

SEMI S29-0712

GUIDE FOR FLUORINATED GREENHOUSE GAS (F-GHG) EMISSION CHARACTERIZATION AND REDUCTION

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NOTICE: This Standard or Safety Guideline has an Inactive Status because the conditions to maintain Current Status have not been met. Inactive Standards or Safety Guidelines are available from SEMI and continue to be valid for use.

1 Purpose

- 1.1 This Document provides guidance to characterize fluorinated greenhouse gas (F-GHG) emitted from manufacturing equipment (ME).
- 1.2 This Document provides guidance to characterize F-GHG destruction or removal efficiency (DRE) of an abatement tool.
- 1.3 This Document also addresses continuous improvement planning for emission reduction on ME or an abatement tool.

NOTE 1: Because this SEMI Standard is a 'Guide,' all criteria using 'should' may be considered optional.

2 Scope

- 2.1 Greenhouse gases (GHGs) to which this Guide applies are CF₄, C₂F₆, C₃F₈, c-C₄F₈, CHF₃, SF₆ and NF₃.

NOTE 2: In addition to above gases, this Guide may be applicable to other F-GHGs.

- 2.2 This Guide applies to F-GHG emission characterization from ME.
- 2.3 This Guide applies to F-GHG emission characterization from an abatement tool.
- 2.4 This Guide applies to characterization of consumption, residues, byproducts or recombination of F-GHG through chemical reaction in ME.
- 2.5 This Guide is applicable to abatement tool specification for F-GHG DRE.
- 2.6 It is recommended to use this Guide in semiconductor, TFT-LCD, photovoltaic industries at least.
- 2.7 This Guide contains the following sections:

- Purpose
- Scope
- Limitations
- Referenced Standards and Documents
- Terminology
- General Provisions
- Baseline Recipe(s)
- Measurement Instruments
- Measurement and Characterization of F-GHG Emission
- Timing and Frequency of F-GHG Emission Characterization
- Reporting
- Record Keeping of Data Characterized

- Roadmap and Continuous Improvement

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 Guide is not intended to supersede the applicable codes and regulations of the region where the characterization is conducted, or the region where the information developed may be used.

3.2 This Guide is not intended to restrict characterization method of F-GHG emission, utilization, or DRE.

3.3 This Guide is not intended to restrict data management of F-GHG emission, utilization, or DRE.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

SEMI S23 — Guide for Conservation of Energy, Utilities and Materials Used by Semiconductor Manufacturing Equipment

4.2 IPCC Document¹

2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 3 Industrial Processes and Product Use – Chapter 6 Electronics Industry Emissions

4.3 ISMI Documents²

#01104197A-XFR — Guideline for Environmental Characterization of Semiconductor Equipment

#06124825B-ENG — Guideline for Environmental Characterization of Semiconductor Process Equipment, Revision 2

4.4 Seiko Epson Document³

Simple Method for PFC Characterization using FT-IR

4.5 US EPA Protocol⁴

EPA 430-R-10-003 — Protocol for Measuring Destruction or Removal Efficiency (DRE) of Fluorinated Greenhouse Gas Abatement Equipment in Electronics Manufacturing

NOTE 3: JEITA⁵ is developing “JEITA Guideline for F-GHG Characterization and Management”.

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 DRE — destruction or removal efficiency

5.1.2 FCs — fluorinated compounds

¹ Intergovernmental Panel on Climate Change (IPCC), IPCC Secretariat: C/O World Meteorological Organization, 7bis Avenue de la Paix, C.P. 2300, CH- 1211 Geneva 2, Switzerland; Telephone: +41.22.730.8208/54/84; Fax: +41.22.730.8025/13; <http://www.ipcc.ch>

² International SEMATECH Manufacturing Initiative, 257 Fuller Road, Albany, NY 12203, USA, Telephone: +1.518.649.1000; <http://ismi.sematech.org>

³ Seiko Epson Corporation, 3-3-5 Owa, Suwa, Nagano, Japan; <http://global.epson.com/SR/environment/method.html>

⁴ United States Environment Protection Agency, 1200 Pennsylvania Avenue Northwest, Washington D.C., DC, USA, Telephone: +1.202.260.2010; <http://www.epa.gov>

⁵ Japan Electronics and Information Technology Industries Association, Ote Center Building, 1-1-3, Otemachi, Chiyoda-ku, Tokyo 100-0004, Japan; <http://www.jeita.or.jp>

5.1.3 *F-GHG* — fluorinated greenhouse gas

5.1.4 *FT-IR* — fourier transform-infrared

5.1.5 *GC-MS* — gas chromatography-mass spectrometry

5.1.6 *GHG* — greenhouse gas

5.1.7 *GWP* — global warming potential

5.1.8 *HTF* — heat transfer fluid

5.1.9 *IPCC* — Intergovernmental Panel on Climate Change

5.1.10 *ISMI* — International SEMATECH Manufacturing Initiative

5.1.11 *ME* — manufacturing equipment (such as semiconductor, flat panel display [FPD] or photovoltaic manufacturing equipment)

5.1.12 *MFC* — mass flow controller

5.1.13 *PFCs* — perfluoro compounds

5.1.14 *QMS* — quadrupole mass spectrometer

5.1.15 *SEMATECH* — Semiconductor Manufacturing Technology Institute

5.2 Definitions

5.2.1 *baseline* — operating conditions, including process chemistry, for which the equipment was designed and manufactured. [SEMI S2]

5.2.2 *environmental impact* — positive and negative effects to the earth environment from a variety of sources including people and their activities, and the operation of manufacturing equipment and facilities.

5.2.3 *recombination* — other material to which is joined after an original material is broken.

5.2.4 *roadmap* — a sequence for the incremental introduction or improvement of technology over time with month or year milestones and supporting information. [SEMI S23]

5.2.5 *source gas residue F-GHG* — unreacted F-GHG after processing such as chamber cleaning or dry etching of substrates.

5.2.6 *system integrator* — party that integrates manufacturing equipment and an abatement system. A system integrator can be a user of manufacturing equipment and an abatement system, or a supplier who is named to be a system integrator by contract.

5.2.7 *utilization* — fraction of a gas destroyed or transformed by reaction process such as CVD or etching (so-called “use rate” in “2006 IPCC Guidelines for National Greenhouse Gas Inventories”).

6 General Provisions

6.1 The document reader is recommended to understand the meaning of GHG emission characterization and DRE of abatement tool written in Chapter 6 “Electronics Industry Emissions” of “2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 3 Industrial Processes and Product Use.”

7 Baseline Recipe(s)

7.1 The measurement, monitoring, improvement, and reporting methods should be conducted using one or several supplier baseline recipe(s).

NOTE 4: The ME or the abatement tool supplier is encouraged to consider baseline recipe(s) which also meet the needs of the users.

7.2 Recipe(s) should include gas species, process time, vacuum pressure, process temperature, idle time, etc.

8 Measurement Instruments

NOTE 5: Outlines of FT-IR and QMS are shown in Related Information 1.

8.1 Measurement instrument should be appropriately calibrated prior to measurement.

8.1.1 Calibration of measurement instrument should be conducted for each F-GHG to be characterized.

9 Measurement and Characterization of F-GHG Emission

NOTE 6: The following documents may be useful to characterize F-GHG emissions.

- 01104197A-XFR and #06124825A-ENG of ISMI
- Simple Method for PFC Characterization using FT-IR

9.1 Total volume of each F-GHG is defined as sum of time integration of values calculated based upon “F-GHG concentration multiply gas flow rate”.

$$V_i = \int_0^T C_i(t) \times F_i(t) dt \quad (1)$$

where:

V_i = gas volume for i th gas (i th: 1st, 2nd, 3rd, 4th, 5th...)

t = measurement timing

T = total time for measurement

$C_i(t)$ = concentration for i th gas

$F_i(t)$ = gas flow rate for i th gas

9.2 Following shows how to measure F-GHGs including byproducts, the emitted gas flow rate, and measurement time. Based upon such data, mass balance between the input and the output of the ME, or the DRE of the abatement tool can be specified.

9.2.1 Measurement of F-GHG Concentration

9.2.1.1 Measure emissions including gas phase byproducts.

9.2.1.2 Measurement should be conducted by a qualified method such as FT-IR, which is described on “Guideline for Environmental Characterization of Semiconductor Process Equipment – Revision 2 (ISMI Technology Transfer #06124825B-ENG)”.

NOTE 7: For use of FT-IR, the simplified FT-IR is shown in Related Information 1.

9.2.2 Identification of F-GHG Flow Rate

9.2.2.1 Sum each flow rate of input gases.

9.2.2.2 A gas, for which the concentration is already known should be used for the reference.

9.2.3 Identification of Measurement Time

9.2.3.1 Identification of F-GHG measurement time can be calculated from time which input gases are flowing other than identifying actual measurement time.

9.2.4 Emission Characterization

9.2.4.1 It should be conducted at a certain change such as process recipe change of the ME, the ME configuration change, or the abatement tool configuration change.

9.2.4.2 If repeatability of each measurement or linearity of concentration to absorbance is not shown, any malfunction of the ME, the abatement tool or the measurement instrument should be investigated.

NOTE 8: Repeatability and/or linearity should be defined by a supplier.

9.2.4.3 Emission from the ME

9.2.4.3.1 Emission from the ME should be characterized for one or several supplier baseline recipe(s).