

EXCIMER EMISSION FROM THICK MICROHOLLOW CATHODE DISCHARGES IN XENON

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The vacuum ultraviolet emission was investigated end-on from the anode and cathode sides of a relatively thick microhollow cathode discharge. For this geometry and high xenon pressures the integral intensity measured from the anode side becomes comparable with that from the cathode side. Also, the excimer spectra corresponding to the two electrode sides are not so different as in the case of standard thin microhollow cathodes or with plane geometry. The homogeneous negative glow plasmas, which are now retained into the thick microhollow cathode, can explain this behavior.

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1. Introduction

High-pressure micro-discharges with plane cathodes [1,2] and different microhollow cathode geometry (MHCD) [3,4] up to the capillary ones [5] are promising sources of vacuum ultraviolet (VUV), ions and radicals, offering some advantages compared to other conventional discharges. Independent on the cathode geometry, the negative glows of these micro discharges are actually the VUV radiation sources. However, for a thin planar MHCD, the part of the negative glow which extends on the external flat surface of the microhollow cathode acts as the main excimer source, that from the inside of the same cathode hole having in this respect a somewhat diminishing role [6]. Therefore, the integral VUV intensity registered end-on through a microhollow anode is at least by an order of magnitude lower than that measured from the microhollow cathode side [3,4]. This can be a major disadvantage for some applications of the thin planar microdischarges with closed cathodes [7].

In this contribution we present some data about the VUV emission from both the electrode sides of a MHCD with a relatively thicker but open microhollow cathode. We investigate the influence of the xenon pressure on the VUV emission. By measuring the MHCD sustaining voltage, a relative radiation efficiency may be also estimated.

2. Experimental

The MHCD device is manufactured from polished molybdenum foils with a relatively larger thickness of about 0.5 mm separated by a 0.25 mm thick mica sheath as insulator. It must be noted that in the standard microhollow geometry the hole diameter is about the same as the thickness. As is seen in Fig. 1, a cylindrical discharge channel with a diameter of about 0,2 mm was drilled through this sandwich structure. Here, the data denominated as "anode side" are measured through the microhollow anodes, whereas those from the cathode side are obtained by simply inverting the

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electrode biasing. So, the open microhollow electrode from the top of Fig. 1 acts now for comparison as an open microhollow cathode.

The experimental arrangement for recording the VUV emission contains a MgF_2 convex lens with a diameter of 34 mm and the focal length of 114.3 mm at 193 nm. This lens separates the high-pressure MHCD chamber from the VUV monochromator and also images end-on the whole micro-discharge on the entrance slit of the monochromator. The broadband VUV emission of xenon with the so-called first and second continuum of the excimer spectra is diffracted in the spectral range from 150 to 190 nm with an optical grating of 1200 lines/mm blazed at 150 nm. Finally, a VUV sensitive CCD detector with a rise time of 20 ns allows for the registration of the excimer spectra.

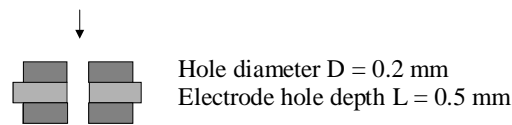


Fig. 1. Sketch of the microelectrode structure. The arrow indicates the end-on VUV measurements.

3. Results and discussion

Fig. 2(a) and (b) show the typical VUV spectra measured from both the anode and cathode sides for the micro- and structure sketched in Fig. 1 with xenon pressure as the parameter.

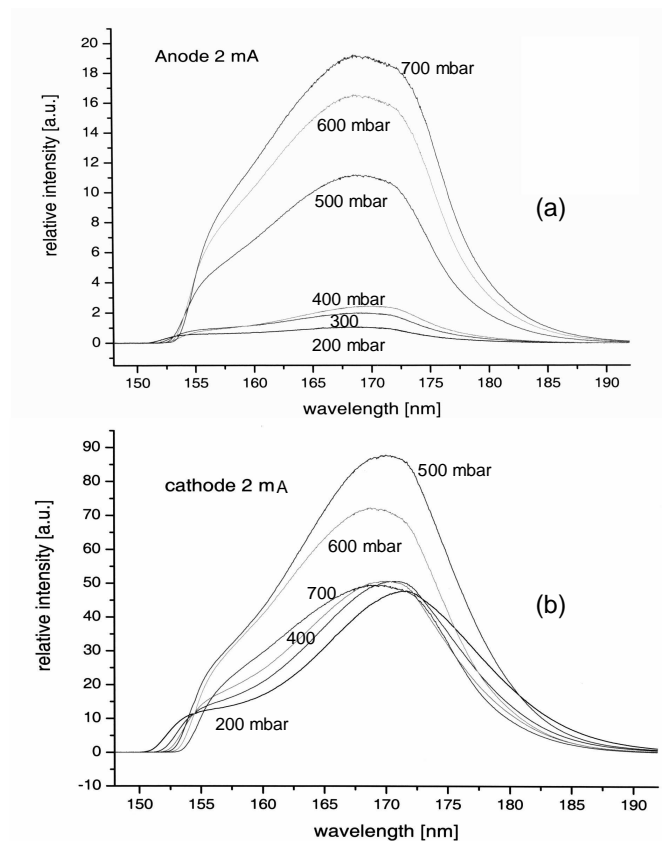


Fig. 2. Excimer spectra registered from the anode side (a) and cathode side (b) for the open thick microhollow cathode shown in Fig. 1 with the xenon pressure as parameter. The discharge current is 2 mA

From the so-called first and second continuum of the excimer spectra of xenon, the large second one at the wavelength of 170 nm can be easily identified in both Figs. 2. The small first continuum at 155 nm can be observed only for the lower xenon pressure and from the cathode side.

The shapes of these VUV spectra, measured end-on from both the identical open microhollow electrode sides are not so different as was found for the micro discharges with thin closed micro cathodes [3,4].

For the same micro discharge conditions, the integral VUV intensities as functions of the xenon pressure for both biasing of the electrodes are shown in Fig. 3 (a). In this figure the squares and circles indicate the data measured from the anode side, whereas the triangles indicate those obtained from the cathode side. It is seen that by increasing xenon pressure the differences between the VUV intensities, measured for the two opposite electrode biasing are nearly disappearing above the pressure of 600 mbar, whilst those corresponding to the cathode side remain nearly constant. As shown, for the same conditions in Fig. 3 (b), the sustaining voltage decreases approximately linearly from 300 to 250 V with the xenon pressure at the constant discharge dc currents of 1 and 2 mA, respectively.

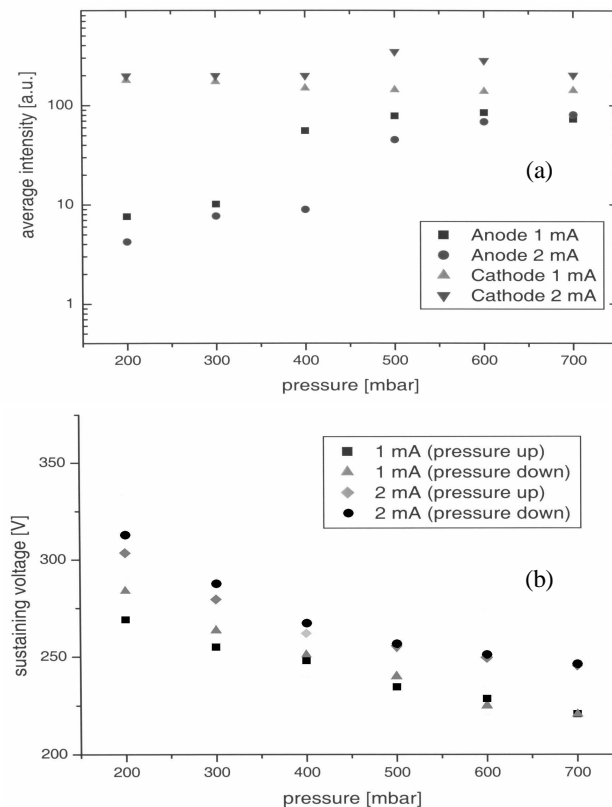


Fig. 3. (a) The VUV intensities registered from the anode side (squares and circles) and cathode side (triangles) together with (b) the sustaining voltages for the thick MHCD geometry sketched in Fig. 1, both as functions on the xenon pressure and for the discharge currents of 1 and 2 mA, respectively.

In Fig. 4 are shown, the dependencies on the xenon pressure of the integral VUV intensities (full points) and the sustaining voltages (open points) for a MHCD with standard geometry, i.e. with a hole thickness which is the same as the internal diameter. It is seen that with increasing xenon pressure up to 800 mbar, the differences between the VUV intensities measured from the two

opposite electrode sides are reduced from three to one order of magnitudes. Again, the VUV intensities measured from the cathode side remain nearly constant, whereas the sustaining voltages for both electrode biasing only decrease from 250 to 200 V. These somewhat lower sustaining voltages are due to retaining of the negative glow inside the microhollow cathode over the whole dc current range.

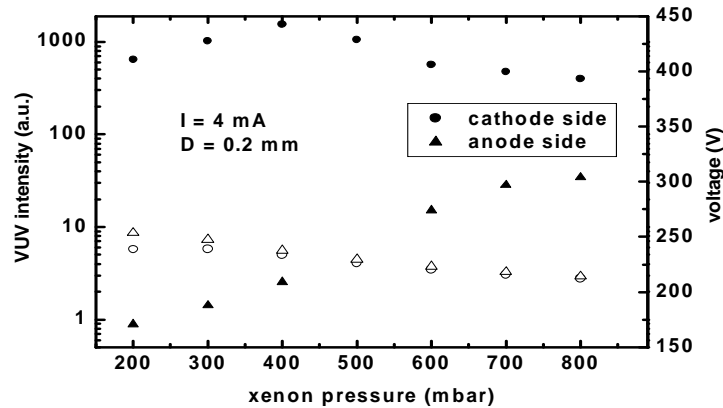


Fig. 4. Dependencies of the integral VUV intensities (full points) and the discharge voltages (open points) for a standard MHCD with the same thickness and hole diameter of $D = L = 0.2$ mm as function of the xenon pressure. Triangles and circles indicate the data from the anode and cathode sides, respectively. The discharge current was 4 mA.

4. Conclusions

In order to obtain at least the geometrical similarity with conventional hollow cathodes, the microhole length was as twice as its diameter. Under these conditions, the entire negative glow remains inside the microhollow cathode showing nearly the same plasma parameters and neutral gas properties. In comparison with the data obtained for the standard thin MHCD [3], this can explain the much lower difference found between the VUV spectra and their averaged intensities measured from both the electrode sides of this thick MHCD.

The study of the VUV emission from the anode and cathode sides of open but relatively thick microhollow cathode indicates that this strongly depends on the local micro hollow conditions. It was found that the geometrical similarity with the conventional hollow cathodes, i.e. a hole depth of at least twice the internal diameter, is the first condition to obtain a comparable VUV radiation intensity from both the microhollow electrode sides at least for a high pressure of the xenon gas.

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