플라즈마 디스플레이에서 페닝 혼합물의 의존성 연구

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A Study on Dependence of Penning mixture in Plasma Display

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Abstract - In this paper, the penning effect was studied to control accelerating of the ionization that means increasing of cross-sectional collision through penning reactions in the plasma cells of Hg-Ar-Ne (x:10-x, 60Torr) gas discharge under various concentrations of Ar.

1. Introduction

Nowadays the display technology includes the function of light source and devices. One of modern trend in the development of next generation display devices is especially related with plasma whose letter expresses the physical fact that when emitting light, matter in its fourth state, made-up of free ions and electrons. Physics labs of yesteryear as well as today have use of a variety of plasma used for numerous purposes involving display including the spectroscopy, materials analysis, studies of gas dynamics, and laser pumping.

The use of electrically excited gas discharges significantly predates the invention of the incandescent lamp. Gas discharge are used in virtually areas of plasma display and modern lighting technology including common fluorescent lighting for home and office - and Plasma Display Panel (PDP), LCD backlights for laptop computers, high intensity discharge lamps for very efficient area lighting, neon and other miniature indicator lamps, germicidal and tanning lamps, neon signs, photographic electronic flashes and strobes, arc lamps for industry and A/V projectors. Unlike incandescent lamps, display from gas discharge have no filament and do not produce light as a result of something solid getting hot. Rather, the atoms or molecules of the gas inside a glass, quartz, or translucent ceramic tube, are ionized by an electric current through the gas or a radio frequency or microwave field in proximity to the tube. This results in the generation of light - usually either visible or ultraviolet. The color depends on both the mixtures of gasses or other materials in plasma as well as the pressure and type and amount of the electric current or RF power[1].

To satisfy the requirement of high performance plasma display, one has to rise the pressure of noble gases or add the penning mixture. The increasing pressure of a gas (more than 10 Torr) leads to some serious problem related electro-kinetic characteristics. Thus in this paper, penning effect was studied to control accelerating of the ionization that means increasing of cross-sectional collision through penning reactions.

2. Experiments

In the experiment, plasma cells of gas discharge, power supply and optical measuring equipment were consisted Plasma cells of gas discharge with a various condition that was different concentration of penning mixture and frequency, used. The structure of plasma cells was same type with previous paper[2]. The electrode was coated inside glass. The inner diameter, the electrode length and electrode interval is respectively 12.9, 10.0 and 128.0㎜. In plasma cells of gas discharge, Hg-Ar-Ne (60 Torr) filled with mixed gas and the concentration of Ar changed with 5, 10 and 15 %.

Power supply(Nippon Stabilizer HVF-200R) restricted to DC 1.5kV, 0.2A and operated on the pulsed mode that mean that had frequency and pulse width property.

The optical measuring equipment described as following. The radiation from plasma cells of gas discharge through the slit was derived to the monochrometer (Mcpherson 2035). The photomultiplier (R928 Hamamatsu Photonics Co. Ltd.) converts to electrical signal and then the radiation was amplified. To measure the distributions of the radiation, the amplified signals were averaged with Boxcar Averager (EG&G PAR 162) and amplified signal output to the pen recorder. To obtain the radiation with time domain variable, the amplified signals were compared with applied signals on the digital oscilloscope (Tektronix 2430A) and stored to the personal computer. To consider the color change, luminance colormeter (BM-7, TOPCON) measured the color locus in the CIE chromaticity chart.

All of measurement, the optical radiation and luminance color from the plasma cell of the gas discharge, were investigation of spectroscopic property in radiation.

3. Results

The radiation from plasma cell of gas discharge had many distributions for mixed gas. This paper focused on the efficiency of colors changed with variable frequency. Hg and Ne gas made many related distributions, which means that their gas had a lot of excitations at distinct wavelength, but especially the wavelengths for Ne(585.2 and 640.0㎚) in visible region were chosen to get a relation with various concentration of penning mixture Ar.

However, two of the 1s levels of Ne are metastable states and are not allowed to emit photons without some additional shock. Typically they last 100 to 1000 times longer than excited species. Such atoms are not charged and like other regular atoms are displaced only by the slow process of diffusion. It has been shown by penning mixture that for an accurately chosen proportion of additional gas, having a lower ionization potential than the energy of that metastable atom, this additional gas will be ionized itself, thus there is a very high probability that a collision results in the ionization of the Ar atom[3].

The radiated intensities of Ne with various concentrations of Ar showed in figure 1. With increasing of Ar concentration, generally the radiated intensities of Ne had a linear relation at 50㎲ 500 and 1000Hz.But especially at 640.0㎚, the highest radiated intensity of Ne was shown by Ar 10%.

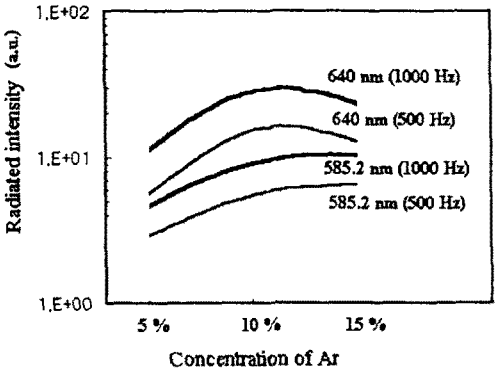

Figure 1. The radiated intensity of Ne with various concentration of Ar at 50 ㎲, 1000 ㎐

The wave forms of radiated intensity from plasma cell of gas discharge under various concentration of Ar(5,10 and 15 %) measured at 50 ㎲ and respectively obtained at 500 and 1000 ㎐.

All of responded wave forms from Ne radiation existed the region of applied signals and wave forms in 1000 ㎐ were bigger than that in 500 ㎐ in figure 2. Equally previous paper[2], at 640.0 ㎚ one of radiation from Ne atom was most biggest response and was mostly similar to applied signals. Ne radiation at 585.2 ㎚ rapidly increases to the peak energy in first stage and exponentially decreases to the stable state. The best performance caused by very high probability that a collision result from ionization due to metastable generation, excitation and penning ionization was in Ar 10%. In Ar 15 %, radiated intensity of Ne atom was less than that of 10 %.

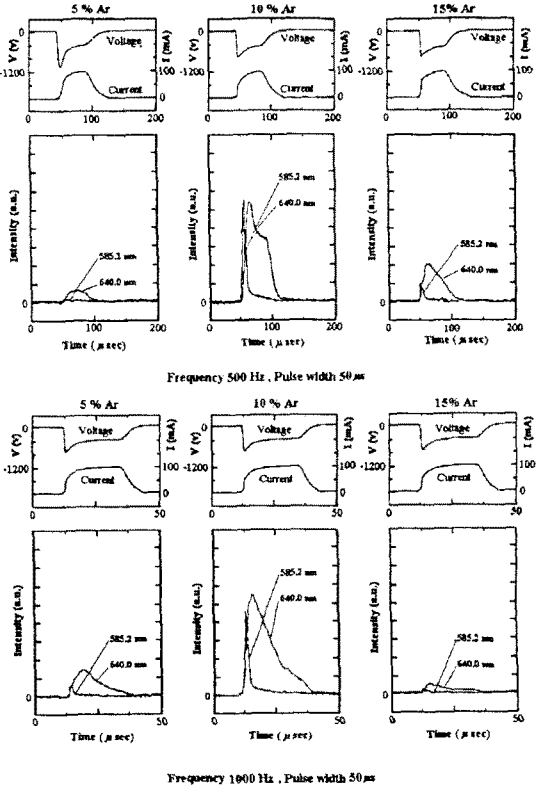

Figure 2. The wave forms from radiated intensity of Ne under various concentration of penning mixture Ar

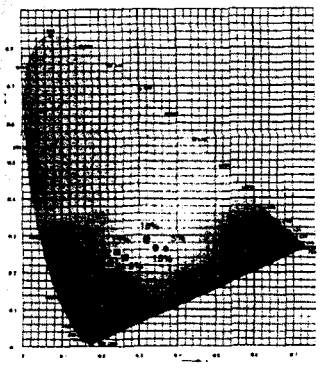

Figure 3. CIE chromaticity diagram for Hg-Ar-Ne(x : 10-x, 60Torr) luminous color

The several processes take place in gas discharge. When the energy of electrons exceeds a threshold which is characteristic for each gas, the type of collision with neutral atoms may change. Instead of an elastic collision which

leaves the energy of the electron almost unaltered it may transfer to the atom a significant part of its kinetic energy which, in turn, raises the energy of an external electron of the atom. These quantities of energy which may be transferred, from a series of discrete values which, again, are characteristic of each gas. Between the ionization potential(21.6 eV in the case of Ne) and the first excitation potential(16.6 eV for Ne) many excitation levels were obtained. From these excitation levels, where the atoms could remain only about 10^{-8} seconds, they would relax to the ground state, or from 2p levels to 1s levels, or still other levels, while emitting a photon of corresponding energy. Therefore the spectrum would be very rich of lines at different wavelengths and in the case of Ne, resulted in a characteristic orange negative glow. Ultra violet, non-visible photons were also emitted, some of which resulted in electron emission from the cathode and corresponding avalanche contribution. By above mechanism, the luminous colors generally located at the points Hg(0.217, 0.198) and Ne(0.705, 0.295) respectively. Increasing the frequency, the luminous color from Hg-Ar-Ne(x:10-x, 60Torr) gas discharge varies from white to blue due to Hg. The luminous colors were respectively white at 500Hz and blue 1000 Hz .When Ar was 10%, white (0.322, 0.294) and blue(0.235, 0.221) showed on CIE chromaticity coordinates. In 5% and 15% concentration Ar, luminous colors were white (0.365, 0.284), blue (0.264,0.248) and white (0.342,0283), blue (0.243,0.239).

4. Conclusions

In this paper, the penning effect was studied to control accelerating of the ionization that means increasing of cross-sectional collision through penning reactions in the plasma cells of Hg-Ar-Ne (x:10-x, 60Torr)gas discharge under various concentration of Ar. The results of the present experimental study can be summarized as follows.

(1) With increasing of Ar concentration, generally the radiated intensities of Ne had a linear relation at 50μs 500 and 1000Hz.But the highest radiated intensity of Ne was shown by Ar 10%.

(2) In all of responded wave forms from Ne radiation, the best performance caused by very high probability that a collision result from ionization due to metastable generation, excitation and penning ionization was in Ar 10%.

(3) The luminous color were as follows.

500Hz	Ar 5 %	Ar 10%	Ar 15%
X	0.365	0.322	0.342
Y	0.284	0.294	0.283

1000Hz	Ar 5 %	Ar 10%	Ar 15%
X	0.264	0.235	0.243
Y	0.248	0.221	0.239

After all, the plasma cell of Hg-Ar-Ne(x:10-x, 60Torr) gas discharge was the best performance in Ar 10 % and their condition got a high possibility to apply Plasma Display Panel.

[Reference]

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