# GaAs HBT wet etch process using reclaimed chemicals

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**Key words: GaAs, HBT, Chemical Etch, Recycling Chemical, Wafer Fabrication**

**Abstract**

**Chemical costs can be a significant part of semiconductor manufacturing materials cost. True chemical cost consists of raw chemical price, handling expenses and disposal of used chemicals. Some of this usage can be cut back by recycling the chemicals for re-use. This paper describes the work done to establish the use of recycled chemical for etch processing during Gallium Arsenide Hetero-junction Bipolar Transistors (GaAs HBT) fabrication.**

## BACKGROUND:

Manufacturing cost reduction has been and remains more than ever one of the major ongoing initiatives at Anadigics. During wafer fabrication wet etch chemicals are used at multiple process steps. Some of these steps involve etch times as long as10 minutes of spray chemistry, consequently large volumes of chemicals are used during these etches. The cost of these chemicals both to purchase and to handle and dispose of can become quite considerable. In addition environmental safety is a significant consideration in the disposal of these chemicals. Recycling a significant portion of the chemicals used brings this cost down drastically.

## EXPERIMENT:

An Equinox spray etch tool from Semitool is used for these etch processes. A Chemical blending system mixes the chemicals to the accurate ratios required. and supplies chemistry to the tool as needed. The Etch chamber uses multiple spray nozzles for chemicals to obtain uniform etch rate across the 150 millimeters diameter GaAs wafers. The Original process dumped the used chemical from process chamber into the chemical drain. The tool was modified to provide an adjustable re-routing of the used chemical back from process chamber to the chemical holding tank on the tool.

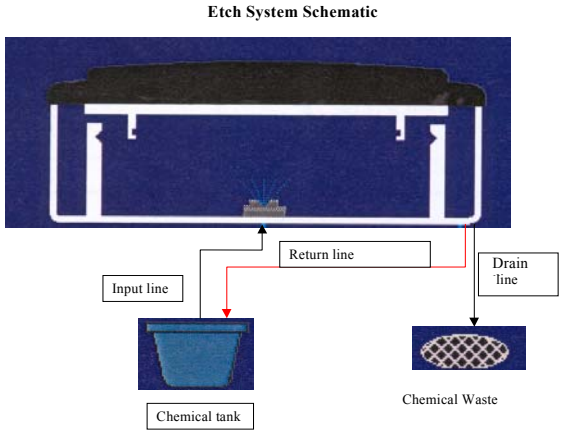


**Figure 1, Etch Tool Configuration**

$H_2O_2$the active component in the etchant is known to lose its chemical activity with time and usage. To determine the chemical activity and shelf life patterned GaAs wafers were etched for extended time while used chemical was rerouted to the holding tank. The experiment was conducted by dumping used chemical at the beginning of etch and then collecting the remaining chemical during long etch times. Etch rate monitoring wafers were interspersed during the extended etch experiments To allow etch rate to be calculated throughout the experiment.

The time for initial dump of used chemical was determined based on the etch rate

performance of the used chemical. The experiment was also repeated over an extended time to test the shelf life of the reclaimed chemical.

In addition reclaimed chemical was also tested for contamination. GaAs wafers were etched using both reclaimed and fresh chemical. They were then sent to Evans lab for TOF SIMS analysis to compare the contamination results between them

An experiment was also conducted with multiple test lots " of device" wafers for process qualification. Half of each these lots were etched with fresh chemical and the other half were etched in reclaimed chemical. These lots were tested under extreme conditions of used chemical using eighty equivalent wafers before processing.

The lots were then processed through the remaining wafer fabrication and were tested for electrical performance at PCM and Die Sort. Reliability of these devices was also tested after Electrical Stress.

RESULTS:

A graph of etch rate tested periodically during reclaimed cycle is shown in figure 2 below. Etch rate using reclaimed chemical was found to be stable even after etching fifty wafers. After etching one hundred wafers, the etch rate of reclaimed chemical had changed by less than ten percent.

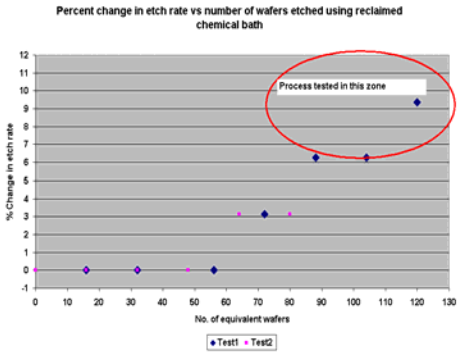


**Figure 2, Change in etch rate for reclaimed chemical**

Test lots for process qualification were processed when the chemical in the tank was used for etching more than eighty wafers and etch rate had dropped by six to eight percent below the starting level. This is indicated in red circle in figure 2.

TOF SIMS analysis of etched surface of samples from fresh and reclaimed chemical showed identical results. Both positive and negative TOF SIMS spectra were obtained for both samples at multiple locations on the wafer. There was no difference between the two wafers for both positive and negative ions spectra.

Electrical test results at PCM for process qualification lots are shown below in figures 3a to 3c. As can be seen from the charts, there is no significant difference in electrical performance between two groups in split lots.

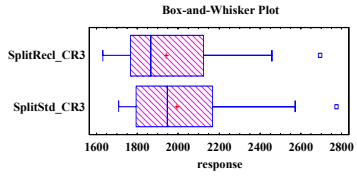


**Figure 3a, Collector contact chain resistance for process qualification lots**

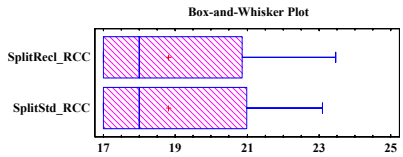


**Figure 3b, Collector contact resistance for process qualification lots**

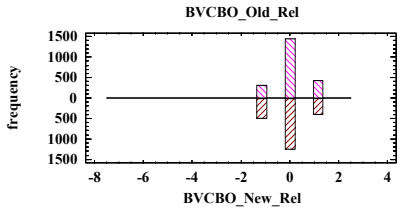


**Figure 3c, Breakdown between Base & Collector contact for old & new processes in production**

Post electrical stress data is shown below in figure 4 for process qualification lots. Fresh chemical process is indicated by "O" for old process and reclaimed chemical process is indicated by "N" for new process. There is no significant difference the two groups.

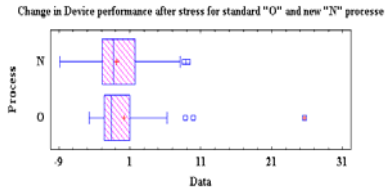


**Figure 4; Change in electrical performance after stress test for "old" & "new" process**

The new process of using reclaimed chemical was implemented in production after testing reliability of these devices. After implementation, raw chemical usage on the tool dropped by more than thirty percent. This is a great success for cost reduction for chemical usage, handling, environmental and safety issues.

SUMMARY

The wet etch tool was modified to reclaim used chemical. Reclaimed chemical was tested for depletion and shelf life. The etch rate was found to be stable even after etching fifty wafers and had dropped by less than ten percent after etching one hundred wafers. The process was qualified using reclaimed chemical. There was no difference found between fresh chemical and reclaimed chemical process regarding TOF SIMS or PCM or reliability results for these devices. The process was successfully implemented in production. Chemical usage dropped by more than thirty percent on this tool, with equivalent reductions in handling and disposal/environmental costs and considerations.

ACRONYMS

GaAs: Gallium Arsenide
HBT: Hetero-junction Bipolar Transistor
$H_2O_2$: Hydrogen Peroxide
TOF SIMS: Time Of Flight Secondary Ion Mass Spectrometer
PCM: Process Control Monitor
CR3: Collector Resistance Chain
RCC: Collector Contact Resistance
BCBO: Breakdown Voltage between Collector and Base