SELECTIVE RESONANCE EXCITATION IN REMOTE LASER SPARK SPECTROSCOPY

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1. INTRODUCTION

Remote express element analysis of terrain and water surfaces, different kinds of aerosols and air with using a laser-induced plasma exited on samples surfaces (Tsipenyuk, 1993, Parriger, 1994, Belyaev, 1994) is a very perspective method of ecological monitoring. This method could give us an important information for solving different problems of ecology, biology, geology, etc. We can obtain information about the element composition of different kinds of terrain surfaces and gases.

The rapid remote spectrochemical method of analysis of matter is based on a registration of emission spectra of laser induced plasma at the surfaces to be investigated. Wile plasma cools, optical energy is emitted at frequencies that are characteristic of the elements of plasma.

In our previous paper (Bunkin, 1994) we presented method and technique for remote sensing of sea and land surfaces element analysis. Our experiments performed as in the laboratory as with the helicopter-based lidar system, show that it is possible clearly to distinguish different kinds of terrain surfaces and to estimate the concentrations of elements in the investigated objects in remote sensing experiments with the accuracy about 0,0001%.

Nevertheless, in some cases it is necessary to increase accuracy of measurements and sufficiently diminish the threshold of registration for certain elements and in the same time simultaneous multielemental analysis isn't so important (for example if we need to register only the level of the concentration Hg in water) For solving this problem we investigate the possibility of increasing the contrast of emission lines of certain elements by initiating plasma by a laser wavelength which coincides with some resonance transition of these elements.

2. EXPERIMENTAL

Experimental arrangement was based on a YAG:Nd laser used as a source of 1064 nm and 532 nm light and in some experiments Kr-F eximer laser (248.5 nm). The YAG:Nd laser produced 15 ns pulses at the repetition rate 1-5 Hz. The laser pulse energy can be changed from 1 to 100 mJ.

A horizontal laser beam was rotated by a glass 90 prism vertically downwards. The beam was then focused onto the object surface by a high-quality telescope objective (with a diameter of 20 and focal length of 40 cm). In the case of the investigations of the salts solutions we used an open glass sell, 4-10 cm deep,contained the aqueous solution under study. It was mounted on an optical platform ensuring high-precision vertical displacement of the cell.

Note that, provided the laser beam waist was more than 2 cm above the water surface, no breakdown was observed. In the case when the beam waist was more than 1 cm below the surface, the plasma plume did not arise, too. In the latter case, propagation of a laser beam in water was accompanied by a series of microexplosions. Only when plasma plume was produced on the water surface emission spectra featured well-pronounced emission lines of elements.

Emission from a laser spark produced on the surface of the aqueous solution was detected at an angle of 90 with respect to the vertical. The emitted light was directed to a detector by two quartz lenses. The first lens (with a diameter of 6 cm and focal length of 50 cm) collimated the beam which was then reflected by mirror in the horizontal plane. The second lens (with diameter of 6 cm and focal length of 25 cm) focused radiation onto the entrance slit of an optical detector. The parameters of the second lens were chosen so as to equality of the angular aperture of the input beam and that of the detector. We assume that the radiation of plasma plume is isotropic and the plume is several millimeters in size. We then find that approximately a 0.0001 fraction of the emitted light arrives at the detector input.

The emitted light was detected by a multichannel spectrum analyzer, which was attached to a polychromator with a different gratings (we used several gratings from 150 to 600 grooves/mm). The light was directed to a

500-channel camera which operated in spectral region from 180 to 950 nm. To reduce experimental errors caused by fluctuations of the energy and spatial distribution of the laser beam spectra were averaged over 30-100 laser pulses.

Next data was fed to an IBM PC/AT computer. Subsequent processing of spectra was carried out by the computer. The wavelength scale of the spectra was calibrated against spectra of standard solutions, consisting of elements with well-known and reliably identified spectral lines and against neon lamp lines.

3. RESULTS AND DISCUSSION

As a result we found the drastic increase of contrast of spectral lines of iron dissolved in water in the integral emission spectra from plasma produced by light from eximer KrF laser in comparison with the excitation of plasma plums by YAG:Nd laser beam. We attributed this effect to the resonant transition of Fe (248.3 nm).

We also found sufficient increasing of signal/noise ratio in experiments on resonant initiation plasma plums by YAG:Nd laser at the surfaces of clear Cu and Cu salt water solution. It was shown that in the case when we initiate plasma by wavelength 532 nm (second harmonic of YAG:Nd laser) which is close to resonant Cu transition the signal/noise ratio of Cu lines was in 7-8 times grater than in the case of initiation plasma by unresonant wavelength 1064 nm (first harmonic of Nd:YAG laser).

These results show that the resonance excitation of plasma by tunable lasers is one of the most promising way for the increasing sensitivity of the remote spectrochemical analysis.

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