RF Bump Wafer Test Optimized through Clean Pad Selection for Membrane Probe Card

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Abstract

The wafer-level testing continues to evolve, and advances in probe card development are becoming critical in high volume production fabs. One of the important parametric and probably one of the biggest factors in probe yield loss is contact resistance. This paper discusses the experiment and the methodology for selecting cleaning pad for membrane probe card to improve probe card yield. The criteria for selecting optimum cleaning pad are yield, wear, and particles using on-line cleaning method. Considering overall performance, P6 cleaning pad exhibited optimum condition for cleaning pad selection for this study.

Introduction

There are many different types of probe cards used in the mass production fabs and most commonly used is Cantilever type. Cantilever probe cards have been around for many decades and cleaning methods for probe cards have been studied and developed extensively. Obtaining reliable test results require careful matching of proper parameters to the type of tester used and the device being tested but also most important is keeping the probe cards in best optimum condition. There have been many papers discussing characterization of contact force, probe tip sharping and particulate removal. In past 10 years, membrane probe cards have experienced phenomenal interest and growth, thus many papers have been written and discussed, especially the cleaning techniques. [1] [2] [3].

In this study, several different cleaning pads were tested on membrane probe card during RF bump pad testing. This paper will not discuss the membrane probe card characteristics or merits since this is beyond the scope and purpose of this paper. An optimization methodology of cleaning pad selection for membrane probe card is presented in terms of lifetime, test yield, and particles on probe tips.

Experiment

Figure 1 shows six different types of cleaning pads used in the study. The pads range in three different grit sizes from 1μm to 3μm and three different models; Lapping Film, Filled Elastomers, and Abrasive Coated Foams. For this test, each cleaning pad had dedicated membrane probe card, and each membrane probe card consisted of core and PCB board. The same PCB was used for the tests to minimize introducing unwanted variables. Figure 2 shows 8 probe tip array on one core that is designed for SPDT RF bump pad. Each probe tip height range from 50μm to 57μm measured by ASA (Alpha Step Analyzer).

Figure 3 shows the process flow of this experiment. First, the probe tip height was premeasured and then the cleaning recipe for full-auto prober was set at one cleaning cycle per every 300 wafer touchdowns. One cleaning cycle equals 10 cleaning pad touchdowns and a single test wafer can accommodate 100 cleaning cycles. In this accelerated wear test, 1,500 cleaning cycles were reached by using 15 test wafers repeating the cycle in four steps with each step doubling the previous cycle. In each step, intermediate post probe height measurement was taken by ASA as shown in Figure 4.

There are three important parameters to be considered for the sequence of clean pad selection and these are: Wear, Yield, and Cdebris. First, Wear is the difference between pre and post Alpha Step measurement of probe tips. Then, Yield is defined by an average value of yields from 15 wafers tested with 30,000 dies on a wafer. If there are too many particles on the tip, this may cause high contact resistance and the data would be out of specification. Lastly, SEM photos were taken to inspect the particles on the probe tips and used to calculate Cdebris. Figure 5 shows a typical SEM photo of probe tip. The debris parameter Cdebris can be expressed with following formula,

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$$Cdebris = 0.7(Rparticle) + 0.2(Ftip) + 0.1(Fmemb)$$

where Rparticle is a ranking of the particle size, Ftip is a frequency of particles appearing on the tip, and Fmemb is a frequency of particles appearing on the membrane. Each parameter has weighted constants. The ranking number starts from 0 and increases by particle size. Ranking 0 equals to zero particles. A red square in figure 5 is a particle unit to evaluate the particle size. There are three units on SEM photo, hence Rparticle is 3. The yellow grid lines show membrane divided into 8 sections. There is only one particle on location Memb-2, Fmemb is 1.

Results

Table 1 shows particle ranking for all the probe tips measured from SEM photos. Figure 6 shows the table of calculated results with corresponding graph of the cleaning pads P1 through P6. For P1 and P2, these similar materials had lowest Cdebris and good yield but had the most wear on the tip between 1.84µm~2.28µm. This may be related to the material. The results show positive correlation to the grit size and structure of the abrasive layer. The results show 0.27µm wear and 2.73~6.43 Cdebris value. P5 and P6 are abrasive coated foam model which had 0.61µm~0.96µm wear and 3.88~4.71 Cdebris value. Cleaning pads P1, P2, P5, and P6 all had good yields at 99%, and P3 and P4 both had less than 90%.

Increasing probe life and time between cleaning are important part of high volume production fab. In order to achieve these goals, choosing best and optimum cleaning pads are critical as these translate into cost savings. Figure 7 shows good cleaning pad selection criteria. First, select high yield above 90%, this eliminates pads P3 and P4. Next, select pads with lower wear value. This eliminates P1 and P2 and that leaves P5 and P6. Lastly, from these two remaining cleaning pads, the lower of the two Cdebris values, 3.8875, P6 is the clear choice for cleaning pad for this study. It also shows the Cdebris does not necessary correlate to the test yield, some particles that appear round the tip did not have any effect on the contact resistance.

To verify the reasoning, we implemented an actual RF bump probe card yield test using cleaning pads P4 and P6. These cleaning pads were installed in full-auto prober. The test was repeated two times to confirm repeatability using same receipt. The test confirms the selection method used in the study by showing P6 resulting in average 99% probe yield and P4 with average 35% probe yield. Figure 8 shows the maps of probe yield for P4 and P6 cleaning pads. Figure 9 and Figure10 show histogram of RF test data for insertion loss. This clearly agrees with the experimental results.

Conclusion

In conclusion, we were able to demonstrate a numerical method to show and select suitable cleaning pads for RF bump probe testing. Although the P6 cleaning pad with 2µm grit size and abrasive coated foam model did not exhibit the best values in each category, one needs to look at overall characteristics of the pad; in this case, the P6 cleaning pad showed optimum cleaning performance.

Reference

[1] Eric Hill and Josh Smith, IEEE SWTW "Probe Card Cleaning Media Survey" June 10,2008
[2] Rainer Gaggl and Dominique Langlois IEEE SWTW "Advanced in offline Resharping and Cleaning for Cantilever, Vertical and Lithographic Probe Cards, June 7-10, 2009
[3] Jerry Broz and Gene Humphrey and Wayne Fitzgerald, IEEE SWTW "Probe Card Cleaning – A Short Tutorial" June 3-6, 2007

Acronym list

SPDT: Single-Port-Double-Throw
PTPA: Probe To Pad Alignment

Clean Paper	Grit size	Model
P1	1um	Lapping Films
P2	3um	Lapping Films
P3	3um	Filled Elastomers
P4	3um	Filled Elastomers
P5	3um	Abrasive Coated Foams
P6	2um	Abrasive Coated Foams

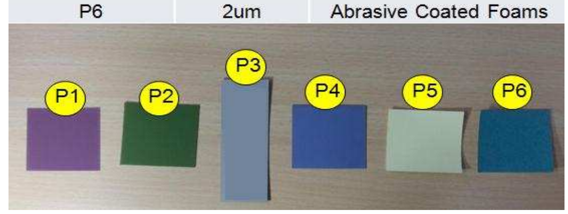

Fig.1 6 types of clean pads

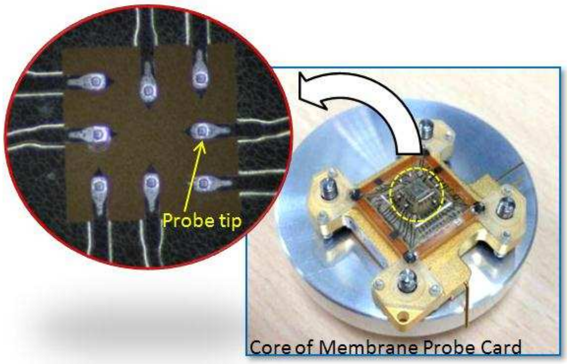

Fig.2 Probe tip and the core of membrane probe card

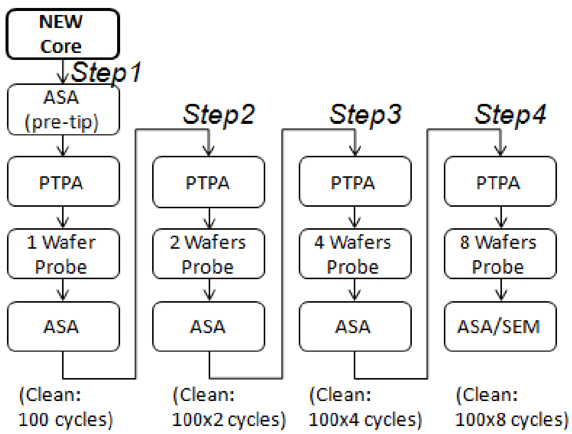

Fig.3 Process flow of full experiment

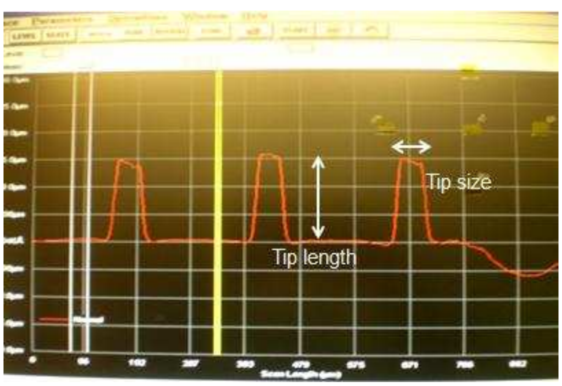

Fig.4 Probe tip length measurement by α -step

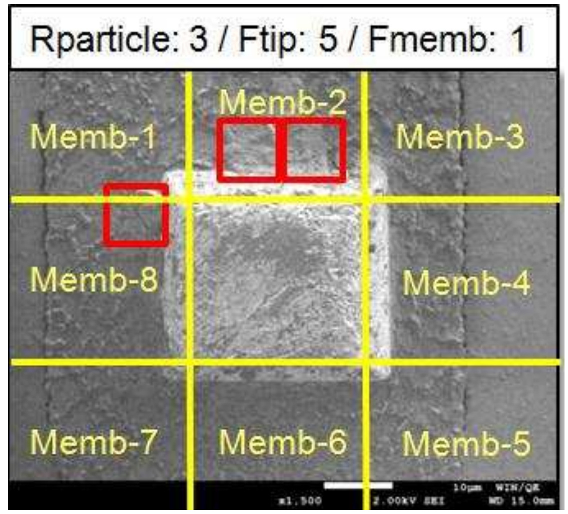

Fig.5 Particle ranking of one tip, red squres are for Rparticle and yellow grids are for Fmemb. The beginning of ranking is 0 which also means zero particles.

Rparticle	Clean Pad					
	P1	P2	P3	P4	P5	P6
Tip.1	0.00	0.00	1.00	3.00	5.00	6.00
Tip.2	1.00	0.00	1.00	12.00	1.00	1.00
Tip.3	1.00	4.00	2.00	7.00	9.00	4.00
Tip.4	1.00	1.00	3.00	7.00	5.00	3.00
Tip.5	1.00	3.00	2.00	5.00	8.00	2.00
Tip.6	0.00	0.00	1.00	8.00	2.00	2.00
Tip.7	0.00	1.00	2.00	3.00	2.00	3.00
Tip.8	0.00	1.00	1.00	8.00	2.00	4.00
Average for 8 tips	0.50	1.25	1.63	6.63	4.25	3.13

Ftip	P1	P2	P3	P4	P5	P6
One core	4.00	5.00	8.00	8.00	8.00	8.00

Fmemb	P1	P2	P3	P4	P5	P6
Tip.1	0.00	0.00	0.00	0.00	1.00	1.00
Tip.2	0.00	0.00	0.00	7.00	0.00	0.00
Tip.3	1.00	2.00	0.00	2.00	4.00	1.00
Tip.4	0.00	0.00	0.00	2.00	2.00	1.00
Tip.5	1.00	1.00	0.00	1.00	3.00	0.00
Tip.6	0.00	2.00	0.00	1.00	0.00	0.00
Tip.7	1.00	0.00	0.00	0.00	0.00	2.00
Tip.8	0.00	2.00	0.00	3.00	1.00	3.00
Average for 8 tips	0.38	0.88	0.00	2.00	1.38	1.00

Table 1 Particle ranking table for all the probe tips from SEM inspection photos

Membrane	Cdebris	Yield	Wear (um)	Wear-Nor.
P1	1.1875	99%	1.8438	0.0369
P2	1.9625	99%	2.2838	0.0457
P3	2.7375	86%	0.0000	0.0000
P4	6.4375	77%	0.2725	0.0055
P5	4.7125	99%	0.6113	0.0122
P6	3.8875	99%	0.9650	0.0193

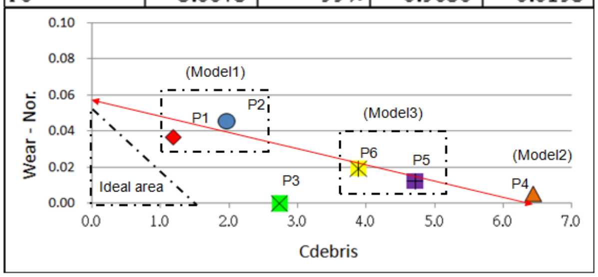

Fig.6 Experimental results and chart (Wear-Nor. means the data with normalize, Wear/Tip length)

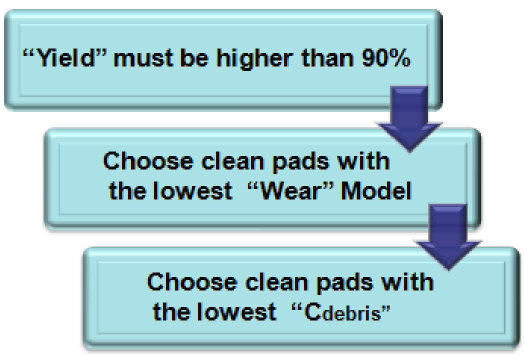

Fig.7 Clean pad selection sequence

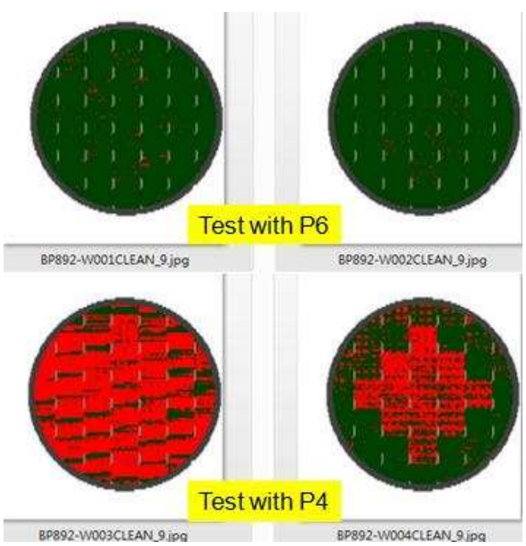

Fig.8 Wafer maps using clean pads P6 & P4

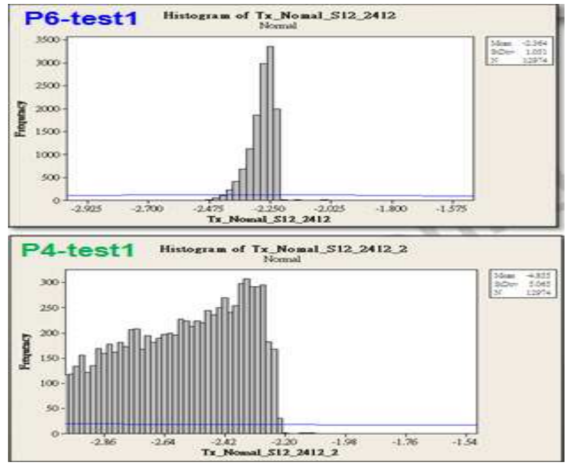

Fig.9 Histogram chart of first P6 & P4 wafer testing data for insertion loss

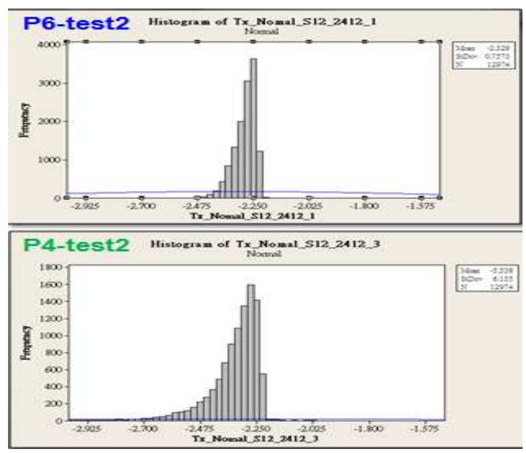

Fig. 10 Histogram chart of second P6 & P4 wafer testing data for insertion loss