

Laser-Induced Breakdown Spectroscopy

Full element analysis of coatings, bulk materials and liquids

LIBS-based systems can quickly and precisely determine the elemental composition of surfaces or solid materials – such as concrete rubble – without sample preparation.

The chemical composition of materials and liquids is an important parameter in many production processes, in quality assurance, or in sorting. Laser-induced breakdown spectroscopy (LIBS) is a method that can be used to analyze the atomic composition of materials quickly, accurately, and without sample preparation. Fraunhofer IPM develops laboratory and inline systems for LIBS measurements on coatings, bulk materials, and liquids.

Real-time spectral analysis

In the LIBS process, a short- or ultra-short-pulse laser quickly heats up a small fraction of the material to be examined – usually only a few μm^3 – to temperatures of up to 15,000 K, thereby transforming it into a plasma. This plasma emits a light spectrum that is specific to the material. Recording the spectral distribution of this light allows the element distribution at the measurement point to be determined in real time using the spectral data.

Non-contact and robust procedure

This purely optical, non-destructive method has several advantages over alternative material

analysis methods such as Inductively Coupled Plasma (ICP), X-ray Fluorescence (XRF), or energy-dispersive X-ray spectroscopy (EDX).

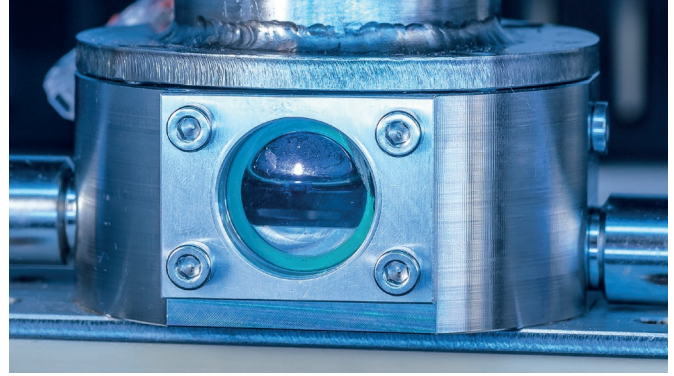
LIBS systems measure without contact and at speeds in the millisecond range, allowing inline analyses. The analysis does not require elaborate sample preparation in the laboratory, such as dissolving, filtering, diluting, or atomizing and is equally suitable for analyzing heavy and light elements. LIBS systems do not require a specific environment for measurement, meaning measurements can be taken directly on a conveyor belt, for example. The measuring point is freely selectable, enabling material analyses to be performed regardless of the components' geometry.

LIBS systems by Fraunhofer IPM

- **ANALIZE**
Analysis of layer thickness and composition of coatings
- **LiVision**
Inline monitoring in liquids
- **RAPID-LIBS**
Process control in laser machining processes



LIBS imaging shows that the coating thickness varies locally on an indexable insert, with values ranging from 9.5 to 13 µm.



For monitoring liquids, the LiVision measuring system uses a short pulse laser to convert a tiny amount of liquid into plasma. The plasma flash provides valuable elemental information, e. g. on the liquid's lithium content.

Analyzing layer thickness, layer composition and multi-layer systems

The LIBS method can be used to analyze alloy composition and determine layer thickness ranging from a few nanometers to 100 micrometers. Emitting a series of laser pulses in rapid succession onto the measuring spot allows for depth-resolved measurements of element composition and distribution to be taken. This enables the full characterization of multi-layer coatings on components.

The LIBS process is used, for example, to test metallic layers on metal or plastic components such as copper coatings for electronic assemblies. Corrosion protection layers on metals can also be examined. The method can also quickly and reliably characterize many other functional layers, such as passivation, finishing, and protective coatings. Fraunhofer IPM's LIBS systems can determine coating thickness in a matter of seconds and output the measured data as a control parameter for downstream processes. (For further information see data sheet "ANALIZE")

Inline liquid monitoring

The LIBS method can be used to quickly and accurately analyze liquids. Fraunhofer IPM has developed a LIBS-based inline monitoring method for liquids (patent pending) that quantitatively analyzes the elemental composition of liquids and provides the results as control variables for process control. The method does not require sampling or dilution and works even under high pressure and high temperatures without precipitation or outgassing. It is suitable for analyzing elements such as sodium, lithium, potassium, magnesium, calcium, or strontium. The system is currently used for monitoring DLE and battery recycling processes. (For further information see data sheet "LiVision")

Detection of material transitions in laser processing

When drilling, ablating, thinning, or cutting materials with lasers, it is important to perform the ablation to a defined depth at a material transition. The RAPID-LIBS system from Fraunhofer IPM is integrated into the beam path of a processing laser. It measures the elemental composition of the processed material with pulse resolution during processing. This allows for the control of laser machining processes, such as the drilling of microvias in printed circuit board manufacturing. (For further information see data sheet "RAPID-LIBS")

Laboratory or inline system

Fraunhofer IPM develops and realizes LIBS systems for specific measuring tasks and production environments. The systems are designed either for sample testing in laboratory analytics or for inline integration into production lines or plants.

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