CUMULATION OF ENERGY BY MULTISPARK DIAPHRAGM AUTOOSCILLATION PROCESS IN ELECTROLYTE

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Abstract

The effect of generation of high-voltage pulses by the synchronous autooscillation process on multiple concentrators of electric current in electrolyte is obtained experimentally. As concentrators the holes in dielectric films and sections of metal wires were used. It is demonstrated that the high-voltage pulses arise from the current interruption on concentrators by bubbles because of inductance in the electric circuit. The maximum energy-release in bubbles (on concentrators) is achieved in period of their growing and overlapping the concentrators. At that the breakdowns of bubbles occur.

1 Introduction

Electrohydrodynamic autooscillations in electrolyte represent the practical interest and explored high in our days.
If we establish current concentrators in electrolyte and supply dc voltage so as the current flows through the concentrators, it will have oscillation character [1]. It is connected with that on the concentrator-electrolyte boundary the rapid heating and boiling of liquid occur due to the high current density. The generated steam and gas bubble overlaps the concentrator and interrupts the current. Then the bubble gets cold and collapses. And the process repeated again.
Certain amount of last papers deals with the autooscillations on multiple current concentrators connected in parallel [2, 3]. The cooperative features if connecting the large number of concentrators in parallel represent the most interest for the technological applications. But the problems of synchronization lead to the difficulties of obtaining the stable autooscillations of total current.
When connecting up to the circuit of the additional inductance in series between voltage source and the electrode the qualitative change of cooperative processes on multiple current concentrators is occurred. Since a certain diversity of concentrator's sizes is always presented the current interruption first occur on the smallest concentrators. In addition the inductance L generates the pulse of overvoltage due to the processes of self-inductance. Thus at the moment of current interruption on the smallest concentrators the redundant voltage on electrodes arises:

$$U_L = -L\sum_i \frac{dI_i}{dt} \qquad (1)$$

where I_i – the current through the concentrator i. This voltage results in acceleration of current interruption on the rest of concentrators. Thus the additional inductance introduces the positive feedback between concentrators and enables to synchronize the autooscillations on all the concentrators [4].
Theoretically if the number of concentrators is increased unrestrictedly the voltage on the electrodes may rise unrestrictedly near the moment of current interruption, when |dI/dt| is maximal. But practically it isn't succeed generally to achieve the considerable voltage rise due to the difference of concentrators sizes and the breakdowns in bubbles which create additional channel of current flow and decrease |dI/dt|. Thus the inductance redistributes the electrical energy and enables to generate high-voltage pulses and obtain high power densities on current concentrators in electrolyte.

2 Experimental arrangement

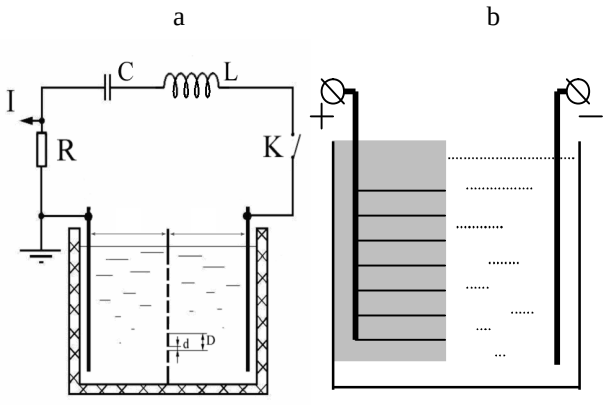

Figure 1. The schemes of experiments for obtaining the synchronous autooscillations on current concentrators in the form of:
a) holes in dielectric film (d – the diameter of hole, D – the distance between the holes),
b) sections of metal wires flush mounted in dielectric plate.

The experiments were carried out in 1-5% solution of NaCl in distilled water. Two types of concentrators were used:

- Dielectric films (teflon, lavsan) of thickness h=20-200mkm with round holes (with diameter 0,1-0,5mm), the number of holes was varied N=1-30 (fig. 1a).
- Sections of metal wires (d=0,2-0,5 mm, N=5-56) flush mounted in dielectric plate (fig. 1b).

The electric circuit of experimental setup is shown on fig. 1a. In experiments the range of additional inductance L=50-7700mkH was used. The capacitor C=100mkF was charged from dc voltage source, then the key K was closed, and the capacitor was discharged through the electrolytic cell. By-pass R was used for current measurement. The self-inductance of the setup is 3mkH.

The time of the capacitor discharge is considerably more than the period of one oscillation so the voltage U_C over the range of several current pulses may be considered as constant. In the experiments U_C=100-500V. The light emission from zone of concentrators' arrangement was registered with PMT-35 and recorded on digital oscilloscope Tektronix TDS-210 together with the registration of current and voltage on the electrodes.

In the experiments the active resistance of electrolytic cell was in the range $> 2\sqrt{L/C}$. Under such parameters the natural oscillations of RLC circuit is not excited (aperiodic capacitor discharge) and not produce qualitative changes in the process of autooscillations.

3 Results

On fig. 2 the oscillograms of current, electrode voltage and light emission for autooscillations on 30 holes in teflon film (d≈100mkm, h=20mkm) are presented. The voltage U_C=200V, L=800mkH. The NaCl concentration is 5%.

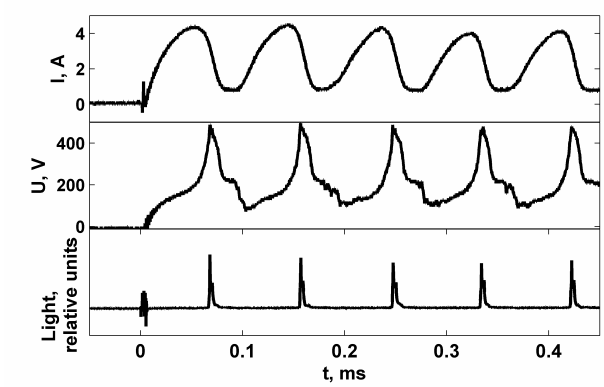

Figure 2. The oscillograms of current I, electrode voltage U and light emission for autooscillations on 30 holes in teflon film (d≈100mkm, h=20mkm). U_C=200V, L=800mkH.

From fig. 2 it can be seen that the maximum electrode voltage U_{max}≈2,5*U_C. In addition at the moments of maximum voltage the breakdown of bubbles occurs, that is indicated by the synchronous light flashes.

The oscillogram of the released electrical power P=U*I for the same experiment is shown on fig. 3. It is seen that the maximums of power is greater than the values on current peaks and concur with the maximums of the electrode

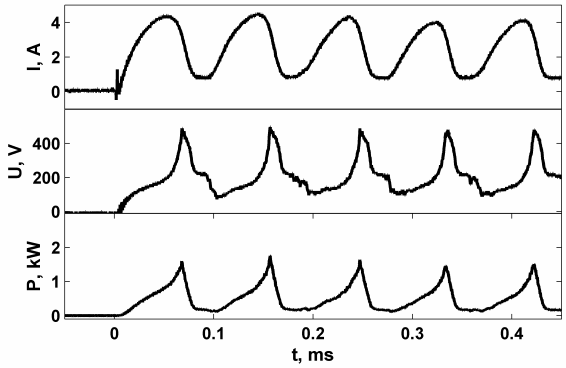

Figure 3. The oscillograms of current I, voltage U and power P for autooscillations on 30 holes in teflon film (d≈100mkm, h=20mkm). U_C=200V, L=800mkH.

voltage. The maximums are placed in the phase of current falling (the growing of bubbles on concentrators), so in the bubbles the electric field of high density is produced, which synchronizes the autooscillations of total current and initiates the breakdowns of the bubbles.

We can estimate the maximal electric field in bubbles as E_{max}~U_{max}/d, so in this experiment E_{max}~50kV/cm. The estimated maximal power density on one concentrator:

$$p_{\max} \sim \frac{P_{\max}}{VN} \sim \frac{2P_{\max}}{d^3 N} \qquad (2)$$

(V – the volume of bubble) in the experiment is p_{max}~10^5kW/cm^3.

On fig. 4 the comparative oscillograms of current and electrode voltage for the setup with concentrators in the form of sections of 5 platinum wires (d=0,5mm) flush mounted in rubber plate are shown: a) without additional inductance, b) with additional inductance L=7,7mH. U_C=200V, the NaCl concentration is 1%.

It is seen that when connecting of the additional inductance the stochastic behavior of autooscillations turns into synchronous. Qualitatively the character of current and voltage oscillations is the same that in the experiment of fig. 2.

Thus by means of autooscillation process in electrolyte we can create a current or voltage generator, moreover with the amplitude which is several times more than the voltage of source (in the carried out experiments it was achieved U_{max}≈3U_C).

In addition the inductance coil operates in the regime of cyclic inductive energy storage and allows releasing energy in bubbles on concentrators in periods of current interruptions, which results in synchronization of autooscillations and initiation of bubbles breakdowns.

The initiation of breakdowns under slight source voltage (150-200V) is the significant result which enables to initiate physicochemical and biological reactions in liquid with less power inputs. It will enable to increase the efficiency of

existent facilities of disinfection [5] and spectrum analysis [6] of liquids.

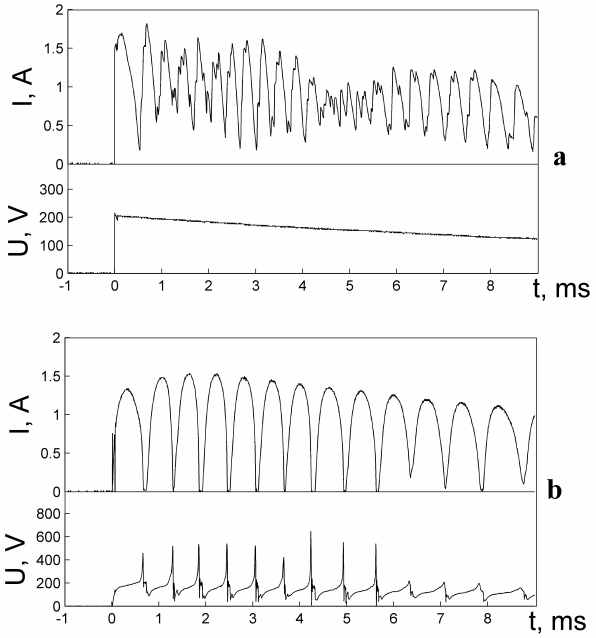

Figure 4. The oscillograms of current I and voltage U for five current concentrators in the form of sections of platinum wires (d=0,5mm) flush-mounted in rubber plate a) without additional inductance, U_C=200V; b) with additional inductance L=7,7mH, U_C=200V.

4 Conclusions

- In the paper the effect of electrical energy cumulation is obtained experimentally in the synchronous process of autooscillations on multiple current concentrators in electrolyte.
- The preliminary explanation of mechanism of energy redistribution is given, which is consisted in the presence of inductive energy storage.
- The given effect is possible to apply for disinfection of water-biological mediums [5], monitoring of water and land resources [6], shock-waves generation and physicochemical reactions initiation in liquid.

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