SEMI F55-0600 (Reapproved 0412)
TEST METHOD FOR DETERMINING THE CORROSION RESISTANCE OF MASS FLOW CONTROLLERS

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NOTICE: This Document was reapproved with minor editorial changes.

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1 Purpose

1.1 A mass flow controller (MFC) is often used to control corrosive gases under unfavorable conditions. This Test Method is intended to help differentiate between MFC designs on the basis of relative resistance to corrosion-induced failure.

2 Scope

2.1 This test is intended to show the effect of corrosion caused when a corrosive gas such as HCl is contaminated by an oxidizer such as atmospheric moisture. For the purpose of this test HCl is the preferred test gas, however this test can also be performed with other gasses. This Test Method describes a corrosive gas exposure test for MFCs. The test is intended to accelerate the corrosion while simulating conditions that may be found within process equipment and gas systems in the semiconductor industry. As the relationship between corrosion and performance may differ with MFC design, corrosion is not measured directly. The effects of corrosion are detected by observing changes in MFC calibration and other operating parameters.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Test Method should not be expected to yield comparable quantitative results from one test facility to another.

3.2 Results may be compromised by the methods used to construct the apparatus.

3.3 This test is designed to be a destructive test. The MFC tested will be destroyed. This test is intended only for MFCs manufactured for use in HCl or a similar highly corrosive gaseous environment. MFCs manufactured for noncorrosive service may develop leaks or other catastrophic failures if tested by this method. For practical reasons in constructing and operating the test bed, test samples may be limited to 100 sccm N_2 equivalent full scale (FS) flow.

3.4 This method does not measure corrosion directly by analyzing or inspecting the gas-wetted surfaces following exposure to a corrosive. No attempt is made to detect particles in the exit gas stream resulting from the corrosion process.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI F1 — Specification for Leak Integrity of High-Purity Gas Piping Systems and Components

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *DUT* — device under test

5.1.2 *FS* — full scale

5.1.3 *kPa* — kiloPascal

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5.1.4 *MFC* — mass flow controller

5.1.5 *MFM* — mass flow meter

5.1.6 *ppbv* — parts per billion by volume

5.1.7 *ppmv* — parts per million by volume

5.1.8 *sccm* — standard cubic centimeters per minute using a standard temperature of 0°C and a standard pressure of 101.32 kPa.

5.2 *Definitions*

5.2.1 *actual flow* — for the purpose of this standard, the output value of the reference flowmeter.

5.2.2 *ambient temperature* — the temperature of the medium surrounding the device. Under ordinary laboratory benchtop conditions, ambient temperature is the temperature of the room.

5.2.3 *indicated flow* — the electrical output of the device under test (DUT).

5.2.4 *valve drive* — electrical output from the DUT which is analogous to the level of power supplied to the control valve. This output is sometimes called valve voltage.

6 Summary of Method

6.1 Corrosive gas and moisture-containing N_2 are alternately flowed through the DUT with intervening dry N_2 purges. The test MFC is monitored over time for changes in performance resulting from corrosion.

6.2 This test is intended to be an accelerated simulation of the effects of alternating corrosive and moisture-exposure conditions. The test records how long it takes for corrosion to affect calibration. MFCs that are more resistant to corrosion failures should last longer under the test conditions. A dry N_2 purge separates each MFC's exposure to the corrosive gas and to the moisture-containing gas. This purging favors MFC designs that perform well in corrosive service because those MFCs can be dried out quickly with limited purging.

6.3 This method is expected to yield data that can be used to compare the relative performance of components tested for the purpose of qualification.

7 Interference's

7.1 Portions of the gas system exposed to HCl may require replacement or cleaning and refurbishment between test sequences to avoid invalidating subsequent tests by prematurely contaminating DUTs. Take care in the design and maintenance of the system so that particles shed from upstream piping components as a byproduct of corrosion are minimized so that they do not affect the DUT.

8 Apparatus

8.1.1 *Containment System* — To contain corrosive gas leaks that may develop in the DUT or gas system. The portion of the system that contains the corrosive gas should be operated in a suitable secondary containment environment.

8.1.2 *Power Supply*, *Controls*, and *Data Collection Devices* — Capable of recording data 20 times per second. Signals should be measured with a resolution of one mV or better. Data may be recorded in convenient units such as volts, sccm, or percent of FS. For the purpose of analysis and reporting, data should be converted to percent of FS except for valve drive, which may be reported in either percent of maximum drive or volts.

8.1.3 *DUT*

8.1.4 *Data Acquisition System* — Recommended as a data collection system to facilitate test sequencing and data collection.

8.1.5 *Plumbing* — With tubing and gas-switching valves constructed from 316L electropolished stainless steel or other material that exhibits superior corrosion resistance compared to 316L. The use of materials such as plastics, which retain or are permeable to water vapor, are not appropriate. All-metal sealed valves (no elastomers) are readily available and must be used.

8.1.6 The test plumbing is intended to represent the technology level found in the semiconductor process gas piping in which a typical DUT will operate.

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8.2 A filter has not been specified immediately upstream of the DUT because it would harbor contaminates and make it difficult to alternate gas types.

8.3 *Dry N_2 Source* — Pressure regulated source with a moisture level no greater than 50 ppbv.

8.4 *Dry HCl Source* — Pressure regulated source with a moisture level no greater than 500 ppbv.

8.5 *Reference Flowmeter* — Traceable with calibration certificate, calibrated for N_2, FS flow 100% to 125% of the FS N_2 equivalent flow range of the DUT Accuracy better than 5%, linear to 0.5% FS repeatable to 0.15% over a three-hour period, and reproducible to 0.3% of the test flow for the duration of the test.

NOTE 1: As this test is concerned with changes in DUT calibration and not the value of DUT calibration itself, the accuracy of the reference flowmeter is not paramount.

8.6 *Moisture Generator* — To introduce water vapor in a concentration of 100 ppmv (µl/l) ±20% in N_2.

8.7 *Moisture Analyzer* — To periodically verify the output of moisture generator.

9 Reagents and Materials

9.1 *HCl*

9.2 *N_2*

10 Safety Precautions

10.1 This Standard may involve hazardous materials, operations, and equipment. This Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this Standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

NOTE 2: The DUT will be contaminated with corrosive material at the conclusion of this test. Caution should be exercised in handling. A contaminated DUT should be properly decontaminated.

10.2 Become familiar with the safe handling practices associated with the corrosive gas before undertaking this test.

11 Preparation of Apparatus

11.1 The test apparatus is the source of three gases—dry N_2, dry HCl, and N_2—containing a known level of water vapor. Each gas can be valved through the DUT individually with minimal cross contamination. The DUT actively controls the gas flow in each case. The gas then flows into either a scrubbed exhaust system for safe disposal or a reclamation system. A reference flowmeter in the dry N_2 supply line is used to detect changes in calibration of the DUT when dry N_2 is flowing in series through both devices.

11.2 *Setup and Schematic* — See Figure 1 for a schematic of the test apparatus. This schematic may not show in detail all the components required in an actual system.

11.3 Supply the manufacturer's recommended power to the DUT. Provide MFC setpoint and purge command (if available). Monitor the following:

11.3.1 DUT setpoint input.

11.3.2 DUT indicated flow output.

11.3.3 DUT valve drive output (if available).

11.3.4 actual flow (output of reference flowmeter).

11.4 Verify that the proper moisture levels exist in each of the test gases.

11.5 Provide a purge flow loop that maintains a constant flow of dry N_2 in the line from the DUT to the exhaust system. Flow in this loop must be sufficient to prevent back diffusion into the DUT of moisture generated in the exhaust system, particularly when flow into the DUT is shut off for measuring zero.

11.6 If the moisture generator is supplied from the same N_2 source that supplies the dry N_2, take precautions to avoid the diffusion of moisture from the moisture generator into the dry N_2 line. Such precautions may include the use of separate pressure regulators and other valving.

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