

SEMI PV81-0318

GUIDE FOR SPECIFYING LOW PRESSURE HORIZONTAL DIFFUSION FURNACE

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1 Purpose

1.1 Compared with atmospheric horizontal diffusion furnace, low pressure horizontal diffusion technology has advantages of higher volume production, lower space requirement, less energy consumption and better sheet resistance uniformity, but all of these advantages are based on several key parameters of equipment. This Guide is provided as a reference for diffusion furnace equipment manufacturers and customers, so that low pressure horizontal diffusion can achieve less cost and higher performance.

2 Scope

2.1 Low pressure horizontal diffusion furnace described in this Guide is mainly used for building p - n junction under low pressure condition in the silicon solar cells diffusion production line.

2.2 This Guide analyzes several key parameters which influence the diffusion process results in low pressure. These parameters which are verified by series of experiments and tests on the production lines are valuable references for horizontal diffusion furnace equipment manufacturers.

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 analyzes several key parameters which influence the diffusion process results in low pressure. It provides references and suggestions for equipment designers, manufactures and final customers. Design and manufacturing methods of the low pressure horizontal diffusion technology are not restricted to this Guide; instead, better parameter settings and design methods are recommended.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E6 — Guide for Semiconductor Equipment Installation Documentation

SEMI E56 — Test Method for Determining Accuracy, Linearity, Repeatability, Short-Term Reproducibility, Hysteresis, and Deadband of Thermal Mass Flow Controllers

SEMI E69 — Test Method for Determining Reproducibility and Zero Drift for Thermal Mass Flow Controllers

SEMI F74 — Test Method for the Performance and Evaluation of Metal Seal Designs for Use in Gas Delivery Systems

SEMI M59 — Terminology for Silicon Technology

SEMI MS10 — Test Method to Measure Fluid Permeation Through MEMS Packaging Materials

SEMI S6 — EHS Guideline for Exhaust Ventilation of Semiconductor Manufacturing Equipment

SEMI T7 — Specification for Back Surface Marking of Double-Side Polished Wafers with a Two-Dimensional Matrix Code Symbol

SEMI T8 — Specification for Marking of Glass Flat Panel Display Substrates with a Two-Dimensional Matrix Code Symbol

SEMI T9 — Specification for Marking of Metal Lead-Frame Strips with a Two-Dimensional Data Matrix Code Symbol

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 Ω — Ohm, the unit of resistance, combined with a linear dimension, usually centimeter, to be the unit of resistivity. [SEMI M59]

5.2 Definitions

5.2.1 *minimum pressure* — the minimum supply pressure that must be maintained or exceeded for the equipment to operate correctly. Minimum pressure should be measured at the equipment point of connection. [SEMI E6]

5.2.2 *accuracy* — the closeness of agreement between an observed value and the true value; the total uncertainty of an observed value, including both precision and bias. [SEMI E56, SEMI E69]

5.2.3 *cell spacing* — the (equal) vertical or horizontal distance between the cell center points of contiguous cells. [SEMI T7, SEMI T8, SEMI T9, SEMI T14, SEMI T14.1]

5.2.4 *absolute pressure* — the pressure measured relative to zero pressure (perfect vacuum). [SEMI E28]

5.2.5 *flow velocity (V)* — the average speed at which an effluent stream travels through an exhaust ventilation duct. It is commonly expressed in meters per second (m/s). The US Customary unit is feet per minute (fpm). [SEMI S6]

5.2.6 *sheet resistance, R_s (Ω or Ω per square)* — of a semiconductor or thin metal film, the ratio of the potential gradient (electric field) parallel with the current to the product of the current density and thickness. This quantity is equal to the bulk resistivity divided by the thickness of the material, taken in the limit as the thickness approaches zero. [SEMI M59]

5.2.7 *atmosphere* — throughout this Document one atmosphere is defined as being equal to 1000 millibars (equal to 100 kPa), often referred to as a technical atmosphere. [SEMI MS10]

6 Key Parameters Guidelines

6.1 Key Parameters

6.1.1 This Guide focuses on five key parameters, they are Minimum Pressure, Pressure Rise Rate, Degree of Vacuum Accuracy, Cell Spacing, and Degree of Temperature Accuracy. Meanwhile, this Guide proposes that key parameters value should refer to in the low pressure diffusion process.

6.2 *Minimum Pressure* — Absolute pressure is less than 5,000 Pa.

6.2.1 In the semiconductor industry, the quantity of chemical gases can be controlled more accurately in vacuum environment, particularly where p - n junction depth or uniformity are critical. In low pressure horizontal diffusion technology, the reduced pressure provides higher gas flow velocity, this can create much better uniformity in wafer and in wafer to wafer. Considering diffusion technical requirement and the cost of equipment, this Guide suggests the Minimum Pressure is less than 5,000 Pa. § 7.1 Minimum Pressure describes the test method of Minimum Pressure.

6.3 *Pressure Rise Rate* — Less than 1,000 Pa per minute at 800°C.

6.3.1 In vacuum environment, excessive Pressure Rise Rate can pollute the clean reaction chamber, change the proportion of chemical gases and destroy the junction depth and uniformities of sheet resistance, thus wafers in reaction chamber are defective. Considering diffusion technical requirement and the cost of equipment, this Guide suggests the Pressure Rise Rate is less than 1,000 Pa per minute at 800°C. § 7.2 Pressure Rise Rate describes the test method of Pressure Rise Rate.

6.4 *Degree of Vacuum Accuracy* — Within ± 300 Pa.

6.4.1 Under univariate control conditions, different vacuum pressure can change the concentration of chemical gases, while the gas concentration affects the value of sheet resistance. Thus, the Degree of Vacuum Accuracy should be controlled. Considering diffusion technical requirement and the cost of equipment, this guide suggests the Degree of Vacuum Accuracy should be within ± 300 Pa.