



HP experience with tin whisker inspection training

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Description of training



- 3 engineers and 3 technicians were trained
- Trainees were given a 1 hr discussion about tin whisker inspection with demonstration of optical inspection.
- JEDEC tin whisker test method was provided with the whisker definition highlighted.
- Each trainee performed inspection separately on 4 samples ranging from 54 to 104 leads each (expected inspection time was 4 hrs each).
 - High density of whiskers (matte Sn on A42, 2000 thermal cycles - 55C to +85C)
 - Moderate density of whiskers (matte Sn on A42, 500 thermal cycles 0C to 60C)
 - Low density of whiskers (matte Sn on C7025, 6 months at 60C/85%RH)
 - No whiskers (matte Sn on C7025, 1.5 yrs at office ambient)



Training materials (1 of 3)

- Training objective: At the end of this training exercise you should feel comfortable determining whether a whisker is present on a given lead, measuring the whisker length, finding the longest whiskers on a given part, and finding the leads with the most whiskers (or highest density of whiskers).
- Instructions: The training steps below will be performed individually. Please don't work together or compare results. Please return the attached inspection reports. The training will take approximately 4 hrs.

Training materials (2 of 3)

- Training steps:
 - Use the optical microscope to evaluate Parts A, B, C, and D. For part A and B, look at all leads. For parts C and D, look at leads 1 to 104 which are marked on the part.
 - Record each lead that has a whisker.
 - Measure the longest whiskers on each part. Take a picture of the whisker. (up to 6 measurements per part)
 - Count the total number of whiskers on the leads with the most whiskers. If there are more than 45 whiskers, stop counting. Classify density as Low (<10 whiskers), Medium (10-45 whiskers), or High (>45 whiskers), according to the attached table. Take a picture of the area. (up to 2 counts per part)
- Optimizing: To obtain the best results, adjust the following
 - the angle at which you view the part
 - the magnification (160x recommended for initial inspection. 300x for whisker determination)
 - the lighting
- Note: Do not touch the plating. Handle parts by touching the plastic body of the part, not the metal leads.

Training materials (3 of 3)

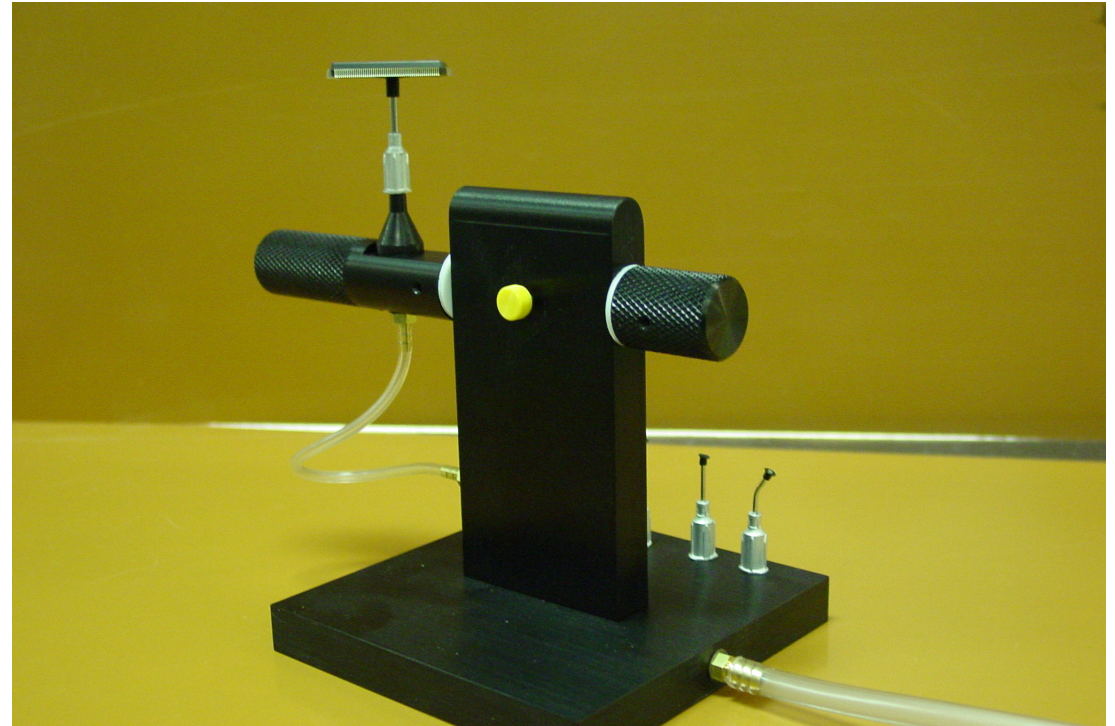


PART -- A -- Lead #	Are any whiskers present on this lead?	Does this lead have one of the 6 longest whiskers on this part? (up to 6 per part)	Length measurement for longest whiskers (up to 6 per part)	Does this lead have the most whiskers on this part? (up to 2 per part)	Number of whiskers on the high density parts (up to 2 per part)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Optical inspection system



- Optical microscope with up to 300x magnification
- Stage with 360 twist and 180 rotation. Placed on x and y travel stage. Component attached by vacuum.
- Digital acquisition of pictures. Digital measurement of lengths with calibration.



Results



Quantitative results of detailed inspection



	Inspector	Part A	Part B	Part C	Part D
Maximum whisker length	A	58	113	70	34
	B	86	116	100	0
	C	80	107	62	0
	D	79	96	97	26
	E		125	81	0
	F	128	146	64	35
	average	86.2	117.1667	79	15.83333
	std dev	25.65541	17.10458	16.51666	17.6229
Average maximum whisker length	A	39.3	92.5	50.0	29.3
	B	51.5	89.3	74.2	0.0
	C	56.8	69.3	40.3	0.0
	D	47.6	77.0	52.8	26.0
	E		97.3	83.7	0.0
	F	64.16667	85.83333	46.83333	29.83333
	average	51.88	85.22222	57.97222	14.18056
	std dev	9.368167	10.36322	17.01549	15.58885

With a pass/fail criterion of 40 microns for JEDEC, 9-25 microns of standard deviation can have a big impact.

Quantitative results of detailed inspection



	Inspector	Part A	Part B	Part C	Part D
Whisker density	A	Med	High	Low	Low
	B	High	High	High	No
	C	Low/High	High	Low	No
	D	Low/Med	High	Low	No
	E				
	F			Low	Low

A whisker density of medium cannot reliably be determined. See Part A for example. High and low density are easier to determine.



Location of maximum length whisker

The same lead was not typically identified by all operators as having the maximum length whisker. Different operators identified a different absolute maximum longest whisker and a different set of the six longest whiskers.

- Part A – 4 different leads – 4 operators
- Part B – 3 different leads - 5 operators
- Part C – 4 different leads – 5 operators

Few of the same whiskers were identified and measured



The same set of six longest whiskers was not typically identified (numbers for 5 operators). Out of three samples with whiskers, the same lead was identified

- by 3 or more operators 6 times
- by 2 operators 11 times.
- by 1 operator 36 times

This does not necessarily mean that a whisker wasn't observed by additional operators, since only the 6 longest whiskers were recorded.

Measurements of the same whisker by multiple operators

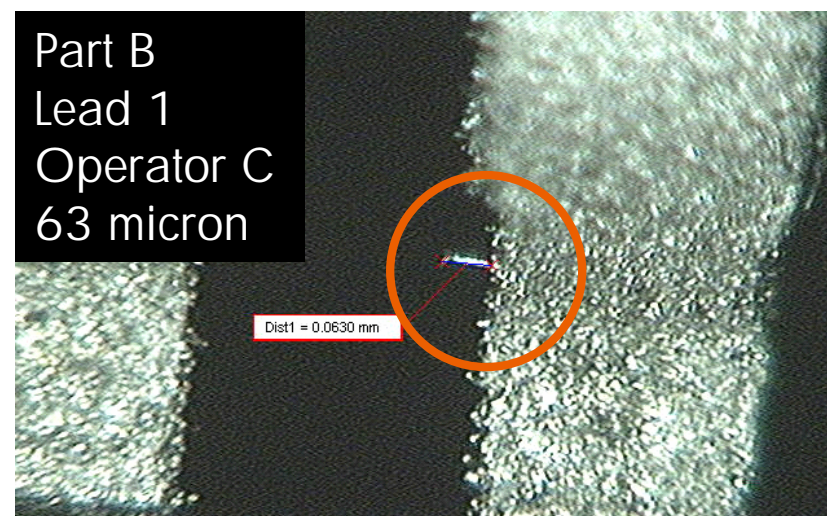
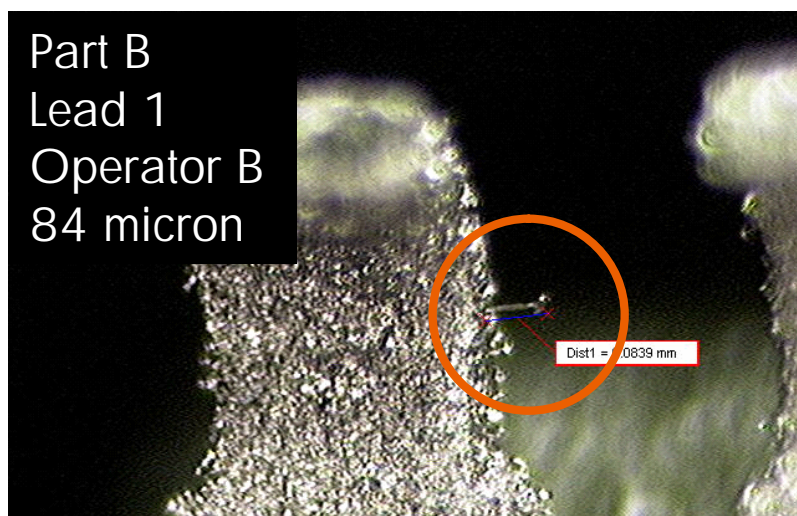


- When the different operators measured (ostensibly) the same whisker, the standard deviation was 7-48% of the length measured and 5-30 microns.
- With a pass/fail criterion of 40 microns for JEDEC and 25 or 50 microns for HP, this degree of measurement error can have a big impact.

Whisker	Number of measurements	Average length	Std dev	Std dev as a % of length
A-62	3	42	5	12
B-1	4	77	13	17
B-32	5	88	6	7
C-58	5	77	30	39
C-54	3	48	23	48
C-48	3	63	15	24

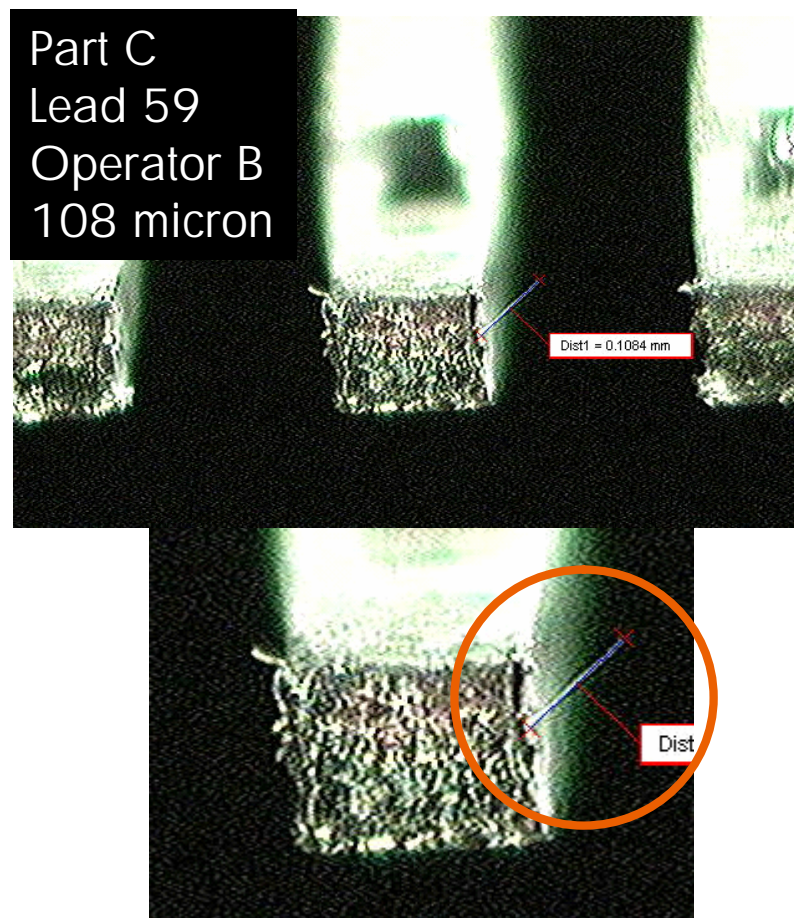
Example of the impact of measurement angle

- It's a nice idea to continue rotating until the maximum length is reached (as in the JEITA and JEDEC docs). However, current optical stages can't rotate on the point of focus, so a few inspection angles will be chosen to be practical. Rotation on the point of focus is possible in state of the art SEMs that use software combined with mechanical rotation.



Example of the impact of measurement angle

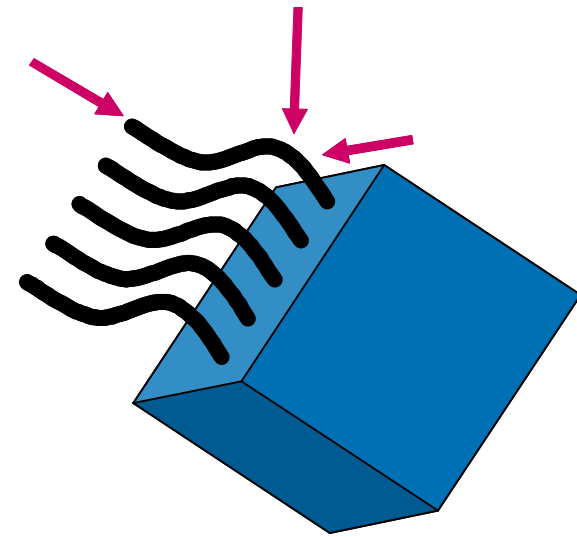
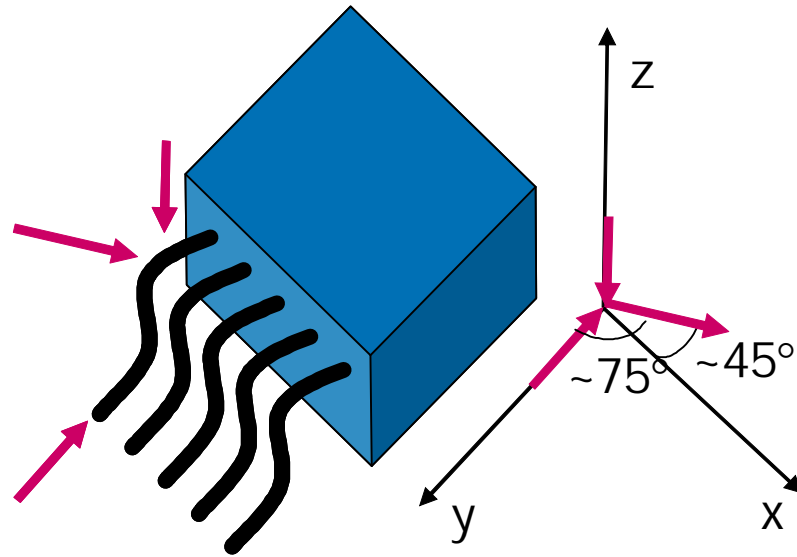
- Same whisker measured as 108 and 70 microns depending on rotation



Additional inspection guidance

- Additional guidance was not provided during training because it is not provided in JEDEC. However, the following were suggested for future training and inspection guidance
- Inspection angles:
 - Use three angles of inspection for a thorough inspection (detail on next slide)
 - Record angles of inspection
 - Record inspection angle for whisker measurement (especially for an experiment with multiple inspection of the same parts after exposure)
- Lighting – turn down or off microscope light. Use two fiber lights instead with at least one illuminating from below.

Preferred inspection angles



Three inspection angles were found to be most useful

- Looking top down in live bug (z axis in schematic)
- Looking straight on the edge of the part at the lead toes (y axis)
- Looking at the edges of leads, which requires about a 45 tilt between the x and z plane plus a little tipping towards y so that the front lead doesn't block the back leads

Other notes



- Exceptionally long whiskers were likely contamination, but could not always be ruled out as whiskers based on optical inspection.
- Short whiskers <25 microns, especially on densely whiskered parts could not be identified as whiskers

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Testing is very sensitive to the inspection -1

- This training exercise reinforces the subjectivity of inspection
- Inspection with poor lighting, inspection angles, operator training, equipment etc., can cause **false passes**
 - a single operator often misses a whisker, even a long whisker
 - Two operators can measure quite different lengths for the same whisker even with apparently reasonable inspection angles on the same equipment

Testing is very sensitive to the inspection - 2

- Even with SEM, whiskers aren't always properly identified. Misidentification can cause **false failures**
- Training showed that whiskers much longer (>50%) than the average length measured by other operators were likely contamination, but this couldn't always be proven by observation under an optical microscope

