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Recent development of double pulse laser induced breakdown spectroscopy (DP-LIBS) setup

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Abstract

Single pulse (SP) LIBS setup was modified to DP setup to achieve more accurate analytical sensitivity and spatial resolution. All parameters, like interpulse delay, acquisition delay or energy of ablation and excitation laser pulses were optimized.

Keywords: DP LIBS, SP LIBS, heavy metals

Introduction

Laser-Induced Breakdown Spectroscopy (LIBS) is a spectrochemical method that can be applied to determine elemental composition of sample using radiation of Laser-Induced Plasma (LIP). The plasma plume is created focusing the ablation laser emission. Nowadays, the mostly used LIBS lasers are nanosecond-pulsed solid state lasers, such as Q-switched Nd:YAG. The basic LIBS setup consists of one (ablation) laser, optical systems for focusing of the laser light and collection of LIP emission, respectively. The spectral analysis is realized by a spectrograph coupled usually to ICCD camera in order to carry out temporally resolved spectroscopic measurements (Miziolek et al. 2006).

Using two lasers instead of one, in so called double-pulse (DP) configuration, allows to control in some extent the LIP plasma parameters (Colao et al. 2002). As a consequence, better signal-to noise ratio or smaller ablation crater diameters can be achieved.

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Orthogonal DP LIBS setup was realized by incorporating an another Nd:YAG laser (Solar LX-318, Belarus) to our SP LIBS setup described in details elsewhere (Kaiser et al. 2009). The DP LIP was studied at different interpulse delay times and laser pulse energies. The goal of these measurements was to obtain strong emission lines together with the smallest ablation craters.

Materials and methods

The emission lines of selected heavy metals (Pb, Cd) were observed in dried plant leaves, used also in our earlier works (Kaiser et al. 2009). In this study the acquisition delay, interpulse delay and first (ablation) and second (re-heating) laser energies were optimized.

Results and Discussion

It was shown that the emission intensities of atomic and ionic lines are strongly enhanced and the ablation crater size is reduced in the case of DP LIBS. As an example, in Table 1, a comparison of ablation craters for the same spectral line intensities from the SP and DP LIBS is shown. In order to reach the same spectral line intensities for SP method, the ablation crater size had to be enhanced approx. twice.

Table 1: Sizes of ablation craters created by the SP LIBS and DP LIBS (same spectral line intensity)

Setup	Diameter/µm
SP LIBS	100
DP LIBS	60

In Fig 1, the comparison of the spectral line intensities for SP and DP LIBS are compared. The energy E of SP LIBS is the same like the energy of ablation pulse E_1 (DP LIBS).

Conclusion

The parametric optimisation process resulted that both the DP LIPS spatial resolution and analytical sensitivity increase rapidly in

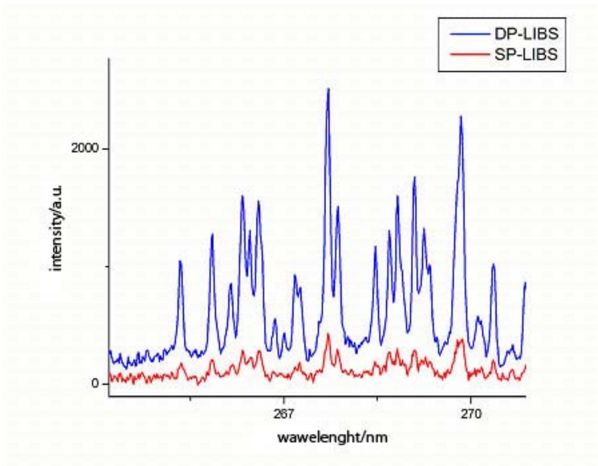

Figure 1: Comparison of line intensities for DP LIBS (blue line) and SP LIBS (red line)

comparison to SP LIBS. As a consequence, this approach can be successfully utilized for both, reduce the ablation crater size and so achieve higher spatial resolution in elemental mapping and simultaneously enhance the signal to noise ratio and achieve lower detection limits.

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