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Quantitative determination of copper in a glass matrix using double pulse laser induced breakdown and electron paramagnetic resonance spectroscopic techniques

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ABSTRACT

A series of lithium-lead-borate glasses of a variable copper oxide loading were quantitatively analyzed in this work using two distinct spectroscopic techniques, namely double pulse laser induced breakdown spectroscopy (DP-LIBS) and electron paramagnetic resonance (EPR). DP-LIBS results measured upon a combined nanosecond lasers irradiation running at 266 nm and 1064 nm pulses of a collinear configuration directed to the surface of borate glass samples with a known composition. This arrangement was employed to predict the electron's temperature (T_e) and density (N_e) of the excited plasma from the recorded spectra. The intensity of elements' responses using this scheme is higher than that of single-pulse laser induced breakdown spectroscopy (SP-LIBS) setup under the same experimental conditions. On the other hand, the EPR data shows typical Cu (II) EPR-signals in the borate glass system that is networked at a distorted tetragonal Borate-arrangement. The signal intensity of the Cu (II) peak at $g\perp = 2.0596$ has been used to quantify the Cu-content accurately in the glass matrix. Both techniques produced linear calibration curves of Cu-metals in glasses with excellent linear regression coefficient (R^2) values. This study establishes a good correlation between DP-LIBS analysis of glass and the results obtained using EPR spectroscopy. The proposed protocols prove the great advantage of DP-LIBS system for the detection of a trace copper on the surface of glasses.

Keywords: Borate glass; DP-LIBS; EPR; quantitative analysis; plasma parameters.

1. Introduction

Lithium-lead-borate glasses are of great technological interest in material science with different possible compositions to check their applicability in photonics, network modifiers, electronic displays, sensors [1, 2], tissue engineering [3], and nuclear waste management [4]. Lithium-borate ($Li_2B_4O_7$) glasses have special physical properties such as high ionic conductance and high thermal expansion coefficient [5-7]. Therefore, their usefulness in various fields is growing over the time. The addition of copper (Cu) in the