Bulgarian Journal of Physics 20 Nos 1/2 (1993) 52–54

OBSERVATION OF DENSITY DISTURBANCES IN THE AMBIENT MEDIUM CAUSED BY SHORT-GAP ELECTRIC ARC IN WATER

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Received 21 November 1991

Abstract. High-speed laser shadowgraphs with magnification of 20X have been used to investigate a short-gap electric arc (length 5 μm) in water. Spherical layer of high density gradient was found to expand radially in the water ambient.

Резюме. Высокоскоростные лазерные тенеграммы с увеличением около 20-ти раз использованы для исследования дуги в коротком промежутке (длина промежутка ∼ 5 μm) в воде. Обнаружен один сферический слой с большим градиентом плотности, распространяющийся радиально в окружающей воде.

The few authors (e.g. Zolotin 1962, Chuanjin and Fui 1986) who have studied electric arcs (approximately from 0.5 to 5 μm in length) in electrode gaps in water used high-speed photographic and X-ray pulse methods. They ascertained the availability of a cavern with spherical symmetry. The typical values of the arc current are between 50 and 200 A, and the arc duration is from 20 μs to 1 ms.

This paper describes detection of optical nonuniformities, caused by short-gap arc in water, using for this aim laser shadowgraphs (the Gabor's holography method). This method has been used to investigate optical nonuniformities caused by short-gap arc in air with visible (580 nm) laser radiation (Djakov, Ivanov, Srebrov 1987).

Since water has weak contraction, the high-quality detection demands improvement of the method and an increase of the spatial resolution. As is known, the spatial resolution can be improved with a decrease of laser radiation wavelength

(Born and Wolf 1971). For this reason the UV laser pulsed radiation (wavelength 337.1 nm and pulse duration 5 ns) was used.

The experimental setup is shown in Fig. 1. The pulsed nitrogen laser L illuminates the quartz cuvette Q where an arc was ignited. The optical nonuniformity

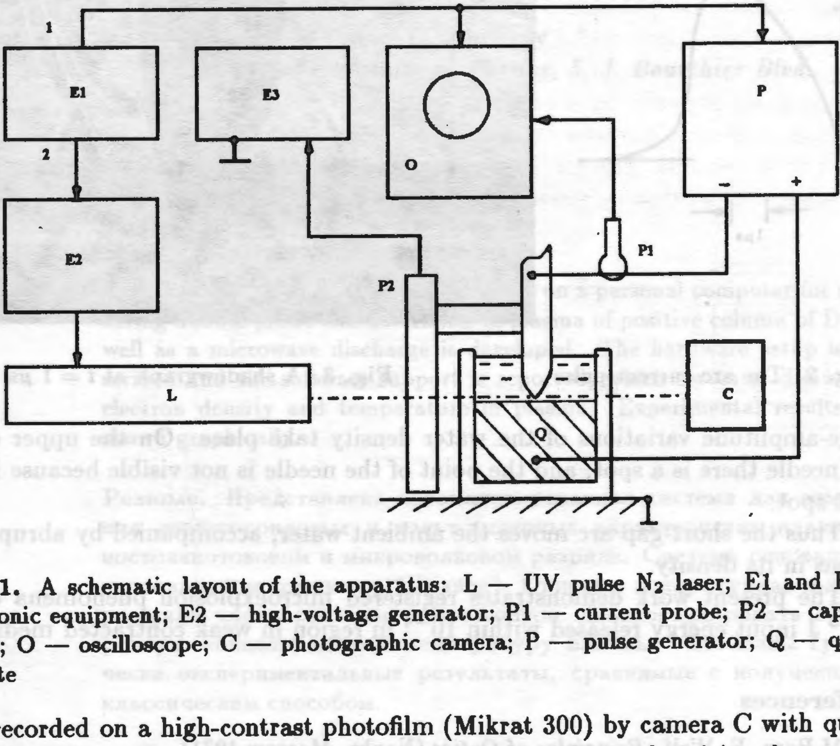

Fig. 1. A schematic layout of the apparatus: L — UV pulse N_2 laser; E1 and E3 — electronic equipment; E2 — high-voltage generator; P1 — current probe; P2 — capacity probe; O — oscilloscope; C — photographic camera; P — pulse generator; Q — quartz cuvette

was recorded on a high-contrast photofilm (Mikrat 300) by camera C with quartz objective. Because water is weak electrolyte and conducts electricity the arc was supplied by a pulse generator P, and not by discharging a capacitor. The gap between the electrodes was fixed in advance, then measured with capacity probe P2 and electronic equipment E3. On the output 1 the electronic equipment E1 provided triggering for the pulse generator P and the oscilloscope O. The pulse of output 2 was with delay time toward output 1; it was a triggering pulse for the high-voltage generator E2 which triggers the laser radiation. The electronic equipment E1 secured delay time t of the laser radiation toward the ignition of the short-gap arc in the range of 0 to 2 μs.

The electrode geometry leaves half-space open for free water motion and it is accessible for optical observations. The anode was iron and flat, the cathode was a copper needle with radius of the curvature 50 μm.

Figure 2 shows oscillogram of the discharge current pulse with value 24 A and 5 μs arc duration.

The shadowgraph of the ambient arc region is shown in Fig. 3. One line is clearly visible on the photograph, and this is an image of a nearly spherical layer where

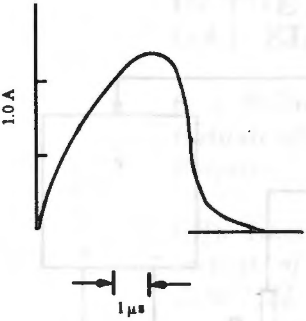

Fig. 2. The arc current pulse

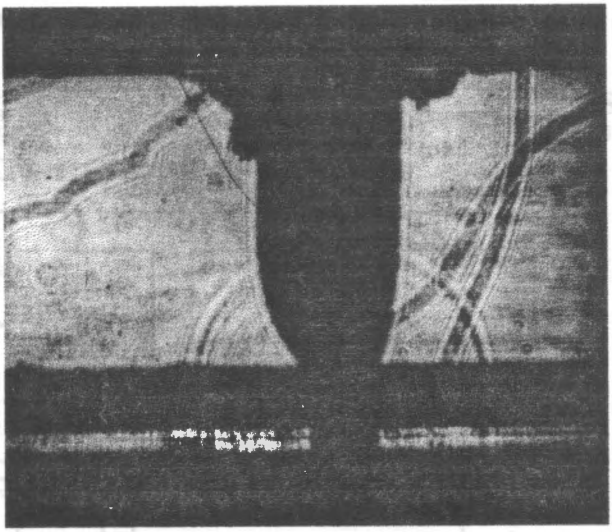

Fig. 3. A shadowgraph at $t = 1$ μs

large-amplitude variations of the water density take place. On the upper end of the needle there is a spot, and the point of the needle is not visible because it is in that spot.

Thus the short-gap arc moves the ambient water, accompanied by abrupt variations in its density.

The present work demonstrates registered microexplosion phenomena due to 10^{-3} J input energy released within 10^{-4} m region in weak contracted medium.

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