

SEMI E136-1104

TEST METHOD FOR DETERMINING THE OUTPUT POWER OF RF GENERATORS USED IN SEMICONDUCTOR PROCESSING EQUIPMENT RF POWER DELIVERY SYSTEMS

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1 Purpose

1.1 The purpose of this Test Method is to provide an accurate method for measuring the output power of RF generators used in RF power delivery systems for semiconductor processing equipment to support SEMI E113.

2 Scope

2.1 This Test Method specifies the testing procedures and test equipment required for determining the true output power (i.e., heating power) output of RF generators. This Test Method uses a calorimetric power meter, which was calibrated previously using precise DC substitution techniques as a reference standard.

2.2 The primary focus for this Test Method is semiconductor processing equipment including, but not limited to, the following equipment types:

- Dry etch equipment, and
- Film deposition equipment (CVD and PVD).

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 is meant to provide a general means of measuring the true output power of RF generators operating over a wide range of frequency and power. Limitations in the frequency and power coverage of this method are determined by the individual system components chosen.

3.2 This Test Method assumes that the transmission system characteristic impedance is 50 Ω .

3.3 International, national, and local codes, regulations, and laws should be consulted to ensure that the equipment and procedures meet regulatory requirements in each location.

3.4 Certain safety issues associated with the test procedures themselves are mentioned as a reminder that safety procedures are necessary for safe conduct of the test.

3.5 This Standard does not address any safety or performance issues related to RF emissions or electrical codes (e.g., Underwriter's Laboratory, Inc. (UL), the National Electrical Code (NEC®), Federal Communications Commission (FCC)). It is the responsibility of the users of this Standard to conform to the appropriate local codes and regulations as applied to this type of equipment, some of which are covered by referenced documents.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E113 — Specification for Semiconductor Processing Equipment RF Power Delivery Systems

SEMI E114 — Test Method for RF Cable Assemblies Used in Semiconductor Processing Equipment RF Power Delivery Systems

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *AC* — alternating current

5.1.2 *CVD* — chemical vapor deposition

5.1.3 *DC* — direct current

5.1.4 *NIST* — National Institute for Standards and Technology

5.1.5 *PVD* — physical vapor deposition

5.1.6 *RF* — radio frequency

5.1.7 *VSWR* — voltage standing wave ratio

5.2 Definitions

5.2.1 *cable assembly* — the section of cable (transmission line), including the connectors, used to connect various parts of the RF power delivery system.

5.2.2 *calorimeter* — an RF power measurement instrument using differential temperature and mass flow rate to determine true heating power.

5.2.3 *harmonic frequency* — the harmonic frequencies are defined as integer multiples of the fundamental frequency. For example, the second harmonic of 13.56 MHz is 27.12 MHz.

5.2.4 *RF generator* — a component in the RF power delivery system used to develop RF energy.

5.2.5 *RF load* — another term used to describe an RF termination.

5.2.6 *RF termination* — a device for terminating RF transmission systems, and converting RF electrical energy into heat. RF terminations normally have values that are the same as the characteristic impedance of the transmission system.

6 Test Apparatus

6.1 *Calorimetric Power Meter* — This instrument is designed to be used in conjunction with a high efficiency water-cooled RF termination, rated for the maximum power output of the RF generator. Typical calorimetric power meters use internal thermocouple- or thermistor-type temperature sensors, a precision coolant flow meter, and processing circuits for storage of calibration constants and coolant physical characteristics. Choose instruments capable of providing a power measurement accuracy of $\pm 1\%$ after calibration at a specific power level.

6.2 *Water-Cooled RF Termination* — This device provides a low VSWR (i.e., high return loss) termination for the testing of the RF generator. Use an RF termination sized appropriately for the RF generator under test. Finally, use an RF termination capable of dissipating DC energy, without damage due to the effects of electrolysis. The return loss of the RF termination, including the interconnecting cable between the RF generator and the termination shall be no less than 30 dB. This return loss ensures maximum power transfer between the RF generator and the calorimeter.

NOTE 1: See § 7 for safety-related recommendations related to RF terminations.

6.3 *Voltage and Current Meters* — These meters are used to measure the voltage and current presented to the calorimeter load during the DC calibration of the calorimeter. These instruments shall have a certificate indicating NIST traceability. Choose meters capable of voltage and current measurement accuracy of less than 0.2%.

6.4 *Calibration Power Supply* — This power supply is used as a source of clean DC energy for the purposes of calibrating the calorimetric power meter. Use a power supply sized for the calibration to be performed and that provides a very stable output at all levels.

6.5 *Cables and Connectors* — Various interconnecting cables are required to perform the tests outlined in this Test Method. These include low-loss cables to connect the DC power source to the measuring instrument and to the RF load, in addition to low-loss RF cables and connectors to connect the RF generator output to the load.

6.5.1 In order to keep cable losses to a minimum, minimize the lengths of interconnecting cables.