Real-time Validation of Probe Contact Quality in GaAs PCM Testing

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Abstract

Process Control Monitor (PCM) test of GaAs wafers can be validated in process by monitoring the actual probe contact resistance of each tip on its probe pad. We present our method for doing that using an existing PCM test track to validate the test and prevent excessive retest.

INTRODUCTION

To vouch this, is no proof,
Without more wider and more overt test…
- *Shakespeare, Othello, Act I, sc. 3*

In-fab final PCM test of GaAs IC wafers is usually done on gold bond pads using Be-Cu probe tips in a cantilever probe card. The quality of the test is critically dependent on the quality of the probe to pad contact resistance, especially for measuring low resistances. That can be impacted by damaged probe cards, by debris on the probe pad, or by incompletely opened pads. Too often, probe contact failure is only seen after completion of lot testing, leading to fab lots on hold and to the need to retest, adversely affecting cycle times. Moreover, frequent poor probe results lead to a loss of faith in the quality of PCM test by the wafer owners.

We have developed a "more wider and more overt test", a method of using an existing PCM module to actively prove solid probe contact before completing test of any site on the wafer. Active real-time responses to poor contact like probe cleans or probe card replacements can then be done so that all completed PCM tests can be shown to be correctly executed, removing bad test as a suspect in why a wafer failed PCM test.

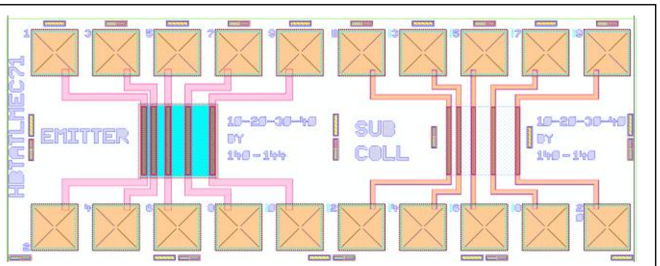

Fig. 1. Transmission Line and Probe Pad Check Track.

BACKGROUND AND RESULTS

Avago Fort Collins traditionally uses a 2 x 10 pad "track" for doing PCM test. Process test structures for active and passive circuit elements are positioned inside the rather large space between the rows of pads. One of those structures is shown in Fig. 1, a transmission line used to measure HBT epi layers in a 4 point or Kelvin test.

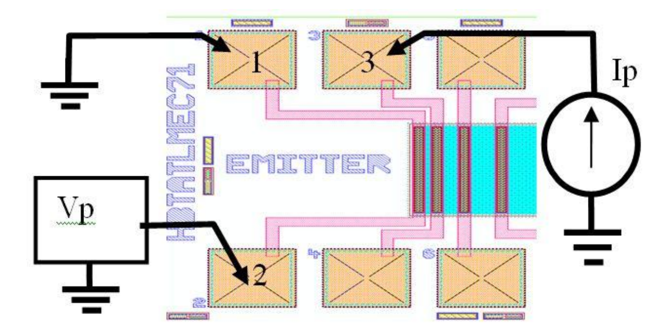

Fig. 2. Close-up of Pad 1 Probe Resistance Measurement.

Fig. 2 shows that by injecting current Ip into pad 3 and sensing the voltage Vp on pad 1 with a high impedance probe on pad 2, we can assess the probe – pad 1 contact resistance Rc with acceptable accuracy. Data from this test shows a typical Rc of about 0.2 – 0.3 Ohms, as shown in Fig. 3, which also shows there is a higher Rc tail for some probe tips, clearly an area for further study.

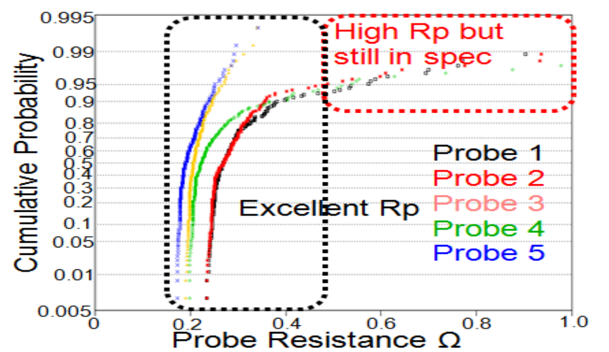

Fig. 3. Statistical Results of Probe Pad Check of Five of our Twenty Probes.

IMPLEMENTATION

The current method of using the probe pad check (PPC) in routine production PCM test is to follow the procedure below for each wafer in a lot.

1. Test all PCM tracks on site
2. Do PPC. If passing, record site data and go on to step 2 for next site or exit if last site.

3. If PPC failed, perform sandpaper / brush clean. If PPC now passes, redo step 2 on the same site, unless two cleans were done already on that site.
4. If two cleans did not help, note the site as PPC bad, record that site's data and go to next site. We do not just stop after one fail to protect against a defective PPC test track, which should rarely or never happen with choice of a robust PPC structure.
5. If two die in a wafer are PPC bad, the wafer is PPC bad. In this case, we stop the test, note the wafer ID of the PPC bad wafer, replace the probe card and restart test of the lot at the PPC bad wafer which had stopped testing.
6. If the same wafer fails PPC again, after replacing the probe card, put the lot on hold for test engineering intervention. This is probably not a case of a damaged probe card.

This procedure allows only site data we have validated (or data for sites believed to have a defective PPC track) to go into our PCM database and provides information to avoid the almost automatic response in many fabs to PCM fails – "retest the wafer/lot with a different probe card and/or on a different tester." A passing probe pad check proves there was nothing wrong with probe placement or probe contact quality on the site just tested, removing the reason to retest.

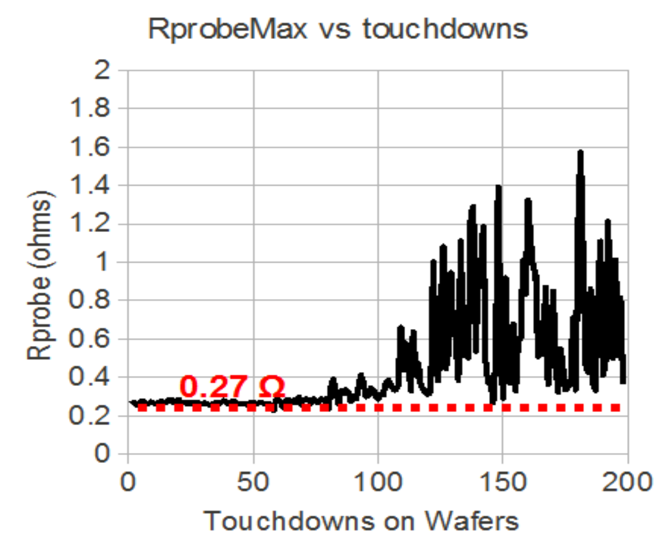

Fig. 4 Probe Contact R vs. Touchdowns, 2x10 PPC Track

Testing this track over repeated touchdowns has shown that our PCM probe cards become increasingly noisy and have higher probe contact resistance after about 100 touches without clean, as shown in Fig. 4.

Furthermore, we can extract the recorded value of individual probe Rc from any PCM measurements of low resistance, improving the test result by removing that parasitic component. This can detect fab problems like residue on probe pads, as illustrated in Fig. 5.

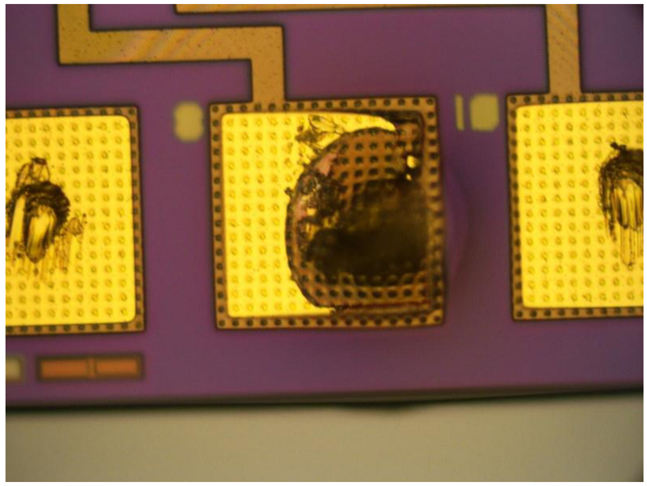
Fig. 5 Example of Pad Residue Detected by PPC

COMPARISON TO "PERFECT" PPC TEST ON NEW 2X6 TRACKS

New masks at our fab have migrated to a more compact 2x6 PCM test track array. In so doing, we have lost the very large and robust 2x10 PCM Transmission Line track discussed above. To recover and to investigate how well that old track determined actual contact R for the probes, we added what we call a "perfect" PPC structure (Fig. 6) which is simply a 5 um thick and 60 um wide stack of Au connecting all 12 pads together, with probe pad openings over the pads.

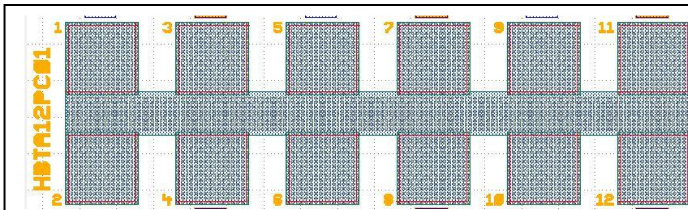
Fig. 6 "Perfect" PPC Track

Testing of this track gives a probe Rc of around 0.13 Ohms, as shown below in Fig. 7, down about 50% from the ~ 0.25 Ohm measured with our old structure (Fig. 4). Given the ideality of this new track for the purpose, we believe this is closer to a correct value. It should be noted that this does not obviate the value of the old track, which is still in use for old masks and provides positive evidence of good contact even if measuring higher than ideal.

PRODUCTION RESULTS

After several months of production use, the value of this methodology has been validated. It usually just sits quietly in the background, but does sometimes intervene in real time to correct bad testing and keep bad data out of our database.

Some examples are shown in Fig. 7 for our new 2x6 tracks at Final PCM test.

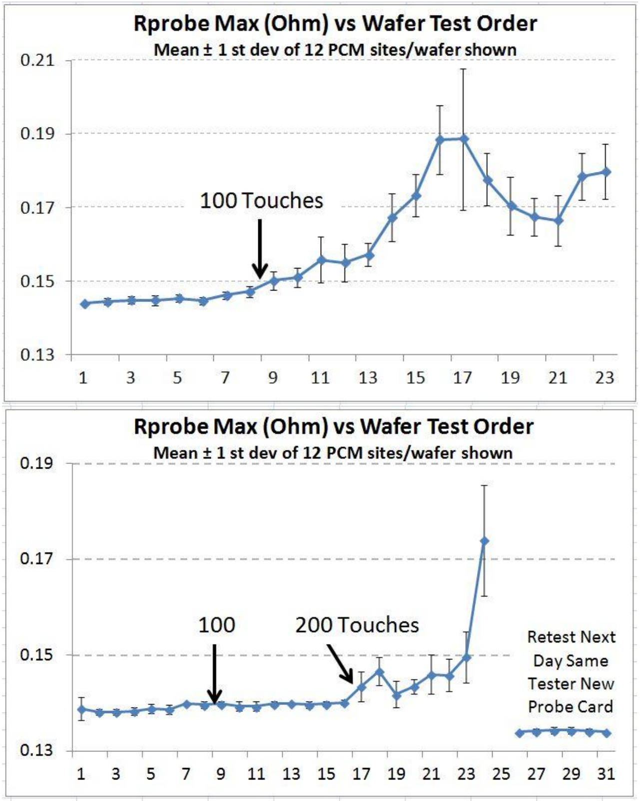

Fig. 7 "Worst of 12" Probe Contact R vs. Number of Probecard Touchdowns without cleans for two recent runs

The top graph shows the average of the worst Rprobe of the 12 probes increasing slightly over repeated touchdowns and getting noisier. The error bars shown are 1 standard deviation of 12 test sites per wafer, simply included to indicate uniformity of the data.

The bottom graph in Fig. 7 shows the same data for another run plus a repeatability test on 6 of the 24 wafers in the lot. The drift up by 0.2 Ohms and the increased variation were both eliminated by retesting with a new probecard.

	Old 2 x 10 PPC Tracks		New 2 x 6 PPC Tracks		
Total Count of Rprobes Tested	1440	3960	3312	4320	3456
Average of all probe R's (Ohm)	0.243	0.250	0.138	0.132	0.123
Stdev of all probe R's Ohms	0.045	0.086	0.012	0.005	0.004

Table 1 – PPC Overall Averages on 5 runs

Summary data for 5 fab runs with new and old PPC tracks is shown in Table 1. The quietness of the data for both tracks is obvious to the most casual observer, though the new track is relatively quieter (smaller standard deviation, both absolute and as a percent of average).

FUTURE PLANS

We have fully installed PPC for Final PCM test of our HBT wafers in Fort Collins. We are now in the process of installing PPC testing for other in-process test points. Early results are showing that improvements in probe quality are possible there with better cleaning of probe cards.

In addition, we plan to propagate this methodology as much as possible to PCM testing of our PHEMT wafers. New masks will get specific PPC tracks and old masks will get PPC test if suitable PCM tracks are present. If no suitable track is there, we can still apply the teachings of this work to set up effective probe tip cleaning frequency.

Finally, we are working towards using a variation of this technique to improve our diesort test quality. This is not as natural as for PCM test where we test whole reticle fields then step to the next reticle field. In diesort we sweep back and forth all across the wafer, so we do not have a natural periodic test point. Furthermore, for the very high number of sites tested at diesort that PPC test cannot take very long and the structure for it must not displace very many sellable die. It also needs to work with multi-site diesort test.

6
b

CONCLUSIONS

Automated validation of probe contact quality has been installed using an existing PCM track in a GaAs production line and using a more accurate custom track in new masks. Active intervention is initiated automatically in several common scenarios. This has led to more reliable and consistent PCM test data and improved confidence in our PCM test results.

ACKNOWLEDGEMENTS

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ACRONYMS

HBT: Heterojunction Bipolar Transistor
PCM: Process Control Monitor
PPC: Probe Pad Check