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Standard Guide for Metallurgical Analysis for Gas Distribution System Components[1]

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INTRODUCTION

Semiconductor clean rooms are serviced by high-purity gas distribution systems. This guide presents a procedure that may be applied for the evaluation of one or more components considered for use in such systems.

1. Scope

1.1 This guide covers corrosion resistant metallic alloys of the general class stainless steel, containing chromium, nickel, manganese, and silicon as major alloying additions and possibly molybdenum, that are qualified or specified for the materials of components used in high-purity gas supply systems for the semiconductor industry. This guide is primarily intended for testing to determine conformance to applicable composition and metallurgical specifications as stated in supplier product specifications or customer purchase specifications, or both.

1.2 Elements analyzed and reported in this guide are as follows:

1.2.1 The alloying additions chromium, nickel, and molybdenum (if specified in alloy, as in type 316L),

1.2.2 The minor elements and residuals manganese, silicon, copper, cobalt, and stabilizers such as titanium and columbium (niobium), if present,

1.2.3 Carbon, sulfur and phosphorus,

1.2.4 Nitrogen and oxygen gases,

1.2.5 Any additional minor element additions that may be made as part of the melting and casting practice, such as aluminum and calcium,

1.2.6 Available standard analytical and reporting techniques are described for these elements.

1.3 Metallurgical characteristics to be analyzed and reported are inclusion contents, grain structure, mechanical properties, and intergranular corrosion susceptibility.

1.4 *Limitations:*

1.4.1 This guide is limited to corrosion resistant metal alloys of the general class stated in the Scope.

1.4.2 The test methods cited in this guide are not intended to preclude the use of other generally accepted techniques of demonstrated equivalent or superior precision and bias.

1.4.3 Inclusion of testing and analysis procedures for any given element or metallurgical characteristic in this guide is not to be construed as being a requirement for incorporation of that element or metallurgical characteristic into any specifications.

1.5 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A479/A479M Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels

A484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings[2]

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

E8 Test Methods for Tension Testing of Metallic Materials

E45 Test Methods for Determining the Inclusion Content of Steel

[1] This guide is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.10 on Contamination Control.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

E112 Test Methods for Determining Average Grain Size
E353 Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
E572 Test Method for Analysis of Stainless and Alloy Steels by X-ray Fluorescence Spectrometry
E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
E1086 Test Method for Atomic Emission Vacuum Spectrometric Analysis of Stainless Steel by Point-to-Plane Excitation Technique
E1122 Practice for Obtaining JK Inclusion Ratings Using Automatic Image Analysis (Withdrawn 2006)[3]
E1245 Practice for Determining the Inclusion or Second-Phase Constituent Content of Metals by Automatic Image Analysis
E1282 Guide for Specifying the Chemical Compositions and Selecting Sampling Practices and Quantitative Analysis Methods for Metals, Ores, and Related Materials
E1382 Test Methods for Determining Average Grain Size Using Semiautomatic and Automatic Image Analysis

3. Terminology

3.1 *Definitions:*

3.1.1 *heat analysis*—chemical analysis of the heat of stainless steel determined by analyzing a sample obtained during the pouring of the heat for the elements designated in a specification.

3.1.2 *inclusion*—discrete second phases (oxides, sulfides, carbides, inter-metallic compounds) that are distributed in the metal matrix.

3.1.3 *verification analysis*—chemical analysis of a semifinished or finished product for the purpose of determining conformance to applicable specifications.

4. Significance and Use

4.1 This guide defines a procedure for testing components being considered for installation into a high-purity gas distribution system. Application of this guide is expected to yield comparable data among components tested for purposes of qualification for this installation.

4.2 This guide establishes a procedure for determining the elemental composition and metallurgical characteristics of metal used to fabricate components for high purity gas distribution systems in the semiconductor industry. The composition and metallurgy of stainless steel may be expected to affect properties of importance to this application, including surface roughness, incidence of surface defects, passivation, corrosion resistance, and welding.

5. Materials and Manufacture

5.1 Materials and instrumentation are specified in the ASTM test methods utilized in this guide.

[3] The last approved version of this historical standard is referenced on www.astm.org.

6. Procedure

6.1 The general requirements of Specification A484/A484M prevail for verification analysis, sampling, and test methods.

6.2 Specification A479/A479M prevails for the determination of conformance of test results to ASTM standard requirements.

6.3 *Chemical Analysis:*

6.3.1 The definitions, reference methods, practices, and reporting related to the chemical analysis of stainless steel alloys for this application shall be in accordance with Test Methods A751.

6.3.2 Use the following wet chemical test methods as control test methods and as the basis for standardizing instrumental analysis techniques, in accordance with Test Method E353:

Element	Concentration Range, %	Test Method E353, Sections
Chromium	0.10 to 35.00	212 to 220
Nickel	10.1 to 48.00	172 to 179
Molybdenum	1.5 to 7.0	242 to 249
Manganese	0.01 to 5.00	8 to 17
Silicon	0.05 to 4.00	46 to 52
Copper	0.01 to 5.00	82 to 89
Copper	0.01 to 5.00	109 to 118
Cobalt	0.01 to 5.00	61 to 70
Titanium	0.01 to 0.35	231 to 241
Sulfur	0.005 to 0.50	37 to 45
Phosphorus	0.002 to 0.35	18 to 29
Phosphorus	0.02 to 0.35	164 to 171
Aluminum	0.003 to 0.20	71 to 81

6.3.2.1 Apparatus, test procedures and data analysis are described in the appropriate sections of the Test Method E353.

6.3.3 Use the method of optical emission vacuum spectrometric analysis in accordance with Method E1086 for heat analysis or verification analysis of stainless steel samples that can be prepared with a flat surface of 13-mm (0.5-in.) minimum diameter. This test method provides analysis of the following elements in the concentration ranges shown:

Element	Concentration Range,%
Chromium	17.0 to 23.0
Nickel	7.5 to 13.0
Molybdenum	0.01 to 3.0
Manganese	0.01 to 2.0
Silicon	0.01 to 0.90
Copper	0.01 to 0.30
Carbon	0.005 to 0.25
Phosphorus	0.003 to 0.15
Sulfur	0.003 to 0.065

6.3.3.1 Apparatus, test procedures, and data analysis are described in the appropriate sections of Method E1086.

6.3.4 Use the method of X-ray emission spectrometric analysis in accordance with Test Method E572 for heat analysis or verification analysis of stainless steel. This test method provides for the analysis of the following elements in the concentration ranges shown:

Element	Concentration Range,%
Chromium	11.0 to 19.0
Nickel	0.20 to 13.0
Molybdenum	0.05 to 3.00
Manganese	0.40 to 2.00
Copper	0.05 to 3.50
Cobalt	0.05 to 0.50
Columbium (Niobium)	0.30 to 0.70