Measurement of the excited Xe atoms density of matastable state($1S_5$) under various binary gas mixtures(Ne-Xe) by Laser Absorption Spectroscopy.

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Abstract

We have developed laser absorption spectroscopy system for the measurement of excited Xe atoms in micro-discharged AC-PDP plasma. In this study, we have measured the absorption signals for the $1S_5$ *xenon metastable state in the PDP cell with the various gas mixtures of Ne-Xe(1%), Ne-Xe(4%) and Ne-Xe(10%) under fixed gas pressure of 350 Torr and the eletrode gap distance of 50um. It is found that the maximum excited xenon densities are* $1.2*10^{12}\ cm^{-3}$, $1.8*10^{12} cm^{-3}$ *and* $2.7*10^{12} cm^{-3}$ *for gas mixtures of Ne-Xe(1%), Ne-Xe(4%) and Ne-Xe(10%) respectively, in this experiment.*

1. Introduction

The xenon atoms in the $1S_4$ and $1S_5$ generate excited Xe^* (147nm) and Xe_2^* (173nm) dimers in Xe plasma. 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] The laser absorption spectroscopy (LAS) is useful to investigate the behavior of such species.[3] The excited xenon density measured in a micro-discharge cell of PDP by near infrared laser of 823nm. We look into the influence of the sustain electrode gap on excited xenon atom in the $1S_5$ metastable state by laser absorption spectroscopy to research influence of the degradation time in AC PDP.

2. Experiment

We used a diode laser to carry out the laser absorption spectroscopy of Xe atoms in this experiment. The diode laser offers many benefits compared to conventional sources for atomic absorption spectroscopy. Their stability, low-cost, simplicity, narrow line-widths, and rapid tenability make diode lasers advantageous sources compared to traditional gas lasers. Diode laser absorption spectroscopy based on wavelength modulation (WM) techniques, is a powerful technique for gas concentration measurements where high sensitivity and fast response time are requires. We use the technique of WM absorption spectroscopy to study the lines ($1S_5$ metastable state) with the Voigt profile.

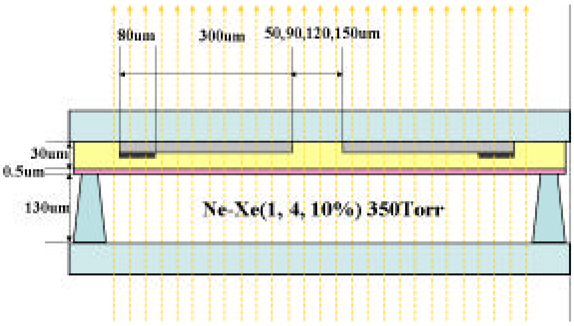


Fig. 1. 5x5 Test panal

Figure 1 shows the test panel which was used in this experiment. The sustaining electrodes that are covered with dielectric layers of 30um in thickness are parallel to each other in front glass. To transmit laser beam, rear glass have no addressing electrodes, barrier rib and phosphor. The 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 bus electrode width is maintained at 80 um. The sustaining discharge in AC-PDP occurs between the parallel-sustaining electrodes of X and Y which are separated by the range of 50 um, 90um, 120 um and 150 um. Spacer of 130 µm, as a role of barrier rib, in height are located. And the discharge space between front and rear panel is filled by mixtures gas of Ne- Xe(1%), Ne- Xe(4%) and Ne- Xe(10%) with its pressure of 350 Torr.

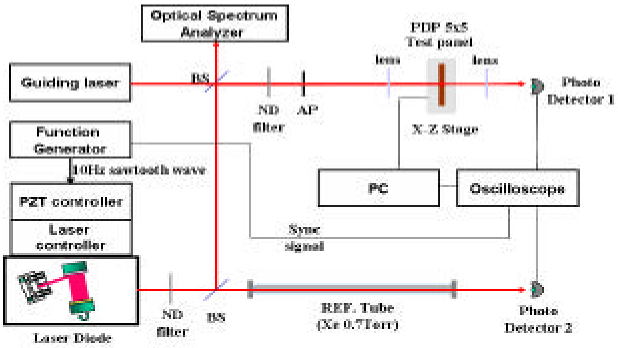


Fig. 2. Schematic diagram of this experiment

Figure2 shows the Schematic diagram of 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. The laser frequency has been adjusted by an order of –30GHz to +30GHz by sweeping the PZT voltage from –3V to +3V in this experiment. 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 gas pressure of 350 Torr., electrodes gap distance of 50um and then the absorbed signal has been fed into the photo-dectector. To transmit laser beam, rear glass has no addressing electrodes, barrier ribs and phosphors.

3. Result and Discussion

Due to xenon atom's thermal energy the frequency spectrum of xenon atom experiences Doppler shift. This Doppler shift results in a broadening of the line, whose half –line width can be written by[4],

$$\Delta_D = 2\frac{\sqrt{2R\ln 2}}{c}\nu_0\sqrt{\frac{T}{M}} = 7.16\times 10^{-7}\sqrt{\frac{T}{M}}\nu_0$$

Where T is the absolute temperature in Kelvins, and M is the atomic number of Xe.

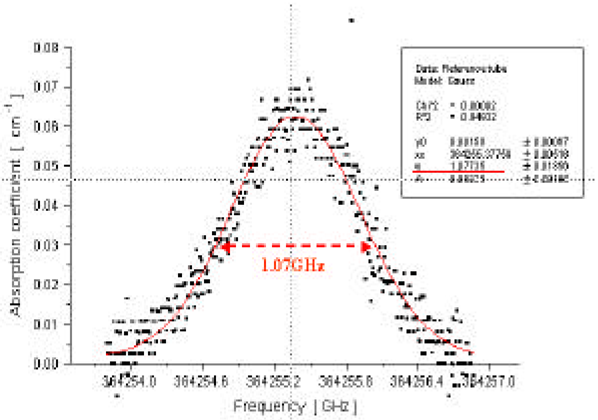
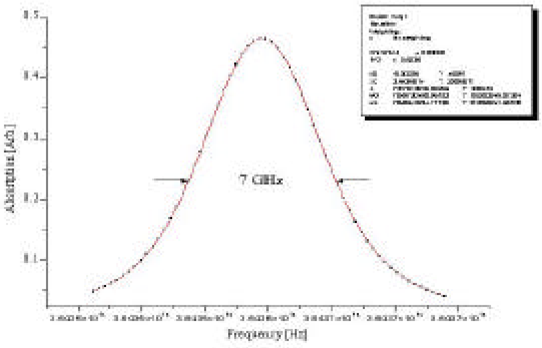


Fig. 3. Absorption coefficient vs. frequency in refernce tube

Figure 3 shows absorption coefficient of the excited xenon atoms in metastable $1S_5$ states according to frequency in reference tube. It is note that FWHM of reference tube is 1.07GHz.



150 um at 270um position

Fig. 4. Voigt absorption profile of matastable in AC-PDP

Figure 4 shows pressure broadening of Voigt absorption line profile of 823.1 nm for excited metastable xenon atoms ($1S_5$) at a position of 270 um away from the left blackstripe side under pressure of 350 Torr. This pressure broadening line width is measured to be 7 GHz around 823.1 nm, which is about 7 times broader than the Doppler line width of 1.07 GHz for reference pure xenon EEFL tube of 0.6 Torr. It is noted i that the atoms are subject to frequent collisions due to high gas pressure in AC-PDP in this experiment.

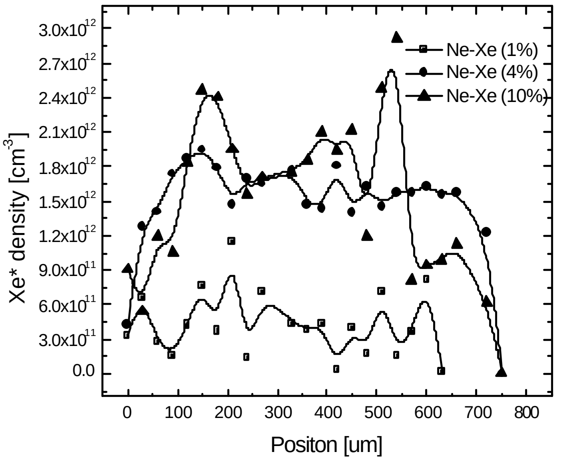


Fig. 5. Spatial distribution of excited metastable ($1S_5$) xenon density under the gas mixtures Ne-Xe(1%), Ne-Xe(4%) and Ne-Xe(10%)in actual coplanar AC-PDPs.

Figures 5 show the spatial distribution of excited xenon densities of $1S_5$ metastable state across the electrode gap for the gas mixtures of Ne-Xe(1%), Ne-Xe(4%) and Ne-Xe(10%) respectively. The beam diameter of diode laser is 10 um and it has been scanned by laser IR probe beam across the electrode gap. It is noted that the maximum excited xenon densities are $1.2*10^{12}cm^{-3}$, $1.8*10^{12}cm^{-3}$ and $2.7*10^{12}cm^{-3}$ for the gas mixtures of Ne-Xe(1%), Ne-Xe(4%) and Ne-Xe(10%), respectively. It can be seen that there are at least almost 2 symmetric peaks in spatial distribution of excited xenon density with respect to the central position for a given sustaining electrode gap. These main peaks in spatial distribution of excited xenon density are strongly attributed to the striations appeared on the MgO surface[5], which are caused by force balance between the accumulated electron and ion charges on the surface in AC-PDP. It is noted here that the main peaks of excited xenon atom have also been occurred adjacent to ITO and BUS electrode, which are in good agreement with those of striations. Hence we might think that several peaks in the excited xenon atom can be regarded as influence of striations in AC-PDP. It is found in Fig. 3 that the density of $1S_5$ metastable excited xenon atom is to be higher at the Ne-Xe(10%) than those for lower Xe contents of 1 Ne-Xe(1%) and Ne-Xe(4%), in this experiment.

4. Conclusion

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. To improve luminous efficiency is studying of vacuum ultraviolet (VUV) rays from micro-cell discharges of a gas mixture that includes Xe. It is noted that several peaks in the excited xenon atoms can be regarded as influence of striations in AC-PDPs. These main peaks in spatial distribution of excited xenon density are strongly attributed to the striations appeared on the MgO surface[4], which are caused by force balance between the accumulated electron and ion charges on the surface in AC-PDP. It is found in this experiment that the density of $1S_5$ metastable excited xenon atom, $3.5 \times 10^{12}cm^{-3}$, is to be higher at the Ne-Xe(10%) than those for lower Xe contents of Ne-Xe(1%) and Ne-Xe(4%).

5. References

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