Spectroscopy Performance Note

Quantitative Depth Profile (QDP) Analysis of Aluminized Steel

- **Aluminum Coating Weight**
- **Coating Thickness**
- **Al-Fe Alloy Layer Characteristics**

Introduction

Aluminum-coated steel products have the benefits of enhanced corrosion resistance, bright metallic appearance, high heat reflectivity and electrical conductivity while retaining the formability of uncoated steel. Additionally the iron-aluminum intermetallic alloy layer provides a second line of defense for oxidation resistance, abrasion resistance and increased hardness.

A specimen of hot dipped aluminized steel was analyzed on the GDS-850A for characterization of the coating. Analysis parameters are shown in Table 1.

Table 1: Method Parameters for Aluminized Steel

Anode Diameter:	4 mm
Lamp Type:	DC
GDS operating Conditions:	40mA, 1000V
Discharge Stabilization:	Current (Control Mode) / Voltage (Pressure Control)
Minimum Data Acquisition Rate:	10 s^{-1}
Profile Duration:	720 s (thickness dependant)
Cooling:	Cooling, 15°C

An overlay of three replicate analyses is shown in Figure 1. The plot is displayed in concentration in weight percent versus depth in micrometers (μm). Characteristics of the coating were calculated using GDS-850A software and displayed in Table 2. The table includes the depth of the free aluminum in micrometers (μm), the thickness of the Al-Fe alloy layer in micrometers (μm), the coating weight of aluminum in grams per square meter (g/m²) and the concentration of Fe in the coating. Also, the coating weight of C on the surface of the steel is calculated and displayed in grams per square meter (g/m²).

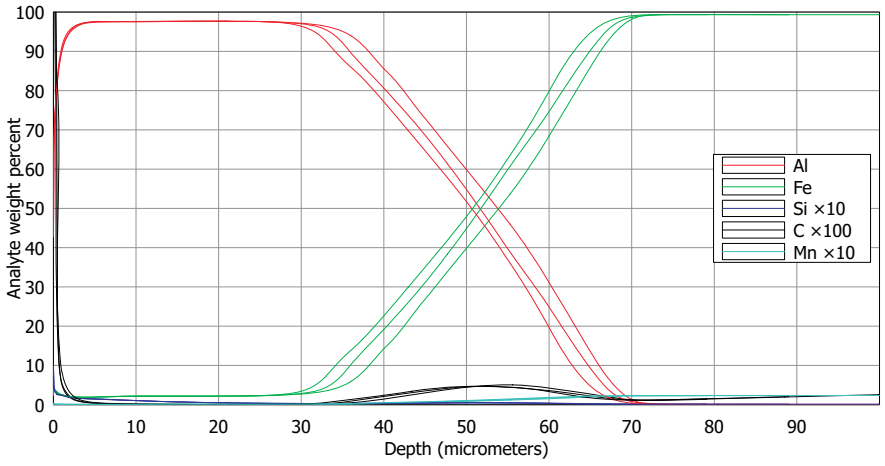

Figure 1. Overlay of three replicate analyses.

GDS850A

Table 2. Coating Characteristics

Name	Free Al, µm	Alloy, µm	Al Coat Wt g/m²	Fe% Coat	C Wt, interface g/m²
Aluminized	41.6	12.3	157	2.20	0.038
Aluminized	39.4	12.4	153	2.19	0.037
Aluminized	38.0	12.8	149	2.16	0.037
Mean	39.7	12.5	153	2.18	0.037
Rsd	4.58	2.12	2.61	0.95	1.5

The GDS-850A software can also display variation with depth of selected analytes. The gradients of Al, Fe and C through the sample are shown in Table 3; composition is expressed in weight percent versus depth in micrometers at a granularity of 2 µm.

For confirmation of the coating thickness the specimen was mounted in cross section and polished. The metallographic cross-sectional image shown at 500X is displayed in Figure 2. The free aluminum and alloy layers of the coating are clearly seen.

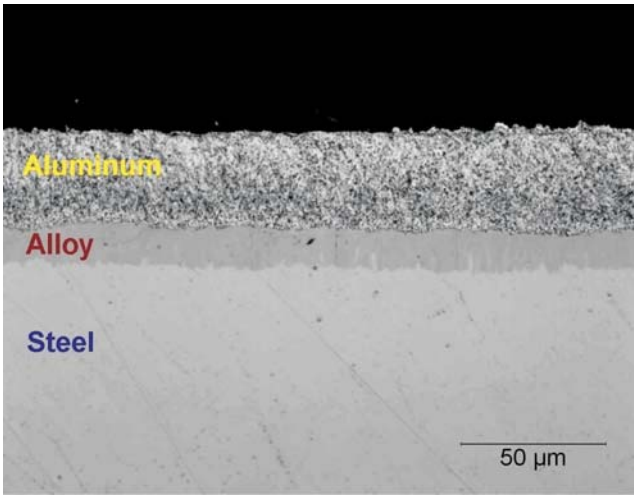

Figure 2. Free aluminum and alloy layers of the coating, 500X magnification.

Summary

Quantitative Depth Profile analysis provides coating thickness information comparable with that found by cross-sectional metallography. Simultaneously, the GDS-850A software calculates coating weights, alloy compositions and elemental gradients. Additionally, contamination on the surface or at the interface can be identified and quantified.

Table 3. Gradients of Al, Fe, and C

Depth (µm)	Al (%)	Fe (%)	C (%)
2	95.7	2.1	0.016
4	97.3	1.9	0.005
6	97.5	2.0	0.003
8	97.5	2.1	0.001
10	97.5	2.2	0.001
12	97.6	2.2	0.001
14	97.5	2.2	0.001
16	97.6	2.2	0.000
18	97.6	2.2	0.000
20	97.6	2.2	0.001
22	97.7	2.2	0.000
24	97.6	2.2	0.000
26	97.5	2.3	0.000
28	97.3	2.5	0.000
30	97.0	2.9	0.001
32	96.3	3.6	0.001
34	94.2	5.7	0.004
36	89.7	10.1	0.008
38	85.0	14.8	0.015
40	80.5	19.3	0.021
42	75.9	23.8	0.026
44	71.0	28.7	0.032
46	66.0	33.7	0.038
48	60.6	39.1	0.042
50	54.7	45.0	0.046
52	48.9	50.8	0.046
54	42.6	57.0	0.045
56	36.7	62.9	0.043
58	30.8	68.7	0.040
60	24.8	74.7	0.036
62	18.3	81.2	0.030
64	12.1	87.4	0.025
66	6.5	93.0	0.019
68	2.4	97.0	0.014
70	0.7	98.7	0.012
72	0.2	99.2	0.011
74	0.1	99.3	0.012
76	0.1	99.4	0.013
78	0.1	99.4	0.014
80	0.1	99.4	0.015
82	0.1	99.3	0.016
84	0.1	99.3	0.017
86	0.1	99.3	0.018
88	0.1	99.3	0.019
90	0.1	99.3	0.020
92	0.1	99.3	0.021
94	0.1	99.3	0.022
96	0.1	99.3	0.023
98	0.1	99.3	0.024
100	0.1	99.3	0.025

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