APPLICATION NOTE: **LASER INDUCED BREAKDOWN SPECTROSCOPY**

Laser Induced Breakdown Spectroscopy employs a laser to ablate a microscopic layer of a sample resulting in a plasma that emits light as it cools. This light can be collected and analyzed with a spectrometer for quantitative and qualitative material analysis.

This virtually nondestructive spectral analysis method has valuable applications across numerous physical science fields.

Laser Ablation in LIBS Measurements

WHAT IS LIBS?

Laser Induced Breakdown Spectroscopy (LIBS) is a process for material analysis that employs a very short-duration pulsed laser (usually a Nd:YAG 1064nm Laser) to excite particles at the sample surface. Such excitation by the laser causes the breaking of chemical bonds and produces vapor, aerosol particulate, and high temperature microplasma. Plasma, the ionized gas produced in laser ablation, can reach temperatures as high as 15000 degrees Kelvin, but cools rapidly. During the cooling phase, plasma emits light that, when analyzed, reveals spectral peaks much like a chemical fingerprint. Every element on the periodic table emits light in the 200-900 nm spectral range and will exhibit its own unique spectral signature. This spectral signature is the theoretical foundation that allows scientists to use LIBS measurements for material qualification and quantification.

ADVANTAGES OF LIBS ANALYSIS

Laser Induced Breakdown Spectroscopy is a highly useful research and analysis tool. LIBS analysis is very versatile because it can be used on any material, whether solid, liquid, or gas, and will detect any and all chemical elements in a sample with a single pulse. LIBS is especially sensitive in the detection of light elements like Helium, Lithium, Beryllium, Nitrogen, and Oxygen that are not easily detected by other analytic methods.

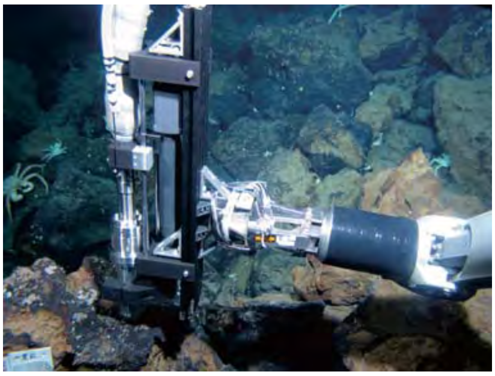
Unlike many other investigative tools, LIBS spectroscopy requires little to no sample preparation. This lack of sample preparation supports field applications and real-time, in-situ LIBS measurements. Furthermore since the sample size per pulse (µg to ng) is so small it may be considered to be virtually non-destructive on a sample's surface. And yet, it is sensitive enough to measure at resolution down to a single grain (below 10 µm) and powerful enough to bore a microscopic crater in a solid sample to target a minute mineral inclusion or individual particle.

Mineral Automated Yield Analyzer MAYA

LIBS IN THE PHYSICAL SCIENCES

Researchers Lebedev and Shestakov of the Institute of Laser Instruments and Technologies, Ustinov, St. Petersburg, Russia produced a series of experiments demonstrating the use of LIBS spectroscopy identification of solids. They document the use of a Q-switched diode pumped Nd3+-YAG laser emitting 20-100 mJ with a repetition rate of generation reaching 30 Hz and a pulse duration of 10ns.

Lebedev's system pairs the excitation laser with the AvaSpec-ULS2048CL-EVO USB3.0 spectrometer by Avantes . The AvaSpec-ULS2048CL-EVO features an ultra-low straylight, symmetrical Czerny-Turner spectrometer with a 2048 pixels CMOS linear image sensor detector. This spectrometer is often chosen for LIBS measurements, especially in a multi-channel or arrayed configuration. The AvaSpec-ULS2048CL -EVO spectrometer is popular for use in applications in the physical sciences, from geology and metallurgy to environmental and climate science measurements.



Deep Ocean LIBS Application

Polar Ice Research

Beryl Samples for Characterization

GEOLOGY

MINERAL, ROCK, SEDIMENT, AND SOIL ANALYSIS

LIBS spectroscopy was employed in the characterization of stalagmites for Magnesium and Strontium in the Caves of Nerja near Malaga, Spain. Researchers isolated deposits of manganese (Mn), magnesium (Mg), strontium (Sr), calcium (Ca) and iron (Fe) in speleothems taken from the the caves .
The Mineral Automated Yield Analyzer System (Maya6060) by Laser Detect Systems, Ltd. uses Avantes spectrometers in real time analysis of minerals and ores.

DEEP OCEAN ANALYSIS

Researchers working to develop deep sea LIBS methodology had to overcome challenges posed by environmental conditions. Several spectroscopic parameters are affected by high-pressure, including energy input requirements and spectral emission intensity. Recent developments, however, have lead to the development of LIBS spectroscopy systems rated to 3000 m below sea level and tested to 1000 m

POLLUTION MONITORING

Climate and environmental testing and monitoring are in-demand fields. LIBS systems have been deployed for continuous, in-line monitoring for industrial pollution in natural waterways where pollution is problematic.

POLAR ICE RESEARCH

Another area where LIBS technology is finding use is the study of polar and alpine glacial ice. Glacial ice formed over millennia of Earth's history, has trapped air and particles from the time the ice was forming. Using laser-induced breakdown spectroscopy to study the composition of ice core samples contributes to our understanding of the role of atmospheric carbon dioxide (CO_2) on Earth's climate.

SPACE EXPLORATION

Laser-induced breakdown spectroscopy has been widely used in space exploration in the investigation of extraterrestrial bodies, such as meteorites, using a calibration-free (CF-LIBS) approach 5.
Expect LIBS systems to take center stage on future missions to Mars, as well. It will be critical to future Mars missions to be able to understand Martian ecology with complete mineral and chemical analysis.

INDUSTRIAL LIBS APPLICATIONS

Metals and metal alloys are used to transport electrical signals in semiconductor components. Manufacturing these increasingly complex devices requires thin film coatings and substrates applied to the wafer. These films which typically are around a few hundred nanometers thick are deposited onto a silicon wafer before and after treatments, such as thermal cycling to strengthen it. Laser-induced breakdown spectroscopy may be used in semiconductor wafer and coating characterization and quality control.
As a minimally destructive techniques, LIBS may be used in gemstone validation and characterization. Laser beam shaping allows for micro ablations of materials such that the measurement spot size is 50 microns in diameter. LIBS is superbly suited to the requirements of the mining and metallurgical industries

AVANTES LIBS SOLUTIONS

Avantes sales engineers are your resource for designing the optimal LIBS system for your unique application. Contact your distributor or sales engineer today to request a demo.
For complete system specifications or sales information, email us at info@avantes.com.