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The Z-axial stability analysis by contactless method and solution of probe mark shift

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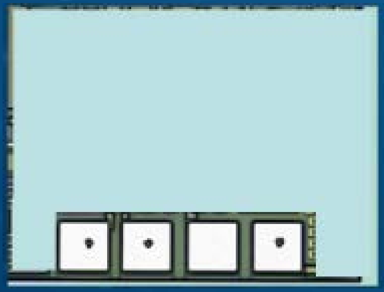
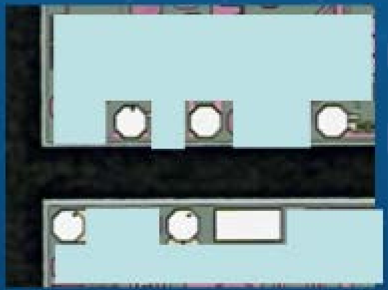
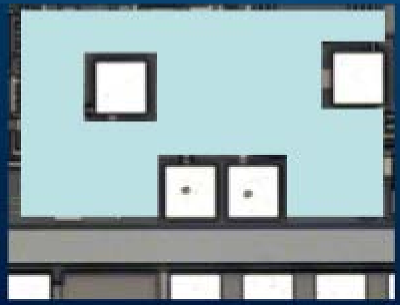
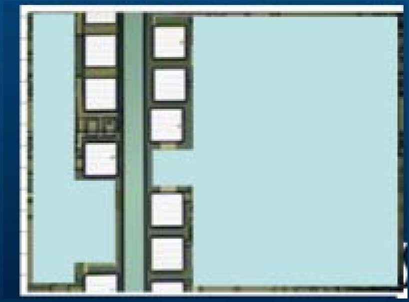
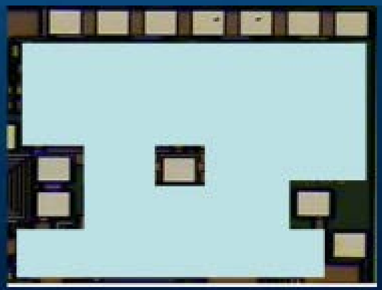
Presenters' Biography

- WIN Semiconductors Corp. founded in October 1999, was the first pure-play 6-inch GaAs foundry in the world, has established two advanced GaAs wafer fabs in recognition of the growing demand for low cost manufacturing of high speed and high quality GaAs MMIC's (monolithic microwave ICs) and RFIC's (radio frequency ICs).

- Chao-Wen Chiang, who has Master degree in mechanical engineering from Chang-Gung University , Taiwan, 2004. 2006 join the WIN semiconductor Corp. Major in DC testing and visual inspection to improve testing.

Introduction / Background

- We belong to the wafer testing division from WIN semiconductor foundry.
- Probe mark uncertainties of thin GaAs wafer are major problems that we met and result in wafer scrap.
- The following photos show the result between pass and NG.

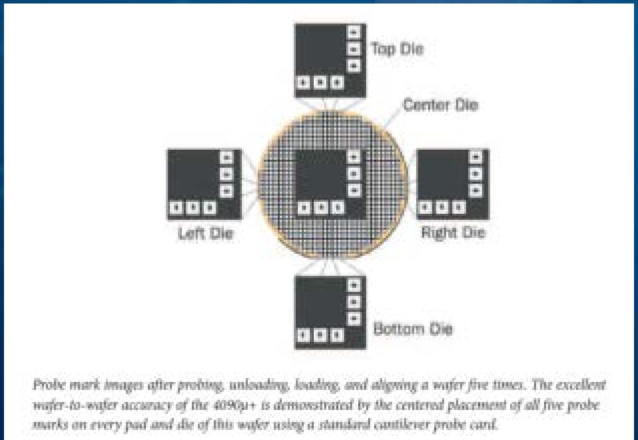
Pass	NG	
		
		

Objectives / Goals

- The stability of prober movement is an important impact on wafer probing quality.
- We would like to check Z-axis status of prober for this purpose of analysis.
- Improve the current inspection method and implement an easier one.
- It conducts a contactless , accuracy and time-reduce for prober checking and maintenance.

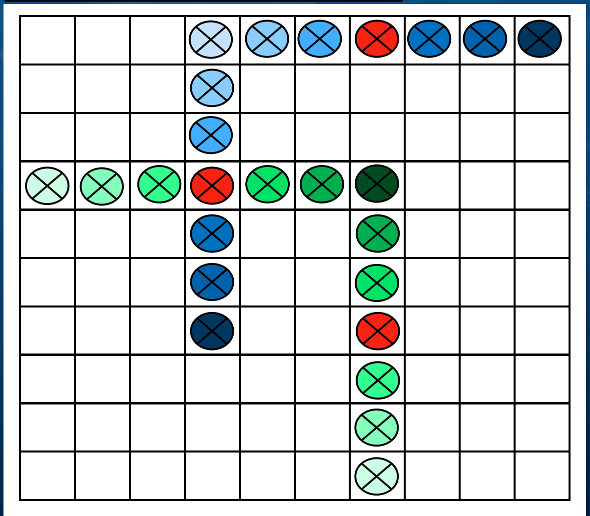
Review

- In 2014 SWTW presentation, we demonstrated how this wafer probe mark inspection system to analyze these probe mark failure modes (Linearity, Rotation, Orthogonality, and Offset) of prober and improved our wafer probing quality and prober utilization rate.
- The analysis purpose included two categories, one is to distinguish failure modes and the other is to do periodically quality check. According to analysis results, it can tell us the misalignment is from prober or operation.
- We implemented an AVI (Auto visual inspection) to the routine to minimize the human mistake and easier to analyze the failure modes .

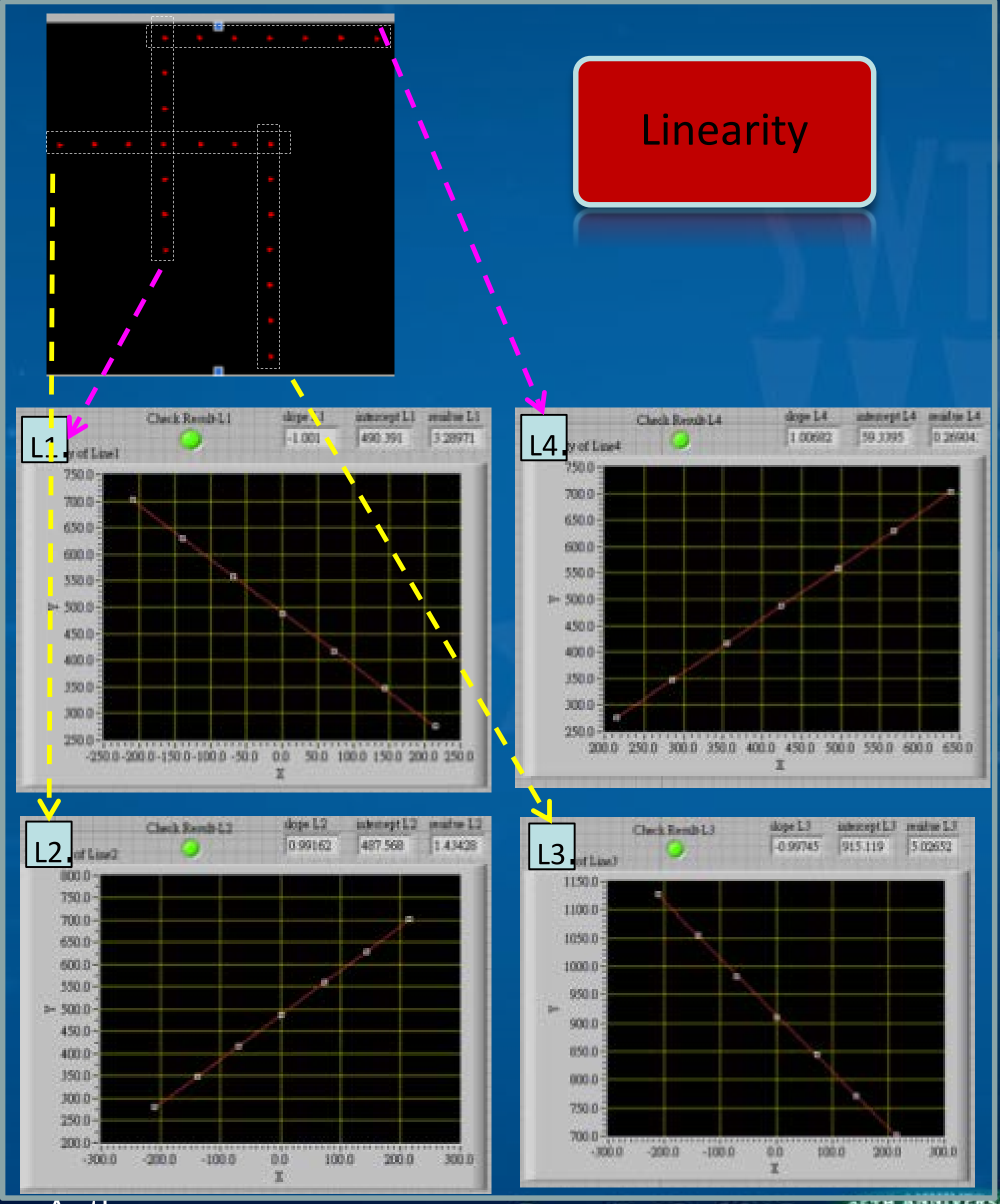


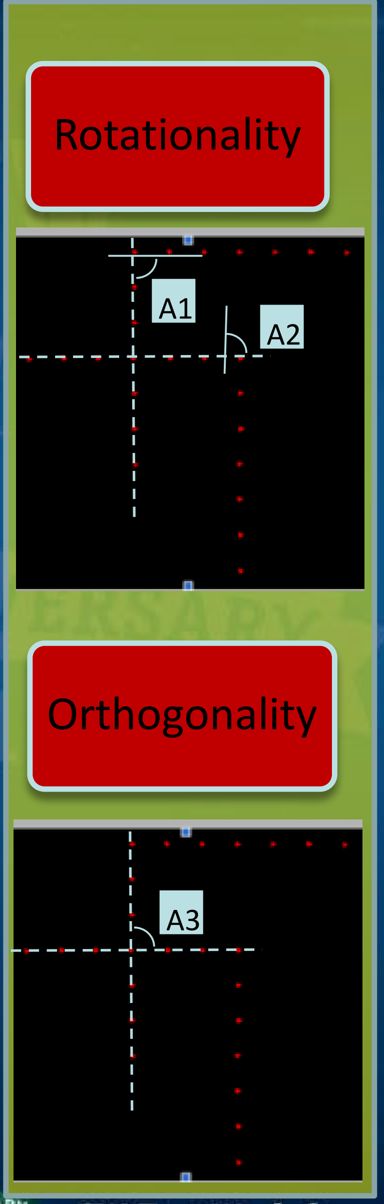
Probe mark images after probing, unloading, loading, and aligning a wafer five times. The excellent wafer-to-wafer accuracy of the 4090μ+ is demonstrated by the centered placement of all five probe marks on every pad and die of this wafer using a standard cantilever probe card.

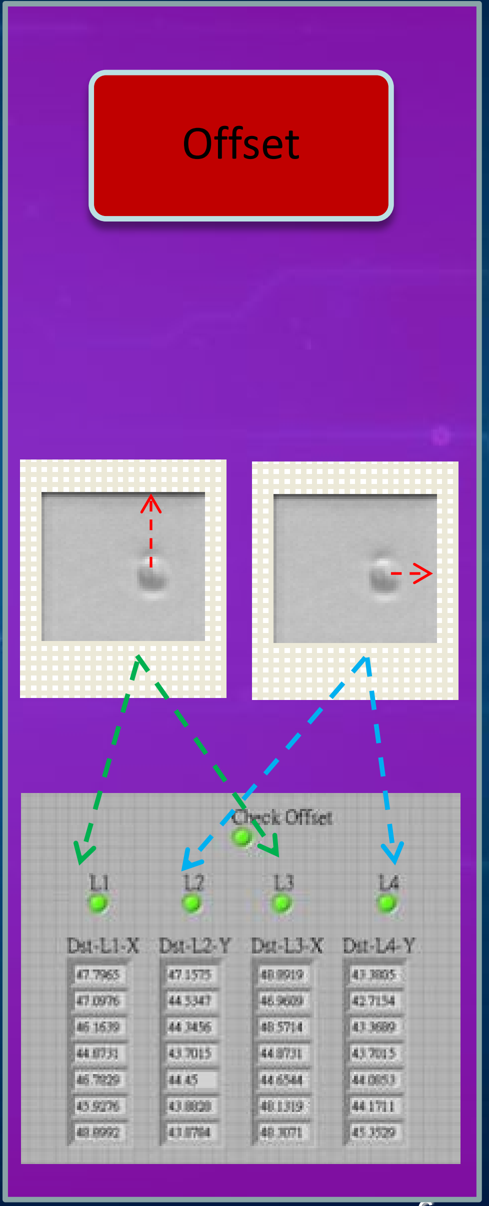
- Recursion Chart



Review (cont'd)







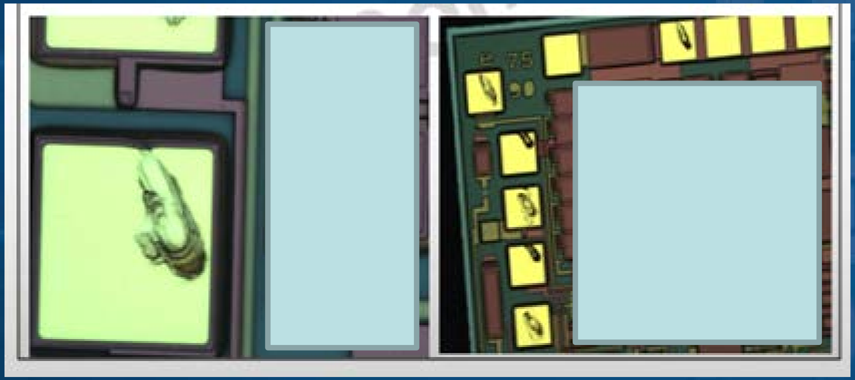
Review (cont'd)

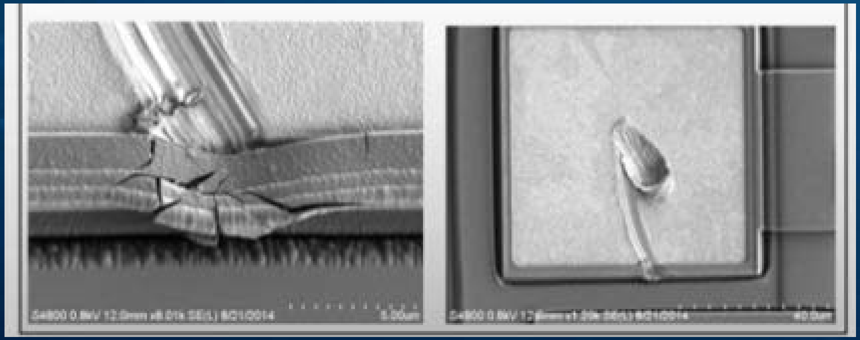
- The analysis purpose includes two categories, one is to distinguish failure modes and the other is to do periodically quality check. According to analysis results, it can tell us the misalignment is from prober or operation.
- Four parameters as below are extracted from recursion chart.
  1. Linearity : linear movement of X-axial and Y-axial.
  2. Rotationality : theta rotation of X-axial and Y-axial.
  3. Orthogonality : Orthogonal correlation of X-axial and Y-axial.
  4. Offset : probe mark position correctness over whole wafer.

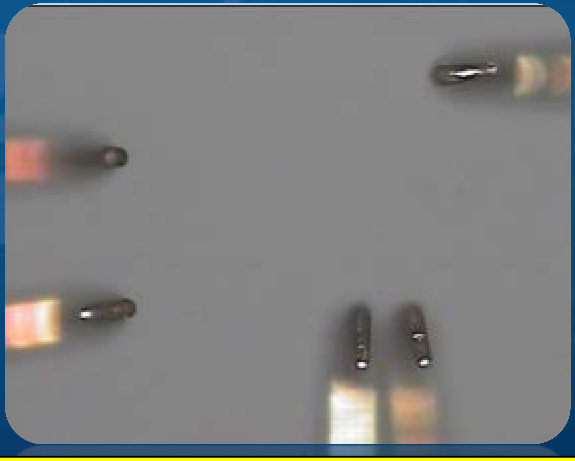
- **Focused on X and Y axis.**

Explanation

- Once the Z axis is unstable, the OD would be unexpected.
- Meanwhile, probe card and DUT would be damaged as well.







- Probe card damaged

Z axis stability analysis

- Besides X and Y axis, the Z-axis of prober is also important. Therefore, to accomplish this system, the stability checking of Z-axis is added.
- The checking method of X and Y axis is by visual inspection, but Z-axis will be detected by Eddy current, which is a contactless method and can measure the highness by the current variation.
- In the former, we use the dial gage to check the planarity of chuck, but the measured value is read by manual and includes some variation between different operators.

EG-Prober Z Axis Check Procedure

Z STAGE DEFLECTION AND CLEARANCE

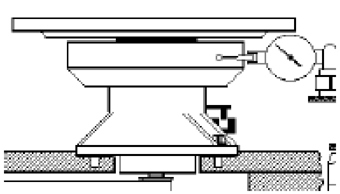
Housing Deflection Measurement

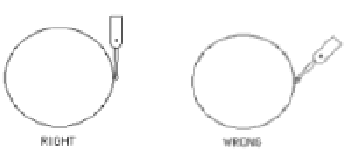
Perform this procedure when you suspect Z stage mounting gaskets are unevenly compressed and are causing stepping errors. The PM should be completed, and the Z stage mounted on the Forcer and ready for operation before doing this procedure.

This is a corrective maintenance procedure and is not part of the normal PM cycle.

Required tools:

1. 0.0001" per division Dial Indicator w/stand.
2. Chatillon Spring Force Gauge, 0-20lbs (P/N 719-20).
3. Matched set of Z Stage mounting .





1. Remove the Ring Carrier.
2. Raise the Chuck top to 400 mils.
3. Disable the air bearing.
4. Setup the Dial indicator and stand on the Platen adjacent to the Z stage.
5. Preload the Dial indicator, with 1-2 mils, against the side of the Z stage housing.
6. Apply 5lbs of downwardis pressure to the edge of the Chuck top in line with the Dial indicator probe. The maximum allowed probe deflection on the Dial indicator is 0.0003" (.3 mils).
7. Repeat step 6 at 45°, 90°, and 135° from the first point.
8. If deflection exceeds .3 mils at any point, then replace the Z stage mounting gaskets. Shim as required and planarize the Chuck.
9. Repeat steps 6 and 7.
10. If new gaskets and shims do not correct the problem, then repair or replace assemblies as needed.

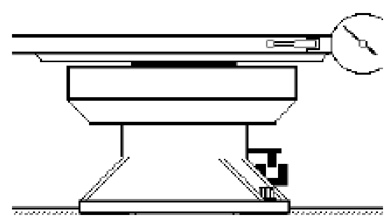
Stem to Bushing Clearance

This procedure is performed to determine the Z stage Stem to Bushing clearance. Factory tolerance is 0.0002"—0.0003" (.2—.3 mils) for a new Z stage/stem assembly. Field tolerance is .4 mils for assemblies in service. Excessive clearance can result in stepping errors and Z slips. Before performing this procedure, measure and correct housing deflection by following the Housing Deflection Measurement procedure.

This is a corrective maintenance procedure and is not part of the normal PM cycle.

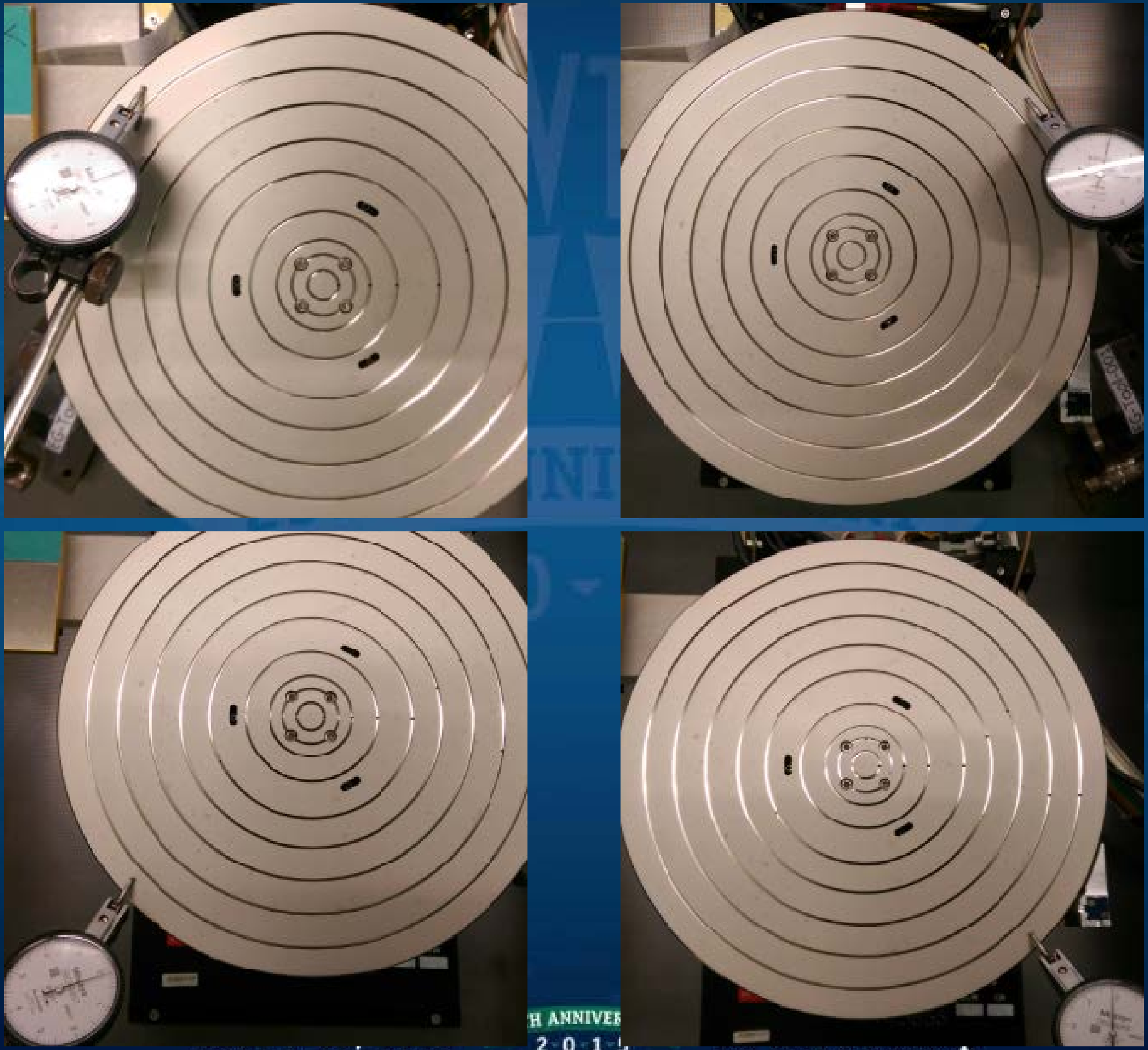
Required tools:

1. 0.0001" per division Dial Indicator w/stand.
2. Chatillon Spring Force Gauge, 0-20lbs (P/N 719-20)



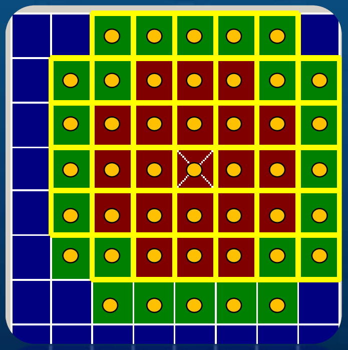
1. To measure side deflection, preload the Dial indicator probe with 1-2 mils on the side of the Chuck top over one of the three mounting gaskets.
2. Using the spring gauge, apply 5 lbs of downward pressure on the Chuck top at a point near the Dial indicator probe. Note the Dial reading.
3. Release spring pressure and let the Chuck top rebound. When the Dial indicator immediately recovers, and before it is stable, note the reading.
4. Subtract the reading in step 3 above from the reading obtained in step 2.
5. Using the spring gauge, apply 5 lbs of downward pressure at a point on the Chuck top opposite the Dial indicator probe.
6. Release spring pressure and let the Chuck top rebound. When the Dial indicator immediately recovers, and before it is stable, note the reading.
7. Subtract the reading in step 6 above from the reading obtained in step 5.
8. Sum the products from both readings to arrive at the stem to bushing clearance for that radian.
9. Repeat the entire procedure for points over the two remaining mounting gaskets.
10. The Maximum reading difference is the stem to bushing clearance for that Z stage.

Chuck-top Planarity Check and Adjustment (Spec. <0.5 mil)



Innovation

- **Improve the current method, we implement a new one, so-call Eddy current.**
- **Their comparison is shown as below.**

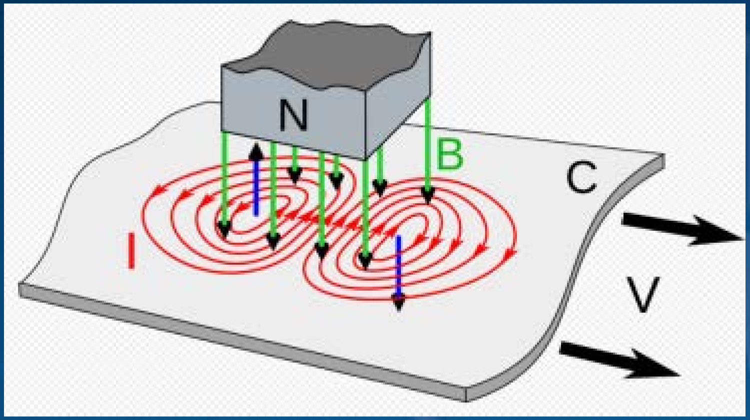
Category	Tool/measure	Comparison
Before	 	• Only 5 points. • Include human error.
Now	 	• At least 45 points. (Depend on measuring map) • Stabile measurement. • Reduce setup time.

Reference

Title	Editor	Description
An experimental comparison of multi-frequency and chirp excitations for eddy current testing on thin defects.	Betta, G; Ferrigno, L; Laracca, M; Burrascano, P ; Ricci, M ; Silipigni, G;	Non-destructive evaluation of materials and structures is still a key issue in some industrial scenarios as the production process and the quality inspection. In the case of metallic materials, economic and implementation reasons push for the use of eddy current testing techniques.
New contactless eddy current non-destructive methodology for electric conductivity measurement .	Bouchala, T; Abdelhadi, B; Benoudjit, A ;	In this paper, a new method of contactless electric conductivity measurement is developed. This method is essentially based on the association of the coupled electric field forward model, which we have recently developed, with a simple and efficient research algorithm.
Method for performing demarcate electric eddy current sensor surface displacement measurement, involves substituting formula which is composed in multi and simultaneous equations to obtain correcting curved surface math expression	GUO D; JIA Z, KANG R; LIU H, LIAN M; WANG Y; SHENG X; WANG F;	NOVELTY - The method involves recording different group distance by measuring radius of curvature. Electric eddy current sensor correcting curved surface is established by semi-spherical demarcate component position shift of different radius of curvature. Minimum second multiplication establishing correcting curved surface is used. Formula is substituted to obtain math expression and the formula is composed in multi-equations, simultaneous equations by obtained coefficient to obtain correcting curved surface math expression.

- **Most application of Eddy current is to inspect the object surface, instead of destructive inspection.**
- **The advantage is to keep the DUT original structure.**

Explanation

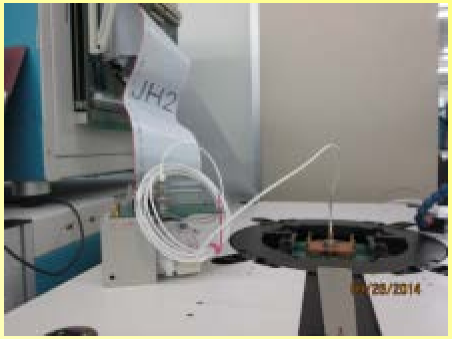


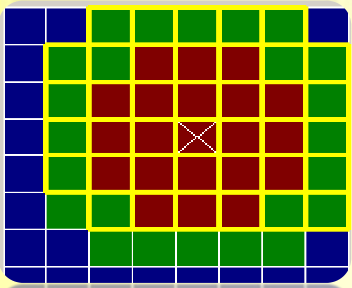
• Eddy currents *(I, red)* induced in a conductive metal plate *(C)* as it moves to right under a magnet *(N)*. The magnetic field *(B, green)* is directed down through the plate.
• From Lenz's law the increasing field at the leading edge of the magnet *(left)* induces a counterclockwise current, which creates its own magnetic field *(left blue arrow)* directed up, which opposes the magnet's field, producing a retarding force. Similarly, at the trailing edge of the magnet *(right)*, a clockwise current and downward counter-field is created *(right blue arrow)* also producing a retarding force.

*From Wikipedia

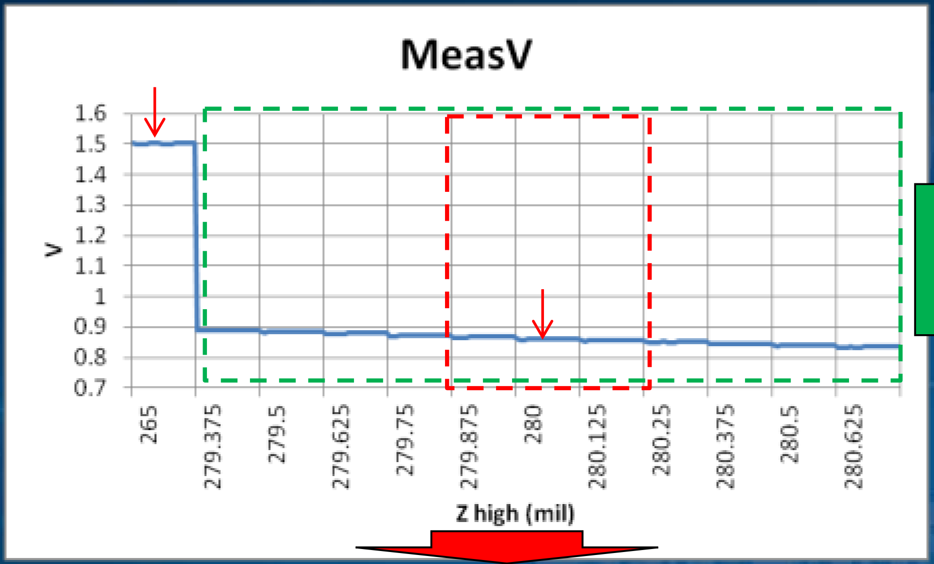
New Method

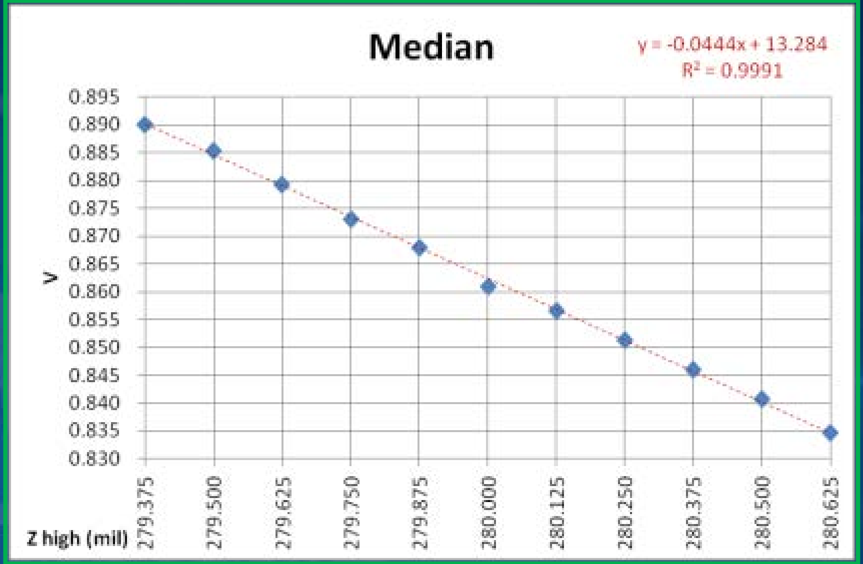
- To improve dial gage measurement, we implement a non-contact method, called Eddy current. The principle is that a conductor in a time-variable magnetic file, the magnetic flux will be changed while passing a conductor.
- Based on the Lenz's law, we can know the conductor will create an induced current against the change of magnetic flux, therefore, such an induced current is Eddy current.

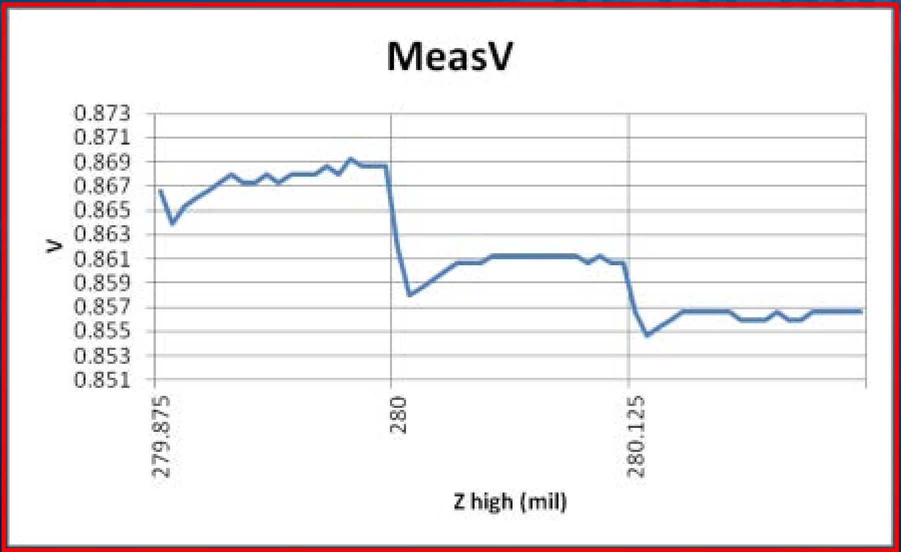




Verify Eddy current



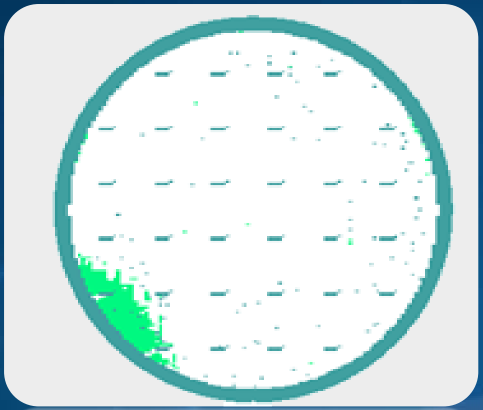




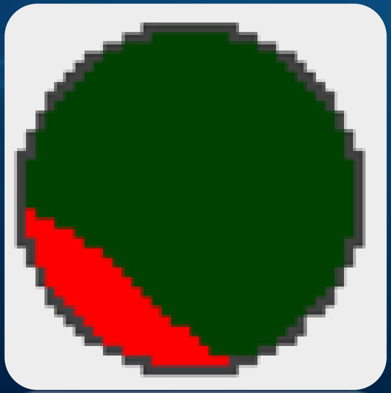
1. Z high is 265 (mil) when chuck is down.
2. Z high is 280 (mil) when chuck is up.
3. Focus on 280 ±0.625 (mil)
4. 0.125 mil (3.125um) express 5mV.

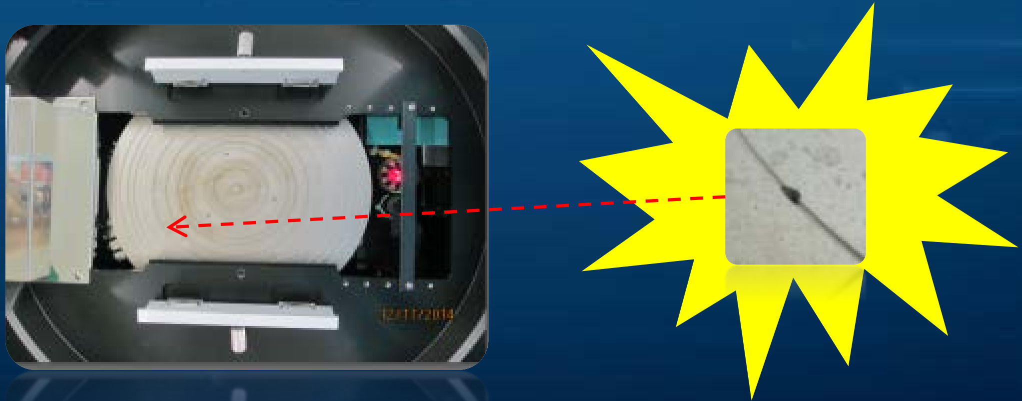
Case Study#1 - Particle exist

- Based on the automatic vision inspection result, some area at the left button are detected abnormally.



- We implement Eddy current to check, and discovery a similar pattern. Finally, we find there is a cracked chip on the chuck.



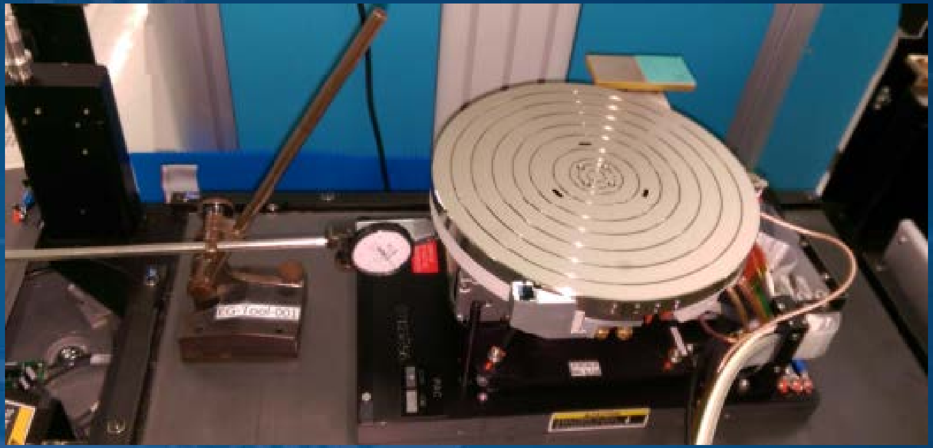


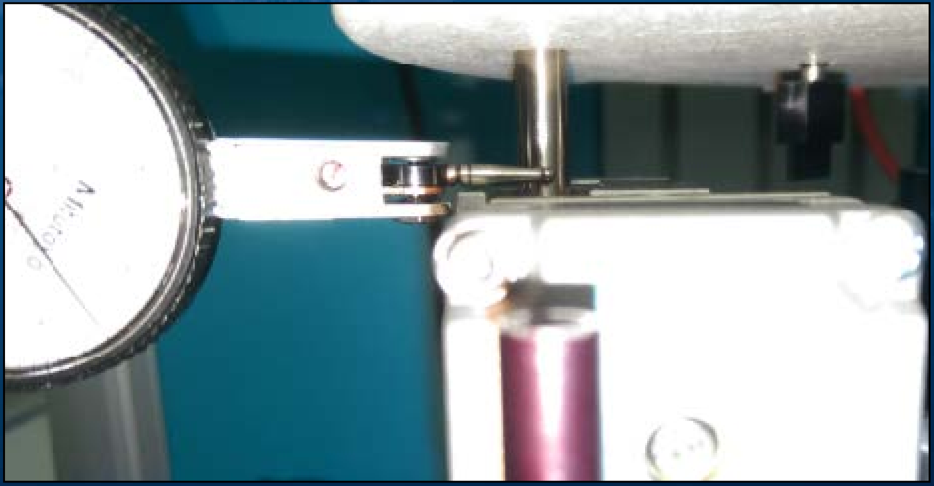
Case Study#2
Guide Pin Comparison

Bad Guide Pin

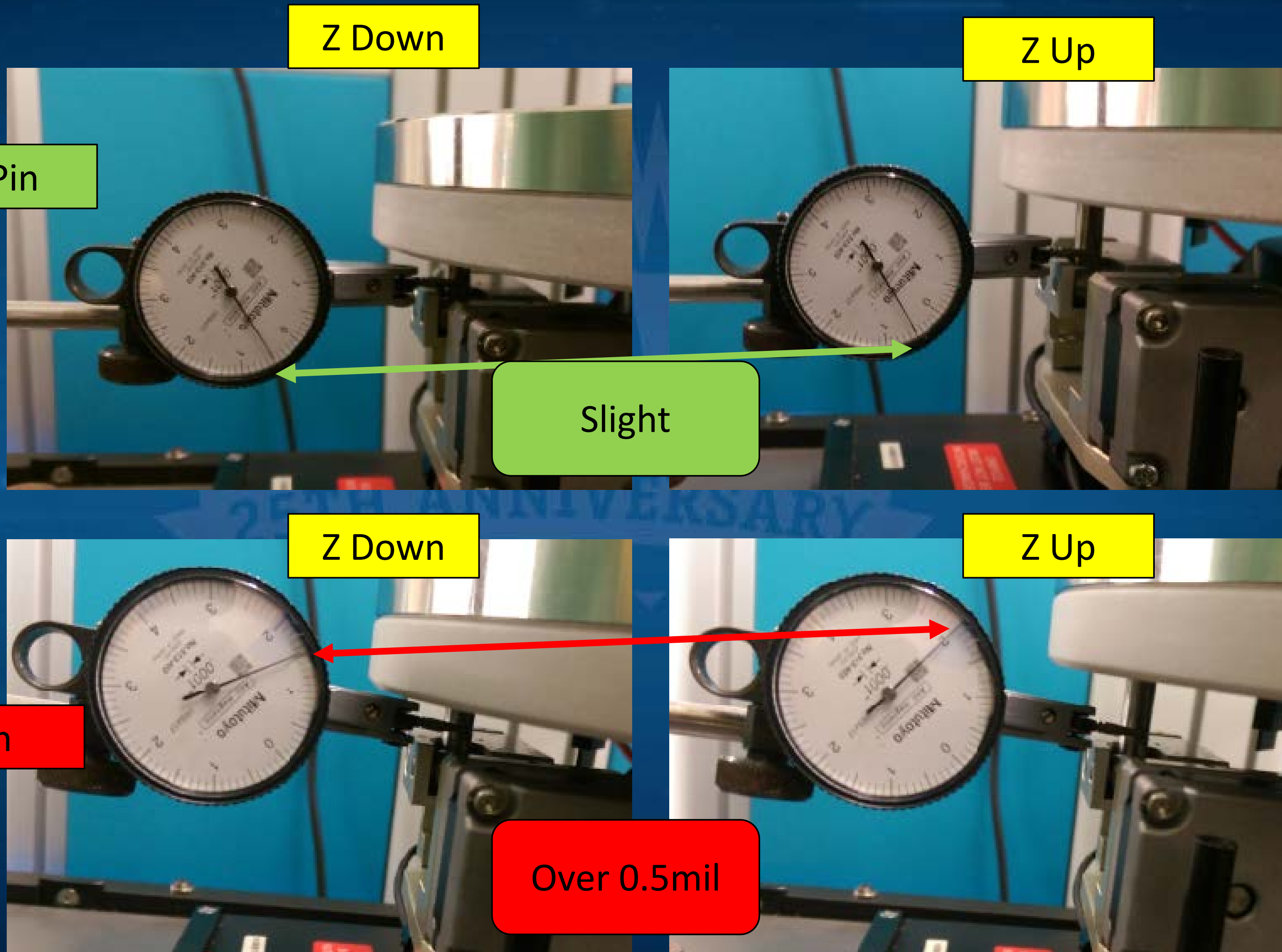
Good Guide Pin

Dial Indicator measure position



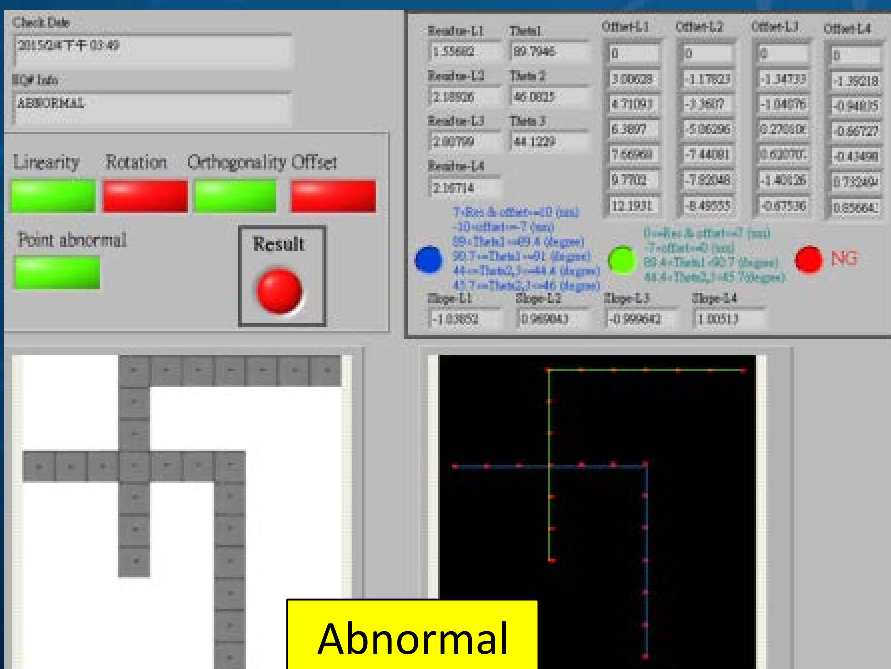


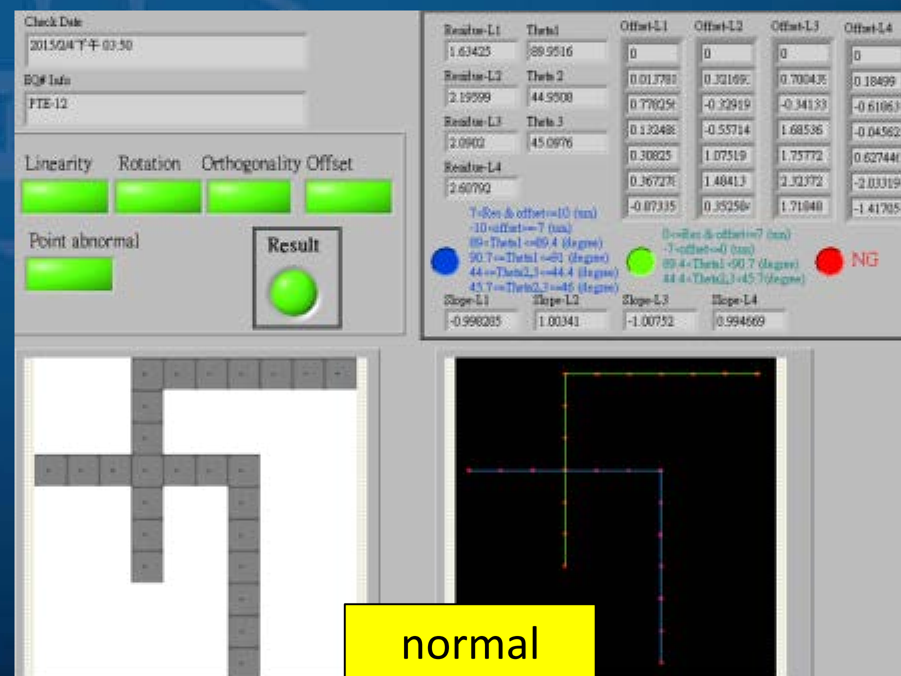
Guide Pin Comparison (cont’d)



Guide Pin Comparison (cont'd)

- Inspected by the recursion chart, we also can see that the result with abnormal guide pin is NG.
- Therefore, we can find X/Y axis would be affected once Z axis is malfunction.





Conclusion

- Through above method, we can quickly detect Z axis status, and check the recursion chart of X and Y axis, the prober performance can be monitored easily.

- After implementing the method to periodically check prober indexing, we get three major advantages,
  – Efficiency : Don't set up dial gage, just probe the golden wafer .
  – Accuracy : Measure the voltage, instead of dial gage.
  – Reliability/Repeatability: The result would be the same by different operators.