Simultaneous vacuum UV and broadband UV-NIR plasma spectroscopy for LIBS improvement

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LIBS (Laser Induced Breakdown Spectroscopy) of light elements was investigated. As a spectrum of some light elements has not enough emission lines in UV-NIR range, such as B, C, P and S, determination of the electron temperature from Saha-Boltzmann plot is very difficult or impossible. Our aim, improvement of the precision of the electron temperature determination by broadening of emission of UV-NIR range up to VUV range allowed observing more emission lines and very often neutral, single ionized and also double ionized. Precision of the electron temperature of other elements such as Si, Ge, Zn was also studied. Ions abundance evolution of the elements allowed us to find the best experimental conditions for generation of the double ionized ions in LIBS plasma.

1. Introduction

LIBS is an analytical method, which determines elemental composition of materials based on atomic emission of spark created by a laser beam focused on the surface. For light elements as *B, C, P* and *S* important characteristic spectral lines are few and appear in VUV range only [1]. Including VUV, in addition to conventional UV-NIR range yields in more reliable data set for Saha-Boltzmann (S-B) plot, which helps to quantify light elements more precisely using calibration free LIBS.

Heavy elements, such as tungsten have plenty lines in UV-NIR, but their overlap makes the S-B unprecise. Therefore the detection of double ionized W III lines in VUV proves to be advantageous [2].

2. Experiment

2.1. Experimental Set-up

LIBS measurements were realized under low pressure (1330 Pa) He and Ar atmosphere for various delays after the laser pulse to ensure narrow emission lines and observation of all three ionization degrees (neutral - double ionised). Plasma was generated by Nd:YAG laser (Quantel) operating at 266 nm (4-th harmonic) - see Figure 1.

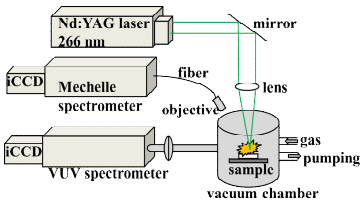

Figure 1. Experimental Setup.

Plasma emission was recorded simultaneously by two spectrometers: broadband UV-NIR echelle type spectrometer (230 nm – 950 nm, ME 5000, Andor) and VUV one (114-295 nm, McPherson), both equipped with iCCD camera (iStar, Andor).

2.2. Results

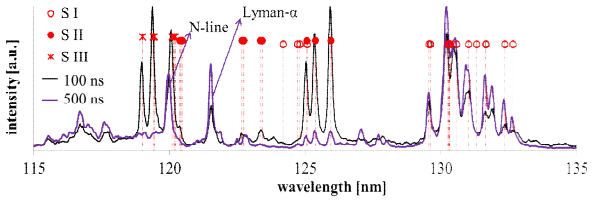

Figure 2. VUV spectra 300 and 500 ns after laser pulse.

The UV-NIR spectra of sulphur doesn't contains neutral S I lines. The VUV spectra allows to observe lines from different degree of ionisation, S I-III lines at 100 ns delay and S I-II lines at 500 ns delay (Figure 2). Clear line detection from three degree of ionisation (S I-III) allows us to determine electron temperature in the early state of the plasma plume (100 ns, Figure 3) and that leads to precise determination of sulphur concentration in a sample. LIBS of other elements (Si, Ge, Zn) was also studied.

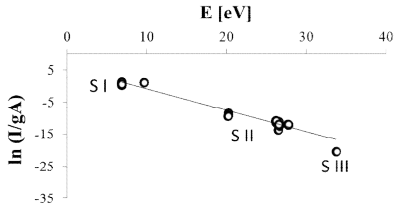

Figure 3. Saha-Boltzman plot of Sulfur.

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3. References

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