

Instrument: GDS900

Titanium Alloy Analysis by Glow Discharge Spectroscopy

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Key Words: Titanium Alloys, GDS900, Atomic Emission Spectrometer

Introduction

Titanium alloys play a critical role in today's high-tech world, offering an exceptional combination of strength-to-weight ratio, corrosion resistance, high-temperature strength retention, and biocompatibility. To achieve these properties, titanium is commonly alloyed with elements such as aluminum, tin, vanadium, zirconium, molybdenum, niobium, and iron. Because alloy composition directly affects material performance and compliance with product specifications, accurate elemental analysis is essential for quality assurance. As researchers continue to investigate new titanium alloy formulations, analytical techniques such as glow discharge spectroscopy (GDS) provide a fast and effective means of determining elemental composition.

Titanium alloys are used extensively across a wide range of industries. Aerospace and defense applications account for the largest share of titanium consumption, while medical and biomedical fields utilize titanium for artificial joints, implants, and surgical instruments. The chemical processing industry relies on titanium alloys for heat exchangers and desalination equipment due to their outstanding corrosion resistance. Titanium also finds application in premium consumer products, including bicycles, golf clubs, and luxury watches.

LECO's GDS900 is an atomic emission spectrometer designed for the elemental analysis of solid conductive materials. The instrument determines elemental composition by measuring the characteristic light emitted from a sample when its atoms are excited. At the heart of the system is a glow discharge source that uniformly sputters material from the sample surface, offering advantages over many other excitation techniques. Because excitation occurs within the glow discharge plasma and is spatially separated from the sample surface, the influence of the sample's metallurgical and chemical history is significantly reduced. Glow discharge spectra are

dominated by neutral atomic emission lines, resulting in relatively simple spectra with minimal spectral interferences. Although singly ionized transitions are also observed, glow discharge spectra remain considerably less complex than those produced by many other atomic emission techniques. In addition, the response of a typical glow discharge analytical line is highly linear across a broad concentration range, reducing the number of wavelengths required for accurate quantitative analysis.

The GDS900 delivers state-of-the-art technology specifically engineered for routine elemental determination in both ferrous and nonferrous materials. LECO's exclusive CCD-based optical design provides the measurement stability, flexibility, and analytical performance required for demanding production and quality-control environments.

Sample Preparation

Titanium samples are prepared using a wet 120-grit or finer zirconium oxide disc. Surface contaminants, if any, are sputtered away during the pre-burn schedule and are not analyzed. Analysis integration is taken from untouched substrate.

Accessories

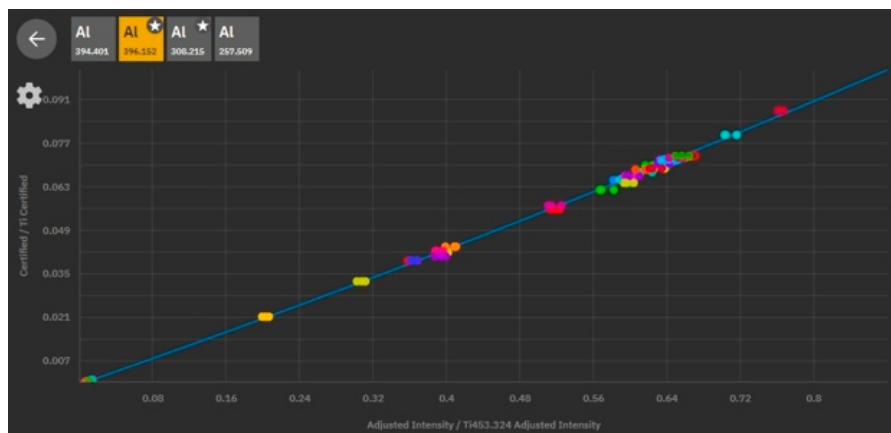
Sample Surface Preparation: LECO PX Series Grinder/Polisher

Calibration Curves

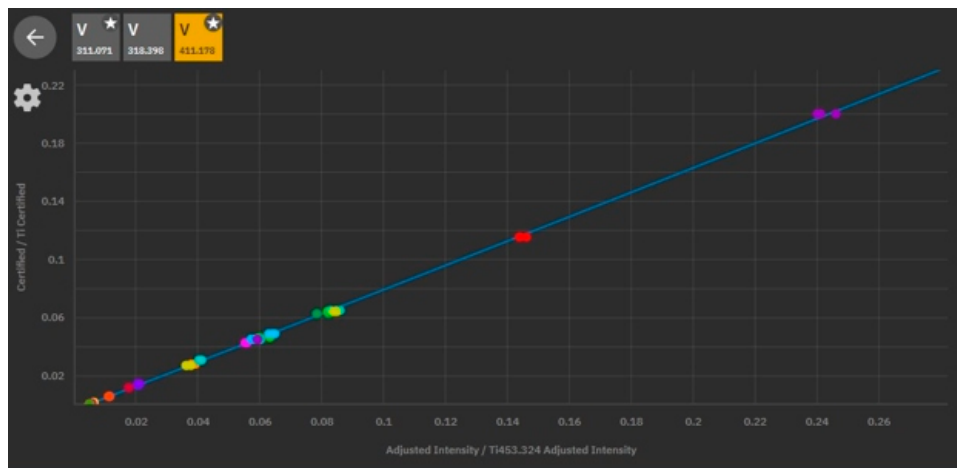
CCD technology provides full spectral coverage providing multiple wavelengths for each element. When needed, a sensitive line can be used along with a less sensitive line to achieve excellent coverage across a wide analytical concentration. In the curves shown the concentration is normalized; both the X- and Y- axes are ratioed to the matrix line.



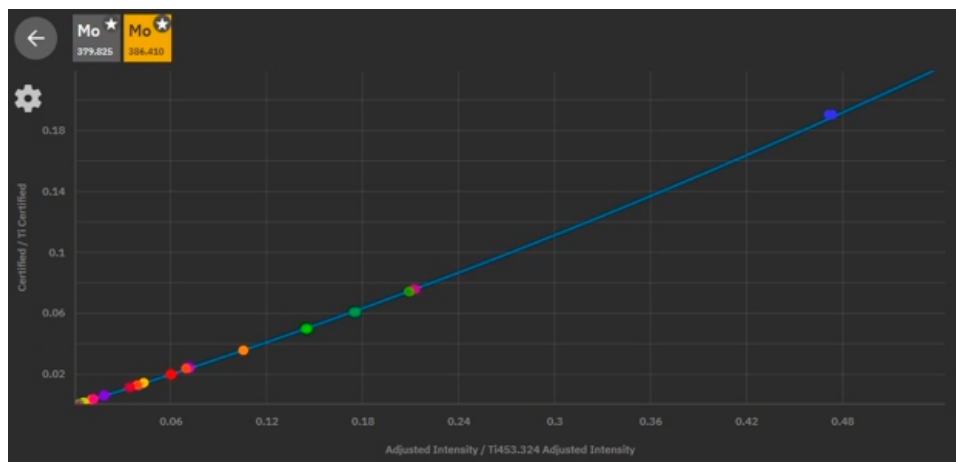
The aluminum calibration curve shows excellent fit through various titanium alloys.



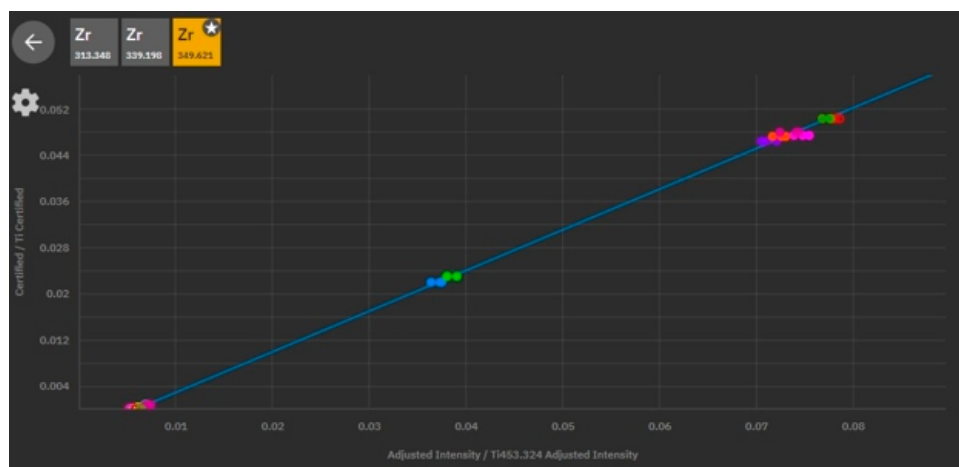
The vanadium calibration curve is linear from bottom to top at 15%.



The molybdenum curve demonstrates a quadratic fit going through the top point at 15%.



The zirconium curve is linear through the upper concentration of 4%.



Calibration Standards

A factory-installed titanium calibration is offered based upon specific customer requirements. Working curves are comprised of Certified Reference Materials (CRMs) and Reference Materials (RMs) and may include standards from the following manufacturers: NIST, Brammer, MBH, and IARM. LECO GDS calibrations are factory installed and ready for use after installation. Calibrations are considered usable for the life of the instrument.

Drift Control

Homogeneous materials are used to drift correct calibration curves. Uncertified, set-up standards are used when available. When needed by customer ranges or lack of suitable SUS material, RMs and CRMs may be substituted. Frequency of drift correction depends upon customer quality control procedures.

Analysis Time

A single analysis takes 70 seconds. The GDS900 can perform multiple analyses without dropping the sample. This is possible due to the removal of material by sputtering to reveal untouched sample. Three analyses can be completed in a 90-second period when using the "Multiple Burns Same Spot" option in the software.

	Single Burn	Three Burns w/o Dropping
Start-up and Pre-burn	60 s	60 s
Analyze	10 s	10 s
Analyze		10 s
Analyze		10 s
Total	70 s	90 s

Typical Results

Ti 6-4/UNS R56400 - NIST 654B

ELEMENT	Cert	Average	STDEV	RSD	Run #1	Run #2	Run #3
Al	6.34	6.44	0.01	0.1	6.43	6.45	6.43
V	4.31	4.32	0.02	0.5	4.31	4.30	4.34
Cr	0.025	0.024	<0.001	-	0.024	0.024	0.024
Fe	0.23	0.24	0.01	2.6	0.24	0.23	0.25
Si	0.045	0.042	0.001	2.0	0.041	0.042	0.043
Ni	0.028	0.034	<0.001	-	0.033	0.034	0.035
Ti	-	88.9	<0.001	-	88.9	88.9	88.9

Ti 6-7/UNS R56700 - IARM 300C

ELEMENT	Cert	Average	STDEV	RSD	Run #1	Run #2	Run #3
Al	5.97	6.01	0.03	0.5	6.03	5.97	6.03
V	0.030	0.05	0.001	1.5	0.045	0.046	0.046
Cr	0.0080	0.0087	0.0001	1.5	0.0088	0.0086	0.0085
Fe	0.181	0.188	0.003	1.5	0.187	0.191	0.185
Nb	6.80	6.77	0.04	-	6.82	6.75	6.74
Si	0.018	0.021	0.001	-	0.020	0.022	0.021
Ni	0.014	0.016	<0.001	-	0.016	0.016	0.016
C	0.010	0.010	<0.001	2.5	0.011	0.010	0.010
Ti	-	86.9	-	-	86.9	87.0	86.9

Ti 6-6-2/UNS R56620 - IARM 178D

<i>ELEMENT</i>	<i>Cert</i>	<i>Average</i>	<i>STDEV</i>	<i>RSD</i>	<i>Run #1</i>	<i>Run #2</i>	<i>Run #3</i>
Al	5.49	5.57	0.01	0.2	5.58	5.58	5.56
V	5.47	5.53	0.02	0.3	5.51	5.54	5.54
Sn	1.84	1.79	0.02	1.3	1.77	1.80	1.81
Mo	0.100	0.097	0.002	1.8	0.098	0.095	0.097
Cr	0.031	0.030	<0.001	1.3	0.030	0.030	0.029
Cu	0.520	0.500	0.004	0.9	0.503	0.503	0.495
Fe	0.550	0.555	0.005	0.9	0.560	0.556	0.550
Si	0.053	0.045	<0.001	-	0.045	0.045	0.045
Ni	0.067	0.054	<0.001	-	0.057	0.052	0.051
C	0.028	0.030	0.001	2.9	0.030	0.031	0.029
Ti	-	85.8	-	-	85.8	85.8	85.8

Ti 6-2-4-2/UNS R54620 - IARM Ti6242

<i>ELEMENT</i>	<i>Cert</i>	<i>Average</i>	<i>STDEV</i>	<i>RSD</i>	<i>Run #1</i>	<i>Run #2</i>	<i>Run #3</i>
Al	6.11	6.07	0.02	0.3	6.08	6.08	6.05
Sn	2.06	2.00	0.01	0.3	1.99	2.00	2.00
Zr	4.05	4.18	0.04	0.9	4.20	4.20	4.14
Mo	2.02	1.99	0.01	0.6	1.97	1.99	2.00
Fe	0.025	0.025	0.002	7.9	0.025	0.023	0.027
Si	0.077	0.079	<0.001	-	0.079	0.080	0.078
Ti	-	85.7	-	-	85.7	85.6	85.7

Ti 6-2-4-6/UNS R56260 - IARM Ti6246

<i>ELEMENT</i>	<i>Cert</i>	<i>Average</i>	<i>STDEV</i>	<i>RSD</i>	<i>Run #1</i>	<i>Run #2</i>	<i>Run #3</i>
Al %	5.95	6.02	0.01	0.2	6.03	6.03	6.01
Sn %	2.00	1.94	0.02	0.9	1.96	1.94	1.93
Mo %	6.04	6.17	<0.01	0.1	6.17	6.16	6.16
Zr %	4.11	4.15	0.02	0.4	4.15	4.17	4.14
Cr %	0.0050	0.0046	0.0002	3.4	0.0046	0.0044	0.0047
Fe %	0.021	0.027	0.002	7.0	0.026	0.025	0.029
Si %	0.052	0.059	<0.001	-	0.059	0.060	0.059
Ti %	-	81.6	-	-	81.6	81.6	81.7

Ti 15-3-3-3/UNS R58153 - IARM 344B

<i>ELEMENT</i>	<i>Cert</i>	<i>Average</i>	<i>STDEV</i>	<i>RSD</i>	<i>Run #1</i>	<i>Run #2</i>	<i>Run #3</i>
V	14.70	14.52	0.06	0.4	14.56	14.45	14.53
Al	3.03	3.17	0.01	0.4	3.19	3.17	3.16
Cr	2.91	2.98	0.04	1.5	3.01	2.93	3.00
Sn	3.01	2.86	0.01	0.4	2.87	2.85	2.87
Fe	0.118	0.138	0.004	3.1	0.134	0.137	0.143
Si	0.030	0.032	<0.001	-	0.032	0.031	0.032
Ni	0.021	0.021	<0.001	-	0.020	0.021	0.021
C	0.0095	0.0099	0.0005	5.3	0.0101	0.0093	0.0102
Ti	-	76.3	-	-	76.2	76.4	76.2