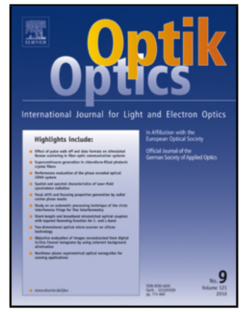
Accepted Manuscript



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PII:	S0030-4026(17)30918-X
DOI:	http://dx.doi.org/doi:10.1016/j.ijleo.2017.08.026
Reference:	IJLEO 59489

To appear in:

Received date:	20-4-2017
Accepted date:	2-8-2017

Spectroscopic Study on the Time Evolution Behaviors of the Double Laser-induced Breakdown of Al Plasma

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Abstract: To study the time evolution characteristics of plasma fluorescence, aluminum feature spectrum was measured and analyzed through dual-pulse laser-induced breakdown spectroscopy in the standard ambient temperature and pressure experimental conditions. Two Nd:YAG lasers were used to perform the experiment; one laser ablated the target, and the other reheated the plasma in air. The plasma emission intensity was enhanced at an optimal inter-pulse delay time of 200ns. The plasma fluorescence lifetime was measured in a dual-pulse laser excitation mode at different inter-pulse delays. The plasma fluorescence lifetime changed with the changing of inter-pulse delay under double pulse excitation. The results can further understand of the time evolution of the plasma under double-pulse laser excitation.

Keywords: Stimulated Raman; Laser-induced breakdown; Pulses laser; The fluorescence lifetime

1. Introduction

Laser-induced breakdown spectroscopy (LIBS) is an important method for detecting elements; this technique, which can detect multiple types of elements directly and rapidly without destroying such elements, has been widely used in industrial inspection, environmental pollution, biomedical science, and archaeology [1–4]. The current research of LIBS technology has focused on reducing detection limits, improving accuracy and reliability , and extending application areas, and many researchers has achieved many results [5–8].

In recent years, double-pulse laser-induced breakdown spectroscopy (DP-LIBS) has been extensively studied for improved limit of detection (LOD) and sample measurement accuracy [9–12]. The DP-LIBS technique excites the sample to generate the plasma using two lasers with a certain inter-pulse delay time; the first laser beam on the sample serves as preablation, and the second laser beam is targeted on the sample for reheating. The DP-LIBS method can improve the spectral detection sensitivity and the repeat measurement stability of the sample. Several researchers have studied the physical properties, such as plasma emission intensity, electron temperature, and density, of the plasma in the sample excited by DP-LIBS technique. Gautier et al. [13] studied the plasma properties of Al samples under DP-LIBS technique. They found that the emission intensity of plasma changes with the inter-pulse delay and obtained the optimum inter-pulse delay in collinear laser conditions. Jennifer et al. [14] used a DP-LIBS system to measure hazardous materials 20 meters away and noted an improved spectral detection sensitivity and detection accuracy. Sanginés et al.[15] studied the enhancement mechanism in double-pulse laser excitation spectra and proposed that the enhancement of spectra emission enhancement was related to the characteristics of sample quality excited by the reheating laser. Ahmed et al.[16] used DP-LIBS technique in various collinear and orthogonal excited copper samples and obtained enhancements of a factor 50 and 15 in spectrum lines compared with the single-pulse excitation spectra[17]. Further, they analyzed the affect of the different inter-pulse delays on the plasma electron temperature[18]. Research on DP-LIBS technology primarily focused on reducing the LOD in the element, improving the accuracy of measurement and expanding the applications of LIBS[19].