Spectroscopy Performance Note

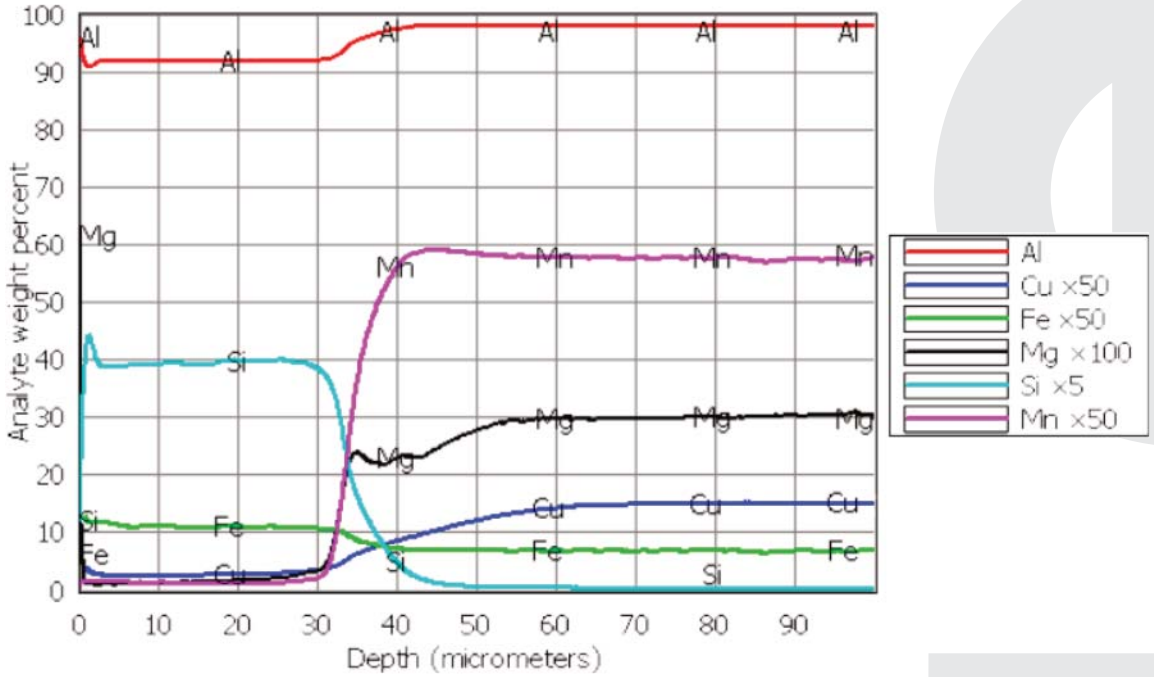
Quantitative Depth Profile (QDP) Analysis of Aluminum Clad

- **Chemical composition of the cladding and core**
- **Clad thickness**
- **Migration and enrichment at surface**

Aluminum clad is a composite-wrought product comprised of an aluminum alloy core having one or both surfaces metallurgically bonded to commercial purity aluminum or a different aluminum alloy coating. Commonly, the substrate (core) is a high-strength aluminum alloy with less corrosion resistance than needed for the application. The cladding alloy is added to protect the core alloy from corrosion. Aluminum clad is used by the automotive industry in conditioners, radiators, and associated products; as well as in the aeronautic field for the "skin" of airplanes. The thickness of the clad may vary from several tens of micrometers (μm) to more than 100 μm. The aluminum industry has manufactured this product for many years, and the technology is well proven. Glow Discharge-Atomic Emission Spectrometry (GD-AES) techniques can verify alloy type and identify defects detrimental to the process.

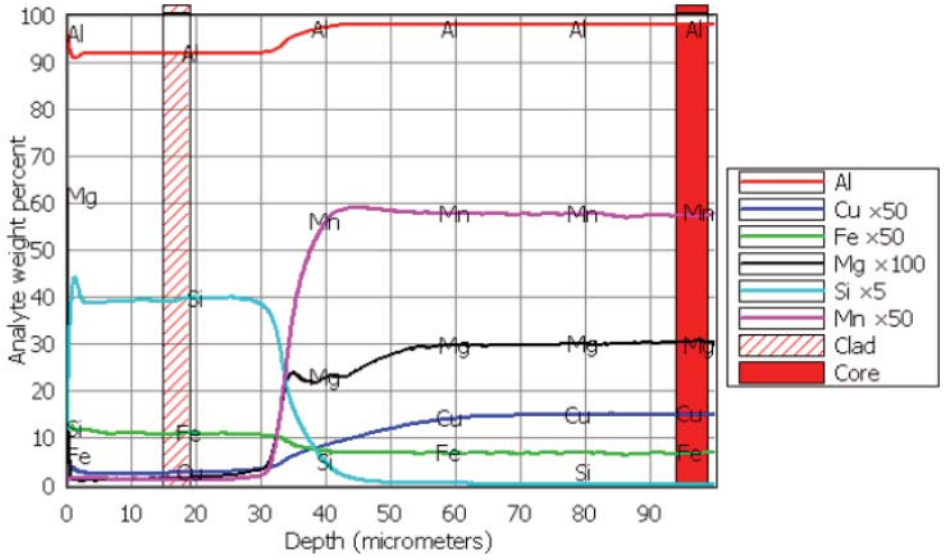
GD-AES Applications for Control of Aluminum Clad Materials

Chemical Composition of Clad and Core: Quantitative Depth Profile (QDP) analysis provides the continuous chemical composition of material from the surface, through the clad, and into the core. The plot (below) is displayed in concentration in weight percent versus depth in micrometers (μm). The complete analysis through the clad and into the core (approximately 100 μm) was obtained in less than 30 minutes.



GDS850A

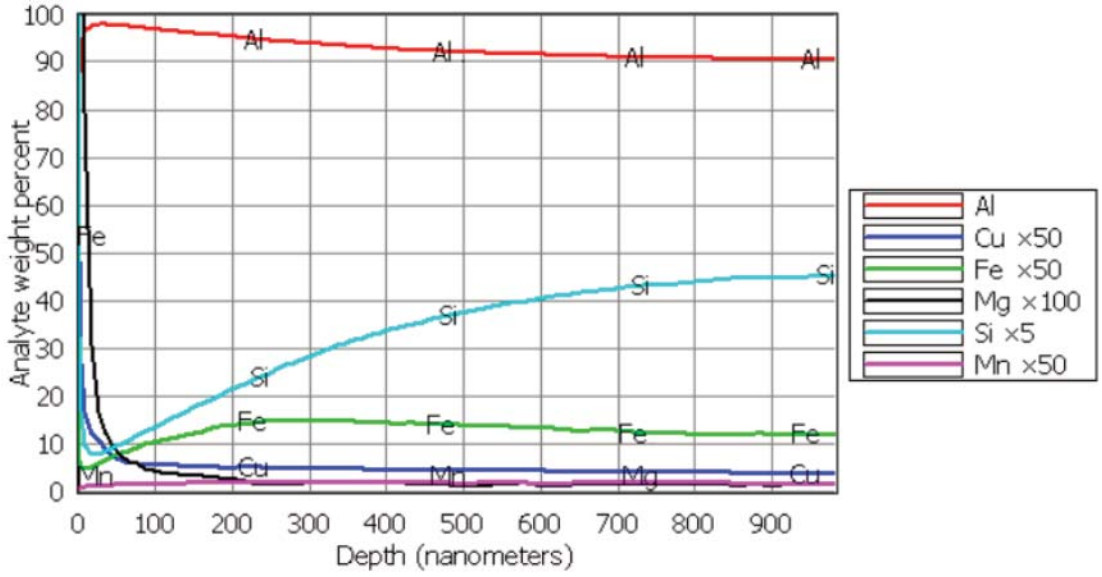
By defining an integration area in the clad and in the core, the software calculates the average chemical composition of both constituents. The clad depth can also be calculated. Calculations are made automatically at the end of the analysis. An example is provided below.



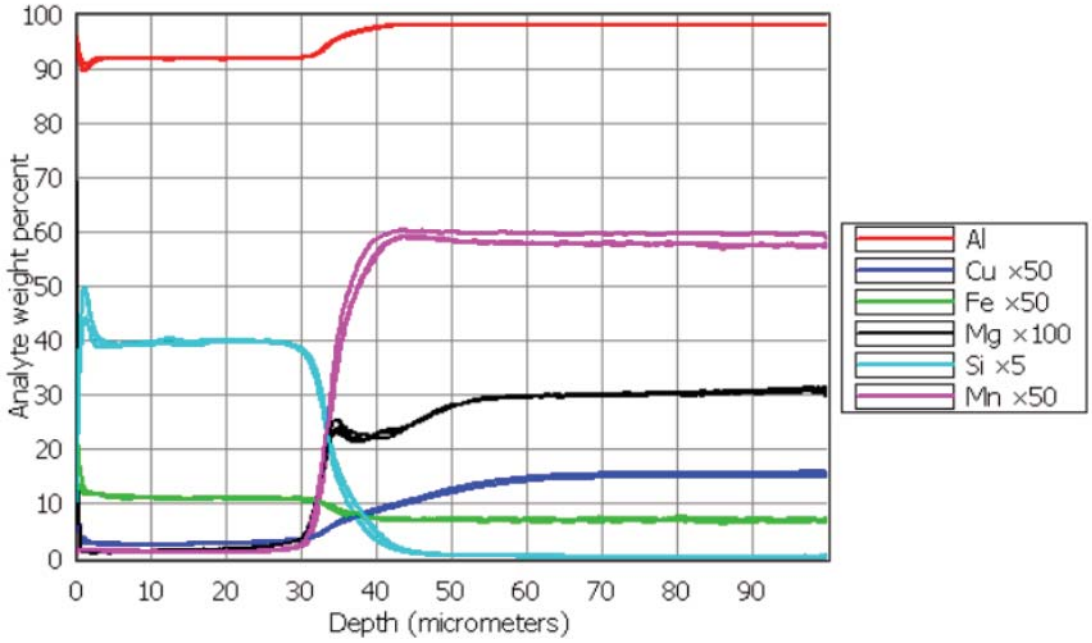
Al% Clad	Cu% Clad	Fe% Clad	Mg% Clad	Mn% Clad	Si% Clad	Clad Depth, µm
91.8	0.052	0.22	0.014	0.025	7.86	33.7

Al% Core	Cu% Core	Fe% Core	Mg% Core	Mn% Core	Si% Core
98.0	0.30	0.30	0.30	1.15	0.061

Enrichment at the Surface: Some alloying constituents become enriched at the surface during the rolling process. The plot below shows the first 1 μm of analysis displayed in concentration in weight percent versus depth in nanometers (nm). The magnesium and copper are both enriched while the silicon is depleted.



Homogeneity: Multiple analyses, obtained on the same sample or different samples, can be compared to determine variation. These analyses can be plotted together and statistical calculations made on values obtained. The plot below shows three replicate analyses on a single sample, and the accompanying tables provide the mean and RSD for each calculated value.

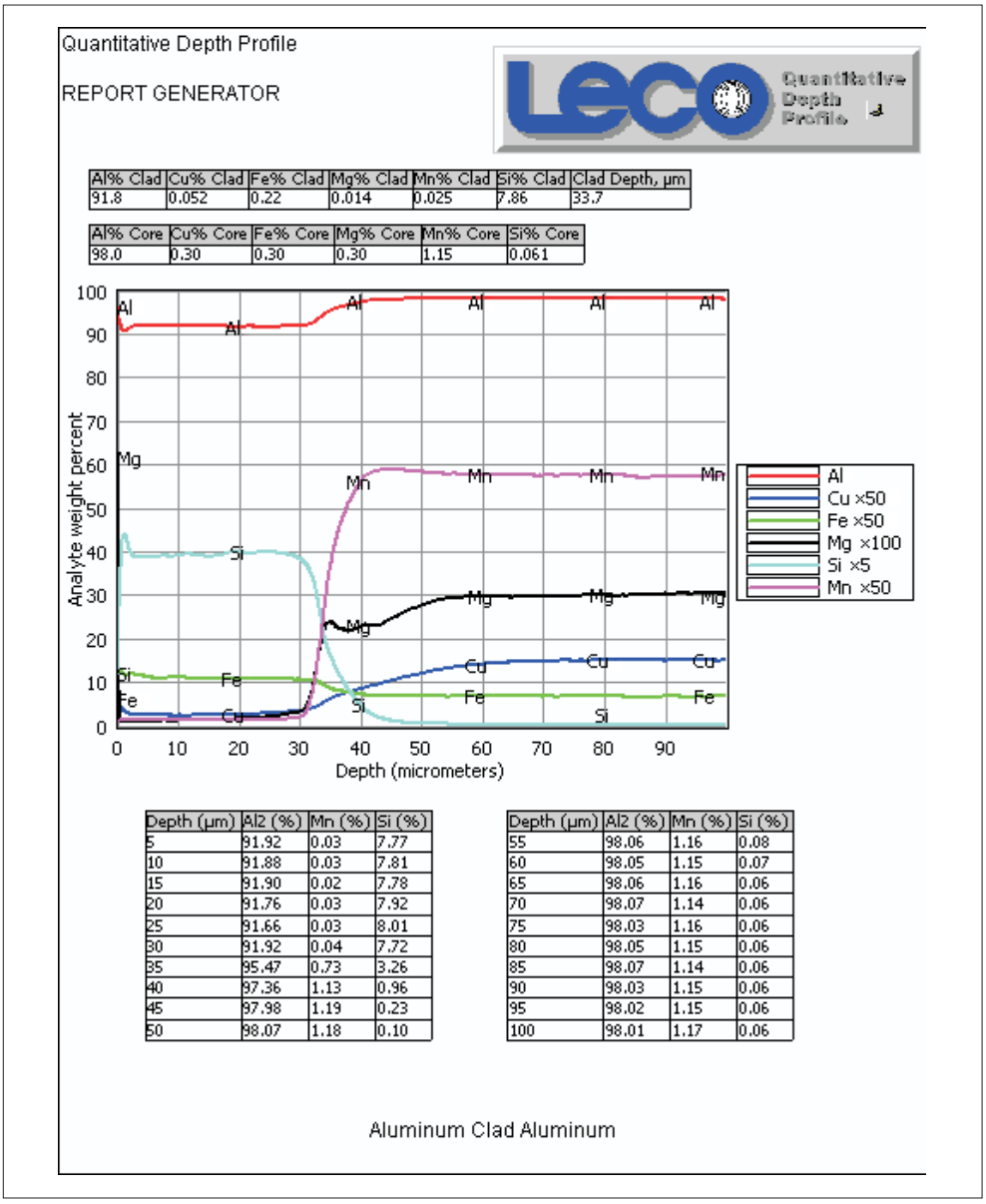


Name	Al% Clad	Cu% Clad	Fe% Clad	Mg% Clad	Mn% Clad	Si% Clad	Clad Depth, µm
Clad-1	91.8	0.052	0.22	0.014	0.025	7.86	33.7
Clad-2	91.8	0.053	0.22	0.015	0.026	7.92	33.2
Clad-3	91.7	0.054	0.22	0.015	0.025	7.97	33.0
Mean	91.8	0.053	0.22	0.015	0.025	7.92	33.3
Rsd		1.9	0.00	3.9	2.3	0.70	1.08

Name	Al% Core	Cu% Core	Fe% Core	Mg% Core	Mn% Core	Si% Core
Clad-1	98.0	0.30	0.30	0.30	1.15	0.061
Clad-2	98.0	0.31	0.31	0.31	1.19	0.063
Clad-3	98.0	0.30	0.30	0.31	1.15	0.062
Mean	98.0	0.30	0.30	0.31	1.16	0.062
Rsd		1.90	1.90	1.88	1.99	1.6

Report Generator

The report generator included in the Quantitative Depth Profile (QDP) software helps the operator to easily produce a complete report. The report shown includes a range of the features available. Text boxes are placed at the top and bottom of the form. A bitmap is included that shows the LECO QDP logo. The sample tables near the top of the page give calculated information on both the clad and the core. The plot shows concentration in weight percent versus depth in micrometers (µm). The multipliers for each element and line color are user selected. The analyte tables below the plot show the concentration change with depth for the aluminum matrix and representative elements from the clad and the core. The report format is stored in the software and can be reused for newly acquired data.



Summary

After less than 30 minutes of acquisition, the operator obtains:

- Continuous composition from the surface into the core
- Chemical composition for both the clad and the core
- Product homogeneity
- Cladding thickness
- Information on contamination and migration

The GD-AES technique provides valuable information for:

- Control of the process and display of deviation
- Quality control of the finished product
- Investigation in R&D for failure analysis

Delivering the Right Results

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