REMOTE EXPRESS ANALYSIS OF GROUND-LAYER AEROSOL BASED ON LASER-INDUCED SPARK SPECTRA

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U S S R

The state of the art of laser technique allows one to observe, in a ground-layer atmosphere, a large group of nonlinear optical effects which bear information on physico-chemical parameters of the atmosphere. In particular, the creation of high-power pulsed CO_2 and Nd-glass lasers enabled one to realize the method for remote spectro-chemical analysis of atmospheric aerosol based on excitation of the emission spectrum of aerosol particles atoms[1]. The essence of the method is that at focusing of a high-power laser pulse in the atmosphere there occurs high-temperature heating and vaporization of solid-aerosol particle matter. In vapors of the matter there can also occur an optical breakdown accompanied by the development of plasma formations around the particles. The presence of free electrons in plasma leads to excitation of atoms and molecules due to inelastic collisions in vapors thus giving rise to their strong nonthermal glow. At remote spectro-chemical analysis the laser source should provide simultaneously developed vaporization of an impact target (aerosol suspension of oil particles, products of metallurgy, organic substances etc.) and excitation of a sufficiently strong linear spectrum in a gas-discharge plasma.

An emission spectral analysis of the matter vapors has high sensitivity. It allows one to identify and obtain quantitative information on element composition of atmospheric-aerosol particles, content of inert gases and vapors of substances.

The paper presents a description of construction and characteristics of a spectrochemical lidar based on both Nd-glass and CO_2 lasers.

In the case of a Nd-glass laser the scheme of a driving oscillator forming a laser 40 ns pulse and a block of an optical quantum amplifier has been used. The radiation at 1.06 μm wavelength was focused at a given point of the atmosphere with the use of an optical Cassegrainian system which simultaneously received the optical breakdown emission. The Nd-glass laser lidar range of detection was 150 m. The spectral selection of plasma emission was carried out by a set of narrow-band interference filters placed into the photo-receiving blocks. The spectral range of the receiving system was 0.3 to 1.1 μm. The spatial selection of radiation was carried out with a block of fibrous optical light conductors. The signals recorded with photo-electronic receivers were amplified,

converted into a numerical code with the use of quick-acting six-digit analog-to-digital converters with 0.1 μs resolution and recorded in high-efficiency storage. Maximum duration of the recorded signal can reach 100 μs. The subsequent processing of signals, according to a given algorithm, was carried out using the computational facilities based on a mini-computer.

When a mono-pulsed electro-ionized CO_2:N_2 laser with electron-beam pre-ionization of an active medium, 3 KJ power, 10.6 μm wavelength, and variation of pulse duration 1 to 5 μs was used as a source of high-power radiation for a spectrochemical lidar, its range of detection increased by an order of magnitude in comparison with the Nd-glass laser. The lidar provides for a quantitative express analysis simultaneously of 15 chemical elements with 30 $\div$ 50% error and mean concentration sensitivity 0.1 - 1.0 μg m^{-3}.

1. V.E.Zuev, A.A.Zemlyanov, A.V.Kuzikovskii. High-power laser radiation in the atmospheric aerosols. D.Reidel Publishing Company, Holland, Dodrecht, 1984.