

SEMI China Compound Semiconductor Materials Std.

Technical Committee

Document Draft 4H-SiC Homoepitaxial Wafer Specification

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Ballot Result

SEMI Draft Document: 4H-SiC Homoepitaxial Wafer Specification 4H-SiC同质外延片标准

Total Voting Interests/Votes: 86/108	Voting Interest Accepts: 51(98.08%)	Voting Interest Rejects: 1
Voting Interest Results: 64	Return Percentage: 60.38%	Voting Interest Distribution: 106

Reject Comments

Reject: Barbieri, Tom

No.1

SiC epi is a highly customizable product/process in today's market. The standard is written toward a specific application (thickness, doping, etc.), which doesn't seem appropriate for a general 4H_SiC homoepitaxy spec.

● Response: **Disagree**

1. Although the epiwafer is customized product, but some general parameters are still needed to be defined for reference when discussing between the supplier and the purchaser, and other epi, such as Si epi, GaN epi, also have the standards.
2. In addition, this standard is a general standard for reference between the supplier and the purchaser. Special product requirements shall be agreed upon between the supplier and the purchaser.

Reject Comments

Reject: Barbieri, Tom

No.2

§5.2: The list for substrate ordering requirements is more exhaustive than M55-0921. Recommend alignment of this list with the list in M55. Specific items not included in M55-0921 ordering requirements are identification of test method to be used, TSD, TED, BPD, flat orientation, flat length.

- Response: Agree

1. The test methods for all substrate parameters (including TSD, TED, BPD, Flat orientation, and Flat Length) are defined in Table 12.
2. "Special requirements of ordering information shall be agreed upon between the supplier and the purchaser." would be added in section 5.1.

Reject Comments

Reject: Barbieri, Tom

No.3

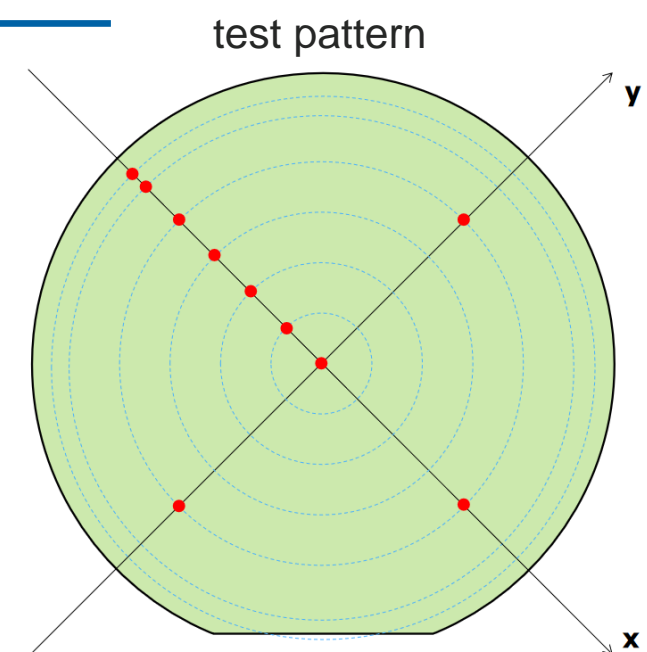
§6.4.3.1 & 6.4.4.1: The proposed pattern is not aligned with how most vendors are current performing the measurement. Requiring a pattern change for these vendors would require a significant adjustment to metrology, reporting, and specifications. This section should be struck, or a note should be added that this is a suggested measurement pattern for situations where no pre-existing pattern exists.

● Response: Agree

1. The test pattern in this standard is established by considering the following three points:

- ①. The wafer is rotated around the center of the wafer during the growth, so the distribution of thickness and doping is central symmetric.
- ②. To reduce the risk of wafer contamination caused by MCV measurements (contact-type test /Hg).
- ③. To avoid the influence caused by the primary flat.

2. Section 6.1 would be modified from "The specified parameters of epitaxial wafer shall conform to the requirements of §6.2 & §6.3 & §6.4, otherwise agreed upon between the supplier and the customer." to "The following specified parameters of the epitaxial wafer in §6.2 & §6.3 & §6.4 are recommended; final parameters and process shall be agreed upon between the supplier and the customer."



Reject Comments

Reject: Barbieri, Tom

No.4

Table 3: The table references SEMI MF1392 as the applicable technique. SEMI MF1392 only accounts for Hg CV as the measurement tool. As the industry is transitioning towards new non_Hg CV techniques, Table 3 should be modified to "SEMI MF1392 or equivalent".

● Response: Agree

The test method of carrier concentration is agreed to be modified to "SEMI MF1392 or equivalent." (see table3 and table12)

Reject Comments

Reject: Barbieri, Tom

No.5

Table 3: Permissible Average carrier concentration and tolerance does not fully represent the available range of the industry.

● Response: **Disagree**

1. The range of carrier concentration specified in this standard ($1 \times 10^{15} \text{ cm}^{-3} \sim 5 \times 10^{17} \text{ cm}^{-3}$) can cover the range used in current mass production.
2. Section 2.1 would be modified from "The specification specifies the parameters of 4H-SiC homoepitaxial wafers with a single epitaxial layer grown on an n-type substrate." to "This Specification specifies the parameters of 4H-SiC homoepitaxial wafers with a single epitaxial layer grown on an n-type substrate, up to and including 30um total thickness."

Reject Comments

Reject: Barbieri, Tom

No.6

Table 5: Table contents are too restrictive. The table does not specify which killer defects are to be counted. Three killer defect types are defined in Section 4 (Terminology); however this does not reflect the true breadth of killer defect types or killer defect classes used in the industry. In addition, the definition of defects is inconsistent from vendor to vendor. A standard must be defined for epitaxial killer defects, similar to Semi M81, before this table can be effective.

● Response: Agree

1. The definition of surface killer defect would be modified from "surface killer defects of 4H-SiC epitaxial wafers are including downfall, triangular defect and carrot defect" to "surface killer defects of 4H-SiC epitaxial wafers caused by epitaxial growth are including downfall and triangular defect".(see section 4.2.19)
2. The specification of surface killer defect would be modified from "Total usable area (%) $\geq 95\%$ " to "Total usable area (%) $\geq 90\%$ ".(see Table 5)
3. Section 6.1 would be modified from "The specified parameters of epitaxial wafer shall conform to the requirements of §6.2 & §6.3 & §6.4, otherwise agreed upon between the supplier and the customer" to "The following specified parameters of the epitaxial wafer in §6.2 & §6.3 & §6.4 are recommended; final parameters and process shall be agreed upon between the supplier and the customer."

Reject Comments

Reject: Barbieri, Tom

No.7

§6.4.10: Post_epi wafer shape is a function of epi thickness and conditions and should only be defined as to be loose enough to accommodate all thickness ranges. Have the writers of this draft considered all thicknesses, including 30 micron epi?

● Response: **Disagree**

1. The standard of wafer shape is established based on the requirements of devices fab. Wafer shape must meet the standard to ensure a smooth device fabrication process.
2. According to the current epitaxial results, the shape of 30 micron epitaxial wafer can also meet the standards.

Reject Comments

Reject: Barbieri, Tom

No.8

§5.4.13 & Table 11 & Table 12: SEMI M55 specifically excludes any reference to wafer bow due to IP considerations. Have the authors of this standard considered all potential IP conflicts prior to including wafer bow in this proposed standard?

● Response: **Disagree**

There is no IP conflicts for 4H-SiC epitaxial wafer.

Reject Comments

Reject: Barbieri, Tom

No.9

Table 12: Substrate items should be aligned with SEMI M55-0921. Surface orientation test method should be updated to “SEMI MF26 (Method A)”. MP Density should be updated to “Determine by a method agreed upon between the supplier and the purchaser”. TSD, TED, and BPD should be combined to “Etch Pit Density” with a test method of “SEMI M83 (etching procedure#5) and SEMI M81 (etch pit classification) or by a method agreed upon between the supplier and the purchaser”.

● Response: Agree

1. The test method of surface orientation is agree to be modified to "SEMI MF26(Method A)".
2. The test method of MP density would be modified to "Determine by a method agreed upon between the supplier and the purchaser."
3. TSD, TED, and BPD are agreed to be combined to "Dislocation Etch Pit Density"(see section 4.2.6、 5.2.14、 table12). The test method of these three defects are agreed to be modified to "KOH Etched Surface, SEMI M83 and SEMI M81 or by a method agreed upon between the suppliers and the purchaser."(see table12)

Accept Comments

Accept: Vargas-Bernal, Rafael

No.1

Some '.' are required, please to verify.

● Response: Agree

We would thoroughly check the punctuation issues in this standard and correct them (see section 2.2 & 5 & 6 which have been modified) .

Examples of the corrections:

5 Ordering Information

5.1 Purchase orders for 4H-SiC epitaxial wafers furnished to this specification shall include the following items from substrate, buffer layer and epitaxial layer. In addition, the purchase order must indicate the test method to be used in evaluating each of the specified items for which alternate test procedures exist. Special requirements of ordering information shall be agreed upon between the supplier and the purchaser.

5.2 Substrate

5.2.1 Substrate Vendor,

5.2.2 Crystal Polytype,

5.2.3 Conductivity Type,

5.2.4 Dopant,

5.2.5 Diameter,

5.2.6 Thickness,

5.2.7 Wafer Surface Orientation,

5.2.8 Resistivity,

5.2.9 Primary Flat Length,

5.2.10 Primary Flat Orientation,

5.2.11 Secondary Flat Length (or none),

5.2.12 Secondary Flat Orientation (or none),

5.2.13 MP density,

5.2.14 Dislocation etch pit density,

5.2.15 GBIR,

5.2.16 SBIR,

5.2.17 Warp, and

5.2.18 Bow.

5.3 Buffer layer

5.3.1 The conductivity type and dopant of buffer layer, and

5.3.2 The thickness and carrier concentration of buffer layer and a description of the test method used to measure it and/or calibrate the growth conditions of that layer.

Examples of the corrections:

6 Requirements

6.1 The following specified parameters of the epitaxial wafer in §6.2 & §6.3 & §6.4 are recommended; final parameters and process shall be agreed upon between the supplier and the customer.

6.2 Substrate

6.2.1 Polytype: 4H.

6.2.2 Conductivity type: n-type.

6.2.3 Dopant: Nitrogen.

6.2.4 Surface orientation: (0001) face 4.0° toward $\langle 11\bar{2}0 \rangle$.

6.2.5 Other specific technical parameters of substrates must meet the requirements of SEMI M55, or must meet the requirements of the specification agreed by the supplier and the customer.

6.3 Buffer layer

6.3.1 Conduction type: n-type.

6.3.2 Dopant: Nitrogen.

6.3.3 Thickness and carrier concentration

6.3.3.1 The thickness and carrier concentration of buffer layer should meet the requirements of Table 1.

Table 1 The specification of buffer layer

<i>Parameter</i>	<i>Target</i>	<i>Test Condition / Technique</i>	<i>Note</i>
Thickness	$\geq 0.5 \mu\text{m}$	Determine by a method agreed upon between the supplier and the customer.	#1
Carrier Concentration	$\geq 1 \times 10^{18} \text{ cm}^{-3}$		

#1: The target value of thickness and carrier concentration of buffer layer is determined by the agreement between the supplier and the customer.