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PDP TYPE BARRIER DISCHARGE ULTRAVIOLET RADIATION SOURCE

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Intense and cheap UV sources are of major interest for a broad area of applications such as germ killing or primary sources for the excitation of the luminescent lamp phosphor. Exciters – excited molecules quickly dissociating de-excitation to lower unstable molecular levels - can facilitate industrial solutions for the above mentioned applications. In this paper we present a simple excimer UV light source built using PDP (Plasma Display Panel) technology.

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1. Introduction

As it is well known, halogen - noble gas discharges can easily generate excimer radiation. A band is emitted at the transition from the upper excited molecular state to the lower level of the non-excited unstable molecule [1]-[7]. For XeCl* excimer, the peak of the band has a wavelength of 308 nm. The reactions at the atomic and molecular level responsible for UV light generation are:

$$Xe^* + Cl_2 = XeCl^* + Cl \quad (1)$$

$$Xe^* + Cl^- + M = XeCl^* + M \quad (2)$$

followed by:

$$XeCl^* \rightarrow XeCl + h\nu = Xe + Cl + h\nu \quad (3)$$

Since the lower of the UV light generating transition corresponds to the ground level of the strongly unstable XeCl molecule, the concentration of the lower level of the transition is practically negligible. Consequently, no absorption of the emitted UV light occurs in the gas mixture volume. We must also underline the huge value of the cross - section for the ion-ion recombination described by equation (2) as pointed in [8].

The pressure of the halogen-noble gas mixture cannot be increased unlimitedly because of the collisional quenching of the excimer molecules before radiating. The following quenching reactions can take place:

$$XeCl^* + Cl_2 = Xe + 3Cl \quad (4)$$

$$XeCl^* + Xe + Xe = Xe_2Cl^* + Xe \quad (5)$$

The second kind of collisions might increase the number of xenon ions or dissociated chlorine atoms if a convenient gas is added to the xenon-chlorine mixture. The produced long living metastable atoms of this added gas could contribute to the increase of the density of the excimer molecules.

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Finally, we must add that excimers efficiently convert the spent energy into light because the useful transition is close to the ground level

2. Experimental arrangement

Two float glass plates with a thickness of 5 mm and the surface size of 300 mm × 50 mm are used to build the discharge device. Each glass plate is covered with a vacuum deposited 1 micrometer thin Al-film linear electrode (see Fig. 1). The length and the width of the electrodes are 190 mm and 4 mm respectively. The electrical connections to the electrodes are on a perpendicular line to the end of each one. The glass surfaces with electrodes are covered with a uniform dielectric layer having a thickness of 18-20 micrometers, except for the surfaces marked in Fig. 1 with black color. These surfaces are used to include the device in an electrical circuitry to generate excimer radiation. The glass plates are vacuums tight assembled, the discharge space being 1 mm.

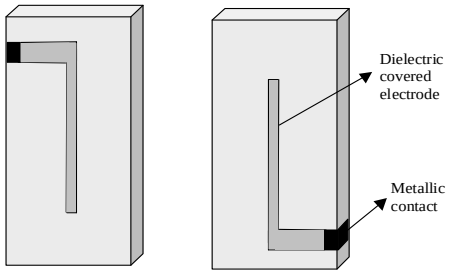

Fig. 1. A view of the deposited thin film electrodes on glass plates.

The linear electrodes are mounted face to face. Polished quartz windows are used to record the emitted UV radiation.

The discharge is ignited and is maintained using a square wave A.C. - voltage with a frequency in the range of from 10 kHz up to 100 kHz and a peak-to-peak value of the applied voltage of 1 kV. The discharge device is connected to a vacuum pumping unit and can be filled with various gas mixtures at the established pressures. During the measurements, the discharge device remained connected to the pumping unit. A grating spectrometer has been used to record the spectra of the emitted radiation, especially the peak of the relative intensity of the excimer radiation.

3. Results

A typical shape of the recorded spectra is shown in Fig. 2 and is very similar to the spectra reported in literature by other authors. The time evolution of the applied voltage and of the discharge current is presented in Fig. 3.

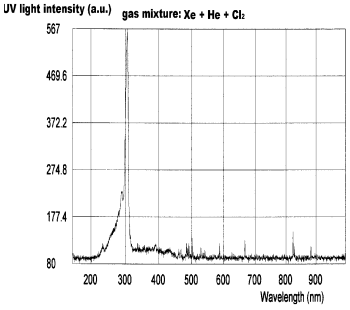

Fig. 2. Recorded excimer spectrum.

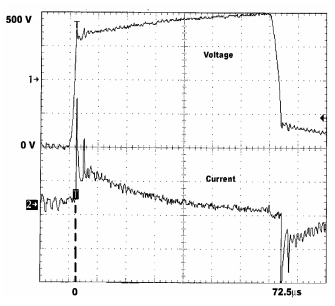

Fig. 3. Time evolution of the applied A.C. voltage/ current of a PDP type device.

In comparison with a PDP type discharge in Ne-Ar gas mixture, in the present case when the gas mixture is xenon-chlorine, the current evolution has an increased time duration and the current has a tendency to oscillate. The total filling gas mixture pressure was kept at 35 torr taking into account that for much higher gas pressures, the discharge becomes filamentary. Two type of gas mixtures have been used as filling gases namely Xe+Ne+Cl_2 and respectively Xe + He + Cl_2. Various percentages of the gas mixtures components have been used keeping the total pressure at 35 torr.

4. Discussion

In Figs. 4 and 5 are given the experimental excimer spectra for the measured relative intensities of the excimer peak value at 308 nm, for various partial pressures of chlorine and xenon respectively, at a total gas mixture pressure of 35 torr.

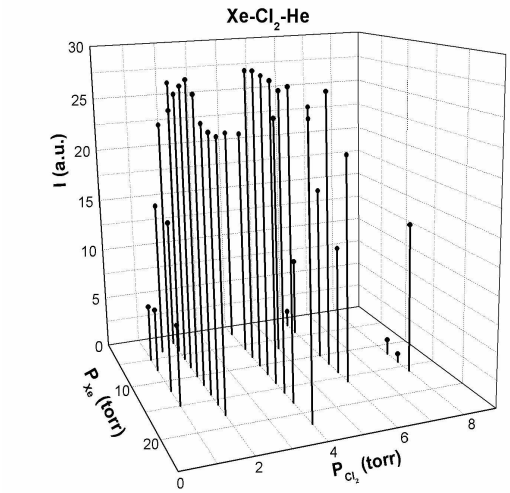

Fig. 4. Relative intensity of the emitted excimer band peak for a constant total gas mixture pressure of 35 torr, for various partial pressures of Cl_2 and Xe. The buffer gas was He.

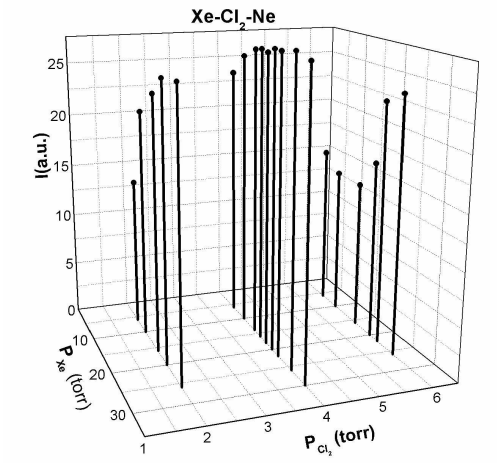

Fig. 5. Relative intensity of the emitted excimer band peak for a constant total gas mixture pressure of 35 torr, for various partial pressures of Cl_2 and Xe. The buffer gas was Ne.

From these obtained data we can see that the use of neon as added gas to the main excimer mixture of xenon-chlorine has a negative effect, the maximum value being obtained when neon is missing in the gas mixture. In contrast, the addition of helium increases the excimer radiation emission, the peak value clearly decreasing when the helium partial pressure goes below 10 torr. As mentioned at the beginning, we assume the helium metastables are contributing to the increase of excimer radiation via Penning-type collisions.

The data given in Fig. 4 and Fig. 5 also show that, surprisingly, the partial pressure of the chlorine for attaining the maximum value of the excimer radiation does not increase with an increase in the partial pressure of the xenon, remaining at an optimum value around 4 - 5 torr. Beyond these values, the intensity of the excimer radiation sharply decreases.

Concerning the discharge system used here, we must point out that measurements performed using tunable diode laser absorption on the dissociation degree of the chlorine molecules in similar devices as those used in the present experiment, have proved an unexpected high degree of dissociation. This was explained by the existence of limited volumes of the PDP discharges with a high power density [9]-[10].

Of course, the geometry used in the present experiment does not ensure full use of the excimer UV radiation. The present geometry has been chosen in order to have a well-defined

discharge space. For practical use, a co-planar geometry of the electrodes will be used placing both electrodes on the same glass surface, as is commonly used in the case of PDP for color TV.

5. Conclusions

We have investigated the possibility of using a PDP type discharge as a source for UV radiation.

Using the addition of He to the main gas mixture, in order to increase the density of xenon ions and chlorine molecules via Penning-type collisions, we obtained a more efficient dissociation by PDP discharge. Consequently, this process enhanced the ion-ion recombination channel described by the reaction (2), increasing the UV excimer radiation.

The use of chlorine as added halogen molecules to generate UV light might, in the near future, offer the possibility to realize a sealed - off cheap UV source.

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