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## Appendix B - ORS Commercial Practice for Internal Vapor Analysis of Microelectronic Devices

### 1.0 Purpose

The purpose of this test method is to quantitatively measure the relative concentration of the internal vapor content, including water vapor, in hermetically sealed, gas filled microelectronic devices using a mass spectrometric technique. This technique is destructive and is intended for the reporting of all volatile atomic and molecular species detected in the microelectronic device. Improvements and variations on this method are permitted when the analytical facility can provide supporting data for the modifications that meet the accuracy and precision requirements of this test method.

### 2.0 Scope

This test method is applicable to all hermetic (i.e., cavity) microelectronic devices fabricated with internal volumes at internal pressures approximating one atmosphere. Any device size may be tested when the analytical instrument system measurement specifications can be demonstrated for the internal cavity size of that device.

Results of this test reflect the internal vapor content in a device at the time of test. Results depend on device history and device preconditioning. It is the responsibility of the submitter to specify the applicable device preconditioning that is to be performed by the analytical facility and to provide adequate supporting information to the analytical facility for the purpose and intended use of the test data.

Although this protocol is destructive, it may be used on electrical or mechanical reject devices provided that hermeticity has not been jeopardized and the devices are fully representative of manufacturing process and environmental conditions per the purpose and intent of the test.

### 3.0 Apparatus

The apparatus to conduct internal vapor analysis shall consist of:

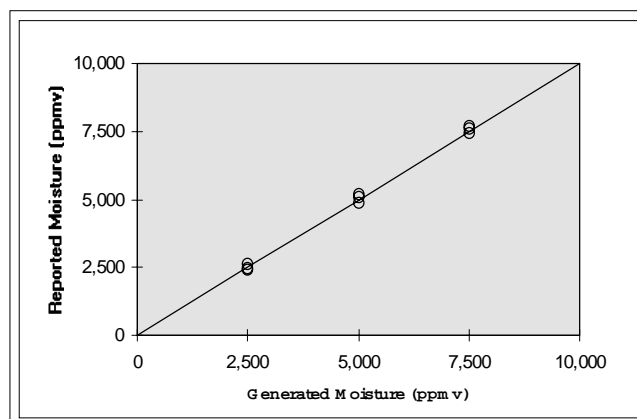
- 3.1 a *mass spectrometer* capable of:
  - 3.1.1 detecting mass ions in the minimum continuous mass range from 2 Atomic Mass Units (AMU) to 100 AMU;
  - 3.1.2 unit mass resolution of spectra;
  - 3.1.3 the ability to measure and control the peak shape tuning and peak-to-peak resolution over the minimum continuous mass range;
  - 3.1.4 spectra acquisition in continuous scan mode in minimum increments of 0.1 AMU;
  - 3.1.5 sufficient ion signal intensity and ion signal dynamic range to meet System Measurement Requirements per Section 4.0 of this document. A minimum of three (3) decades of dynamic range of the ion signal intensity is required.
- 3.2 a *heating system* to maintain the device casing at a specified minimum temperature during the test. The specified minimum temperature shall be  $100^{\circ}\text{C} \pm 5^{\circ}\text{C}$  unless otherwise specified;
- 3.3 a *puncture mechanism* capable of piercing a hole in the device without compromising the integrity of the test;
- 3.4 a *vacuum system* capable of achieving the System Measurement Specifications per Section 4.0;
- 3.5 a *heated transfer path*, which shall be maintained at  $125^{\circ}\text{C} \pm 5^{\circ}\text{C}$ , capable of transferring the device gases from the device to the mass spectrometer chamber;

- 3.6 *pressure sensor(s)* to provide a means of measuring the pressure in the transfer path and in the mass spectrometer chamber;
- 3.7 a *leak valve* or equivalent mechanism to control the flow of gases from the device to the mass spectrometer chamber;
- 3.8 a *calibration system* to provide a means of calibrating the mass spectrometer for each of the commonly detected gases (i.e., water vapor, nitrogen, oxygen, argon, carbon dioxide, hydrogen, helium, where applicable), at concentration ranges and volumes typical of the devices to be tested, and in a manner that reproduces actual device testing protocol;
- 3.9 a *moisture generator system* capable of generating moisture concentrations in the range specified in Paragraph 4.5 and a dew point analyzer capable of measuring dew point in the same range to an accuracy of  $\pm 0.2^{\circ}\text{C}$  or better. Calibration of this device shall occur at least once every year to NIST traceable standards or other internationally recognized standards;
- 3.10 *profile calibrated oven(s)* or equivalent to precondition devices at a specified temperature as needed prior to hot insertion into the device holder.

#### 4.0 System Measurement Specifications

The measurement system of the mass spectrometer shall meet the following measurement specifications and shall be demonstrated on an as needed basis.

- 4.1 Sufficient dynamic range of the ion signal intensity to directly measure the unsaturated amplitude of all mass peaks within the minimum continuous mass range.
- 4.2 Detection of 100 ppmv of oxygen, argon, carbon dioxide, hydrogen and helium in a nitrogen balance for the volume range of devices to be tested.
- 4.3 Quantitative analysis of oxygen, argon, carbon dioxide, hydrogen and helium in a nitrogen balance to a reproducible accuracy of  $\pm 5\%$  of the true value or  $\pm 100$  ppmv, whichever is greater (e.g., if the true value of oxygen is 20.95%, then the accuracy must be  $\pm 1.05\%$  which is 5% of 20.95%).
- 4.4 Quantitative analysis of moisture at 5000 ppmv in a nitrogen balance to a reproducible accuracy of  $\pm 10\%$ .
- 4.5 Validation of a linear calibration curve for moisture between the concentration levels of 2500 ppmv and 7500 ppmv in a nitrogen/moisture mixture. The system shall demonstrate an average error that is less than 500 ppmv using a minimum of nine (9) data points over this range. The data shall be generated in three groupings of three data points, each at the median and extremes of the range (ref. Figure 1).



**Figure 1: 3-Point Calibration Curve in Triplicate**

**4.6** Quantitative analysis of all other gases not specified in Paragraphs 4.2 through 4.5 shall be performed assuming a unit calibration factor using the primary peak.

**5.0 Calibration**

**5.1** At a minimum, weekly calibration shall be performed for nitrogen, oxygen, argon, hydrogen, helium and carbon dioxide per Paragraph 4.3. Air, at room temperature, may be used as an acceptable standard for the calibration of oxygen and argon, if calibrated relative to nitrogen. NIST traceable standards or other internationally recognized standards shall be used for the calibration of hydrogen, helium and carbon dioxide.

**5.2** A daily calibration shall be performed for moisture at 5000 ppmv at the volume ranges representative of devices to be tested on that instrument on that day. This calibration shall have a reproducible accuracy of  $\pm 10\%$ .

**5.3** Unless otherwise calibrated, on an as needed basis, unit calibration shall be assumed for the remaining inorganic and organic gases.

Generated Moisture (ppmv)	Reported Moisture (ppmv)	Absolute Error (ppmv)
2,500	2,396	104
2,500	2,628	128
2,500	2,452	48
5,000	5,077	77
5,000	4,876	124
5,000	5,199	199
7,500	7,682	182
7,500	7,598	98
7,500	7,456	44
Average Error:		112

**6.0 Information to be Submitted to the Analytical Facility**

The following information shall be provided by the Submitter to the Analytical Facility along with the devices to be tested:

- 6.1** the number of devices to be tested;
- 6.2** where applicable, device failure criteria which typically specifies concentration of specific gases (e.g., moisture) in ppmv or percent;
- 6.3** the estimated internal pressure of the device;
- 6.4** the presence of polymeric materials, organics or desiccants in the cavity of the device;
- 6.5** prebake conditions, if any;  
**Note:** A prebake of 12-24 hours at 100°C is recommended for devices containing polymeric materials, organics or desiccants in the cavity of the device.
- 6.6** the device minimum test temperature if other than 100°C  $\pm 5^\circ\text{C}$ ;
- 6.7** the preferred puncture site on the device as well as the thickness and internal clearance at the selected site; if critical.

**7.0 Device Handling and Preparation**

- 7.1** Devices shall be inspected visually for obvious defects that may prevent adequate testing of the device.
- 7.2** The exterior of the device must be free of process materials (e.g., conformal coating) and contamination so as not to interfere with the test protocol. The exterior of the device may be cleaned if warranted. Any mechanical or chemical cleaning shall be performed in a manner so as not to compromise the integrity of the test.
- 7.3** Leads of the device may be bent or trimmed when permitted and only in a manner that does not compromise the integrity of the package seal.
- 7.4** If specified, the device shall be preheated prior to insertion in the mass spectrometer for testing. Preconditioning shall be reported on the test report.
- 7.5** The device may be thinned by abrasion at the designated puncture site to facilitate puncturing. Thinning must be done immediately prior to insertion into the mass spectrometer.

## 8.0 Test Procedure

- 8.1 Devices shall be prepared for testing per the device handling and preparation procedure in Section 7.0.
- 8.2 At the conclusion of any preconditioning as required, devices shall be removed individually from the oven. The puncture site shall be thinned as needed and the device loaded immediately into the device mounting fixture. If preconditioning is not required, the device shall be thinned as needed and then loaded into the device mounting fixture.
- 8.3 The mass spectrometer chamber shall be pumped down until background spectra and pressure levels are sufficient to achieve the System Measurement Specifications per Section 4.0. The background levels of all volatile species for which calibration has been conducted shall be undetectable or sufficiently low so as not to impair system detection limits or accuracy requirements.
- 8.4 The background spectra for the minimum mass range of 2 AMU to 100 AMU shall be acquired.
- 8.5 The device shall then be punctured and the following properties of the released gases shall be measured immediately:
  - 8.5.1 a mass spectra scan(s) to measure the internal vapor content of the device at the time of puncture. The mass spectra shall be generated per the minimum capabilities as detailed in Section 3.1.
  - 8.5.2 the increase in transfer path pressure as the gases are released from the punctured device.

**Note:** The measured pressure indicates the relative amount of gas in the device. If the measured pressure deviates from the norm for that device type, the measured pressure may indicate, among other things, that: (1) the device package was not hermetic; (2) the device was sealed under reduced pressure or partial vacuum; (3) the puncture was not fully accomplished; or (4) the device may not have been mounted properly in the test fixture.
- 8.6 The laboratory shall interpret the data and make a determination as to the following:
  - 8.6.1 that the test was or was not a valid test, using the pressure reading cited in Paragraph 8.5.2 and other system performance indicators;
  - 8.6.2 the proportions (by volume) of all the released gases with data corrected for system-dependent matrix effects, when applicable.
  - 8.6.3 the occurrence of significant unidentified peaks in the mass spectra which shall be reported as unknowns.
- 8.7 Test results shall be recorded on a report and shall include the following data and notes:
  - 8.7.1 the proportions (by volume) of all the released gases or, if the test of an individual device is invalid, the device test attempt reported as a "No Test" with an explanation;
  - 8.7.2 prebake conditions, as performed;
  - 8.7.3 any test-related information that may impact the interpretation of the test results.
- 8.8 A copy of the test report, raw data and related calibration data sufficient to requantitate the test results shall be archived.