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Plasma–cathode interface of glow discharges as medium of particles activation for material spectrometry

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Optical emission spectroscopy (ES) and mass spectrometry (MS) often use the plasma of large range of glow discharges for both optical activation and ionization of matter molecules appearing at all aggregation states even for solid evaporation to the plasma phase.

The plasma–cathode (P-C) interface of glow discharges under low gas pressure is a "subtle" object where a distinct phase boundary appears between the solid state (cathode) and the gaseous phase (plasma). This boundary exists in spite of the presence of both high energy electrons and ions (even hundreds of eV). These energies are extremely high if compared with the energy 0.3 eV that corresponds to the temperature of carbon melting.

Activation of the P-C interface is much affected with classical processes, ionization and excitation, which have well determined cross sections, but also with specific processes such as the Penning ionization and excitation whose cross sections are generally unknown.

Application of glow discharge plasmas for material spectrometry has a few well developed scientific descriptions for the use in both engineering and physical chemistry. The monograph [1] is an excellent example of the above statement. However such treatment assumes glow discharge plasma as a homogeneous object existing under a local thermodynamic equilibrium. This allows the simple relation between optical line intensities and ionization efficiency and plasma temperature. However, this treatment fails in the case of the P-C interface because of large discrepancies between the average energies of each plasma component.

Mechanism of P-C plasma activation is complex and possible to be described and optimized by the theoretical modelling of the space-electro-dynamic structure (**SEDS**) of the P-C interface as well as the space–mass-energy distribution $F(s, m, \varepsilon)$ of both activating and activated particles. This modelling must relate **SEDS** and $F(s, m, \varepsilon)$ characteristics to the outer discharge parameters easily measured: gas pressure p, voltage U_{ac} on the P-C interface, discharge current density j_d, etc., which are characteristic of the studied P-C interface.

The results of both analytical and numerical modeling of the S**EDS** structure and $F(s, \varepsilon)$ of glow discharges working under low pressures $p \approx 1$ Tr will be presented, which are important from the point of view of molecules activation. Moreover, the results of the measurements of the $F(s, m, \varepsilon)$ distributions made by the MS spectrometry of ions formed at the P-C interface as well as those of the space-line distributions $I(\lambda, s)$ of the light emitted by the molecules of the **P-C** interface will be presented, see [2,8,9].

On the basis of the interpretation of the experimental results in the light of the above modelling the peculiar properties of the P-C plasma will be explained, which are important from the point of view of MS i OES spectrometries. These properties are as follows: dependence of $I(\lambda, s)$ distribution on density j_d and the characterristics of "selecting" excitation of some molecules, etc.

Moreover, the effect of the Penning processes on $I(\lambda, s)$ distributions as well as that without-emission deexcitation of molecules during their leaving the hot cathode surface will be discussed, see [3,4].

Complex character of the measured $F(s, m, \varepsilon)$ distributions of ions passing through the extraction hole of cathode will be also explained, see [2]. Special attention will be paid to a peculiar lack of low energy ions in the $F(s, m, \varepsilon)$ spectra experimentally observed, see [5]. These ions are predicted by the theoretical modelling of the S**EDS** structure to be dominating ions. This fact is a serious deficiency of the P-C interface when used for MS spectrometry. Some reduction of this deficiency will be proposed.

The presentation is the review work, hence it is based on the scientific material taken from the papers of other physicists in part. However, main material of the proposed presentation contains original results of theoreticcal and experimental studies of the P-C interface physics by the author. The papers, the most connected with this abstract, are enclosed below.

References

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