Chemical Analysis of Battery Materials

Conventional analytical tools face significant challenges when investigating the chemical composition of battery materials. Choosing **ICP-OES** requires careful consideration of carbon content, as it may lead to device damage, making the analysis unsuitable. **XRF** struggles to detect the light elements, which are often the object of the analysis in batteries. Additionally, **SEM** analysis is time-consuming and limited in its ability to visualize light elements, restricting the analysis to only a small portion of the material. However, **LIBS analysis** eliminates the need for any sample preparation. Lightweight elements can be easily detected and quantified while allowing the investigation of larger surfaces or electrode material depths.

The evidence speaks for itself – our Sci-Trace and M-Trace LIBS analyzers are perfectly suited to conduct a comprehensive and fast examination of battery chemical composition.

In Figure 1, it is demonstrated that LIBS technology offers a fast and easy way for elemental characterization and comparison of electrodes. Furthermore, Figure 2 illustrates that LIBS enables the detection of Li and common impurities (Na, Ca) with impressive resolution.

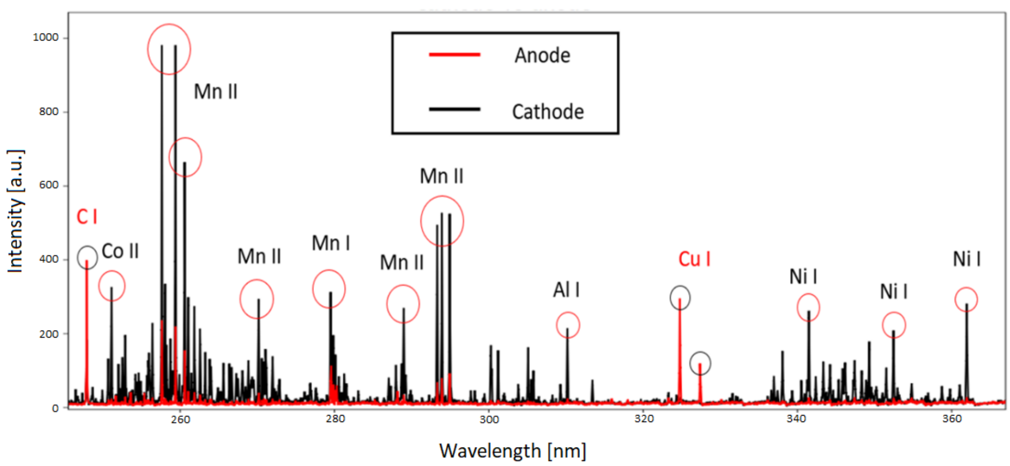

Figure 1: Anode and cathode spectra comparison

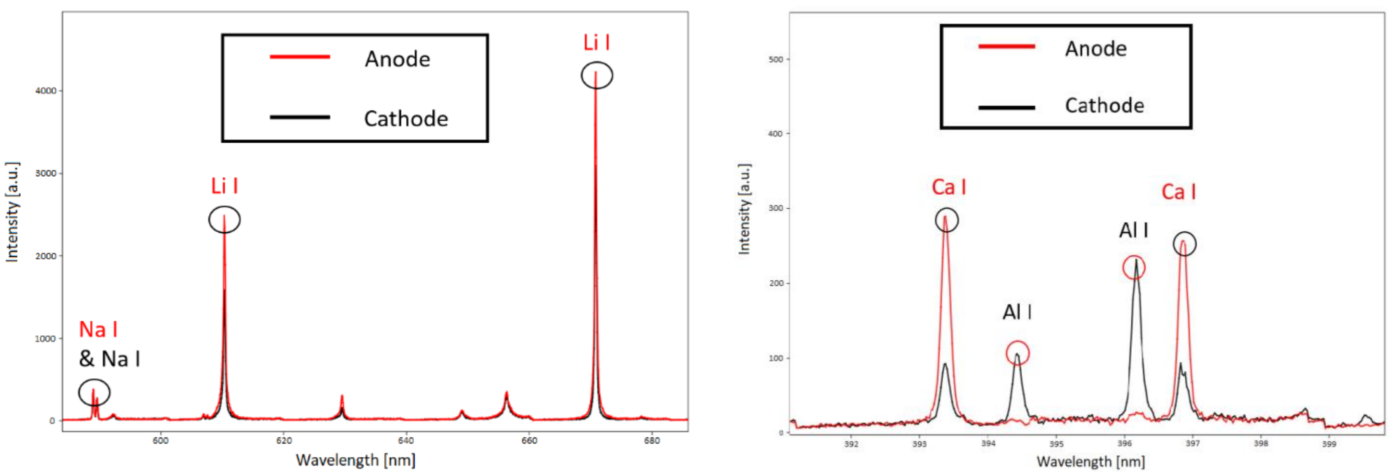

Figure 2: Detection of lithium, sodium and calcium impurities

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The migration of Li^+ ions from the cathode to the anode has been further investigated. Four specific locations on the cathode, spaced 10 cm apart, were selected for analysis. The relative concentration of Li has been determined using the technique of surface chemical mapping. A total of 81 spectra were measured at each location (arranged in a 9 x 9 pixel raster). For the evaluation process, the emission line Li I 670.78 nm has been selected.

Table 1 – Average S/N ratio, Peak integrals, and their SD for each measured part of the cathode

Part of the cathode foil	S/N of Li I line (mean)	Peak integral [a.u.] (mean)	SD [a.u.] (mean)	RSD [%]
1st	813	2214	233	10,5
2nd	740	1951	181	9,3
3rd	757	1753	133	7,6
4th	900	1620	225	13,9

Figure 3 shows a visualisation of the relative Li^+ concentration across the cathode layer of a lithium battery. We were able to visualise the trend typical for discharged batteries – the concentration formed a gradient reaching from the highest values at the center of the battery to the lowest on the outside. With the help of a calibration curve, the absolute concentration could be easily determined as well.

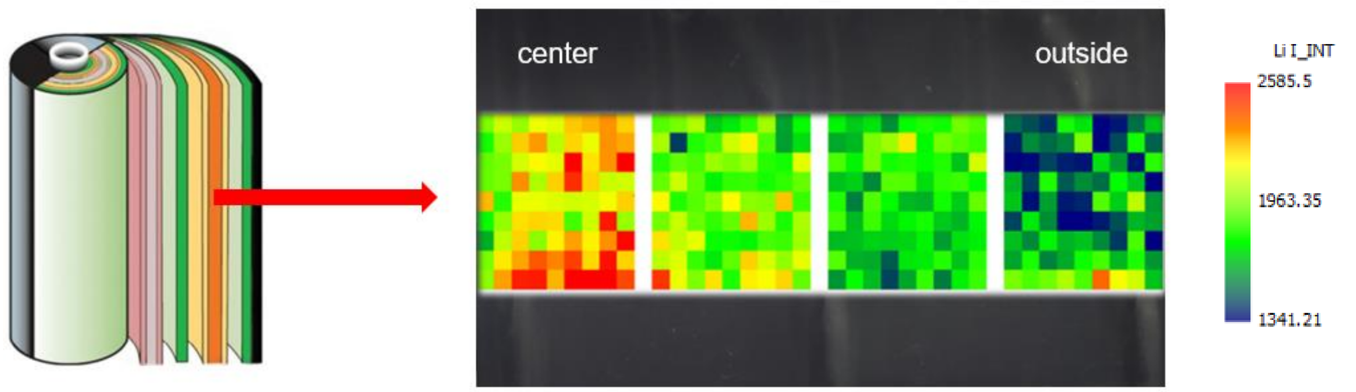

Figure 3: Determination of relative Li distribution in the cathode foil of the battery

LIBS Principles

Laser Induced Breakdown Spectroscopy (LIBS) is an optical emission tool for the quick characterization of chemical elements in a broad range of materials, including biological, geological, and ceramic materials. A highly energetic laser pulse is directed at the target sample (Figure 4), resulting in the creation of an expanding microplasma upon impact. This microplasma emits luminous species that provide valuable information about the material composition and the sample environment.

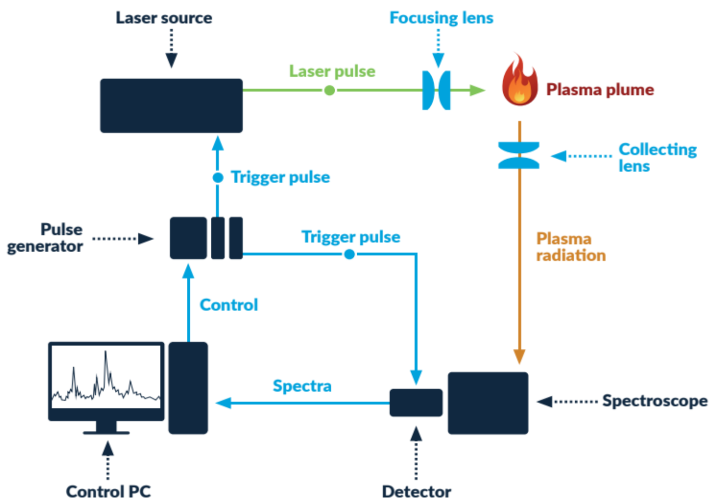

Figure 4: Sci-Trace LIBS set-up scheme