POWER and ENERGY INPUT DETERMINATION for BARRIER DISCHARGE EXCILAMPS

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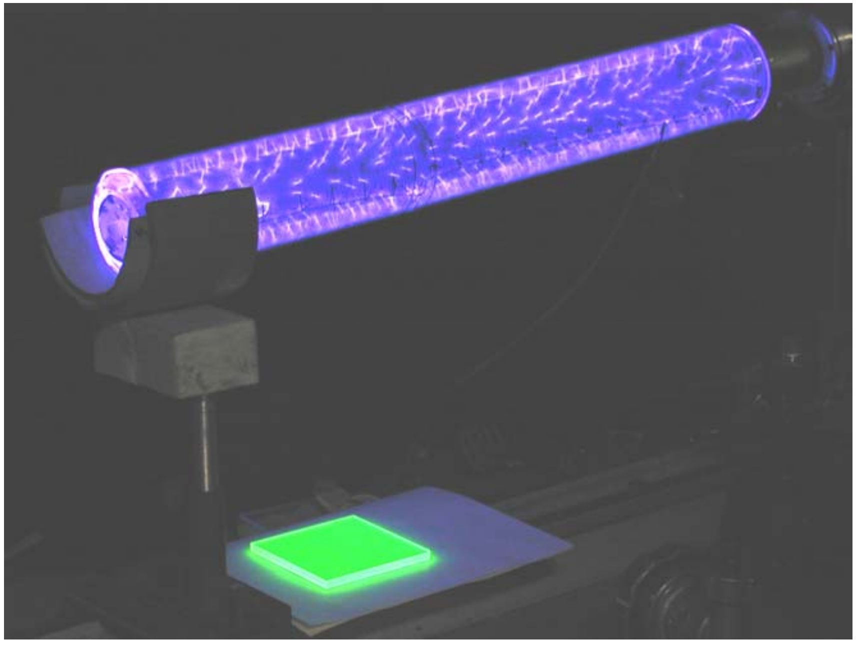
- Introduction:
- There are several methods to calculate average input power and deposited energy into barrier discharge plasma per excitation cycle:
  - calculation of volt-ampere power in the primary circuit of power supply;
  - calorimetric method;
  - discharge volt-coulomb characteristic (loops) according to ozonizer electric theory;
  - using effective current and voltage values measured over the discharge cell taking into account phase bias.
- References:

- 1. T. C. Manley "The electric characteristics of the ozonator discharge," *Trans. Electrochem. Soc.* **84,** pp. 83-96, 1943.
- 2. V.G. Samoilovich, V.I. Gibalov, K.V. Kozlov. *Barrier Discharge Physical Chemistry*, Moscow State Univ., 1989.
- 3. Z. Falkenstein, J.J. Coogan. "Microdischarge behavior in the silent discharge of nitrogen-oxygen and water-air mixtures", J. Phys. D: Appl. Phys. **30**, pp. 817-825, 1997.

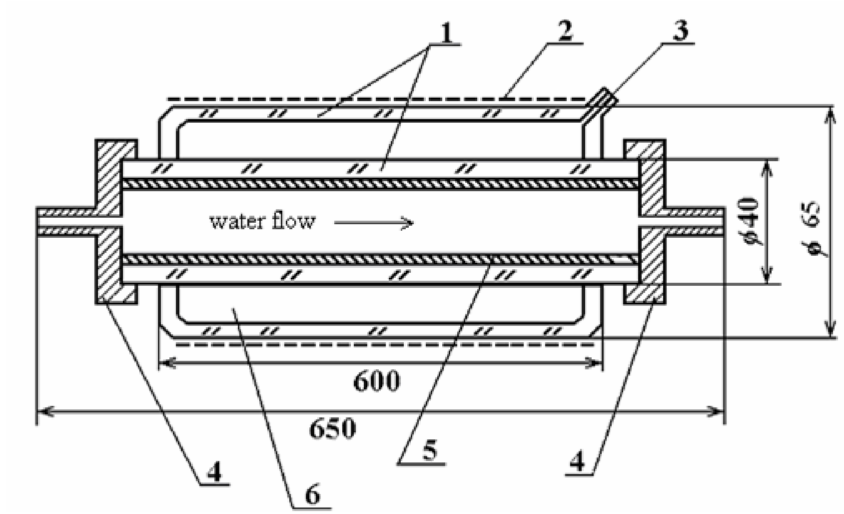
- The work is aimed to determine the waveforms of voltage drop at gas discharge gap, power, and deposited energy for the barrier discharge excilamp.

Experimental setup and methods



KrCl barrier discharge excilamp in operation regime

Experimental setup and methods



<u>Schematic diagram</u>

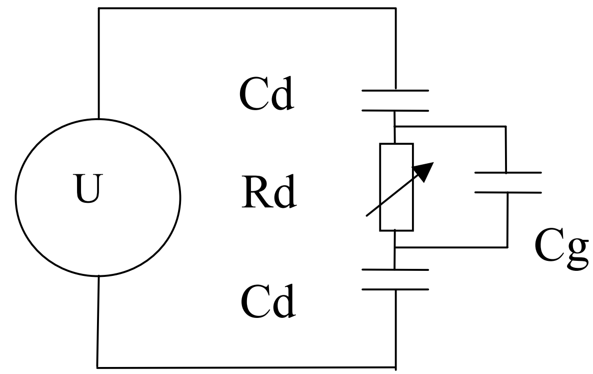
<u>of the barrier discharge excilamp</u>:

1- quartz tube walls; 2 – grid electrode;

3 - gas mixture inlet; 4 –water flow port;

5 – aluminum foil electrode;

6- gas discharge gap.



<u>Equivalent electrical circuit</u>:

U – generator voltage,

*C*d - dielectric barrier capacity,

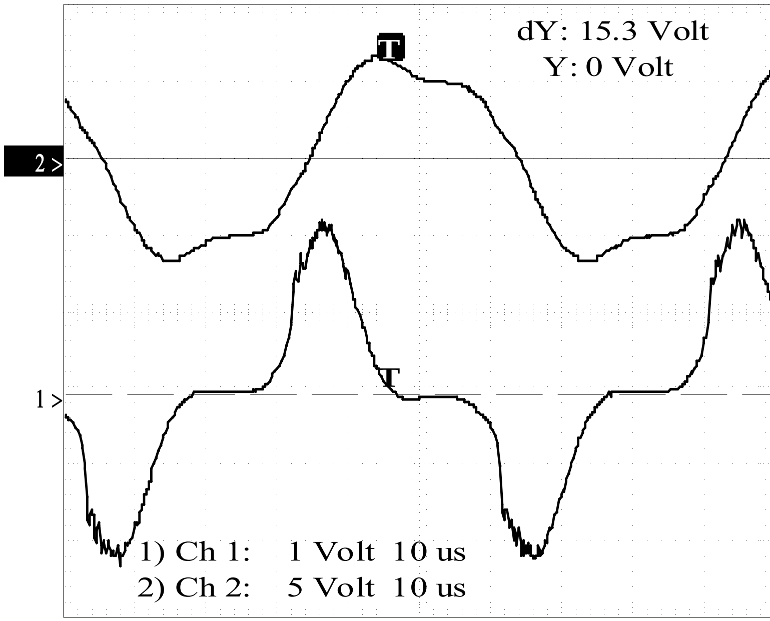
*C*g - gas gap capacity,

*R*d - resistance of gas discharge plasma.

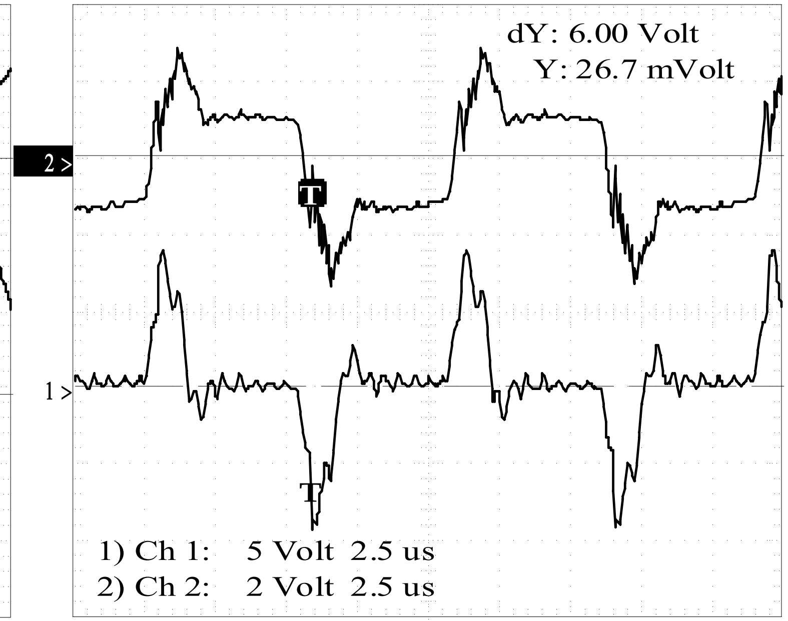
Main equations

Active Power P(t) :	$P(t) = U_g(t) \cdot I_a(t)$	(1)
Gas Discharge Voltage Ug(t):	$Ug(t) = U(t) - Ud(t)$	(2)
Dielectric Voltage Ud(t) :	$Ud(t) = Q(t) / Cd$	(3)
Displacement Charge Q(t):	$Q(t) = \int_0^t I(t')dt' + Q_0$	(4)
	$Ug(t) = U(t) - Q(t) / Cd$	(5)
Active Current Ia(t) :	$Ia(t) = I(t)\frac{\tilde{N}g + \tilde{N}d}{\tilde{N}d} - \tilde{N}g\frac{\partial U}{\partial t} = I(t) - \tilde{N}g\frac{\partial Ug}{\partial t}$	(6)
Active Power P(t) :	$P(t) = \{U(t) - Q(t) / Cd\} \cdot Ia(t)$	(7)
Deposited Energy E(t) :	$E(t) = \int_0^t P(t')dt'$	(8)

Experimental results



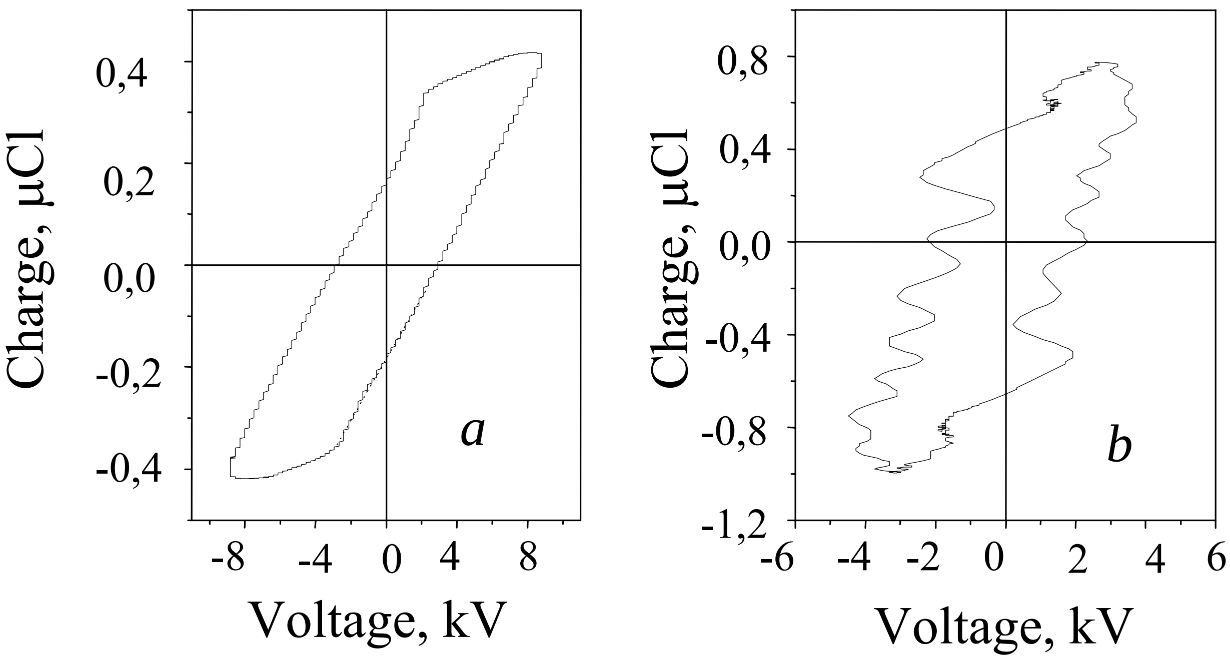
a



b

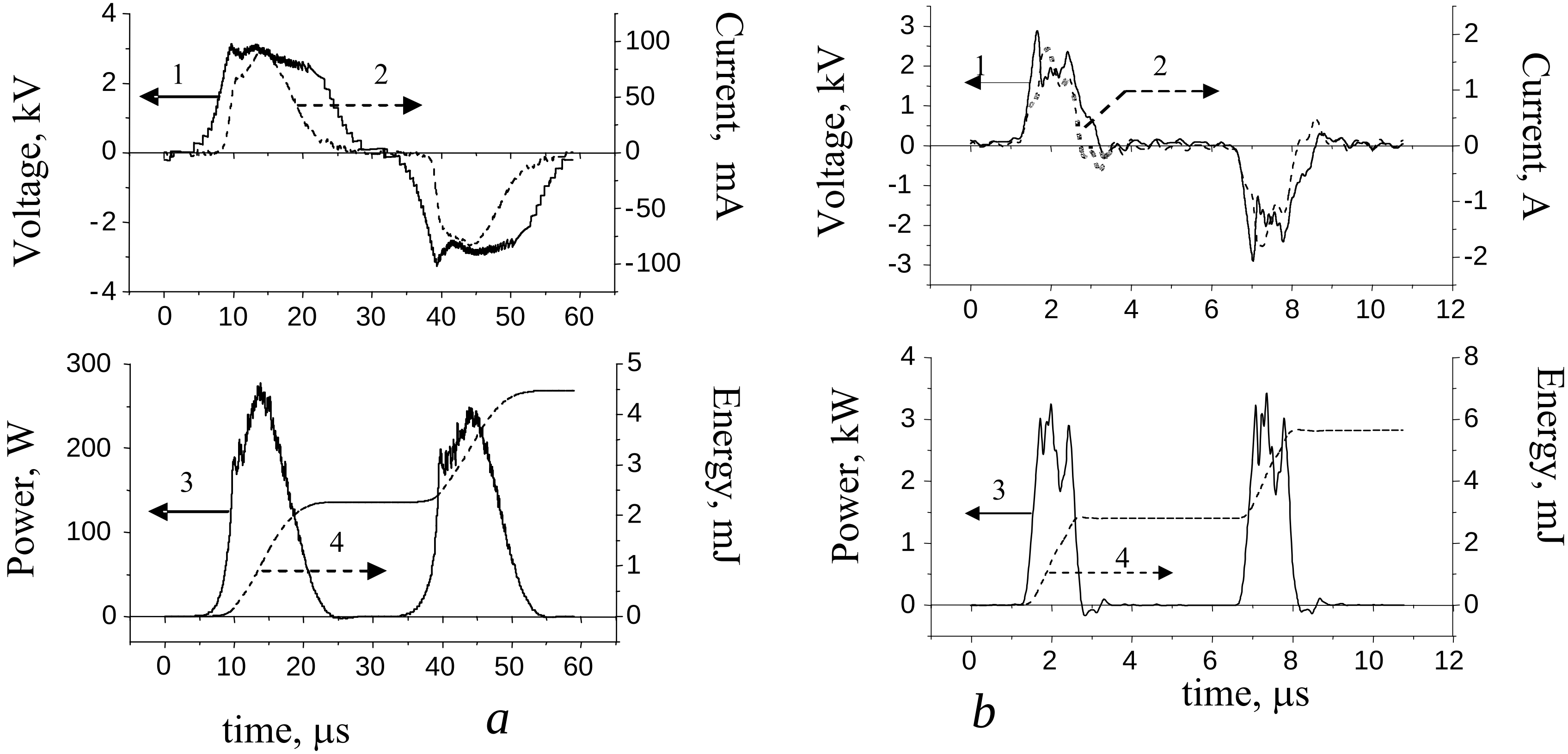
Oscilloscope traces of current pulses – channel *1* and voltage – channel *2* at lamp electrodes for sine (*a*) and steeply rising voltage excitation modes (*b*).

Experimental results



Volt-charge loops for sine (*a*) and steeply rising voltage excitation modes (*b*).

Calculation results

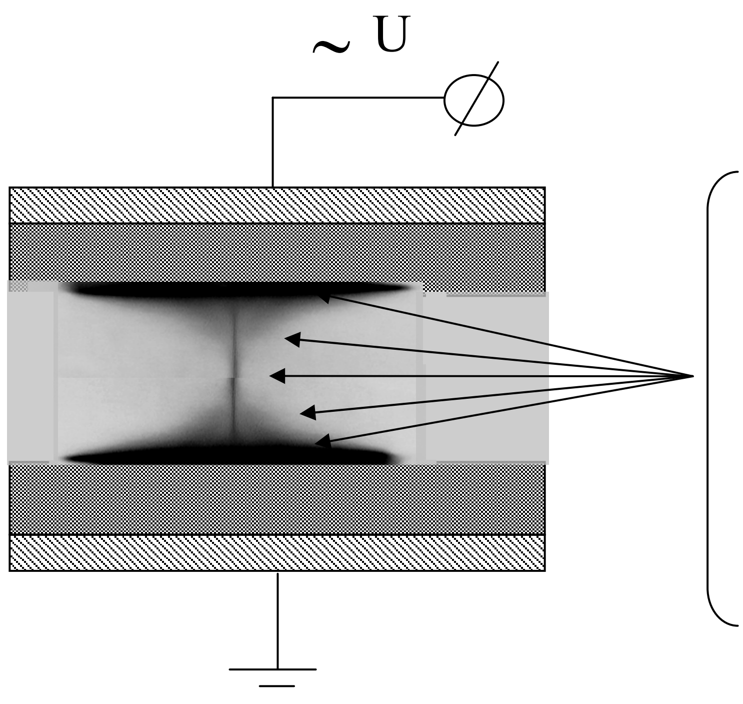


Gas discharge voltage (1), active part of current (2), power (3) and deposited energy (4) calculated curves for sine (*a*) and steeply rising voltage excitation modes (*b*).

Calculation results

- Evaluation the accuracy of excitation parameters calculation was made. For both excitation modes the energy deposited in one cycle and excitation average power were determined by traditional volt-charge loops and calorimetric methods, and using Eqs. (1)–(8) using the same experimental conditions.
- Results obtained by various methods differ not more than ~8%.

Discussion



Values of calculated voltage drop on gas discharge plasma, active part of current correspond in the main to zones with filaments, i.e. energy deposition volume zones.

Conclusions

- In this work the calculation of waveforms of voltage drop on gas discharge plasma, active part of current across the discharge gap, power and energy excitation of barrier discharge excilamp was done.

- Average excitation power values found by three methods (calorimetric, volt-charge loops, and integration of calculated power) differ not much than ~ 8%.

- It is mostly important to take into account gas discharge gap capacity *C*g at steeply rising voltage excitation which allows obtain the more data on parameters and average power of an excitation pulse.