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THE PARAMETERS AND PHASE COMPOSITION CONTROL OF LASER EROSION JETS WITH AN EMPLOYMENT ELECTRIC AND ELECTROMAGNETIC FIELDS.

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Abstract. We have found possibility to control composition of the erosion laser jets with an employment external electric and electromagnetic fields. Erosion laser plasma with a minimal composition of the liquid drop phase have been obtained.

1. INTRODUCTION

The products of damage caused by moderate-intensity (10^5 - 10^8 W cm^{-2}) laser radiation to metals is two-phase jets. These jets consist of a vapour, a plasma, and liquid drops. It is interesting to use an external electric and electromagnetic fields to control parameters and composition of these erosion jets.

Lead target was placed between two plates. An external electric field was applied to these plates. It allowed to determine an influence of the external electric field on dynamics of a fine-disperse liquid-drop phase formation. The target was damaged by near-rectangular neodymium laser pulses of a power density $4{,}6\times10^5$ W cm^{-2}. The monitoring of sizes and liquid drops density was carried out by transverse probing the erosion products with radiation from an auxiliary ruby laser. The probing was carried out on the distance 1 mm from a targets surface. Electric field was changed from 0 up to 4 kV cm. Investigation results we can see on fig.1. The solid curve is result of measurements when field is absence, large dashes at E=1 kV cm, small dashes - E=4 kV cm. They show that at exposure laser radiation to the lead target drop density (N) increase in erosion laser jet if electric field was applied in comparison when electric field was absence, and drop diameters (d) decrease. It can be explained by a drop fragmentation as charges appear on these drops. It can be used for a control of erosion jets parameters.

Another control method of the erosion plasma jets parameters and composition is exposure to jets by rather intensity electromagnetic radiation. The investigation in crossed laser beams have been made when the interacting laser radiation was directed perpendicular to the target surface and radiation from an auxiliary laser propagated parallel to the surface at some distance from it. Auxiliary laser radiation interacted with the erosion products and evaporated additionally the condensed phase without altering the conditions on the target surface.

We used a lead target. The interacting radiation was in the form of near-rectangular neodymium laser pulses of 400-500 μs duration. The intensity of this radiation was 1.4×10^{6} W cm^{-2} in all experiments and the irradiation spot diameter was 6 mm. The additional evaporation was caused by radiation from a free-running pulsed neodymium laser generation pulses of ~ 10^{-3} s duration. The diameter of the laser beam in the evaporation zone was 8 mm. The center of this beam was 2 mm above the target surface, so that the lower part of the beam was screened by the target itself and the rest interacted with the erosion jet. The intensity of the radiation causing additional evaporation was varied, depending on the experimental conditions. The monitoring condensed phase parameters was on the distance 2 mm from a targets surface.

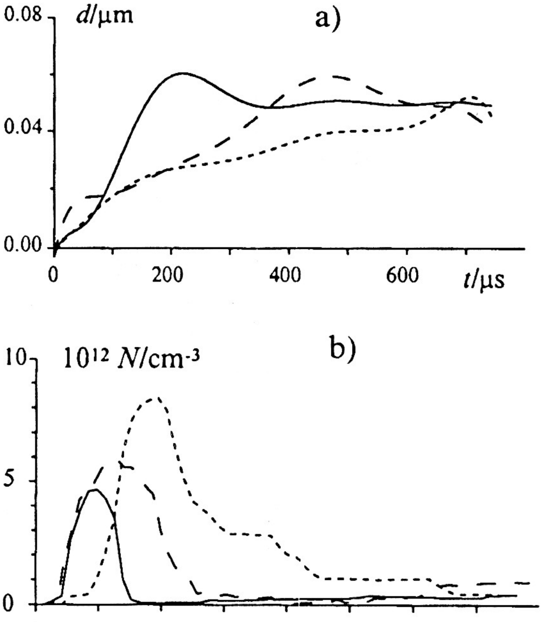

Fig. 1.

Kinetics of the condensed phase can highly depend on particles sizes and consequence on particle formation mechanism. Therefore, it is useful to consider three cases: case 1, when an erosion jet contains small particles generated by bulk vapour formation (during the action of plasma-forming neodymium laser pulse); case 2, when an erosion jet contains particles formed by both mechanisms (it follow 450 - 500 μs from beginning of a laser pulse); case 3, when an erosion jet contains primarily large particles formed by the hydrodynamic mechanism (it follow after 650 - 700 μs from beginning of a laser pulse acting on the target).

Experiments showed that the additional evaporation of the condensed-phase particles in case 1 began at the laser radiation intensities causing additional evaporation as low as ~ 10^{5} W cm^{-2} and, when power density reached ~ 5×10^{5} W cm^{-2}, particles became so small that probe ruby laser radiation scattered by them was below the sensitivity limit of our measuring system, which was 10^8 cm^{-3}.

Fig.2 gives results of our experiments on a laser target exposed to neodymium laser pulses of 1.4×10^6 W cm^{-2} intensity in the absence of the radiation causing additional evaporation (solid curve) and in the presence of such radiation of ~ 2.3×10^5 W cm^{-2} intensity (dashed curve). We found that even when the intensity of the radiation causing additional evaporation was low (compared with the intensity of radiation producing the initial damage), the dimensions of the condensed-phase particles and their concentration fell significantly.

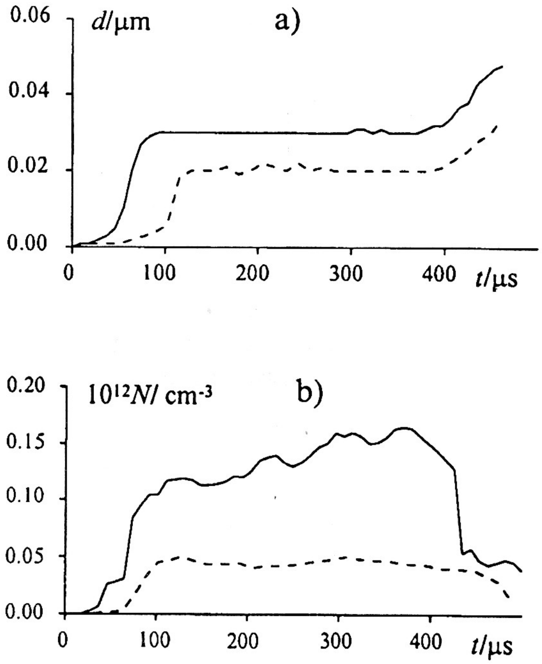

Fig. 2.

Experimental results for case 2 was showed fig 3a. The interacting radiation once again had the intensity 1.4×10^6 W cm^{-2}. The intensity of the radiation causing additional evaporation was varied from zero to ~ 10^6 W cm^{-2}. The size of the particles first increased with increase in the intensity of radiation causing additional evaporation. This was observed because the smallest particles formed by bulk vapour formation were evaporated completely and a major fraction of the large particles formed by the hydrodynamics mechanism remained in the jet. A further increase in the intensity of the radiation causing additional evaporation reduced the particle size. A reduction in volume concentration C (ratio of the volume occupied by the condensed-phase particles in the investigated zone to the total volume of this zone) indicated sufficiently effective additional evaporation of the condensed phase of the target material when the intensity of the radiation causing additional evaporation was increased.

For case 3 (fig.3b) particle size decreased with increase in the intensity of the radiation causing additional evaporation. The behavior of the volume concentration indicated that the mass of the material concentrated in the condensed-phase particles decreased significantly with increase in the intensity of the radiation causing additional evaporation and at some intensity of this radiation the particles could evaporate completely.

2. RESULTS

Our investigation of the kinetics of the condensed-phase particles in erosion jets in crossed laser. beams showed that radiation from an auxiliary laser could be used to control effectively the parameters of the liquid-drop phase particles and thus the parameters of the erosion jets themselves. Radiation of lower intensity should be sufficient for this purpose and radiation of much lower intensity should be for particles generated bulk vapour formation. It have been shown that the simultaneous interacting of crossed laser beams and external electric field on erosion jets can be used for an effective of the material target condensed phase in erosion jets. Electric field allow decrease of the particles sizes and small particles can be effectively to evaporate the auxiliary laser radiation.

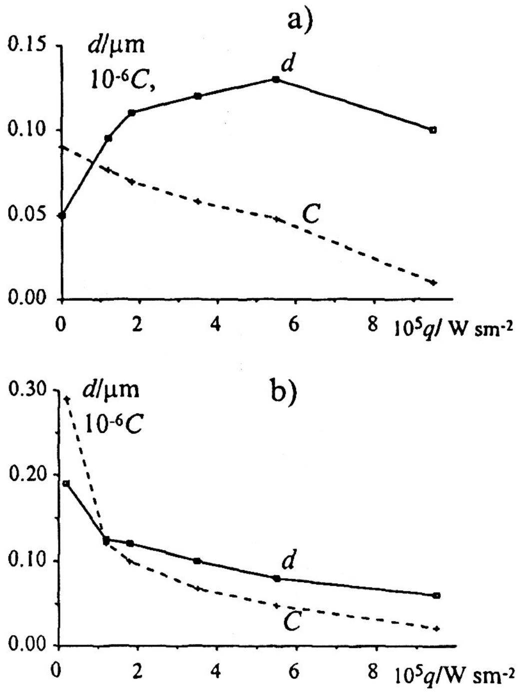

Fig. 3.

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