containing Ne-Xe(4%) gas mixtures of 350 Torr., and then the absorbed signal has been fed into the photodectector. To transmit laser beam, rear glass has no addressing electrodes, barrier ribs and phosphors. A MgO protective layer is deposited on the dielectric layer by the electron beam evaporation method with 0.5 um in thickness. The cell pitch is set to be 1080 um, and the electrode width is maintained at 300 um. The sustaining discharge in AC-PDP occurs between the parallel-sustaining electrodes of X and Y. The sustaining electrode gap has been kept to be 150 um in this experiment. Spacer of 130 μm, as a role of barrier rib, in height are located between the front and rear glasses in the AC-PDPs. And the discharge space between front and rear panel is filled with gas mixture of Ne-Xe(10%) with its pressure of 350 Torr. The diode laser beam has a spectral width of 3.66 MHz around at 823.1 nm and 5.29 MHz around at 828 nm, respectively, and beam diameter of 10 um in this experiment. It is also noted the wavelength of diode laser can be adjusted from 820 nm to 830 nm

Experimental Results and Discussions

Figure 2 shows a schematic of the unit discharge cell scanned by laser IR probe beam across the electrode gap of 150 um. The scanning distance between the left blackstripe to the right one is 800 um in this experiment.

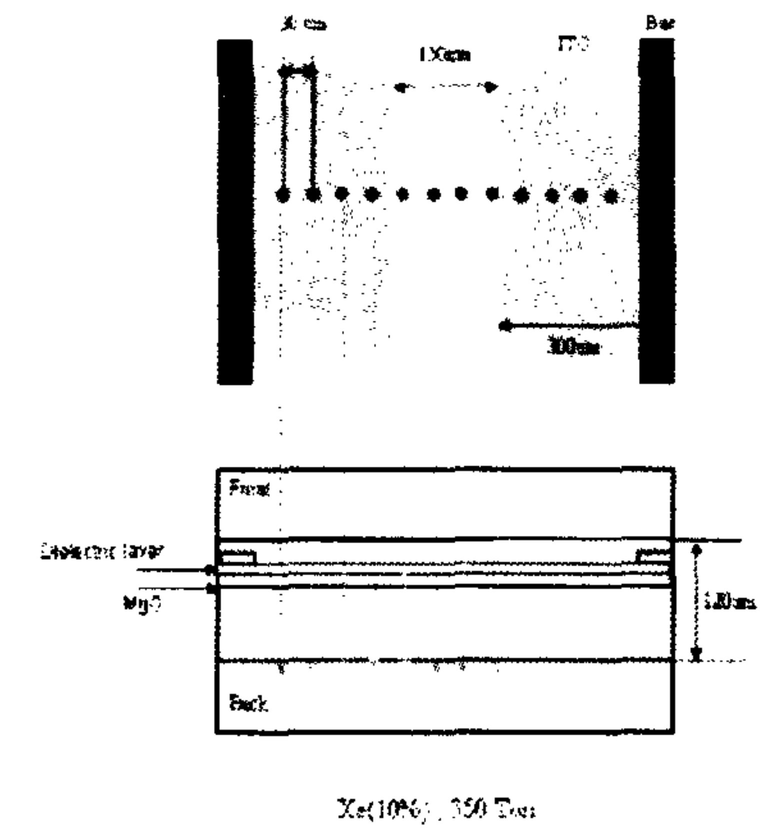

Fig. 2. Unit discharge cell scanned by laser IR probe.

Figure 3 shows pressure broadening of Voigt absorption line profile of 823.1 nm for excited metastable xenon atoms (1S5) at a position of 270 um away from the left blackstripe side under high pressure of 350 Torr. This pressure broadening line width is measured to be 7 GHz around 823.1 nm, which is about 13 times broader than the Doppler line width of 550.9 MHz in this experiment. It is noted that the atoms are subject to frequent collisions due to high gas pressure in AC-PDPs.

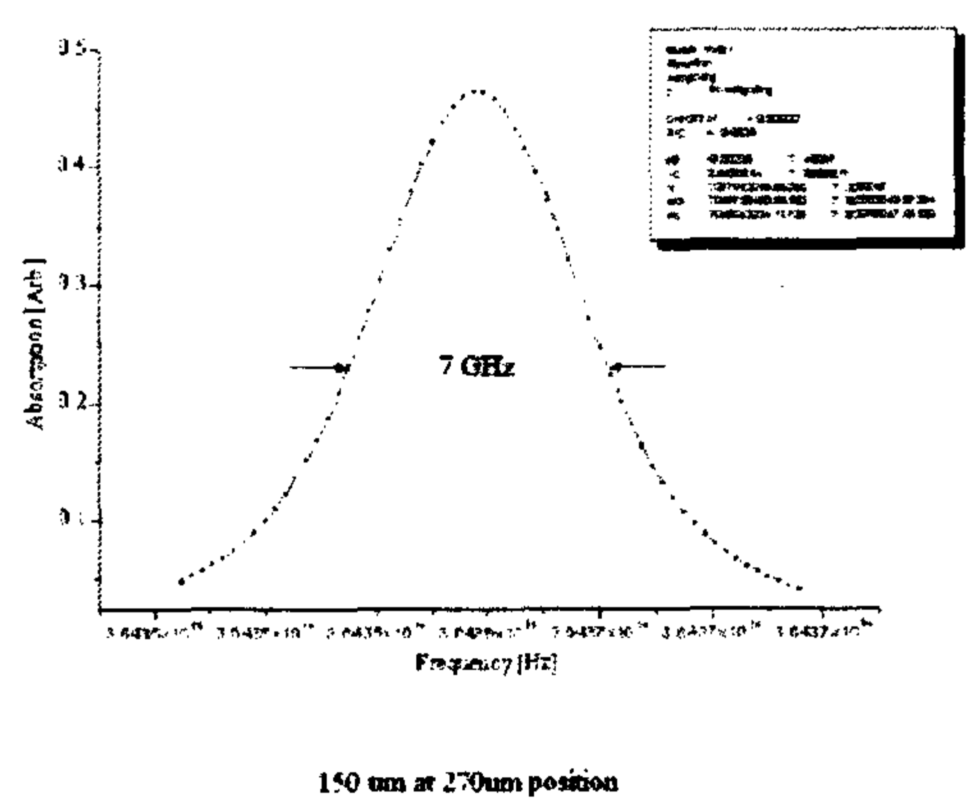

Fig. 3. Voigt absorption line profile of 823.1 nm.

It is also noted that the pressure broadening line width for excited resonant xenon atom ($1S_4$) is measured to be 22 GHz around 828 nm, which is about 44 times broader than the Doppler line width of 500.5 MHz in this experiment. Fig. 4 shows the spatial density distribution of excited resonant ($1S_4$), designated by soild squares, and metastable ($1S_5$) xenon states, denoted by solid circles, respectively, across the electrode gap under the sustaining electrode gap of 150 um in actual coplanar AC-PDPs. The center of gap is noted to be 450 um for gap distances 150 um in this experiment. It is noted that the maximum excited resonant ($1S_4$) and metastable ($1S_5$) xenon densities are 5.7 x $10^{11}cm^{-3}$ and 2.2 x $10^{12}cm^{-3}$, respectively, for sustaining electrode gap 150 um and gas pressure of 350 Torr in real AC-PDPs. It can be seen that there are at least almost 2 symmetric peaks in both spatial distribution of excited resonant ($1S_4$) and metastable ($1S_5$) xenon densities with respect to the central position of 450 um. It is noted here that these main peaks of excited xenon atoms have been occurred adjacent to inner boundary regions between ITO and bus electrode, which are in good agreement with those of striations[4].

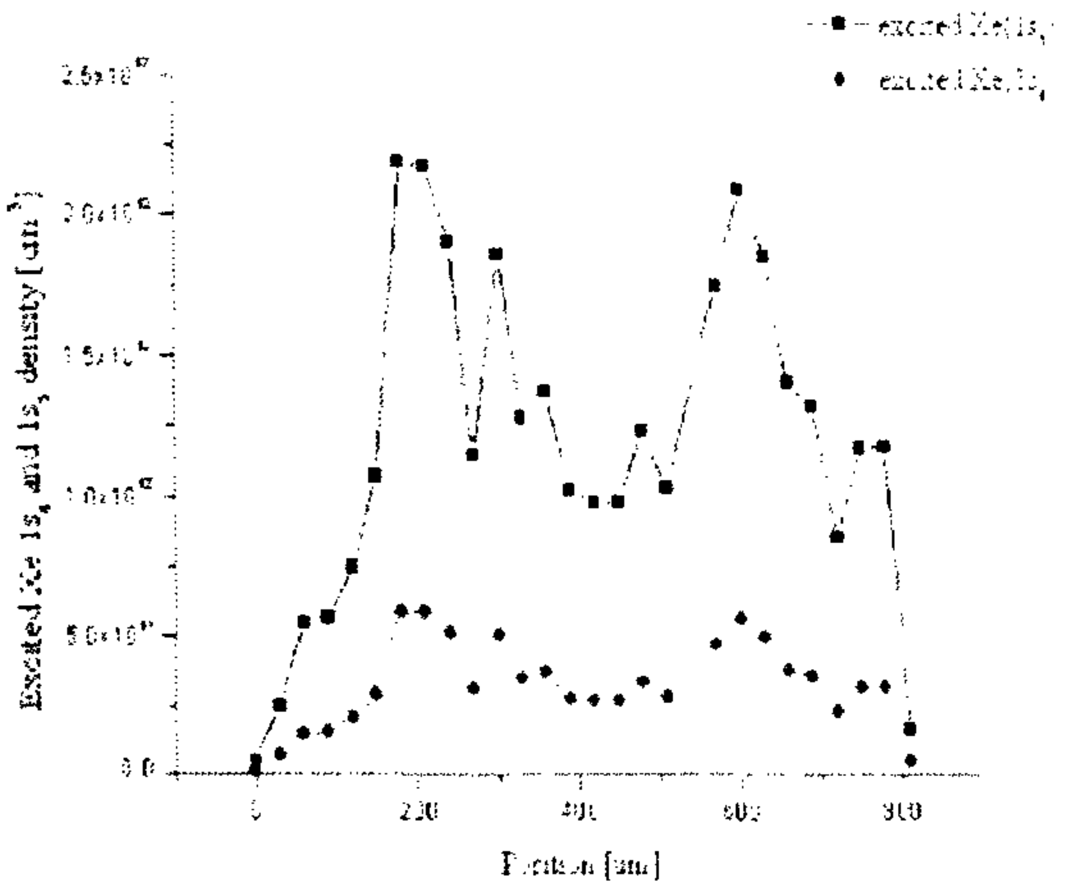

Fig. 4. Spatial density distribution of excited resonant ($1S_4$) and metastable ($1S_5$) xenons under the sustaining electrode gap of 150 um in actual coplanar AC-PDPs.

Conclusion

It is found that the maximum excited resonant ($1S_4$) and metastable ($1S_5$) xenon densities are 5.7 x $10^{11}cm^{-3}$ and 2.2 x $10^{12}cm^{-3}$, respectively, for sustaining electrode gap 150 um and gas pressure of 350 Torr in real AC-PDPs. We might think that several peaks in the excited xenon atoms can be regarded as influence of striations in AC-PDPs

References

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