

Instrument: GDS950

Compositional Depth Profile Analysis of Galvanized Steel

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- **Thickness and Coating Weight of Galvanized Steel**
- **Elemental Composition of the Coating and Substrate**
- **Compositional Analysis of Surface Treatments**

Introduction

The application of zinc and zinc-alloy coatings to steel provides protection against galvanic and barrier corrosion. Galvanized coatings can be applied by either continuous hot-dip coating or electroplating. Hot-dip coatings include galvanized (zinc), galvanized, and 55% aluminum-zinc. Electroplated coatings include zinc and zinc-nickel. The choice of coating depends on the application. Thin coatings provide sufficient corrosion resistance where the corrosion rate is low, such as interior panels and painted parts. Thick coatings are needed where corrosion rate is high and long service life is required, such as marine or underground applications. Compositional Depth Profile (CDP) using the LECO GDS950 rapidly provides analysis of various galvanized coatings on steel. The analyses shown in this Application Note conform to and is in accordance with ISO 16962.

Parameters

Current: 30 mA
Voltage: 700 V
Time: 60 to 900 s, sample dependent

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Conclusion

As demonstrated in this application note, CDP analysis on the LECO GDS950 provides coating composition as a function of depth for a variety of galvanized coatings, including both conductive and non-conductive coatings. Most zinc coatings can be analyzed in 60-300 s. The 55% aluminum-zinc alloy sputters more slowly and can be analyzed in 600-900 s. CDP using the LECO GDS950 provides a single flexible method to analyze multiple zinc and zinc-alloy coating types.

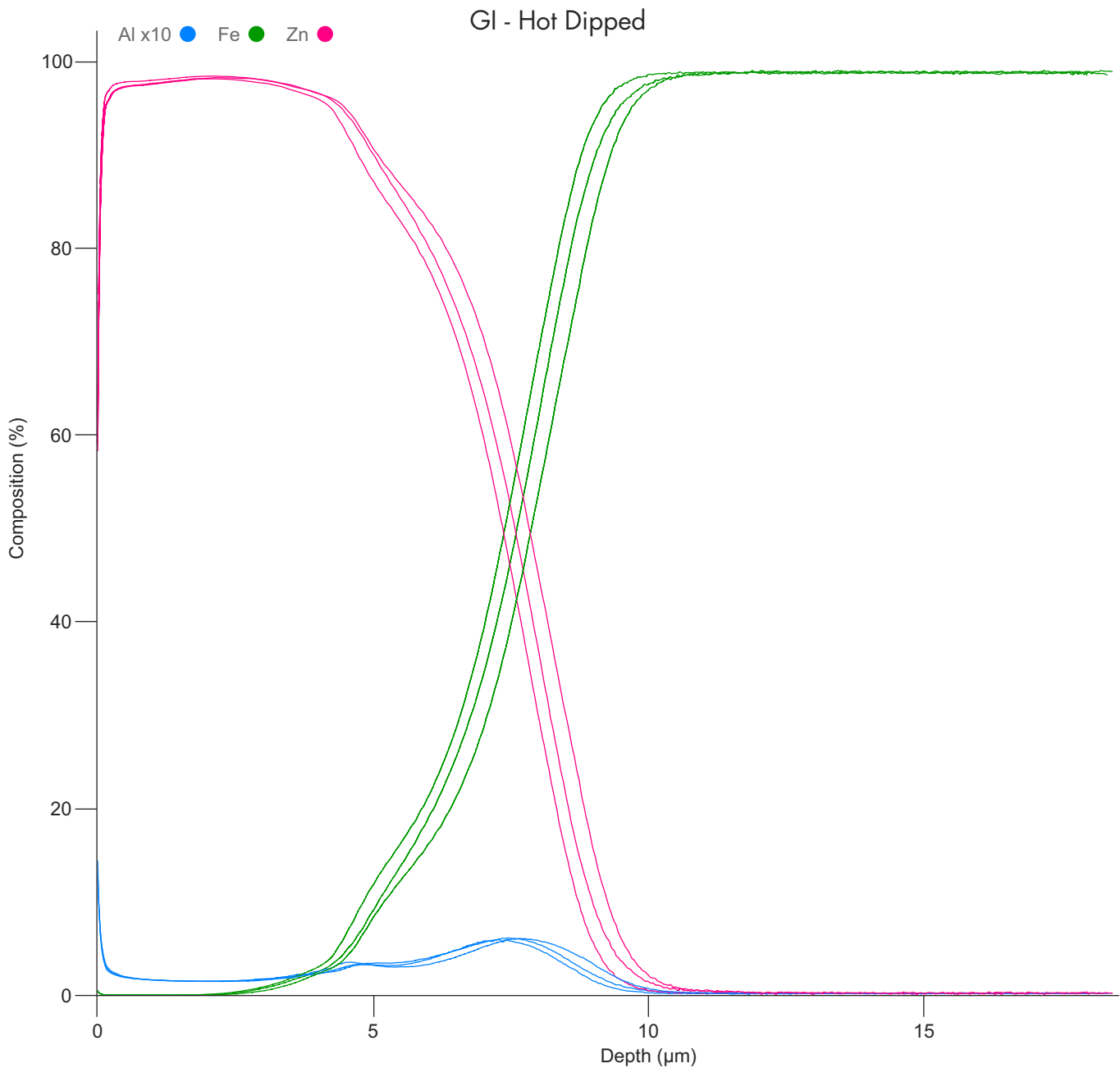


Hot-Dip Galvanized Coatings

Galvanized (Zinc) Coatings

Zinc Galvanized Steel is the most common hot-dip coated product. Zinc provides both galvanic and barrier protection of the underlying steel. A small amount of aluminum, typically 0.2 to 0.3%, is present in galvanized coating. Typical coating weights for galvanized coatings range from 45 to 300 g/m². The table and plot below show replicate analyses of a galvanized coating. The variability within the coating is demonstrated both in the plot and by the statistics shown in the table.

Name: Hot Dipped	Description: GI		
Comments	Depth (μm)	Coating Weight (g/m^2)	Al (%)
Run 1	7.60	51.4	0.43
Run 2	7.39	49.5	0.42
Run 3	7.87	52.9	0.42
Average	7.62	51.3	0.42
RSD (%)	3.16	3.25	1.1



Galvannealed Coatings

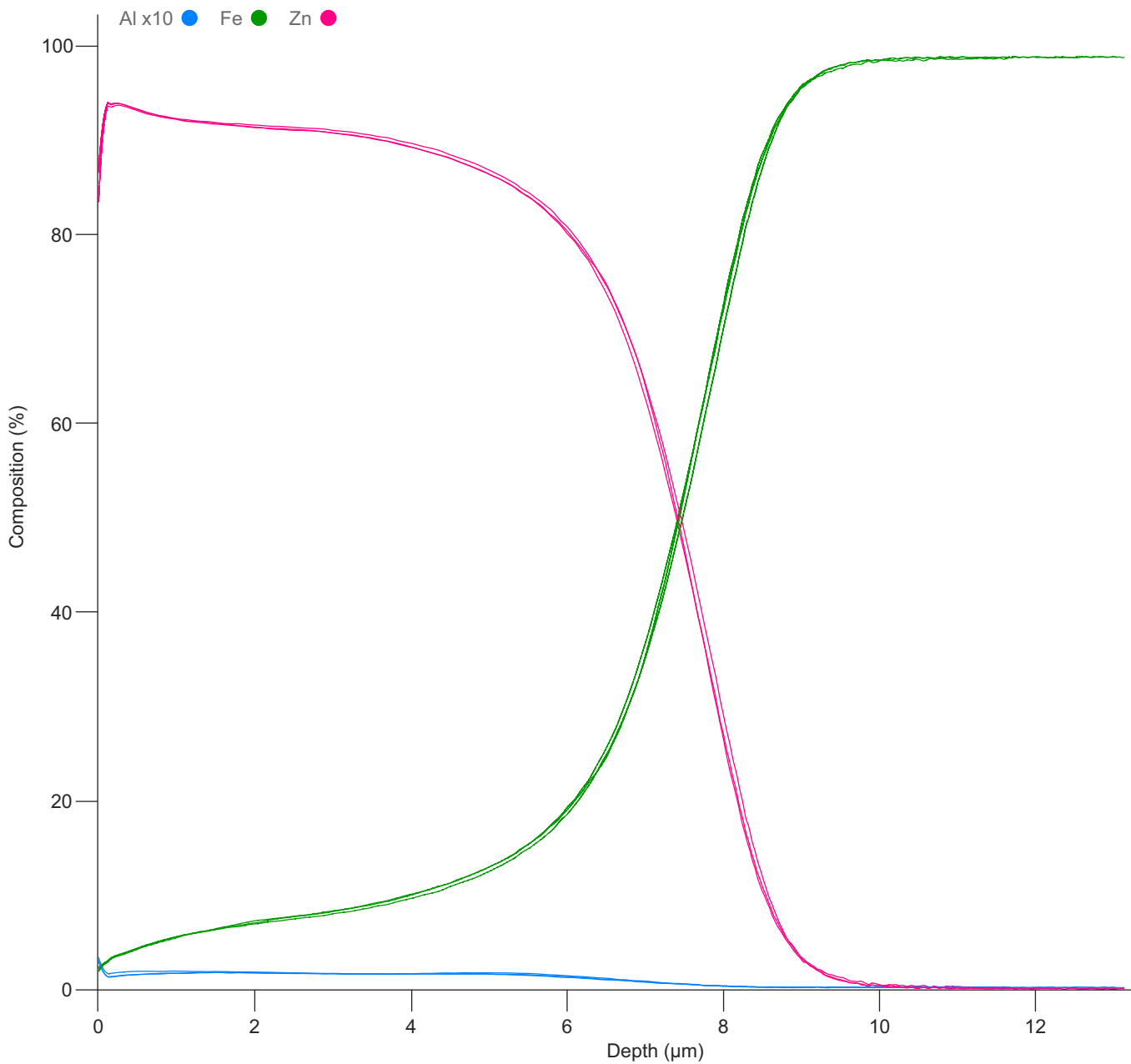
Galvannealed coatings are characterized by diffusion of 8 to 11% iron into the zinc coating. The zinc is applied by a continuous hot-dip process which is diffusion-alloyed by the application of additional heating after the galvanized layer is formed. Galvannealed coatings are painted for most applications. The coating weight ranges from 50 to 180 g/m². The table and plot below show replicate analyses of a galvannealed coating.

Name: Galvannealed

Description: GA

Comments	Depth (μm)	Coating Weight (g/m^2)	Fe (%)	Al (%)
Run 1	7.49	53.2	9.95	0.18
Run 2	7.55	53.8	10.2	0.18
Run 3	7.50	53.4	9.75	0.18
Average	7.51	53.5	9.95	0.18
RSD (%)	0.43	0.57	2.07	1.96

GA - Galvannealed



55% Aluminum-Zinc Coatings

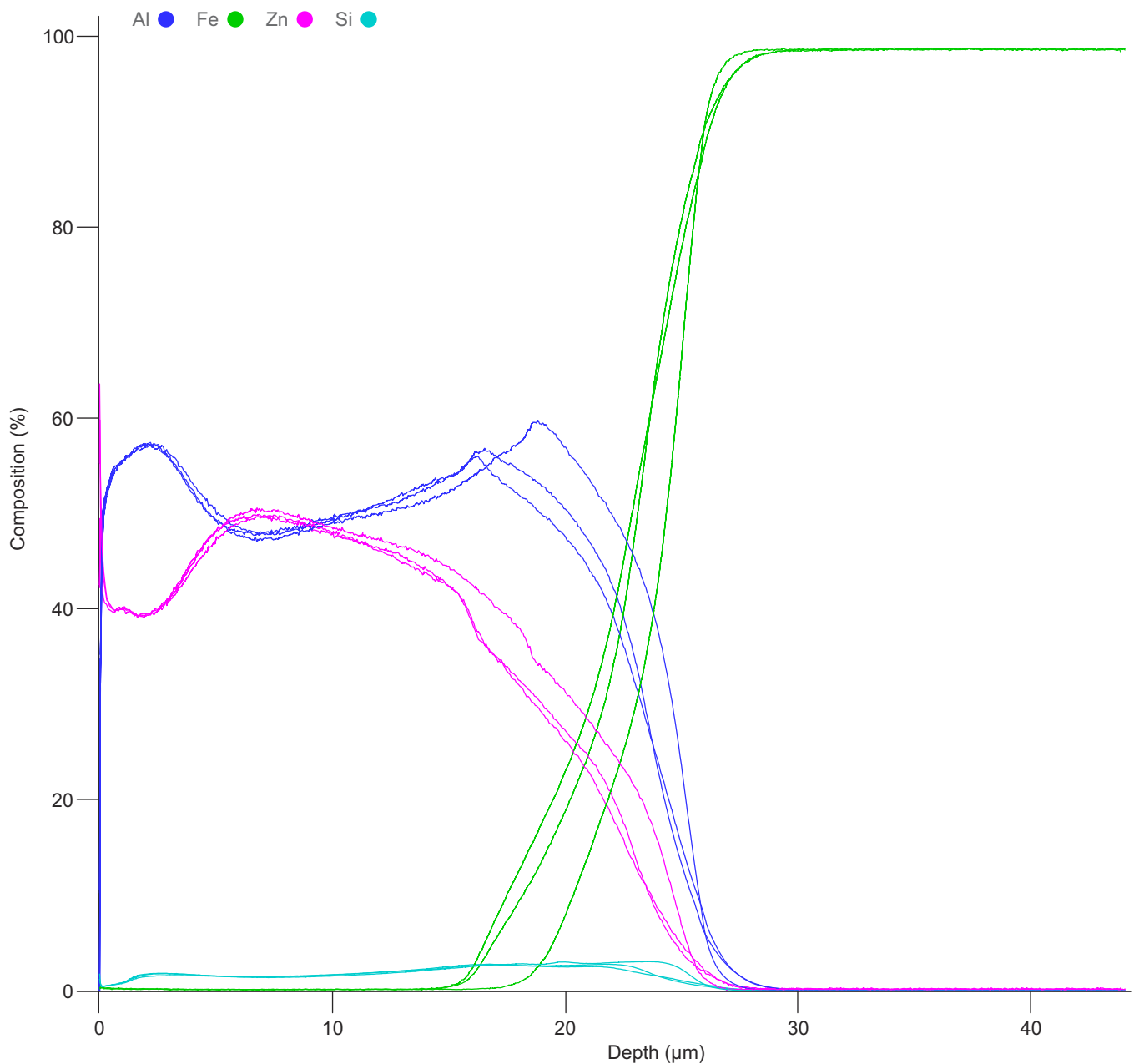
The 55% aluminum-zinc alloy is used in applications where improved corrosion resistance is required. In addition to aluminum and zinc, silicon is present at approximately 1.5% to control the alloy layer growth and improve adhesion during forming. The table and plot below show replicate analyses of a aluminum-zinc coating.

Name: Aluminum Zinc

Description: GL

Comments	Depth (μm)	Coating Weight (g/m^2)	Zn (%)	Al (%)	Si (%)
Run 1	20.9	86.1	41.9	55.8	2.35
Run 2	18.7	86.3	42.1	55.5	2.36
Run 3	19.8	89.8	42.6	55.0	2.40
Average	19.8	87.4	42.2	55.4	2.37
RSD (%)	5.58	2.35	0.95	0.77	0.96

GL - Aluminum Zinc

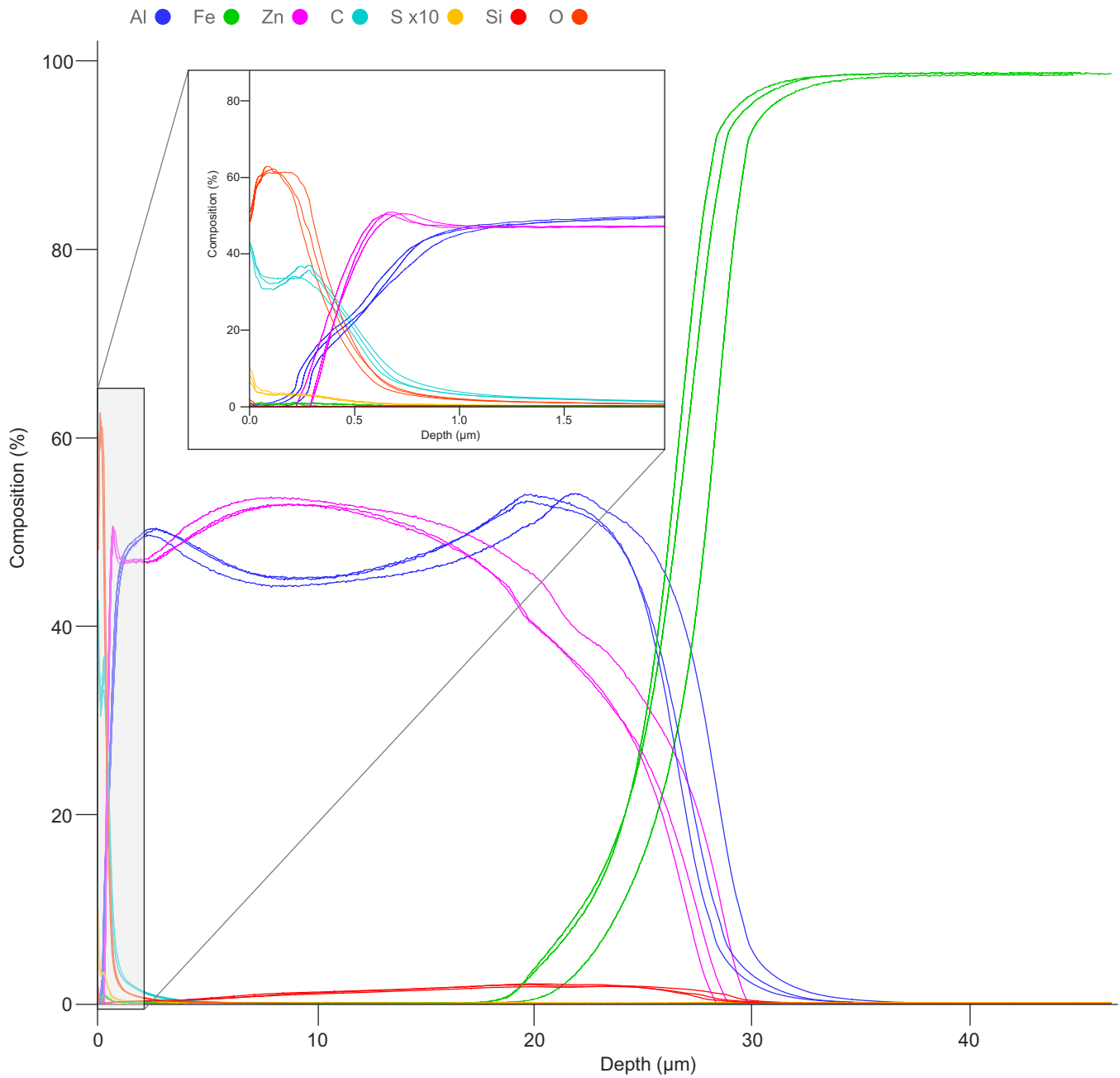


55% Aluminum-Zinc Coating with an Organic Surface Layer

For some applications an organic coating is applied to the 55% aluminum-zinc alloy. The organic coating can be analyzed using an RF method, which is required for analysis of non-conductive samples or coatings. The table and plot below show replicate analyses of an organic coated 55% aluminum-zinc alloy.

Name: Aluminum Zinc w/AFP	Description: Al-Zn AFP				
Comments	Depth (μm)	Coating Weight (g/m^2)	Zn (%)	Al (%)	Si (%)
Run 1	25.2	96.6	42.7	55.6	1.69
Run 2	24.6	95.7	44.2	54.1	1.63
Run 3	24.0	92.1	42.9	55.6	1.51
Average	24.6	94.8	43.3	55.1	1.61
RSD (%)	2.52	2.52	1.92	1.54	5.72

GL AFP-RF - Aluminum Zinc w/AFP



Electroplated Zinc Coatings

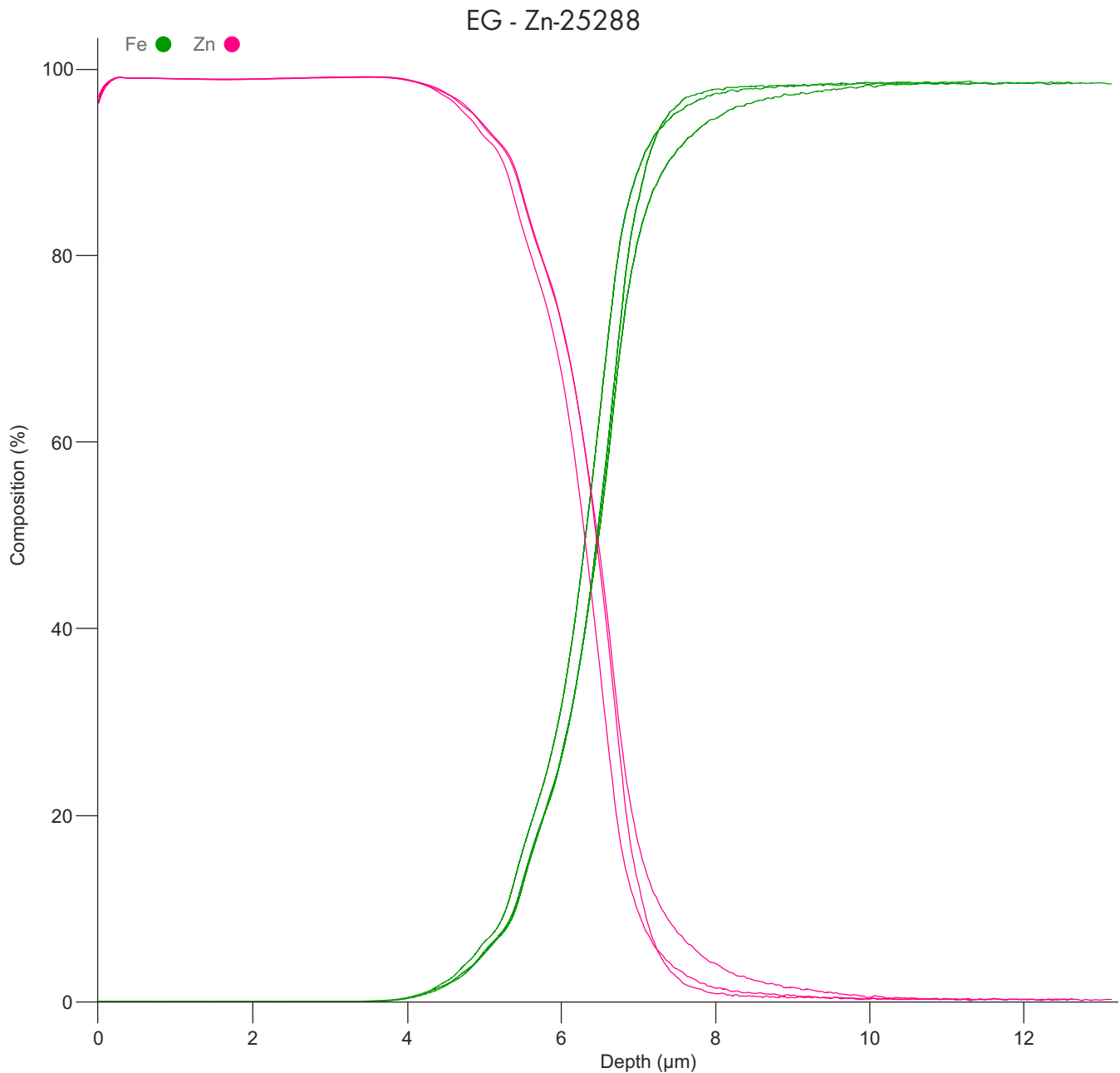
Electroplated Zinc

Electroplated zinc is applied by passing the steel strip at a high speed through a series of plating cells, building the coating thickness a little at a time. An advantage of electrogalvanized coatings is their excellent surface finish. Typical coating weights for electrogalvanized coatings range from 50 to 80 g/m². An electroplated coating thickness standard from Kocour Company, Chicago, Illinois with a certified thickness of 6.40 μm ±10% was analyzed. Replicate analyses of electrogalvanized steel are shown below. The uniformity of the layer is clearly seen in the plot and table below.

Name: Zn-25288

Description: 6.4 μm

Comments	Depth (μm)	Coating Weight (g/m ²)
Run 1	6.47	44.8
Run 2	6.30	43.5
Run 3	6.45	44.4
Average	6.40	44.2
RSD (%)	1.46	1.48



Electroplated Zinc-Nickel

The electroplated zinc-nickel alloy is formed by co-depositing the zinc and nickel to create the alloy coating. The typical alloy contains 10 to 16% nickel with the remaining balance zinc. The table and plot below show replicate analyses of a typical electroplated zinc-nickel coating.

Name: Zinc Nickel

Description: Zn-Ni

Comments	Depth (μm)	Coating Weight (g/m^2)	Ni (%)
Run 1	3.09	21.7	12.6
Run 2	3.26	22.7	12.2
Run 3	3.23	22.2	12.4
Average	3.20	22.2	12.4
RSD (%)	2.85	2.30	1.52

Zn-Ni - Zinc Nickel

