Use of Re-etched and Re-polished Epi-wafers for MBE Calibration Substrates

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ABSTRACT

Re-polished and re-etched 100mm SI GaAs Epi-wafers have been studied to determine their usefulness as MBE reactor calibration substrates in place of prime wafers.

Keywords: GaAs manufacturing, GaAs ICs, Epi-wafers, MBE, Reclaim, Repolish

INTRODUCTION

Approximately thirty-five to forty-five percent of the cost of producing an epi-wafer is due to the cost of the substrate itself. This not only includes the cost of the substrate the epi-wafer is grown on, but also the cost of the substrates used to calibrate the MBE reactor to ensure customer specifications are met before product is grown. Although the GaAs industry has seen a significant decrease in prime GaAs substrate prices in recent times, the use of prime material to calibrate an MBE reactor can still be very expensive for high volume MBE manufacturing. Mechanical grade substrates are often used as a substitute for prime grade; however, quality issues with mechanical material, such as, poor surface morphology and poor surface cleanliness, can compromise the results of a critical calibration run. Because of the above issues with high prime substrate costs, and questionable quality for mechanical grade material, the alternative of reclaiming rejected epi-wafers for the purpose of reactor calibration is very attractive when looking into methods of reducing manufacturing costs.

When reclaiming epi-wafers, two methods were considered; chemically etching the epi-structure away, or removing the epi-layers by use of a chemical/mechanical polish.

RE-ETCHING

Epi-wafers, such as PHEMTs, that have no etch-stop layers, have been easily re-etched using a proprietary etch[1]. Through experimentation, the balance between the chemical constituents of the etch were obtained that effectively removes the epi-layers, while still maintaining a relatively low defect count and low haze level as measured by a Tencor Surfscan 6220. Also, through SIMS analysis the re-etched, and re-polished, wafers exhibited low interfacial surface contaminants, such as, oxygen, carbon, silicon and sulfur [see Illustration 1]. These re-etched substrates are suitable for "internal" reactor calibration runs such as, doping calibrations, growth rate calibrations, and bringing a reactor back on-line after a maintenance cycle.

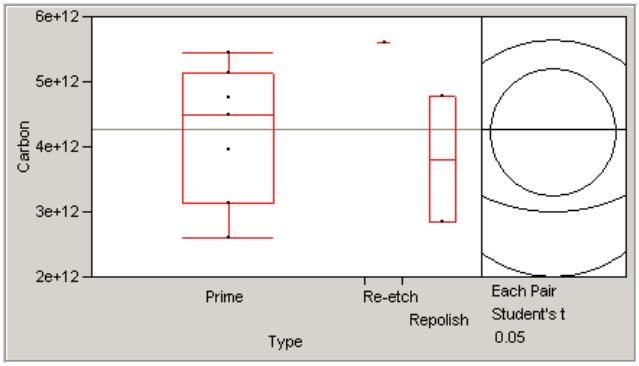

Illustration 1 – SIMS Analysis Carbon at Interface (atoms/cc)

Level		Mean
Re-etch	A	5.59e+12
Prime	A	4.22e+12
Repolish	A	3.81e+12

Levels not connected by the same letter are significantly different

RE-POLISH

Epi-wafers that have etch-stop layers have proven to be more difficult to etch. Even after applying a multi-step etch method, the surface exhibits many small defects detectable under both Surfscan and Nomarski microscopic inspection. Due to this issue a chemical/mechanical polish was deemed a more effective means by which to remove the epi-layers; while still maintaining a low defect and low haze surface. These re-polished substrates are very useful when a critical "customer" calibration substrate is required.

COMPARISON OF RE-ETCH AND RE-POLISH TO PRIME

In order to evaluate the usefulness of re-etched and re-polished substrates for reactor calibration, several MBE growth experiments were performed. Aluminum calibration and HEMT calibration runs were chosen for the experiment. Re-etched, re-polished and prime substrates were included in each run of a multi-wafer reactor, with the prime substrates considered as the "control wafer" for each test. Then a complete characterization was performed on each wafer, and the results were analyzed using the

Student's t-test for independent variables to test for any significance in the test samples using JMP™ software.

ALUMINUM CALIBRATION RESULTS

For the aluminum calibration runs there did not appear to be a significant difference in all of the test samples for:

- Small LPD
- Area
- Haze
- Large LPD
- Resistance Average
- Resistance Percent Deviation
- Room Temperature Mobility

There did appear to be a significant difference for Photo Luminescence (PL) intensity, where as, the prime substrates appeared to be significantly higher than the re-etched samples; however, the re-polished substrates seemed to be comparable to the prime test samples [see Illustration 2]. It is important to note that the re-etched wafers had a high enough PL intensity that they still could be used when running an initial "internal" aluminum calibration run. When a more critical "customer" aluminum calibration wafer is needed, a re-polished substrate could still be used in place of prime.

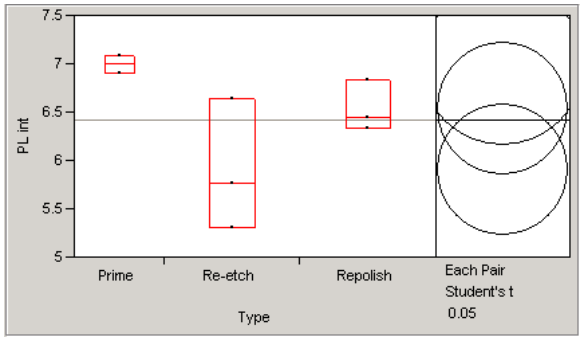

Illustration 2 – PL Intensity by Type (Al Calibration)

Level			Mean
Prime	A		6.9950000
Repolish	A	B	6.5333333
Re-etch		B	5.9033333

Levels not connected by the same letter are significantly different

HEMT CALIBRATION RESULTS

For the HEMT calibration runs there appeared to be no significant differences in all of the test samples for:

- Haze
- Resistance Average
- Resistance Percent Deviation
- Liquid Nitrogen (LN) Temperature Mobility

There did appear to be a significant difference in the test samples for small and large LPD, and area; however, the prime wafer appeared to be significantly higher than the re-etched and re-polished substrates [see Illustration 3]. There also seemed to be a significant difference between the re-etched and re-polished substrates for room temperature mobility, but both were comparable to the prime test samples [see Illustration 4]. From the results of the experiment re-etched or re-polished substrates may be used for HEMT calibration runs in place of expensive prime material.

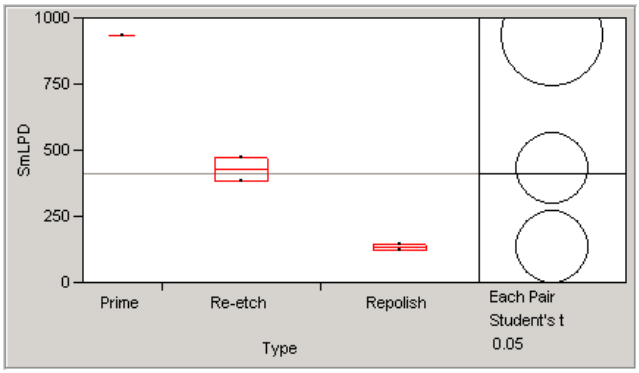

Illustration 3 – Small LPD by Type (>1.3µm^2) – HEMT Calibration

Level			Mean
Prime	A		934.00000
Re-etch		B	430.50000
Repolish		C	134.50000

Levels not connected by the same letter are significantly different

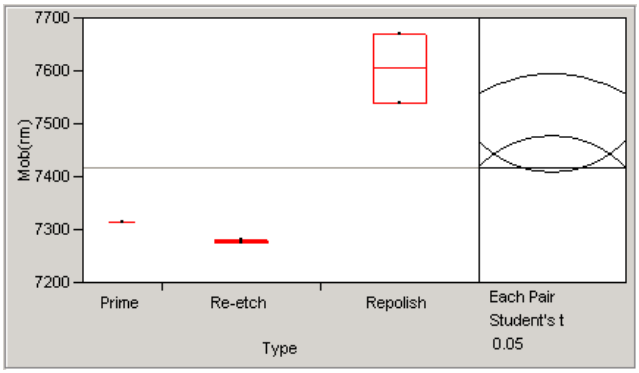

Illustration 4 – Room Temperature Mobility (HEMT Calibration)

Level			Mean
Repolish	A		7605.0000
Prime	A	B	7315.0000
Re-etch		B	7278.5000

Levels not connected by the same letter are significantly different

CONCLUSION

In summary, rejected Epi-wafers can be successfully reclaimed through the use of re-etching or re-polishing the Epi-structure away. These wafers can be very useful in calibrating an MBE reactor instead of using costly prime substrates. Calibration runs such as, growth rate

calibrations, doping calibrations, HEMT calibrations, and aluminum calibrations have been performed using these types of reclaimed substrates.

Since implementing the reclaim program, IQE has realized an approximate thirty percent savings in prime substrate usage.

ACKNOWLEDGEMENT

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REFERENCE

1. J.J. Gannon and C.J. Nuese, J. Electochem. Soc.: Solid-State Science and Technology, 1215-1219 (1974)

ACRONYMS

MBE: Molecular Beam Epitaxy
PHEMT: Pseudomorphic High Electron Mobility Transistor
SIMS: Secondary Ion Mass Spectroscopy
HEMT: High Electron Mobility Transistor
LPD: Light Point Defects

