Process Optimization to Improve Known-Good-Die (KGD) Test Accuracy and Wafer Final Yield

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Introduction:

Massive production of GaAs wafer requires appropriate wafer level test scheme to filter out defective die from a wafer. Accuracy and efficiency of so-called Known-Good-Die (KGD) test directly impact product yield, cost, and fabrication cycle time. Over years of KGD test results analysis, we observed a variety of false failures due to KGD tester malfunctioning, flawed test scheme, or bad contact between test probe and die bond pad. Some false failed die can be reclaimed through retest at the cost of cycle time, more labor, and probe card consumption. While unrecoverable false failure generates negative impact on wafer level yield. In this paper, we discussed an approach through process optimization to improve probe/bond pad contact and minimize KGD 1st pass false failure. KGD data analysis utilizes Universal Data Query software to access test results from millions of die. [1]

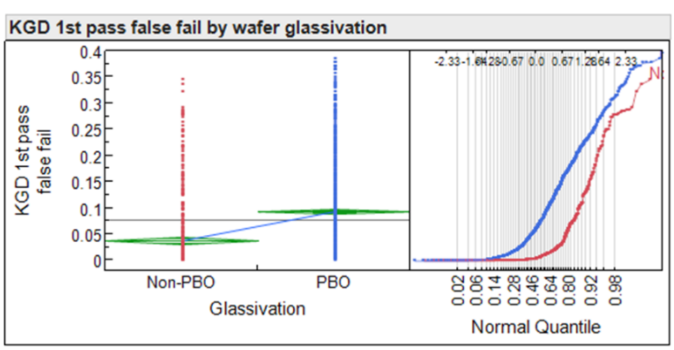

Figure 1. KGD first pass false fail rate for wafers with and without PBO coating. Quantile plot also shows significant difference between the two types of wafers.

Si nitride has been commonly used as GaAs wafer glassivation layer to prevent moisture penetration. To protect Si nitride from scratch, in recent years, a photoresist-based polymer layer polybenzoxazole (PBO) coating is applied on top of Si nitride to protect nitride from any mechanical damage. Since the application of PBO, we have surprisingly observed a significant increase in KGD 1st pass false fail from ~3.9% to ~9.4% (as shown in Fig 1). With further KGD data analysis, we found most of the 1st pass false failed die on PBO-coated wafers failed a KGD parameter that is particularly sensitive to probe/ bond pad contact (as shown in Fig 2). Therefore, we attributed this test accuracy degradation to process change that affects bond pad surface condition. Based on our observation on production wafers with PBO coating, we tested varied bond pad clean methods after PBO deposition/cure, and prior to KGD test. Experimental details and results are discussed in following sections.

Experimental:

In this work, we tested both wet and dry etch in order to improve gold bond pad surface purity. As shown in table 1, after PBO was coated and cured, four bond pad clean conditions have been tested, including PBO developer dip clean, oxygen plasma etch at varied energy, and the combination of both wet and dry surface clean methods. Mild and strong plasma etch were performed at low and high plasma power, respectively. KGD test was carried on immediately after gold bond pad clean. All wafers were tested through the same KGD tester and probe card to minimize test variation caused by equipment. KGD false fail rate is simply calculated from subtraction of 1st pass yield from final yield after retest. All test wafers were processed through standard fabrication process with an additional optical microscope inspection after wafer singulation to exam PBO surface cosmetics.

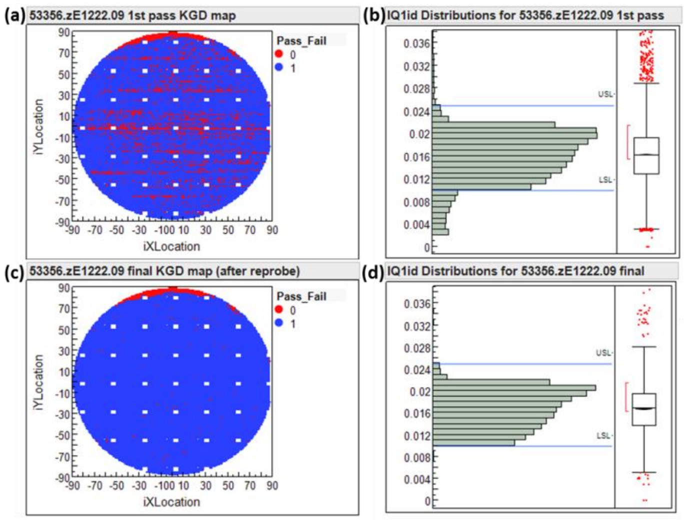

Figure 2. (a) KGD first pass map (red – fail, blue – pass) and (c) final map after retest. (b) and (d) are distribution of IQ1id, a test parameter sensitive to probe touch quality.

Table 1. PBO-coated test wafer gold bond pad clean methods prior to KGD test.

Wafer #	Bond pad clean prior to KGD test	
	Wet etch	Plasma dry etch
01, 05, 09, 13	Developer dip clean	No
02, 06, 10, 14	Developer dip clean	Mild descum (low power)
03, 07, 11, 15	No	Mild descum (low power)
04, 08, 12, 16	No	Strong descum (high power)

Results and discussion:

It is interesting to find out that plasma etch can effectively improve gold bond pad surface condition and consequently reduce KGD test 1st pass false failure. In our full paper we will include 1st pass false fail maps for all 16 test wafers. We observe a higher false fail rate for wafers only wet etched in PBO developer. In addition, wafers dry etched under a higher plasma power tend to have the lowest KGD test 1st pass false fail rate. Figure 3 compares false fail rate for test wafers processed through varied bond pad clean procedure prior to KGD test. Clearly, oxygen plasma clean improves electrical contact between gold bond pad and KGD tester probe resulting in lower false fail rate in 1st pass KGD test. However, we also observed high power plasma etch decorated PBO surface causing wafer cosmetic issue. In table 2, we summarize test wafer cosmetics as well as KGD false fail rate. Further optimization in plasma clean will be presented in full paper. We will also explore a potential impact on final yield when bond pad/probe contact is improved through process optimization.

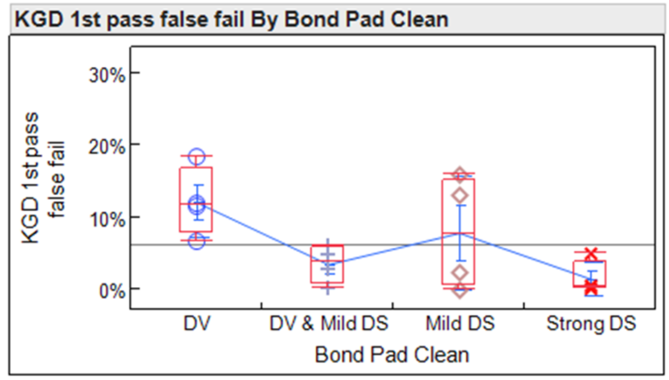

Figure 3. KGD first pass false fail rates for wafers etched only in PBO developer (DV), wafers etched in developer followed by mild plasma etch (DV & Mild DS); wafer plasma etched only at low power (Mild DS); wafer plasma etch only at high power (Strong DS).

Table 2. Summary for KGD false fail rate and PBO cosmetics for 16 test wafers with varied bond pad clean procedure.

Wafer #	Bond pad clean prior to KGD test	Wafer cosmetics	KGD false fail (average)
01, 05, 09, 13	Developer clean only	Good	12.2%
02, 06, 10, 14	Developer clean plus mild descum	Good	3.6%
03, 07, 11, 15	Mild descum only	Bad	7.9%
04, 08, 12, 16	Strong descum only	Bad	1.6%

Conclusions:

Based on massive data analysis, we demonstrated an approach through process optimization to improve KGD test accuracy and efficiency. A plasma dry etch process was developed to minimize KGD 1st pass false fail rate. More importantly, this joint effort on process and test improvement may lead to an increase in final yield at wafer level.

[1] P. Carroll *et al.*, 2012 CSMANTECH Tech. Dig., May 2012.