

SEMI M42-0816 (Withdrawn 1021) SPECIFICATION FOR COMPOUND SEMICONDUCTOR EPITAXIAL WAFERS

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NOTICE: This Document was balloted and approved for withdrawal in 2021.

1 Purpose

1.1 Compound semiconductor epitaxial layers have been extensively used for many years as the basis of high speed electronics and optoelectronic devices. There are suppliers of epitaxial layers who will grow material to the customer's specification. There is a need to define standardized descriptive terms, tolerance schedules and recommended test methods to reduce ambiguity in the interpretation of specifications for such wafers. Special emphasis is placed on the definitions pertaining to uniformity. This Specification addresses only the basic requirements. Further clarification may be required between supplier and purchaser for the particular layers required.

2 Scope

2.1 This Specification covers the requirements for epitaxial layers of the generic composition $A_nB_mC_p...N_r$ grown on monocrystalline wafers of GaAs or InP (other substrates may be considered where appropriate documents exist to describe the specification of the substrate). This Document may only cover a portion of the properties considered to be part of the purchase specification.

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 Referenced Standards and Documents

3.1 SEMI Standards and Safety Guidelines

SEMI M1 — Specification for Polished Single Crystal Silicon Wafers

SEMI MF673 — Test Method for Measuring Resistivity of Semiconductor Wafers or Sheet Resistance of Semiconductor Films with a Noncontact Eddy Current Gauge

3.2 ASTM Standards¹

ASTM F76 — Standard Test Methods for Measuring Resistivity and Hall Coefficient and Determining Hall Mobility in Single-Crystal Semiconductors

4 Terminology

4.1 Definitions

4.1.1 *epitaxy* — the growth of a single crystal layer on a substrate of the same material, homoepitaxy; or on a substrate of different material with compatible crystal structure, heteroepitaxy.

4.1.2 *fixed quality area (FQA)* — (refer to Figure 1 of SEMI M1) the central area of the wafer surface, defined by a nominal edge exclusion, X, over which the specified values of a parameter apply.

4.1.3 *graded layer* — a layer whose properties vary smoothly in the direction perpendicular to the surface. The properties of a graded layer are specified in terms of the parameters at the top (last to grow surface) and bottom (first

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to grow surface) of the layer and unless otherwise specified, are expected to vary linearly between these two end values.

4.1.4 *mismatch* — the ratio, m_c , defined by the lattice constant of the epitaxial layer perpendicular to the surface, c , minus that of the substrate, a_o divided by the substrate lattice constant.

$$m_c = (c - a_o) / a_o \quad (1)$$

4.1.5 *mole fraction* — the normalized fraction of a particular element occupying the same lattice site in a compound. For example, in the compound $A_aB_bC_cD_d$, a , b , c and d are the mole fractions of the elements A, B, C and D respectively. If, in this example, A and B share the same lattice site, and C and D share the other lattice site, then by definition the sum of a and b , and the sum of c and d each must be 1.

5 Wafer Ordering Information

5.1 Purchase orders for epitaxial layers must include the following items:

5.1.1 The substrate (as described by the relevant SEMI Standard).

5.1.2 The epitaxy growth method.

5.1.3 The nominal edge exclusion used to define the fixed quality area (FQA).

5.1.4 The composition of each layer in terms of mole fraction(s) and a description of the test method used to measure it and/or calibrate the growth conditions of that layer. Note that in the case of a ternary compound, the purchaser may require that the specification for mismatch or bandgap energy take precedence over that for nominal composition. Similarly, in the case of a quaternary compound, a specification of mismatch and bandgap energy may be preferred. This is because the mismatch and bandgap energy, which depend on the composition, are often easier to measure than the composition directly.

5.1.5 The thickness of each layer and a description of the test method used to measure it and/or calibrate the growth conditions of that layer.

5.1.6 The dopant used for each layer.

5.1.7 The carrier concentration of each layer and a description of the test method used to measure it and/or calibrate the growth conditions of that layer. In the case of layers with significant interface or surface depletion, the carrier concentration refers to the value that would be observed in thicker layers, once the appropriate correction is applied for interface and surface depletion effects.

5.1.8 *Optional Criteria* — The following items may also be specified in addition to those listed above.

5.1.8.1 The mobility of each layer.

5.1.8.2 The sheet resistance of the epitaxial layers.

5.1.8.3 The mismatch for each layer. The test method must be described.

5.1.8.4 The bandgap energy for each layer. The test method must be described.

5.1.8.5 The sheet carrier concentration and mobility of the whole structure. This is relevant to those structures where the carriers are expected to redistribute to an adjacent material or interface.

5.1.8.6 The surface defect density.

5.1.8.7 The end values and thickness of each graded layer.

5.1.8.8 The surface roughness. The test method must be described.

5.1.8.9 The growth and test methods of a calibration structure along with a schedule for the growth of such a structure.

6 Tolerance Requirements

6.1 The tolerance requirements for the specified parameter, unless otherwise agreed to between the supplier and purchaser, are as in Table 1. Tolerance is defined as the allowed range of values permissible within the FQA and includes variations due to nonuniformity and deviation from the customer's target value. The measurement point