A TRANSVERSE SPATIAL STRUCTURE OF THE BARRIER DISCHARGE IN RARE GASES

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The excimers as VUV-radiation sources are attractive because of their high efficiency to transform the electrical energy into the VUV-radiation. It is common practice to create the excimer plasma by either a fast electron beam or some kind of gas discharge.

The results of experimental investigations of the barrier discharge in pure He and the mixture He+Xe are presented in this report. An interelectrode distance was chosen as much as 1.5 mm. A gas pressure and frequency of applied voltage were varied in our experiments from 100 Tor to 770 Tor and from 100 Hz to 100 kHz, respectively. The sketch of our experimental set up is drown on Fig. 1. The waveforms of discharge currents and applied voltage were simultaneously recorded with a digital oscilloscope (Fig. 2). The spatial distribution of a visible light emission in the bulk of the barrier discharge was recorded with a special digital camera.

It was revealed the existence of three modes for barrier discharge: a) a diffusive mode (Fig. 3) that is defined as discharge with homogeneous plasma throughout its cross-section; b) a spatially-periodical mode that represents itself as the discharge divided into a lot of glow plasma columns located periodically within interelectrode gap (Fig. 4). It is common, the plasma column diameter and the average intercolumn distance are close to each other, however, the both are far in excess of the length of an interelectrode gap; c) a streamer mode that is wellknown mode for barrier discharge at higher gas pressure.

As far as we know, the spatially-periodical mode of the barrier discharge was not before described in the literature. This mode can be realised if the frequency $\mathbf{f}$ of applied voltage is in excess of some value $\mathbf{f_b}$ named by us as boundary frequency. We have recognised an influence on the value $\mathbf{f_b}$ of both the total gas pressure and the composition of gas mixture. At low frequencies $\mathbf{f} < \mathbf{f_b}$, the barrier discharge under small current corresponds to the homogeneous diffusive mode and goes into streamer mode with increase in its current. At high frequencies $\mathbf{f} > \mathbf{f_b}$, the barrier discharge under small current corresponds to the spatially-periodical mode. We observed two scenario for transition of barrier discharge from mode **b** into **c** as the current was increased: either streamer mode **c** follows just behind the mode **b** or the mode **b** goes at first into the diffusive mode **a** and thereafter the mode **a** goes into streamer mode **c**. The specific scenario for transition of discharge from spatially-periodical mode into streamer one is defined by the total gas pressure and the composition of gas mixture. The representative current/voltage dynamic caracteristic is given on Fig. 5. Corresponding voltage/charge Lissajous figure is presented on Fig. 6.

These peculiarities of barrier discharge observed by us have to be taken into account to chose the most effective operating regime for excimer VUV-radiation source.

Acknowledgements

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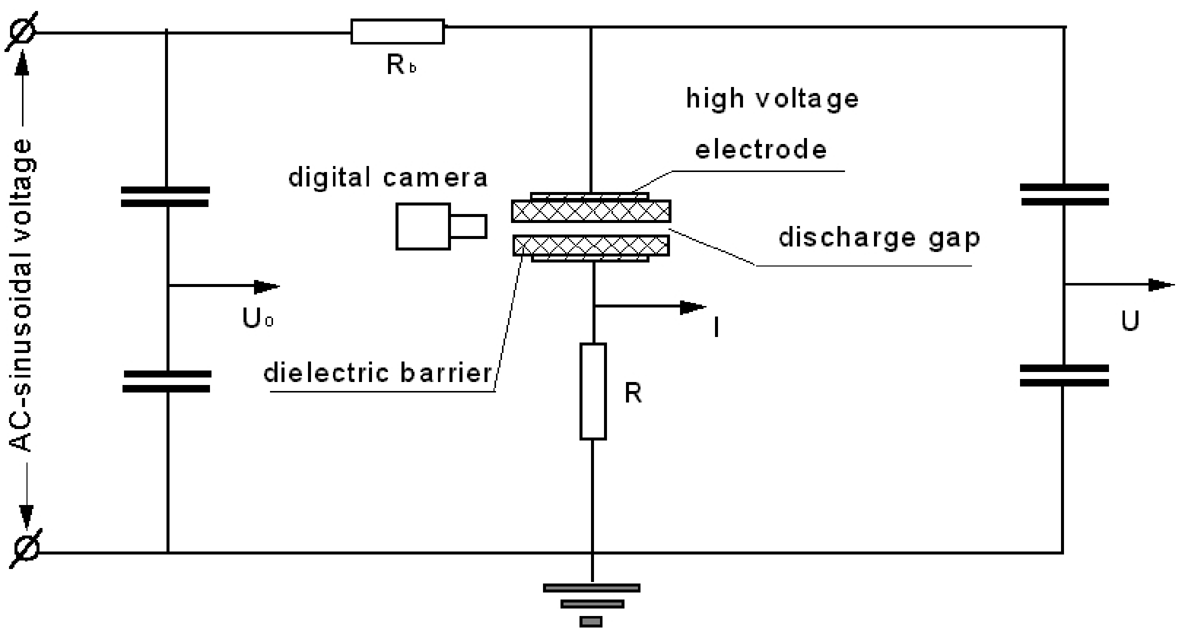

Figure 1. Schematic diagram of the experimental set-up.

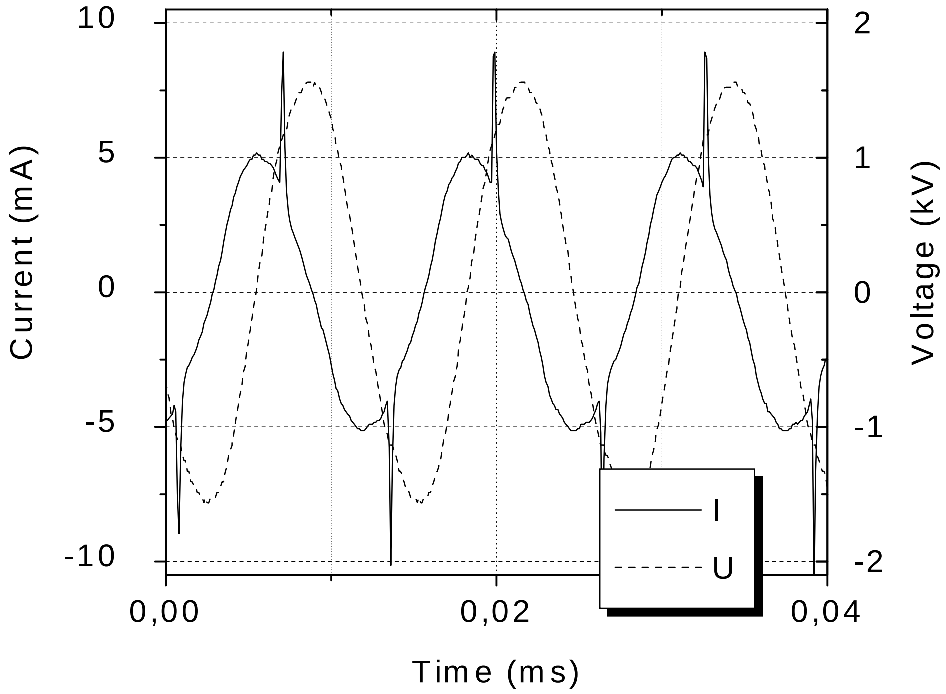

Figure 2. The waveforms of discharge currents and applied voltage (conditions as in Fig. 4).

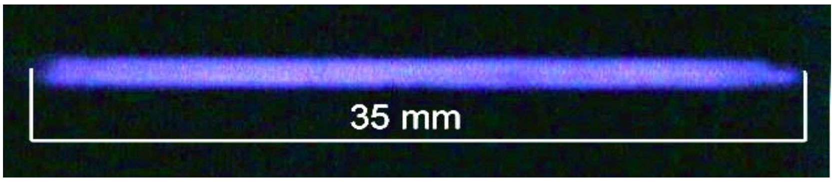

Figure 3. The diffusive mode of the barrier discharge.

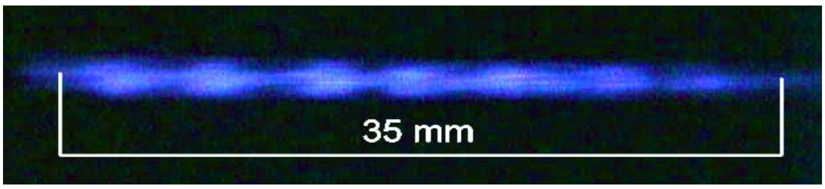

Figure 4. The spatially-periodical mode of the barrier discharge (mixture He[95%]+Xe[5%], P=100 Tor, F=78 kHz, discharge gap 1.5 mm, thickness of dielectric 2 mm).

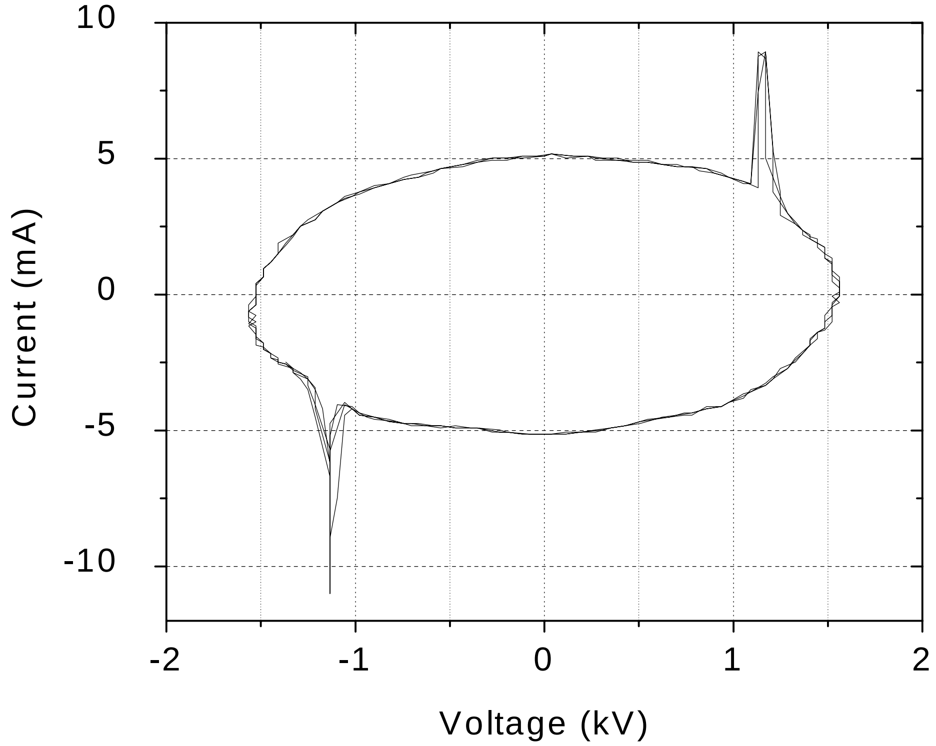

Figure 5. The current/voltage dynamic characteristics (conditions as in Fig.4).

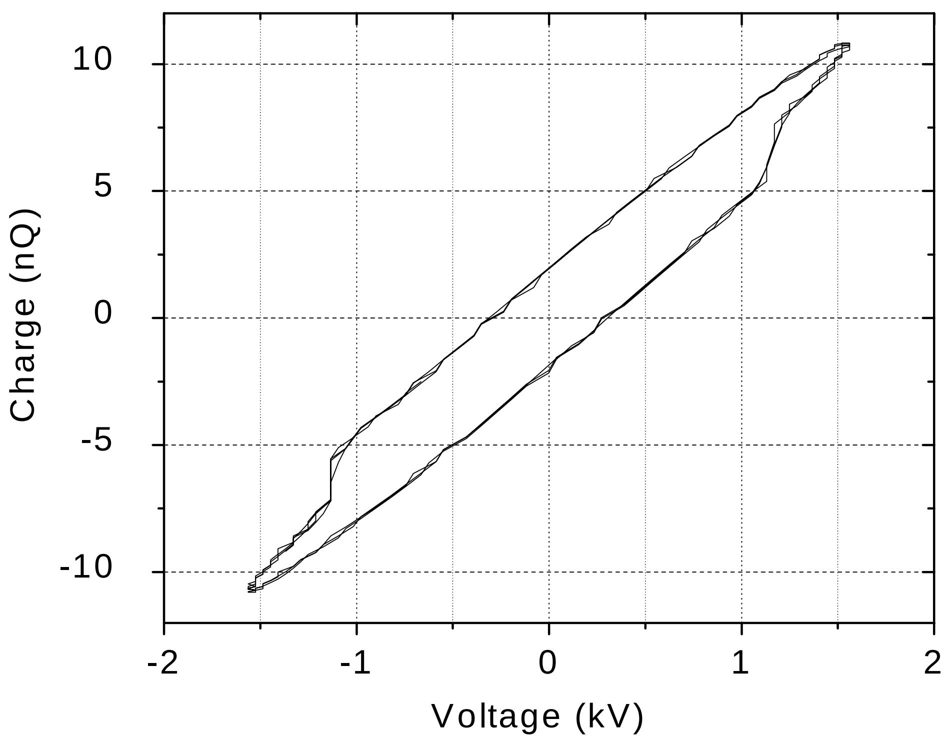

Figure 6. The voltage/charge Lissajous figure (conditions as in Fig. 4).