Chapter 9
Plasma Formation and Its Parameters Used in Calibration-Free Laser-Induced Breakdown Spectroscopy

Alina Saleem
University of Agriculture, Faisalabad, Pakistan

Yasir Jamil
University of Agriculture, Faisalabad, Pakistan

ABSTRACT

A rapidly developing technique over the last two years is laser induced break-down spectroscopy (LIBS), also known as laser-induced plasma spectroscopy (LIPS), a non-destructive spectroscopy technique that is mostly used for the analytical study of samples. With this technique, multiple elemental composition of elements are analyzed simultaneously without considering the form of sample that may be solid, liquid, or gas. Moreover, economically it is a very beneficial and valuable technique because no sample preparation is required, and sample consumption is very small. This technique is powerful enough that it can bore a microscopic crater usually in the solid samples to target. This technique has great sensitivity to find the resolution down to a single grain. It has a variety of applications in the field of science such as archeology, soils, environmental protection, and so on.

DOI: 10.4018/978-1-7998-8398-2.ch009

INTRODUCTION

Calibration-Free LIBS (CF-LIBS) method was presented by Ciucci et al. in 1999 to analyze composition in LIBS spectra. (Aguilera, Aragón, Cristoforetti, & Tognoni, 2009). The configuration of different elements are find out by using some mathematical models without calibration curves as well as reference samples availability and ignore the matrix effect. The accuracy of the result depends on the intensities of spectral lines and temperature of plasma .There are some important parameters of CF-LIBS method such as plasma temperature which is find out on the basis of Boltzmann plot. As the plasma temperature is considered to be same for the different species in the identical sample there are radiations which are emitted from the plasma when laser light falls on it and these radiations are usually depends in the temperature of the atmosphere. These emitted radiations are not affect the sample properties but after some time these radiations are begin to absorb in the sample then Local Thermal Equilibrium occurs.

Local Thermal Equilibrium

To fulfill his condition, introduce the number density

Electron Number Density

$$N_0 \geq 1.6 \times 10^{12} T^{\frac{1}{2}} (\Delta E)^3$$

Where T = temperature of plasma
(ΔE) = energy difference between energy levels

According to this condition, quantitative analysis of the sample is done when plasma is kept in local thermal equilibrium and some of the radiations are just scattered across the sample.

Optically Thin Plasma

To check the optically thin plasma condition, intensity ratios are required which are given below:

$$\frac{I_2}{I_1} = \frac{\lambda_2 A_2 g_2}{\lambda_1 A_1 g_1} \exp(\mathrm{E}_2 - \mathrm{E}_1)/\mathrm{k}_\beta \mathrm{T}$$