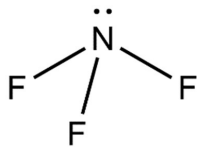


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The Problem

Nitrogen Tetrafluoride (NF3) is critical in Chemical Vapor Deposition (CVD) cleaning applications. It is the preferred cleaning chemistry for CVD deposition due to its high fluorine atom production and higher etch rate and cleaning efficiency compared to other cleaning methods, such as Octafluoropropane (C3F8), which is used in older model machines. This project aims to explore the methods that can be used to reduce the NF3 usage during CVD processing and the resultant effects on the on-wafer results. This is essential to reduce production costs and wasted resources.

The problem currently being observed is high NF3 consumption on the SPTS Delta APM module. NF3 is expensive to purchase due to the high purity NF3 required for this application, It also has high lead times of approximately 12 weeks per bottle. Finally, it is a toxic gas with high environmental impact, with a global warming potential of 17,000. The aim of the project was to reduce the overall NF3 usage on site by a minimum of 10% while maintaining consistent on wafer results.



Nitrogen trifluoride

Methodology

Multiple solutions were tested to reduce the NF3 consumption of the module. Including increasing the number of wafers between cleans, from 5 to 8 wafers between clean cycles, as well as decreasing the NF3 flow rate from 5000sccm to 4000sccm. This involved producing alternate cleaning recipes for each test, these were developed on the delta APM module, with alternate post wafer and post cassette cleans with end point detection.

Pre-Implementation testing

Pre-implementation was completed prior to the implementation. This included, baselining the metrology tools with a known wafer in order to ensure it was achieving accurate and consistent results.

The Delta APM module was also baselined using CapOx, a BKM Oxide, and SiN (Silicon Nitride) to ensure that the module was achieving expected results prior to completing any official testing

CapOx Baseline testing results

	Thickness(nm)	Uniformity (%)	Stress (Mpa)	RI
CapOx	1014	2.1%	-137	1.45
Specification	1000	<2.5%	-140	1.45

SiN Baseline testing results

	Thickness(nm)	Uniformity (%)	Stress (Mpa)	RI
SiN 5WBC	5000	0.5	-105	2.04
Specification	5000	<3%	-110	2.03

Implementation

Silicon ‘dummy’ wafers were used to condition the chamber prior to testing. This ensures each wafer sees the same environment, producing more consistent results. Prime, pre measured silicon wafers were then used for the clean frequency and reduced NF3 flow rate testing. These wafers were measured for thickness, Non-uniformity and Stress post deposition, using a filmetrics thin film measurement tool and a TOHO flexus stress measurement tool.

Conclusion

SIN	5WBC	6WBC	7WBC	8WBC	SIN	4000sccm	5000sccm
Action	cm3 NF3	cm3 NF3	cm3 NF3	cm3 NF3	Action	cm3 NF3	cm3 NF3
Pre Cassette	10000	10000	10000	10000	Pre Cassette	10000	10000
Post Wafer	16666	20000	21666	23750	Post Wafer	10000	10000
Post Cassette	8333	8333	8750	8750	Post Cassette	6666	7500
Total usage	34999	38333	40416	42500	Total usage	26666	27500
Usage per wafer	6999.8	6388.833	5773.714	5312.5	Usage per wafer	26666	27500
Reduction		8%	18%	25%	Reduction	3%	

The implementation produced a minimum of 3% reduction in NF3 usage, with the reduction in NF3 flow being the least effective method. While the increased number of wafers between cleans achieved between 8 –25% total reduction of NF3 consumption.

Overall the project was successful in reducing the NF3 consumption of the site by 18% by implementing 7 wafers between cleans as identified during the clean frequency testing. The customer has now implemented this method into production, reducing the usage of NF3, while maintaining the on wafer results, as well as improving the throughput on the module, meeting the aims of the project