

The meaning of coordinates in SEMI M1

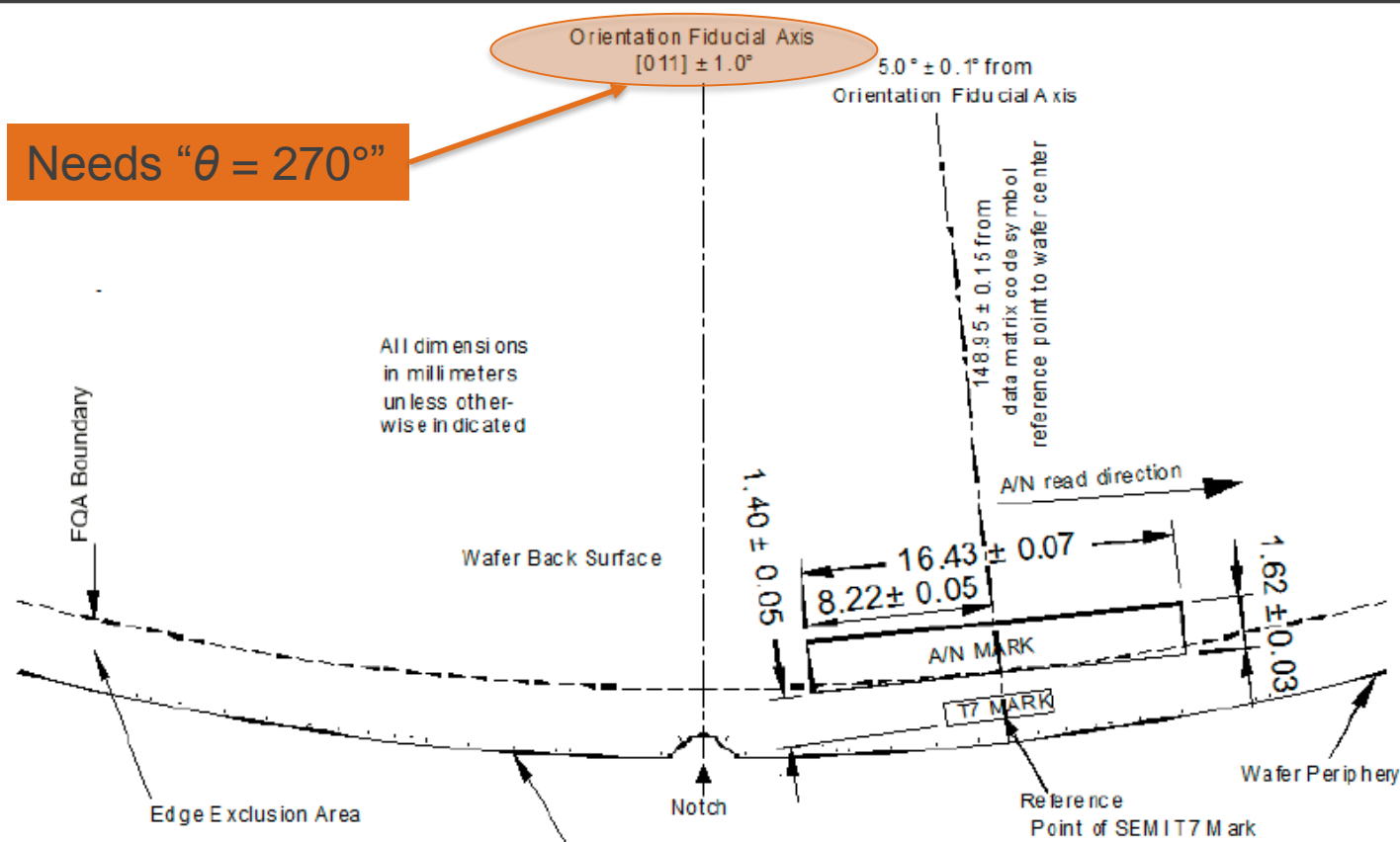
SEMICON Europa, John Valley, 2016 Oct 25



Purpose of this presentation

- SEMI M1 uses coordinates with tolerances to specify feature locations.
- When reading M1 in detail it became clear to me that the meaning of the tolerances is getting confused.
 - One tolerance is clearly specified.
 - Other tolerances appear to be less well thought out.

Figure 3 issue



- #1 A/N mark field dimensions are defined by the centers of the topmost and bottommost dot rows and the center of the leftmost and rightmost dot columns of the A/N characters. The field dimensions are more tightly controlled than those of a field constructed using SEMI M12. This results from the availability of laser marking capabilities not available when SEMI M12 was developed. In addition, the tolerance on the field dimensions is not cumulative.

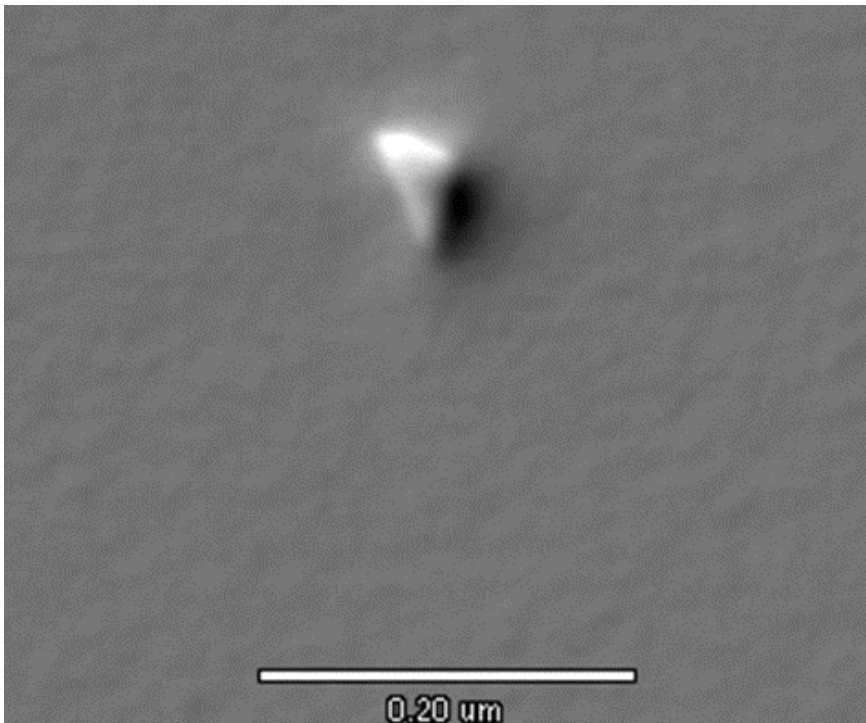
Figure 3
SEMI T7 Mark and Optional A/N Mark Locations on the Back Surface of Notched 300-mm Diameter Wafers (Category 1.15.1) with EE = 2.0 mm

Orientation fiducial axis meaning?

- The notch is the orientation fiducial used in Fig. 3 above
- The orientation fiducial axis is the negative y-axis.
- SEMI M20 further defines the orientation fiducial axis as:
 - Negative y-direction (M20: 6.1.4)
 - Bisector of primary fiducial (M20: 6.2.1)
 - Diameter that bisects the primary fiducial (M20: 7.1.5)
 - Primary fiducial is in negative y-direction (M20: 7.1.7)
- There is no tolerance between the bisector of the primary fiducial and the negative y-axis at $\theta = 270$ degrees.
- **There is a specified tolerance between the diameter that bisects the primary orientation fiducial and a specified crystalline axis.**
- Real-world wafer coordinates are determined by pre-aligners
- Wafer aligners will find:
 - The center of the wafer periphery to excellent precision
 - The bisector of the primary fiducial to good precision
- **Wafer aligners do not resolve the crystal axes.**

What does this mean?

- The crystal axis orientation to the fiducial has a tolerance.
 - After the fiducial is established we use it to establish coordinates.
- Therefore, the diameter that bisects the primary fiducial defines the angle $\theta = 270$ degrees, exactly, with no tolerance.
 - There are issues with $\theta = 270$ degrees precision.
 - There are issues with tool-to-tool matching of $\theta = 270$ degrees.
 - There are issues of cross-tool correlation of $\theta = 270$ degrees.



SEM review image
Defect coordinate is:
(123.316, -18.369)
Crystal axes directions???

Figure 4 issues

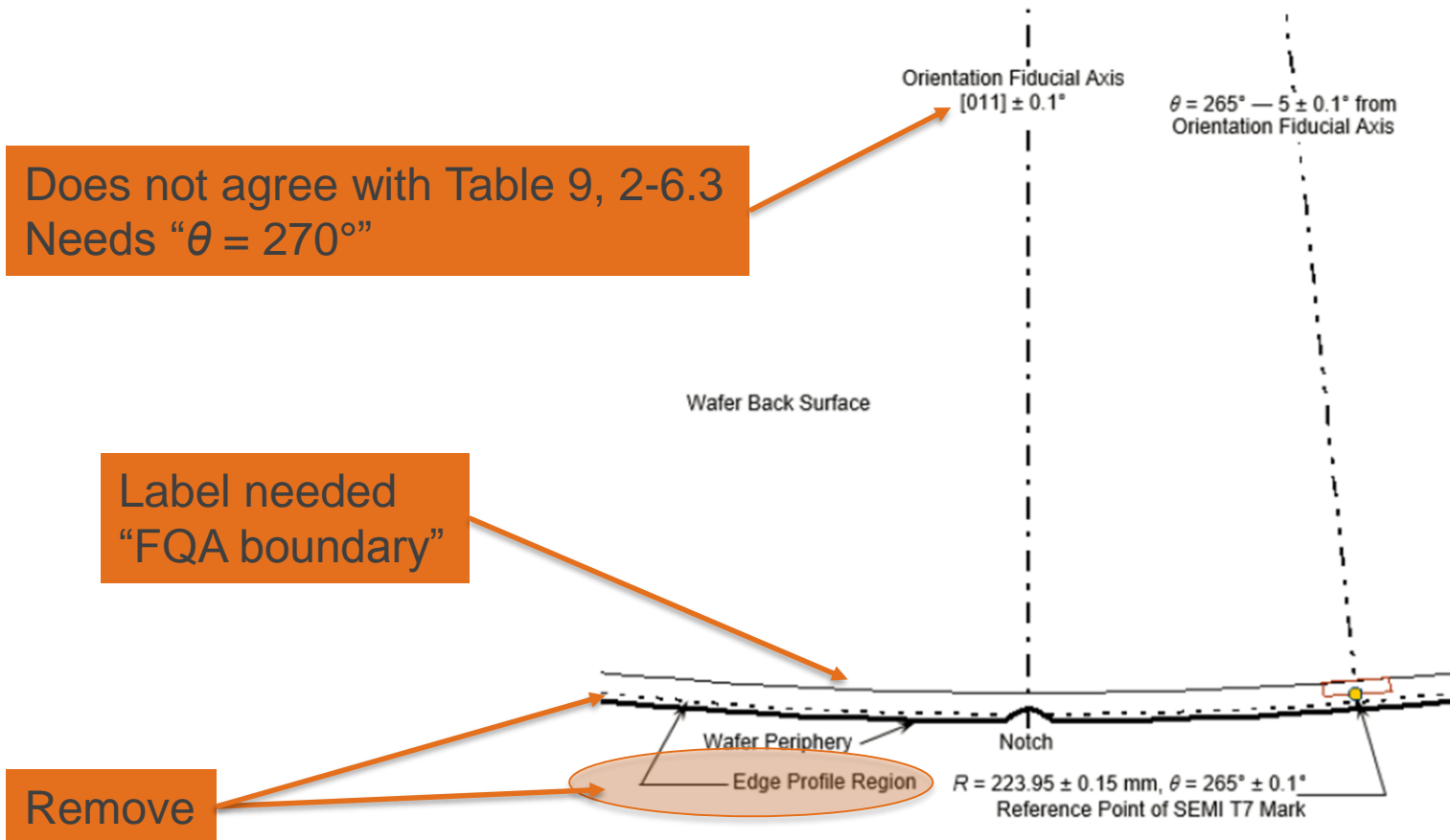


Figure 4
SEMI T7 Mark Location on the Back Surface of Notched 450-mm Diameter Wafers
(Categories 1.16.1 and 1.16.2) with EE = 2.0 mm

Table 9 concerning orientation of fiducial

Table 9 Specified Requirements for 450 mm Polished Single Crystal Silicon Wafers

<i>Property</i>		<i>450 mm Wafers^{#1, #2}</i>		
<i>Previous SEMI Reference:</i>		<i>None</i>		
<i>Wafer Category</i>		<i>1.16.1</i>	<i>1.16.2</i>	<i>1.16.3</i>
2-1.1	Growth Method	Supplier Option of Cz or MCz		
2-1.3	Conductivity Type	<i>p</i>		
2-1.4	Dopant	Boron		
2-1.6	FQA radius	223 mm		223.5 mm ^{#3}
2-1.8	Wafer Surface Orientation	$(100) \pm 0.5^\circ$		
2-5.1	Wafer ID Marking	SEMI T7		
2-5.7	Edge Surface Condition ^{#4}	Polished		
2-5.8	Back Surface Condition ^{#4}	Polished		
2-6.1	Diameter	450.00 ± 0.10 mm		
2-6.2	Notch Dimensions (see Figure 5)			No Notch
	Depth	1.00 mm + 0.25 mm - 0.00 mm		
	Angle	$90^\circ + 5^\circ - 1^\circ$		
2-6.3	Orientation of:			
	Notch Axis ^{#5}	$\langle 110 \rangle \pm 1^\circ$	$\langle 010 \rangle \pm 1^\circ$	
	Primary Orientation			$\langle 110 \rangle \pm 1^\circ$
	Fiducial Mark ^{#5}			

Figure 7 issues

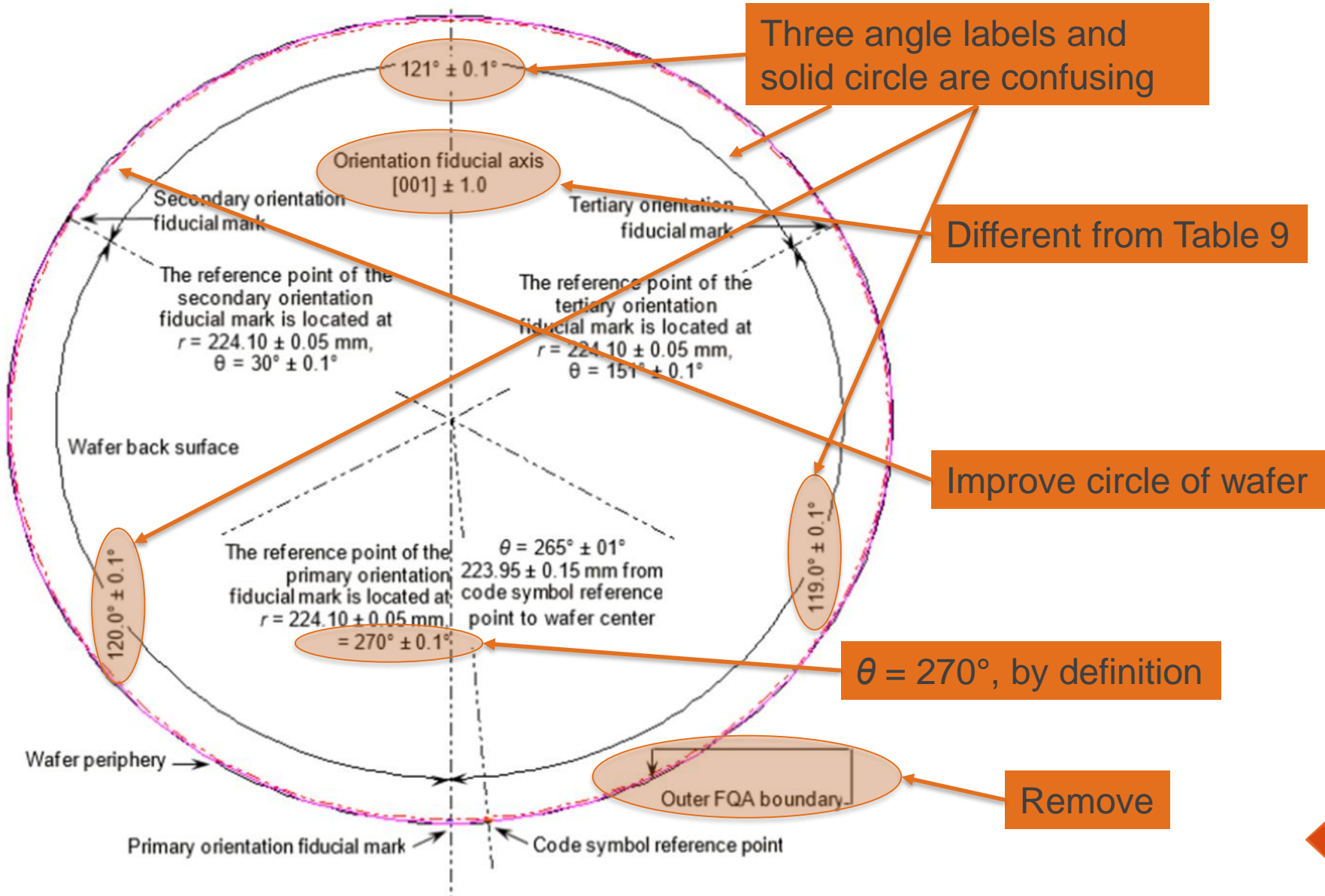
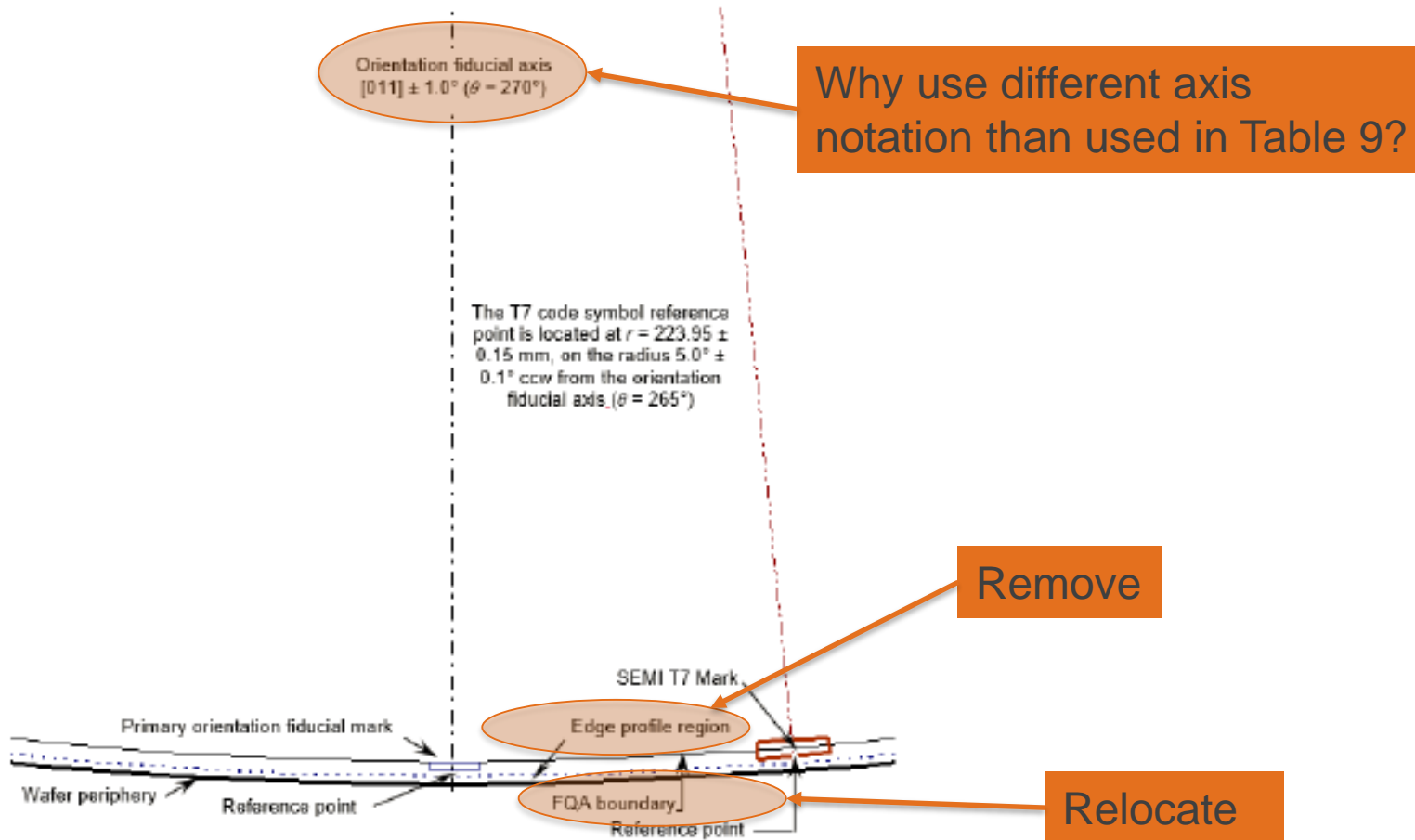
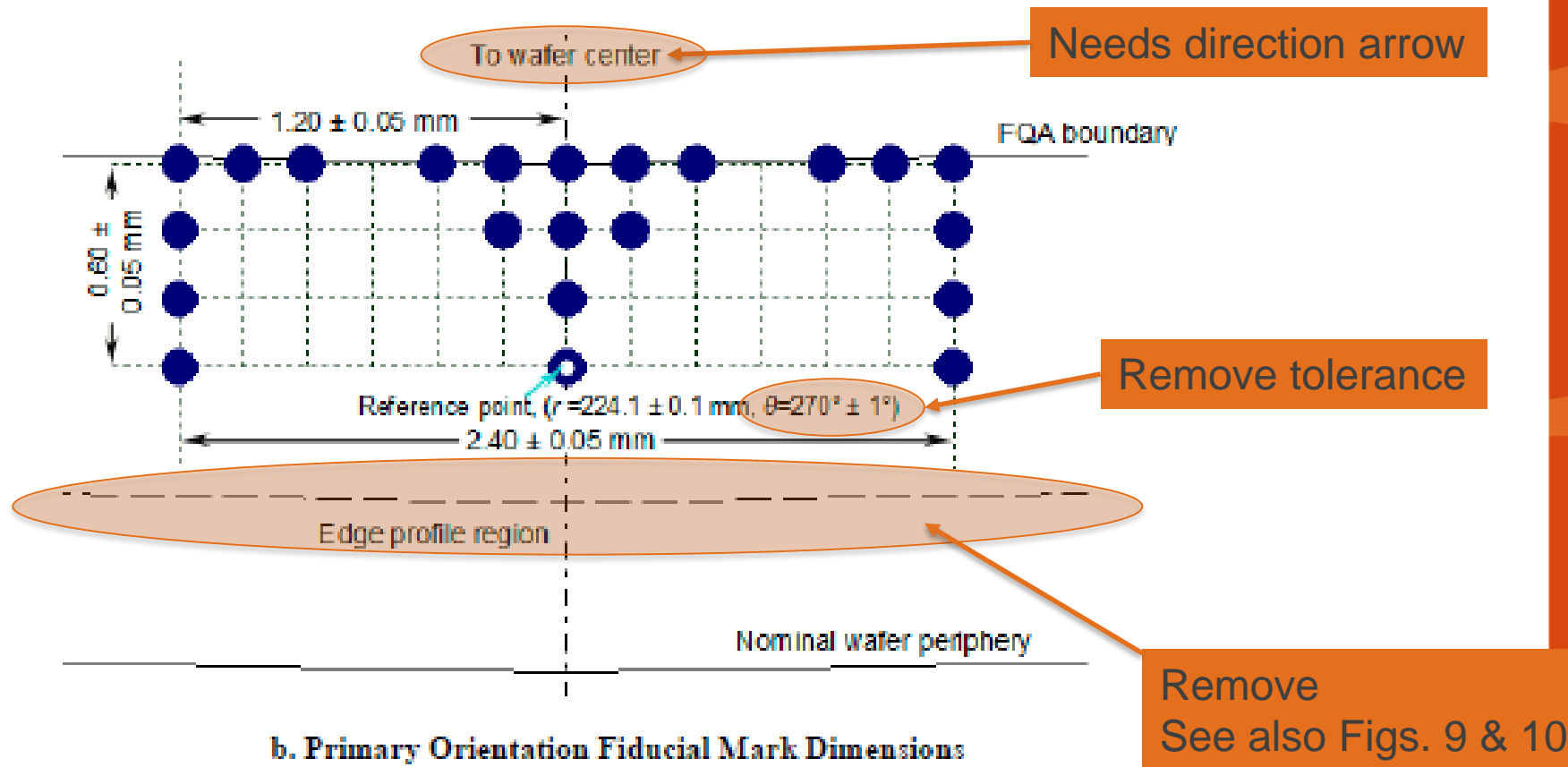


Figure 8a issues



a. Locations of Primary Orientation Fiducial Mark and SEMI T7 Identification Mark on 450 mm Notchless Wafers

Figure 8b issues



b. Primary Orientation Fiducial Mark Dimensions

Figure 8
Primary Orientation Fiducial Mark Viewed from the Back Surface

A little clean-up here.

6.7.1.4.1 The primary orientation fiducial mark is shown in Figure 8 together with the detailed location of the of the SEMI T7 identification mark. The reference point of the primary orientation fiducial mark is the center of the outermost dot located on the orientation fiducial axis. This is equivalent to $\theta = 270^\circ$ in the back surface wafer coordinate system of SEMI M20.

6.7.1.4.2 The secondary orientation fiducial mark is shown in Figure 9. The reference point of the secondary orientation fiducial mark is the outermost dot located $120.0^\circ \pm 0.1^\circ$ clockwise from the orientation fiducial axis when viewed from the back surface. This is equivalent to $\theta = 30^\circ$ in the back surface wafer coordinate system of SEMI M20.

6.7.1.4.3 The tertiary orientation fiducial mark is shown in Figure 10. The reference point of the tertiary orientation fiducial mark is the center of the outermost dot located $119.0^\circ \pm 0.1^\circ$ counterclockwise from the orientation fiducial axis when viewed from the back surface. This is equivalent to $\theta = 151^\circ$ in the back surface wafer coordinate system of SEMI M20.


$$\theta = 30^\circ \pm 0.1^\circ$$

$$\theta = 151^\circ \pm 0.1^\circ$$

Similar clean-up is required in the Figure 7 notes

Conclusion

- There is considerable work to do on the figures of M1 with regards to coordinates and
- The goal is to achieve self-consistency across text, tables and figures.
- Secondary goal is to achieve clarity between:
 - Crystal axis to primary fiducial tolerance.
 - M20 theta coordinate tolerances of wafer surface features.
- Tertiary goal is improve the figures for clarity of purpose.
 - Remove extraneous markings not required for the figure purpose.
 - Improve the circularity of wafer in Figure 7.



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