BREAKDOWN IN ARGON AND NITROGEN UNDER THE INFLUENCE OF A 0.35-μ PICOSECOND LASER PULSE

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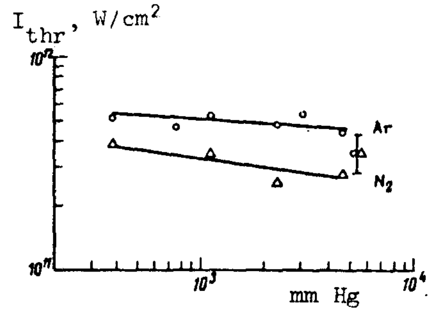
It was shown experimentally in [1, 2] that optical breakdown produced by a picosecond laser radiation pulse of wavelength 0.69 μ in argon, helium, and nitrogen is due to multiphoton ionization of the atoms or molecules of the gas. In the case of nitrogen, this mechanism plays a decisive role also in the breakdown produced by a laser of 1.06 μ wavelength [3].

The present investigations were aimed at explaining the mechanism whereby breakdown is produced in argon and nitrogen by laser radiation of picosecond duration and 0.35 μ wavelength. To this end, as in the cited investigations, we measured the dependence of the threshold breakdown intensity on the pressure of the investigated gas.

The experimental setup is similar to that described in [1]. The picosecond radiation pulse was produced by a ruby laser system [2] whose fundamental radiation was converted into the second harmonic by a KDP crystal. The second-harmonic laser radiation was focused by a lens of focal length 1.8 cm inside a chamber filled with the investigated gas at the required pressure. To separate the fundamental-frequency radiation from the second harmonic, a filter based on a saturated aqueous solution of $CuSO_4$, 1 cm thick, was placed in front of the lens. The second-harmonic power was measured with a calibrated electron-optical receiver with a time resolution not worse than 20 psec. The transverse dimension of the focal region was determined by direct photometry of the intensity distribution in the vicinity of the focus. The area at half-intensity was 1.4×10^{-5} cm^2. The breakdown which produced a glow in the focal region, was observed visually. The threshold intensity was assumed to be the peak intensity at which the glow was still visible.

The results of the experiments are shown in the figure. The laser pulse duration ranged from 30 to 50 psec. We see that in the pressure range from 400 to 4500 mm Hg the threshold intensity of the breakdown depends little on the pressure both in the case of argon and in nitrogen. This indicates that the onset of the breakdown under the investigated conditions is connected with multiphoton ionization of the atoms or molecules of the gas in the strong radiation field [4]. The breakdown threshold intensities for argon and nitrogen turned out to be quite close.

A comparison with the results of [2] shows that when the radiation frequency is doubled the breakdown threshold is decreased by a factor of almost 20 in argon and by a factor of 300 in nitrogen. This indicates precisely a multiphoton ionization mechanism, rather than tunneling of the electrons from the atom. In the latter case, the probability of the process does not depend on the frequency [5].



Experimental dependence of the threshold breakdown intensity I_{thr} on the pressure: o - in argon, Δ - in nitrogen.

An analysis of the experimental results of the present study and of work by others [6] shows that the relative increase of the photoionization probability with increasing frequency of the optical radiation is satisfactorily described by the analytical quasiclassical formula derived in [7]. As already indicated [6], the absolute values of the probabilities calculated by means of this formula, turn out to be smaller by several orders of magnitude than those determined experimentally. The values of the effective ionization potential of argon and of the degree of quantum multiplicity used in the calculations are those presently known from the experimental research [6].

We note that when application of laser radiation of wavelength 0.35 μ and duration 20 nsec also revealed a decrease of the threshold breakdown intensity in Ar and Xe [8]. However, unlike breakdown by picosecond laser radiation, this fact has not yet been theoretically explained. The universally accepted theory of avalanche breakdown in the case of nanosecond pulses of radiation, predicts a monotonic increase of the threshold in breakdown intensity with increasing frequency of the laser radiation [9].

It is apparently necessary in the theory to take additional account of the specific nature of the processes in the optical band, particularly the influence of resonant transitions between excited states, effects of self-focusing, etc.

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MAGNETIC CONTRIBUTION TO THERMAL EXPANSION OF PALLADIUM

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The contribution of paramagnons to the thermal expansion of metals with primitive cubic lattices, in the nearest-neighbor interaction approximation, is determined by the relation [1]

$$\left(\frac{\delta a}{a}\right)_{eq} = \frac{\epsilon N}{3C}\, g(T), \qquad (1)$$

where ε determines the change of the width of the unfilled band with increasing lattice, g(T) is a parameter that connects the electron correlation functions with the lattice periods at the different temperatures, with the energy U of exchange interaction on the atom, the polarization χ_p of the spins of