View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Purdue E-Pubs

The Summer Undergraduate Research Fellowship (SURF) Symposium
7 August 2014
Purdue University, West Lafayette, Indiana, USA

Double-pulse Nd:YAG-CO_2 LIBS Excitation for Bulk and Trace Analytes

Jason R. Becker, Patrick J. Skrodzki, Prasoon. K. Diwakar , Sivanandan. S. Harilal, and Ahmed Hassanein
Center for Materials Under eXtreme Environment, School of Nuclear Engineering, Purdue University

ABSTRACT

Laser-induced breakdown spectroscopy [LIBS] is a commonly used technique for multi-element analyses for various applications such as space exploration, nuclear forensics, environmental analysis, process monitoring. The advantages of the LIBS technique include robustness, ease of use, field portability, and real-time, non-invasive multi-element analyses. However, in comparison to other lab based analytical techniques, it suffers from low precision and low sensitivity. In order to overcome these drawbacks, various approaches have been used, including double-pulse LIBS [DPLIBS]. Typically, various wavelength combinations of two Nd: yttrium aluminum garnet [YAG] lasers have been used for DPLIBS. However, the use of long wavelength (CO_2) laser in combination with Nd:YAG laser has not been sufficiently studied. In this study, signal enhancement mechanisms in Nd:YAG:CO_2 DPLIBS are investigated. Nd:YAG laser pulse at 1064 nm was used as pre-ablation laser while CO_2 laser at 10.6 µm was used as reheating laser pulse. The results exhibit significant improvement in sensitivity of both bulk and trace analytes in the sample using DPLIBS as compared to conventional single-pulse LIBS [SPLIBS]. The bulk and trace analytes used for comparing figures of merit in the brass sample were Cu and Fe emission lines, respectively. Pre-pulse energies ranging from 20 to 120 mJ from a 1064 nm Nd: YAG laser reheated by a 10.6 µm TEA CO_2 laser at constant energy of 400 mJ aligned in near collinear geometry. The observed signal intensity and signal-to-background ratio of bulk analyte as well as trace analyte increased significantly. In order to understand signal enhancement mechanisms, various experimental parameters apart from pre-pulse energy were also studied, including inter-pulse delay and ICCD gate delay. Time resolved studies showed that persistence of neutral lines increases by ~10 times for DPLIBS as compared to PLIBS. Plasma was characterized by estimation of excitation temperature and electron density using the Boltzmann method and Stark broadening method, respectively. Plasma temperature was found to be higher for DPLIBS, which shows that reheating mechanism is dominant mechanism for signal enhancement and increased persistence in YAG:CO_2 DPLIBS. The mechanisms involved in signal enhancement and persistence of neutral and ionic species from bulk and trace analyte are presented and their implications to improving figures of merit are discussed.

KEYWORDS

Double-Pulse LIBS, Plasma Characterization, Sensitivity, Material Processing