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SELF-SUSTAINED UNSTABLE MODES FOR OPERATION OF GLOW DISCHARGE. AN APPLICATION

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Abstract. Two self-sustained unstable modes for operation dependent on the operating i-V point are observed in a hollow cathode discharge (HCD). They manifest themselves as either galvanic oscillation or pulsation. The instabilities take place under i-V sections of both positive and negative differential resistance. The frequency f of the instabilities is found depending on the current discharge value i. The function $f(i)$ is a precondition some deviations of the both gas pressure and purity fixed to be noticed.

1. INTRODUCTION

Glow discharge (GD) is known as a medium of certain important and only possible applications (Marcus et al. 1993). As a rule, the stability of the selected mode for operation is a necessity vs. above field. A GD modification, e.g. hollow cathode discharge (HCD) is known as a stable light - and sputtered atoms source enlarging some of these applications (Caroli et al. 1993). However, from another point of view the plasma in a GD is known as a typical nonlinear dynamical " open system" with a large number of degrees of freedom. Within these frames a HCD should possess one more additional degree of freedom due to the intensive atomization of the cathode surface. Some new HCD application fields revealed instabilities vs. both induced and spontaneous Δi-ΔV deviations (Lee et al. 1987 and Zhechev et al. 1998). The instabilities are observed under i-V branch of $(\partial U/\partial i) < 0$. The latter arises due to Penning ionization (Dimova et al. 2004 and Dimova et al. 2003).

In this study two self-sustained unstable modes for operation of a HCD are analyzed vs. the operating i-V point. The self-sustained instabilities are analyzed as an indicator of Δp - and ΔP deviations of both pressure p and purity P of the gas medium.

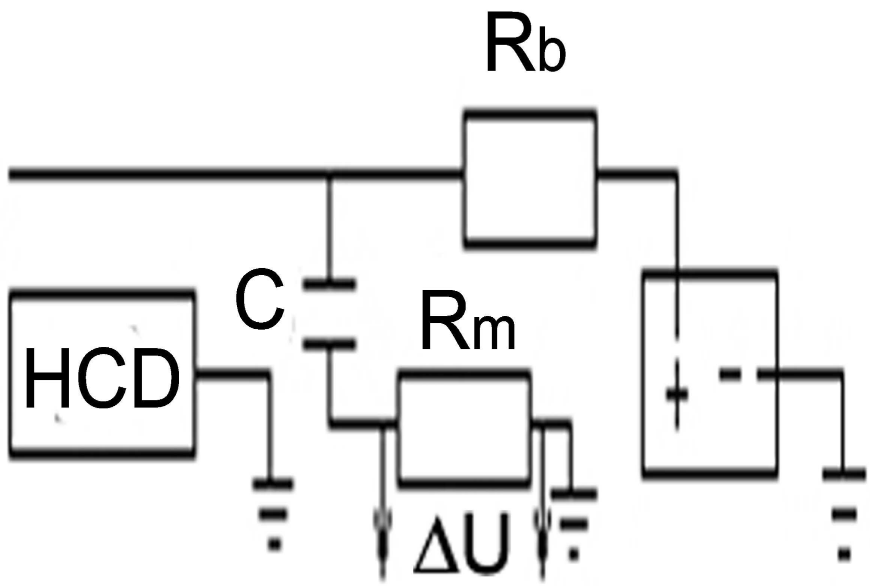

Figure 1: Experimental scheme: R_b - ballast resistor (11 kΩ), C (0.47μF) - decoupling condenser, R_m - measuring resistor.

2. EXPERIMENTAL

The stability of a HCD dc operation is studied at absence of any external perturbation. Figure 1 contains a schematic drawing of the standard experimental set-up. Time - dependent change in the impedance of the discharge was determined by measuring the voltage ΔU(t) across the 50 Ω resistor R_m. A trademarked HCD modifications, i.e. trademarked lamp Ne/Ca/Ba ("Cathodeon Inc") was used.

Both regions of negative dynamic resistance $\partial U/\partial i< 0$ and great slope variety of some HCD i-V curves (Zhechev et al. 1998) drew our attention to i-V operating points of different $\partial U/\partial i$ values.

3. RESULTS AND DISCUSSION

3.1. Generally, self-sustained oscillating components were observed under some operating i-V points on overlapping i-V parts of both $\partial U/\partial i< 0$ and $\partial U/\partial i> 0$ (Figure 2) and under operating i-V point close enough to the critical low one. At the beginning a self - sustained oscillating voltage component (18 Hz, $\sim$ 7 V) was detected under operating points of $\partial U/\partial i< 0$ (Figure 3). Both frequency f and shape of oscillation change within the discharge current values of (1.5 - 1.9) mA. Earlier, self-sustained oscillations were observed in (Lee et al. 1987). The oscillation negative peaks were observed to extinguish the discharge and HCD passes into a twinkling mode for operation of the same frequency. Self-sustained instabylity of pulsing type and frequency (50kHz) was observed for the first time. It takes place at $i\in[3.0\div6.8]$mA where $\partial U/\partial i> 0$.

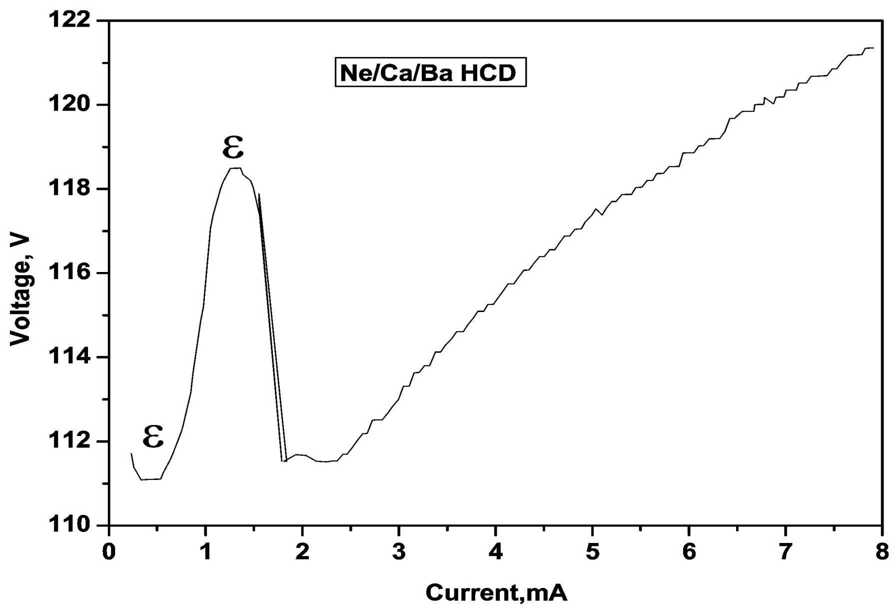

Figure 2: A section of i-V- curve of HCD lamp (”Cathodeon Inc”).

Both oscillation-and pulsation frequencies depend strongly on their i-value.

The genesis of the observed instabilities may be analyzed formally within the frames of an equivalent HCD circuit.

Both self-sustained oscillations and light-induced conductivty are precondition for OG optogalvanic transfer of instability within the sections of a segmented GD including that used as a laser medium (Mihailova et al. 2003). This opportunity was checked.

3.2. Generally, the methods for monitoring of either gas pressure p or purity P are based on some simple *measurable effect* dependent on the value of p and P. Earlier the shape of the optogalvanic signal was discussed as a sensitive indicator of changing p and P (Zhechev et al. 2003). The sensitivity of both oscillation - and pulsation frequency f vs. current discharge value, i is a precondition any deviation Δp or ΔP to be noticed by using the function $f(i)$. Indeed, either of Δp or ΔP stimulates change in the gas medium effective potential of ionization, i. e. $\Delta i(\Delta p)$. The latter influences the self-sustained oscillation frequency f.

Obviously, the sensitivity $\Delta f(\Delta p)$is a function of the operating i-V point. The steeper the i-V sections the higher sensitivity $\Delta f(\Delta p)$.

4. CONCLUSIONS

Two self-sustained unstable modes for operation of a HCD are observed. The low frequency oscillations (of tens Hz) take place under i-V operating points of negative dynamic resistance. The disharge passes into a twinkling mode for operation of the same frequency. Pulsations of tens kHz frequency arise under i-V operating points of

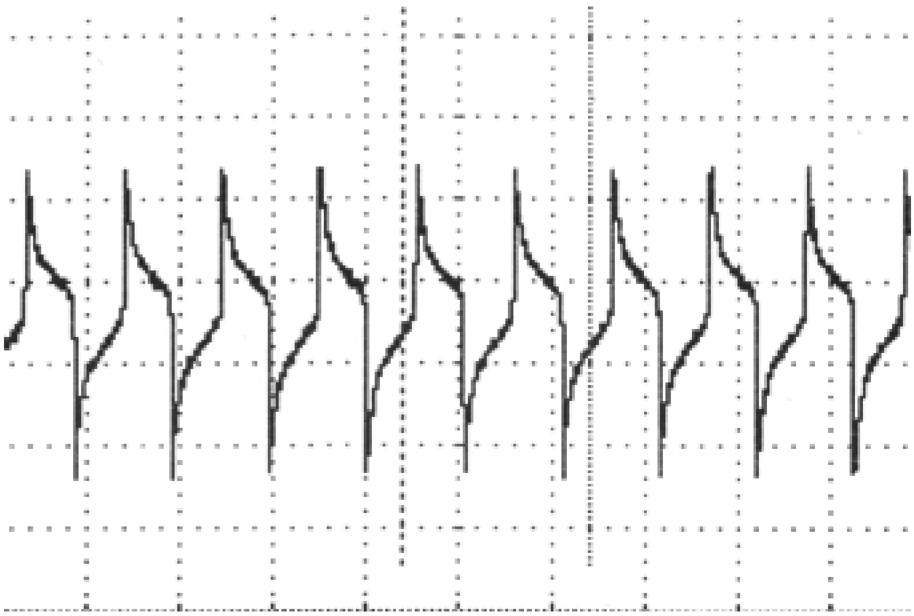

Figure 3: Oscillations under $i = 1{,}5$ mA, $\partial U/\partial i < 0$.

positive dynamic resistance. The frequency of the self-sustained unstable modes for operation depends on the discharge current value. This function is a precondition for gas pressure and purity monitoring.

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