Plasma formation during pulse-periodical laser treating of metals

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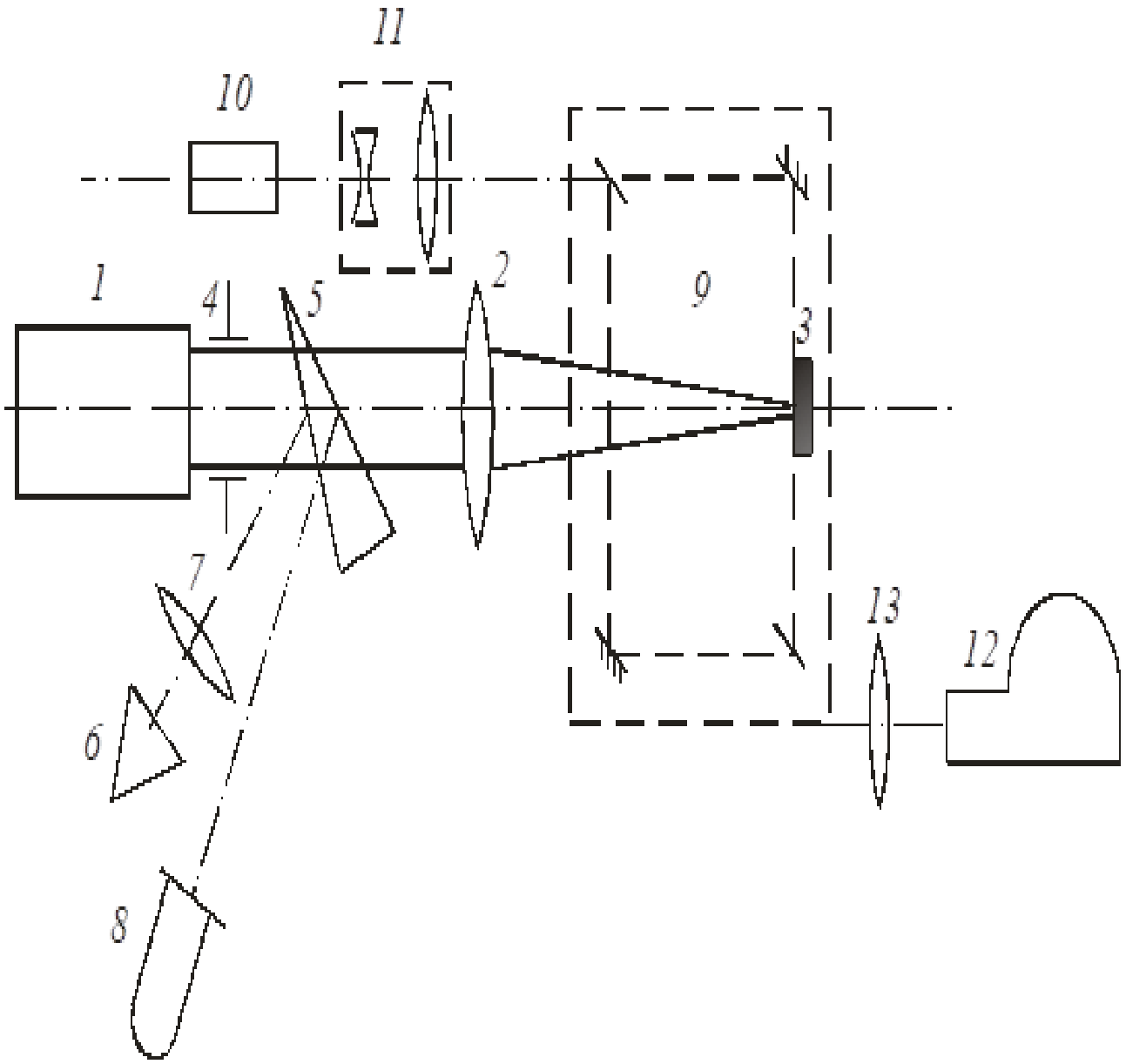
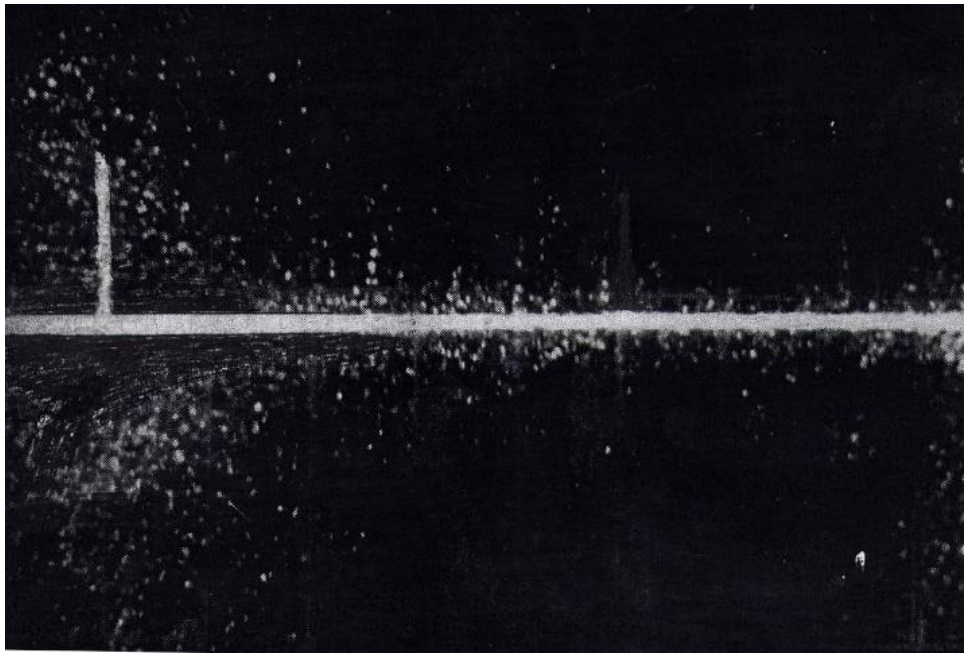
The aim

- The purpose of the present research was investigation of plasma during mono-pulse and two-pulse action of laser radiation with wavelength upon the metal samples in air on atmospheric pressure and its influence on laser destructed zone form.

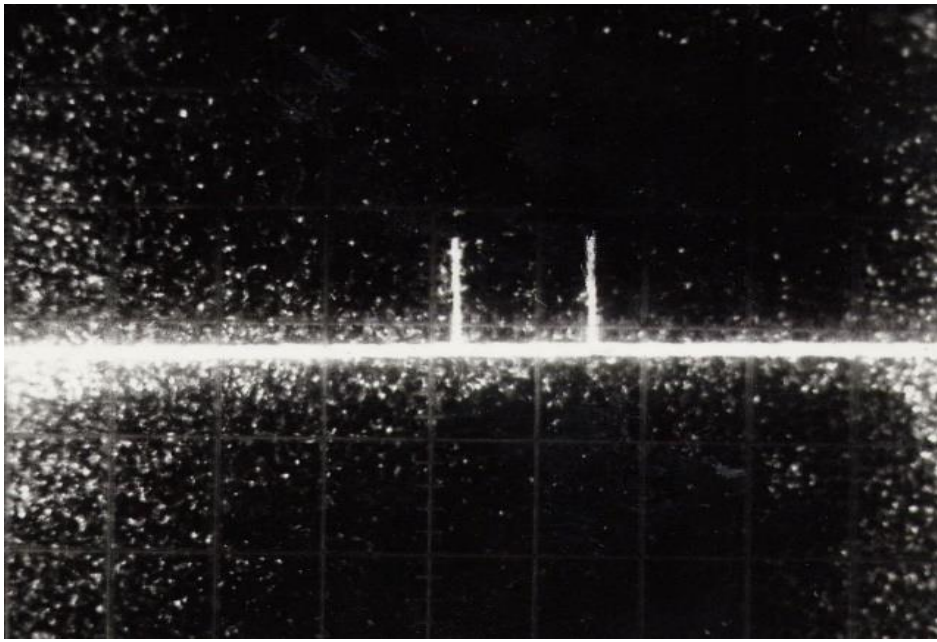
Schematic diagram of the experimental setup.



Oscillograms of forms of laser pulse having 1 (a) and 2 (b) peaks. Point on the ordinate axis is 10 MW, velocity of scanning – 100 μs/point.



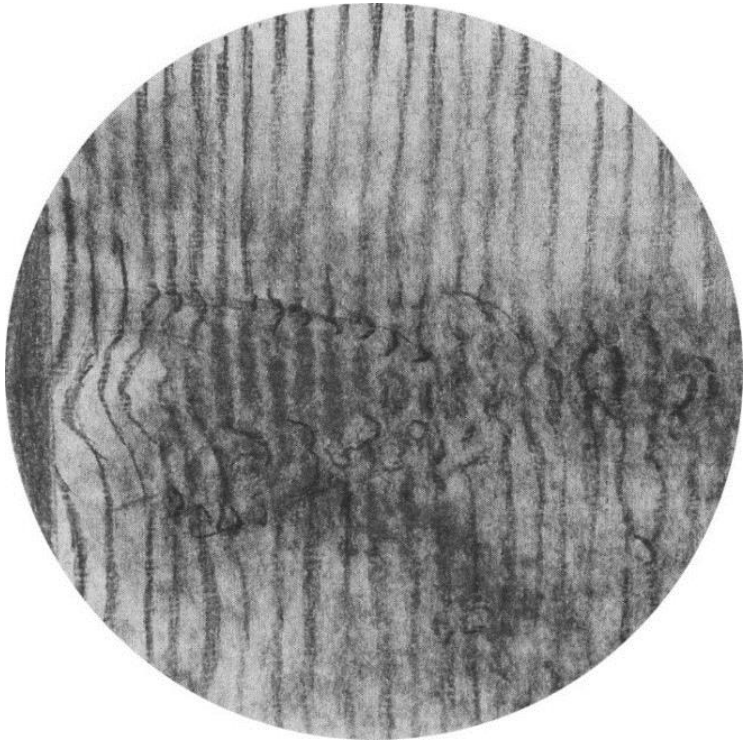
a)



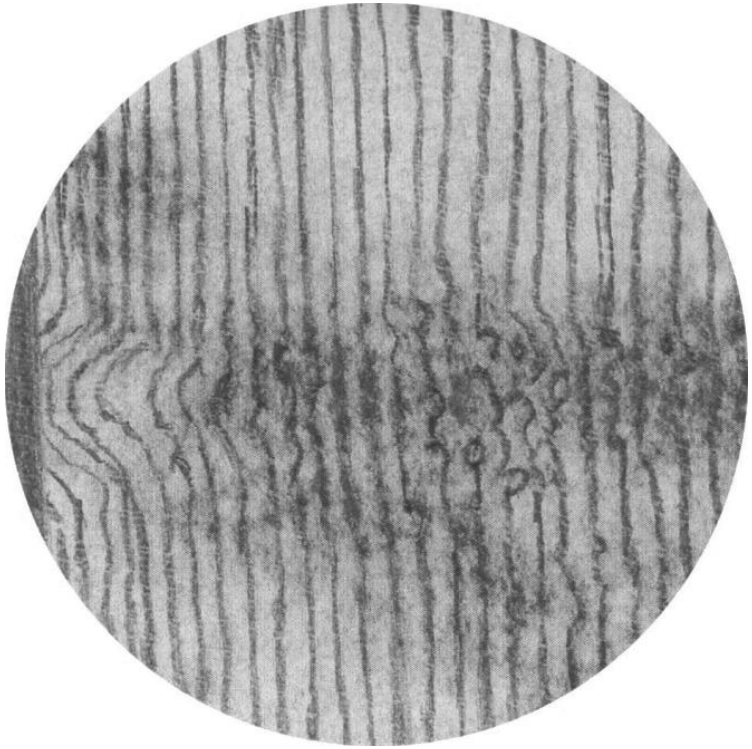
b)

b)

Interferograms of laser plasma obtained during irradiation of led sample by one (a) and two (b) laser pulses.



a)



b)

Abel equation

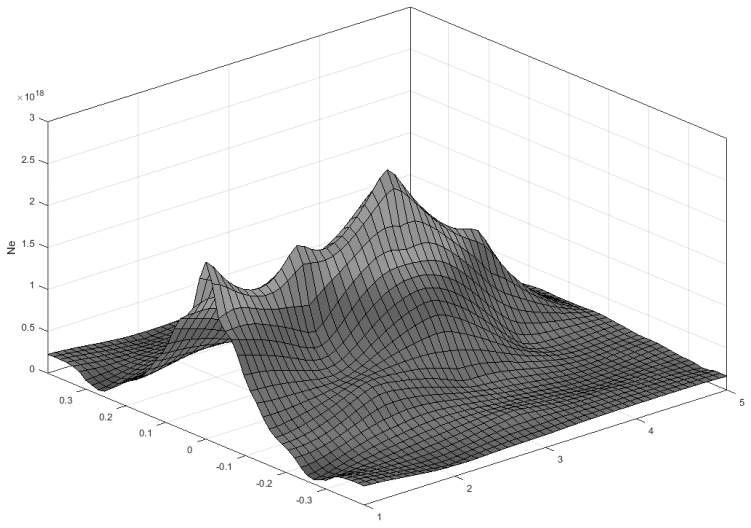
$$k(x,y)=\frac{2}{\lambda}\int_{r=y}^{R}\left[n(x,r)-n_0\right]\frac{r\,dr}{\sqrt{r^2-y^2}} \qquad r=\sqrt{z^2+y^2}$$

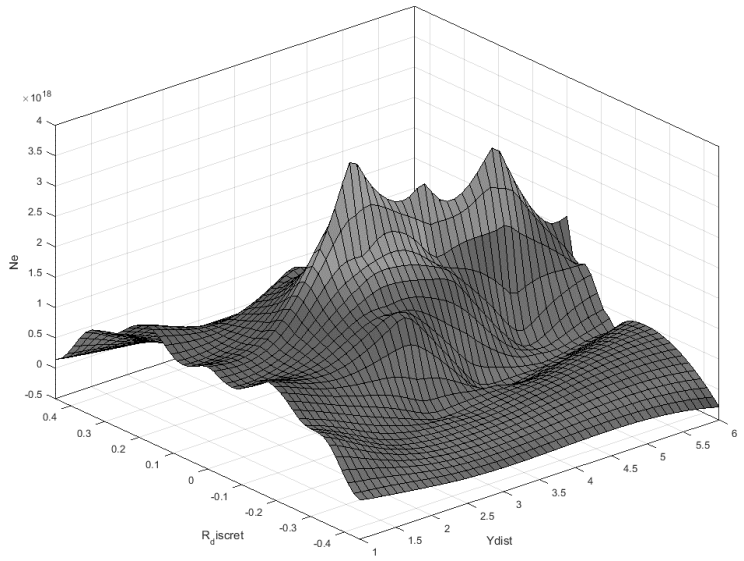
$$n(x,r)-n_0=-\frac{\lambda}{\pi}\int_{r}^{R}\frac{dk(x,y)/dy}{\sqrt{y^2-r^2}}dy$$

$$n-1=-\frac{e^2\lambda^2 N_e}{2\pi m c^2}$$

b)

Electron density in the different sections of plasma plume for one-pulse (a) and two-pulse (b) laser treating of led sample.





a)

b)

Electron density in the different sections of plasma plume for one-pulse (a) and two-pulse (b) laser treating of led sample.

- The density of plasma plume on the borders of irradiated spot and in the centre are different. This effect is connected with different conditions of energy dissipation from the plasma connected with lateral unloading. Lateral unloading has a surface character; intensive dissipation are mainly going on the border of laser beam.

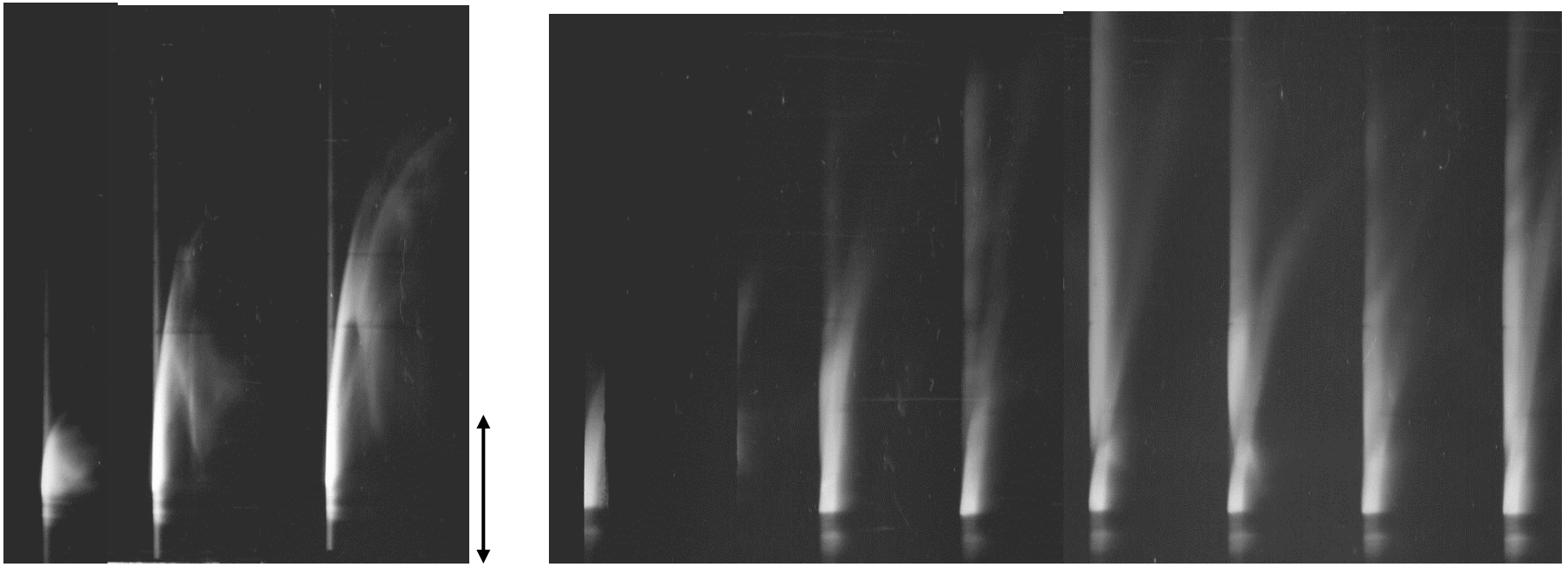
Electron density in the different sections of plasma plume for one-pulse (a) and two-pulse (b) laser treating of led sample.

- The difference of concentration maximums on different regimes of laser treating is also observed. For instance, during mono-pulse action maximum is disposed in the centre of irradiated spot, during two-pulse action two maximums symmetrically removed from the centre are observed. This effect can be connected with the refraction of laser radiation in the already existing plasma.

Electron density in the different sections of plasma plume for one-pulse (a) and two-pulse (b) laser treating of led sample.

- During two-pulse laser treating of metal turbulences in plasma plume are pronounced more distinctly. This is connected with action of the second laser pulse on the droplets of melted metal already thrown out from the target.

Fast photo-scanning films of plasma plumes generated near the irradiated surface during treating of led sample with three (a) and series (b) laser pulses.



Fast photo-scanning.

Each laser pulse brings separate contribution in laser plasma formation on the surface of irradiated sample. For plasma plumes forming by the second and by next laser pulses presence of several plasma fronts supported by laser radiation and spreading along the laser beam in the already existing plasma is characteristic.

Fast photo-scanning.

Shock waves reflecting from the border of plasma and air and from the surface of the irradiated target are seen distinctly on the photographs. During many-pulse laser treating of metal samples one can observe quasi-stationary plasma-dynamical structures formation.

CONCLUSIONS

The investigations showed that the discovered peculiarities of pulse-periodical laser treating of metal samples expends the possibilities of application of pulse laser radiation for treating of matters.

thank you for attention