PHOTEK Application Note

Laser Induced Breakdown Spectroscopy

Laser Induced Breakdown Spectroscopy (LIBS) is a powerful atomic emission spectroscopy technique used to determine elemental composition of almost any material. A fast laser pulse, typically nanoseconds or less in pulse width, is focused onto the sample. The high energy density of the laser pulse causes a very small amount of material on the sample surface, as small as nano-grams, to be ablated. The material lifted off the surface is heated to temperatures of tens of thousands of degrees, forming a plasma. A continuum of light is initially emitted from this hot plasma, containing little useful information. As the plasma cools and expands, the ionized atoms begin to recombine with electrons, producing characteristic spectral emissions that are fingerprints of the elemental composition of the surface. For nanosecond laser pulses, useful spectral information can be obtained after a microsecond. For femtosecond laser pulses useful spectral information can be measured after tens of nanoseconds. The optical light emitted by the expanding plume is collected by lenses and/or fiber optics and coupled to a spectrometer. The spectral signature is detected by an **Image Intensified CCD (ICCD)** which is gated off during the initial continuum emission and then gated on to measure the atomic spectra from the optimal time period for the specific application. The ability to rapidly gate the **Image Intensifier** on and off makes it the preferred detector for LIBS.

There are many benefits of LIBS including:

- The ability to measure elemental composition without preparing or touching the sample. Sample preparation for other elemental measurement techniques is often time consuming and subject to contamination. For LIBS sample preparation is simple. This hands-off sample preparation enables remote testing of materials, or *Stand-off* LIBS, which can be used to detect *explosives* or other *contraband* at safe distances. LIBS is also been used to monitor materials in *nuclear power plants*.
- The measurement is performed in real-time, making it an ideal industrial process monitoring and control measurement technique. LIBS can be used to measure and control the composition of *metals* or for monitoring *industrial waste* streams to detect heavy metal contamination.
- The technique is considered non-destructive since it uses such little material. This has enable LIBS to be used in applications such as *art restoration* and *archaeology*.

Photek Limited
26 Castleham Road, St Leonards on Sea, East Sussex, TN38 9NS, United Kingdom
T +44 (0)1424 850555 F +44 (0)1424 850051 Email: sales@photek.co.uk Web: www.photek.co.uk

Registration Number: 2641768 England
Registered Office: 23 St Leonards Road, Bexhill on Sea, East Sussex, TN40 1HH
Version Date 03/15

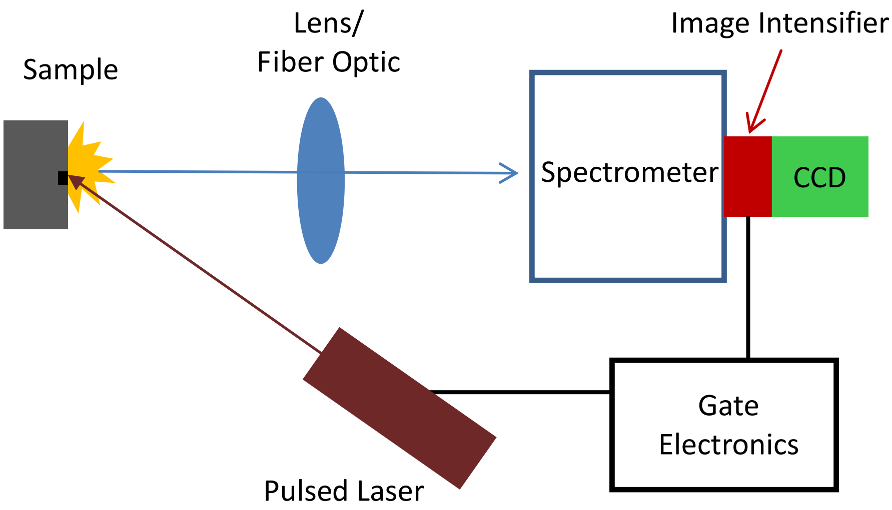

Figure 1: Typical LIBS set-up. The ICCD and laser are controlled by a common gating electronic unit which can be used to block the initial continuum emission and collect only the atomic emissions needed for element identification.

- The two dimensional spatial resolution can be as high as a few microns, depending on the characteristics of the laser pulse used and the collecting optics. In addition, three dimensional imaging is possible by repeated sampling at the same location. Elemental composition can then be obtained as a function of depth.
- The technique can be used on material in all phases of matter and for all elements; solid, liquid and gas. In addition, it can be used on *hard materials* such as ceramic. LIBS has been used in *planetary exploration* including the surface of Mars.
- Instrumentation is simple and relatively inexpensive.

Instrumentation

A diagram of a typical LIBS set-up is given in Figure 1. The most common laser used is a Nd:YAG emitting in the Near Infrared. The pulse widths are typically tens of nanoseconds. Optical collection of the atomic emissions from the ablated material is either via a lens system (microscope or telescope) or fiber optics. A number of spectrometers can be used for LIBS including Echelle and Czerny-Turner. The preferred detector is an **Image Intensified CCD** with moderate gating capabilities. The wide spectral range of an **ICCD** along with its excellent gating capabilities enables direct measurement of the atomic emission from the ablated plume without contamination from the initial continuum emission.

PHOTEK Recommendations

Intensified CCD - ICCD118 or ICCD125 (2ns gated)

OR

Image Intensifier - MCP118

Gate Module - GM300-3 (3ns)