

THE PROCESSES ON THE PLASMA-LIQUID INTERFACE. THE NON-EQUILIBRIUM EVAPORATION AND RADIATION OF GLOW DISCHARGE

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The plasma-liquid system is interested from point of view technological application such as cleaning and sterilization water and devices, modification of synthetic and natural polymers and coating oxides films on the metallic and dielectric surfaces also. We choose the glow discharge with electrolyte cathode as subject of investigation. This system allows study physical and spectral features of such discharge and chemical and physical processes occurring into solution and plasma-liquid interface under discharge action.

The ion bombardment of liquid cathode surface leads to sputtering solution, so called the non-equilibrium evaporation. The early experiments [1] showed that up to 1000 water molecules and 30-50 molecules of dissolved substances have been sputtered from liquid surface in account on the one falling ion. Whereas it was noted that ratio of transferred cations and anions was unequal and depends from experimental conditions.

In this work data on the non-equilibrium transfer of solution components under action of atmospheric pressure glow discharge are presented. The investigations were carried out by spectral and gravimetric methods. The water solutions of MgCl₂, CaCl₂ and BaCl₂ are used as electrolyte cathodes.

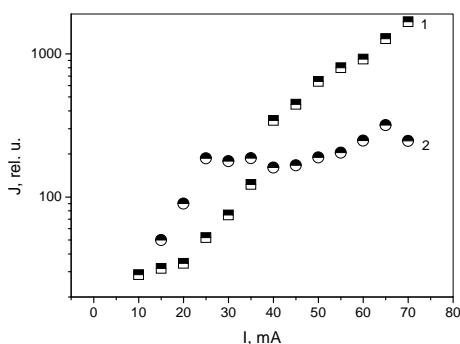


Fig. 1. The dependence of intensity from discharge current. 1 – line of Ca ($\lambda=657$ nm triplet), 2 – line of Mg ($\lambda=457$ nm)

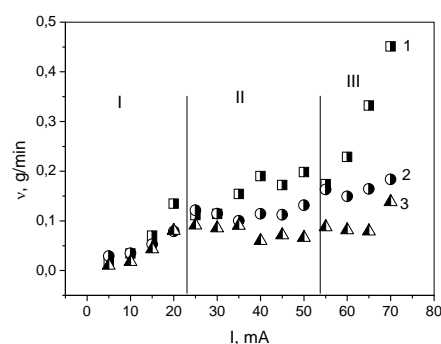


Fig. 2. The influence of discharge current on velocity of non-equilibrium evaporation. 1 – CaCl₂, 2 – BaCl₂, 3 – MgCl₂.

Experimental data showed that the appearance of the metal atom radiation is threshold process (fig. 1). The precursor of metal atom is cation of dissolved salt in the solution. It means that on the plasma-liquid interface the redox reaction occurs. The growth of the discharge current leads to increasing spectral line intensity. The gravimetric measurements of non-equilibrium evaporation velocity showed that at the range of 5-70 mA can allocate the three field of discharge

current (fig. 2). The fields of low currents (I) (5-25 mA) and large currents (III) (>50 mA) are characterized by linear growth of velocity with increasing current. In the middle field (II) the fluctuation of velocity's values near average magnitude or small dip has been noted. Obtained data are conformed to data on the non-equilibrium transfer of dissolved substances. Experiments showed the transfer of cations and anions occurs with stoichiometry violation. The ratio can reach of 1:10 (1 ion of Mg and 10 ion of Cl). Experiments showed that the anion flow from solution is decreased at discharge current that accords to start of cations transfer (fig. 3).

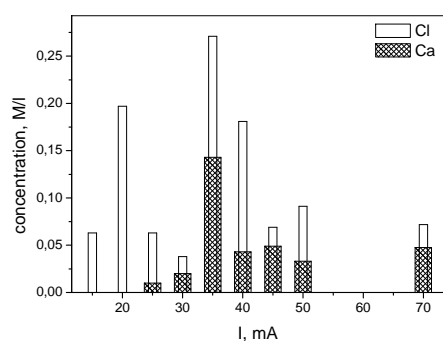


Fig. 3. The histogram of the qualitative analysis of condensate in the case of CaCl_2 solution

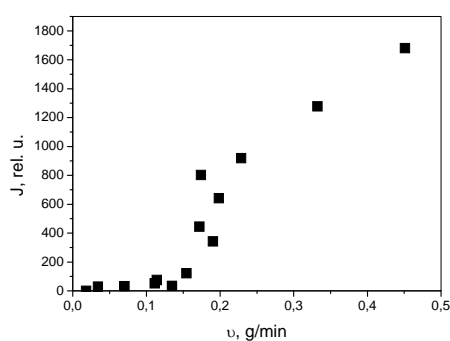


Fig. 4. The correlation between spectral line intensity and velocity of non-equilibrium evaporation

In fig. 4 the dependence of metal atom radiation intensity from non-equilibrium transfer velocity is presented. One can mark three regions. 1) the region of low flow velocity concerning to low discharge current featured absence of radiation, 3) the region of large velocity characterized linear intensity growth. The middle region is featured fluctuation of mass transfer velocity values. It means that in this region the competition between transfer mechanisms occurs. We assumed that the classic molecular evaporation and cluster non-equilibrium transfer are able to consider as operating transfer mechanisms.

Reference

- [1] A. Maximov, A. Khlustova, 2007 *High Temp. Mater. Proc.* **4** 527