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TECHNICAL PAPER

OEE improvement by pogo pin defect detection in wafer probing process

Woonyoung Yeo[1] · Yung-Chia Chang[1] · Wayne Liu[1]

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Abstract

It is usually very difficult to find the causes of low yield performance in semiconductor manufacturing. In a typical wafer probing process, when the yield is low, engineers are required to examine both the equipment and the products to clarify if the low yield performance could be contributed by the testing conditions or the products. No matter which were the main cause, the time-consuming trouble-shooting process itself demanded resources thus the overall equipment effectiveness (OEE) is also damaged. This paper dealt with the trouble shooting data of wafer probing process. By examining the main factors that may affect the yield and equipment downtime in the wafer probing process, this study conducted various experiments to explore the relationship between yield and various wafer probing settings such as cleaning sheet size, probing overdrive, touch down time, and contact resistance. As a results, the optimal conditions of the main factors for improving yield and OEE are presented.

1 Introduction

Wafer level testing or wafer probing is a key inspection process in semiconductor manufacturing to test the characteristics and performance of semiconductor products after the wafer bumping process. Wafer level testing examines electrical characteristics through the connection and contact between the wafer, probe card, and the wafer level test facility. Figure 1 depicted a schematic of a vertical probe card.

Stable process control of wafer level testing directly affects the test yield. In addition, since the yield is generally directly proportional to the profit that can be obtained compared to that of the production cost, engineers are constantly monitoring the yield after each wafer-probing test. The yield of wafer probing test can be instantaneously affected by an accident in the production line, which is a problem that cannot be easily solved. Process engineers are trying to derive process optimum conditions according to the yield improvement activities.

Engineers are required to look for the causes of the problem when yield dropped. They usually need to run several analysis such as the correlation analysis between the measured value of equipment occurred in the first line and the yield, correlation analysis between the measured data and the yield measured from the instrument during the production process, and the commonality analysis that leads to the common problem equipment.

Based on our practical experience, probe and final test equipment (testers) represent a significant portion of the fixed cost of final test manufacturing operations in the semiconductor industry. It is important to maximize utilization for lower operating costs. In this case, maintenance is a key factor in increasing equipment utilization. This is because low maintenance and tester production leads to a more frequent machine down. However, more maintenance than necessary on the other hand will waste valuable engineering resources. It will also take a lot of money and time to deal with facilities/retest problems which engineers have to face when the semiconductor test yield is low. It often triggers a series of wafer holding and manual validation of engineers in these cases.

In the wafer level test, if low product yield is found, it may be resulted from one of the two types of defects. One

✉ Woonyoung Yeo
fsscfuture@naver.com

Yung-Chia Chang
jasmine.chang@g2.nctu.edu.tw

Wayne Liu
wayne04223@gmail.com

[1] Department of Industrial Engineering and Management, National Chiao Tung University, 1001 University Road, Hsinchu 300, Taiwan, ROC

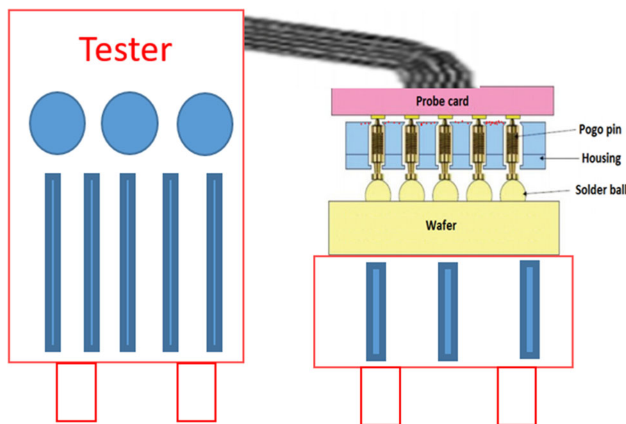

Fig. 1 Schematic of a vertical probe card

would be the intrinsic failure due to the product problems and the other one would be the non-intrinsic failure caused by the wafer level tester or the setup of test equipment. Analysis of the defects is a must when the product yield is found to be low to determine whether it is a real failure or not. If the low-yield problem is caused by the product, the product needed to be scrapped according to the defective phenomenon. However, to make sure whether it is in a non-intrinsic failure or not, the equipment set-up conditions need to be checked by equipment engineers after checking up the contact status of pogo pin including the probing overdrive, the cleaning status, the contact resistance, and more. After that, if the defective product is not a genuine defect, it needs to be re-tested again. No matter what caused the low-yield problem, whenever there is a need to perform failure analysis, the entire testing lot was hold until the situation is cleared.

The pogo pin socket, a consumable used for semiconductor test, has excellent electrical contact stability. However, in case of breakage or contamination due to long use, contact with semiconductor pins will become unstable, resulting in high contact resistance between the pins and the product. Increasing the contact resistance adversely affects the quality of inspection. When a fault caustic determination in which the good product is judged to be a defective one, it may decrease in the semiconductor yield. On the other hand, auto cleaning is required during the test process to reduce the contact resistance. The frequency of cleaning is an important factor to consider since cleaning disrupts the regular production even though it may prevent unwanted machine breakdown and also the long product hold periods. Moreover, the material to use for cleaning may also affect its effectiveness which in turns may affect the yield as well as the overall process efficiency of production.

Frequent false caustic determination caused frequent wafer probe test machine down which then decreased the equipment utilization thus impacted on the overall equipment effectiveness (OEE) performance. The OEE initiative is to be the most efficient and effective manufacturer in the market that minimize these major losses.

World-class OEE has a benchmark OEE rating of over 85% (Nagajima 1989). However, simply maintaining an 85% rating does not guarantee a world-class status. OEE is calculated by multiplying the measures of the availability, the performance and the quality. Each component of OEE must meet different levels of individual performance. Nagajima (1989) indicated that under ideal conditions of manufacturing, the equipment run time within the availability part must be over 0.9, the equipment out per unit time in the performance part must be over 0.95, and the total output in the quality part must be over 0.99. These numbers result in an OEE around 85%. For world-class firms, a value of 85% of OEE is considered to be a good benchmark for an emblematic manufacturing capability. OEE analysis and its value allows manufacturers to identify patterns and impacts of equipment problems and make improvements.

Fundamentally, when launching a new product, equipment investment occurs in the standard of the client company's demand in the product factory, in which the equipment investment has been reached conservatively based on the scale with the OEE level, universally set as 80 to 85%. As the equipment is costly, when making a wrong investing decision on the equipment, which means the investment cannot meet up with the customers' demand, there would be a high possibility of the left-over stock of the facilities to fall according to the suspension of the service. That is why the final decision of the equipment investment need to be approved by the executive manager. However, in the current process of mass production, due to frequent equipment breakdown as well as the repairment of them, the OEE level of the probe tests was below 50%, resulting in the loss of the invested equipment which was planned using the benchmarked OEE level of 80 to 85% based on the launch of preexisting products in contrast with the demand. The biggest problem under this situation is deserting customers. It is often found that customers continuously shop around for finding other rival companies' service due to the occurrence of delivery problems when their demand can't be matched as planned.

Moreover, due to the problems such as frequent equipment down and low yield of probe test, many of the work-in-process got held thus could not flow to the next process. The probe test process is the biggest bottleneck of the entire testing process which means the productivity in this step determining the entire process.

Two possible remedies could be implemented to increase the capacity of probe test: one is to invest on additional equipment; another is to pull up the OEE by

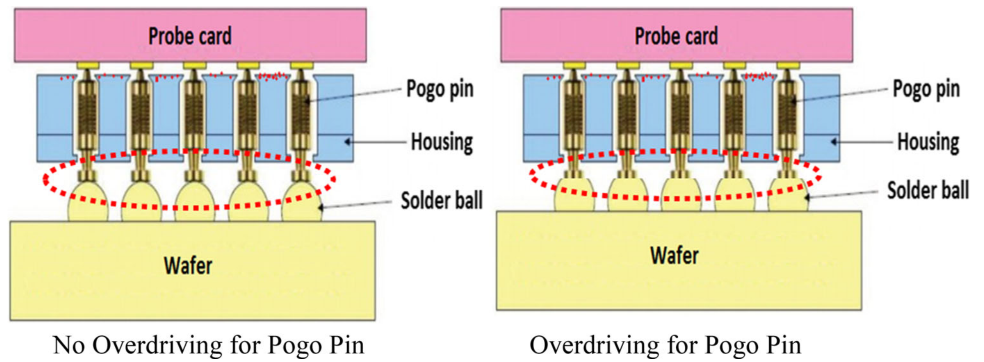

Fig. 2 Probing overdrive (OD) on wafer probe test

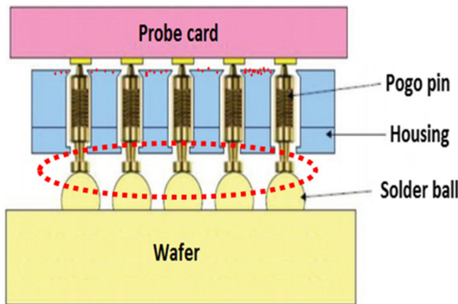

Fig. 3 Pogo pins in contact with the wafer

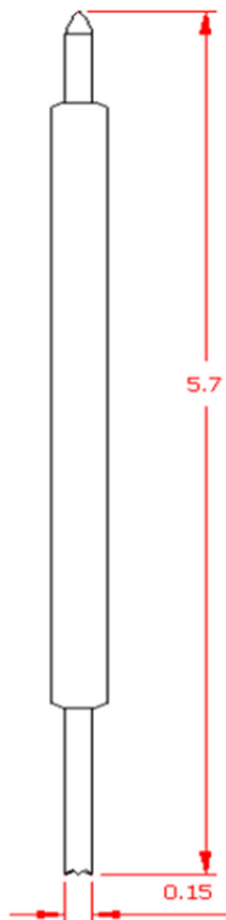

Fig. 4 The dimensions of pogo pin (model VS_JA_400_C_5.7) (in mm)

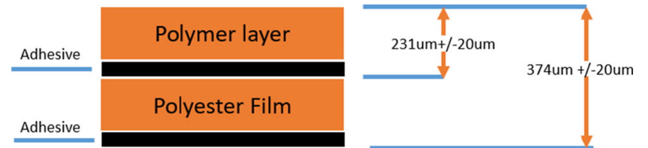

Fig. 5 Vertical structure for the cleaning sheet, Probe Polish PP99

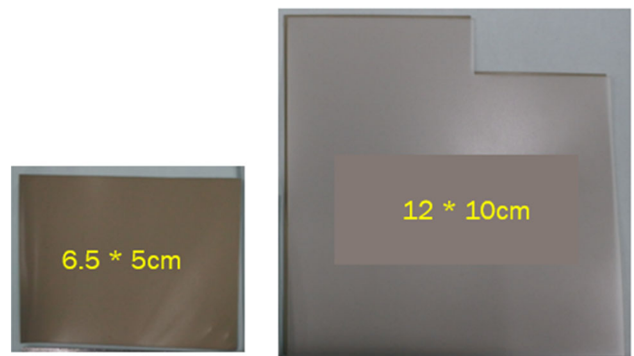

Fig. 6 Two sizes of cleaning sheets

identifying the equipment problem at the early stage so that the repairing time due to equipment breakdown could be minimized. Since the equipment is very expensive, in this study, we focus on the improvement of the process.

The study for improving the probe yield and OEE is constantly being continued. As the types of probing interface are various, the factors that influence the probe yield in the probe test process will be considerably many, therefore, a lot of research is needed in order to set the optimum level of process condition. As for the types of probing interface on Cu Pillars, the process condition needed for the probe yield improvement is well established. According to Chen et al. (2014) and Lee et al. (2015), the conditions that influence the probe yield are defined as optimized probing overdrive, probing touchdowns and probe polishes. However, in fact, other than conditions like optimized probing overdrive and probing touchdowns that influence probe yield, probe pin (i.e., material and type), probe polishes (i.e., material and type of clean sheet), and each process condition influence probe yield. De-Shin et al.

Table 1 Levels of independent variables

Clean sheet size	Clean sheet change (hours)	Probing overdrive (μm)	Touchdown times
Big, Small	24, 48, 72	50, 100, 150, 200, 250	30, 60, 90, 120, 150, 180

(2008) investigated that the BeCu material pins are more suitable when probe hardness requirement is less strict and lower and more stable resistance was obtained, by using the thermo-mechanical properties of the three different types of probe pin. Moreover, Broz et al. (2000) established the probe cleaning time per production period time using Electrohydrodynamic (EHD).

That being said, in this study also focuses on the improvement of the probing test process. Taking in current mass-production condition based on practical experience as a condition, from the process variance that can influence the probe yield, the variance that can give the biggest influence is chosen, and with more than 900 wafer probe test yield data experiments per variance, the condition of the optimum production process is found. To avoid errors that can come from a short period of time or from a small sample size, the population data is increased to lessen the examination error of the process variance. Therefore, production optimum condition is proposed with more than 9000 wafer probe data that was collected for 7 months.

In this study, an existing mass production process on wafer probing was examined to identify the main factors that may affect the yield and equipment downtime in the wafer probe test process. In order not to interrupt the mass production process, data to be analyzed was extracted from trouble shooting data and yield analysis data. By identifying their relationship, we could suggest the best condition to stable the process to operate thus may in turns improving the OEE. The rest of paper is organized as follows. Section 2 reviewed the related literature, Sect. 3 described the experiments, Sect. 4 provided data analysis and Sect. 5 concluded this paper.

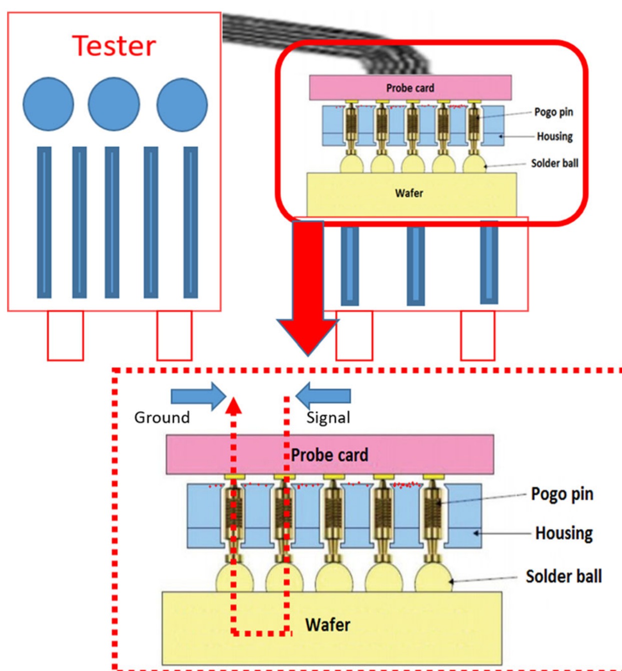

Fig. 7 Measurement of contact resistance between pogo pin and wafer solder ball top

2 Experiment

In order to examine the relationships between the wafer probing conditions and yield, a series experiments were conducted in this session. Pogo pin is mainly used as a type of electrical connector mechanism between tester and wafer. Once a semiconductor product was made, it needs to be checked whether it was built correctly. As shown in Fig. 3. The golden pins mounted on the probe card connected to the wafer probe tester are pogo pins, which are in contact with the wafer to measure the periodic characteristics to distinguish between a good or a bad product. Figure 2 shows the probing overdrive (OD) with the existing depth and the changed depth (Fig. 3).

In this paper, the experiment was conducted using the VS_JA_400_C_5.7 model pogo pin, from the Japan Electronic Materials Corporation (America Corp). As shown in Fig. 4, the length and width of each pogo pin is 5.7 mm and 0.15 mm, respectively. The initial spring force of each pogo pin is 14 gf. The material of the pogo pin is beryllium copper (BeCu) with Au plated for plunger, phosphor bronze with Au plated for barrel, and the spring is music wire with Au plated.

The cleaning sheet is designed to remove embedded and bonded debris from probe tips and pogo pin and collect any loose debris that was generated during probing. The cleaning sheet used in this experiment is Probe Polish PP99, whose vertical structure is shown in Fig. 5. It refers to a polymer of high molecular weight (m), which is composed of a number of monomers having low molecular weight connected by covalent bonds. Usually, different molecules of the same compound may have different molecular weight due to different isotopes contained.

There are two types of prob cleaning sheet used in this experiment in terms of their sizes, which are 12 cm by 10 cm and 6.5 cm by 5 cm, as shown in Fig. 6, respectively. This is because in the current production, there are

Table 2 Correlation between wafer probe yield and the contact resistance under different voltages

	Resistance under 4.5 V (RS1S2_4.5 V)	Resistance under 3.8 V (RS1S2_3.8 V)	Resistance under 2.5 V (RS1S2_2.5 V)
Correlation	− 0.655	− 0.394	− 0.178

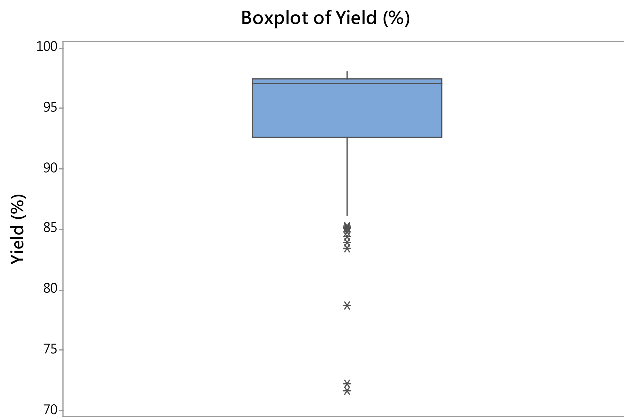

Fig. 8 Box plot of wafer probe yield

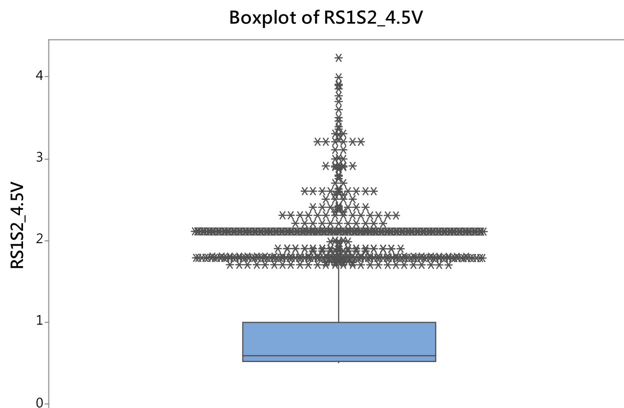

Fig. 9 Box plot of RSIS2_4.5 V

Table 3 Statistics for outliers analysis

Statistics	Wafer probe yield	RS1S2_4.5 V
Sample Size_before revised	8698	
Correlation_before revised	− 0.655	
Q1	92.56	0.52
Q2	97.01	0.58
Q3	97.39	0.99
IQR	4.83	0.47
Lower Outlier	85.315	
Upper Outlier		1.695
Sample Size_after revised	8230	
Correlation_after revised	− 0.726	

two types of cleaning sheet holder: one type is 12 cm by 10 cm and the other is 6.5 by 5 cm.

Periodically cleaning of probe tip in contact with the probe card in-line during regular wafer probing is a common practice. The cleaning frequency is usually determined by the number of times of contact (touchdown) between the probe tip and the probe card. The number of cleanings currently applied in mass production may vary between the types of mass production and mass production facilities. A rule of thumb setting is to clean every 150 touchdowns. Furthermore, the replacement of a cleaning sheet requires no downtime. The normal replacement period is suggested as 3 days for a normal production process.

In order to explore the relationship between probe test yield (the dependent variable) and the variables that might affect it, different experiments were conducted under different settings of cleaning sheet size, probing overdrive, touchdown times, and the time to change cleaning sheet, which are the defined as the independent variables. The purpose is to find the appropriate settings on the independent variables so that the wafer probe test yield could be optimized. When the wafer probe test yield is improved, OEE could be improved as well. Furthermore, for each combination of different settings on contact resistance under different given voltages are measured and recorded. The purpose is to eliminate outlier for abnormal production process data.

Table 1 organized the levels of each independent variables, including cleaning sheet size, probing overdrive, touchdown times, and contact resistance. According to Table 1, the two types of clean sheet are used. The "Big" one is with the size of 12 cm by 10 cm and the "Small" one is with the size of 6.5 cm by 5 cm. The period of time to change the cleaning sheet is set as three levels, 24 h, 48 h, along with the current setting of 72 h. The probing overdrive is setting as five levels, which are 50, 100, 150, 200 and 250 µm. The current production setting is 200 µm. Another independent variable is touchdown times, which was defined as six settings, starting from 30 times until 180 times, spacing up every 30 times. The current mass production condition is 150 touchdowns. For each combination of different levels of independent variables, the wafer probe yield and the contact resistance measured under three different voltages, 2.5 V, 3.8 V and 4.5 V, are recorded.

As shown in Fig. 7, when a signal is sent from the tester, it is then transferred to the wafer through the pogo pin connected to the probe card. At that time, read the value of

Fig. 10 Results for test on equal variances: yield (%) versus clean sheet change

Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	α = 0.05

95% Bonferroni Confidence Intervals for Standard Deviations

Clean Sheet Change	N	StDev	95% CI
24	2826	2.26010	(2.15723, 2.36989)
48	2721	2.60925	(2.54237, 2.68026)
72	2683	2.71255	(2.66057, 2.76801)

Individual confidence level = 98.3333%

Tests

	Test	
Method	Statistic	P-Value
Multiple comparisons	—	0.000
Levene	263.29	0.000

Fig. 11 Results of one-way ANOVA: yield (%) versus clean sheet change

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were not assumed for the analysis.

Factor Information

Factor	Levels	Values
Clean Sheet Change	3	24, 48, 72

Welch's Test

Source	DF num	DF Den	F-Value	P-Value
Clean Sheet Change	2	5413.61	272.83	0.000

Model Summary

R-sq	R-sq(adj)	R-sq(pred)
5.88%	5.86%	5.81%

Means

Clean Sheet Change	N	Mean	StDev	95% CI
24	2826	96.2305	2.2601	(96.1472, 96.3139)
48	2721	95.2873	2.6093	(95.1892, 95.3854)
72	2683	94.7007	2.7125	(94.5980, 94.8034)

contact resistance for each bias condition and check the change of contact resistance. The bias review condition was divided into three conditions, namely RS_4.5 V, RS_3.8 V, and RS_2.5 V, and the correlation between Wafer Probe Test Yield and each difference bias condition value are to be analyzed.

3 Results and discussion

Based on the design of independent variables as described in previous section, this study collected 8,693 wafer probing data. Since in addition to the wafer prob yield, we need to measure the contact resistance under three different voltages, which is an extra step to the regular mass production process, it took us about 7 months to collect all the required data.

3.1 Outliers analysis

We first computed the correlation coefficients between contact resistance under different voltages, respectively, and the wafer probe yield. The result is organized in Table 2.

From Table 2, we found that RSIS2_4.5 V has the highest correction with the wafer probe yield. Therefore,

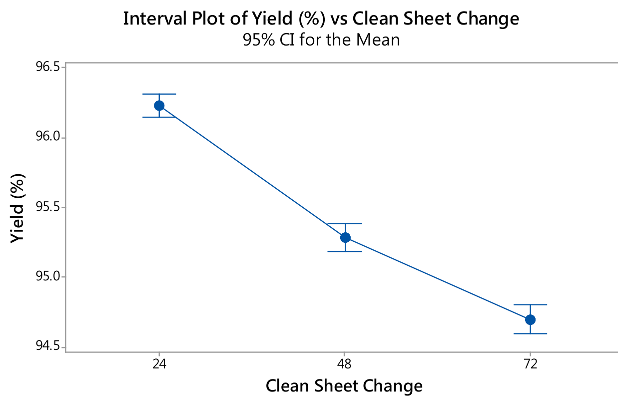

Fig. 12 Mean wafer probe yield among different clean sheet change

we make further analysis between these two variables. Since the data were collected from mass production runs, we need to check if there are any outliers that might not be appropriated for use to include in our analysis.

Figure 8 is the box plot of wafer probe yield, Fig. 9 is the box lot based on RSIS2_4.5 V, and the corresponding numbers are organized in Table 11.

Based on the box plot of wafer probe yield and contact resistance, we found some outliers. Per Table 3, we identified the data whose wafer probe yield is lower than 85.31% and whose contact resistance under 4.5 V is higher than 1.695 as outliers. The outliers identified were further discussed with the process engineer who was in charge of data collection. Permission were granted to exclude these data from our analysis because they do not represent normal production process. As a result, 468 wafers were removed, and the revised sample size is 8230. Using these 8230 data, we re-computed the correlation coefficient between wafer probe yield and contact resistance under 4.5 V and found the coefficient is -0.726.

3.2 Test for equal variances: wafer prob yield versus clean sheet change

In order to explore the relationship between each independent variable and the wafer probe yield, we test on the variances among different settings of independent variable.

For the variable of clean sheet change, there are three different levels, which are 24, 48 and 72 h. Before comparing the mean wafer probe yield between different clean sheet change, we need to test on if the variance between different clean sheet change are equal. According to Fig. 10, at least one level of clean sheet change's variance is significantly different from others.

Then we performed a one-way ANOVA to explore if the means of wafer probe yield associated with different levels of clean sheet change are different while assuming non-equal variance between different clean sheet change. Based on Welch's test, it is concluded that the means of wafer probe yield of different clean sheet change are different. At least one level of clean sheet change's mean is significantly different from others. The result is as shown in Fig. 11. The means of yield on different clean sheet change was plotted in Fig. 12. According to Fig. 12, the clean sheet change of 24 has the highest yield.

3.3 Test for equal variances: wafer prob yield versus clean sheet size

For the variable of clean sheet size, there are two different types of sizes. Before comparing the mean wafer probe

Fig. 13 Results for test on equal variances: yield (%) versus clean sheet size

Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	$\alpha = 0.05$

95% Bonferroni Confidence Intervals for Standard Deviations

Clean Sheet Size	N	StDev	95% CI
1	4553	1.05723	(0.98472, 1.13563)
2	3677	2.39862	(2.35924, 2.44014)

Individual confidence level = 97.5%

Tests

	Test	
Method	Statistic	P-Value
Multiple comparisons	—	0.000
Levene	4412.86	0.000

Fig. 14 Results of one-way ANOVA: yield (%) versus clean sheet size

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were not assumed for the analysis.

Factor Information

Factor	Levels	Values
Clean Sheet Size	2	1, 2

Welch's Test

Source	DF num	DF Den	F-Value	P-Value
Clean Sheet Size	1	4824.09	8075.97	0.000

Model Summary

R-sq	R-sq(adj)	R-sq(pred)
53.13%	53.12%	53.10%

Means

Clean Sheet Size	N	Mean	StDev	95% CI
1	4553	97.1282	1.0572	(97.0975, 97.1589)
2	3677	93.3047	2.3986	(93.2272, 93.3823)

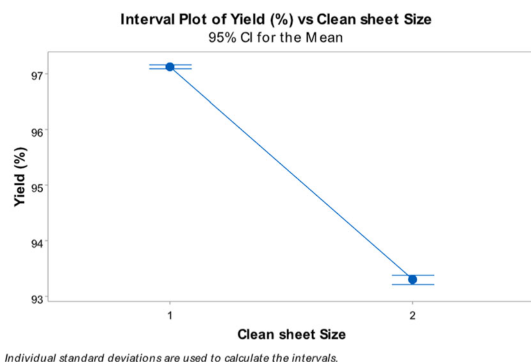

Fig. 15 Mean wafer probe yield among different clean sheet change

yield between different clean sheet size, we need to test on if the variance between different clean sheet size are equal. According to Fig. 13, at least one level of Clean Sheet Size's variance is significantly different than others.

Then we performed a one-way ANOVA to explore if the means of wafer probe yield associated with different levels of clean sheet size are different while assuming non-equal variance between different clean sheet size. Based on Welch's test, we concluded that the means of wafer probe yield of different clean sheet size are different. At least one level of clean sheet size's mean is significantly different from others. The result is as shown in Fig. 14. The means of yield on different clean sheet size was plotted in Fig. 15. According to Fig. 15, the clean sheet size of 1 has the highest yield.

3.4 Test for equal variances: wafer prob yield versus clean online-clean touch down method

For the variable of online-clean touch down, there are six different levels, which are 30, 60, 90, 120, 150, and 180 touchdowns. Before comparing the mean wafer probe yield between different online-clean touch down, we need to test on if the variance between different online-clean touch down method are equal. According to Fig. 16, at least one level of Online-clean Touch Down's variance is significantly different than others.

Then we performed a one-way ANOVA to explore if the means of wafer probe yield associated with different levels of online-clean touchdown are different while assuming non-equal variance between different online-clean touchdown. Based on Welch's test, it is concluded that the means of wafer probe yield of different online-clean touchdown are different. At least one level of online-clean touchdown's mean is significantly different from others. The result is as shown in Fig. 17. The means of yield on different online-clean touchdown was plotted in Fig. 18. According to Fig. 18, the online-clean touchdown of 60 has the highest yield.

3.5 Test for equal variances: wafer prob yield versus probing overdrive

For the variable of probing overdrive, there are five different levels, which are 50, 100, 150, 200, and 250 cm.

Fig. 16 Results for test on equal variances: yield (%) versus online-clean touchdown

Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	α = 0.05

95% Bonferroni Confidence Intervals for Standard Deviations

Online-clean Touch Down	N	StDev	95% CI
30	2104	2.61505	(2.50799, 2.73010)
60	1832	2.19350	(2.07060, 2.32705)
90	1902	2.58657	(2.44893, 2.73575)
120	785	2.55501	(2.48845, 2.63220)
150	848	1.99357	(1.92151, 2.07479)
180	759	2.39213	(2.32163, 2.47338)

Individual confidence level = 99.1667%

Tests

	Test	
Method	Statistic	P-Value
Multiple comparisons	—	0.000
Levene	40.58	0.000

Fig. 17 Results of one-way ANOVA: yield (%) versus online-clean touch down

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were not assumed for the analysis.

Factor Information

Factor	Levels	Values
Online-clean Touch Down	6	30, 60, 90, 120, 150, 180

Welch's Test

Source	DF num	DF Den	F-Value	P-Value
Online-clean Touch Down	5	2958.86	283.39	0.000

Model Summary

R-sq	R-sq(adj)	R-sq(pred)
12.94%	12.89%	12.82%

Means

Online-clean Touch Down	N	Mean	StDev	95% CI
30	2104	95.8318	2.6150	(95.7200, 95.9436)
60	1832	96.2710	2.1935	(96.1705, 96.3715)
90	1902	95.8924	2.5866	(95.7761, 96.0087)
120	785	94.6444	2.5550	(94.4654, 94.8234)
150	848	93.9340	1.9936	(93.7996, 94.0684)
180	759	93.5023	2.3921	(93.3319, 93.6728)

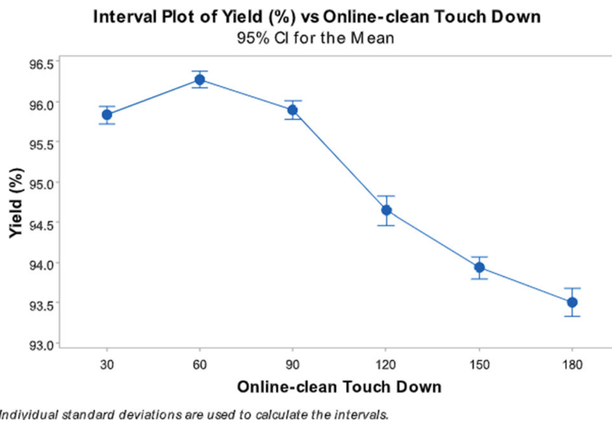

Fig. 18 Mean wafer probe yield among different online-clean touch down

Before comparing the mean wafer probe yield between different probing overdrive, we need to test on if the variance between different probing overdrive are equal. According to Fig. 19, at least one level of Probing overdrive variance is significantly different than others.

Then we performed a one-way ANOVA to explore if the means of wafer probe yield associated with different heights of probing overdrive are different while assuming non-equal variance between different probing overdrive. Based on Welch's test, we concluded that the means of wafer probe yield of different probing overdrive are different. At least one level of probing overdrive's mean is significantly different from others. The result is as shown in Fig. 20. The means of yield on different probing overdrive was plotted in Fig. 21. According to Fig. 21, the probing overdrive of 150 has the highest yield (Fig. 22).

3.6 Conclusion

As the main effects plot and several ANOVA results shown above, we observed that each control variable at different levels doesn't perform equally. The best combination that has the highest yield is as organized in Table 4.

Table 5 organized the R^2 of the models. Note that the higher value of the R2, the stronger relationship between the independent variable and dependent variable, which was the probe test yield. Therefore, from Table 5, we can see that among the four variables, probing OD and the change of clean sheet are two variables that have relatively stronger relationship with the probe test yield then the other two.

We can say "Probing Overdrive" effect the yield the most.

However, not only the probe test yield is important to the process, the overall OEE is also an important measure that needs to be considered. The optimized conditions called for performing cleaning every 60 touchdowns and changing clean sheet every 24 h. This would increase the production cost and make the cleaning more frequent which may damage the OEE. Since, from Table 5, clean sheet change and online-clean touchdowns did not have strong model, we decided to still keep to the current

Fig. 19 Results for test on equal variances: yield (%) versus probing overdrive

Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	α = 0.05

95% Bonferroni Confidence Intervals for Standard Deviations

Probing overdrive	N	StDev	95% CI
50	2001	0.920404	(0.857310, 0.98941)
100	2188	0.323562	(0.312096, 0.33585)
150	1816	0.076316	(0.073999, 0.07882)
200	1481	0.972926	(0.924191, 1.02602)
250	744	0.751008	(0.674322, 0.83932)

Individual confidence level = 99%

Tests

	Test	
Method	Statistic	P-Value
Multiple comparisons	—	0.000
Levene	503.26	0.000

Fig. 20 Results of one-way ANOVA: yield (%) versus probing overdrive

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were not assumed for the analysis.

Factor Information

Factor	Levels	Values
Probing Overdrive	5	50, 100, 150, 200, 250

Welch's Test

Source	DF num	DF Den	F-Value	P-Value
Probing Overdrive	4	2755.18	26344.6	0.000

Model Summary

R-sq	R-sq(adj)	R-sq(pred)
93.29%	93.29%	93.28%

Means

Probing Overdrive	N	Mean	StDev	95% CI
50	2001	91.2375	0.9204	(91.1972, 91.2779)
100	2188	97.2450	0.3236	(97.2314, 97.2586)
150	1816	97.4659	0.0763	(97.4624, 97.4694)
200	1481	96.4108	0.9729	(96.3612, 96.4604)
250	744	94.3351	0.7510	(94.2811, 94.3892)

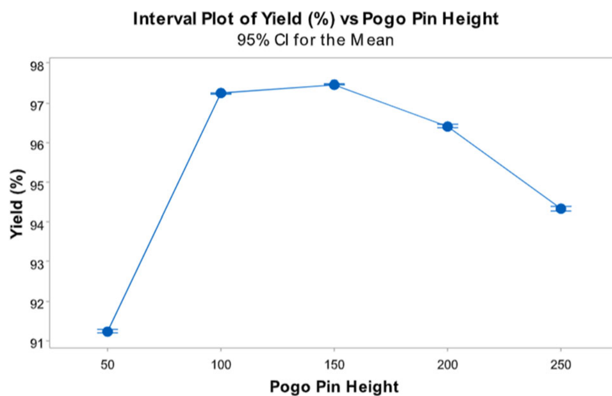

Fig. 21 Mean wafer probe yield among different probing overdrive

production settings, cleaning every 150 touchdowns and changing sheet every 72 h, and only change the probing OD from 200 to 150 μm and use large clean sheet.

4 Conclusion

Fundamentally, when launching a new product, equipment investment occurs in the standard of the client company's demand in the product factory, which the equipment investment is been reached conservatively calculating the investment scale with the OEE level, universally set as 80 to 85%. However, in the current process of mass production, due to frequent equipment down problems as well as the repairment of them, the OEE level of the probe tests are below about 50%, bringing up the shortage phenomenon of the invested equipment when calculating the OEE level as 80 to 85% when launching preexisting products in contrast with the demand. The biggest problem in this case is deserting customers, in other words, there will be circumstances where customers continuously find other rival companies' products due to the occurrence of delivery problems when the client's demand can't be matched in contrast with the early invested number of equipment.

Moreover, due to problems such as frequent equipment down and low yield of probe test, many of the work-in-process of the whole the production process of the probe test does not flow to the next process but it's in a situation where they get held. Also, the probe test process is falling to the shop flow's biggest bottleneck process which is exerting a bad influence on the whole probe test production process' capacity.

In the wafer level test, if the product yield is low, it can be categorized into two types of defects. One would be the intrinsic failure due to the product problems and the other one would be the non-intrinsic failure due to wafer level tester or equipment set-up. Analysis of the defects is a must to determine whether it is a real failure or not. If the problem is caused by the product, the product needed to be scrapped according to the defective phenomenon.

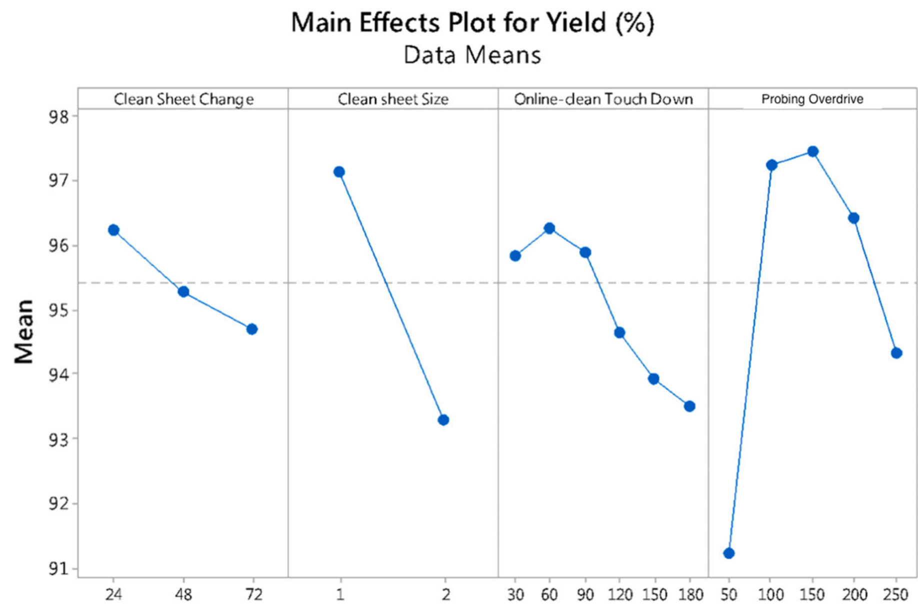

Fig. 22 Main effects

Table 4 The best combination that has the highest yield

Clean sheet change	Clean sheet size	Online-clean touch down	Probing overdrive
24	1	60	150

The average yield of the combination is 97.47%

Table 5 The R^2 of each variable with probe test yield

Clean sheet change	Clean sheet size	Online-clean touchdown	Probing overdrive
5.88%	53.13%	12.9%	93.29%

However, in case of non-intrinsic failure after failure analysis, the equipment set-up condition should be checked by equipment engineers to repair the problem after checking the contact status of pogo pin including the probing overdrive, the cleaning status, the contact resistance, and more. After that, if the defective product is not a genuine defect, it needs to be re-tested again.

The pogo pin socket, a consumable used for semiconductor test, has excellent electrical contact stability. However, in case of breakage or contamination due to long use, contact with semiconductor pins will be unstable, resulting in contact resistance between the pins. Increasing the contact resistance adversely affects the quality of inspection. When a fault caustic determination in which the good product is judged to be a defective one, it will result in a decrease in the semiconductor yield. On the other hand, the auto cleaning is required to perform in the tester process to reduce the contact resistance. The size and number of cleaners used at that time are also important factors that can affect the yield as well as the overall process efficiency of production, such as long machine downtime, and long product hold periods. Moreover, it may also disrupt the production planning disruptions and product delivery to customers.

More than 9000 wafer probe test yield data were collected for about 7 months, and each condition of each independent variable was classified to analyze the correlation between the probe variable test yields. According to the analysis results, the optimal conditions judging by yield performance were the clean sheet change with 24 h of independent variables, using the large clean sheet, clean the pogo pin every 60 online-clean touchdowns, with probing Overdrive of 150um. However, in practice, changing the sheet every 24 h and perform cleaning every 60 touchdowns would increase too much production cost and interrupt the production too much. Judging from the R-square of each model, we decided that in order to improve both yield and OEE, the level probing overdrive is set to be 150 μm and using large clean sheet while still clean the pogo pins every 150 touchdowns and change

cleaning sheet every 72 h, stick to the current mass production conditions.

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