REGIME OF SYNCHRONOUS MULTICHANNEL ELECTROHYDRODYNAMIC AUTOOSCILLATIONS FOR EMISSION SPECTROSCOPY

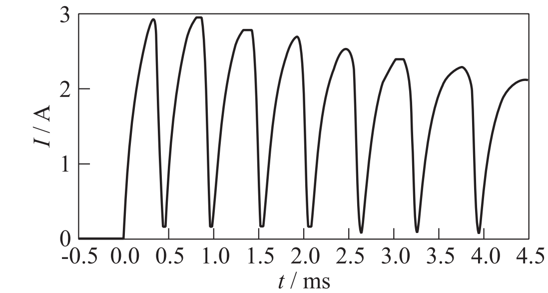
R. N. Medvedev, K. A. Lomanovich, and V. S. Teslenko

Lavrentyev Institute of Hydrodynamics
Siberian Branch of the Russian Academy of Sciences
Novosibirsk, Russia

The technique of nonthermal plasma generation during multichannel diaphragm discharge in electrolyte under supplied voltage 100–300 V is described. The method consists in using the synchronous autooscillatory regime on multiple current concentrators in electrolyte [1] and enables to raise the efficiency of spectral analysis of conductive liquids under low supplied voltage. At present, the spectral analysis of substances is widespread in the field of chemical technologies and medical-biological investigations. Quick definition of admixtures composition in water is one of the most urgent issues today. There are different techniques of substance analysis in different aggregative states. Meanwhile, the devices and systems used for control have complicated facilities with expensive elements and reagents.

The presented technique is based on electronic photography and digital processing of light emission spectra of electric discharges in holes of dielectric films (diaphragms) in electrolyte. The diaphragm discharge excludes the parasitic spectrum of electrodes due to their ejection from intense discharge area. In this case, the area of high current concentration is in the diaphragm holes where due to the intense liquid heating, evaporation followed by a corona-like discharge in the generated vapor–gas bubble occurs.

In [1–3], the synchronous autooscillatory regime of discharge in conductive liquids was described which enables to generate high-voltage pulses and high energy densities on current concentrators under relatively low applied voltage and to ionize the molecules of substances con-



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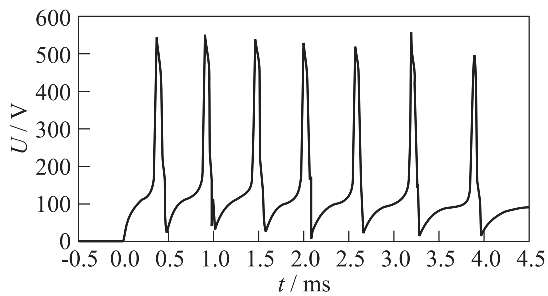

(*b*)

Figure 1 Oscillograms of autooscillations of current I (a) and electrode voltage U (b) for 20 holes in Teflon film ($d = 200$–300 μm), $U_C = 200$ V, and $L = 7.7$ mH

tained in liquid. The synchronous regime was obtained by connecting an additional inductance coil in the discharge circuit, so that equalization of current pulsation phases on all concentrators occurs. Due to the effect of self-inductance, the electric energy redistributes in such a manner that at the moment the current interrupts by a growing bubble on concentrator, the positive pulses of voltage are generated, and the negative ones during bubble collapsing (in the period of current raise). If the number of concentrators $N > 10$ and inductance $L = 1$–10 mH, at the moment when current interrupts, the voltage on concentrators can attain $\sim 10^3$ V [3].

Figure 1 shows the oscillograms of current I and electrode voltage U for the regime of synchronous autooscillations on 20 holes in Teflon film

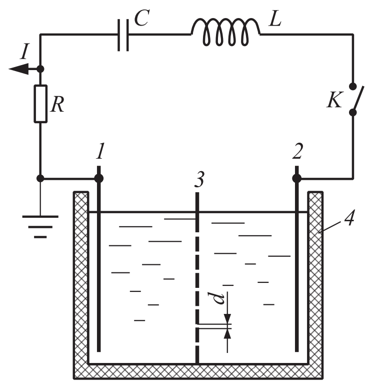

Figure 2 Schematic of experimental setup

(diameter of holes $d = 200$–$300\ \mu$m, and film thickness $h = 20\ \mu$m). The supplying voltage (the voltage of capacitor C in Fig. 2) was $U_C = 200$ V, the inductance was $L = 7.7$ mH. Hereby, enlarging the inductance in the discharge circuit, one can increase the amount of ionized substance and, therefore, the intensity of light emission.

The experimental setup is shown in Fig. 2. Metal electrodes *1* and *2* were placed on both sides of diaphragm *3* with holes into a nonconductive cuvette *4* with electrolyte. The distance from the diaphragm to electrodes and the area of electrodes exceeded considerably the diameter and area of the holes. Capacitor $C = 100\ \mu$F was charged from the external source to voltage $U_C = 100$–300 V. The commutation of the discharge circuit was realized by mechanical switch K. The self-inductance of the setup was 5 μH. Additionally connected inductance coil was $L = 0.4$–30 mH. Light radiated from the discharge region passed through the spectroscope ISP-51 and was registered with digital camera SensiCam LF360. The data obtained were processed with the specially developed computer code.

The number of holes was $N = 1$–25, holes diameter was $d = 50$–$300\ \mu$m, the diaphragm was made from Teflon with thickness $h \ll d$.

In the experiments, the active resistance of electrolyte cell R_c was $R_c > 2\sqrt{L/C}$. At such parameters, natural oscillations of the R_cLC circuit were not excited.

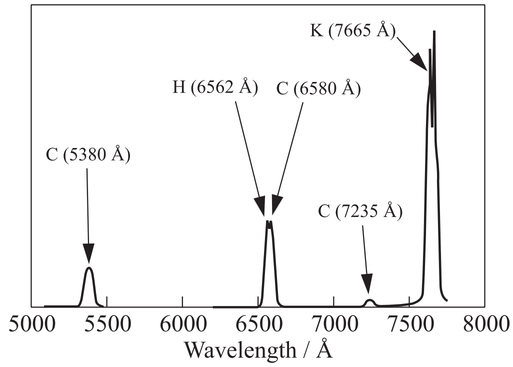

Figure 3 Spectrum of 5 percent solution of K_2CO_3

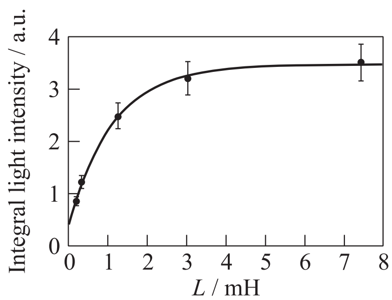

Figure 4 Dependence of integral intensity of light emission of the discharge on inductance L

Figure 3 shows the spectrum of light emission of 5 percent solution of K_2CO_3 in distilled water. The bright spectral line with wavelength 7665 Å corresponds to potassium (K). The spectral line with wavelength 6562 Å belongs to hydrogen (H). The remaining spectral lines correspond to carbon (C). The prevalence of potassium line in the spectrum is explained by small ionization energy (1.62 eV).

Figure 4 shows the dependence of integral intensity of light emission of the discharge on the inductance L. The experimental data can be approximated by curve $y \sim \exp(-L/L_0)$ (shown in Fig. 4 by the solid line), where $L_0 \approx 1.1$ mH, with a good accuracy.

The tendency of the intensity dependence to a horizontal asymptote can be explained by the fact that at inductance increasing the frequency of autooscillations is reduced due to increasing of current raise time. The integral intensity decreases correspondingly as the number of current pulses during discharge is reduced.

The dependence of Fig. 4 shows that at inductance increasing in the discharge circuit, the integral intensity of light emission increases several times, indicating the raise in efficiency of capacitor C energy transformation into the energy of light emission. This enables to increase the efficiency of the emission spectral analysis during diaphragm discharge in the regime of autooscillations at voltages $U_C = 100$–300 V.

Acknowledgments

This work was supported by the Russian Foundation for Basic Research (grants Nos. 06-02-17453 and 07-08-00195).

References

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