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CREATION OF CONDUCTIVITY IN DIELECTRIC LIQUIDS

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ABSTRACT
In this article, a study was made of the possibility of creating and using a stable conducting channel in a dielectric liquid under the influence of laser radiation

The paper shows the dependence of the type of breakdown on the radiation power density and frequency. The calculation of the main parameters of the breakdown, such as the breakdown temperature, the calculation of the values of the intensity and intensity of the radiation, the dimensions of the focusing region of the laser radiation to achieve the goal of the work, was carried out.

Experimental setup

To carry out experimental studies, an experimental setup was created, consisting of an experimental cell with a test sample and a laser technological setup LTU-200, which was not previously used for these purposes.

The created experimental setup included:
1) Experimental cell (EC);
2) Power supply;
3) LTU-200;
4) Measuring instruments that detect the presence of a breakdown (voltmeter, ammeter, oscilloscope).

The layout of the installation and the methodology for conducting the experiment are shown in Fig. 1 and are as follows:

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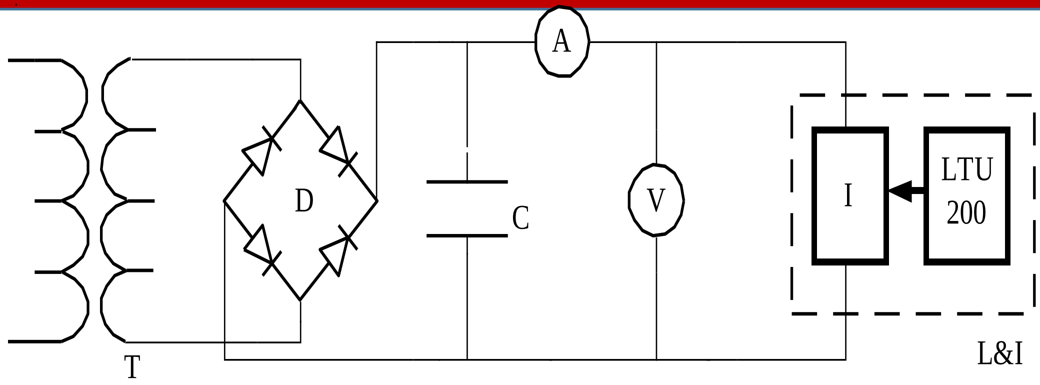

Figure 1. Scheme of the installation, where L&I is a radiation source and an experimental cell with a test sample (liquids), where T is an alternating voltage source, D is a diode bridge, C is a capacitor, A is an ammeter, V is a voltmeter, L&I is an experimental cell with test sample and laser processing unit LTU-200

To increase the efficiency of generating radiation from carbon dioxide molecules, most CO_2 lasers use a gas mixture with different percentages of carbon dioxide CO_2, nitrogen N_2 and helium He. The addition of nitrogen to the working gas mixture enhances the generation of laser radiation, and helium mainly intensifies the removal of heat during generation due to the high heat capacity and thermal conductivity, thereby lowering the overall temperature of the mixture.

In CO_2 lasers, the most common scheme is with an independent electric discharge, which combines the functions of pumping the working mixture and ionization. Such types of lasers are structurally designed in the simplest way, and in most well-known domestic and foreign lasers with a radiation power of up to 1000 W, an electric-discharge laser with a self-sustained discharge is used [1,2,3].

In modern designs of CO_2 lasers, in order to increase the efficiency of using the working mixture, it is necessary to maintain its temperature at an optimal level and prevent overheating. For this purpose, cooling is carried out either according to the principle of heat removal from the discharge tube (CO_2 - lasers with diffusion cooling of the working mixture) [1], or by direct circulation of the working mixture in order to replace the heated volumes (lasers with convective cooling) [2].

The laser has the following specifications:
- wavelength 10.6 μm;
- range of radiation power change from 5 to 100 W;
- LI divergence 0.002 rad;
- output beam aperture 12 mm;
- mode composition of TEM_{10} radiation;
- supply voltage 27 ± 1.5 V;
- maximum power consumption 2.7 kW;
- frequency of driving pulses 10 kHz;
- radiation quantum energy – hv=0.117 eV.

Selecting the type of liquid to be tested

The choice of the type of the studied liquid was due to a number of features in accordance with the goal and task of the work. We list the main requirements:

1. Use in traditional methods of electroerosive processing of materials.
2. The possibility of using the investigated liquid in our setup.
3. Small ionization potential.

Methodology of experimental studies

The main purpose of the experiments was to study the effect of laser radiation on the electrical conductivity of dielectric liquids and to study the practical possibility of realizing electroerosive phenomena in a dielectric medium. Experiments are carried out to study the influence of the following parameters:

- Distance between electrodes;
- voltage drop on the electrodes;
- Power of laser radiation

The experiment itself consisted of two main parts and consisted of the following:

1. The experimental cell was filled with the liquid under study (bidistilled water, alcohol, transformer oil), then a voltage from 0 V to 150 V was applied, and we fixed the breakdown voltage for this type of liquid, at which erosion begins.
2. The experimental cell was filled with the liquid under study (bidistilled water, alcohol, transformer oil), then a voltage from 0 V to 150 V was applied, and a laser beam of different power from 10 W to 100 W was focused in the zone between the two electrodes.
3. After the experimental part of the work, data processing and plotting of the current-voltage dependence are carried out.

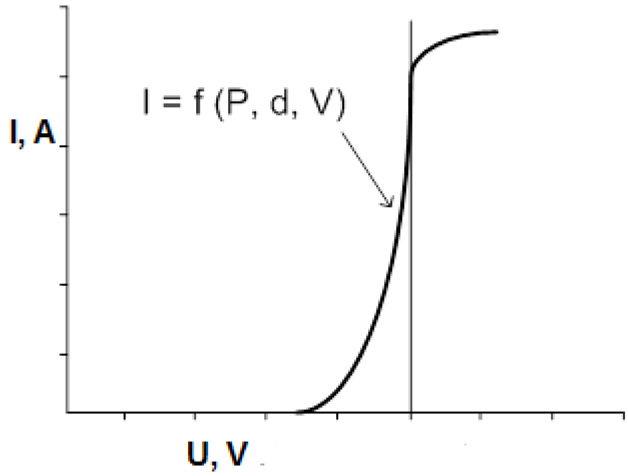

Figure 2. Graph of the volt-ampere dependence of the studied substance as a function of the parameters

It should be noted the experimental difficulties in the study of laser breakdown, which make it difficult to obtain reproducible thresholds, are as follows:

1. Irreproducibility of the temporal and spatial structure of a laser pulse due to the multimode nature of high-power pulses. This problem can be solved by careful transverse and longitudinal mode selection.
2. Influence of absorbing inclusions (impurities). During linear absorption in an intense laser field, the energy is deposited so rapidly that the temperature of the absorbing inclusion can rise by thousands of degrees and cause local melting and evaporation of the substance. Thermal stress can cause the destruction of the material in which the inclusion is located. The problems of thermal conductivity and mechanical stress can be solved by classical methods. Of course, much depends on the dimensions of the absorbing inclusion, on the duration of the laser pulse, and on the

optical thickness of the inclusion. In practice, the fracture threshold is often determined by submicroscopic absorbing particles; for example, neodymium glass laser rods always contain particles of platinum. Such inclusions can be removed. The threshold determined by them, of course, is not connected with the fundamental properties of the substance, and in an ideally pure substance the threshold should be much higher. In experiments on laser breakdown, it is important to be able to either remove these inclusions or distinguish their effect from absorption effects in truly transparent materials.

3. In ideally transparent materials, the destruction threshold is often determined by the phenomenon of self-focusing. An example is the well-known characteristic thread-like traces of destruction in optical glasses. Although electrical breakdown and avalanche ionization can occur in the self-focusing region, the threshold observed in such cases is determined by the critical power of self-focusing rather than the threshold electrical breakdown power density. In quantitative studies of breakdown, it is necessary to avoid not only self-focusing, but also the slightest deformation of the laser beam due to a change in the refractive index, which depends on the radiation intensity.

conclusions

- Experiments were carried out to study the effect of laser radiation on the electrical conductivity of dielectric liquids.
- The type of investigated dielectric liquids, which will be used in the experiment, has been determined.
- The main criterion for choosing the type of liquid was the use in traditional methods of electroerosive processing of materials, the possibility of using the investigated liquid in the installation.

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